September 26, 2024

USDA Forest Service
Southwestern Region
ATTN: Objection Reviewing Officer
333 Broadway SE
Albuquerque, NM 87102

Submitted electronically via
https://cara.fs2c.usda.gov/Public//CommentInput?Project=51887

RE: Objection to Revised Land Management Plan, Final EIS, and Draft Record of Decision for the Gila National Forest

Dear Regional Forester Michiko Martin:

We are filing this objection with the United States Forest Service (Forest Service) to the final revised land management plan (Final LMP),[1] Final Environmental Impact Statement (FEIS),[2] and Draft Record of Decision (Draft ROD)[3] for the Gila National Forest (GNF) because the planning process and substance of the Final LMP, FEIS, and Draft ROD fail to comply with a set of laws, implementing regulations, and associated policy that apply to decisions about recommended wilderness suitable for inclusion in the National Wilderness Preservation System and stream segments eligible for inclusion in the National Wild and Scenic Rivers System. This objection is timely submitted on or before September 30, 2024. This objection is submitted on behalf of the New Mexico Wilderness Alliance (New Mexico Wild), The Wilderness Society (TWS), Great Old Broads for Wilderness, WildEarth Guardians, and The Center for Biological Diversity.

New Mexico Wilderness Alliance (New Mexico Wild) is a nonprofit organization dedicated to the protection, restoration, and continued enjoyment of New Mexico's wildlands, wilderness areas, and wild and scenic rivers, with thousands of members across the state. We have played an active role in the Gila National Forest plan revision

[1] USDA Forest Serv., Gila National Forest, Land Management Plan (July 2024), *available at* https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd1194081.pdf [hereinafter Final LMP].
[2] USDA Forest Serv., Gila National Forest, Revised Forest Plan Final Environmental Impact Statement (July 2024), *available at* https://www.fs.usda.gov/detail/gila/home/?cid=STELPRD3828671 [hereinafter FEIS].
[3] USDA Forest Serv., Gila National Forest, Draft Record of Decision Gila National Forest Land Management Plan (July 2024), *available at* https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd1194079.pdf [hereinafter Draft ROD].

process since scoping and have submitted a citizen's proposal outlining over 600,000 acres of recommended wilderness, in addition to hundreds of miles of eligible wild and scenic rivers that our members and staff physically inventoried out in the field over the course of four and half years.

The Wilderness Society (TWS) has a mission of uniting people to protect America's wild places. We envision a future where people and wild nature flourish together, meeting the challenges of a rapidly changing planet. For over eight decades, TWS has been a national leader in the conservation movement, creating some of our country's most important conservation laws and working with partners across the U.S. to protect more than 110 million acres of wilderness in 44 states. TWS has also worked with communities and government agencies to protect another 100 million acres as national monuments or with other designations. Our niche in the conservation community is its national policy experience, combined with deep local roots and scientific expertise. TWS is now building on our history and experience to pursue two new, bold priorities: Making public lands a solution to the climate and extinction crises; and transforming conservation policy and practice so all people benefit equitably from public lands.

Great Old Broads for Wilderness is a women-led national grassroots organization that engages in and inspires activism to preserve and protect wilderness and wild lands. Our volunteer-led chapters (called Broadbands), located in rural and urban communities across the nation, organize members to engage as advocates to protect and steward wilderness and wild places. Aldo's Silver City chapter focuses on public and wild lands issues within southwestern New Mexico and surrounding areas of the Southwest.

WildEarth Guardians (Guardians) is a nonprofit conservation organization whose mission is to protect and restore wildlife, wild places, wild rivers, and the health of the American West. Guardians has offices throughout the western United States, including New Mexico and Arizona, and has more than 206,700 members and supporters across the United States and the world. As an organization, Guardians seeks to ensure the Forest Service complies with all environmental laws during the Forest Plan revision process. It also has a demonstrated history of advocating for an ecologically and economically sustainable transportation system on the Gila National Forest, and protecting at-risk species.

The Center for Biological Diversity is a national, nonprofit conservation organization with more than 1.7 million members and online activists dedicated to the protection of endangered species and wild places. The members and activists of the Center are concerned with the management of our federal public lands, including our national forests, especially as that management relates to the recovery and viability of native species and their habitats. The Center has fought for protection of wilderness, wild and scenic rivers, and wildlife on the Gila National Forest for decades. We will continue to use science, media, and legal strategies to advance the preservation and restoration of this incredible National Forest.

Our organizations have participated throughout the Gila National Forest (GNF) planning process and have submitted comments on several occasions, including most recently on the Draft Land Management Plan (Draft LMP) and Draft Environmental Impact Statement (DEIS). We appreciate the evident work you and your staff have put into the forest planning process. We are concerned, however, that the proposed Final LMP, FEIS, and Draft ROD fail to strike the appropriate balance regarding recommended wilderness and eligible wild and scenic river segments, and that the Final LMP, FEIS, and Draft Record of Decision (ROD) are inconsistent with applicable law, regulation, and policy and reflect arbitrary and capricious decision making. We therefore submit this formal objection to the proposed Final LMP, FEIS, and Draft ROD for the GNF. We look forward to meeting with you to discuss remedies to our objections.

I. REQUIRED INFORMATION

Lead Objector: New Mexico Wilderness Alliance (New Mexico Wild)
Sally Paez, Staff Attorney
P.O. Box 25464
Albuquerque, NM 87125
(505) 843-8696
sally@nmwild.org

Reference to: Gila National Forest Revised Land Management Plan

Responsible Official: Camille Howes, Forest Supervisor

II. STATEMENT OF THE ISSUES

A. Wilderness Recommendations:

1. The GNF should have analyzed the Citizens' Proposal for recommended wilderness as a separate alternative in the EIS.

2. Problems with the GNF's recommended wilderness analysis process resulted in an inadequate Draft LMP and DEIS that included only 110,402 acres for recommended wilderness in the proposed action (Alternative 2).

    a. The proposed action's threshold criterion, that recommended wilderness must contribute to the "wilderness niche of a large, mostly contiguous wilderness complex," is arbitrary and capricious.

    b. The GNF used inappropriate criteria ("steps") to reduce the size of and eliminate recommended wilderness units from the proposed action.

c. The GNF inappropriately reduced the size of many recommended units based on justification that was incorrect or nonfactual, misaligned with agency policy, or unsupported by the project record.
    - Aldo Leopold Seco Addition, Aldo Leopold Addition Northeast, Mineral Creek, Nolan North, Aspen Mountain, Aldo Leopold Addition - McKnight Canyon, Taylor Creek, and Rabb Park.

d. The GNF inappropriately excluded many areas that should have been recommended based on justification that was incorrect or nonfactual, misaligned with agency policy, or unsupported by the project record.
    - Lower San Francisco, Mother Hubbard, Upper Frisco Box, Devil's Creek, North Mogollon Mountains (Deep Creek), Mogollon Box/Tadpole Ridge, and Gila Middle Box.

3. In the Final LMP, the Responsible Official made an arbitrary and capricious decision to eliminate four areas that had been included in the proposed action in the Draft LMP, reducing the amount of recommended wilderness in preferred Alternative 2 from 110,402 acres to 72,103 acres.
    - Nolan North, Aspen Mountain, Aldo Leopold Addition West, and Aldo Leopold Addition - McKnight Canyon.

B. Wild and Scenic Rivers Eligibility:

1. The GNF erred by failing to consider the national scale when using regions of comparison to evaluate outstandingly remarkable values.

2. The GNF erred by using insufficient definitions and unreasonably restrictive Gila-Specific Eligibility Evaluation Criteria (GSEEC) for ORVs and by applying some of the criteria in an inconsistent and arbitrary manner.

3. The GNF incorrectly found that fourteen qualifying stream segments were ineligible for inclusion in the National Wild and Scenic River System, despite public input demonstrating that the fourteen segments are free-flowing and possess ORVs.
    - Apache Creek, Black Canyon Creek, East Fork Gila River, East Fork Mimbres River (McKnight Canyon), Gilita Creek, Indian Creek, Little Creek, Mogollon Box Gila River, Mogollon Creek, San Francisco River (Devil's Creek), Sapillo Creek, Taylor Creek, Turkey Creek, and West Fork Mogollon Creek.

4. The Final LMP, FEIS, and Draft ROD contain insufficient documentation, data, and justification to support the GNF's ineligibility determinations.

III. LINK BETWEEN PRIOR SUBSTANTIVE FORMAL COMMENTS AND THE CONTENT OF THIS OBJECTION

On June 17, 2017, New Mexico Wild, WildEarth Guardians, and partner organizations submitted scoping comments on the Gila National Forest plan Revision, focused primarily on wilderness inventory and wild and scenic river inventory. On March 27, 2018, New Mexico Wild and partner organizations submitted a proposal titled Citizens' Proposed Wilderness and Eligible Wild and Scenic Rivers. On April 16, 2020, New Mexico Wild, The Wilderness Society, Great Old Broads for Wilderness, WildEarth Guardians, and The Center for Biological Diversity, and additional partners collectively identified as the "Gila Coalition" filed a substantive formal comment on the Draft LMP and DEIS.[4]

Regarding recommended wilderness, our Gila Coalition Comments on the Draft LMP and DEIS included concerns with the recommended wilderness process, the range of alternatives, and the diminutive acreage in the proposed action (Alternative 2). We specifically identified units that were recommended in the proposed action, as set forth in the Draft LMP and DEIS, but were inappropriately reduced in size due to flaws in the analysis process, including the following units discussed in this objection. (Page numbers correspond to the Coalition Comments on the Draft LMP and DEIS.)

- B1a - Aldo Leopold Seco Addition (p. 233)
- B1c - Aldo Leopold Seco Addition (p. 234)
- B10 - Aldo Leopold Addition Northeast (p. 235)
- G1 - Mineral Creek (p. 238-39)
- QG1 - Nolan North (p. 241-43)
- RG1 - Aspen Mountain (p. 244-45)
- W3 - Aldo Leopold Addition West (p. 246)
- W4 - Aldo Leopold Addition McKnight Canyon (p. 247-48)
- WB1 - Taylor Creek (p. 249, 269)
- WSB1 - Rabb Park (p. 250, 268)

We also identified units that were suitable for wilderness designation but were not recommended in the proposed action (Alternative 2), as set forth in the Draft LMP and DEIS, including the following units discussed in this objection. (Page numbers correspond to the Coalition Comments on the Draft LMP and DEIS.)

- G6 - Lower San Francisco (p. 251-52)
- RG2 - Devil's Creek (p. 255)
- RG4 - North Mogollon Mountain (Deep Creek) (p. 256)
- S2 - Gila Middle Box (p. 257-59)
- S1 - Mogollon Box/Tadpole Ridge (p. 260-61, 266)

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[4] A Citizens Comment Letter: Gila National Forest Draft Forest plan and Draft Environmental Impact Statement, Prepared by the Gila Coalition (Apr. 16, 2020) [hereinafter Coalition Comments on Draft LMP/DEIS].

- QR1 - Upper Frisco Box (p. 262-63)
- Q11 - Mother Hubbard (p. 264-65)

Regarding stream segments that should be eligible for inclusion in the National Wild and Scenic River System, our comments identified fourteen stream segments that are both free-flowing and have at least one ORV, yet were not identified as eligible by the GNF, including the following segments discussed in this objection. (Page numbers correspond to the Coalition Comments on the Draft LMP and DEIS.)

- Apache Creek (12 miles) (p. 293)
- Black Canyon Creek (24 miles) (p. 294)
- East Fork Gila River (9 miles) (p. 295)
- East Fork Mimbres River (17 miles) (p. 296)
- Gilita Creek (4 miles) (p. 297)
- Indian Creek (9 miles) (p. 298)
- Little Creek (13 miles) (p. 299)
- Mogollon Box Gila River (16 miles) (p. 300)
- Mogollon Creek (30 miles) (p. 301)
- San Francisco River/Devil's Creek (19 miles) (p. 302)
- Sapillo Creek (7 miles) (p. 303)
- Taylor Creek (19 miles) (p. 304)
- Turkey Creek (21 miles) (p. 305)
- West Fork Mogollon Creek (8 miles) (p. 306)

The GNF has not addressed the concerns we raised in our comments on the Draft LMP and DEIS. Rather than correcting issues raised, in the Final LMP and Draft ROD the Responsible Official has eliminated four recommended wilderness units that had been included in the proposed action in the Draft LMP and DEIS, reducing the amount of recommended wilderness in preferred Alternative 2 from 110,402 acres to 72,103 acres. The amount of recommended acreage in the Final LMP and Draft ROD is less than any of the action alternatives that were proposed in the Draft LMP. Finally, new information related to the 30x30 initiative and the importance of the GNF to meeting our climate and biodiversity goals has compounded our concerns and the need to reconsider decisions about recommended wilderness and eligible wild and scenic river segments in the Final LMP and ROD.

IV. OBJECTIONS RELATED TO PROPOSED FINAL RECOMMENDED WILDERNESS

A. Law, Regulation, and Policy Applicable to Wilderness Recommendations

Our objections related to the proposed final wilderness recommendations are based on law, regulation, and policy including the Wilderness Act, the Wild and Scenic Rivers Act, the National Environmental Policy Act, the National Forest Management Act, the 2012 Planning Rule, and Chapter 70 of the Forest Service Handbook on Land Management Planning, as further described below.

Congress passed the Wilderness Act of 1964 to establish the National Wilderness Preservation System, which provides protection for lands relatively unimpacted by human activity.[5] The Act defines wilderness as "an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain . . . undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation."[6] The Act provides four criteria for lands suitable for wilderness designation, as follows:

> (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.[7]

The Wilderness Act directs the Forest Service to assist Congress in designating wilderness by reviewing "primitive" areas of the national forests to determine their "suitability or nonsuitability for preservation as wilderness."[8]

National Forests conduct this wilderness review during the forest planning process, which is governed by the National Forest Management Act of 1976 (NFMA).[9] NMFA requires the Forest Service to "develop, maintain, and, as appropriate, revise land and resource management plans for units of the National Forest System, coordinated with the land and resource management planning processes of State and local governments and other Federal agencies."[10] Additionally, the Forest Service's 2012 Planning Rule provides binding regulatory direction regarding "the development, amendment, and revision of land management plans[.]"[11] The 2012 Planning Rule mandates that, "in developing a proposed new plan or proposed plan revision," the Forest Service must "[i]dentify and evaluate lands that may be suitable for inclusion in the National Wilderness Preservation System and determine whether to recommend any such lands for wilderness designation."[12]

Additional policy guidance is set forth in Chapter 70 of the Forest Service Handbook.[13] Chapter 70 "describes the process for identifying and evaluating lands that may be suitable for inclusion in the National Wilderness Preservation System and determining

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[5] *See* Wilderness Act of 1964, 16 U.S.C. §§ 1131-1136; *Nat'l Audubon Soc'y v. Forest Serv.*, 46 F.3d 1437, 1440 (9th Cir. 1993).
[6] *Id.* § 1131(c).
[7] *Id.*
[8] *Id.* § 1132(b).
[9] National Forest Management Act of 1976 (NFMA), 16 U.S.C. §§ 472a, 1600-1606, 1607-1614.
[10] *Id.* § 1604(a).
[11] 36 C.F.R. Part 219; 77 Fed. Reg. § 21260.
[12] 36 C.F.R. § 219.7(c)(2)(v).
[13] USDA Forest Service, Forest Service Handbook (FSH) 1909.12 - Land Management Planning Handbook, Chapter 70 - Wilderness (effective 1/30/2015) [hereinafter Chapter 70].

whether to recommend any such lands for wilderness designation."[14] "The process occurs in four primary steps: inventory, evaluation, analysis, and recommendation."[15] As explained by the GNF, "the first two steps of the process are intended just to determine if areas contain Wilderness Characteristics (COULD the area be Wilderness?) and the third and fourth steps allow the Forest Supervisor to consider other factors to determine whether or not to recommend an area to Congress for designation (SHOULD an area be managed as wilderness, or are there compelling reasons to manage it otherwise)."[16]

In the inventory step, the Forest Service must include "all lands that may be suitable" for designation based on size and improvement criteria and must consider information submitted by the public.[17] In the evaluation step, the Forest Service must apply the criteria set forth in the Wilderness Act to determine whether an inventoried area qualifies for designation under the Act.[18] Considerations in the evaluation step include natural appearance, opportunities for solitude or primitive and unconfined recreation, size, special features or values, and the "degree to which an area may be managed to preserve its wilderness characteristics."[19] In the analysis step, the Forest Service must "consider the areas evaluated and determine which areas to further analyze for recommendation as part of one or more alternatives" in the EIS.[20] Finally, in the recommendation step, the Forest Service must "decide, based upon the analysis and input from Tribal, State, and local governments and the public, which areas, if any, to recommend."[21] Each step requires public participation and documentation.[22] The Forest Service must "complete this process before the Responsible Official determines, in the plan decision document, whether to recommend lands within the plan area to Congress for wilderness designation."[23]

Similarly, once lands have been identified and evaluated for suitability, the National Environmental Policy Act of 1989 (NEPA) requires that an EIS discuss reasonable alternatives to the proposed action for recommended wilderness management.[24] The NEPA alternatives analysis required by 42 U.S.C. § 4332(C)(iii) is the "heart" of the NEPA process.[25] The forest must "[r]igorously explore and objectively evaluate reasonable alternatives to the proposed action, and, for alternatives that the agency eliminated from detailed study, briefly discuss the reasons for their elimination."[26]

[14] *Id.* at p. 2.
[15] *Id.* at p. 4.
[16] USDA Forest Service, GNF, Inventory and Evaluation of Wilderness Characteristics Process, Frequently Asked Questions, pp. 8-9.
[17] Chapter 70, pp. 4-5, 6-10.
[18] *Id.* at p. 5.
[19] *Id.* at pp. 11-12.
[20] *Id.* at p. 5.
[21] *Id.*
[22] *Id.* at p. 4.
[23] *Id.* at p. 4 (citing 36 C.F.R. § 219.7 (c)(2)(v)).
[24] 42 U.S.C. § 4332(2)(C).
[25] 40 C.F.R. § 1502.14.
[26] *Id.* § 1502.14(a).

B. <u>The GNF's Wilderness Recommendation Process</u>

In the current GNF plan revision effort, the GNF went through the process of identifying and evaluating lands for suitability, and then analyzing which units should be managed as recommended wilderness.[27] During the inventory step, the GNF removed areas with roads and applied buffers ranging from 100 feet to 1000 feet around roads and substantially noticeable improvements.[28] The GNF's "final inventory . . . included 1,219,019 acres within 100 separate area polygons."[29]

For the evaluation step, the GNF began by evaluating each of the polygons to determine its manageability, including its "location relative to substantially noticeable improvements" and the "[f]easibility of boundary adjustments that could make the area manageable to wilderness characteristics."[30] The GNF eliminated 39 units from further evaluation based on these considerations.[31] The GNF evaluated remaining units for wilderness characteristics and assigned a numeric score corresponding to an overall wilderness characteristic ranking of "none," "low," "moderate," "high," or "outstanding."[32] The GNF's evaluation found that 63 units totaling 827,475 acres had some level of wilderness characteristics.[33]

The GNF completed the analysis step through the comparison of alternatives in the Draft EIS.[34] The GNF issued a Draft LMP/DEIS with four action alternatives:[35]

Table 24. Acres of recommended wilderness by alternative

Alternative	Acres of Recommended Wilderness
Alternative 2	110,402
Alternative 3	130,012
Alternative 4	72,901
Alternative 5	745,286

The GNF identified Alternative 2 as the proposed action. Areas included as recommended wilderness in the proposed action needed to score an overall evaluation ranking of moderate/high, high, or outstanding and needed to "contribute to the existing wilderness niche of a large, mostly contiguous wilderness complex."[36] Areas that met these threshold requirements were subject to subsequent reduction or

27 *See generally* FEIS, Vol. 3, Appendix H.
28 *Id.* at pp. H-2 to H-3.
29 *Id.* at p. H-3.
30 *Id.* at p. H-5.
31 *Id.* at pp. H-5 to H-8.
32 *Id.* at pp. H-8 to H-18.
33 FEIS, Vol. 2, p. 531.
34 FEIS, Vol. 3, p. H-19
35 USDA Gila National Forest, Draft Revised Forest Plan Draft Environmental Impact Statement, Vol. 1, p. 194, Table 24 (Dec. 2019), *available at* https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd687232.pdf [hereinafter DEIS].
36 FEIS, Vol. 3, p. H-19.

elimination based on additional criteria, including probability of stand-replacing fire, presence of grazing infrastructure requiring motorized maintenance, and presence of more than one total mile of range fencing.[37] At the end of this analysis process, the proposed action, Alternative 2, included thirteen areas (110,402 acres) to be managed as recommended wilderness, as follows:[38]

Table 2. Areas recommended to Congress for wilderness designation as part of the Gila forest plan revision process

Recommended Area	Acres
B10-ALDO LEOPOLD ADDITION NORTHEAST	8,381
B11-ALDO LEOPOLD ADDITION SOUTHEAST	944
B14-ALDO LEOPOLD ADDITION CARBONATE CREEK	2,819
B1a-ALDO LEOPOLD SECO ADDITION	4,724
B1c-ALDO LEOPOLD SECO ADDITION	48
G12-GILA WHITEWATER ADDITION	1,960
G1-MINERAL CREEK	16,538
QG1-NOLAN NORTH	6,718
RG1-ASPEN MOUNTAIN	19,053
W3-ALDO LEOPOLD ADDITION WEST	1,110
W4-ALDO LEOPOLD ADDITION MCKNIGHT CANYON	11,094
WB1-TAYLOR CREEK	10,012
WSB1-RABB PARK	27,002
Alternative Total Acres	**110,402**

In the Final LMP, the Responsible Official did not proceed with the proposed action (Alternative 2) and instead decided to eliminate four of the recommended wilderness areas, consisting of 37,975 total acres or 35% of the recommended acreage, as follows:

- QG1-Nolan North (6,718 acres);
- RG1-Aspen Mountain (19,053 acres);
- W3-Aldo Leopold Addition West (1,110 acres); and
- W4-Aldo Leopold Addition McKnight Canyon (11,094 acres).[39]

As a result, the Final LMP and Draft ROD include only nine areas (72,103 acres) recommended for inclusion in the National Wilderness Preservation System: (1) Aldo Leopold Addition Northeast, (2) Aldo Leopold Addition Southeast, (3) Aldo Leopold Addition Carbonate Creek, (4) Aldo Leopold Seco Addition B1a, (5) Aldo Leopold Seco Addition B1c, (6) Gila Whitewater Addition, (7) Mineral Creek, (8) Taylor Creek, and (9) Rabb Park.[40] The proposed decision includes fewer acres of recommended wilderness than any of the action alternatives that had been presented in the Draft LMP and DEIS.

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[37] *Id.* at pp. H-19 to H-20.
[38] USDA, Draft Revised Forest Plan Gila National Forest, p. 226 (Dec. 2019), *available at* https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd687231.pdf [hereinafter Draft LMP].
[39] Draft ROD, pp. 19-21.
[40] See explanations in Draft ROD, pp. 11, 19- 21.

C. Objections and Arguments Related to Wilderness Recommendations

As further explained below, we object to the GNF's failure to analyze the Citizen's Proposal as a separate alternative, and the analysis process and criteria that the GNF used to eliminate or reduce the size of areas included in the proposed action (Alternative 2) in the Draft LMP and DEIS. We raised these issues in our 2020 comments, but the Responsible Official dismissed our concerns with little discussion or rationale. Additionally, we strongly object to the Responsible Official's decision in the Final LMP and Draft ROD to eliminate four areas that had been included in the proposed action (Alternative 2) in the Draft LMP and DEIS.

1. **The GNF should have analyzed the Citizens' Proposal as a** separate alternative in the EIS.

The GNF failed to adequately evaluate the Citizens' Proposal, including the numerous KMZ files that detailed field notes, GPS photo-waypoints, and associated narratives that all adhered to the agency's own planning directives outlined in Chapter 70 of the Forest Service Handbook. An extensive, on-the-ground effort was led by New Mexico Wild and numerous volunteers trained in application of the process and criteria set out in Chapter 70. This documentation can be found in detail within the Citizens' Proposed Wilderness and Eligible Wild & Scenic Rivers proposal (Citizens' Proposal), submitted to the Gila National Forest on March 27, 2018, and included as Attachment 1 to the Gila Coalition Comments on the Draft LMP and DEIS on April 16, 2020. The Citizens' Proposal represents the best available data and on-the-ground assessment of current conditions, adheres to criteria and guidelines outlined in Chapter 70, and should have been used to inform the planning process.

Between 2013 and 2018 (a period of four and a half years), hundreds of people conducted more than 15,000 hours of field work to objectively assess the apparent naturalness of areas in the proposal, in addition to monitoring opportunities for solitude and primitive forms of recreation, while also considering the manageability of areas based on valid existing uses and roads open to the public and administrative access. This field-based assessment included identification of human modifications, such as decommissioned roads, fence lines, stock tanks, pipelines, fuelwood treatment areas, and other elements that could be considered to detract from overall wilderness character or that raised manageability concerns.

All the field work conducted in the GNF was provided to the Forest Service in the form of detailed KMZ files, extensive written narratives, and associated photographs and field notes, which outlined the numerous trails, canyons, ridgelines, rivers, and adjacent boundary roads inventoried and evaluated for recommended wilderness under the Citizens' Proposal.

The GNF should have analyzed this data as its own alternative in the DEIS. In the FEIS, the GNF states that this

> suggestion was considered, but not analyzed in detail because alternative 5 includes over 745,000 acres that includes and exceeds the 432,166 acres recommended by the citizens' proposal. The boundaries of most areas recommended by the citizens' proposal are within very close alignment to those of alternative 5, with some adjustments made to accommodate alternative criteria identified in the analysis process. The forest supervisor has the discretion to choose the citizens' proposal because it is within the range of alternatives analyzed.[41]

We continue to assert that the GNF should have analyzed the Citizens' Proposal as its own alternative (outside of Alternative 5) due to the scope and scale of the inventory and evaluation effort conducted by citizens trained in the Chapter 70 directives. Although the GNF undoubtedly conducted a robust GIS desk analysis, a GIS analysis does not provide an understanding of the landscape like on-the-ground surveys. The GNF's response did not address the meticulous detail provided by the Citizens' Proposal. Additionally, as discussed below, the GNF's alternatives were based on arbitrary criteria and processes outside the basic framework set forth in Chapter 70. The GNF's failure to address and respond to the public input violates NEPA and contravenes the guidance set forth in Chapter 70.

2. Problems with the GNF's recommended wilderness analysis process resulted in an inadequate Draft LMP and DEIS that included only 110,402 acres for recommended wilderness in the proposed action (Alternative 2).

As described in this section, we object to the way the GNF arrived at its proposed action (Alternative 2) in the Draft LMP and DEIS. The proposed action was based on an arbitrary "niche" criterion that is inconsistent with the Wilderness Act. Additionally, the GNF's analysis process used inappropriate "steps" or additional criteria to reduce the size of many qualifying areas and to omit many qualifying areas from the draft recommendation.

a. The proposed action's threshold criterion, that recommended wilderness must contribute to the "wilderness niche of a large, mostly contiguous wilderness complex," is arbitrary and capricious.

In its recommended wilderness analysis process, the GNF's preferred Alternative 2 limited consideration to areas that "contribute to the existing Gila National Forest wilderness niche of a large, mostly contiguous wilderness complex."[42] The GNF explains that this niche is like

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[41] FEIS, Vol. 1, p. 21.

[42] GNF, Wilderness ID Team Alternatives Analysis Process Documentation at p. 2, *available at* https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd624618.pdf (last visited Sept. 23, 2024) [hereinafter Analysis paper].

> Aldo Leopold's original vision when he recommended to the Forest Service that the Gila be preserved as wilderness. "By 'wilderness'", he wrote, "I mean a continuous stretch of country preserved in its natural state, open to lawful hunting and fishing, big enough to absorb a two weeks' pack trip, and kept devoid of roads, artificial trails, cottages, or other works of man."[43]

By cherry-picking this single quote, the GNF overlooks Leopold's prolific body of written work addressing the importance of conserving biodiversity and wild, natural landscapes. Moreover, the GNF ignores the fact that Leopold's recommendation resulted in Congress enacting the Wilderness Act, which includes explicit criteria for designated Wilderness, including size requirements. The Wilderness Act requires a Wilderness Area to be either at least 5,000 acres in size or "of sufficient size as to make practicable its preservation and use in an unimpaired condition."[44] The potential duration of a pack trip is irrelevant to whether an area is of sufficient size for Wilderness designation.

Additionally, the GNF's use of the "large, mostly contiguous wilderness complex" criterion is unsupported by any reasonable justification or explanation, which renders the proposed action (Alternative 2) arbitrary and capricious for the following additional reasons. First, the GNF failed to define "mostly contiguous" or "wilderness complex," leading to ambiguity about which units might qualify. The plain language interpretation of "mostly contiguous" appears to allow the establishment of Recommended Wilderness that is not contiguous with or directly adjacent to existing wilderness or other Recommended Wilderness units. Yet, the GNF mechanically employed this language to inappropriately limit consideration to areas that are entirely contiguous with existing, designated Wilderness on the GNF. Similarly, the GNF does not define what constitutes a "wilderness complex," and absent clarity on this definition, the application of the "wilderness niche" threshold is arbitrary and capricious.

Second, as applied by the GNF this niche does not consider roadless lands that are similar to Wilderness, i.e., lands that are designated or managed to protect roadless areas and/or wilderness characteristics. These wild lands include Inventoried Roadless Areas (IRAs), Wilderness Study Areas (WSAs), and the Blue Range Primitive Area located in the Apache-Sitgreaves Forest, just across the New Mexico-Arizona state line, which is contiguous with the western boundary of the GNF.

The GNF used its niche statement to limit its recommended wilderness to areas that are adjacent to or contiguous with designated Wilderness Areas, with no stated management or protection rationale. As further described below, this requirement led to the disqualification of several areas with a high degree of wilderness characteristics that possess sufficient size for designation, including some that arguably meet the "wilderness niche" concept because they are located contiguous with IRAs, WSAs, or the Blue Range Primitive Area. We raised this issue in our comments on the Draft LMP and DEIS, but the Responsible Official failed to address our concerns.

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[43] *Id.*

[44] 16 U.S.C. § 1131(c).

b. **The GNF used inappropriate criteria (“steps”) to reduce the size of and eliminate recommended wilderness units from the proposed action.**

In addition to applying its arbitrary “niche” criterion, which limited consideration to areas that contribute to a “large, mostly contiguous wilderness complex,” in the recommended wilderness analysis process the GNF used other inappropriate criteria (“steps”) to further reduce the size of and eliminate recommended wilderness units from the proposed action (Alternative 2). These problematic criteria include the likelihood of stand replacing fire (Step 3), the presence of water sources for permitted grazing that require maintenance by motorized means (Step 5), the presence of more than one mile of fencing that requires repair and maintenance by motorized means (Step 6), and the ability of the Responsible Official to make boundary adjustments to exclude areas based on management concerns in Steps 3, 5, and 6, and for other reasons (Step 7).[45]

Under Step 3 of the analysis process, the GNF identified “*areas with 10% or more of their forested ERU area coincident with moderate or greater relative probabilities of stand-replacement fire should a fire occur under extreme fire weather conditions; thus being candidates for restoration work that could include mechanical treatments.*”[46] Step 3 is problematic because the Final LMP, Standard 2 expressly allows “mechanical preparation work in support of prescribed fire” within recommended wilderness.[47] Additionally, stand-replacing fire is a natural process in some forest types; these forests should not be categorically excluded from recommended wilderness on this basis. Further, it is not feasible for the GNF to restore all lands that are at risk of stand-replacing fire. Restoration activities are limited by multiple factors including topography, capacity, and budget. Absent any specific project proposals or even long-range plans to conduct restoration treatments in a specific area, a theoretical risk of stand-replacing fire should not preclude the designation of recommended wilderness where the Forest Service may never conduct restoration treatments.

Under Steps 5 and 6 of the analysis, the GNF identified areas with range infrastructure. Step 5 looked at “*areas that contain more than 10% of all water sources within the area that are associated with permitted grazing and require frequent maintenance or access by motorized means. Such improvements may include (but are not limited to) developed springs or wells, pipelines, solar panels, pumps, large above ground water storage structures or similar types of improvements.*”[48] Step 6 looked at “*areas that contain more than 1 mile of the total length of range fence within its boundaries that is currently accessed by the permittee for authorized purposes of fenceline inspection, repairs and maintenance by motorized means.*”[49]

Steps 5 and 6 are problematic because Forest Service policy pertaining to the management of recommended wilderness in Chapter 70 of the Forest Service Handbook

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45 Analysis paper, p. 2.
46 *Id.*
47 Final LMP, p. 246.
48 Analysis paper, p. 2.
49 *Id.*

does not preclude the use of motorized equipment in recommended wilderness. The policy states only that the plan components "must protect and maintain the social and ecological characteristics that provide the basis for wilderness recommendation."[50] Similarly, the Final LMP's Desired Conditions, Standards, Guidelines and Management Approaches[51] do not prohibit the use of motorized equipment for administrative purposes and, additionally, allow several exceptions within the LMP's plan components for range infrastructure maintenance. The need for occasional, ongoing repair and maintenance of range infrastructure with motorized equipment should not preclude the designation of recommended wilderness.

Similarly, the Wilderness Act and Congressional Grazing Guidelines specifically allow for continued grazing in wilderness areas. The Wilderness Act states: "the grazing of livestock, where established prior to [the effective date of this Act], shall be permitted to continue subject to such reasonable regulations as are deemed necessary by the Secretary of Agriculture."[52] Additionally, as quoted in our previous comments, the Congressional Grazing Guidelines address maintenance of grazing infrastructure in designated wilderness as follows:

> The maintenance of supporting facilities, existing in the area prior to its classification as wilderness (including fences, line cabins, water wells and lines, stock tanks, etc.), is permissible in wilderness. Where practical alternatives do not exist, maintenance or other activities may be accomplished through the occasional use of motorized equipment. This may include, for example, the use of backhoes to maintain stock ponds, pickup trucks for major fence repairs, or specialized equipment to repair stock watering facilities. Such occasional use of motorized equipment should be expressly authorized in the grazing permits for the area involved. The use of motorized equipment should be based on a rule of practical necessity and reasonableness...Moreover, under the rule of reasonableness, occasional use of motorized equipment should be permitted where practical alternatives are not available and such use would not have a significant adverse impact on the natural environment. Such motorized equipment uses will normally only be permitted to those portions of a wilderness area where they had occurred prior to the area's designation as wilderness or are established by prior agreement.[53]

Under Step 7, the GNF identified "*areas where boundaries may be adjusted to allow exclusion of any of the management concerns identified above, or for any documented additional relevant factors considered by the forest supervisor, and determine if the remaining modified areas would be manageable to protect wilderness characteristics*."[54] Step 7 is problematic because the GNF does not need to make

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[50] Chapter 70, p. 15.
[51] Final LMP, pp. 246-247.
[52] 16 U.S.C. § 1133(d)(4).
[53] USDA Forest Serv., Forest Service Manual 2320 – Wilderness Management, § 2323.22 (Jan. 22, 2007); *see also* Coalition Comments on Draft LMP/DEIS, pp. 266-67.
[54] Analysis paper, p. 2.

boundary adjustments to address the use of mechanical treatments associated with prescribed burns or the use of motorized equipment for range infrastructure, as explained above.

Moreover, Step 7 duplicates previous steps in the wilderness review process, resulting in unjustified reductions in recommended wilderness. Prior to the analysis step of the review process, the GNF had already made boundary adjustments and accounted for improvements as part of the evaluation step. During the evaluation, the GNF adjusted unit boundaries to address things like the presence of private property, cherry-stemmed roads, wildland urban interface (WUI), need for defensible space, mining developments or abandoned mines, and similar improvements. The evaluation also included an assessment of apparent naturalness, the presence of abandoned mines, range infrastructure, and other developments, among other factors. The presence of improvements was considered when the GNF assigned numeric scores and wilderness characteristic ratings to each unit. Rankings corresponding to apparent naturalness, solitude, opportunities for primitive or unconfined recreation, and other features of value were combined, resulting in overall rankings and numeric scores for each unit.

Additionally, when evaluating units for manageability, the GNF considered the area's size and shape, the presence and amount of non-federal land in the area, and the management of surrounding lands.[55] Units deemed to lack manageability received a ranking of "none" for overall wilderness characteristics.[56] Step 7 of the analysis process permitted the Forest Supervisor to apply all of these considerations again, taking another bite at the apple to inappropriately reduce the size of or eliminate many highly ranked areas from the recommended wilderness included in the proposed action.

Finally, the GNF's approach is additionally problematic because the analysis documentation in the project record broadly cites developments like range infrastructure, mining infrastructure, etc. to justify sometimes substantial reductions in acreage or the elimination of recommended wilderness units without providing specific information to clarify where these developments are located or specifically why the units must be reduced in size or eliminated, including why the infrastructure or developments in question are inconsistent with the unit's evaluation rating. The lack of documentation and specific information is inconsistent with Chapter 70 of the Forest Service Handbook, which provides, "[f]or each evaluated area or portions thereof that are not included in an alternative in the applicable NEPA analysis, the Responsible Official shall document the reason for excluding it from further analysis."[57]

The GNF's use of the "steps" in Alternative 2 to reduce the acreage of or eliminate units from the recommended wilderness in the proposed action was therefore arbitrary and capricious.

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[55] FEIS, Vol. 3, p. H-5.
[56] *Id.* pp. H-13 to H-18.
[57] Chapter 70, p. 13.

c. The GNF inappropriately reduced the size of many recommended units based on justification that was incorrect or nonfactual, misaligned with agency policy, or unsupported by the project record.

As described above, the GNF used inappropriate criteria and steps in its wilderness analysis process to reduce the acreage of many units included in the proposed action (Alternative 2), as set forth in the Draft LMP and DEIS. Our previous comments raised concerns about the inappropriate size reduction of multiple units, including the following nine units discussed in this section. The GNF did not address our concerns, and we continue to object to GNF's inappropriate reduction in the acreage of these units, as included in the proposed action in the Draft LMP and DEIS.

(i) *B1a - Aldo Leopold Seco Addition*

In the evaluation process, the GNF determined that unit B1a - Aldo Leopold Seco Addition consisted of 5,741 acres and ranked "high" for wilderness characteristics.[58] In the analysis process, the GNF reduced the unit to 4,724 acres and included the unit as Recommended Wilderness in the proposed action (Alternative 2).[59] The GNF reduced the size of the unit due to probability of stand replacing fires (Step 3), and the presence of water developments for grazing requiring motorized equipment for maintenance (Step 5), and to accommodate riparian/wildlife management (Step 7).[60] The size reduction between evaluation and analysis was 1,017 acres, approximately 18%.

As explained above, there was no need for the GNF to carve down the size of this unit during the analysis process because the evaluation process already accounted for range improvements, and plan components allow for motorized access to range improvements if required for maintenance and for mechanical treatments associated with prescribed fire. The GNF should have moved forward with a proposed action that included 5,741 acres, and the justification provided for reducing the size of this unit is arbitrary and capricious.

(ii) *B1c - Aldo Leopold Seco Addition*

In the evaluation process, the GNF determined that unit B1c - Aldo Leopold Seco Addition consisted of 78 acres and ranked "high" for wilderness characteristics.[61] In the analysis process, the GNF reduced the unit to 48 acres and included the unit as Recommended Wilderness in the proposed action (Alternative 2).[62] The GNF reduced the size of the unit to exclude areas requiring defensible space (Step 7).[63] The size reduction between evaluation and analysis was 30 acres, approximately 38%.

58 FEIS, Vol. 3, p. H-25.
59 *Id.*
60 Analysis paper, pp. 52-53.
61 FEIS, Vol. 3, p. H-25.
62 *Id.*
63 Analysis paper, p. 56.

As explained above, there was no need for the GNF to carve down the size of this unit during the analysis process because plan components allow for mechanical treatments associated with prescribed fire. The GNF should have moved forward with a proposed action that included 78 acres, and the justification provided for reducing the size of this unit is arbitrary and capricious.

(iii) *B10 - Aldo Leopold Addition Northeast*

In the evaluation process, the GNF determined that unit B10 - Aldo Leopold Addition Northeast consisted of 15,909 evaluation acres and ranked "high" for wilderness characteristics.[64] In the analysis process, the GNF reduced the unit to 8,381 acres and included the unit as Recommended Wilderness in the proposed action (Alternative 2).[65] The GNF reduced the size of the unit due to presence of water developments for grazing and fences requiring motorized equipment for maintenance (Steps 5 and 6), and to exclude mining developments and areas requiring defensible space (Step 7).[66] The size reduction between evaluation and analysis was 7,528 acres, approximately 47%.

As explained above, there was no need for the GNF to carve down the size of this unit during the analysis process because the evaluation process already accounted for WUI, need for defensible space, and presence of range improvements and mining developments. Additionally, plan components allow for motorized access to range improvements if required for maintenance and for mechanical treatments associated with prescribed fire. The GNF should have moved forward with a proposed action that included 15,909 acres, and the provided justification for reducing the size of this unit is arbitrary and capricious.

(iv) *G1 - Mineral Creek*

In the evaluation process, the GNF determined that unit G1 - Mineral Creek consisted of 20,525 acres, ranked "outstanding" for wilderness characteristics, and received the highest numeric score of any unit evaluated.[67] In the analysis process, the GNF reduced the unit to 16,538 acres and included the unit as Recommended Wilderness in the proposed action (Alternative 2).[68] The GNF reduced the size of the unit due to presence of fences requiring motorized equipment for maintenance (Step 6), and to exclude abandoned mines, defensible space, and WUI areas (Step 7).[69] The size reduction between evaluation and analysis was 3,987 acres, approximately 19%.

As explained above, there was no need for the GNF to carve down the size of this unit during the analysis process because the evaluation process already accounted for WUI, need for defensible space, and presence of range improvements and mining developments. Additionally, plan components allow for motorized access to range

[64] FEIS, Vol. 3, p. H-25.
[65] *Id.*
[66] Analysis paper, p. 60.
[67] FEIS, Vol. 3, p. H-24.
[68] *Id.* at p. H-25.
[69] Analysis paper, p. 31.

improvements if required for maintenance and for mechanical treatments associated with prescribed fire. The GNF should have moved forward with a proposed action that included 20,525 acres, and the justification provided for reducing the size of this unit is arbitrary and capricious.

(v) *QG1 - Nolan North*[70]

In the evaluation process, the GNF determined that unit QG1 - Nolan North consisted of 8,685 evaluation acres and ranked "high" for wilderness characteristics.[71] The GNF acknowledged that the unit "fits the Forest niche for contributing to a large, fairly contiguous wilderness complex, due to its proximity to the Blue Range Wilderness and Blue Range primitive area," that most of the area is located in an IRA with slopes of 40% or greater, and "there is demonstrated public demand to recommend this area."[72] In the analysis process, the GNF reduced the unit to 6,718 acres and included the unit as Recommended Wilderness in the proposed action (Alternative 2).[73] The GNF reduced the size of the unit due to presence of fences requiring motorized equipment for maintenance (Step 6), and to exclude defensible space and WUI areas (Step 7).[74] The size reduction between evaluation and analysis was 1,967 acres, approximately 23%.

As explained above, there was no need for the GNF to carve down the size of this unit during the analysis process because the evaluation process already accounted for WUI, need for defensible space, and presence of range improvements. Additionally, plan components allow for motorized access to range improvements if required for maintenance and mechanical treatments associated with prescribed fire. The GNF should have moved forward with a proposed action that included 8,685 acres, and the justification provided for reducing the size of this unit is arbitrary and capricious (as is the Responsible Official's subsequent decision to eliminate this unit from the wilderness recommendations all together).

(vi) *RG1 - Aspen Mountain*[75]

In the evaluation process, the GNF determined that unit RG1 - Aspen Mountain consisted of 22,089 acres and ranked "outstanding" for wilderness characteristics.[76] The GNF acknowledged that the unit "fits the Forest niche for contributing to a large, fairly contiguous wilderness complex, due to its proximity to the Blue Range Wilderness and Blue Range primitive area," that the majority of the unit is within IRAs, and that there "is public support and compelling reasons for the forest supervisor to recommend the area."[77] In the analysis process, the GNF reduced the unit to 19,053 acres and included

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70 As described further below, we also object to the Forest Supervisor's decision to drop the Nolan North unit all together in the Final LMP and Draft ROD.
71 FEIS, Vol. 3, p. H-24.
72 Analysis paper, p. 16.
73 FEIS, Vol. 3, p. H-24.
74 Analysis paper, p. 16.
75 As described further below, we also object to the Forest Supervisor's decision to drop the Aspen Mountain unit all together in the Final LMP and Draft ROD.
76 FEIS, Vol. 3, p. H-24.
77 Analysis paper, pp. 27-28.

the unit as Recommended Wilderness in the proposed action (Alternative 2).[78] The GNF reduced the size of the unit due to presence of fences requiring motorized equipment for maintenance (Step 6) and to exclude defensible space and WUI areas (Step 7).[79] The size reduction between evaluation and analysis was 3,036 acres, approximately 14%.

As explained above, there was no need for the GNF to carve down the size of this unit during the analysis process because the evaluation process already accounted for WUI, need for defensible space, and presence of range improvements. Additionally, plan components allow for motorized access to range improvements if required for maintenance and for mechanical treatments associated with prescribed fire. The GNF should have moved forward with a proposed action that included 22,089 acres, and the justification provided for reducing the size of this unit is arbitrary and capricious (as is the Responsible Official's subsequent decision to eliminate this unit from the wilderness recommendations all together).

(vii) *W4 - Aldo Leopold Addition McKnight Canyon*[80]

In the evaluation process, the GNF determined that unit W4 - Aldo Leopold Addition McKnight Canyon consisted of 12,458 acres and ranked "outstanding" for wilderness characteristics.[81] In the analysis process, the GNF reduced the unit to 11,094 acres and included the unit as Recommended Wilderness in the proposed action (Alternative 2).[82] The GNF reduced the size of the unit due to water developments for grazing that require motorized equipment for repair/maintenance (Step 5) and to exclude a fish barrier (Step 7).[83] The size reduction between evaluation and analysis was 1,364 acres, about 11%.

As explained above, there was no need for the GNF to carve down the size of this unit during the analysis process because the evaluation process already accounted for the presence of range improvements. Additionally, plan components allow for motorized access to range improvements if required for maintenance. The GNF should have moved forward with a proposed action that included 12,458 acres, and the justification provided for reducing the size of this unit is arbitrary and capricious (as is the Responsible Official's subsequent decision to eliminate this unit from the wilderness recommendations all together).

(viii) *WB1 - Taylor Creek*

In the evaluation process, the GNF determined that unit WB1 - Taylor Creek consisted of 27,335 acres and ranked "high" for wilderness characteristics.[84] In the analysis

78 FEIS, Vol. 3, p. H-24.
79 Analysis paper, pp. 27-28.
80 As described further below, we also object to the Forest Supervisor's decision to drop the McKnight Canyon unit all together in the Final LMP and Draft ROD.
81 FEIS, Vol. 3, p. H-26.
82 *Id.*
83 Analysis paper, p. 89.
84 FEIS, Vol. 3, p. H-26.

process, the GNF reduced this acreage to 10,012 acres and included the unit as Recommended Wilderness in the proposed action (Alternative 2).[85] The GNF reduced the size of the unit due to risk of stand replacing fire (Step 3), presence of water developments for grazing and fences requiring motorized equipment for maintenance (Steps 5 and 6), and to exclude cherry-stemmed roads and private property (Step 7).[86] The size reduction between evaluation and analysis was 17,323 acres, about 63%.

As explained above, there was no need for the GNF to carve down the size of this unit during the analysis process because the evaluation process already accounted for the presence of range improvements, cherry-stemmed roads, and private property. Additionally, plan components allow for mechanical treatments associated with prescribed fire and for motorized access to range improvements if required for maintenance. The GNF should have moved forward with a proposed action that included 27,335 acres, and the justification provided for reducing the size of this unit is arbitrary and capricious.

(ix) *WSB1 - Rabb Park*

In the evaluation process, the GNF determined that unit WSB1 - Rabb Park consisted of 43,998 acres and ranked "high" for wilderness characteristics.[87] In the analysis process, the GNF reduced this acreage to 27,002 acres and included the unit as Recommended Wilderness in the proposed action (Alternative 2).[88] The GNF reduced the size of the unit due to water developments for grazing (Step 5) and fencing for grazing (Step 6) that require the use of motorized equipment for repair and maintenance, and due to mining developments and need for defensible space (Step 7). The size reduction between evaluation and analysis was 16,996 acres, approximately 39%.

As explained above, there was no need for the GNF to carve down the size of this unit during the analysis process because the evaluation process already accounted for presence of range improvements, mining developments, and need for defensible space. Additionally, plan components allow for motorized access to range improvements if required for maintenance and mechanical treatments associated with prescribed fire. The GNF should have moved forward with a proposed action that included 43,998 acres, and the justification for reducing the size of this unit is arbitrary and capricious.

d. The GNF inappropriately excluded many areas that should have been recommended based on justification that was incorrect or nonfactual, misaligned with agency policy, or unsupported by the project record.

As described above, the GNF used inappropriate criteria and steps in its wilderness analysis process to eliminate many eligible units from the proposed action (Alternative

[85] *Id.*
[86] Analysis paper, p. 46.
[87] FEIS, Vol. 3, p. H-26.
[88] *Id.*

2). Our previous comments raised concerns about the exclusion of multiple units, including the seven units discussed in this section. The GNF did not address our concerns, and we continue to object to GNF's inappropriate omission of these units from the proposed action.

(i) *G6 - Lower San Francisco*

In the evaluation process, the GNF determined that unit G6 - Lower San Francisco consisted of 21,196 acres and ranked "outstanding" for wilderness characteristics, with the second-highest numeric score of any evaluated unit.[89] Yet, in the analysis process, the GNF chose to not recommend this unit for inclusion in the proposed action (Alternative 2). The GNF reasoned that the "area does not fit the Forest niche for contributing to a large, fairly contiguous wilderness complex."[90] The GNF further stated that the outstanding wilderness characteristics are limited to the area "within the narrow river corridor area, and not the outlying parts of the area that were included by virtue of being roadless and with minimal development, but do not share the high quality of the scenic, recreational, and other qualities available nearby to the river."[91]

Given that this unit ranked as outstanding and received the second-highest score of any area, the GNF should do more to comply with its obligation to provide a well-reasoned explanation for excluding this unit. As explained above, the "niche" concept is arbitrary, ambiguous, and inconsistent with the Wilderness Act. The size of the Lower San Francisco unit far exceeds the 5000-acre threshold required for designation and obviates the need to connect to a larger complex. Additionally, the unit is a WSA, which should factor into a more generous interpretation of the niche statement. The plain language of the niche statement, "large, fairly contiguous wilderness complex," suggests that a large unit should be sufficient for recommendation and that there should be some flexibility in allowing units that are not contributing to an existing complex. Finally, the GNF's assertion that the areas away from the river possess a lesser degree of wilderness characteristics is unexplained and inconsistent with the record, which reflects that the 21,196-acre unit has outstanding wilderness characteristics. The GNF should have moved forward with a proposed action that included 21,196 acres, and the provided justification for excluding this unit from the wilderness recommendations is arbitrary and capricious.

(ii) *Q11 - Mother Hubbard*

In the evaluation process, the GNF determined that unit Q11 - Mother Hubbard consisted of 5,728 acres and ranked "high" for wilderness characteristics.[92] In the analysis process, the GNF found that the area met the "niche" due to "proximity to the Blue Range Wilderness and Blue Range primitive area."[93] The GNF nonetheless chose not to recommend this unit for inclusion in the proposed action (Alternative 2).

89 *Id.* at p. H-24.
90 Analysis paper, p. 34.
91 *Id.*
92 FEIS, Vol. 3, p. H-24.
93 Analysis paper, p. 14.

The GNF excluded the unit due to boundary adjustments resulting from need for range fences to be repaired and maintained by motorized means (Step 6), and an assertion that a recommended wilderness designation would have significant operational and financial impacts on a range permittee.[94] As explained above, however, the Final LMP and Forest Service policy allow motorized equipment use in recommended wilderness for administrative purposes such as fence repairs. The idea that managing this area as recommended wilderness would place an exceptional burden on the permittee is not supported by the facts that the area by definition has no roads and that the use of motorized equipment is allowable in recommended wilderness based on plan guidance and agency policy. Moreover, the FEIS states, "For the size of the area, there is relatively little range infrastructure aside from a fence in the northeast portion,"[95] which is inconsistent with the assertions in the analysis that there is significant range infrastructure requiring maintenance with motorized equipment and that this maintenance would have an unreasonable level of impact on the permittee. The GNF should have moved forward with a proposed action that included 5,728 acres, and the justification provided for excluding this unit from the wilderness recommendations is arbitrary and capricious.

(iii) *QR1 - Upper Frisco Box*

In the evaluation process, the GNF determined that unit QR1 - Upper Frisco Box consisted of 41,047 acres and ranked "high" for wilderness characteristics.[96] In the analysis process, the GNF chose to not recommend this unit for inclusion in the proposed action (Alternative 2). The GNF reasoned that the "area does not fit the Forest niche for contributing to a large, fairly contiguous wilderness complex."[97] Given the large size of this unit, high wilderness ranking, and the special values of the area, which consists of "a unique, spectacularly scenic, and physically challenging slot canyon along the San Francisco River,"[98] the GNF should apply its niche criterion in a flexible manner to include the unit as recommended wilderness. The GNF should have moved forward with a proposed action that included 41,047 acres, and the justification provided for excluding this unit from the wilderness recommendations is arbitrary and capricious.

(iv) *RG2 - Devil's Creek*

In the evaluation process, the GNF determined that unit RG2 - Devil's Creek consisted of 61,067 acres and ranked "moderate/high" for wilderness characteristics.[99] In the analysis process, the GNF chose to not recommend this unit for inclusion in the

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[94] *Id.* at pp. 14-15.
[95] FEIS, Vol. 3, p. H-39.
[96] *Id.* at pp. H-24, H-44.
[97] Analysis paper, p. 19. The analysis paper inaccurately states that the area scored only "moderate/high" in the evaluation, which is contradicted by the FEIS and the evaluation map for the Quemado Ranger District, *available at* https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd687562.pdf.
[98] FEIS, Vol. 3, p. H-44.
[99] *Id.* at p. H-24.

proposed action (Alternative 2). The GNF reasoned that the "area does not fit the Forest niche for contributing to a large, fairly contiguous wilderness complex."[100]

The determination that this unit does not meet the "niche" is arbitrary and capricious because the unit is "fairly contiguous" to the North Mogollon Mountains unit. These units are separated by only a narrow road corridor, and a portion of the border (approximately .5 miles) is directly connected/adjacent.[101] If the North Mogollon Mountains unit had not been inappropriately excluded from the proposed action (Alternative 2) as discussed below, these units arguably would together meet the "niche" concept as a "wilderness complex." Moreover, this unit is more than twelve times larger than the 5,000-acre size threshold required for designation under the Wilderness Act, and accordingly this unit constitutes a large wilderness complex on its own. The GNF should have moved forward with a proposed action that included 61,067 acres, and the justification provided for excluding this unit from the wilderness recommendations is arbitrary and capricious.

(v) *RG4 - North Mogollon Mountain (Deep Creek)*

In the evaluation process, the GNF determined that unit RG4 - North Mogollon Mountain (Deep Creek) consisted of 21,591 acres and ranked "moderate/high" for wilderness characteristics.[102] In the analysis process, the GNF chose to not recommend this unit for inclusion in the proposed action (Alternative 2). The GNF reasoned that the "area does not fit the Forest niche for contributing to a large, fairly contiguous wilderness complex."[103]

This reasoning is nonfactual and unsupported by the record. The North Mogollon Mountains unit is located directly north of the Mineral Creek unit, separated only by a narrow road corridor. The Mineral Creek unit is included in the proposed action as recommended wilderness and is separated from the Gila Whitewater Addition unit, also recommended as wilderness in Alternative 2, by a narrow road corridor.[104] The GNF's statement that recommendation of this unit would be inconsistent with the niche is plainly inconsistent with the GNF's logic and reasoning related to other units that were included in Alternative 2.

Additionally, while this reasoning was not included in the Analysis paper; Volume 3, Appendix H of the FEIS; or the Draft ROD, the Final LMP states that the North Mogollon Mountains unit was removed from Alternative 2

> because it contained the only acreage of Spruce-Fir Forest outside of designated wilderness. Spruce-Fir Forest is very highly vulnerable to

[100] Analysis paper, p. 28.
[101] *See* GNF, Glenwood RD evaluation map, *available at* https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd687563.pdf.
[102] FEIS, Vol. 3, p. H-24.
[103] Analysis paper, p. 29.
[104] See GNF Glenwood RD evaluation map, *available at* https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd687563.pdf.

> climate change, and if Congress were to designate, it could take some adaptation options completely off the table. For example, reducing coarse woody debris or redistributing it to protect natural conifer regeneration, or planting nursery-raised conifer seedlings.[105]

This statement in the Final LMP is inconsistent with the Final EIS, which states,

> This steep, rugged area contains spruce-fir and mixed conifer forests, with ponderosa pine and pinyon juniper at lower elevations and on warmer, drier sites. It is almost entirely within inventoried roadless areas and is managed to preserve roadless characteristics. Little management activity has occurred or is likely to occur in the future, mostly due to terrain.[106]

This inconsistency demonstrates that the GNF's post-hoc rationale for excluding this unit from Alternative 2 in the was not rooted in fact and that terrain limitations would essentially preclude the management activities described in the Final LMP. The GNF should have moved forward with a proposed action that included 21,591 acres, and the justification provided for excluding this unit from the wilderness recommendations is arbitrary and capricious.

(vi) *S1 - Mogollon Box/Tadpole Ridge*

In the evaluation process, the GNF determined that unit S1 - Mogollon Box/Tadpole Ridge consisted of 48,067 acres and ranked "outstanding" for wilderness characteristics.[107] In the analysis process, the GNF found that the area met the "niche" because it "is adjacent to existing wilderness."[108] The GNF nonetheless chose not to recommend this unit for inclusion in the proposed action (Alternative 2). The GNF excluded the unit due to water sources used by range permittees needing maintenance by motorized means (Step 5), range fences repaired and maintained by motorized means (Step 6), boundary adjustments due to mining developments (Step 7), and an unsupported conclusion during the analysis that the unit no longer met the initial outstanding rating (Step 8).[109]

The reasons given for excluding this unit from the proposed action are unsupported by the law and record. First, as explained above, both the Final LMP and Forest Service policy permit motorized equipment use in recommended wilderness for administrative purposes, including maintenance of grazing infrastructure. Second, there was no need to carve mining developments out of the unit in the analysis step because the evaluation of the unit and the initial unit boundaries included consideration of mining developments and resulted in a ranking of "outstanding." The Final EIS states that "Improvements are few, not substantially noticeable or concentrated in specific locations."[110] The GNF's

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[105] Final LMP, pp. 242-43.
[106] FEIS, Vol. 3, p. H-62.
[107] *Id.* at p. H-25.
[108] Analysis paper, p. 68.
[109] *Id.*
[110] *Id.* at p. 98.

determination that the unit should be downgraded from "outstanding" to "moderate" and therefore excluded from the proposed action is inconsistent with the description in the EIS. The GNF should have moved forward with a proposed action that included 48,067 acres, and the justification provided for excluding this unit from the wilderness recommendations is arbitrary and capricious.

(vii) *S2 - Gila Middle Box*

In the evaluation process, the GNF determined that unit S2 - Gila Middle Box consisted of 25,335 acres and ranked "outstanding" for wilderness characteristics.[111] In the analysis process, the GNF chose to not recommend this unit for inclusion in the proposed action (Alternative 2). The GNF reasoned that the "area does not fit the Forest niche for contributing to a large, fairly contiguous wilderness complex."[112] The GNF also asserted that the "outstanding" ranking "was primarily due to quality of wilderness characteristics within the narrow river corridor area, and not the outlying parts of the area that were included by virtue of being roadless and with minimal development, but do not share the high quality of the scenic, recreational, and other qualities available nearby to the river."[113]

As with some of the other large units, the GNF should have applied the "niche" concept in a more flexible manner to include the Gila Middle Box, which is over five times larger than the minimum size needed to designate the area as wilderness. Moreover, the unit scored "outstanding" for wilderness characteristics, and GNF's statement that the full unit lacks qualities justifying recommendation as wilderness is directly contradictory to the unit's rating. The GNF's justification for omitting this unit from the proposed action is not supported by the project record and is therefore inaccurate. The GNF should have moved forward with a proposed action that included 25,335 acres, and the justification provided for excluding this unit from the wilderness recommendations is arbitrary and capricious.

3. In the Final LMP, the Responsible Official made an arbitrary and capricious decision to eliminate four areas that had been included in the proposed action in the Draft LMP, reducing the amount of recommended wilderness from 110,402 acres to 72,103 acres.

As set forth above, the proposed action (Alternative 2) in the Draft LMP included 110,402 acres of recommended wilderness, as follows:

- B10-Aldo Leopold Addition Northeast (8,381 acres);
- B11-Aldo Leopold Addition Southeast (944 acres);
- B14-Aldo Leopold Addition Carbonate Creek (2,819 acres);
- B1a and B1c-Aldo Leopold Seco Addition (4,724 and 48 acres);
- G12-Gila Whitewater Addition (1,960 acres);
- G1-Mineral Creek (16,538 acres);

[111] FEIS, Vol. 3, p. H-25.
[112] Analysis paper, p. 71.
[113] *Id.*

- QG1-Nolan North (6,718 acres);
- RG1-Aspen Mountain (19,053 acres);
- W3-Aldo Leopold Addition West (1,110 acres);
- W4-Aldo Leopold Addition McKnight Canyon (11,094 acres);
- WB1-Taylor Creek (10,012 acres); and
- WSB1-Rabb Park (27,002 acres).[114]

In the Final LMP and Draft ROD, the Responsible Official eliminated four of the recommended areas, consisting of 37,975 total acres and about 35% of the recommended acreage from the draft proposed action, as follows:

- QG1-Nolan North (6,718 acres);
- RG1-Aspen Mountain (19,053 acres);
- W3-Aldo Leopold Addition West (1,110 acres); and
- W4-Aldo Leopold Addition McKnight Canyon (11,094 acres).[115]

This reduction resulted in a Final LMP that includes only 72,103 acres of recommended wilderness, which is about 9% of the total lands with wilderness characteristics identified in the GNF's evaluation process (827,475 acres[116]) and less acreage than any of the action alternatives that were included in the Draft LMP.[117] The Responsible Official removed these areas without any public outreach to discuss new issues or significant changes with the stakeholders who had advocated for the GNF to maximize recommended wilderness acreage, including New Mexico Wild, TWS, Great Old Broads for Wilderness, WildEarth Guardians, and The Center for Biological Diveristy.

As further explained below, we strongly object to the removal of the four recommended areas from the Final LMP for the following reasons. First, the eliminated areas had extremely high overall rankings in terms of wilderness characteristics. Second, the areas met the analysis criteria developed for the proposed action, including by contributing to the "wilderness niche of a large, mostly contiguous wilderness complex." And finally, the reasons provided for eliminating these recommended areas are factually and logically unsupported, rendering their proposed elimination arbitrary and capricious.

a. The Responsible Official's elimination of units RG1 - Aspen Mountain and QG1 - Nolan North from the recommended wilderness in the Final LMP and Draft ROD is arbitrary and capricious.

Regarding units RG1 - Aspen Mountain and QG1 - Nolan North, the Citizens' Proposal submitted in 2018 recommended the designation of 22,302 acres within this area as the Aspen Mountain Unit. The Draft LMP and DEIS, released in 2019, included Aspen Mountain in the wilderness recommendations under the preferred Alternative 2 (19,053 acres) and Alternative 5 (21,895 acres).[118] The Aspen Mountain unit had an overall

[114] Draft LMP, p. 226.
[115] Draft ROD, pp. 19-21.
[116] DEIS, Vol. 2, p. 531.
[117] DEIS, Vol. 3, Table 7, p. 119.
[118] Draft LMP, p. 226; DEIS, Vol. 2, pp. 540, 547.

evaluation ranking of "outstanding" in wilderness character, with a score of 16 under the Gila National Forest scaling system.[119] Nolan North is contiguous with Aspen Mountain. The Draft LMP and DEIS included Nolan North in the wilderness recommendations under the preferred Alternative 2 (6,718 acres) and Alternative 5 (7,609 acres).[120] The Nolan North unit had an overall evaluation ranking of "high" in wilderness character, scoring nearly as high as Aspen Mountain with a 15.7.[121]

The Draft ROD provides two reasons for eliminating Aspen Mountain and Nolan North from the wilderness recommendations in the Final LMP: (1) "they did not contribute to a larger, mostly contiguous wilderness complex as they may have if the Apache-Sitgreaves National Forests had moved forward with recommendations on the Arizona side of the state line"; and (2) "perimeter roads between the Blue Range Wilderness, Aspen Mountain, and Nolan North may detract from the quality of the larger area that would have been created by their recommendation."[122] These statements are inaccurate and inconsistent with the planning record.

First, the Aspen Mountain unit is part of a large, contiguous wilderness complex because it is located directly adjacent to the northern boundary of the Blue Range Wilderness in New Mexico (29,099 acres). This complex of wilderness quality lands also includes the Blue Range Primitive Area of the Apache-Sitgreaves National Forests in Arizona. The Blue Range Primitive Area, along with the presidential recommended additions to the area, comprise a total of 199,502 acres, which are "managed as wilderness, with one exception: the area is open to mineral prospecting and mineral development."[123] The Blue Range Primitive Area was established in 1933, and the Blue Range Wilderness was designated in 1980; thus, both were created long before the recent planning effort on the Apache-Sitgreaves Forests. Second, as documented by the GNF Wilderness ID Team, the Aspen Mountain unit is separated from the Blue Range Wilderness and Blue Range Primitive Area by a single "low-development lightly traveled road."[124] These factors led the Wilderness ID Team to conclude that the Aspen Mountain area "fits the Forest niche for contributing to a large, fairly contiguous wilderness complex . . . and would be a high-quality addition to the wilderness complex."[125] The Responsible Official's assertion that the Aspen Mountain unit does not adequately contribute to a "large, fairly contiguous wilderness complex" is plainly contrary to these findings by the ID Team.

The Final LMP elaborates that the Responsible Official removed Aspen Mountain from the recommendations because she was "concerned by the network of roads separating

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[119] GNF Plan Revision, Evaluation Report of Lands Inventoried for Potential Wilderness Characteristics, Final Report, p. 76 (Dec. 2019), *available at* https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd687560.pdf [hereinafter Final Evaluation Report].
[120] Draft LMP, p. 226; DEIS, Vol. 2, pp. 540, 547.
[121] Final Evaluation Report at 37.
[122] Draft ROD, pp. 20-21.
[123] USDA Forest Serv., Land Management Plan for the Apache-Sitgreaves National Forests, p. 128 (Aug. 2015; slightly rev. Oct. 2017), *available at* https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd589689.pdf.
[124] Analysis paper, p. 27.
[125] *Id.*

the Blue Range Wilderness from the draft recommended units," stating, "One road was one thing, like National Forest System Road 150 that separates the Gila and Aldo Leopold Wildernesses, or the Bursum Road that separates the Mineral Creek unit from the Gila Whitewater Addition, but a network of roads running between multiple units smaller than the Gila or Aldo Leopold Wildernesses crossed a threshold for her."[126] The Draft ROD provides the additional rationale that the Responsible Official has "concerns that the perimeter roads between the Blue Range Wilderness, Aspen Mountain, and Nolan North may detract from the quality of the larger area that would have been created by their recommendation."[127]

This rationale provided in the Final LMP and Draft ROD is inconsistent with the project record and Forest Service policy in several ways. First, as reflected by the Final EIS (and elsewhere in the project record), there is only one road separating the Blue Range Wilderness from the Aspen Mountain unit.[128] As stated above, the ID Team described this road as a "low-development lightly traveled road."[129] Furthermore, the Gila National Forest defines a "high" ranking for solitude as, "Across most of the area, it's easy to attain a feeling of being alone or remote from civilization ... The sights and sounds of human activities are possible, but infrequently experienced."[130] The ID Team rated solitude in the Aspen Mountain unit as "high,"[131] confirming that visitors to Aspen Mountain may only infrequently experience impacts to their solitude from the sights and sounds of human activities. The ID Team's definition of "high" as it relates to apparent naturalness does not appear to include or consider factors external to the area.[132] Lastly, with respect to outstanding opportunities for solitude, Chapter 70 of the Forest Service Handbook states that an "area does not have to possess ... outstanding opportunities on every acre," and further, "impacts that are pervasive and influence a visitor's opportunity for solitude within the evaluated area [should be considered]."[133] Based on this policy, coupled with the ID Team's findings that the Aspen Mountain unit has a high degree of solitude, the edge effects of a lightly traveled primitive road along the boundary of the unit do not justify the elimination of Aspen Mountain from wilderness recommendation. The assertion that perimeter roads detract from the quality of the larger area is unsupported and inaccurate, and the Responsible Official's decision to remove Aspen Mountain from the wilderness recommendations is arbitrary and capricious.

Nolan North is contiguous with Aspen Mountain, and like Aspen Mountain, the Wilderness ID Team concluded that the Nolan North "area fits the Forest niche for contributing to a large, fairly contiguous wilderness complex, due to its proximity to the Blue Range Wilderness and Blue Range primitive area."[134] Nolan North is located in a remote area, consists of "steep and rugged terrain with deeply incised canyons and

[126] Final LMP, p. 243.
[127] Draft ROD, p. 21.
[128] FEIS Vol. 1, p. 353; Analysis paper, p. 27.
[129] *Id.*
[130] FEIS Vol. 3, p. H-9.
[131] *Id.* at p. H-14.
[132] *Id.* at pp. H-9, H-14.
[133] Chapter 70, p. 11.
[134] Analysis paper, p. 15.

drainages," and is separated from two large inventoried roadless areas (Mother Hubbard and Aspen Mountain) "by low-development forest system roads."[135] Although the Apache-Sitgreaves National Forests declined to include the inventoried roadless area on the Arizona side in a recommended wilderness decision, the existing IRA designation precludes road building and commercial timber harvest, which led the ID Team to find Nolan North "manageable to protect wilderness characteristics."[136]

The FEIS reflects concern that the Nolan North unit has "an odd shape and configuration, narrowly arching out from the Aspen Mountain recommended area,"[137] but the shape makes sense, given that the unit consists of steep and rugged canyons. In fact, the Draft ROD describes Nolan North as "a crescent-shaped area dominated by steep, rugged terrain with deeply incised canyons" and includes the unit as an example of an area that is appropriate for recommended wilderness management because its "boundaries are easily identifiable based on existing natural features" that consists of "steep and rugged terrain, making pursuit of nonconforming uses more difficult."[138]

Additionally, whereas the Aspen Mountain unit was rated by the ID Team as having "high" solitude, Nolan North was rated as having "outstanding" solitude.[139] The ID Team defined "outstanding" solitude as "easy to attain a feeling of being alone or remote from civilization throughout the area ... The sights and sounds of human activities are very rare to nonexistent."[140] Given the outstanding solitude finding, the post hoc conclusion that perimeter roads on the edge of the Nolan North unit may detract from the quality of the larger area is unsupported by the record. Similar to Aspen Mountain, reliance on this justification to remove the unit from the wilderness recommendations is inconsistent with the ID Team's factual findings and Forest Service policy directives in Chapter 70. The Responsible Official's decision to remove Nolan North from the wilderness recommendations is arbitrary and capricious.

Finally, there are several problems with the Responsible Official's explanation that the Aspen Mountain and Nolan North units were dropped because "a network of roads running between multiple units smaller than the Gila or Aldo Leopold Wildernesses crossed a threshold for her" and "[t]his was not the contribution to the wilderness legacy she wanted to make."[141] First, as explained above, the "niche" threshold is not defined or explained. Second, as discussed above, this justification is contrary to the findings by the ID Team, which concluded that these units fit the niche for contributing to a large, fairly contiguous wilderness complex, due to their proximity to the Blue Range Wilderness and Blue Range primitive area. And third, the Gila Wilderness (approx. 559,000 acres) and Aldo Leopold Wilderness (approx. 203,000 acres) are the largest and third largest Wildernesses, respectively, in New Mexico. The notion that a complex of several wildernesses must include units that are upwards of 200,000 acres in size represents an

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[135] Final Evaluation Report, p. 35.
[136] *Id.* at p. 36.
[137] FEIS, Vol. 1, p. 353.
[138] Draft ROD, p. 20.
[139] FEIS, Vol. 3, p. H-13.
[140] *Id.* at p. H-9.
[141] Final LMP. p. 243.

impossible threshold to meet and is exceptionally inconsistent with policy guidance in Chapter 70 of the Forest Service Handbook and the Wilderness Act itself, which requires wilderness to have at least 5,000 acres or "sufficient size as to make practicable its preservation and use in an unimpaired condition."

b. **The Responsible Official's elimination of W3** - Aldo Leopold Addition West from the recommended wilderness in the Final LMP and Draft ROD is arbitrary and capricious.

Regarding unit W-3 Aldo Leopold Addition West, the Draft LMP and DEIS, released in 2019, included the Aldo Leopold Addition West in the wilderness recommendations under the preferred Alternative 2 (1,110 acres).[142] In the evaluation process, the Aldo Leopold Addition West unit included 3,394 acres and had an overall evaluation ranking of "moderate to high" in wilderness character, with a score of 12 under the Gila National Forest scaling system.[143]

The Draft ROD explains that the Aldo Leopold Addition West unit was removed from the recommended wilderness in the Final LMP "based on its proximity to the National Forest System Road 150 corridor."[144] The GNF further states, "This corridor has been used as a fuel break for managing wildland fire, albeit not always successfully. According to district fire and fuels staff, the 2022 Black Fire confirmed the need to do more along the road corridor to improve and maintain its effectiveness as a fuel break, which may necessitate repeated mechanized intrusion into the area, impacting wilderness characteristics and the degree to which Aldo Leopold Addition West contributes to the wilderness character of the Aldo Leopold Wilderness."[145]

The fact that the National Forest System 150 Road corridor has been used as a fuel break for managing wildland fire and the assertion that more fuel reduction work is needed along this road do not justify the removal of this area from the wilderness recommendations. Although the Responsible Official does not provide any specific detail to support the rationale that additional fuel reduction work is needed - for instance how much, where, how far from the road, etc. - the ID Team already designed the unit boundary to be buffered from the road by 300 feet.[146] Furthermore, based on our own GIS desktop analysis, we found that at the narrowest, the corridor between the Aldo Leopold Addition West unit boundary and the Gila Wilderness boundary to the west is approximately 1,200 feet. The 300 feet between the unit boundary and the 150 Road would appear to allow ample space to maintain or even expand existing fuels treatments, and if for some reason that this space were not adequate, the additional 900 feet (at a minimum - this distance is the narrowest point between the 150 road and the Gila Wilderness in the vicinity of the Aldo Leopold Addition West unit) would surely be

[142] Draft ROD, p. 20.
[143] FEIS Vol. 3, p. H-26.
[144] Draft ROD p. 20.
[145] *Id.*
[146] GNF, Gila National Forest Plan Revision, Inventory Process for Identifying Lands with Potential Wilderness Characteristics, FINAL Process Paper, p. 4 (Sept. 2017); FEIS Vol. 3, pg. H-87.

adequate. Furthermore, in the analysis step of the wilderness review, this unit was cut from the 3,394 acres that were evaluated to 1,110 acres, a reduction of 67%.[147] If the minimum 1,200 foot corridor between the unit boundary and the Gila Wilderness is deemed inadequate in discrete places to address fuels treatment needs, the Responsible Official could make specific boundary adjustments to address this issue, as already occurred in the alternatives analysis process. Based on our own GIS analysis, the unit is approximately 3,300 feet wide at its narrowest point, which provides ample room to make boundary adjustments if needed. The Responsible Official's decision to remove Aldo Leopold Addition West from the wilderness recommendations is arbitrary and capricious.

c. **The Responsible Official's elimination of unit W4** - Aldo Leopold Addition McKnight Canyon from the recommended wilderness in the Final LMP and Draft ROD is arbitrary and capricious.

Regarding unit W-4 Aldo Leopold Addition McKnight Canyon, the Citizens' Proposal submitted in 2018 recommended the designation of 13,296 acres as the "McKnight Canyon - Proposed Aldo Leopold Wilderness Addition." The Draft LMP and DEIS, released in 2019, included McKnight Canyon in the wilderness recommendations under the proposed action (Alternative 2) (11,094 acres) and Alternative 5 (12,458 acres).[148] The McKnight Canyon unit had an overall evaluation ranking of "outstanding," with a numeric score of 16.3.[149]

The Draft ROD explains that the McKnight Canyon unit was removed from the recommended wilderness in the Final LMP "based on the impacts of the 2022 Black Fire to the trail system."[150] The Final LMP reflects that 6% of the McKnight unit experienced high severity fire, and 19% experienced moderate severity fire.[151] The GNF states that these "impacts, added to those the trail was still experiencing after the 2013 Silver Fire, are expected to create a need for frequent, heavy maintenance for many years to come."[152]

The fact that the Black Fire impacted one quarter of the McKnight Canyon unit does not justify removal of this area from the wilderness recommendations. The GNF states that the "trail in McKnight Canyon is a high-value trail to many local community members,"[153] but the GNF also acknowledges that this area "receives little visitation outside of hunting seasons."[154] As the GNF admits, "volunteers and partner organizations" have largely maintained the McKnight Canyon trail.[155] Partner

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[147] Analysis paper, p, 87.
[148] Draft LMP, p. 226; DEIS, Vol. 2, pp. 540, 547.
[149] Final Evaluation Report, p. 188.
[150] Draft ROD, p. 20.
[151] Final LMP, p. 352
[152] Draft ROD, p. 20; *see also* Final LMP, pp. 244-45.
[153] Draft ROD, p. 20.
[154] FEIS Vol. 3, p. H-121.
[155] Draft ROD p. 20.

organizations such as New Mexico Wild and others are trained on the use of non-mechanized trail maintenance equipment including crosscut saws.

Moreover, as recognized in the Draft ROD, the Final LMP's "direction for recommended wilderness areas allows exceptions to the prohibition on mechanized and motorized equipment for the purpose of trail maintenance."[156] None of the Desired Conditions, Standards, Guidelines, or Management Approaches in the Final LMP prohibit the use of motorized equipment to undertake trail maintenance in Recommended Wilderness.[157] Directly relevant guidance includes Standard 2 in the Final LMP, which expressly allows trail maintenance as an exception to the directive that prohibits the "cutting of trees" and mechanical treatments within recommended wilderness.[158] Similarly, Guideline 2 expressly allows for the construction of new trails or the realignment of existing trails to protect wilderness characteristics or public health and safety.[159] Additionally, in the evaluation process the ID Team acknowledged, "Very little management activity has occurred or is likely to occur [in McKnight Canyon] in the future, mostly due to terrain."[160] This suggests that outside of chainsaw use, which per the above is clearly allowable for trail maintenance in recommended wilderness, it would likely be infeasible to bring larger equipment (e.g. a trail tractor) into McKnight Canyon for trail maintenance. The Responsible Official's decision to remove McKnight Canyon from the wilderness recommendations is unnecessary, unjustified, and arbitrary and capricious.

D. Requested Remedy to Address Recommended Wilderness Issues

To address the GNF's failure to consider the Citizens' Proposal as a separate alternative, problems with the GNF's recommended wilderness analysis process, and the arbitrary and capricious removal of four units that had been included in the proposed action (Alternative 2) from the Final LMP and Draft ROD, we request the following remedies:

- Include the following units in the Final Record of Decision as areas to be managed as recommended wilderness, consistent with the proposed action:
  - RG1-Aspen Mountain (minimum of 19,053 acres);
  - QG1-Nolan North (minimum of 6,718 acres);
  - W3-Aldo Leopold Addition West (minimum of 1,110 acres); and
  - W4-Aldo Leopold Addition McKnight Canyon (minimum of 11,094 acres).

- Restore the following units, which were reduced in size for unsupported reasons during the analysis process, to their original acreage as determined in the evaluation process:
  - B1a - Aldo Leopold Seco Addition
  - B1c - Aldo Leopold Seco Addition
  - B10 - Aldo Leopold Addition Northeast

[156] *Id.*
[157] Final LMP, pp. 246-248.
[158] *Id.* at p. 246.
[159] *Id.*
[160] FEIS Vol. 3, p. H-121.

- G1 - Mineral Creek
- QG1 - Nolan North
- RG1 - Aspen Mountain
- W4 - Aldo Leopold Addition McKnight Canyon
- WB1 - Taylor Creek
- WSB1 - Rabb Park

- Include the following units in the Final Record of Decision as areas to be managed as recommended wilderness because the units ranked highly for wilderness characteristics during the evaluation process and were inappropriately eliminated during the analysis process:
  - G6 - Lower San Francisco
  - QR1 - Upper Frisco Box
  - Q11 - Mother Hubbard
  - RG2 - Devil's Creek
  - RG4 - North Mogollon Mountain (Deep Creek)
  - S2 - Gila Middle Box
  - S1 - Mogollon Box/Tadpole Ridge

V. OBJECTION RELATED TO WILD AND SCENIC RIVERS ELIGIBILITY STUDY

A. Law, Regulation, and Policy Applicable to Wild and Scenic Eligibility

Our objections related to the eligible Wild and Scenic River segments are based on law, regulation, and policy including the Wild and Scenic Rivers Act, the National Environmental Policy Act, the National Forest Management Act, the Endangered Species Act, the 2012 Planning Rule, and Chapter 80 of the Forest Service Handbook on Land Management Planning, as further described below.

Congress enacted the Wild and Scenic Rivers Act of 1968[161] to protect "free-flowing" rivers and streams with "outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values . . . for the benefit and enjoyment of present and future generations."[162] The Act permits Congress to designate qualifying river segments into the National Wild and Scenic River System, thereby affording permanent protection for their free-flowing nature and outstandingly remarkable values (ORVs). Federal land management agencies are required during the land use planning process to identify and protect rivers that are "eligible" to be included in the National Wild and Scenic River System.[163] A river is eligible if it is free-flowing and has at least one river-related ORV of national or regional significance.[164]

[161] Wild and Scenic Rivers Act of 1968, 16 U.S.C. §§ 1271-1287.
[162] *Id.* § 1271.
[163] *Id.* § 1276(d)(1).
[164] *Id.* § 1273(b).

Under the 2012 Planning Rule, the Forest Service is required to evaluate eligibility as part of a forest plan revision. The rule provides that "the responsible official shall . . . [i]dentify the eligibility of rivers for inclusion in the National Wild and Scenic Rivers System, unless a systematic inventory has been previously completed and documented and there are no changed circumstances that warrant additional review."[165] The rule also requires the Forest Service to "include plan components, including standards or guidelines, to provide for . . . management of rivers found eligible or determined suitable for the National Wild and Scenic River system to protect the values that provide the basis for their suitability for inclusion in the system."[166]

Chapter 80 of Forest Service Land Management Planning Handbook 1909.12 provides detailed guidance on the required inventory of eligible rivers and interim management of those rivers to protect their ORVs and free-flowing nature.[167] Chapter 80 defines an ORV as a "scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar river-related value that is a unique, rare, or exemplary feature and is significant when compared with similar values from other rivers at a regional or national scale."[168] Chapter 80 defines a "Region of Comparison" as the "geographic area of consideration for each [ORV] that will serve as the basis for meaningful comparative analysis."[169] Chapter 80 establishes baseline criteria for evaluating river-related values and permits the evaluation team to further refine the criteria to make them more applicable to the region of comparison.[170] "In conducting an eligibility study, the Forest Service must provide opportunities for public participation "early and throughout the process"[171] and utilize the best available scientific information.[172]

B. <u>The GNF's Wild and Scenic River Eligibility Process</u>

In 2002, the GNF conducted an inventory of eligible wild and scenic rivers in response to a court order and found that the following eight river segments were eligible: Whitewater Creek, Spruce Creek, Middle Fork Gila River, West Fork Gila River, Diamond Creek, South Diamond Creek, Holden Prong, and Las Animas Creek.[173] In the current planning process, the GNF recognized that the 2002 study process did not fulfill the requirements of the 2012 Planning Rule directives set forth in Chapter 80 of the Forest Service Handbook because not all rivers named on a U.S. Geological Survey quadrangle map were evaluated.[174] The GNF further found that "the forest had seen enough changes since 2002 that an evaluation of changed circumstances was warranted."[175]

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165 36 C.F.R. § 219.7(c)(2)(vi).
166 *Id.* § 219.10(b)(1)(v).
167 USDA Forest Serv., Forest Service Handbook (FSH) 1909.12 - Land Management Planning Handbook, Chapter 80 - Wild and Scenic River Evaluation (effective 1/30/2015) [hereinafter Chapter 80].
168 *Id.* at p. 5.
169 *Id.*
170 *Id.* at pp. 12-13.
171 *Id.* at p. 8.
172 *Id.* at p. 7.
173 Final LMP, pp. 252-53.
174 Draft ROD, p. 21.
175 *Id.*

Thus, in the current planning process, the GNF evaluated a total of 245 river segments,[176] which included "all rivers named on a standard U.S. Geological Survey 7.5-minute quadrangle map."[177] The evaluation included 87 segments that had been evaluated in the 2002 study and 158 segments that had not.[178] The GNF identified regions of comparison for each river-related value[179] and added more specificity to the baseline ORV criteria in Chapter 80 by crafting "Gila-Specific Eligibility Evaluation Criteria" (GSEEC).[180] Through this process, the GNF found "16 rivers (24 segments totaling 224.11 miles) eligible for inclusion in the Wild and Scenic Rivers System,"[181] as follows:[182]

Table 12. Updated plan revision study identified eligible wild and scenic rivers on the Gila National Forest with classifications and segment lengths

River Name	Outstanding Remarkable Values	Total Miles	Classification (# of miles)
Diamond Creek	Fish, Historic	23.80	Wild (22.12) Scenic (1.68)
Middle Box of the Gila River	Wildlife, Scenic, Recreation, Fish, Historic	8.90	Recreational (1.34) Wild (7.56)
Middle Fork Gila River	Scenic	35.54	Wild (35.54)
West Fork Gila River	Scenic, Historic	30.01	Wild (30.01)
Wilderness Run of the Gila River	Geologic, Scenic, Recreation, Historic, Wildlife	40.39	Wild (33.67) Recreational (6.72)
Holden Prong	Fish	7.27	Wild (7.27)
Iron Creek	Fish	3.53	Wild (3.53)
Las Animas Creek	Fish, Historic	7.35	Wild (2.53) Scenic (4.82)
Mineral Creek	Fish, Recreation	8.71	Wild (8.71)
Mule Creek	Geologic	4.33	Scenic (4.33)
Lower Box of the San Francisco River	Scenic, Recreation, Wildlife	17.02	Scenic (2.43) Wild (14.59)
Upper Box of the San Francisco River	Scenic, Recreation	5.70	Scenic (3.78) Wild (1.92)
South Diamond Creek	Fish	8.05	Wild (8.05)
Spruce Creek	Fish	3.74	Wild (3.74)
Whitewater Creek	Recreation, Historic	14.73	Wild (11.79) Recreational (2.94)
Willow Creek	Recreation	4.95	Recreational (4.95)
Total Eligible River Miles:		**224.11**	

The GNF determined that the remaining 221 segments are ineligible for inclusion in the Wild and Scenic Rivers System. Ineligible segments are listed in a table in the FEIS, Volume 3, Appendix I.[183]

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176 *Id.*
177 Final LMP, p. 252.
178 FEIS, Vol. 3, Appendix I, p. I-2.
179 *Id.* at pp. I-3 to I-9.
180 *Id.* at pp. I-9 to I-11.
181 Draft ROD, p. 11.
182 Final LMP, p. 253.
183 FEIS, Vol. 3, pp. I-26 to I-27, Table I-5 (titled, "List of ineligible rivers: values present are not outstandingly remarkable in the regions of comparison").

C. Objections and Arguments Related to Wild and Scenic River Eligibility

We strongly support the GNF's identification of sixteen rivers (twenty-four segments totaling 224.11 miles) as eligible for inclusion in the Wild and Scenic Rivers System.[184] We object, however, to the GNF's (1) failure to consider ORVs at a national scale; (2) use of unreasonably restrictive GSEEC for identifying ORVs, (3) omission of at least 14 additional segments that are free-flowing and possess ORVs; and (4) failure to provide sufficient documentation and justification for the segments deemed ineligible during the evaluation process.

1. The GNF erred by failing to consider the national scale when using regions of comparison to evaluate ORVs.

In considering ORVs, the GNF defined regions of comparison for each value but failed to consider multiple scales of comparison. Specifically, the GNF ignored the "national" aspect of the phrase, "regional or national scale."[185]

As explained in Chapter 80, "To be identified as outstandingly remarkable, a river-related value must be a unique, rare, or exemplary feature that is significant when compared with similar values from other rivers at a regional *or national* scale. Unique, rare, or exemplary features are those that are conspicuous examples of these values, among the best representatives of these features, within a region *or the nation*."[186] Chapter 80 provides guidance on defining the regional scale by directing the Forest Service to "identify the 'region of comparison,' for each [ORV]. The region of comparison may vary for different rivers or categories of [ORVs] and thus, multiple regions of comparison may be used to evaluate one river. A region of comparison should be scaled at an appropriate level for the type of river value being evaluated."[187]

In the FEIS, the GNF documented its regions of comparison for each value.[188] The GNF failed, however, to consider the national scale. In our previous comments, we cited the 1999 Report from the Interagency Wild and Scenic Rivers Coordinating Council, which concluded that the regions of comparison must include multiple scales and that "[i]n addition to regional or statewide comparison, values must also be considered from a national perspective."[189] The GNF did not address this comment in the Final LMP and FEIS. The GNF's failure to evaluate whether stream values are unique, rare, or exemplary on a national scale is inconsistent with the intent of the Wild and Scenic Rivers Act and with Forest Service policy set forth in Chapter 80.

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[184] Draft ROD, p. 21.
[185] Chapter 80, p. 5.
[186] *Id.* at p. 10 (emphasis added).
[187] *Id.* at p. 11.
[188] FEIS, Vol. 3, Appendix I, pp. I-3 to I-9.
[189] Coalition Comments on Draft LMP/DEIS, p. 274 (citing Interagency Wild and Scenic Rivers Coordinating Council, The Wild & Scenic River Study Process (1999)).

2. The GNF erred by using insufficient definitions and unreasonably restrictive Gila-Specific Eligibility Evaluation Criteria for identifying ORVs and by applying some of the criteria in an inconsistent and arbitrary manner.

In the eligibility study process, the GNF adopted insufficient definitions for the Gila-Specific Eligibility Evaluation Criteria (GSEEC) for certain values and applied some of the GSEEC in an inconsistent and arbitrary manner.

a. Scenery ORV

The implementation guidance set forth in Chapter 80 provides the following baseline criteria for identifying an ORV for scenery:

> Landscape elements of landform, vegetation, water, color, and related factors result in notable or exemplary visual features or attractions. Additional factors, such as seasonal variations in vegetation, scale of cultural modifications, and the length of time negative intrusions are viewed, may be considered. Scenery and visual attractions may be highly diverse over different parts of the river or river segment. Outstandingly remarkable scenic features may occupy only a small portion of a river corridor.[190]

In the eligibility study process, the GNF modified the scenery criteria with the following GSEEC: "*Vast, expansive viewsheds are possible in certain stretches within the river corridor. Air quality and natural night sky are important values*."[191]

Although the GSEEC for scenery identify important considerations, the GSEEC are insufficient on their own because they exclude considerations of scenery, including landscape elements that are fundamental to the scenic experience of river canyons. Many of the free-flowing streams within the GNR, and segments within those streams, are located within incised river canyons. These river canyons may not offer "vast, expansive viewsheds," and the GNF's overemphasis on this aspect of scenery alone is inappropriate and insufficient to evaluate scenic character.

Other scenery considerations are more appropriate for evaluating the stream segments that include river canyons. These considerations include extremely narrow sections or "box canyons," high cliffs, sheer walls, spires, drop offs, pinnacles, cascades, and waterfalls. The GNF should have considered these scenery elements to evaluate whether the presence of box canyons, steep cliff walls, spires, high concentrations of cascades, and waterfalls within a particular river canyon are exceedingly rare, exemplary, occurring in a remarkably high concentration, or otherwise particularly notable, either within the region of comparison or nationally.

[190] Chapter 80, p. 12.
[191] FEIS, Vol. 3, Appendix I, p. I-10, Table I-1.

The GNF's reliance on the GSEEC for the scenery ORV precluded the GNF from making an eligibility finding for some of the most scenically remarkable stream segments in the GNF, as further described below.

b. Fish and Wildlife ORVs

The implementation guidance set forth in Chapter 80 provides the following baseline criteria for identifying an ORV for fish:

> Fish values may be judged on the relative merits of either fish populations or habitat, or a combination of these river-related conditions.
>
> a. Populations. The river is nationally or regionally an important producer of resident and/or anadromous fish species. Of particular significance are a diversity of fish species or the presence of wild stocks and/or Federal or State-listed or candidate threatened, endangered, or species of conservation concern.
>
> b. Habitat. The river provides uniquely diverse or high quality habitat for fish species indigenous to the region of comparison. Of particular significance is exemplary habitat for wild stocks and/or Federal or State-listed or candidate threatened or endangered species, or species of conservation concern. Consider also rare and unique habitats within the corridor.[192]

The implementation guidance set forth in Chapter 80 provides the following baseline criteria for identifying an ORV for wildlife:

> Wildlife values may be judged on the relative merits of either terrestrial or aquatic wildlife populations or habitat, or a combination of these conditions.
>
> a. Populations. The river, or area within the river corridor, contains nationally or regionally important populations of indigenous wildlife species. Of particular significance are species diversity, species considered to be unique, and/or populations of Federal or State-listed or candidate threatened or endangered species, or species of conservation concern.
>
> b. Habitat. The river, or area within the river corridor, provides uniquely diverse or high quality habitat for wildlife of national or regional significance, and/or may provide unique habitat or a critical link in habitat conditions for Federal or State listed or candidate threatened or endangered species, or species of conservation concern. Contiguous habitat conditions are such that the biological needs of the species are met.

The baseline criteria for wildlife is similar to the baseline criteria for fish, with the added clarifications that a wildlife ORV may arise from "either terrestrial or aquatic wildlife

[192] Chapter 80, pp. 12-13.

populations or habitat" and that the wildlife ORV may be associated with either the "river, or area within the river corridor."[193]

In the eligibility study process, the GNF modified the fish criteria with the following GSEEC: "*Irreplaceable populations, distinct lineages and diverse assemblages of multiple threatened and endangered species*."[194] The GNF similarly modified the wildlife criteria with the following GSEEC: "*Irreplaceable populations* and diverse, unique assemblages of multiple threatened and endangered species*."[195]

The asterisk in the wildlife GSEEC corresponds to the following footnote:

> Gila trout are native to higher elevation streams in portions of the Gila River and San Francisco River drainage basins in New Mexico and Arizona. They are considered rare in the Southwest and nationally. However, they occur in many streams in the region of comparison. Most of these streams also contain non-native trout species (i.e., brown and rainbow trout) that interbreed and compete with Gila trout. On the Gila National Forest, Gila trout populations are only considered an outstandingly remarkable value where one of the five remnant lineages (Main Diamond, South Diamond, Whiskey Creek, Iron Creek, and Spruce Creek) are present. Streams throughout the Gila River, San Francisco and other drainage basins in the region of comparison also commonly contain other rare native fishes. These assemblages are only considered an outstandingly remarkable value when they are distinctly unique.[196]

Although the GSEEC for fish and wildlife describe important components of fish and wildlife ORVs, we are concerned that the inappropriately narrow GSEEC for the fish and wildlife ORVs and the way in which the GNF applied those criteria precluded the GNF from making adequate eligibility determinations for certain stream segments within the GNF. We provide specific examples below.

i. Gila Trout

First, the GSEEC are insufficient on their own because the criteria ignore the iconic, exceedingly rare, exemplary status that should be afforded to all stream segments where federally listed Gila trout (*Oncorhynchus gilae*) populations are found. In considering the fish and wildlife ORVs, the GNF should have considered the highly limited extent of the Gila trout range on both a national scale and in the historical and regional context. Additionally, the GNF should have considered the best available science that informs Gila trout recovery efforts and the biological context of the species, as described in the Revised Gila Trout Recovery Plan, finalized in 2022.[197]

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[193] Chapter 80, p. 13.
[194] FEIS, Vol. 3, Appendix I, p. I-10, Table I-1.
[195] *Id.* at p. I-11, Table I-1.
[196] *Id.*
[197] We did not rely on the 2022 Gila Trout Recovery Plan in our previous comments on the Draft LMP and DEIS because it was finalized after the issuance of the draft documents.

Regarding the Gila trout range, the precise extent of the historical range of Gila trout is not known, but the best available science shows that "the historical distribution likely included montane, cold-water stream habitats in Sierra, Grant, and Catron counties in New Mexico and Greenlee, Apache, Graham, Gila, Maricopa, and Yavapai counties in Arizona."[198] This included an expansive region across the Gila, San Francisco, Verde, and Agua Fria drainages and countless tributaries.[199] The best available science and historical records indicate that at the end of the 19th century, Gila trout occurred in "all of the Gila headwaters."[200] Alarmingly, by 1975, habitat degradation and the introduction of nonnative fish had reduced the distribution of the species to merely five individual populations occurring in five streams, all within the GNF.[201] By 2022, recovery efforts resulted in the presence of Gila trout populations in twenty-three streams, all populated by the five remnant lineages.[202] Fourteen of these streams are within the GNF.[203] These fourteen streams, including both the remnant populations and the streams populated by those lineages, represent a tiny fraction of the Gila trout's historic range.

Based on this historical record and context, all Gila trout populations within the GNF constitute "a unique, rare, or exemplary feature that is a conspicuous example or among the best representatives of that feature, within a region or the nation when compared to similar rivers," per the definition of an ORV. Each of the stream segments with Gila trout populations are nationally important producers of this federally listed threatened species and therefore meet the baseline fish ORV criteria set forth in Chapter 80. Of the 245 streams that the GNF inventoried for Wild and Scenic eligibility, only fourteen, or approximately 6%, currently host Gila trout populations. Moreover, many of the 245 streams do not provide suitable trout habitat. Additionally, the 245 streams that the GNF studied for eligibility constitute only a fraction of the streams within the regions of comparison, as defined by the GNF for the fish and wildlife ORVs.[204] The GNF's statement in the FEIS that Gila trout occur in "many streams in the region of comparison"[205] does not align with the quantitative data or the best available science.

The GNF should take into consideration the geographic and historical context and should conclude that the mere presence of a Gila trout population, regardless of whether the population is a distinct lineage, necessarily must be considered exceedingly rare on a national and regional scale and exemplary for the purpose of establishing an ORV.

Moreover, the GSEEC for fish and wildlife, and the way the GNF has applied the criteria to Gila trout, fail to adequately consider the listing of Gila trout as a threatened species

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[198] Attachment A - U.S. Fish & Wildlife Serv., Revised Recovery Plan for Gila Trout (*Oncorhynchus gilae*), p. 25 (4th Rev. 2022) [hereinafter Gila Trout Recovery Plan].
[199] *Id.* at pp. 19, 25-34.
[200] *Id.* at p. 28.
[201] *Id.* at p. 35.
[202] *Id.*
[203] *Id.* at p. 40.
[204] FEIS, Vol. 3, Appendix I, p. I-7, Figure I-4 (fish); p. I-8, Figure I-5 (wildlife).
[205] *Id.* at p. I-11, Table I-1.

under the Endangered Species Act of 1973 (ESA)[206] and the best available science that informs Gila trout recovery efforts. In accordance with the 2012 Planning Rule, plan components must provide the "ecological conditions necessary to: contribute to the recovery of federally listed threatened and endangered species."[207] The baseline criteria for fish and wildlife ORVs dovetail with this regulatory requirement by emphasizing the importance of listed species when evaluating whether a fish population or habitat constitutes an ORV.[208]

Contrary to the 2012 Planning Rule and the baseline criteria, the GSEEC for the fish and wildlife ORVs appear to have restricted the GNF's consideration to "irreplaceable populations" and "distinct lineages." These limitations are unreasonably narrow and present an egregiously high standard. These limitations are also inconsistent with the conclusions by the interdisciplinary team, which considered impacts of the Black Fire on eligible streams and concluded that "even if fish were no longer present, these streams still contain important habitat and future work would be directed toward recovering those [ORVs]."[209] These conclusions demonstrate that all Gila trout streams, regardless of relict population status, should be found to possess an ORV for fish. By any reasonable and sufficient definition that accurately takes into consideration the requirements of the ESA and the historical, geographic, and biological context of the species, the presence of any Gila trout population must be included in the GSEEC for the fish and wildlife ORVs.

Additionally, the Final LMP and FEIS must comply with the ESA. Section 7(a)(1) of the ESA explicitly directs all federal agencies to "utilize their authorities" to carry out "programs for the conservation of endangered species and threatened species."[210] The ESA defines "conservation" to mean "the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this [Act] are no longer necessary."[211] In this sense, "conservation" and "recovery" are essentially synonymous.

To conserve Gila trout, the Recovery Plan emphasizes the importance of "redundancy," defined as establishing viable populations of Gila trout "in watersheds throughout the historical range of Gila trout, as constrained by availability of suitable habitat."[212] The plan also reflects the importance of "resiliency," defined as the "combination of numbers and sizes of Gila trout populations are sufficient to maintain genetic diversity, allow for persistence, and maintain evolutionary potential."[213] Together, these concepts, which are informed by the best available science, demonstrate that the presence of Gila trout in streams beyond those with distinct remnant populations is not only important, but fundamental to species recovery. The GNF ignored the mandates of the ESA and the

[206] Endangered Species Act of 1973, 16 U.S.C. §§ 1531-1544.
[207] 36 C.F.R. § 219.9(b)(1).
[208] Chapter 80, pp. 12-13 (stating that listed species are of "particular significance").
[209] FEIS, Vol. 3, Appendix I, pp. I-11 to I-12.
[210] 16 U.S.C. § 1536(a)(1).
[211] *Id.* § 1532(3).
[212] Gila Trout Recovery Plan, p. 7.
[213] *Id.* at pp. 7-8.

biological context of the species by finding that only the five streams with distinct remnant populations of Gila trout are eligible based on a fish ORV.

ii. Assemblages of multiple listed species

As described above, the GNF modified the baseline ORV criteria for fish by including a GSEEC for "diverse assemblages of multiple threatened and endangered species" and the criteria for wildlife by including a GSEEC for "diverse, unique assemblages of multiple threatened and endangered species."

While we agree that an assemblage of multiple threatened and endangered species should qualify as an ORV for fish and/or wildlife, we are concerned that the GNF has set too high a bar in applying this criterion to stream segments. The GNF supports some of the highest biodiversity and most valuable aquatic and riparian systems in the Southwest. As reflected in the Final LMP, the GNF is home to over a dozen species that are federally recognized under the Endangered Species Act.[214] Moreover, [a]lmost 60 additional species are recognized through the 2012 Planning Rule and agency directives as species of conservation concern, approximately two-thirds of which are dependent on riparian or aquatic ecosystems."[215] The Final LMP further explains that "[s]pecies of conservation concern are species that are native and known to occur in the forest and for which there is science that establishes a substantial concern about the species' ability to persist in the forest."[216]

We are also concerned about the use of the word "unique" in the GSEEC for wildlife. The GNF should not interpret "unique" as literally occurring nowhere else but rather should apply this criterion as encompassing all assemblages of threatened and endangered species that are rare, including all instances where more than one federally listed species is found in a single stream.

Given the importance of the streams in the GNF to biodiversity and imperiled species, the GNF should apply its "diverse assemblages" criterion, as set forth in the fish and wildlife GSEEC, in a manner that finds ORVs for fish and/or wildlife in every stream segment with more than one federally listed species or with designated critical habitat for more than one federally listed species.

c. Recreation ORV

The implementation guidance set forth in Chapter 80 provides the following baseline criteria for identifying an ORV for recreation:

> Recreational opportunities are high quality and attract, or have the potential to attract, visitors from throughout or beyond the region of comparison; or the recreational opportunities are unique or rare within the region. River-related recreational opportunities include, but are not limited

[214] Final LMP at 130.
[215] *Id.*
[216] *Id.*

to, sightseeing, interpretation, wildlife observation, camping, photography, hiking, fishing, hunting, and boating. The river may provide settings for national or regional use or competitive events.[217]

In the eligibility study process, the GNF modified the scenery criteria with the following GSEEC: "*Consider exceptional opportunities for solitude, birdwatching, fishing for endemic species like Gila trout, canyoneering, rafting or hot springs, gold panning, and ecotourism*."[218]

i. Fishing for Gila trout

The GSEEC for recreation expressly recognize that a stream segment possesses ORVs if it presents opportunities to fish for endemic Gila trout. All stream segments containing Gila trout should be found to have an ORV for recreation on that basis.

The GSEEC for recreation are inconsistent with the GSEEC for fish and wildlife, which ostensibly limit ORVs to irreplaceable populations, distinct lineages, and diverse assemblages of multiple federally listed species. Whether an individual population of an endemic species is a relict population or was reintroduced does not have any bearing on that species' status as an endemic, and by extension on the unique recreational value of fishing for the endemic species. Recreational fishing contests that include catching Gila trout do not differentiate between remnant relic populations and reintroduced populations.[219]

ii. Rafting

Opportunities for rafting, and especially multi-day rafting trips, are exceedingly rare and nearly non-existent in the region of comparison. In the few stream segments where multi-day rafting is possible, and especially where those segments are considered particularly exceptional for multi-day rafting, those segments must be considered to contain a recreation ORV per the GSEEC defined by the GNF.

3. The GNF incorrectly found that fourteen qualifying stream segments were ineligible for inclusion in the National Wild and Scenic River System, despite public input demonstrating that the fourteen segments are free-flowing and possess ORVs.

This section discusses fourteen stream segments that the GNF found ineligible for protection under the Wild and Scenic Rivers Act. As the GNF knows, these segments are included in legislation pending before Congress, known as the M.H. Dutch Salmon Greater Gila Wild and Scenic River Act.[220] We provided additional comments about the

[217] Chapter 80, p. 12.
[218] FEIS, Vol. 3, Appendix I, p. I-10, Table I-1.
[219] *See, e.g.*, https://westernnativetroutchallenge.org/; https://wildlife.dgf.nm.gov/fishing/fishing-challenges/nmtc/.
[220] Final LMP, pp. 253-54.

values of these stream segments in our previous comments on the Draft LMP and DEIS and in the Citizen's Proposal, and we incorporate our previous comments by this reference. In this objection, rather than repeating all the ORVs previously described, we aim to identify at least one ORV for each segment to demonstrate baseline eligibility and to illustrate flaws in the GNF's eligibility study process, including the use of inappropriately narrow GSEEC to evaluate ORVs, as described in the previous section.

a. Apache Creek

The Apache Creek segment is located within the Gila Wilderness and is an important tributary feeding the East Fork Gila River. In the Gila Coalition Comments on the Draft LMP and DEIS, we asserted that the GNF should find a 12-mile segment of Apache Creek eligible for Wild and Scenic River protection, with ORVs for recreation, wildlife, fish, botany, climate adaptation, and ecosystem services.[221] In the FEIS, the GNF includes Apache Creek in Table I-5, entitled, "List of ineligible rivers: values present are not outstandingly remarkable in the regions of comparison."[222] The FEIS provides no additional documentation regarding the GNF's finding of ineligibility for Apache Creek.

The GNF erred by finding Apache Creek ineligible based on a lack of ORVs. First, Apache Creek contains Gila trout, and therefore the GNF should have found ORVs for fish, wildlife, and recreation, for the reasons described above. Additionally, Apache Creek supports multiple federally listed threatened and endangered species, including Chiricahua leopard frog, Mexican spotted owl, and Gila trout, as well as designated critical habitat for narrow-headed garter snake, providing additional justification for finding an ORV for wildlife. As a free-flowing river segment possessing multiple ORVs, Apache Creek should be found eligible under the Wild and Scenic Rivers Act.

b. Black Canyon Creek

Black Canyon Creek has its headwaters at the Continental Divide in the Aldo Leopold Wilderness and its lower portion in the Gila Wilderness. In the Gila Coalition Comments on the Draft LMP and DEIS, we asserted that the GNF should find a 24-mile segment of Black Canyon Creek eligible for Wild and Scenic River protection, with ORVs for scenery, geology, wildlife, fish, recreation, climate adaptation, and ecosystem services.[223] In the FEIS, the GNF includes Black Canyon in Table I-5, entitled, "List of ineligible rivers: values present are not outstandingly remarkable in the regions of comparison."[224] The FEIS provides no additional documentation regarding the GNF's finding of ineligibility for Black Canyon.

The GNF erred by finding Black Canyon ineligible based on a lack of ORVs. First, Black Canyon contains Gila trout, and therefore the GNF should have found ORVs for fish, wildlife, and recreation, for the reasons described above. Additionally, Black Canyon supports multiple federally listed threatened and endangered species, including

[221] Coalition Comments on Draft LMP/DEIS, p. 293.
[222] FEIS, Vol. 3, p. I-26.
[223] Coalition Comments on Draft LMP/DEIS, p. 294.
[224] FEIS, Vol. 3, p. I-27.

Chiricahua leopard frog and Gila trout, as well as designated critical habitat for spikedace, loach minnow, Mexican spotted owl, and narrow-headed garter snake, providing additional justification for finding an ORV for wildlife. And finally, Black Canyon Creek contains outstanding river canyon-specific scenery features, including large drop-offs, pinnacles, and balanced rocks in its upper section and a large waterfall in its lower section. Therefore, Black Canyon possesses an ORV for scenery. As a free-flowing river segment possessing multiple ORVs, Black Canyon Creek should be found eligible under the Wild and Scenic Rivers Act.

c. East Fork of the Gila River

A portion of the East Fork of the Gila River traverses the Gila Wilderness. In the Gila Coalition Comments on the Draft LMP and DEIS, we asserted that the GNF should find a 9-mile segment of the East Fork of the Gila River eligible for Wild and Scenic River protection, with ORVs for scenery, wildlife, fish, recreation, climate adaptation, and ecosystem services.[225] In the FEIS, the GNF includes East Fork Gila River in Table I-5, entitled, "List of ineligible rivers: values present are not outstandingly remarkable in the regions of comparison."[226] The FEIS provides no additional documentation regarding the GNF's finding of ineligibility for the East Fork of the Gila River.

The GNF erred by finding East Fork Gila River ineligible based on a lack of ORVs. First, the East Fork of the Gila River contains Gila trout, and therefore the GNF should have found ORVs for fish, wildlife, and recreation, for the reasons described above. Additionally, the East Fork of the Gila River supports multiple federally listed threatened and endangered species, including Chiricahua leopard frog, Gila trout, and Chihuahua chub, and includes designated critical habitat for narrow-headed garter snake, loach minnow, and spike dace, providing additional justification for finding an ORV for wildlife. As a free-flowing river segment possessing multiple ORVs, the East Fork of the Gila River should be found eligible under the Wild and Scenic Rivers Act.

d. East Fork of the Mimbres River (McKnight Canyon)

The East Fork of the Mimbres River flows through 600-feet-deep McKnight Canyon. In the Gila Coalition Comments on the Draft LMP and DEIS, we asserted that the GNF should find a 17-mile segment of the East Fork of the Mimbres River eligible for Wild and Scenic River protection, with ORVs for scenery, wildlife, fish, and botany.[227] In the FEIS, the GNF includes East Fork Mimbres River (McKnight Canyon) in Table I-5, entitled, "List of ineligible rivers: values present are not outstandingly remarkable in the regions of comparison."[228] The FEIS provides no additional documentation regarding the GNF's finding of ineligibility for the East Fork of the Mimbres River.

The GNF erred by finding the East Fork of the Mimbres River ineligible based on a lack of ORVs. First, the East Fork of the Mimbres River contains Gila trout, and therefore the

[225] Coalition Comments on Draft LMP/DEIS, p. 295.
[226] FEIS, Vol. 3, p. I-26.
[227] Coalition Comments on Draft LMP/DEIS, p. 296.
[228] FEIS, Vol. 3, p. I-26.

GNF should have found ORVs for fish, wildlife, and recreation, for the reasons described above. Additionally, the East Fork of the Mimbres River supports multiple threatened and endangered species, including Gila trout and Chihuahua chub, and the area includes designated critical habitat for Mexican spotted owl, providing additional justification for finding a wildlife ORV. And finally, the East Fork of the Mimbres River contains the exceptional 600-foot-deep McKnight Canyon and several waterfalls, and therefore possesses an ORV for scenery. As a free-flowing river segment possessing multiple ORVs, the East Fork of the Mimbres River (McKnight Canyon) should be found eligible under the Wild and Scenic Rivers Act.

e. Gilita Creek

Gilita Creek is an essential tributary to the Middle Fork Gila River, which the GNF has found eligible for protection under the Wild and Scenic Rivers Act, and flows almost entirely through the Gila Wilderness. In the Gila Coalition Comments on the Draft LMP and DEIS, we asserted that the GNF should find a 4-mile segment of Gilita Creek eligible for Wild and Scenic River protection, with ORVs for wildlife, fish, and botany.[229] In the FEIS, the GNF includes Gilita Creek in Table I-5, entitled, "List of ineligible rivers: values present are not outstandingly remarkable in the regions of comparison."[230] The FEIS provides no additional documentation regarding the GNF's finding of ineligibility for Gilita Creek.

The GNF erred by finding Gilita Creek ineligible based on a lack of ORVs. First, Gilita Creek contains Gila trout, and therefore the GNF should have found ORVs for fish, wildlife, and recreation, for the reasons described above. Additionally, Gilita Creek supports multiple threatened and endangered species, including Gila trout and Chihuahua leopard frog, and the area includes designated critical habitat for narrow-headed garter snake and Mexican spotted owl, providing additional justification for finding a wildlife ORV. As a free-flowing river segment possessing multiple ORVs, Gilita Creek should be found eligible under the Wild and Scenic Rivers Act.

f. Indian Creek

Indian Creek flows into the Gila Wilderness through a deeply incised canyon to join the Middle Fork of the Gila River, which the GNF has found eligible for protection under the Wild and Scenic Rivers Act. In the Gila Coalition Comments on the Draft LMP and DEIS, we asserted that the GNF should find a 9-mile segment of Indian Creek eligible for Wild and Scenic River protection, with ORVs for scenery, wildlife, and fish.[231] In the FEIS, the GNF includes Indian Creek, Indian Creek #2, and Indian Creek #3 in Table I-5, entitled, "List of ineligible rivers: values present are not outstandingly remarkable in the regions of comparison."[232] The FEIS provides no additional documentation regarding the GNF's finding of ineligibility for these three segments of Indian Creek.

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[229] Coalition Comments on Draft LMP/DEIS, p. 297.
[230] FEIS, Vol. 3, p. I-27.
[231] Coalition Comments on Draft LMP/DEIS, p. 298.
[232] FEIS, Vol. 3, p. I-27.

The GNF erred by finding Indian Creek ineligible based on a lack of ORVs. Indian Creek has an ORV for wildlife because it supports multiple threatened and endangered species, including Chiricahua leopard frog, yellow-billed cuckoo, spikedace, and loach minnow, and includes designated critical habitat for narrow-headed garter snake and Mexican spotted owl. Additionally, Indian Creek flows through an extensive, dramatic, and deeply incised canyon containing many spectacular cascades and therefore contains an ORV for scenery. As a free-flowing river segment possessing multiple ORVs, Indian Creek should be found eligible under the Wild and Scenic Rivers Act.

g. Little Creek

Little Creek flows entirely within the Gila Wilderness, with multiple trailheads popular for backpacking, horse- and mule-packing, and day hiking through outstanding scenic areas. In the Gila Coalition Comments on the Draft LMP and DEIS, we asserted that the GNF should find a 13-mile segment of Little Creek eligible for Wild and Scenic River protection, with ORVs for recreation, wildlife, fish, botany, climate adaptation, and ecosystem services.[233] In the FEIS, the GNF includes Little Creek in Table I-5, entitled, "List of ineligible rivers: values present are not outstandingly remarkable in the regions of comparison."[234] The FEIS provides no additional documentation regarding the GNF's finding of ineligibility for Little Creek.

The GNF erred by finding Little Creek ineligible based on a lack of ORVs. First, Little Creek contains Gila trout, and therefore the GNF should have found ORVs for fish, wildlife, and recreation, for the reasons described above. Additionally, Little Creek supports multiple threatened and endangered species, including Chiricahua leopard frog, Gila trout, Mexican Gray wolf, and Gila Chub, and the area includes designated critical habitat for spikedace, loach minnow, Mexican spotted owl, and narrow-headed garter snake, providing additional justification for finding a wildlife ORV. As a free-flowing river segment possessing multiple ORVs, Little Creek should be found eligible under the Wild and Scenic Rivers Act.

h. Mogollon Box of the Gila River

The Mogollon Box of the Gila River traverses the Gila Valley, Forest Service Mogollon Box Recreation Area, and The Nature Conservancy's Gila Riparian Reserve. In the Gila Coalition Comments on the Draft LMP and DEIS, we asserted that the GNF should find a 16-mile segment of the Mogollon Box eligible for Wild and Scenic River protection, with ORVs for recreation, wildlife, and botany.[235] It is unclear whether Mogollon Box corresponds to one or more of the segments included in the FEIS, Table I-5, entitled, "List of ineligible rivers: values present are not outstandingly remarkable in the regions of comparison."[236]

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233 Coalition Comments on Draft LMP/DEIS, p. 299.
234 FEIS, Vol. 3, p. I-26.
235 Coalition Comments on Draft LMP/DEIS, p. 300.
236 FEIS, Vol. 3, pp. I-26, I-27.

The GNF erred by not finding Mogollon Box eligible. Mogollon Box of the Gila River contains exemplary river canyon-specific scenery, including views of towering and distinctive cliffs. and is notable for its ease of access relative to other river segments containing remarkable cliff scenery. This segment therefore contains an ORV for scenery. Additionally, the Mogollon Box of the Gila River offers phenomenal multi-day rafting opportunities and is frequently combined with the contiguous, upriver run of the Wilderness run of the Gila River and therefore contains an ORV for recreation. Finally, the Mogollon Box has an ORV for wildlife because the area includes designated critical habitat for multiple threatened and endangered species including southwestern willow flycatcher, Mexican spotted owl, yellow-billed cuckoo, northern Mexican garter snake, and narrow-headed garter snake. As a free-flowing river segment possessing multiple ORVs, the Mogollon Box of the Gila River should be found eligible under the Wild and Scenic Rivers Act.

i. Mogollon Creek

Mogollon Creek flows within the Gila Wilderness. In the Gila Coalition Comments on the Draft LMP and DEIS, we asserted that the GNF should find a 30-mile segment of Mogollon Creek eligible for Wild and Scenic River protection, with ORVs for wildlife, fish, botany, climate adaptation, and ecosystem services.[237] It is unclear whether Mogollon Box corresponds to one or more of the segments included in the FEIS, Table I-5, entitled, "List of ineligible rivers: values present are not outstandingly remarkable in the regions of comparison."[238]

The GNF erred by not finding Mogollon Creek eligible. First, Mogollon Creek contains Gila trout, and therefore the GNF should have found ORVs for fish, wildlife, and recreation, for the reasons described above. Additionally, Mogollon Creek supports multiple threatened and endangered species, including Chiricahua leopard frog, Gila trout, Gila chub, and the area includes designated critical habitat for spikedace, loach minnow, Mexican spotted owl, southwestern willow flycatcher, narrow-headed garter snake, Mexican garter snake, and yellow-billed cuckoo, providing additional justification for finding a wildlife ORV. Mogollon Creek contains one significant waterfall, several minor waterfalls, many spectacular cascades, and an exceptional box canyon section. "Buds Hole" is a named and well-known geographical feature just above the significant waterfall near the confluence with the West fork of Mogollon Creek. These features warrant a finding that Mogollon Creek has an ORV for scenery. As a free-flowing river segment possessing multiple ORVs, Mogollon Creek should be found eligible under the Wild and Scenic Rivers Act.

j. San Francisco River (Devil's Creek)

The San Francisco River (Devil's Creek) provides rare and unique opportunities for rafting. In the Gila Coalition Comments on the Draft LMP and DEIS, we asserted that the GNF should find a 19-mile segment of the San Francisco River/Devil's Creek eligible

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[237] Coalition Comments on Draft LMP/DEIS, p. 301.

[238] FEIS, Vol. 3, pp. I-26, I-27.

for Wild and Scenic River protection, with ORVs for wildlife, recreation, and fish.[239] In the FEIS, the GNF includes a segment identified as "San Francisco River – US 180 at Salinas to Big Dry" in Table I-5, entitled, "List of ineligible rivers: values present are not outstandingly remarkable in the regions of comparison."[240] The FEIS provides no additional documentation regarding the GNF's finding of ineligibility for this segment of the San Francisco River.

This section of the San Francisco River is listed in American Whitewater's database for rivers that can be rafted. There are only a few multi-day paddling runs in New Mexico that are both accessible and possible to run, and this section of the San Francisco River is one of them. Therefore, this segment contains an ORV for recreation. Additionally, this section of San Francisco River has been described by American Whitewater as containing "a geologic wonderland of igneous, sedimentary and metamorphic rock." The river-canyon scenery is exemplary and therefore contains an ORV for scenery. Finally, this section of the San Francisco River supports multiple threatened and endangered species including Gila chub and Chiricahua leopard frog, and therefore contains an ORV for wildlife. As a free-flowing river segment possessing multiple ORVs, the San Francisco River Devil's Creek segment should be found eligible under the Wild and Scenic Rivers Act.

k. Sapillo Creek

Sapillo Creek is an important tributary to the Wilderness Run of the Gila River, which the GNF has found eligible. In the Gila Coalition Comments on the Draft LMP and DEIS, we asserted that the GNF should find a 7-mile segment of Sapillo Creek eligible for Wild and Scenic River protection, with ORVs for scenery, wildlife, fish, botany, cultural, climate adaptation, and ecosystem services.[241] In the FEIS, the GNF includes Sapillo Creek in Table I-5, entitled, "List of ineligible rivers: values present are not outstandingly remarkable in the regions of comparison."[242] The FEIS provides no additional documentation regarding the GNF's finding of ineligibility for Sapillo Creek.

The GNF erred by finding Sapillo Creek ineligible based on a lack of ORVs. First, Sapillo Creek contains Gila trout, and therefore the GNF should have found ORVs for fish, wildlife, and recreation. Additionally, Sapillo Creek supports multiple threatened and endangered species, including Gila Trout and Chiricahua leopard frog, providing additional justification for an ORV for wildlife. And finally, the middle narrows of Sapillo Creek contain the preeminent example of a box canyon in all of the GNF. Multiple waterfalls and slot canyons feed into this exquisitely carved, narrow section as tributaries, and this section also contains one waterfall within its watercourse along with countless cascades. The sustained, narrow, soaring cliff walls featuring multiple sections with wall-to-wall, overhead water are at a scenic level that likely exceeds any other canyon in the Gila. As a free-flowing river segment possessing multiple ORVs, Sapillo Creek should be found eligible under the Wild and Scenic Rivers Act.

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[239] Coalition Comments on Draft LMP/DEIS, p. 302.
[240] FEIS, Vol. 3, p. I-27.
[241] Coalition Comments on Draft LMP/DEIS, p. 303.
[242] FEIS, Vol. 3, p. I-27.

l. Taylor Creek

In the Gila Coalition Comments on the Draft LMP and DEIS, we asserted that the GNF should find a 19-mile segment of Taylor Creek eligible for Wild and Scenic River protection, with ORVs for scenery, wildlife, fish, botany, and cultural.[243] In the FEIS, the GNF includes two segments identified as Taylor Creek and Taylor Creek #2 in Table I-5, entitled, "List of ineligible rivers: values present are not outstandingly remarkable in the regions of comparison."[244] The FEIS provides no additional documentation regarding the GNF's finding of ineligibility for Taylor Creek.

The GNF erred by finding Taylor Creek ineligible based on a lack of ORVs. Taylor Creek supports multiple threatened and endangered species, including Chiricahua leopard frog, spikedace, and loach minnow, and therefore contains an ORV for wildlife. As a free-flowing river segment possessing one or more ORVs, Taylor Creek should be found eligible under the Wild and Scenic Rivers Act.

m. Turkey Creek

Turkey Creek is an important wilderness tributary to the Gila River. In the Gila Coalition Comments on the Draft LMP and DEIS, we asserted that the GNF should find a 21-mile segment of Turkey Creek eligible for Wild and Scenic River protection, with ORVs for scenery, recreation, cultural, wildlife, fish, botany, climate adaptation, and ecosystem services.[245] In the FEIS, the GNF includes three segments identified as Turkey Creek, Turkey Creek #2, and Turkey Creek #3 in Table I-5, entitled, "List of ineligible rivers: values present are not outstandingly remarkable in the regions of comparison."[246] The FEIS provides no additional documentation regarding the GNF's finding of ineligibility for these three segments of Turkey Creek.

The GNF erred by finding Turkey Creek ineligible based on a lack of ORVs. First, Turkey Creek contains Gila trout, and therefore the GNF should have found ORVs for fish, wildlife, and recreation. Additionally, Turkey Creek supports multiple threatened and endangered species, including Chiricahua leopard frog and Gila trout, providing additional justification for an ORV for wildlife. Turkey Creek also contains numerous waterfalls, rockslides, deep pools, and narrow sections with high steep walls, and therefore contains an ORV for scenery. And finally, Turkey Creek contains a well-known, high quality, and unique hot spring nestled in a bedrock pool, which qualifies the segment for an ORV for recreation under the GSEEC. As a free-flowing river segment possessing multiple ORVs, Turkey Creek should be found eligible under the Wild and Scenic Rivers Act.

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[243] Coalition Comments on Draft LMP/DEIS, p. 304.
[244] FEIS, Vol. 3, p. I-27.
[245] Coalition Comments on Draft LMP/DEIS, p. 305.
[246] FEIS, Vol. 3, p. I-26.

n. West Fork Mogollon Creek

The West Fork Mogollon Creek flows entirely within designated wilderness. In the Gila Coalition Comments on the Draft LMP and DEIS, we asserted that the GNF should find an 8-mile segment of West Fork Mogollon Creek eligible for Wild and Scenic River protection, with ORVs for scenery, wildlife, fish, botany, climate adaptation, and ecosystem services.[247] In the FEIS, the GNF includes West Fork Mogollon Creek in Table I-5, entitled, "List of ineligible rivers: values present are not outstandingly remarkable in the regions of comparison."[248] The FEIS provides no additional documentation regarding the GNF's finding of ineligibility for West Fork Mogollon Creek.

The GNF erred by finding West Fork Mogollon Creek ineligible based on a lack of ORVs. First, West Fork Mogollon Creek contains Gila trout, and therefore the GNF should have found ORVs for fish, wildlife, and recreation. Additionally, West Fork Mogollon Creek supports multiple threatened and endangered species, including Chiricahua Leopard frog, Gila trout, and spikedace, and the area includes designated critical habitat for Mexican spotted owl and narrow-headed garter snake. And finally, West Fork Mogollon Creek contains a deeply incised canyon with cascading waterfalls and pools. Combined with distant mountain views in all directions, many consider this stream corridor to be the best mountain vista in all of the Gila Wilderness. This stream segment therefore contains an ORV for scenery. As a free-flowing river segment possessing multiple ORVs, West Fork Mogollon Creek should be found eligible under the Wild and Scenic Rivers Act.

4. The Final LMP, FEIS, and Draft ROD contain insufficient documentation, data, and justification to support the **GNF's** ineligibility determinations.

In our previous comments we identified a lack of sufficient documentation, data, or justification for the GNF's findings of eligibility or ineligibility.[249] In the Draft ROD, the Responsible Official states that "staff completed a systematic study, as documented in appendix I of the final environmental impact statement."[250] As reflected in the above discussion, however, Appendix I is devoid of information explaining why the GNF found 229 of the 245 segments ineligible. A partial explanation can perhaps be gleaned from the title of Table I-5: "values present are not outstandingly remarkable in the regions of comparison."[251] This title implies, but does not confirm, that the GNF found each of the listed segments to be free-flowing as required for protection under the Wild and Scenic Rivers Act. But there is no information whatsoever about where these segments are located, which ORVs were considered, or why no ORVs were identified. The lack of a transparent process and documentation contravenes the 2012 Planning Rule, which emphasizes the importance of public participation and transparency.

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[247] Coalition Comments on Draft LMP/DEIS, p. 306.
[248] FEIS, Vol. 3, p. I-27.
[249] Coalition Comments on Draft LMP/DEIS, p. 273
[250] Draft ROD, p. 41.
[251] FEIS, Vol. 3, pp. I-26, I-27.

Additionally, the documentation in the Draft ROD, Final LMP, and FEIS falls far short of the requirements of Chapter 80 of the Forest Service Handbook. The Handbook requires that the "environmental document for developing, revising, or amending a land management plan should contain an appendix containing the study report for all rivers studied for their eligibility for inclusion in the System."[252] This appendix must contain "separate river narratives for each river segment evaluated in the planning process and a map showing the rivers, their termini and corridors."[253] The river narratives for each segment, including those found ineligible, must include "a synopsis of the pertinent information related to eligibility and classification factors."[254] This documentation "should include . . . [o]ne or more tables listing each river segment with information supporting whether the river is deemed eligible or not (such as free-flowing characteristics, water quality, and presence or absence and a description of outstandingly remarkable values)."[255]

The fourteen stream segments discussed in the previous section illustrate that the GNF adopted unreasonably narrow GSEEC and applied the baseline ORV criteria and GSEEC in an inappropriate manner, resulting in arbitrary and capricious ineligibility determinations. The GNF must provide additional narratives, maps, and justification for its ineligibility findings to demonstrate that each segment was adequately analyzed. In the absence of documentation and justification, the public cannot evaluate whether the GNF's eligibility study complied with applicable law, regulation, and policy.

D. Requested Remedy for Eligible Wild and Scenic Issues

To address the GNF's failure to consider the national scale when evaluating ORVs, reliance on unreasonably restrictive GSEEC, failure to find fourteen qualifying stream segments eligible for inclusion in the National Wild and Scenic Rivers System, and failure properly document its ineligibility findings, we request the following remedies:

- Update the eligibility study to reflect that the following stream segments are eligible for inclusion in the National Wild and Scenic River System because the segments are free-flowing and possess at least one ORV: Apache Creek, Black Canyon Creek, East Fork Gila River, East Fork Mimbres River (McKnight Canyon), Gilita Creek, Indian Creek, Little Creek, Mogollon Box Gila River, Mogollon Creek, San Francisco River (Devil's Creek), Sapillo Creek, Taylor Creek, Turkey Creek, and West Fork Mogollon Creek.

- Revise the FEIS to include adequate justification and documentation regarding stream segments found ineligible for inclusion in the National Wild and Scenic Rivers System, as required by Chapter 80 of the Forest Service Handbook.

[252] Chapter 80, p. 18.
[253] *Id.*
[254] *Id.*
[255] *Id.*

VI. NEW INFORMATION: CLIMATE IMPACTS, BIODIVERSITY LOSS, AND THE 30X30 INITIATIVE

In addition to the issues raised above, new information warrants the GNF taking a different approach to its final wilderness recommendations and eligible Wild and Scenic River determinations. On January 27, 2021, President Biden signed Executive Order 14008, *Tackling the Climate Crisis at Home and Abroad*.[256] This Executive Order, among other ambitious goals, committed the administration to preserve 30% of lands and waters by 2030, often referred to as 30x30. The Executive Order was followed by the publication of the America the Beautiful report in May.[257] These new commitments and goals, published in the interim between the issuance of the Draft LMP and the Final LMP, warrant a heightened focus in the plan on the protection of lands with wilderness values and stream segments that are eligible for Wild and Scenic River designation.

As reflected by the 30x30 initiative, it is essential that we conserve and restore natural landscapes and free-flowing rivers to protect biodiversity, limit carbon emissions, and adapt to climate impacts. In 2022, New Mexico Wild commissioned a scientific study from a team of scientists at EcoAdapt, an independent non-governmental organization, to identify and prioritize areas of New Mexico that hold the highest potential value for protecting biodiversity and mitigating climate change.[258] The EcoAdapt Report reflects that in New Mexico, "the percent of protected lands managed primarily for biodiversity lags behind national levels (6.1% in New Mexico compared to 12.6% nationally) despite the relatively high proportion of public lands and rich biodiversity present in the state."[259]

Across the state, the EcoAdapt Report modeled three indicators of ecosystem adaptation to climate change, including biodiversity, connectivity, and resilience,[260] and also analyzed the value of protecting various areas for carbon sequestration and storage.[261] The lands managed by the GNF in the general vicinity of the Gila, Aldo Leopold, and Blue Range Wilderness emerged as some of the highest priority areas for expanding and strengthening the existing protected area network to meet 30X30 goals.[262]

The GNF is of local, regional, national, and global significance, in terms of its potential to maintain biodiversity and adapt to climate impacts. As the GNF works to resolve our objections and finalize the LMP and ROD, we urge the GNF to consider the new policy goals of 30x30 and the research reflecting the importance of prioritizing conservation of the lands and waters in the Gila region.

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[256] Attachment B, Exec. Order 14008, 86 Fed. Reg. 7,619 (Jan. 27, 2021).
[257] Attachment C, Dep't of Interior et al., Conserving and Restoring America the Beautiful (2021).
[258] Attachment D, EcoAdapt, New Mexico Public Lands and Their Significance to Climate Change Adaptation and Mitigation: Identifying Priorities for Conservation and Stewardship (Dec. 2022) [hereinafter EcoAdapt Report]
[259] *Id.* at p. 4.
[260] *Id.* at p. 10.
[261] *Id.* at pp. 12.
[262] *Id.* at pp. 30-32.

VII. MEETING REQUEST

In accordance with the 2012 Planning Rule,[263] we respectfully request to meet with the Reviewing Officer to discuss the issues raised in this objection and potential resolutions. We anticipate that other interested persons or organizations may wish to participate in such meetings, and we acknowledge that the Reviewing Officer must permit interested parties to participate if they file a request to participate in an objection within 10 days after publication of the notice of objection by the Responsible Official.[264]

VII. CONCLUSION

Thank you for considering our objections and requested remedies related to the provisions in the Final LMP, FEIS, and Draft ROD related to recommended wilderness management areas and eligible wild and scenic river segments. These issues are vitally important because they will directly impact the success or failure of our collective efforts to combat the increasingly severe impacts of climate change and biodiversity loss for the next three decades, and potentially longer if these wild areas and free-flowing streams are lost. We look forward to meeting with you to discuss the issues we have raised and find equitable solutions that will benefit everyone and ensure the Forest Service finalizes this plan in conformity with applicable laws, regulations, and Forest Service policies.

Sincerely,

Sally Paez, Staff Attorney
New Mexico Wilderness Alliance
P.O. Box 25464
Albuquerque, NM 87125
sally@nmwild.org
(505) 843-8696

Michael Casaus, New Mexico State Director
The Wilderness Society
1801 Pennsylvania Ave. NW, Suite 200
Washington, DC 20006
michael_casaus@tws.org
(505) 247-0834

[263] 36 C.F.R. § 219.57(a).
[264] *Id.* § 219.56(f).

Marcia Stout, Co-leader
Aldo's Silver City Chapter of
Great Old Broads for Wilderness
904 N. Santa Rita St.
Silver City, NM 88061
aldosgob@gmail.com

Adam Rissien, ReWilding Manager
WildEarth Guardians
P.O. Box 7516
Missoula, MT 59807
arissien@wildearthguardians.org
(406) 370-3147

Brian Nowicki, Southwest Deputy Director
The Center for Biological Diversity
P.O. Box 710
Tucson, AZ 85702-0710
bnowicki@biologicaldiversity.org
(505) 917-5611

Encl: Attachment A: Gila Trout Revised Recovery Plan (2022)
Attachment B: Executive Order 14008 (Jan. 27, 2021)
Attachment C: Conserving and Restoring America the Beautiful (2021)
Attachment D: EcoAdapt Report (Dec. 2022)

Attachment A

August 2022

U.S. Fish and Wildlife Service
Revised Recovery Plan
for
Gila Trout
(*Oncorhynchus gilae*)
4th Revision
August 2022

Photo by: Joseph R. Tomelleri

August 2022

Revised Recovery Plan
for
Gila Trout (*Oncorhynchus gilae*)
4th Revision
(Original approved 12 January 1979)
(First revision approved 3 January 1984)
(Second revision approved 8 December 1993)
(Third revision approved 15 August 2003)

Prepared by the
Gila Trout Recovery Team
Albuquerque, New Mexico

Approved: ______________________________
Regional Director
U.S. Fish and Wildlife Service, Southwest Region

August 2022

Disclaimer

Recovery plans delineate such reasonable actions as may be necessary, based upon the best scientific and commercial data available, for the conservation and survival of species listed under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.). Plans are published by the U.S. Fish and Wildlife Service (USFWS) or National Marine Fisheries Service (NMFS), sometimes prepared with the assistance of recovery teams, contractors, State agencies and others. Recovery plans do not necessarily represent the views, official positions or approval of any individuals or agencies involved in the plan formulation, other than the USFWS or NMFS. They represent the official position of the USFWS or NMFS only after they have been signed by the Regional Director (USFWS) or Assistant Administrator (NMFS). Recovery plans are guidance and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions.

Literature citation should read as follows:

U.S. Fish and Wildlife Service. 2022. Revised Recovery Plan for Gila trout (*Oncorhynchus gilae*). U.S. Fish and Wildlife Service, Southwest Region, Albuquerque, New Mexico. 185 pages.

August 2022

Additional copies may be obtained from:

U.S. Fish and Wildlife Service
Southwest Region
500 Gold Avenue SW, Room #4012
Albuquerque, New Mexico 87102-3118

The recovery plan may also be downloaded at:
USFWS ECOS Gila trout species profile webpage

Acknowledgements

The U. S. Fish and Wildlife Service (USFWS) gratefully acknowledges the contributions of the following individuals in developing the Recovery Plan for Gila trout.

Recovery Team members:

Julie Meka Carter and Zack Beard (Arizona Game and Fish Department)
Nate Caswell (New Mexico Fish and Wildlife Conservation Office, Service)
Yvette Paroz (Recovery Team Leader, U.S. Forest Service)
Kirk Patten (New Mexico Department of Game and Fish)
Dr. David Propst and Dr. Thomas Turner (Department of Biology, University of New Mexico)
Jill Wick (New Mexico Department of Game and Fish)

Other contributors:

U. S. Fish and Wildlife Service: Andy Dean, Chad Baumler, Rosalinda Gonzalez, James Gruhala, Serena Kucera, Melissa Mata-Gonzalez, Trevor Luna, Gary Pandolfi, Susan Pruitt, Nathan Weise, Wade Wilson, Angela Anders.
U. S. Forest Service: Jerry Monzingo and Dustin Myers.
University of New Mexico: Megan Osborne
Recovery Team Consultants: James Brooks and John Pittenger

Executive Summary

Current Species Status

As of April 2022, there were 23 populations of Gila trout (*Oncorhynchus gilae*) inhabiting approximately 210.8 kilometers (km) (131.0 miles (mi)) of stream habitat. All known, remnant genetic lineages (Main Diamond Creek, South Diamond Creek, Whiskey Creek, Iron Creek and Spruce Creek) were represented by at least three wild populations. These five remnant lineages encompass the existing genetic diversity of the species, and each contributes significantly to it. Heterozygosity of all the remnant lineages of Gila trout, with the exception of Iron Creek, has declined from 2002 to 2013. Loss of genetic diversity has been particularly acute in the Spruce Creek lineage. The Main Diamond and South Diamond lineages were relatively secure, with hatchery broodstock and production having been successfully developed in 10 of the 23 occupied streams. The current status of the other three lineages is less secure, with three mixed-lineage populations established by 2022. The remnant-lineage populations in Whiskey Creek and Spruce Creek were extirpated following large-scale, high-severity wildfire in 2012. Spruce Creek was restocked in 2018, bringing the total occupied streams to three, and the Whiskey Creek lineage is represented in four streams. The Iron Creek lineage occurred in three streams at the beginning of 2022, and those populations contained unique genetic variation. Resiliency of Gila trout is constrained by the patchy distribution and geographic isolation of cold-water streams, many of which are single-stream systems that are relatively small, throughout the species' historical range. Few extant populations of Gila trout are large enough to survive extremes in environmental conditions without experiencing a severe population bottleneck (drastic reduction in population size). Even the largest single-stream systems where Gila trout have been repatriated (e.g., Black Canyon) have been subject to extirpations associated with environmental stochasticity. Currently the Mogollon and Willow Creek drainages (where the South Diamond lineage has been established) and Whitewater Creek (mixed-lineage) have a dendritic (branching stream network) metapopulation structure. Recovery actions implemented to date have greatly improved redundancy by increasing the number of populations of Gila trout. However, spatial distribution of populations is constrained by the geographical distribution of currently suitable habitat for the species, due to both human-induced and natural factors.

Habitat Requirements and Limiting Factors

Persistent, viable populations of Gila trout require *perennial* stream flow, which must be adequate to maintain sufficient habitat diversity and volume to support all life stages of Gila trout (eggs, fry, juveniles, adults). Flow regimes required to maintain sufficient habitat diversity and volume vary depending on site-specific characteristics of stream reaches (e.g., stream gradient, seepage, substrate composition, channel dimensions, watershed hydrology). Gila trout require cold-water aquatic habitats with unimpaired water quality. Suitable water temperature was observed up to 26°Celsius (C) by Lee and Rinne (1980). Their observations noted normal activity during temperature fluctuations between 20-26°C; however, as temperature rose to 27°C, abnormal activity and eventual mortality occurred. Suitable water quality for Gila trout is characterized by high dissolved oxygen concentration, low turbidity and conductivity, low levels of total dissolved solids, and near-neutral pH. In addition to perennial stream flow and suitable water temperature and water quality, Gila trout require a diversity of habitats sufficient to sustain all life stages of the species. This includes suitable spawning habitat, habitat where fry can find shelter and food, and areas suitable for occupancy by juvenile and adult Gila trout. The two most important features with respect to population persistence are likely sufficient pool habitat and spawning habitat. The threat of local extinction of native salmonid populations increases with isolation and decreasing population size. Long term persistence of Gila trout requires the combination of sufficiently large, occupied habitats and, where possible, connectivity in dendritic stream networks. Populations of Gila trout occurring in dendritic stream networks are often larger in population size while also supporting appropriate maintenance of genetic variation, and access to suitable habitat in response to environmental variation and life history requirements. A key biological requirement for sustaining viable populations of Gila trout is the absence of nonnative salmonids (Family Salmonidae), with viable populations defined as those that exhibit annual reproduction, size structure indicating multiple ages, and individuals attaining sufficient sizes to indicate three to seven years of survival (USFWS, 2006). The threats of predation, inter-species competition, and human-mediated introgressive hybridization all result from the presence of nonnative salmonids. Viable populations of Gila trout cannot persist when either, or both, of these threats are present. Consequently, the absence of nonnative salmonids is a fundamental requirement for sustaining viable populations of Gila trout.

Recovery Goal

The goal of the recovery plan is to improve the conservation status of Gila trout to the extent that the species is viable and no longer requires protection under the Endangered Species Act. To ensure that the Gila trout will no longer meet the definition of threatened or endangered, multiple resilient populations must be well distributed in suitable habitats throughout the species' historical range, and threats to its existence must be eliminated or sufficiently abated.

Recovery Strategy

The primary focus of the recovery effort for Gila trout has been to evolve from a crisis-management situation focused on preventing extinction to a perspective of sustainable populations established throughout the historical range that contain the breadth of genetic diversity of the species. Going forward, recovery will entail incremental replacement of nonnative salmonids with Gila trout in suitable habitat throughout the historical range of the species. This strategy will be implemented by conducting actions to substantially improve redundancy, representation, and resiliency to the point that protections under the Endangered Species Act are no longer necessary.

Recovery Objectives

The recovery goal is expressed by the following objectives:

1. Secure the existing genetic diversity of Gila trout through the establishment of additional populations (both single-lineage stream segments and mixed-lineage metapopulations), the prevention of introgression by nonnative salmonids, the continued development of broodstock and hatchery production programs, and the continued research on assessment of genetic diversity and detection of introgression.
2. Increase the geographic distribution of the species so that it inhabits a substantial portion of its historical range which represents the spectrum of ecological conditions present in suitable habitats (Carroll et al., 2010).
3. Increase the size, dendritic population structure, and interconnectedness of populations through nonnative salmonid removal and the strategic installation or modification of barriers (to prevent nonnative salmonid invasion but also to improve access to diverse habitats).

These objectives can also be presented in the context of redundancy, representation and resiliency:

- Redundancy: Viable populations of Gila trout are established in watersheds throughout the historical range of Gila trout, as constrained by availability of suitable habitat.
- Representation: Genetic diversity of Gila trout is maintained by establishing viable populations that replicate remnant genetic lineages, genetic diversity is augmented through planned lineage mixing, and all recovery streams are free of and protected from invasion by nonnative trout.
- Resiliency: The combination of numbers and sizes of Gila trout populations are sufficient

to maintain genetic diversity, allow for persistence, and maintain evolutionary potential.

Recovery Criteria

The following are objective, measurable criteria which, when met, may result in a determination that Gila trout be removed from the endangered species list:

Criterion A – Area of Occupancy

Gila trout occupy at least 280 km. (174 mi) of total combined stream within the historical range of the species. Occupancy, in the context of this criterion, refers to streams with suitable habitat to support all life stages of Gila trout (see Habitat Characteristics, Chapter 3) being inhabited by viable populations. Criterion A explicitly addresses recovery objectives 1, 2 and 3.

Criterion B – Remnant Genetic Lineages

Each remnant genetic lineage of Gila trout is represented by at least three geographically separate, viable populations. One replicate population of each lineage must be geographically separated by at least 34.0 km (21.1 mi) from the other two replicate populations of that genetic lineage. These populations and the streams they inhabit would contribute to meeting the area of occupancy threshold in Criterion A. Criterion B explicitly addresses recovery objective 2.

Criterion C – Dendritic Metapopulations

At least four dendritic metapopulations of Gila trout are established. These metapopulations and the streams they inhabit would contribute to meeting the area of occupancy threshold in criterion A. Criterion C explicitly addresses recovery objective 3 and contributes to meeting objectives 1 and 2.

Criterion D – Absence of Nonnative Salmonid Species

Nonnative salmonids are absent from recovery streams and measures are in place to prevent re-invasion by nonnative salmonids. In limited circumstances where non-hybridizing, nonnative salmonids persist in recovery streams, active management and suppression may occur to mitigate effects on the Gila trout recovery populations until complete eradication of nonnative salmonids is achieved. Criterion D explicitly addresses recovery objectives 1 and 2.

Actions Needed

Recovery actions are the site-specific management actions needed to address threats to the species and achieve recovery criteria. For the Gila trout, implementation of the following recovery actions will involve participation from the USFWS, U.S. Forest Service, Arizona Game and Fish Department, and New Mexico Department of Game and Fish.

1. Repatriate Gila trout to streams within its historical range (Priority 1).
2. Establish and maintain captive propagation methods and conservation hatchery facilities in suitable locations (Priority 1).
3. Manage the presence of nonnative salmonid species in recovery streams in Arizona and New Mexico (Priority 1).
4. Monitor remnant and repatriated Gila trout populations within the Gila River drainage basin (Priority 2).
5. Conduct public education, involvement, and outreach in areas with an interest in Gila trout (Priority 3).
6. Develop and implement rules to maintain sustainable Gila trout populations in recovery streams opened to sport fishing in Arizona and New Mexico (Priority 3).

Recovery actions are assigned numerical priorities, as defined below, to highlight the relative contribution they may make toward species recovery.

- Priority 1: An action that must be taken to prevent extinction; or to prevent the species from declining irreversibly in the foreseeable future.
- Priority 2: An action that must be taken to prevent a significant decline in species population/habitat quality, or some other negative impact short of extinction.
- Priority 3: All other actions necessary to meet recovery objectives.

Flexibility, which is essential to Gila trout recovery, can be hard to obtain with rigid timelines and schedules. Therefore, we will develop a supplemental Recovery Implementation Strategy (RIS), which provides additional detailed, site-specific activities needed to implement the actions identified in this Recovery Plan.

Estimated Date and Cost of Recovery

The estimated date of recovery of Gila trout is 2032, and the estimated total cost of recovery over this 10-year period is $15,619,030.

August 2022

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Chapter 1- Introduction
Background

The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*; ESA), establishes policies and procedures for identifying, listing, and protecting species of wildlife and plants that are endangered or threatened with extinction. Recovery is defined as “the process by which listed species and their ecosystems are restored and their future is safeguarded to the point that protections under the ESA are no longer needed”, according to the 2010 updated National Marine Fisheries Service’s and U.S. Fish and Wildlife Service’s (USFWS) Interim Recovery Planning Guidelines (2010).

Recovery plans are strictly advisory documents developed to provide recovery recommendations based on alleviating the threats to the species and ensuring self-sustaining populations in the wild. According to the ESA, recovery plans are to include (1) a description of such site-specific management actions as may be necessary to achieve the plan’s goal for the conservation and survival of the species; (2) objective, measurable criteria which, when met, may result in a determination that the species be removed from the Federal List of Endangered and Threatened Wildlife (List); and (3) estimates of the time required and the cost to carry out those measures needed to achieve the plan’s goals and intermediate steps toward that goal.

The original recovery plan for Gila trout (*Oncorhynchus gilae*) was approved on January 12, 1979 (USFWS, 1979), with subsequent revisions approved on January 3, 1984 (USFWS, 1984), December 8, 1993 (USFWS, 1993), and August 19, 2003 (USFWS, 2003). This Revised Recovery Plan for Gila Trout (Recovery Plan) represents the fourth revision and considers updated information on genetics, population status, and threats (principally wildfire effects and introgressive hybridization) in the development of revised recovery objectives, actions, and implementation.

Brief Overview and Status

The Gila trout (*Oncorhynchus gilae*) is endemic to mountain streams in the Gila, San Francisco, Agua Fria, and Verde River drainages in New Mexico and Arizona (Miller, 1950; Minckley, 1973; Behnke, 1992; Budy et al., 2019). Although Gila trout had been known in the upper Gila River basin since at least 1885, the species was not described until 1950, by which time its distribution had been dramatically reduced (Miller, 1950).

The Gila trout was originally recognized as endangered under the Federal Endangered Species Preservation Act of 1966 (USFWS, 1967). Federally designated status of the fish as endangered was continued under the ESA. The Gila trout was reclassified, or down-listed, from endangered to threatened in 2006 (USFWS, 2006). The 2006 reclassification also included a special rule under section 4(d) of the ESA that enabled the New Mexico Department of Game and Fish (NMDGF) and the Arizona Game and Fish Department (AZGFD) to promulgate special regulations, in collaboration with the USFWS, allowing recreational fishing for Gila trout. The Gila trout was listed as endangered by the NMDGF in 1975 under the Wildlife Conservation Act and was down-listed to threatened in 1988. In Arizona, Gila Trout are recognized as a tier 1A species of greatest conservation need in the Arizona State Wildlife Action Plan (AZGFD, 2012).

The Gila trout is assigned a recovery priority number of 8 in the most recent 5-year review (USFWS, 2020), meaning that the species has a moderate degree of threat with high potential for recovery.

Chapter 2- Life History, Biology, Distribution, and Resource Needs

Morphological Description

Gila trout are readily identified by their iridescent gold sides that blend to a darker shade of copper on the opercles (bony plates surrounding the gills) (Figure 1). Spots on the body of this trout are small and profuse, generally occurring above the lateral line and extending onto the head, dorsal fin, and caudal fin. Spots are irregularly shaped on the sides and increase in size dorsally. On the dorsal surface of the body, spots may be as large as the pupil of the eye and are rounded. A few scattered spots are sometimes present on the anal fin, and the adipose fin is typically large and well-spotted. Dorsal, pelvic, and anal fins have a white to yellowish tip that may extend along the leading edge of the pelvic fins. A faint, salmon-pink band is present on adults, particularly during spawning season when the normally white belly may be streaked with yellow or reddish orange. A yellow cutthroat mark is present on most mature specimens. Parr marks (markings present when trout are less than a year old) are commonly retained by adults, although they may be faint or absent (Miller, 1950; David, 1976).

Field characteristics that distinguish Gila trout from other co-occurring nonnative trout include the golden coloration of the body, parr marks, and fine, profuse spots above the lateral line (Figure 1). These characters differentiate Gila trout from rainbow (*O. mykiss*), brown (*Salmo trutta*), and cutthroat trout (*O. clarkii*).

See Appendix A for additional information on Gila trout morphology, including differentiation between lineages.

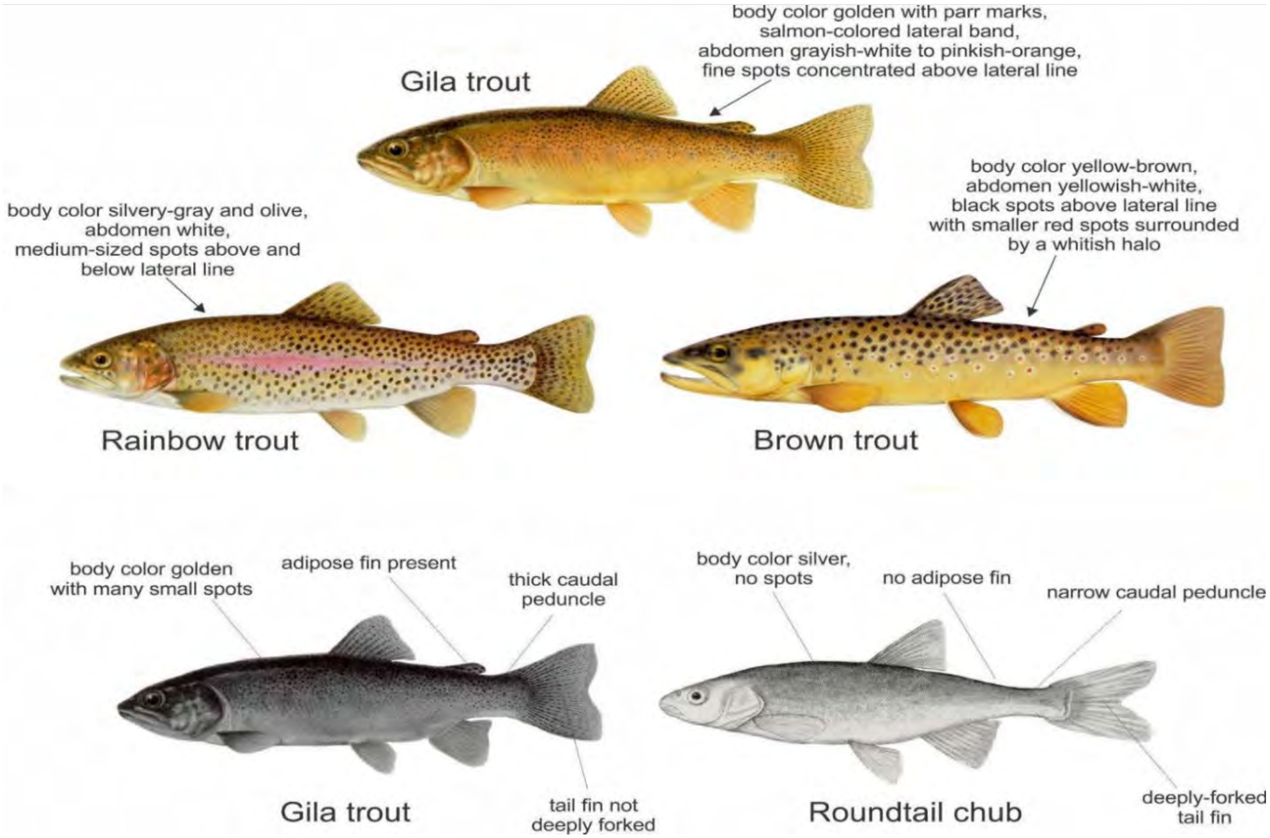


Figure 1. Comparison of field characteristics that distinguish Gila trout from co-occurring, nonnative trout and roundtail chub (Joseph R. Tomelleri).

Systematics

The genus *Oncorhynchus* is monophyletic (Wilson and Turner, 2009) meaning that it consists of a common ancestor and all of its descendants. Gila trout is in the Pacific trout clade (a common ancestor and all lineal descendants) along with Apache trout (*O. apache*), rainbow trout (*O. mykiss*) and cutthroat trout (*O. clarkii*) (Figure 2). The Pacific trout lineage split from the Pacific salmon lineage approximately 6.3 million years ago, the cutthroat trout and rainbow trout lineages diverged approximately 2.3 to 3.8 million years ago, and lineages of the rainbow trout clade diverged sometime in the last 1.4 million years (Wilson and Turner, 2009). The Gila trout and rainbow trout lineages split 0.61 to 2.3 million years ago, and the Gila trout and Apache trout lineages diverged approximately 0.15 to 1.3 million years ago (Wilson and Turner, 2009). Therefore, Gila trout and Apache trout are more closely related to rainbow trout than they are to cutthroat trout. In addition, Gila trout and Apache trout are closely related, and the two taxa compose a monophyletic group. The analysis conducted by Wilson and Turner (2009) confirmed earlier work that indicated Gila and Apache trout were derived from an ancestral form that also gave rise to rainbow trout (Behnke, 1992; Dowling and Childs, 1992; Utter and Allendorf, 1994; Nielsen et al., 1998; Riddle et al., 1998).

Genetics

Since the time of listing, a vast number of genetic studies have been conducted on Gila trout, with most analyses focused on assessing the 'purity' (extent of distinctiveness in terms of lineages and extent of hybridization) and diversity of remnant populations. Early studies analyzing genetic differentiation between Gila trout, Apache trout, rainbow trout, and cutthroat trout confirmed separation of Gila trout from other *Oncorhynchus* species (Figure 2). Genetic similarity is not surprising as these species share a common ancestor. However, examination of allozymes revealed differentiation between Gila trout, rainbow trout, and cutthroat trout (Loudenslager et al., 1986; Dowling and Childs, 1992; Leary and Allendorf, 1999). Analysis of mitochondrial DNA also indicated genetic differentiation of Gila trout, Apache trout, rainbow trout, and cutthroat trout (Dowling and Childs, 1992; Riddle et al., 1998; Wares et al., 2004; Wilson and Turner, 2009).

See Appendix B for an in-depth discussion of Gila trout genetics.

Description of Lineages

Historical collections from streams in the upper Gila River Basin and San Francisco River Basin along with genetic analysis indicated that five lineages of Gila trout persist on the landscape:

Main Diamond Creek, South Diamond Creek, Whiskey Creek, Spruce Creek, and Iron Creek. Allozyme data has revealed divergence between Gila trout populations of the San Francisco River drainage and the Gila River Drainage (Wares et al., 2004). The Spruce Creek population (San Francisco drainage) contained four unique alleles not found in the Gila River drainage populations. The common allele found in all the upper Gila River drainage populations was absent in the Spruce Creek population. Further investigations (using microsatellites, mitochondrial DNA, and MHC) into variation among the five remnant populations indicated that the Whiskey Creek lineage was likely an intermediary between the Main Diamond Creek and South Diamond Creek lineages and is highly genetically diverse. Spruce Creek lineage, however, had the least genetic diversity of all lineages. Iron Creek lineage possessed more unique variation than all other lineages of Gila trout and is evolutionarily important to Gila trout recovery (Turner, 2013).

There is considerable genetic variation among populations of Gila trout in Main Diamond Creek, South Diamond Creek, Whiskey Creek, and Spruce Creek. Introgression of nonnative trout has not been detected in any of these four populations. There is substantial genetic divergence of the Spruce Creek population from the Main Diamond Creek, South Diamond Creek, and Whiskey Creek populations (Leary and Allendorf, 1999; Wares et al., 2004; Peters and Turner, 2008). The populations of Gila trout from Main Diamond Creek and South Diamond Creek are in the East Fork Gila River drainage, the Whiskey Creek population is in the West Fork Gila River drainage, and the Spruce Creek population is in the San Francisco River drainage. A fifth population, located in Iron Creek (David, 1976), is in the Middle Fork Gila River drainage. These populations, hereafter referred to as remnant lineages, encompass the breadth of local adaptation and evolutionary potential represented by known genetic variation that presently exists within the species.

See Appendix C for an in-depth discussion of Gila trout lineages.

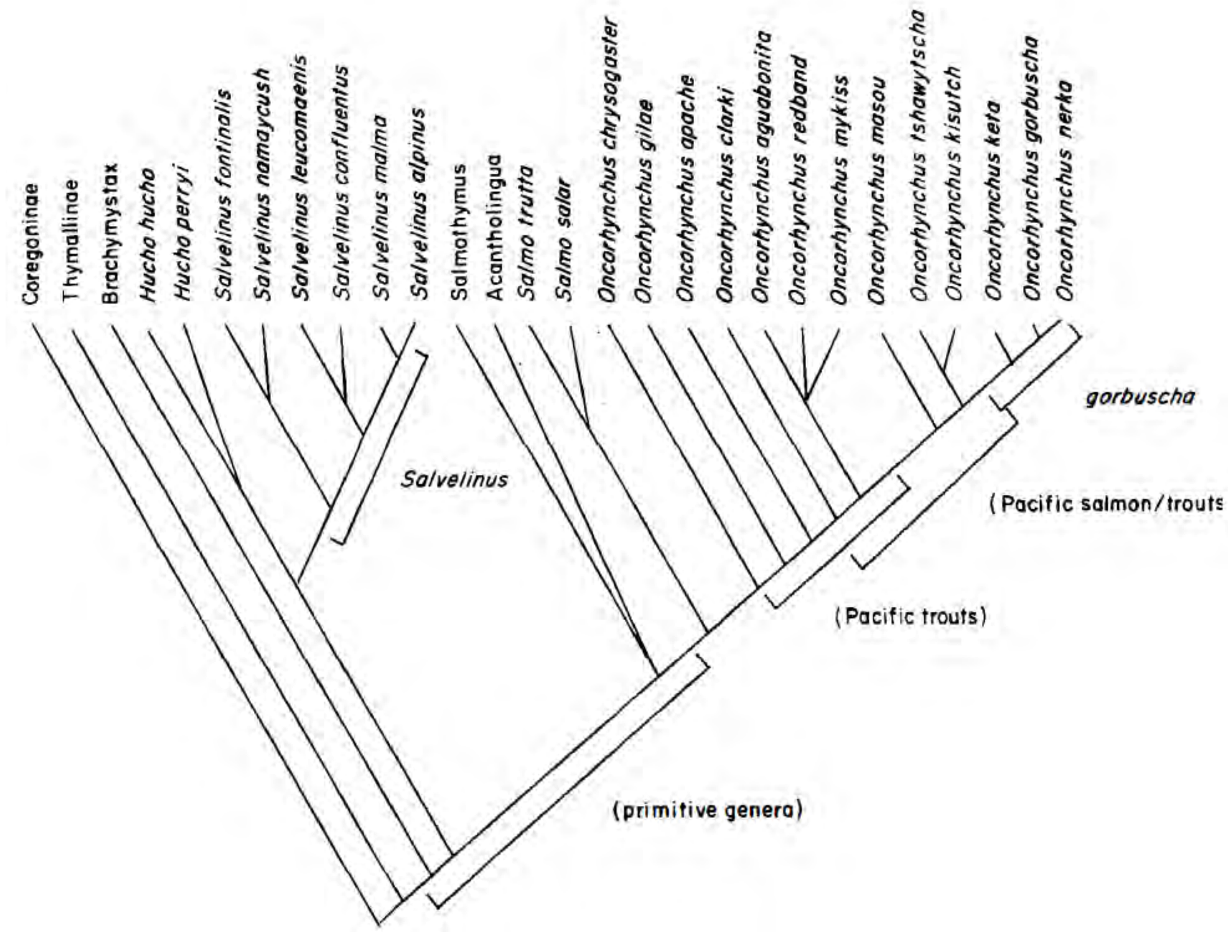


Figure 2. Hypothetical phylogenetic tree of Salmonidae based on morphology and karyotypes, modified from Phillips and Pleyte (1991).

Historical Range and Current Distribution

Historical Range

The historical range of Gila trout is not definitively known and can only be inferred from available evidence, which includes: a few early collection records; reports of native trout from drainages prior to the introduction of nonnative species (with the understanding that confusion of chubs and trout was locally common, *cf*. Appendix A – Morphological Description); current distributions of trout in the Gila River drainage basin; and distributions of historically co-occurring species. Based on these information sources, the historical distribution likely included montane, cold-water stream habitats in Sierra, Grant, and Catron counties in New Mexico and Greenlee, Apache, Graham, Gila, Maricopa, and Yavapai counties in Arizona (Figure 3).

In order to map the potential historical extent of habitat suitable for Gila trout, mapping efforts visualized perennial stream segments over 1,524 m (5,000 ft.) using National Hydrography Dataset (NHD) data from U.S. Geological Survey (2016*b*; Figure 3). The 1,524 m (5,000 ft.) lower elevation limit was defined because it roughly corresponds with contemporary distributional limits for *Oncorhynchus* species (with the upper elevation limit for Gila trout estimated at just above 2,800 m (9,200 ft)). The NHD represent contemporary stream conditions (post-1950), and therefore may not be an entirely accurate depiction of the potential distribution of Gila trout prior to the onset of large-scale Euro-American settlement of the Southwest (*ca*. 1848). An assumption was made that prior to widespread Euro-American settlement largely unaltered watershed and riparian conditions would have sustained stream flows and adequate temperatures suitable for habitation by native trout throughout most stream segments above 1,524 m (5,000 ft.) that are mapped as perennial by the NHD. However, it is likely that not all this habitat was occupied by native trout due to stream isolation, site-specific conditions that rendered habitat unsuitable, and errors in mapping. With this understanding, it was assumed that NHD mapping of perennial streams over 1,524 m (5,000 ft.) elevation provided a reasonable facsimile of the “potential” extent and distribution of suitable habitat for Gila trout throughout its historical range prior to large-scale settlement by Euro-Americans.

Historically, the Gila River had surface flow from its headwaters to its confluence with the Colorado River (Corle, 1951 cited in Rinne et al., 2005). Miller (1961) described the historical character of the main-stem Gila River as a “large, essentially permanent stream of clear to sea-green water.” Consequently, at least some of the watersheds within the historical range of Gila trout (Figure 3) may have been hydrologically connected periodically. Consequently, conditions may have been suitable for at least occasional, seasonal movement of trout through main-stem river habitats in the current climate period (Marine Isotope Stage 1, Holocene epoch) prior to substantial human-caused habitat changes. The potential historical distribution of Gila trout in various sub-basins of the Gila River drainage is described below.

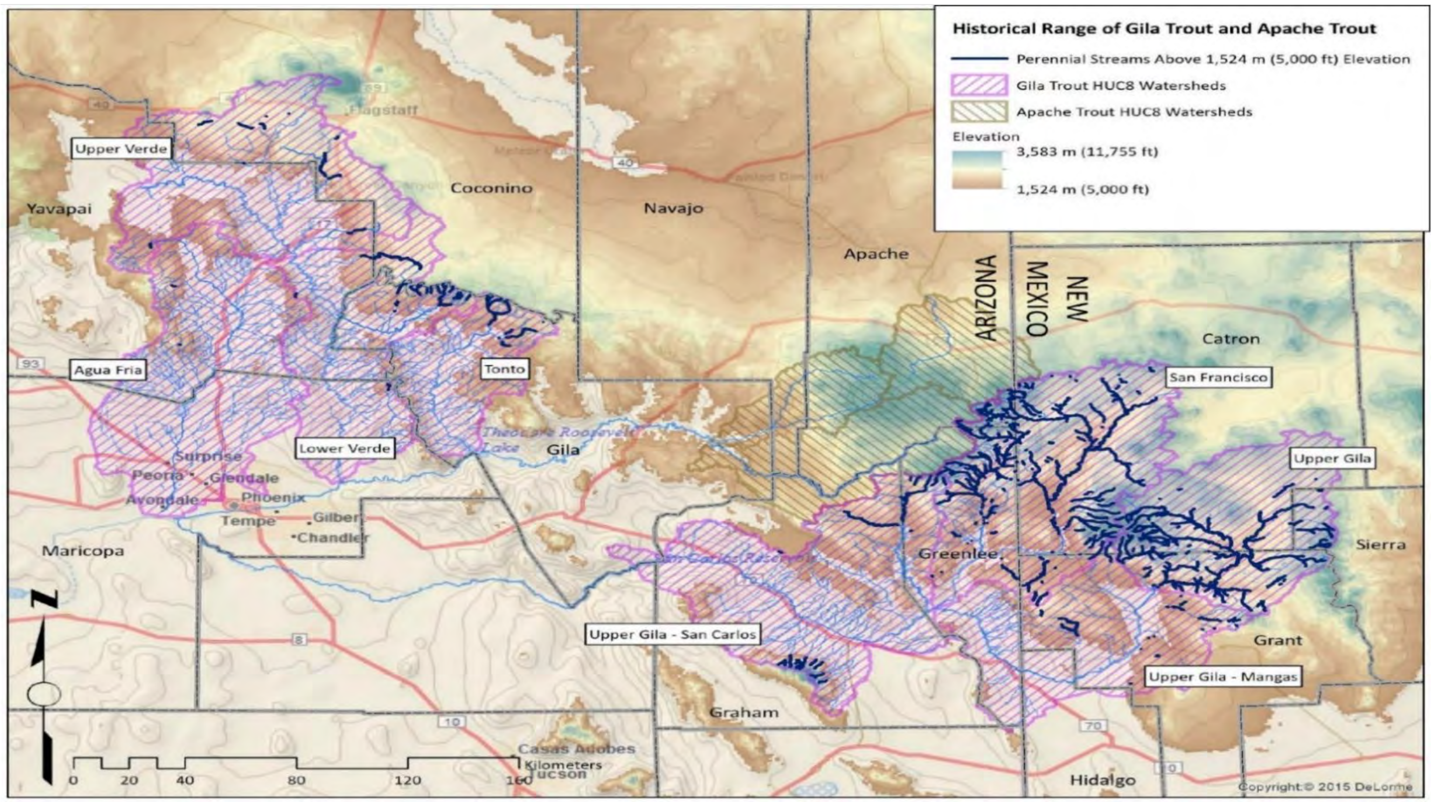


Figure 3. Historical range of Gila trout based on past observations and collections. Highlighted river segments are the potential historical suitable habitats established by mapping the streams and stream segments that lie above 1,524 m (5,000 ft.) elevation. The upper elevation limit for Gila trout is estimated at just above 2,800 m (9,200 ft).

Upper Gila River, New Mexico

The earliest documented collections of Gila trout in the upper Gila River drainage (Figure 4) were from Main Diamond Creek, made by R.R. Miller in 1939 (UMMZ 137089; museum acronyms follow Leviton et al., 1985). Gila trout was collected from White Creek in 1952 (E. Huntington, MSB 002045) and from Langstroth Canyon and South Diamond Creek in 1953 (J. Sands, MSB 2046 and MSB 2047 & 2050). Huntington (1955) reported Gila trout from 17 streams in the Gila River drainage in New Mexico. These streams in the Gila (Figure 4) and San Francisco River drainages (Figure 5) included:

- Main Diamond Creek and South Diamond Creek in the East Fork drainage;
- Little Creek, McKenna Creek, Trail Canyon, Langstroth Canyon, White Creek, Cub Creek and the upper West Fork in the West Fork Gila River drainage;
- Upper Willow Creek and Iron Creek in the Middle Fork drainage;
- Rain Creek, West Fork Mogollon Creek, Mogollon Creek in the Mogollon Creek drainage and Turkey Creek, a tributary to the Gila River main-stem upstream from Mogollon Creek; and
- Whitewater Creek and Spruce Creek in the San Francisco River drainage.

Dinsmore (1924) reported that the headwaters of the West Fork Mogollon Creek were fishless prior to the stocking of 23 “trout” there in 1914. The source of the stocked “trout” was not specified. In 1975, Gila trout was collected from McKenna Creek (P. Turner, NMSU 3 and 4) and Iron Creek (R. David, NMSU 5). Gila trout was discovered in Whiskey Creek, a tributary to the upper West Fork Gila River, by N. W. Smith in 1992 (Figure 4). Beginning in the late 1970s, hybrids of Gila trout and rainbow trout (Gila x rainbow) were reported from Black Canyon, Sycamore Creek, Langstroth Canyon, Miller Spring Canyon, Trail Canyon, upper Mogollon Creek, upper Turkey Creek, and West Fork Mogollon Creek (David, 1976; Riddle et al., 1998; Figure 4).

Early reports indicate that Gila trout was found throughout tributary streams of the upper Gila River drainage. Rixon (1905) noted that “Snow Creek drains the Mogollon Mountains in this township (Township 10 South, Range 16 West); it is a large stream, well stocked with mountain trout, but is being rapidly depleted owing to lack of proper protection.” Miller (1950) recounted reports from long-time residents of the region that indicated Gila trout occurred in “all of the Gila headwaters” at the turn of the century. Specific streams mentioned included Gilita Creek, Willow Creek, South Diamond Creek, Black Canyon, Mogollon Creek (including West Fork Mogollon Creek; Figure 4). Gila trout was reported as occurring in the Middle and West forks of the Gila River and in the main stem of the Gila River downstream to near the Mogollon Creek confluence, approximately 11 km (7 mi) upstream from Cliff.

Collections of pure Gila trout and Gila x rainbow trout hybrids, reports from around the turn of the century, and the distribution of streams in the upper Gila drainage that currently support trout populations indicate that Gila trout was likely found in many cold-water streams throughout the drainage upstream from the confluence of Mogollon Creek and the Gila River.

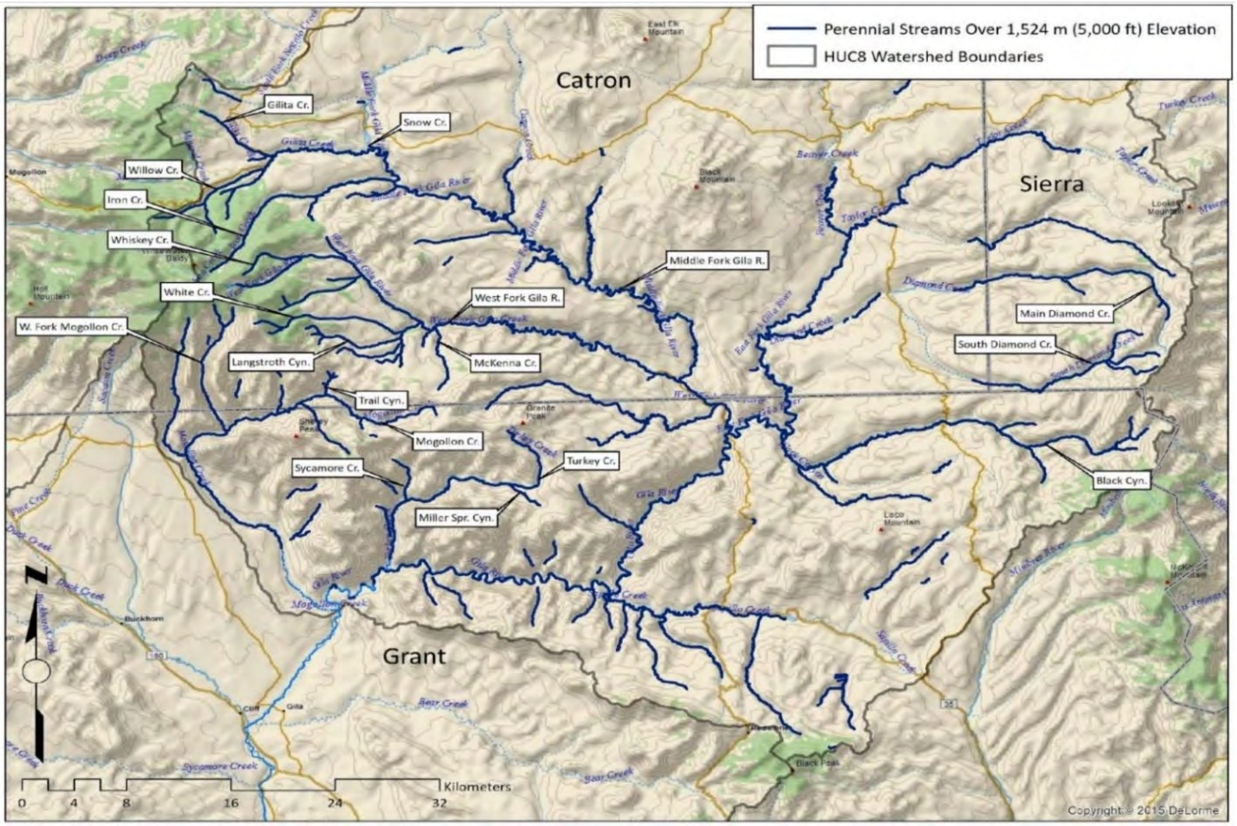


Figure 4. The upper Gila River drainage in New Mexico, showing location references in discussion of the historical distribution of Gila trout.

San Francisco River, Arizona and New Mexico

Native trout were reported from the San Francisco River drainage (Figure 5) as early as 1885 (Leopold, 1921). Lack of collections prior to introduction of nonnative trout and absence of preserved specimens from many drainages led investigators to consider this native fish variously as Gila trout, Apache trout, or an intergrade between the two. Leopold (1921) reported that the valley of the Blue River (Figure 5), a tributary to the San Francisco River, was "at the time of settlement in about 1885, stirrup-high in gramma grass and covered with groves of mixed hardwoods and pine. The banks were lined with willows and the river abounded with trout." Native trout were collected from KP Creek (Figure 5), a tributary to the Blue River, in 1904 by F. Chamberlain (Miller, 1950).

David (1976) collected and described Gila trout (NMSU 6) from above a series of waterfalls in Spruce Creek (Figure 5), a tributary to the San Francisco River in New Mexico. Miller (1950) reported that Spruce Creek contained a population of Gila trout, with the implication that it was native to that stream. This was inconsistent with the report that the San Francisco River was originally devoid of Gila trout and that the species was stocked into Big Dry Creek, Little Dry Creek, Little Whitewater Creek, Whitewater Creek, and Mineral Creek in 1905 (Miller, 1950). However, native trout occurred in the Blue River and there are no physical barriers that would have prevented native trout from migrating up into the San Francisco River drainage (Behnke, 1979; David, 1998). Gila x rainbow trout hybrid populations were found in several tributaries to the San Francisco River including Whitewater Creek, Big Dry Creek, Mineral Creek, and Lipsey Canyon (Figure 5; David, 1976; Riddle et al., 1998).

These early reports and collections of a native trout in the San Francisco River drainage, and the occurrence of a population of Gila trout in Spruce Creek above a series of waterfalls, suggest that Gila trout likely occurred throughout the drainage in suitable habitats. Historically occupied streams may have included the Blue River and its tributaries and perennial tributaries of the San Francisco River in New Mexico.

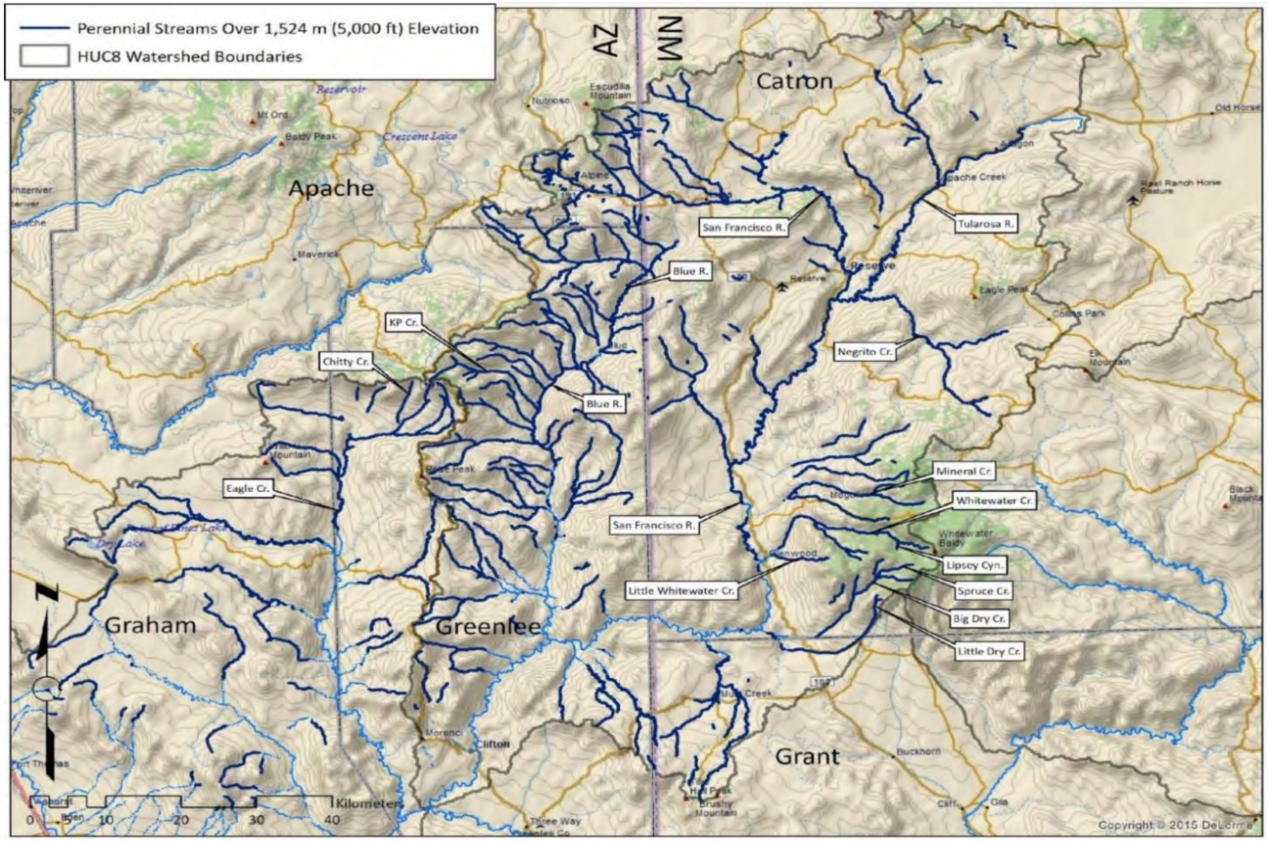


Figure 5. The San Francisco River and Eagle Creek drainages in New Mexico and Arizona, showing location references in discussion of the historical distribution of Gila trout.

Tributaries to the Gila River, Arizona

Native trout occurred in the Eagle Creek drainage (Figure 6), a tributary of the Gila River in Arizona located west of the San Francisco River drainage (Mulch and Gamble, 1956; Kynard, 1976; USFWS, 2009). The identity of this native trout, collected in Chitty Creek (Figure 6) and now lost through hybridization with rainbow trout, is uncertain (Marsh et al., 1990). Native trout were reported from Oak Creek (Figure 6), a tributary to the Verde River, before the turn of the century (Miller, 1950). Specimens collected from Oak Creek before 1890 (USNM 39577-79, 41568) were ascribed to Gila trout (Miller, 1950; Minckley, 1973). Native trout were also reported from West Clear Creek (Miller, 1950; Figure 6). Trout collected in 1975 from Sycamore Creek (Figure 6) in the Agua Fria River watershed were reported to be Gila x rainbow trout hybrids. However, this determination was based solely on examination of spotting pattern (Behnke and Zarn, 1976). A note in the archives of Aldo Leopold, dated 1923, contains anecdotal evidence of a native trout in Tonto Creek: “Trout in Tonto Cr. seem to be Eastern Brook. First put in 1920. Now seem to be up to 16. (Hubert says there are also natives in it).”

Historical occurrence of Gila trout in the Verde and Agua Fria drainages was inferred by Minckley (1973) based on parallel distribution of a morphological form of roundtail chub. At that time Gila trout was the only recognized native trout in the Gila River drainage. Subsequent description of Apache trout demonstrated differentiation of native trout within the Gila River drainage (Miller, 1972). The degree of differentiation of the native trout in the Agua Fria River and Verde River drainages is unknown (Minckley, 1973) and cannot be resolved because specimens are lacking. However, this native trout was likely very closely related to Gila trout based on lack of long-term hydrologic isolation of the Verde and Agua Fria drainages from the main-stem Gila River.

Based on these early reports and collections of native trout within various tributaries of the Gila River within Arizona, historically occupied streams may include the Verde, Agua Fria, Tonto, and Blue River drainages in Arizona

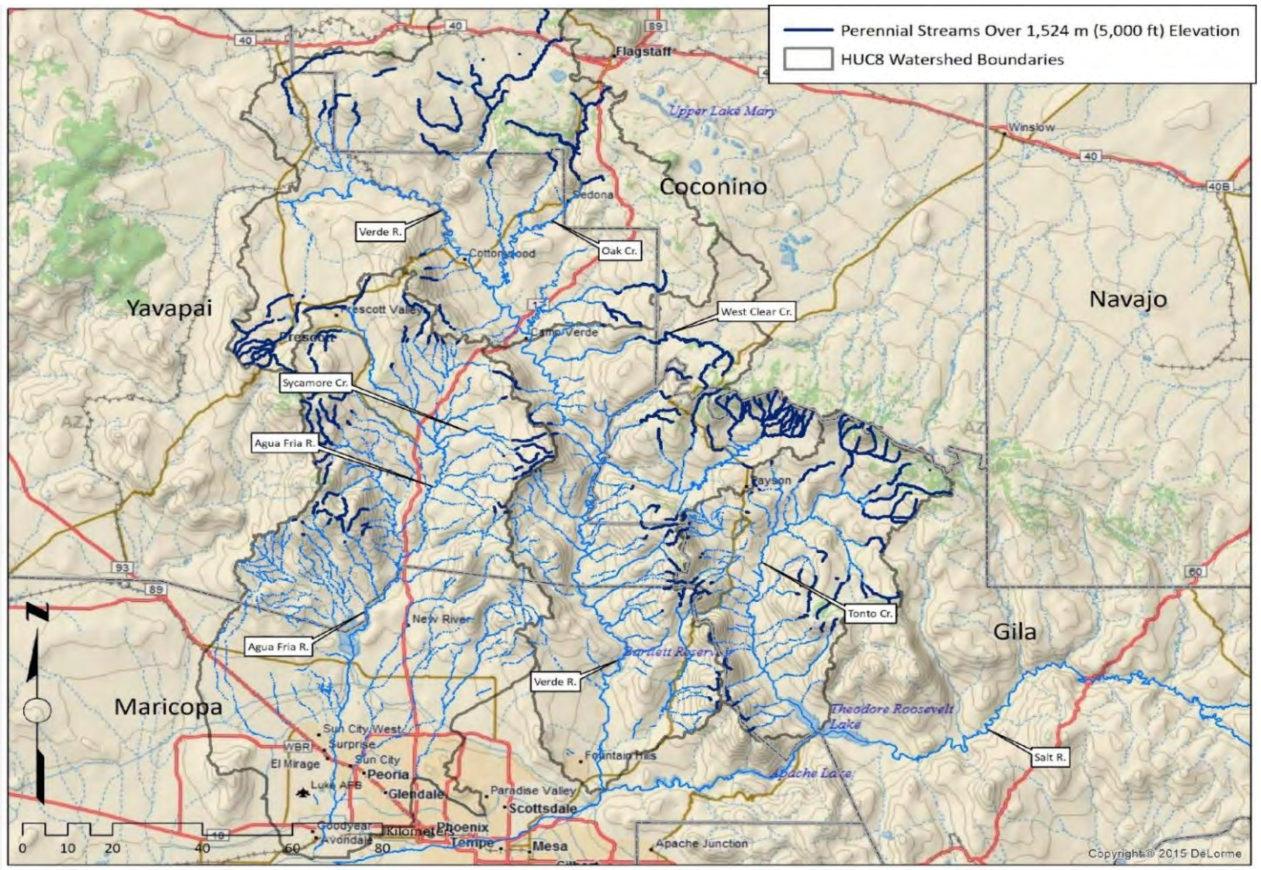


Figure 6. Tributaries of the Gila River in Arizona, showing locations references in the discussion of the historical distribution of Gila trout.

Current Distribution

The five lineages of Gila trout (Main Diamond Creek, South Diamond Creek, Whiskey Creek, Spruce Creek, and Iron Creek) have fluctuated in distribution since 1975; at that time, only five remnant populations were known, with populations being defined as self-sustaining groups of Gila trout which exhibit annual reproduction, size structure indicating multiple ages, and individuals attaining sufficient sizes to indicate three to seven years of survival (USFWS, 2006). As of April 2022, there were 23 populations of Gila trout inhabiting approximately 210.8 km (131.0 mi) of stream habitat (Table 1 and Figure 7). Currently, there are 5 populations of the Main Diamond Creek lineage, 5 populations of the South Diamond Creek lineage, 4 populations of the Whiskey Creek lineage, 3 populations of the Spruce Creek lineage, 3 populations of the Iron Creek lineage, and 3 populations that are considered a mixed-lineage population (a stream or metapopulation that contains multiple lineages of Gila Trout instead of a single lineage) (Table 1 and Figure 7).

Several of these populations may occur in complex, dendritic drainage systems as a metapopulation, spatially structured populations where: 1) habitat consists of discrete patches or collections of habitats capable of supporting local breeding populations; 2) the dynamics of occupied patches are not perfectly synchronous; and, 3) dispersal among the component populations influences the dynamics and/or the persistence of the metapopulation (Rieman and Dunham, 2000). The metapopulation concept critical to this criterion is the establishment of spatially structured populations, in which a lost portion of the metapopulation may be repopulated by individuals from the remaining portions. For example, Trail Canyon, Woodrow Canyon, Mogollon Creek and South Fork Mogollon Creek are all considered single populations that collectively compose a dendritic metapopulation.

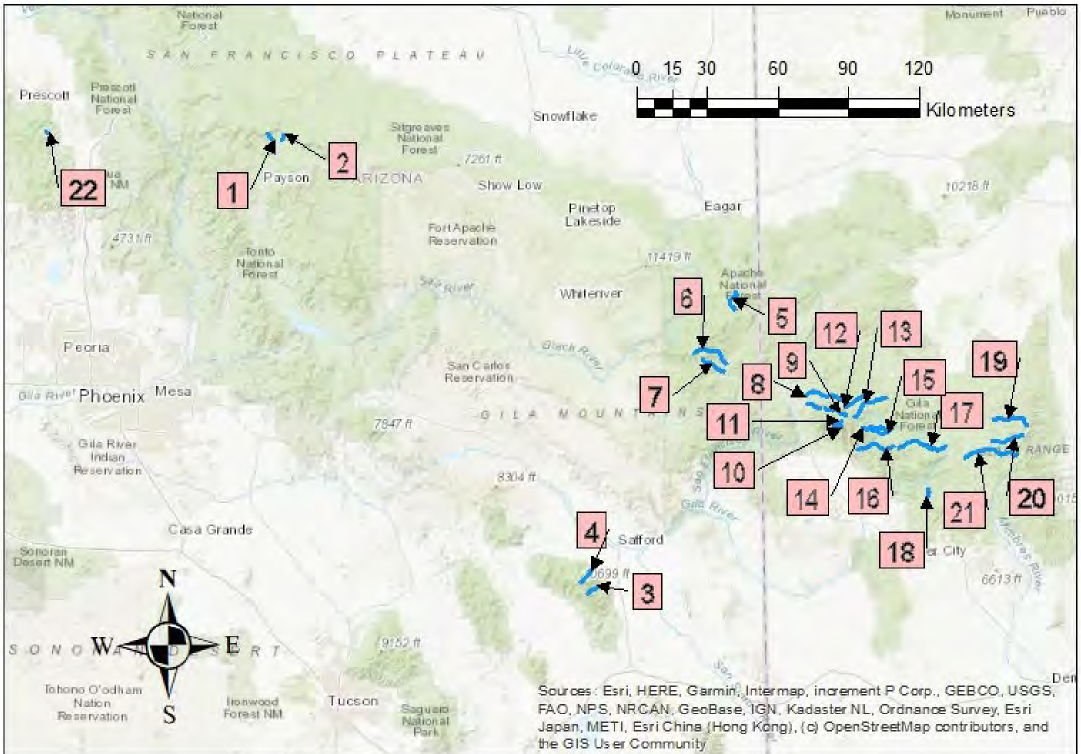
Table 1. Extant populations of Gila trout as of April 2022. Map No. refers to the notations on Figure 7. Codes for mixed lineages are SC= Spruce Creek, WC= Whiskey Creek, MD= Main Diamond Creek, and SD= South Diamond Creek

Lineage	**Stream**	**Map No.**	**Occupied habitat (km)**	**Occupied habitat (mi)**	**HUC 8 Watershed**	**County**	**State**
Main Diamond Creek Lineage	Main Diamond Creek	19	6.3	3.9	Upper Gila (East Fork Gila River)	Sierra	NM
Main Diamond Creek Lineage	Black Canyon	21	17.4	10.8	Upper Gila (East Fork Gila River)	Grant	NM
Main Diamond Creek Lineage	Sheep Corral Canyon	18	1	0.6	Upper Gila (Sapillo Creek)	Grant	NM
Main Diamond Creek Lineage	Langstroth Canyon (upper)	15	5.9	3.7	Upper Gila (West Fork Gila River)	Catron	NM
Main Diamond Creek Lineage	Little Creek (lower)	17	4.6	2.9	Upper Gila (West Fork Gila River)	Grant Catron	NM
Main Diamond Creek Lineage	Subtotal		35.2	21.9	5 Populations		

South Diamond Creek Lineage	South Diamond Creek	20	5.2	3.2	Upper Gila (East Fork Gila River)	Sierra	NM
South Diamond Creek Lineage	Mogollon Creek (Includes tributaries upstream of West Fork Mogollon Creek)	16	23.5	14.6	Upper Gila (Mogollon Creek)	Grant Catron	NM
South Diamond Creek Lineage	Grapevine Creek	22	1.9	1.2	Agua Fria (Big Bug Creek)	Yavapai	AZ
South Diamond Creek Lineage	Willow Creek (Includes tributaries upstream of Gilita Creek)	12	19	11.8	Upper Gila (Middle Fork Gila River)	Catron	NM
South Diamond Creek Lineage	Frye Creek	4	8	5	Middle Gila River Drainage	Graham	AZ
South Diamond Creek Lineage	Subtotal		58.9	36.6	5 Populations		
Whiskey Creek Lineage	White Creek	14	11	6.8	Upper Gila (West Fork Gila River)	Catron	NM

Whiskey Creek Lineage	Mineral Creek (Includes South Fork Mineral Creek)	8	18.8	11.7	San Francisco (San Francisco River)	Catron	NM
Whiskey Creek Lineage	Raspberry Creek	7	4.1	2.5	San Francisco (San Francisco River)	Greenlee	AZ
Whiskey Creek Lineage	Upper Marijilda Creek	3	2	1.2	Middle Gila River Drainage	Graham	AZ
Whiskey Creek Lineage	Subtotal		35.9	22.3	4 Populations		
Iron Creek Lineage	Iron Creek	13	4.4	2.7	Upper Gila (Middle Fork Gila River)	Catron	NM
Iron Creek Lineage	Chase Creek	1	1.9	1.2	Lower Verde (East Verde River)	Gila	AZ
Iron Creek Lineage	KP Creek	6	15	9.3	Blue River	Greenlee	AZ
Iron Creek Lineage	Subtotal		6.4	3.9	3 Populations		
Sprue Creek Lineage	Spruce Creek (upper)	10	5.7	3.5	San Francisco (San Francisco River)	Catron	NM

Spruce Creek Lineage	Big Dry Creek (upper)	11	2.9	1.8	San Francisco (San Francisco River)	Catron	NM
Spruce Creek Lineage	Coleman Creek	5	4	2.5	Blue River	Apache Greenlee	AZ
Spruce Creek Lineage	Subtotal		12.6	7.8	3 Populations		
Mixed Lineages	Dude Creek (MD, SD, WC, SC x WC)	2	3.1	1.9	Lower Verde (East Verde River)	East Verde	AZ
Mixed Lineages	Lower Marijilda Creek	3	4.8	3	Middle Gila River Drainage	Graham	AZ
Mixed Lineages	Whitewater Creek	9	39	24.2	San Francisco	Catron	NM
Mixed Lineages	Subtotal		46.9	29.1	3 Populations		
	Grand Total		210.8	131	23 Populations		



Stream	Number
Chase Creek	1
Dude Creek	2
Marijilda Creek	3
Frye Creek	4
Coleman Creek	5
KP Creek	6
Raspberry Creek	7
Mineral Creek	8
Whitewater Creek	9
Spruce Creek	10
Big Dry Creek	11
Willow Creek	12
Iron Creek	13
White Creek	14
Langstroth Creek	15
Mogollon Creek	16
Little Creek	17
Sheep Corral Canyon	18
Main Diamond Creek	19
South Diamond Creek	20
Black Canyon Creek	21
Grapevine Creek	22

Figure 7. Current distribution of Gila trout as of April 2022.

Ecology and Life History

Reproduction and Growth

Spawning of Gila trout occurs mainly in April (Rinne, 1980). Spawning begins when water temperatures reach about 8°C (46°F), but day length may also be an important cue. Stream flow is apparently of secondary importance in triggering spawning activity (Rinne, 1980). Female Gila trout typically construct redds (spawning nests) in water 6 to 15 cm (2.4 to 6 in) deep within 5 m (16 ft.) of cover. Redds are three to four cm (1.2 to 1.6 in) deep in fine gravel and coarse sand substrate (particle size ranging from 0.2 to 3.8 cm [0.08 to 1.5 in] diameter). Redd size varies from less than 0.1 to 2.0 m^2 (1.1 to 21.5 $ft.^2$). Spawning activity typically occurs between 1300 and 1600 hours. Rinne (1980) noted one pair of Gila trout normally occurred over a redd and spawning behavior was typical of other salmonids (Family Salmonidae).

Females reach maturity at Age II to Age IV (time since hatching) (Nankervis, 1988), with a minimum length of about 130 mm (5 in) reported for mature fish (Nankervis, 1988; Propst and Stefferud, 1997). However, most individuals are mature at a length of 150 mm (6 in) or greater (Propst and Stefferud, 1997). Males typically reach maturity at Age II or Age III. Fecundity is dependent upon body size and condition (Behnke and Zarn, 1976; Behnke, 1979). Behnke and Zarn (1976) reported a general figure of 2.20 ova per gram of body weight (62 ova/oz.) for native trouts. Brown et al., (2001) reported individual fecundity (count of mature ova) of approximately 62 for Gila trout 100 to 150 mm (3.9 to 5.9 in) total length and 197 for Gila trout greater than 150 mm (5.9 in) total length. Gila trout had an average of 2.54 ova per gram of body weight (72 ova/oz.) in Main Diamond Creek and 3.33 ova/g of body weight (94 ova/oz.) in McKnight Creek (Nankervis, 1988).

Gila trout fry (20 to 25 mm [0.8 to 1.0 in] total length) emerge from redds in 56 to 70 days (Rinne, 1980). By the end of the first summer, fry attain a total length of 70 to 90 mm (2.7 to 3.5 in) at lower elevation streams and 40 to 50 mm (1.6 to 2.0 in) at higher elevation sites (Rinne, 1980; Turner, 1986). Growth rates are variable, but Gila trout generally reach 180 to 220 mm (7.1 to 8.7 in) total length by the end of the third growing season in all but higher elevation streams (Table 2).

Mean annual survival rates for life stages of Gila trout range from 0.128 to 0.497 (Table 2; Brown et al., 2001). Survival rate is defined as the proportion of individuals of age x that survive to age x + 1. On the average, for every 100 eggs that hatch about half will survive to the juvenile life stage. Of those 49 or 50 fish, only about six will survive to the subadult stage and of those six subadults, only two will survive to the adult life stage. Most adult Gila trout live to about Age

V (Turner, 1986), with a maximum age of IX reported by Nankervis (1988). Thus, the majority of adult female Gila trout only spawn twice before dying and most adult males only spawn three or four times before dying.

Table 2. Life-stage specific survival rates for Gila trout (Brown et al., 2001).

Life Stage	Total Length	Survival Rate (mean ± one standard deviation)
Juvenile	< 100 mm (< 4 in)	0.497 ± 0.445
Subadult	100 to 150 mm (4 to 6 in)	0.128 ± 0.063
Adult	> 150 mm (> 6 in)	0.430 ± 0.068

See Appendix D for additional information on Gila trout ecology and life history, including specific information on each lineage as well as the impacts of disease on the Gila trout.

Diet

Gila trout are generally insectivorous. However, the species coevolved with several other fishes and there is some evidence of piscivory in Gila trout. Regan (1964) reported that adult Diptera (true flies), Trichoptera (caddisfly) larvae, Ephemeroptera (mayfly) nymphs, and aquatic Coleoptera (beetles) were the most abundant food items in stomachs of Gila trout in Main Diamond Creek. There was little variation in food habits over the range of size classes sampled (47 to 168 mm [1.8 to 6.6 in] total length). These taxa were also predominant in stomach contents of other trout species in the Gila River drainage, indicating the potential for interspecific competition. Hanson (1971) noted that Gila trout established a feeding hierarchy in pools during a low flow period in Main Diamond Creek. Larger fish aggressively guarded their feeding stations and chased away smaller fish.

Van Eimeren (1988) compared food habits of Gila trout and speckled dace in Little Creek and found no significant overlap in diet even though the two species were found in general proximity. Large Gila trout occasionally consumed speckled dace and may also consume smaller Gila trout (Van Eimeren, 1988; Propst and Stefferud, 1997). Gila trout diet shifted on a seasonal basis as the relative abundance of various prey taxa changed. In February, Diptera larvae (primarily blackflies, Family Simuliidae) were very abundant in the stream and were the principal prey of Gila trout. By May, the principal prey shifted to Ephemeroptera nymphs (primarily *Paraleptophlebia*) that were present at very high density. No single prey taxon dominated the diet of Gila trout in June. In October, Gila trout shifted to consuming primarily terrestrial insects and larvae of the caddisfly *Helicopsyche*. Gila trout fed mainly between the hours of 0900 and 1300, while speckled dace fed primarily between the hours of 2100 and 1300

(Van Eimeren, 1988). As in Regan's (1964) study, Van Eimeren (1988) reported a large overlap in food habits throughout all size classes of Gila trout.

Movement

Rinne (1982) considered adult Gila trout to typically be quite sedentary, with movement influenced by population density and territoriality. However, individual fish may move considerable distances (over 1.5 km [0.9 mi]). Gila trout showed a tendency to move upstream in South Diamond Creek, possibly to perennial reaches with suitable pool habitat in response to low summer discharge. Gila trout movement was predominately in a downstream direction in Main Diamond and McKnight creeks. Most of these fish were one- or two-year-old Gila trout (Rinne, 1982). High density of log structures in Main Diamond Creek appeared to reduce mobility of Gila trout in that stream.

Data collected from White Creek in 1999 and 2000 indicate that dispersal by Gila trout is slow, even when there are no physical barriers to movement. The Lookout Complex fire in 1996 burned much of the White Creek watershed upstream to near Halfmoon Park. During sampling in 1999, Gila trout was found to be absent from all portions of the stream except from the vicinity of Halfmoon Park and upstream from that location. In 2000, the downstream limit of Gila trout was only about 0.5 km (0.3 mi) downstream from Halfmoon Park. Fire-affected reaches of the stream below Halfmoon Park had recovered and were suitable for Gila trout in 2000. In contrast, upstream movement of over three kilometers following stocking of Gila trout was reported in Willow Creek.

Population Dynamics

Population Size

Regulation of population size and dynamics of populations (size and age structure) of Gila trout are not well understood. Inferences about factors that control population size have been made from analysis of time-series data (Turner and McHenry, 1985; Turner, 1989; Propst and Stefferud, 1997). Density-independent factors, namely hydrologic variability, appear to be most important in regulating population size of Gila trout in many of the streams occupied by the species (McHenry, 1986; Turner, 1989a and 1989b; Brown et al., 2001). However, density-dependent regulation in the form of competition for space (territoriality) was suggested as a factor contributing to controlling population size in Main Diamond Creek before that population was extirpated by a stand-replacing forest fire in 1989 (Nankervis, 1988).

The changes in abundance of Gila trout in McKnight Creek from its establishment through 2000 suggest that population was regulated primarily by hydrologic regime. The population was founded in November 1970 when 307 Gila trout were transplanted from Main Diamond Creek to McKnight Creek. The population declined to about 20 fish in 1971, concurrent with a period of low total annual stream discharge. Consequently, the population was augmented with 110 Gila trout translocated from Main Diamond Creek in April 1972, and the population size increased substantially from 1974 to 1976 (Mello and Turner, 1980).

The McKnight Creek population remained relatively stable from 1977 to 1984 (Turner and McHenry, 1985). Flood flows in December 1984 were followed by a marked reduction in abundance of Gila trout (Figure 8; Turner, 1989). The population expanded following the 1984 flood and by June 1985 had recovered to near pre-flood abundance and size structure. The apparent reduced abundance of Gila trout in October 1985 was likely an artifact of reduced sampling efficiency due to high flows, and Gila trout abundance remained relatively stable through June 1988. Flooding in August 1988 was followed by elimination of the 1988-year class and reduced abundance of all other size classes (Figure 8; Turner, 1989). By fall 1990, the McKnight Creek population had recovered from the 1988 flood impacts (Figure 9; Propst and Stefferud, 1997). The population remained relatively stable from 1991 through spring 1994. However, very low flows in summer 1994 followed by winter flooding was associated with reduced abundance of juvenile Gila trout in spring 1995 (Figure 9). After two years of no monitoring, sampling from 1998 through 2000 indicated continued reproduction and relative stability of adult Gila trout abundance.

The role of hydrologic variation in regulation of Gila trout populations may be most relevant in influencing the abundance of Age 0 fish. For example, Cattanéo et al., (2002) found that high flows during emergence significantly reduced Age 0+ brown trout densities, and that Age I+ brown trout densities were linked to Age 0+ densities from the previous year. Similarly, hydrologic variables including peak flows and extreme low flows were found to influence young-of-year abundance in cutthroat (Owens, 2013), rainbow and brook trout (Parker, 2008). Furthermore, Richard et al., (2015) reported density-dependent regulation of Age 0+ brown trout abundance during summer low-flow periods. Wood et al., (2012) determined that minimum territory size for juvenile rainbow trout (5 cm [2 in] total length) was approximately 0.2 m^2 (2.15 $ft.^2$), which they hypothesized as a threshold for activation of density-dependent regulation. Vincenzi et al., (2008) suggested that resilience of marble trout (*Salmo marmoratus*) to irregular, severe flooding was a function of increases in size-dependent fecundity resulting from reduced population size following peak flow events.

Populations of Gila trout may vary in sensitivity and response to removal of adult fish. Populations with high densities and reduced growth rates due to crowding may benefit from limited harvest of adult fish, which may be removed and used to supplement other populations. For example, biomass and condition of Gila trout increased following experimental removal of fish from a section of Main Diamond Creek in 1986 to 1987 (Nankervis, 1988). Brown et al., (2001) found that simulated catch-and-release angling mortality of adult Gila trout of 5 to 15 percent per year had no effect on population viability.

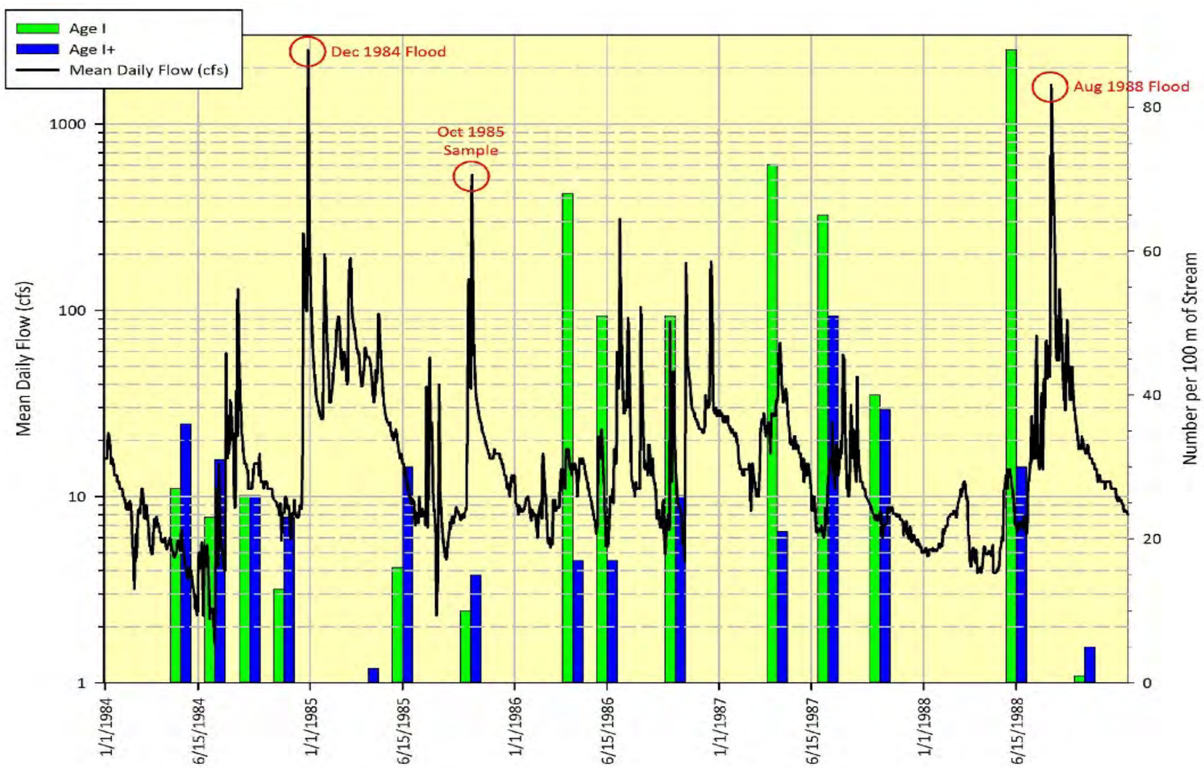


Figure 8. Catch per unit effort of Gila trout in McKnight Creek, 1984 through 1988, along with mean daily discharge data from U.S. Geological Survey gauge no. 08477110 Mimbres River at Mimbres, New Mexico.

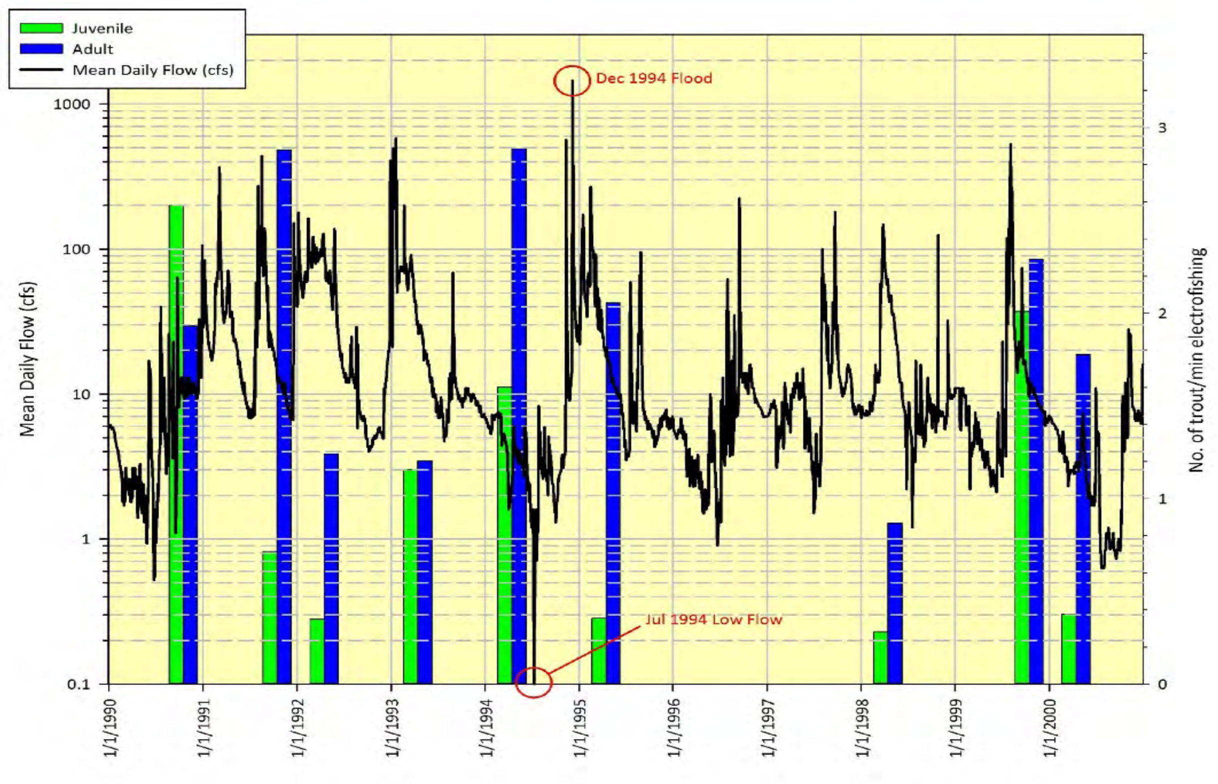


Figure 9. Catch per unit effort of Gila trout in McKnight Creek, 1990 through 2000, along with mean daily discharge data from U.S. Geological Survey guage no. 08477110, Mimbres River at Mimbres, New Mexico

Population Persistence and Viability

Persistence of a species is generally defined as the ability of populations to remain in a location over time. Viability of a species is generally defined as the ability to sustain populations over time. Historically, populations of Gila trout existed in multiple streams and tributaries within the Gila River and San Francisco River drainages. Fragmentation of the historical distribution of Gila trout has resulted in several populations confined to smaller, isolated segments of those streams and tributaries. These remnant populations characteristically have high densities during relatively stable flow periods. Platts and McHenry (1988) showed a mean density of 0.39 fish per square meter. The overall importance of environmental factors, specifically quantity and variability of stream discharge, in determining persistence of Gila trout populations is evidenced by the effects of fire, flood, and low flow on population size and density of this species. The elimination or extreme reduction of Gila trout populations following large-scale, high-severity wildfire and subsequent flooding provide a vivid example. Similarly, prolonged low flows or stream drying may also eliminate or markedly reduce populations of Gila trout (see tables 17 and 18). The importance of stream discharge in the population dynamics of Gila trout has been consistently reported in the literature (Regan, 1964; Mello and Turner, 1980; McHenry, 1986; Turner, 1989; Propst and Stefferud, 1997).

Catastrophic events were found to have a much larger influence on the viability of Gila trout populations than population size, fecundity, or population structure (Brown et al., 2001). The risk of extinction of Gila trout was found to be closely related to the number of extant populations. Brown et al., (2001) reported that increasing the number of populations by 11 significantly reduced the probability of extinction from 36 percent to 12 percent. The Spruce Creek lineage of Gila trout was considered at higher risk of extinction than the Gila River lineages due to the small number of populations. Increasing the number of populations in the San Francisco River basin by six was estimated to reduce the risk of extinction from 81 percent to 44 percent. The population viability analysis conducted by Brown et al., (2001) was completed prior to recent large-scale, high-severity wildfires that caused numerous population extirpations (see section on Large-Scale, High-Severity Wildfire and tables 4 and 5). These recent events indicate that spatial distribution is also an important component of population viability and persistence. Spatial distribution was not incorporated in the population viability analysis conducted by Brown et al., (2001).

Habitat Characteristics

Elevation and Vegetative Community Associations

Habitat of Gila trout currently consists of montane streams ranging from approximately 1,660 m (5,400 ft.) to over 2,800 m (9,200 ft.) elevation (Propst and Stefferud, 1997). Suitable stream habitat within the range of the species is situated between about 33º to near 35º north latitude and 107º 45' to near 112º 15' west longitude. Streams with suitable habitat for Gila trout are found in coniferous and mixed woodland, montane coniferous forest, and subalpine coniferous forest (Dick-Peddie, 1993). Coniferous and mixed woodland vegetation occur at lower elevations and on southern exposures within the range of Gila trout. Dominant tree species in the coniferous and mixed woodland are piñon (*Pinus edulis*), juniper (*Juniperus* spp.), and oak (*Quercus* spp.). Montane coniferous forest occurs up to about 3,048 m (10,000 ft.) elevation. Below 2,591 m (8,500 ft.) elevation, this forest is characteristically dominated by ponderosa pine (*Pinus ponderosa*). Above about 2,438 m (8,000 ft.) elevation Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), blue spruce (*Picea pungens*) and aspen (*Populus tremuloides*) are common. Subalpine coniferous forest is characterized by Engelmann spruce (*Picea engelmannii*) and corkbark fir (*Abies lasiocarpa*) and is generally found from about 2,896 m (9,500 ft.) elevation to timberline (Dick-Peddie, 1993).

Riparian habitats include the montane riparian vegetation type described by Dick-Peddie (1993) and the arctic-boreal and cold-temperate riparian communities of Brown (1982). Thirteen of the 18 series described for the montane riparian vegetation type are found in habitats of Gila trout (Dick-Peddie, 1993). These series are: Willow; Willow-Mountain Alder; Willow-Dogwood; Blue Spruce; Aspen; Aspen-Maple; Boxelder; Alder; Narrowleaf Cottonwood; Narrowleaf Cottonwood-Mixed Deciduous; Broadleaf Cottonwood; Broadleaf Cottonwood-Mixed Deciduous; and Sycamore.

Hydrologic Conditions

Stream flow in habitat of Gila trout is characterized by a snowmelt-dominated hydrograph (Figure 10). Snowmelt runoff peaks from February to April, and stream flow then gradually decreases through May. Base flow conditions prevail in June and into July. Mean monthly discharge characteristically increases in July through September coincident with runoff from convectional summer thunderstorms. Sporadic periods of runoff from winter rains or mid-season snowmelt often results in flows slightly elevated above base level in December and January. Discharge from springs may provide substantial flow augmentation in some drainages, notably in streams originating along the Mogollon Rim in the Verde River and Tonto Creek (Arizona Department of Water Resources, 2009) watersheds in central Arizona.

There is substantial variation in this general pattern of stream discharge. Although the shape of the annual hydrographs may be similar, actual discharge may vary by an order of magnitude or more between wet and dry years. During low-flow years, marginal habitats may become too warm to support trout or surface flow may cease and stream segments may dry. Pool depth may diminish to the extent that winter mortality of trout is greatly increased. Large magnitude flood events during high flow years may scour stream channels and eliminate year classes of trout. These frequent, recurring extremes in flow conditions are a basic element of the relatively harsh environment that distinguishes habitat of Gila trout from the typical trout streams of more northern latitudes.

Long-term discharge data from streams inhabited by or suitable for Gila trout are lacking. Short-term or single point-in-time measurements of stream discharge have been made by numerous investigators (Regan, 1966; Mello and Turner, 1980; Rinne, 1980; McHenry, 1986; Propst and Stefferud, 1997). Propst and Stefferud (1997) reported summer base flow in habitats of Gila trout in New Mexico ranging from less than 5 L/sec (0.18 cfs) in the smallest streams (Sheep Corral Canyon and Sacaton Creek), 30 to 50 L/sec (1.0 to 1.8 cfs) in intermediate-sized streams (Spruce and McKnight creeks), and about 60 L/sec (2.1 cfs) in large streams (Mogollon Creek). Minimum discharge measured in Mogollon Creek from 1967 through 1995 (discontinuous measurements, N = 158) was 0.001 m^3/sec (0.03 cfs) while maximum discharge measured during that period was 7.4 m^3/sec (261.3 cfs; Mast and Turk, 1999).

Rinne (1980) reported mean daily flow in McKnight Creek during March and April of 1978, which included a peak snow-melt runoff flow of approximately 53 m^3/sec (1,872 cfs) on 23 March. Snow-melt runoff began to diminish on 1 April 1978, and stream flow declined steadily from approximately 51 m^3/sec (1,801 cfs) on 1 April to approximately 0.15 m^3/sec (5.3 cfs) on 25 April 1978. The McKnight Creek watershed encompassed approximately 2,043 ha (5,048 ac) at the point of Rinne's (1980) stream-flow measurement.

The relationship between watershed area and bankfull flow in streams throughout the historical range of Gila trout was investigated by Moody et al., (2003). Bankfull discharge is defined as the stream stage where flooding begins, which is associated with the point where the stream is just about to flow out of its banks and onto the floodplain (Rosgen, 1996). Bankfull flow is also associated with the dominant channel-forming discharge (Dunne and Leopold, 1978), which transports the majority of available sediment (Wolman and Miller, 1960).

The regional curve describing the relationship between watershed area and bankfull discharge for eastern Arizona and New Mexico streams within the historical range of Gila trout is $y = 15.31x^{0.6119}$ ($R^2 = 0.8591$) while the curve for streams in central Arizona within the historical range is $y = 88.73x^{0.4711}$ ($R^2 = 0.6649$), where y = bankfull discharge in cfs and x = watershed area in mi^2 (Moody et al., 2003). Local calibration (offset) curves were also developed for streams in the Blue River drainage and Prescott, Arizona area. These local calibration surveys indicated no offset from the regional curve for the Prescott area streams but a slight, consistent offset above the eastern Arizona-New Mexico regional curve for the Blue River sites (Moody et al., 2003). Recurrence interval for bankfull flow of streams in the historical range of Gila trout ranges from 1.1 to 1.8 years, with central Arizona streams typically having lower values than streams in eastern Arizona and New Mexico (Moody et al., 2003).

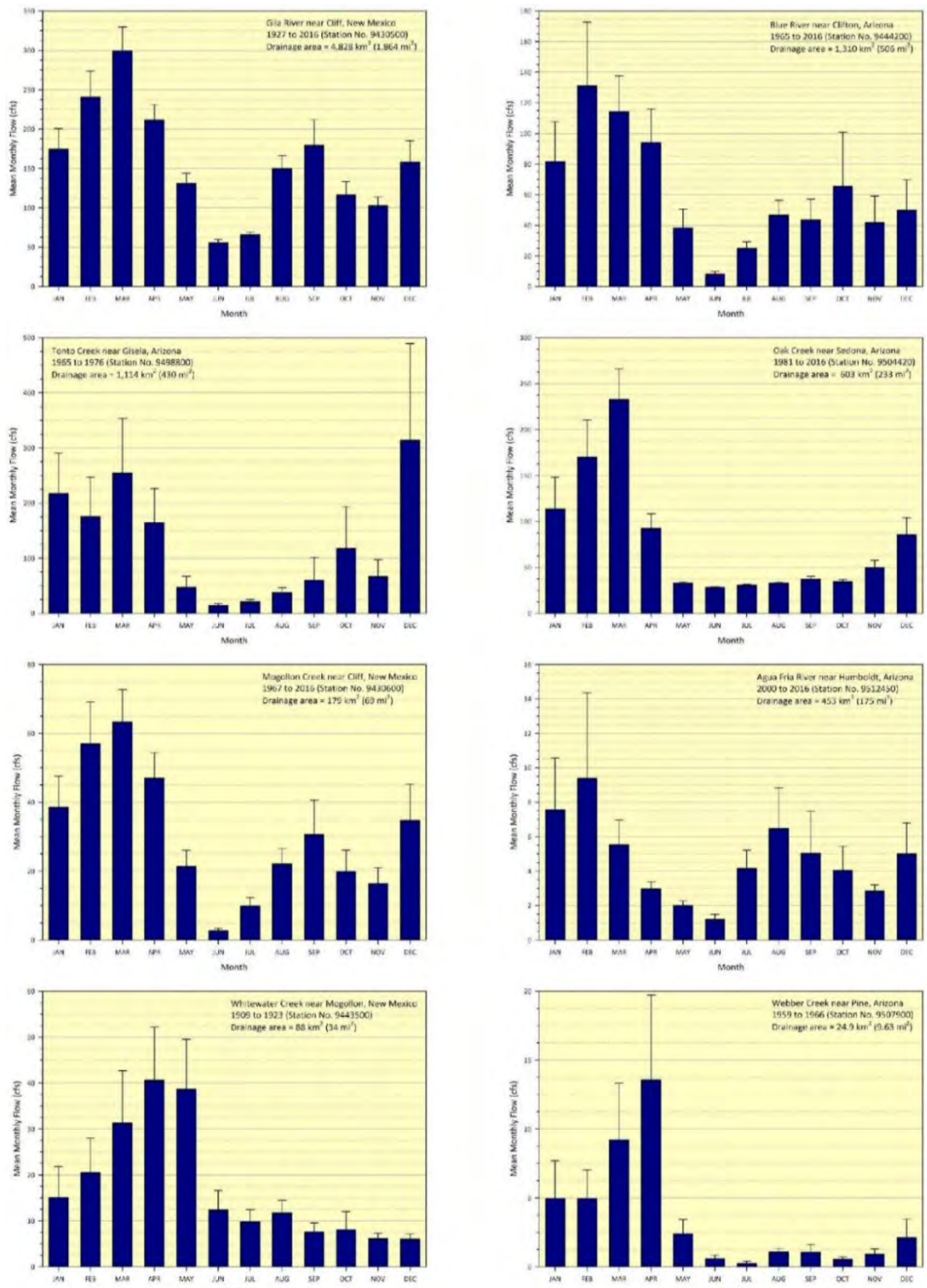


Figure 10. Mean monthly flow at locations throughout the historical range of Gila trout (U.S. Geological Survey 2016b).

Water Quality

Water quality in Gila trout habitat is generally characterized by high dissolved oxygen concentration, low turbidity and conductivity, low levels of total dissolved solids, near-neutral pH, and low conductivity (Appendix E: Tables 1-3). However, localized and radical changes in water quality may occur with removal of canopy shading and introduction of ash and sediment following forest fires (Baker, 1988; Novak, 1988; Amaranthus et al., 1989; Rinne, 1996; Gresswell, 1999). For example, a maximum suspended sediment concentration of 10,140 mg/L was recorded in Main Diamond Creek in the year following a high-severity wildfire in that watershed (Wood and Turner, 1992). Similarly, Rinne (1996) reported suspended sediment concentrations of up to 700,000 mg/L during “slurry flows” in headwater streams affected by the 1990 Dude Fire.

Water-quality impairment in cold-water streams within the historical range of Gila trout falls into two main categories: chemical or physical impairment and water temperature impairment (Table 2). Water temperature impairment in cold-water streams in New Mexico results when temperature exceeds 20^{o}C (68^{o}F) for six or more consecutive hours in a 24-hour period on more than three consecutive days, or when maximum temperature exceeds 24^{o}C (77^{o}F; 20.6.4)(New Mexico Administrative Code, 2018). Lee and Rinne (1980) found that Gila trout could tolerate temperatures up to 27°C (81^{o}F) for only up to two hours. There are no water temperature standards for cold-water streams in Arizona. Chemical or physical impairment includes elevated turbidity, excessive sediment deposition, chemical constituents present at chronic or acutely toxic concentrations, and high nutrient levels (eutrophication) in excess of established standards (20.6.4 NMAC; R18-11-1 Arizona Administrative Code).

See Appendix E for more detailed information on water quality, including specific water quality parameters and specific examples of water quality impairment in streams within Gila trout habitat.

Table 3. Impaired cold-water streams in watershed within the historical range of Gila trout in New Mexico (New Mexico Environment Department, 2016). An asterisks * indicates streams that contain viable populations of Gila trout.

Stream Segment	**Temperature**	**Nutrients**	**Turbidity**	**Sediment Deposition**	**Depressed Benthos**	**Chemical Pollutant**
Black Canyon (East Fork to headwaters)*	Impaired					
Canyon Creek (Middle Fork to headwaters)		Impaired	Impaired			
East Fork Gila River (West Fork Gila River confluence to headwaters)					Impaired	
Gila River (Mogollon Cr. to confluence of East and West forks of the Gila R.)	Impaired					
Gilita Creek (Middle Fork to Willow Cr.)	Impaired					
Iron Creek (Middle Fork to headwaters)*	Impaired					
Middle Fork Gila River (Canyon Cr. to headwaters)	Impaired					

Middle Fork Gila River (West Fork Gila R. to Canyon Cr.)	Impaired					
Mogollon Creek (perennial potions, USGS gage to headwaters)*						Aluminum
Taylor Creek (perennial portion, Beaver Cr. to headwaters)	Impaired	Impaired				
Turkey Creek (Gila R. to headwaters)	Impaired					
West Fork Gila River (East Fork to Middle Fork)	Impaired					
West Fork Gila River (Middle Fork to headwaters)	Impaired					
Willow Creek (Gilita Cr. to headwaters)*	Impaired					Aluminum
Centerfire Creek (San Francisco R. to headwaters)	Impaired	Impaired	Impaired	Impaired		
Negrito Creek (Tularosa R. to confluence of North and South forks)	Impaired					
San Francisco River (NM12 crossing to Centerfire Cr.)	Impaired		Impaired			

San Francisco River (Centerfire Cr. to state line)	Impaired				Impaired	
South Fork Negrito Creek (Negrito Creek to headwaters)	Impaired					
Trout Creek (perennial portion, San Francisco R. to headwaters)	Impaired					
Tularosa River (San Francisco R. to Apache Cr.)	Impaired		Impaired			
Total	18	3	4	1	2	2

Stream Morphology

Quantitative data on channel pattern, bankfull channel dimensions, and substrate characteristics of streams within the range of Gila trout are sparse or lacking. Channel gradient varies widely in habitat of Gila trout, from near 1 percent to over 14 percent (McHenry, 1986; Propst and Stefferud, 1997). Average substrate composition in spawning habitat of Gila trout in Main Diamond, South Diamond, and McKnight creeks consisted of 6.6 percent silts, clays, and very fine to coarse sands (less than 1 mm diameter), 14.4 percent very coarse sand (1 to 2 mm), 27.4 percent very fine to medium gravels (2 to 9 mm), 20.1 percent medium to coarse gravels (9 to 18 mm), 17.8 percent coarse gravels (18 to 38 mm), 6.9 percent very coarse gravels (38 to 63 mm), and 6.7 percent cobbles (64 to 256 mm; data summarized from Rinne, 1980; particle diameter class names adapted from Rosgen, 1998).

Stefferud (1995*a*, 1995*b*) reported Rosgen stream types A1, A2, B3, B4 and D4 for several streams within the range of Gila trout (White Creek, Langstroth Canyon, West Fork Gila River, Mogollon Creek, South Fork Mogollon Creek, Trail Canyon, and Corral Canyon). Moody et al., (2003) reported stream types B4, B4c, C3, C4b, E3b, and F4 in habitats within the range of Gila trout, based on detailed field measurements. Basin-wide habitat typing conducted on White Creek found step-run habitat to be the dominant type in a reach with a channel slope of 4.6 percent (Stefferud, 1994). Width-to-depth ratio in McKnight Creek ranged from 7.6 to 51.7 (Medina and Martin, 1988).

Pool area relative to riffle area is variable among streams. Stefferud (1994) reported a pool-to-riffle ratio in White Creek of 0.26:1 based on length and 0.30:1 based on area. Nankervis (1988) found pool-to-riffle ratios ranging from 0.23:1 to 0.28:1 in Main Diamond Creek, while values ranging from 0.05:1 to 1.17:1 were reported for numerous streams by Mello and Turner (1980). Rinne (1981*a*) found significantly greater mean and maximum depths in pools created by log structures compared to natural pools. Log structures have been constructed in numerous streams within the range of Gila trout including McKnight Creek, Main Diamond Creek, South Diamond Creek, Sheep Corral Canyon, White Creek, Beaver Creek et al., (Regan, 1966; Rinne, 1981*a*; Stefferud, 1994). Mean and maximum water depth has been reported by several investigators, but measurements were not recorded relative to bankfull stage or any other consistent elevation (Rinne, 1978; Rinne, 1981*a* and 1981*b*; Stefferud, 1994). Therefore, meaningful comparisons and generalizations about variation in depth are not possible.

McHenry (1986) reported cover values ranging from 10.7 percent to 45.8 percent in seven streams occupied by Gila trout or Gila x rainbow hybrids, while Nankervis (1988) reported cover values ranging from 13.7 percent to 21.3 percent in Main Diamond Creek. Cover was defined as areas providing refuge from current velocity, predators, and light and included undercut banks, woody debris, root wads, deep pools, overhanging vegetation, aquatic macrophytes, rock shelter, and areas of surface turbulence (McHenry, 1986; Nankervis, 1988).

Habitat Types

Spawning Habitat

Spawning habitat is defined as areas suitable for deposition and fertilization of eggs and development of embryos of Gila trout. The egg and embryo life stages are completed in the substrate of the stream. Essential habitat elements for these life stages include adequate dissolved oxygen concentration, circulation of fresh water in the stream substrate, appropriate substrate composition, and the absence of gametes or eggs of rainbow trout or Gila x rainbow trout.

Suitable substrate composition for development of eggs and embryos is characterized by approximately seven percent or less fines (particles less than 1 mm [0.04 in] diameter) by weight (Rinne, 1980). Coarse sands and gravels ranging from 1 mm (0.04 in) to 18 mm (0.7 in) diameter compose approximately 60 percent of the substrate in suitable habitat for eggs and embryos. Intra-gravel water flow and substrate conditions that provide dissolved oxygen concentrations at or near 100 percent saturation are optimal for development of eggs (Piper et al., 1983). This typically translates to dissolved oxygen concentrations of nine to 12 mg/L (ppm) or higher (Behnke, 1992). Minimum intra-gravel water flow for development of eggs has not been quantified for Gila trout. However, stagnant or still water conditions would very likely result in elevated or complete egg mortality. Populations of Gila trout may withstand losses of individual redds and even whole year classes that may result from siltation, low flows, or scouring floods (Nankervis, 1988). However, conditions of excessive siltation, low intra-gravel dissolved oxygen concentrations, or inadequate intra-gravel water circulation that persist over two or more years may result in population decline and eventual extirpation. Absence of rainbow trout or rainbow x Gila hybrid trout is another essential element of spawning habitat. Rainbow trout and Gila trout have concurrent spawning periods. Therefore, rainbow trout may fertilize eggs of Gila trout and vice versa, resulting in hybrid offspring.

Nursery and Rearing Habitat

Nursery and rearing habitats are areas used by larval and fry life stages of Gila trout. Although no studies have been done on habitat use by this life stage of Gila trout, generalizations can be made based on characteristics of related trout species. Suitable nursery habitat for trout includes areas with slow current velocity such as stream margins, seeps, shallow bars, and side channels (Behnke, 1992). Threshold current velocities, water depths, water temperatures, and substrate conditions that define nursery and rearing habitat of Gila trout are not known. Similarly, threshold values for the quantity of nursery and rearing habitat required to maintain populations of Gila trout are not known. Survival rate of Gila trout larvae and fry may be influenced by characteristics of the annual hydrograph as well. Low flows during emergence from the egg and early growth of larval trout may result in strong year classes (Behnke, 1992), as may constant, elevated flows during summer. Absence of predation by nonnative trout, particularly brown trout, is another essential element of nursery and rearing habitat.

As with spawning habitat, populations of Gila trout can withstand impacts to nursery and rearing habitat of short duration and if the population has an existing size structure that will ensure reproduction in subsequent years. Populations of Gila trout may be able to withstand low levels of predation by brown trout. However, predation effects exerted over several consecutive years, coupled with population expansion of brown trout, may result in extirpation of Gila trout from a stream.

Subadult and Adult Habitat

Subadult and adult habitats are defined as areas suitable for survival and growth of these life stages of Gila trout. Subadults are immature individuals generally less than 150 mm (6 in) total length and adults are mature individuals typically greater than or equal to 150 mm (6 in) total length (Propst and Stefferud, 1997). The quantity and quality of adult habitat typically limits population biomass of trout (Behnke, 1992). Essential elements of subadult and adult habitat relate principally to channel dimensions, cover, and hydrologic variability. Absence of competition with brown trout for foraging habitat is also an essential element of subadult and adult habitat.

Populations of Gila trout are particularly sensitive to impacts that cause reductions in cover and pool depth. These elements of subadult and adult habitat are major components that influence biomass and size structure of populations of Gila trout. Cover includes overhanging woody and herbaceous riparian vegetation, undercut banks, woody debris in the stream channel, boulders, and deep water. Populations of the species may also be dramatically affected by variation in stream flow (McHenry, 1986; Turner, 1989; Propst and Stefferud, 1997). Impacts to habitat of Gila trout that increase variability of stream flow, such as changes in watershed condition, can result in population decline and extirpation.

Subadult Gila trout occur primarily in riffles, while adults are found mainly in pools (Rinne, 1978). Cover is an important component in both riffle and pool habitat (Hanson, 1971; McHenry, 1986; Rinne, 1981*a* and 1981*b*). Size of Gila trout is positively correlated with maximum pool depth and individuals larger than 200 mm (8 in) total length are typically found in pools that are

0.5 m (1.6 ft.) deep or deeper (Rinne, 1978; Rinne, 1981*a* and 1981*b*). Pool depth in suitable habitats is generally 0.3 m (1 ft.) or greater. Areas within pools with current velocity ranging from 0 to 0.1 m/sec (0 to 0.3 ft. /sec) adjacent to areas of swifter flow provide locations where trout can rest and obtain food from drift (Behnke, 1992). Large woody debris has been identified as an important component of pool habitat, both in terms of pool formation and providing cover (Stefferud, 1994).

Variation in stream flow has been identified as a major factor affecting subadult and adult population size (McHenry, 1986; Turner, 1989; Propst and Stefferud, 1997). Specifically, reduction in abundance is often associated with major flood events. These events result in short-term, radical changes in habitat conditions, primarily in flow velocity. Because most habitats of Gila trout are characterized by relatively narrow floodplains, the forces associated with major floods are concentrated in and immediately adjacent to the bankfull channel. High stream flow velocities and shear stresses cause channel scouring and displacement of fish downstream, often into unsuitable habitats (Rinne, 1982).

Overwintering Habitat

Overwintering habitat is defined as areas used by Gila trout that afford shelter during periods of water temperature minima generally from November through February. Rinne (1981*a* and 1981*b*) and Propst and Stefferud (1997) indicated the importance of pool habitat for overwinter survival of Gila trout. Essential elements of overwintering habitat are deep water with low current velocity and protective cover (Behnke, 1992). Examples include deep pools with cover such as boulders or tree root masses or deep beaver ponds. Access to larger main-stem habitats from headwater streams may be an important function of overwinter survival where a perennial surface water connection between streams exists. Similar to subadult and adult habitat, populations of Gila trout may be quite sensitive to impacts that result in reduced cover and pool depth. Creation of barriers to fish movement that may prevent fish from accessing overwintering habitat may also result in impacts to populations of Gila trout.

Aquatic Macroinvertebrates

Aquatic macroinvertebrate community composition in habitats of Gila trout has been reported by numerous investigators (Regan, 1966; Hanson, 1971; Mello and Turner, 1980; Mangum, 1981, 1984, and 1985; McHenry, 1986; Jacobi, 1988; Van Eimeren, 1988). Benthic macroinvertebrate communities are typically dominated by Diptera (true flies), Ephemeroptera (mayflies), and Trichoptera (caddisflies). Plecoptera (stoneflies), Coleoptera (beetles), and other orders typically constitute less than 10 percent of the number of aquatic benthic macroinvertebrates in habitats of Gila trout. Density of benthic macroinvertebrates varies considerably among streams and within streams between years. Aquatic macroinvertebrate densities ranging from 69 to 1,934/m^2 (742 to 20,810/$ft.^2$) have been reported (Regan, 1964; Hanson, 1971; Mello and Turner, 1980; Mangum, 1984; Mangum, 1985; McHenry, 1986; Van Eimeren, 1988).

Trophic Structure and Trout Biomass

Gross primary productivity (comprised of both allochthonous and autochthonous inputs) in streams within the range of Gila trout has not been directly measured. Allochthonous primary production is the input of organic matter into a stream that is derived from an external source, such as leaves falling into the stream from riparian vegetation. Autochthonous production refers to organic matter produced within the stream itself through the process of photosynthesis (Wetzel, 1983). In general, allochthonous primary production exceeds autotrophic production in headwater streams (Vannote et al., 1980). This results in a ratio of gross primary productivity to community respiration of less than one in headwater stream habitats. The relative importance of allochthonous versus autochthonous production is largely a function of the degree of stream shading by riparian vegetation or topography. Moreover, there may be seasonal shifts in the relative importance of the two forms of production (Minshall, 1978).

Benthic macroinvertebrate communities in headwater stream ecosystems are typically dominated by two functional feeding groups: shredders and collectors (Cummins and Klug, 1979). The shredder feeding group forage on coarse particulate organic material, such as leaves, conifer needles, and scales of conifer cones. Particulate materials that have been colonized by microorganisms are preferentially selected. Foraging action by macroinvertebrates in the shredder feeding group produce fine particulate organic matter. This material, together with fine particulate and dissolved organic matter produced by microbial decomposition and mechanical breakdown, is consumed by the collector feeding group. The collector feeding group consists of macroinvertebrates that gather or filter fine or dissolved particulates. These organisms, together with terrestrial invertebrates that fall into the stream or that metamorphose from aquatic larvae, constitute the primary food source of Gila trout (Van Eimeren, 1988).

Fish community structure in streams within the range of Gila trout is typically characterized by low species richness. In most streams, trout are the only fishes present. However, historically Gila trout coexisted with other native fishes. Native fish species that may occur in habitats of Gila trout include longfin dace (*Agosia chrysogaster*), roundtail chub (*Gila robusta*, formerly headwater chub *G. nigra*), speckled dace (*Rhinichthys osculus*), desert sucker (*Catostomus clarkii*), and Sonora sucker (*Catsotomus insignis*). McHenry (1986) reported Gila trout biomass ranging from 2.6 to 20 grams/m^2 (23.2 to 178.4 lbs./ac) in Main Diamond, South Diamond, McKenna, Iron, Spruce, McKnight, and Big Dry creeks. Biomass (g/m^2) of Gila trout is comparable to and often higher than that of other western trouts (Platts and McHenry, 1988).

Chapter 3- Assessment of Threats

Introduction

Recovery of Gila trout requires that threats to its existence are removed or reduced and properly managed so that the species is no longer at risk of extinction, may be delisted, and will adequately be managed so that future ESA protections are not required.

Consequently, thorough identification and description of threats is the foundation of effective recovery planning (Lawler et al., 2002). Section 4(a) (1) of the ESA describes five factors, or categories of threats, that are evaluated in determining whether a species is endangered or threatened. These factors include:

- A) the present or threatened destruction, modification, or curtailment of the habitat or range of the species;
- B) overutilization of the species for commercial, recreational, scientific, or educational purposes;
- C) disease or predation;
- D) the inadequacy of existing regulatory mechanisms; and
- E) other natural or man-made factors affecting the continued existence of the species.

Gila trout were recognized as endangered in 1967 (USFWS, 1967) prior to passage of the Endangered Species Act of 1973. Consequently, an evaluation of the five listing factors was not developed when the species was originally designated as endangered. However, the five listing factors were subsequently evaluated in the reclassification rule to downlist the Gila trout from endangered to threatened (USFWS, 2006). Specifically, the reclassification rule evaluated the following as threats to Gila trout under Factors A, B, C, and E: habitat degradation from livestock grazing, timber harvest, and wildfire (Factor A); sport fishing (Factor B); predation from brown trout (*Salmo trutta*) and disease (Factor C); inadequate regulatory mechanisms to protect and enhance Gila trout populations and their habitat (Factor D); and hybridization and competition with nonnative trout, drought, wildfire, and floods (Factor E).

The following discussion describes historical and contemporary threats to Gila trout as identified in the reclassification rule and new information that has since become available. Threats identified in the reclassification rule were reevaluated and in some instances, re-characterized through consideration of the recent histories of individual populations, newly understood attributes of Gila trout life history and ecology, research conducted on the species, and trends in environmental conditions. Threats were systematically evaluated and described in terms of the specific stressors that affect individuals or populations of Gila trout, the source of each stressor, and the exposure and response of the species to each stressor. The description of specific stressors was then used to assess the magnitude of its effect. Magnitude was qualitatively described as a function of the geographic extent or scope of the stressor, the timing over which the stressor acts or acted in the past, and the intensity (strength of the effect) of the stressor.

Summary of Current Threats

Eight specific threats to the continued existence of Gila trout have been identified and are evaluated as follows: Three threats are habitat-related and discussed under listing factor A: large-scale, high-severity wildfire; effects of climate change; and grazing. One threat is discussed under listing factor B: illegal harvest. Two threats are discussed under listing factor C: nonnative trout predation and competition; and disease. Two threats are discussed under listing factor E: human-mediated introgressive hybridization; and small, isolated populations. Consistent with the reclassification rule, no threats are identified under listing factor D. The stressors associated with each threat and the species response are identified in Table 3 and described in detail in the following sections. Also, each stressor was evaluated based on the scope (geographic extent; e.g., range-wide or localized), time frame (e.g., historic, imminent, or future), intensity (strength of the effect of the stressor; e.g., high, medium, or low), and magnitude (overall level of threat to the species which integrates scope, time frame, and intensity; e.g., high, medium, or low).

Table 3. Assessment of threats. Threats are organized by listing factor (**A** through **E**) as described in the text. **Scope** is the geographic extent of the threat and is coded as range-wide (R) or localized (L). **Time Frame** is coded as historic (H), imminent (I) or future (F). **Intensity**, or the strength of the effect of the stressor, is coded as high (H), medium (M) or low (L). **Magnitude**, coded as high (H), moderate (M) or low (L), is the overall level of threat to the species and is an integration of scope, time frame and intensity.

Listing factor; threat description	Stressors Associated with Threat	Response of Species to Threat	Scope	Time Frame	Intensity	Magnitude
A; Large-scale, high-severity wildfire	Ash flows, sediment slugs, low dissolved oxygen	Extirpation of Gila trout populations, mortality, reduced abundance	R	I, F	H	H
A; Large-scale, high-severity wildfire	Post-fire habitat degradation (sedimentation, increased water temperature, reduced prey base, habitat simplification)	Reduced abundance, mortality, reduced growth and survival, reduced reproduction, and recruitment	R	I, F	H	H
A; Large-scale, high-severity wildfire	Loss of watershed function (increased peak flows, reduced phreatic groundwater and stream base flows, higher flow variation)	Reduced abundance, mortality, reduced growth and survival, reduced reproduction, and recruitment	R	I, F	H	H

A; Effects of climate change	Loss of suitable habitat (increased water temperature, reduced flow, increased sediment input), shift in precipitation patterns, earlier snowmelt, shift in storm intensity	Reduced population size, contraction of geographic distribution, population isolation	R	I, F	M	H
A; Grazing	Loss of riparian vegetation (increased stream temperature, increased sedimentation, decrease food supply)	Reduced abundance, mortality, reduced growth and survival, reduced reproduction and recruitment	R	H, I, F	L	L
A; Illegal harvest	Unsustainable removal of fish, selective harvest of larger fish, introduction of nonnative trout	Extirpation of Gila trout populations, reduced abundance, genetic effects	L	H	M	L
C; Nonnative species (predation and competition)	Mortality of early life stages, competition for food and space	Reduced abundance, reduced growth and survival, reduced reproductive output	L	I	M	M
C; Disease	Bacterial kidney disease and whirling disease which lead to impaired metabolic function	Mortality, reduced survival, reduced abundance	L	F	L	L

E; Human-mediated introgressive hybridization	Hybridization with rainbow or cutthroat trout and subsequent backcrossing resulting in introgression and development of hybrid swarms	Genetic modification, genomic extinction	R	I	H	H
E; Small population size	Loss of connectivity between populations and increased demographic stochasticity	Reduced genetic diversity, increased vulnerability to extirpation	R	H, I	M	H

Large-Scale, High-Severity Wildfire

In the 2006 reclassification rule, we identified severe wildfire as a relatively recent threat to Gila trout habitat (USFWS, 2006). Although native trout of the western U.S. have evolved with and adapted to natural forest fire regimes (Gresswell, 1999), natural fire regimes have been altered or interrupted throughout the historical range of Gila trout, leading to increased occurrence and probability of uncharacteristic, high-severity, large-scale wildfires (Covington et al., 1994; Allen et al., 2002; Fulé et al., 2013; Dennison et al., 2014; Hunter et al., 2014; O'Connor et al., 2014). This departure from natural fire regimes has created novel disturbance conditions and processes in cold-water stream habitats, often resulting in dramatically reduced abundance or extirpation of local populations of Gila trout. Local extirpation of Gila trout populations caused by high-severity wildfire has been documented throughout the historical range of Gila trout, as indicated in the following:

- The Divide Fire in 1989 (7,408 ha [18,305 ac]; Gila National Forest, 2005) caused extirpation of the remnant population of Gila trout in Main Diamond Creek (Propst et al., 1992).
- In 1995 the Bonner Fire (*ca.* 10,157 ha [25,098 ac]; Gila National Forest, 2005) eliminated the remnant population of Gila trout in South Diamond Creek and its headwater tributary, Burnt Canyon (Propst and Stefferud, 1997).
- The Lookout Fire in 1996 (3,873 ha [9,570 ac]; Gila National Forest, 2005) extirpated populations of Gila trout in Trail and Woodrow canyons, both tributaries to Mogollon Creek, and Sacaton Creek (Brown et al., 2001).
- The Wallow Fire in 2011 (217,523 ha [537,509 ac]; Apache-Sitgreaves National Forest, 2016) extirpated the Gila trout population in Raspberry Creek (Gila trout Recovery Team, 2011).
- The Whitewater-Baldy Complex Fire in 2012 (120,334 ha [297,351 ac]; Gila National Forest, 2016) eliminated five Gila trout populations in Willow Creek and Mineral Creek (Wick et al., 2014).
- The Silver Fire in 2013 (56,129 ha [138,698 ac]; Gila National Forest, 2013) eliminated Gila trout population in McKnight Creek and markedly reduced the population in Black Canyon (USFS, 2013).
- The Frye Fire in 2017 burned approximately (20,234 hectares [50,000 acres]) on the Coronado National Forest in Mount Graham. Gila trout were salvaged immediately post fire and the streams became fishless after floods in 2017.

High-severity, or stand-replacing, wildfire in small- to moderate-sized patches was a component of the natural fire regime in mesic to wet forest types such as mixed conifer and spruce-fir (Margolis et al., 2011; Hunter et al., 2014). Prior to human alteration of forest fuel loads and fire return frequency, such wildfires in the historical range of Gila trout may have extirpated trout from some headwater stream reaches. However, recolonization of accessible reaches in historically unfragmented cold-water stream systems would have enabled natural restoration of trout populations in affected areas (Dunham et al., 2003; Howell, 2006). The isolation of Gila trout populations and increased fragmentation of the distribution of the species has decreased this natural recovery process, which has heightened the vulnerability of the species to adverse effects of wildfire.

The occurrence of large-scale, high-severity wildfire in a watershed containing Gila trout does not necessarily reduce the potential for subsequent high-severity fire and the associated stressors on the species. Holden et al., (2010) found that re-burned areas in the Gila National Forest where initial fire was severe showed a higher probability of re-burning at high severity likely due to large changes in vegetation following the initial, high-severity fire. This pattern of high-severity re-burning was suggested to be a relatively new phenomenon outside of the historical range of variation. In contrast, the same study reported that areas with initial low-severity fire tended to re-burn at low severity.

Stressors

Fire effect is a function of severity and extent of fire and the storms that follow, the distribution and connectivity of adjacent populations, and effects of past land and water management (Howell, 2006). Large-scale, high severity wildfire can have both direct, immediate effects on trout populations as well as persistent, longer term indirect effects on physical and ecological attributes of aquatic habitat (Rinne and Jacobi, 2005; Rieman et al., 2012; Bixby et al., 2015). Stressors associated with this particular threat include the direct effects from ash flows, sediment slugs, and low dissolved oxygen, as well as post-fire habitat degradation (e.g., increased sedimentation, increased water temperature, reduced prey base, and habitat simplification) and loss of watershed function (e.g., increased peak flows, reduced groundwater and stream base flows, and higher flow variation).

Direct, immediate effects of fire on a population may occur in the form of direct mortality of trout during fire in situations where the riparian corridor has high fuel loads and experiences high-severity fire (Rinne and Jacobi, 2005; Howell, 2006). While specific cause-and-effect mechanisms have not been studied, trout mortality during high-severity wildfire likely results from rapid increases in water temperature and toxic chemical conditions associated with smoke and ash (i.e., ash flows and sediment slugs), and decreased dissolved oxygen (Minshall and Brock, 1991; Rieman et al., 2012; Bixby et al., 2015).

Indirect effects of high-severity wildfire on a population may include post-fire habitat degradation and loss of watershed function. Examples of post-fire habitat degradation include changes in the hydrologic cycle that affect stream flow as well as changes in physical channel conditions (e.g., habitat simplification), altered water quality (e.g., increased sedimentation, increased water temperature), and reduced aquatic macroinvertebrate abundance (reduced prey base) (Bixby et al., 2015). Examples of loss of watershed function include increased peak flows, reduced groundwater and stream base flows, and higher flow variation.

Low-severity fire does not typically result in adverse effects on watershed condition. Prescribed fire treatments are one of the primary land management tools used to restore historic fire regimes and improve watershed condition throughout the range of the Gila trout, thereby helping to address the threat of large-scale, high severity fires. Generally, this use of prescribed fire should not constitute a threat to the species (Brown, 2001), though projects may affect Gila trout in some instances. Large-scale, high-severity fires usually have extensive, adverse effects on watershed condition that result in hydrologic responses well beyond the natural range of variation (Neary et al., 2008).

In summary, the characteristic hydrologic response following high-severity wildfire in forest vegetation is a decrease in infiltration, an increase in overland flow, and stream flow patterns that are more immediately responsive and sensitive to precipitation events (e.g., flash floods orders of magnitude higher than pre-fire flows). Altered stream flow patterns following extensive high-severity wildfire in a watershed are typically characterized by reduced base flow, greatly increased flood peak flows (which may be exacerbated by formation and subsequent failure of debris dams), and greater temporal variation in flow magnitude (Neary et al., 2008). Increases in peak flows following high-severity wildfire are greatest in smaller sized watersheds. In extreme situations, perennial streams may become ephemeral following high-severity wildfire that affects a substantial portion of a stream's watershed, such as occurred in upper Little Creek following the Dry Lakes Complex Fire in 2003. It should be noted that severe wildfire in arid shrub vegetation sites characterized by deep soils may result in increased base flow when deep-rooted woody plants are replaced by shallow-rooted herbaceous vegetation (Neary et al., 2008).

When wildfire is severe enough to expose bare soil, the following effects on the hydrologic cycle are likely to occur (Neary et al., 2008):

- The soil surface is exposed to erosion due to loss of interception of precipitation by vegetation and litter, resulting in increased soil loss and sediment transport to the stream.
- Infiltration is reduced due to combustion of organic matter on the soil surface, ash and charcoal residue clogging of soil pores, and collapse of soil structure.
- Soils (particularly in oak shrub vegetation) may also develop a characteristic of water repellency following wildfire (hydrophobic soils), which reduces infiltration.
- Reduced infiltration results in increased overland flow in response to precipitation that in turn causes increases in stream discharge, and often severe flooding.
- Evapotranspiration loss is reduced, resulting in increased overland flow in response to precipitation events.
- Less snow accumulation and faster snow melt, resulting in increased overland flow.

Impacts to water quality in a stream following high-severity wildfire include pulses of greatly increased suspended sediment concentration (e.g., ash slurry flows), increased sedimentation caused by accelerated rates of soil erosion, increased water temperature caused by loss of shading and reduced base flow (Dunham et al., 2007), and increases in pH in the first year or two following high-severity wildfire (Neary et al., 2008). Chemical constituents including nitrogen, phosphorus, potassium, and calcium may also increase in the first year or two following high-severity wildfire (Earl and Blinn, 2003). Nutrient loading following high-severity wildfire, coupled with increases in water temperature, characteristically result in reduced dissolved oxygen concentrations in affected streams. Sedimentation and changes in stream flow (primarily peak flow characteristics) following high-severity wildfire often result in stream channel reorganization and degraded trout habitat. Increased stream width, reduced cover, loss of pool habitat, and homogenization of stream depth are typical channel changes following high-severity wildfire (Minshall et al., 1997; Moody and Martin, 2001; Zelt and Wohl, 2004).

Species Response

Responses of Gila trout to the threat of large-scale, high-severity wildfire and its associated stressors may include reduced abundance, reduced growth and survival, reduced reproduction and recruitment, and extirpation of Gila trout populations. Specific examples of these responses have included the following:

- Elimination of local Gila trout populations in 1989 (Main Diamond Creek), 1995 (South Diamond Creek), 1996 (Sacaton Creek), 2003 (upper Little Creek), 2004 (Raspberry Creek), 2011 (Raspberry Creek), 2012 (Spruce Creek, White Creek, Cub Creek, upper West Fork Gila River, Whiskey Creek), and 2013 (McKnight Creek and Black Canyon).
- Post-fire degradation and loss of habitat such as in upper Little Creek following the Dry Lakes Complex Fire in 2003, where a previously perennial stream reach became ephemeral, and in Dude Creek where habitat degradation following the 1989 Dude Fire precluded re-establishment of a trout population until 2015.
- Reduced Gila trout abundance, physical condition, and reproductive output due to habitat degradation (i.e., loss of pools, reduced macroinvertebrate prey base, higher water temperatures, lower dissolved oxygen) following high-severity wildfire in South Diamond Creek following the 1989 Divide Fire; in Little Creek following the Bloodgood (2000), Dry Lakes Complex (2003), and Miller (2011) fires; in the upper West Fork Gila River following the Whitewater-Baldy Complex Fire (2012); and in Mogollon Creek following the Sprite (1995) and Dry Lakes Complex (2003) fires.

Populations of Gila trout persisted in Whiskey Creek following the Cub Fire in 2002 (Gila trout Recovery Team, 2003) and in Raspberry Creek following the Raspberry Fire in 2004 (Gila trout Recovery Team, 2005). As a result of the Whitewater-Baldy Complex Fire in 2012, many isolated Gila trout populations were eliminated; however, trout populations survived in all dendritic systems within the fire footprint, including Whitewater Creek, Willow Creek, West Fork Gila River, and Mogollon Creek. Larger dendritic systems may provide more refuge habitat during stressful environmental disturbances such as fires or floods (Nakamura et al., 2000). Too, persistence of Gila trout populations following wildfire appears to be a function of the proportion of the watershed that is subject to high-severity (i.e., stand-replacement) fire. For example, only 4.6 percent of the Cub Creek watershed was subject to 50 percent or greater stand-replacement fire during the 2002 Cub Fire, which the population of Gila trout in the stream withstood. Similarly, although approximately 35 percent of the watershed of Big Dry Creek had moderate- to high-severity burn from the 2012 Whitewater-Baldy Complex Fire (Gila trout Recovery Team, 2012), most of this area was downstream from habitat occupied by Gila trout.

Unexpected benefits have arisen from large-scale wildfires. Large-scale wildfires have extirpated Gila trout from streams within the fire perimeter; however, post-fire effects have also eliminated nonnative trout from several streams, opening the possibility for Gila trout repatriations. The Dude Fire in summer 1990 (*ca.* 12,000 ha [29,652 ac]) extirpated or markedly reduced populations of brook trout or rainbow trout in Dude, Ellison and Bonita creeks in the Lower Verde River watershed, Arizona (Rinne, 1996). These creeks were subsequently successfully stocked with Gila trout. Mineral Creek was another stream that benefitted from post-fire extirpation of nonnative trout. Mineral Creek was subsequently stocked with Whiskey Creek lineage Gila trout from 2016-2018, with natural reproduction reported in 2018. The Whitewater Creek drainage also lost most of the rainbow and brook trout that previously inhabited the drainage. In response, the recovery team recommended a renovation of Whitewater Creek to remove the remaining nonnative trout. NMDGF performed rotenone piscicide treatments from 2017 to spring 2020 in Whitewater Creek. After verifying success with eDNA samples and electroshocking, Gila trout stocking began in fall 2020. Stocking will continue for three years, ending in August 2022. Whitewater Creek is a stream system containing a dendritic metapopulation. All five lineages were stocked in Whitewater Creek in 2020 and 2021, with a final stocking planned for 2022.

Overall, larger Gila trout populations occurring within longer stream segments, and those occurring within a dendritic metapopulation structure, may experience fewer and shorter-term impacts of large-scale, high-severity wildfire relative to smaller, isolated populations. Too, greater numbers of populations provide additional redundancy, such that the temporary extirpation of one or a few populations has a decreased impact on overall Gila trout viability.

Magnitude of Threat

The overall magnitude of the threat of large-scale, high-severity wildfire (and its associated stressors) to persistence of Gila trout is ranked as high (Table 3). The geographic extent of the threat and its associated stressors is range-wide because cold-water streams throughout the historical range of Gila trout are situated in forest vegetation, and large-scale, high-severity wildfire has occurred throughout the historical range. The time frame over which the stressors may act is both immediate and in the future, which reflects the direct and short-term indirect (imminent with occurrence of wildfire) effects, as well as the longer term indirect (future) effects of wildfire on Gila trout and its habitat. Climate change is expected to lead to an increase in high severity wildfire and a prolongment of the fire season across the Southwestern United States (Hurteau et al., 2014, Heidari et al., 2021). The intensity of the stressors associated with the threat of large-scale, high-severity wildfire is high, as indicated by the history of wildfire impacts on populations of Gila trout.

Effects of Climate Change

In the Gila trout reclassification rule, drought and floods were evaluated as specific threats to Gila trout under listing Factor E (USFWS, 2006). In this Recovery Plan, these threats are more broadly characterized as the effects of climate change on Gila trout habitat and evaluated under

Factor A. Usage of the terms “climate” and “climate change” in this Recovery Plan are as defined by the Intergovernmental Panel on Climate Change (IPCC). The term “climate” refers to the mean and variation of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007*a*). Concordantly, the term “climate change” refers to a change in the mean or variation of one or more measures of climate (e.g., temperature, precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC, 2007*a*).Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of greenhouse gas emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (Meehl et al., 2007; Ganguly et al., 2009; Prinn et al., 2011). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, which is average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that greenhouse gas emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of greenhouse gas emissions (IPCC, 2007*a*; Meehl et al., 2007; Ganguly et al., 2009; Prinn et al., 2011). The IPCC also summarized other global projections of climate-related changes, such as frequency of heat waves and changes in precipitation (IPCC, 2007*b*) and observations and projections of extreme climate events (Field et al., 2011).

Climate modeling projections indicate that average winter temperatures may increase up to 1.5^{o}C (2.7^{o}F) within the range of the Gila trout in the next 20 years, while summer temperatures may increase up to 2.0^{o}C during the same time span (van Oldenborgh et al., 2013). Average temperature change projected for 2046-2100 during winter months is 1^{o}C to 3^{o}C (1.8^{o}F to 5.4^{o}F) over the baseline, and for summer months the change is projected to be 2^{o}C to 3^{o}C (3.6^{o}F to 5.4^{o}F) (Appendix F). Projections of precipitation changes within the Gila trout range show no change compared to 1986-2005 conditions except for a -20 percent to +30 percent change for April-September precipitation over the next 20 years in the 25th percentile of model runs (Appendix F). The climate change model projections indicate that although total precipitation amounts may not change substantively compared to 1986-2005 conditions, air temperature is likely to increase both in summer and winter months (Appendix F). The temperature and precipitation projections are more pronounced in model scenarios with higher radiative forcing, which correspond to situations with higher greenhouse gas emissions (representative concentration pathway [RCP] scenarios 6.0 and 8.5; Appendix F; van Oldenborgh et al., 2013).

All figures mentioned in this section are located in Appendix F.

Stressors

Stressors for Gila trout associated with climate change include loss of suitable habitat (due to, e.g., increased water temperatures, altered stream flow regimes, and increased sediment input), shift in precipitation (reduced precipitation), earlier snowmelt, and shift in storm intensity (due to, e.g., increased frequency of large-scale, high-severity wildfire) (Williams et al., 2009; Wenger et al., 2011; see section on Large-Scale, High-Severity Wildfire threat). Except for habitats with stream flow dominated by spring discharge or hypolimnetic reservoir releases, water temperature in the historical range of Gila trout is closely correlated with air temperature (New Mexico Environment Department, 2010). Increasing air temperatures associated with anthropogenic inputs of greenhouse gases are expected to result in a loss of suitable habitat for Gila trout, with estimates of up to a 70 percent reduction in suitable, summer-time habitat for this species (Kennedy et al., 2008).

Using a regional climate model, Kennedy et al., (2008) predicted a 20 percent reduction in summer precipitation, an increase in summer average temperature of approximately 2ºC (3.6ºF), and a pronounced increase in the number of days with temperature above 32ºC (90ºF) and 37ºC (99ºF) by 2040-2059 for Gila trout. The modeling indicated that the projected climate changes would result in the lower elevation limit of Gila trout habitat rising 269 m (882 ft.) to 286 m (938 ft.; Kennedy et al., 2008). In addition to changing the geographic extent of suitable habitat, increased water temperatures can result in direct mortality. Increased water temperatures may also cause shifts in aquatic macroinvertebrate community structure and abundance, increased microbial metabolism, and reduced dissolved oxygen concentration (Poff et al., 2002). Warmer winter temperatures are likely to result in reduced snowpack, earlier runoff, and reduced summer flows (Poff et al., 2002; Williams et al., 2009; Luce et al., 2012).

While recent large-scale modeling indicated no marked shifts in precipitation within the Gila trout range (van Oldenborgh et al., 2013), such general circulation models are not particularly good at predicting changes in precipitation (Johnson and Sharma, 2009). Others have reported the likelihood of a drier climate in the region encompassing the historical range of Gila trout. In the near future, the Southwest is likely to become drier and experience more droughts that last longer (12 years or more; Cayan et al., 2010). Seager et al., (2007) forecasted an imminent change in climate in the Southwest of increased aridity similar to levels experienced during the Dust Bowl or the extended 1950s drought.

Species Response

The threat of climate change and factors associated with climate change (e.g., wildfire, drought, and stream temperature) are highly variable throughout Gila trout habitat (Dennison et al., 2014, Kennedy et al., 2014, and Isaak et al., 2016). The responses of Gila trout to the threat of climate change, which is manifest primarily in a loss of suitable habitat, include reduced population size, contraction of the geographic distribution of the species, and increased isolation of populations. For the closely related, higher-elevation Apache trout (occurring up to approximately 3,170 m (10,400 ft)), a model of effects of climate change on habitat availability and species distribution indicates that increasing temperatures would not result in decreased habitat availability, and that habitat suitability would improve through 2080, due to warming of high-elevation headwater reaches that are currently too cold for occupancy (USFWS, 2021; Appendix C). For Gila trout, which occur at a lower maximum elevation (up to just above 2,800 m (9,200 ft)), this shift in available habitat to higher, cooler elevations is not possible, as the species already occurs close to the maximum elevations within its range. For Gila trout, a warmer and drier climate will compound the intensity of stressors associated with the threats of high-severity, large-scale wildfire, habitat loss and fragmentation, long-term changes in suitable habitat, and possibly disease (Westerling et al., 2006; Williams et al., 2009; Luce et al., 2012). Although climate change is a threat to Gila trout, a recent analysis of vulnerability of Gila trout to future wildfire and stream temperature projections indicates that most currently occupied and unoccupied available streams will maintain suitable temperatures into the 2080s (Dauwalter et al., 2017).

Magnitude of Threat

The overall magnitude of the threat of climate change is ranked as high based primarily on the small size of streams in suitable habitat, which are sensitive to any environmental changes (Table 3). The geographic extent of the threat is range-wide. The time frame over which the stressors of climate change may act is both immediate and in the future, based on modeling and climate projections for the Southwest. The intensity of the stressors associated with the threat of climate change is moderate due to the uncertainty of the strength of climate effects, the accuracy of climate change projections, and the potential for gradual changes in habitat suitability as opposed to abrupt shifts in habitat characteristics.

Effects of Grazing

Improper livestock grazing has been shown to increase soil compaction, decrease infiltration rates, increase runoff, change vegetative species composition, decrease riparian vegetation, increase stream sedimentation, increase stream water temperature, decrease fish populations, and change channel form (Meehan and Platts, 1978; Kaufman and Kruger, 1984; Schulz and Leininger, 1990; Platts, 1991; Fleischner, 1994; Ohmart, 1996). Although direct impacts to the riparian zone and stream can be the most obvious sign of intensive livestock grazing, effects on upland watershed condition are also important, as changes in soil compaction, percent cover, and vegetative type influence the timing and amount of water and sediment delivered to stream channels from upland areas (Platts, 1991). Grazing can increase the runoff rate of precipitation into streams due to increased soil compaction and decreased vegetation cover. Increases in terrestrial runoff rates can result in increased peak flood flows, lower summer base flow, and decreased groundwater recharge (Platts, 1991; Ohmart, 1996; Belsky and Blumenthal, 1997). Therefore, streams impacted by intensive livestock grazing are more likely to experience extreme flood events during monsoons that negatively affect riparian and aquatic habitats and are more likely to become intermittent or dry in September and October (Platts, 1991; Ohmart, 1996). An indirect effect of grazing can include the development of water tanks for livestock. In some cases, stock-tanks are used to stock nonnative fish for fishing, or they may support other nonnative aquatic species such as bullfrogs or crayfish. In cases when stock-tanks are near live streams, they may occasionally be breached or flooded, with nonative fish escaping from the stock-tank and entering stream habitats (Hedwall and Spooholtz, 2004; Stone et al., 2007).

Stressors

Livestock grazing practices that degrade riparian and aquatic habitats generally cause decreased production of salmonids, including trout (Platts, 1991). Livestock affect riparian vegetation directly by eating grasses, shrubs, and trees, trampling vegetation, and compacting the soil. Riparian vegetation benefits streams and trout by providing insulation (e.g., cooler summer water temperatures, warmer winter water temperatures), by filtering sediments so they do not enter the stream (e.g., sediment clogs spawning gravel and reduces the survival of salmonid eggs), by providing a source of allochthonous nutrients to the stream from leaf litter (e.g., increases stream productivity), and by providing root wads, large woody debris, and small woody debris to the stream (e.g., provides cover for the fish) (Kauffman and Krueger, 1984; Platts, 1991; Ohmart, 1996). Poor livestock grazing practices can increase stream sedimentation through trampling of the stream banks, which results in the removal of riparian vegetation and dislodges riparian soil banks, and through soil compaction. Increased sedimentation is detrimental to trout because it decreases the survival of their eggs (Meehan, 1991) and has a negative impact on aquatic macroinvertebrates, a primary food source for trout (Wiederholm, 1984).

Species Response

Gila trout respond negatively to the effects of grazing. Grazing results in reduced riparian vegetation and an increase in sedimentation rates, which can lead to reduced Gila trout growth, survival, and reproduction as well as a reduction in cold water refugia.

Magnitude of Threat

In the late 1800s and early 1900s, livestock grazing was uncontrolled and unmanaged over many of the watersheds that contain Gila trout, and much of the landscape was denuded of vegetation (Rixon, 1905; Duce, 1918; Leopold, 1921; Leopold, 1924; Ohmart, 1996). Livestock grazing is more intensely managed now, livestock numbers are greatly reduced, and in some cases livestock access to streams occupied by Gila trout is prevented or limited through fencing, natural barriers, seasonal restrictions, or suspension of the grazing allotment. In addition, all grazing allotments with a federal nexus must be reviewed by the USFWS under Section 7(a)(2) of the ESA. While there are still Gila trout streams authorized for grazing and occasional livestock do trespass into riparian areas of Gila trout populations, the overall magnitude of the threat is lower than in the past due to a combination of seasonal restrictions, monitoring of these areas, installation and repair of exclosure infrastructure, natural topography barriers, and removal of trespass cattle when they are discovered. The threats to Gila trout habitat from livestock grazing have been greatly reduced over time and contributed to the reclassification of the species from endangered to threatened (USFWS, 2006).

Illegal Harvest

The deleterious effects of illegal harvest on fish and wildlife populations were not generally acknowledged until the end of the 19th century, by which time overexploitation had decimated American bison (*Bison bison*) and contributed significantly to the extinction of the passenger pigeon (*Ectopistes migratorius*). In the West, excessive harvest of native trout apparently was not uncommon. For example, Minckley (1973) recounted a report of large groups making annual forays into the headwaters of the Little Colorado River in the mid-1880s to harvest Apache trout, which were salted and stored in barrels for use as food during the winter. Yellowstone cutthroat trout were harvested in increasingly great quantities from Yellowstone Lake from 1870 to the early 1900s, with associated declines in catch rates (Gresswell and Varley, 1988).

Historically, illegal harvest of Gila trout likely contributed to the reduction in distribution of the species by the 1960s (Rixon, 1905; Propst, 1994). The impact of illegal harvest of Gila trout is evident from an account of a July 1923 survey of trout streams on the Gila National Forest where it was observed that Gila trout "… are absolutely at the mercy of anyone who wants them. In a similar pool in another creek, they took grasshoppers eagerly from Mr. Soule's fingers. If this opinion is correct, it is probably the cleanings of these small streams that has so rapidly exterminated the fish in the river. If the river is to be restocked the first step should be the closing of these streams for all time" (Dinsmore, 1924). At Iron Creek, it was reported that "… sportsmen were seen with their limit – perhaps more – of 50 fish" and that "an aeroplane from El Paso had landed fishermen near here, a new menace to this very limited area of trout waters" (Dinsmore, 1924). In the upper West Fork Mogollon Creek, it was reported that two fishermen took 37 trout from a single pool (Dinsmore, 1924). Similarly, the fishless condition of former trout streams near Silver City was noted in 1924, with the implication that the streams (Meadow Creek, Trout Creek, Cow Creek, Sheep Corral Canyon, Snow Creek and Panther Canyon) had been overfished to the point that the populations were extirpated (Sportsmen's Association of Southwestern New Mexico, 1924*a*).

Stressors

Stressors associated with illegal harvest may include unsustainable removal of fish, selective harvest of larger fish, and the introduction of nonnative trout. By the time regulations were implemented to limit the harvest of fish, the range of Gila trout had been reduced to several isolated headwater streams. Illegal harvest that results in exploitation of large individuals may result in unnatural selection in the population for traits such as reduced body size, earlier sexual maturity, and slower growth rate (Biro and Post, 2008; Allendorf and Hard, 2009). However, any genetic effects of size-selective harvest may only be temporary (O'Conover et al., 2009). Streams depleted of native trout were stocked with nonnative species, including rainbow trout, brook trout, cutthroat trout and brown trout, to support recreational fishing. In situations where Gila trout co-occur with brown trout, even modest harvest of native trout may result in an increase in brown trout and eventual extirpation of the native trout population (Behnke, 1992). The threat of nonnative trout competition and predation is discussed below. Introduction of rainbow trout and, potentially, cutthroat trout into the range of Gila trout resulted in genetic introgression, which is discussed below in the section on human-mediated introgressive hybridization.

Species Response

The response of Gila trout to historical, illegal harvest is largely documented as extirpation of local populations or substantial reduction of abundance and the genetic effects of small population size. Potential effects of prolonged, selective removal of large fish are unknown because by the time studies of phenotype and genetics of the species were conducted, the distribution of Gila trout was so diminished that it occurred only as isolated populations in small, headwater habitats. Harvest-induced changes in life history or size-related traits may occur in fish populations, resulting in permanent loss of adaptive genetic variation (Allendorf and Hard, 2009; Darimont et al., 2009; Kuparinen and Merilä. 2009). The responses of Gila trout to the interconnected effect of nonnative trout introductions following illegal harvest are discussed below.

Magnitude of Threat

In the reclassification rule (USFWS, 2006), we determined that overutilization of Gila trout would not be a threat to the species because of the remoteness of recovery streams, the special regulations that would be imposed on angling through implementation of a 4(d) rule, and the small number of Gila trout collected for scientific and educational purposes (USFWS, 2006). The magnitude of this threat remains ranked as low. Currently, angling for Gila trout is allowed only in selected areas, thus has a localized geographic extent, and is regulated to ensure that populations are not adversely affected, making for a moderate intensity of the stressor.

Nonnative Species (Predation and Competition)

Nonnative trout now occur and are naturalized throughout the historical range of Gila trout (Minckley, 1973; Sublette et al., 1990). Brook trout were introduced into New Mexico in the late 1800s and brown trout in the early 1900s (Sublette et al., 1990: 70). Both brook trout and brown trout are piscivorous species, which also compete for food and resources with native trout species. As the species response to predation and competition are similar, we discuss these threats together. However, competition with nonnative trout was evaluated as a threat under Factor E in the reclassification rule.

Stressors

Stressors associated with the threat of nonnative trout include mortality of early life stages from predation and competition for food and space. Piscivory by nonnative trout may have a substantial adverse effect on native trout populations. Wilkinson (1996) found that fish constituted a greater percentage of the diet of brown trout with increasing size, and that brown trout larger than 500 mm (20 in) total length preyed almost exclusively on fish. Among fish prey of brown trout, salmonids composed the greatest percentage. At one of the sites studied, rainbow trout biomass declined 71 percent over a 16-year period while brown trout biomass increased 494 percent over the same interval.

Additionally, brown trout may negatively impact Gila trout through competition. For example, McHugh and Budy (2005) reported significantly lower condition of Bonneville cutthroat trout raised in sympatry with brown trout. Al-Chokhachy and Sepulveda (2019) showed significantly lower growth rates of Yellowstone cutthroat trout in the presence of brown trout. Wang and White (1994) documented competitive advantage of brown trout over greenback cutthroat trout for energetically profitable sites in pools and near food sources. Dietary overlap between brown trout and native trout likely leads to competition for available food resources (McHugh et al., 2008). Brown trout can also exclude native trout from thermal refugia (Hitt et al., 2016).

Species Response

Gila trout likely negatively respond to predation by and competition with brown trout, similar to other native western U.S. trout species, via reduced abundance, reduced growth and survival, and reduced reproductive output. Nonnative trout predation on young Gila trout may reduce year-class strength and result in population decline. Mello and Turner (1980) reported the absence of Gila trout less than 150 mm (6 in) total length in a pool in Iron Creek that was occupied by one large (303 mm [12 in]) brown trout that had a high condition factor (K_{TL} = 1.02), suggesting that small Gila trout were eliminated from the pool by brown trout predation. Competitive interactions may result in reduced condition of Gila trout, with cascading effects on survival and reproductive output.

Magnitude of Threat

At the time the Gila trout was reclassified (USFWS, 2006) the threat of nonnative trout predation and competition had been reduced through nonnative trout removal efforts and the construction of barriers to prevent nonnative reinvasions (USFWS, 2006). Studies have predicted that brown trout may be less affected by climate change than native trout, which could lead to an increase in the brown trout range (Al-Chokhachy et al., 2016; Bell et al., 2021), potentially leading to increased predation as well as more competition for forage and thermal refugia with native trout (Hitt et al., 2016). Currently, the geographic extent of brown trout and Gila trout sympatry has been localized and limited to instances where brown trout were found subsequent to Gila trout repatriation. In these cases, and where possible, brown trout populations have been suppressed using electrofishing. Therefore, the overall magnitude of the threat of nonnative trout predation and competition is ranked as moderate (Table 3). While the threat is considered imminent, the intensity of the threat is ranked as moderate because in cases where non-hybridizing nonnative trout are found subsequent to Gila trout repatriation, predation and competition can be alleviated through removal of nonnative trout before a population of Gila trout is lost.

Disease

Pathogen introduction may result in loss of aquatic biodiversity or negative impacts on wild fish populations (Gozlan et al., 2006). For example, the causative bacterium (*Renibacterium salmoninarum*) of bacterial kidney disease (BKD) occurs in very low amounts in brown trout populations in the upper West Fork Gila River drainage and in the Whiskey Creek population of Gila trout. The bacterium was also detected in the Main Diamond Creek, South Diamond Creek, and Iron Creek populations and in rainbow x Gila trout hybrid populations in McKenna Creek and White Creek. Trout populations in the Mogollon Creek drainage, McKnight Creek, Sheep Corral Canyon, and Spruce Creek have all tested negative for BKD. In the wild, BKD is not likely a threat to Gila trout populations because of limited distribution, low occurrence within populations, and lack of any clinical evidence of the disease in Gila trout (N. Wiese, USFWS, Mora National Fish Hatchery, pers. comm., 24 August 2017).

In the western U.S., whirling disease (*Myxobolus cerebralis*) has had devastating effects on some wild trout populations (Hedrick et al., 1998). Whirling disease is caused by the metazoan parasite *Myxobolus cerebralis*. The disease is a serious problem in hatchery and wild populations of rainbow trout throughout the western United States. Annual fish health inspections (which include testing for whirling disease) of selected wild and hatchery stocks of Gila trout have been conducted since 2011, and all wild and hatchery populations of Gila trout have tested negative for whirling disease. There have been no documented cases of whirling disease in Arizona or New Mexico (N. Wiese, USFWS, Mora National Fish Hatchery, pers. comm., 24 August 2017).

For more information on disease and pathogens related to Gila trout, see Appendix G.

Stressors

Potential diseases that may affect Gila trout include whirling disease and bacterial kidney disease. Other diseases may affect populations of Gila trout. For example, there is an anecdotal report from 1924 of a fungal infection in the Gila trout population in Big Dry Creek (Sportsmen's Association of Southwestern New Mexico, 1924*b*). Whirling disease and bacterial kidney disease both lead to stressors on Gila trout that include impaired metabolic function.

Species Response

Responses to stressors associated with disease may include mortality, reduced survival, and reduced abundance within Gila trout populations. Whirling disease can cause year-class losses and marked reductions in trout abundance (Nearing and Walker, 1996; Vincent, 1996). Elevated water temperature may increase mortality of fingerling trout infected with whirling disease (Schisler et al., 2000). Prolonged crowding, such as may occur in pool habitats during severe drought, can result in elevated plasma cortisol levels, leading to increased mortality due to fungal and bacterial diseases (Pickering and Pottinger, 1989). Loss of variation in genes of the Major Histocompatibility Complex may increase susceptibility of Gila trout populations to disease (Radwan et al., 2010).

Magnitude of Threat

Bacterial kidney disease and Whirling disease were determined to be unlikely threats to Gila trout in the reclassification rule (USFWS, 2006). Currently, the overall magnitude of the threat of disease is ranked as low. There are no indications that diseases are currently affecting any population of Gila trout. However, considering an increase in water temperature and lower dissolved oxygen due to climate change, Gila trout may experience increases in rates of disease threatening populations or contributing to the vulnerability of Gila trout in the future. The geographic extent of the threat of disease is considered localized, as it may impact some populations and not others, and the intensity of this threat is considered low based on the low prevalence of disease within populations of Gila trout.

Human-mediated Introgressive Hybridization

Hybridization is the mating of two different species (or two genetically distinct populations) that produces offspring, regardless of the fertility of the offspring. Introgression is the incorporation of genes from one population or species into another through hybridization that results in fertile offspring, which further hybridize with parental populations or species (backcross). Over several generations introgression can result in a complex mixture of parental genes, while in simple hybridization 50 percent of genes will come from each of the two parental species. Without introgression, the parental species or populations are not genetically altered by hybridization.

Natural hybridization and introgression are creative evolutionary processes that may give rise to new species or increase genetic diversity of existing populations (Dowling and Secor, 1997). However, human-mediated introgressive hybridization between geographically isolated taxa (previously allopatric species brought into contact by human introductions) may result in genomic extinction and loss of the evolutionary legacy of a native species (Rhymer and Simberloff, 1996; Allendorf et al., 2001; Ellstrand et al., 2010; Todesco et al., 2016). External fertilization of eggs and the lack of strong pre-zygotic reproductive barriers make many fish taxa, including trout, very susceptible to introgressive hybridization (Hubbs, 1955; Scribner et al., 2001).

Widespread human-mediated introgressive hybridization of native trout in the southwestern U.S. has resulted from extensive stocking of rainbow trout, which is not native to the region (Dowling and Childs, 1992; Propst et al., 1992; Carmichael et al., 1993). Rainbow trout was first introduced into New Mexico in 1896 (Sublette et al., 1990) and into Arizona in 1897 (Arizona Department of Game and Fish, 2011). Stocking of rainbow trout within the historical range of Gila trout began in 1907 (Miller, 1950). By the early 1970s, reproducing populations of rainbow trout were well established throughout the historical range of Gila trout (Minckley, 1973; Sublette et al., 1990).

Introgressive hybridization with cutthroat trout has not been observed in Gila trout but has been documented in Apache trout (Carmichael et al., 1993). Carmichael et al., (1993) identified four allozyme loci with alleles diagnostic for cutthroat trout: *ADA-2**, *LDH-C**, *PEPB-1** and *PGM**.

Some or all of these loci were examined by Loudenslager et al., (1986), Dowling and Childs (1992) and Leary and Allendorf (1999), but no cutthroat trout alleles were reported in any of the populations of Gila trout examined. Similarly, Riddle et al., (1998) found no evidence of cutthroat trout influence in their analysis of mtDNA variation in Gila trout.

Nonnative cutthroat trout were first stocked in Arizona around the turn of the 20th century, but most populations did not persist due to introduction of rainbow trout (Minckley, 1973). Yellowstone cutthroat trout were widely stocked throughout New Mexico beginning in 1902 (Sublette et al., 1990). Cutthroat trout were introduced into streams in the upper Gila River drainage in the early 1920s via planting of fertilized eggs. In 1923, 25,000 fertilized cutthroat trout eggs from Yellowstone (described as "blackspotted trout eggs … from the Yellowstone") were planted in streams on the Gila National Forest, as follows: 2,000 each in Little Turkey Creek, Willow Creek, Iron Creek and Langstroth Canyon,; 4,000 in Little Creek; 1,000 in Cub Creek; and 12,000 in the West Fork Gila River at White Creek confluence (Dinsmore, 1924). The planted eggs were monitored, and apparently there was successful hatching and fry production in the streams (Dinsmore, 1924). Populations of introduced cutthroat trout in the upper Gila River drainage in New Mexico were apparently extirpated by the early 1950s (Sublette et al., 1990).

For information on ways to measure the degree of hybridization in Gila trout populations, see Appendix H.

Stressors

The principal stressors associated with human-mediated introgressive hybridization include hybridization with rainbow trout, which is a major cause of decline and continued imperilment of Gila trout (Miller, 1950; Behnke and Zarn, 1976; David, 1976). Introduced rainbow trout hybridize extensively with Gila trout, resulting in formation of hybrid swarms and eventual replacement of the native species (Rinne and Minckley, 1985; Loudenslager et al., 1986). This has occurred throughout the historical range of Gila trout. Hybrid Gila x rainbow trout populations have been removed from White Creek, the upper West Fork Gila River, McKenna Creek, Black Canyon, Little Creek, Mogollon Creek, and other streams (see section on Conservation Efforts for detailed accounts).

Species Response

Responses to stressors associated with human-mediated introgressive hybridization include genetic modification and genomic extinction (Allendorf et al., 2013). Hybridization may also affect fitness-related traits (Drinan et al., 2015). For example, Brown et al., (2004) reported faster hatching time in developmental crosses of rainbow x Apache trout compared to pure Apache trout crosses, which could potentially infer a competitive advantage to hybrids and accelerate introgression. Boyer et al., (2008) reported long-distance and stepping-stone dispersal of rainbow x cutthroat hybrid trout that promoted the spread of rainbow trout introgression in a drainage network. Hybridization may also result in reduced fitness due to outbreeding depression. For example, Muhlfeld et al., (2009) reported a 50-percent decline in reproductive success in a population of westslope cutthroat x rainbow trout with 20-percent admixture. However, hybridization spread rapidly despite this fitness cost. Repeated genetic modification may lead to genomic extinction, which would constitute the loss of the evolutionary legacy of remnant, pure Gila trout lineages.

Magnitude of Threat

When the Gila trout was listed as endangered, the most important reason for the species' decline was hybridization and competition with and/or predation by nonnative trout (USFWS, 1987). At the time the Gila trout was reclassified, some of the threats from nonnative trout, such as predation and competition with brown trout, had been reduced. (USFWS, 2006). However, rainbow trout and Gila x rainbow hybrid trout are naturalized throughout the historical range of Gila trout. Hatchery-raised triploid (infertile) rainbow trout continue to be stocked in ponds, lakes and some streams within the historical range of Gila trout in Arizona (Arizona Department of Game and Fish, 2011; Arizona Department of Game and Fish, 2015). Fertile rainbow trout are no longer stocked within the historical range of Gila trout in New Mexico or Arizona. Because rainbow trout are present, either as naturalized populations or as stocked fish, throughout the historical range of Gila trout, the geographic scope of the threat of human-mediated introgressive hybridization was considered range-wide. Muhlfeld et al., (2014) and Young et al., (2016), indicated climate change may lead to an expansion in rainbow trout ranges, and this could increase the opportunity for introgressive hybridization with native trout species, including Gila trout. The timeframe of the threat is immediate. Intensity of the threat is high due to the unidirectional and persistent nature of introgressive hybridization. Therefore, the overall magnitude of the threat of human-mediated introgressive hybridization is high.

Small Population Size

Historical changes in the extent, quality and connectivity of cold-water stream habitat within the historical range of Gila trout has resulted in the establishment of small, isolated populations. These changes can only be qualitatively assessed due to the lack of quantitative baseline data on habitat conditions prior to the mid-1800s and the onset of widespread Euro-American settlement of the region. Historical reports provide evidence of major habitat changes occurring around the turn of the 20th century that were brought about by a suite of coinciding, intensive human factors including fuel-wood cutting, timber harvest, water diversion, and open-range grazing by sheep, goats, and cattle. These factors acted in concert with severe drought around the turn of the 20th century, followed by destructive flooding, to cause major alterations of many stream systems within the historical range of Gila trout. Select examples of these impacts are described below.

The Blue River in Arizona was highly affected by grazing and logging. Browsing of vegetation by large herds of goats apparently was particularly destructive in the Blue River watershed, as reported by W.W.R. Hunt of the U.S. Forest Service following the massive floods of 1904 and 1905. Historical logging and clearing of streams for log drives also caused destabilization of streams and "tremendous damage to stream channel and banks" (National Riparian Service Team unpublished report, as cited in Stauder, 2009). Leopold reported that timber harvest in the watershed in the early 1900s was approximately 15 million board feet a year, and that logs were delivered via stream channels and the Blue River. The combined effect of unchecked logging, fuel-wood cutting, and grazing throughout the watershed undoubtedly had a major impact on the extent and quality of cold-water stream habitat. Additionally, watershed function was apparently altered throughout the drainage to the point that stream flows were visibly affected. These reports point to not only physical impacts to stream habitat, but also marked reduction in base flows resulting from reduced infiltration. Consequently, increased fragmentation of cold-water habitats that were formerly connected, at least on a periodic basis (e.g., during wet years or seasonally), in the Blue River drainage was a likely result.

Miller (1950) also described changes in suitability of habitat for trout in the upper Gila River drainage in New Mexico. In 1898, Gila trout was reported to be found in the upper Gila River drainage from the headwaters downstream to the Mogollon Creek confluence. By 1915, the downstream limit in the Gila River had receded upstream to the confluence of Sapillo Creek. By 1950, water temperature in the Gila River at Sapillo Creek was considered too warm to support any trout species. The causes of habitat degradation that led to this range contraction were not reported. However, the effects of unregulated, open-range grazing of domestic livestock in the late 1800s throughout the upper Gila River drainage (Baker et al., 1988) along with localized, indiscriminate logging in stream bottoms (Rixon, 1905) likely resulted in changes in habitat characteristics such as reduced riparian shading, timing and duration of peak flows, extent of perennial flow, base flow discharge, increased water temperature, and increased sediment loading (Rich, 1911; Duce, 1918).Contemporary habitat fragmentation may continue to persist on the landscape as a result of historic land management practices. For example, effects of unregulated, open-range livestock grazing in the late 1880s persist to varying degrees throughout the upper Gila River watershed in New Mexico via alterations to watershed form and function which may take millennia to fully recover (Stauder, 2009). However, the threats to Gila trout habitat from livestock grazing and timber harvest have been greatly reduced over time, contributing to the reclassification of the species from endangered to threatened (USFWS, 2006). Contemporary habitat loss now occurs primarily as the result of large-scale, high-severity wildfire and effects of climate change (discussed above), however, the persistence of fragmented habitat on the landscape continues to impact the long-term persistence of Gila trout populations.

Additional information and personal accounts can be found in Appendix H

Stressors

The effects of historical habitat loss and fragmentation may include the establishment of small, isolated populations and increased demographic stochasticity within those populations. The risk of population extinction increases with decreasing population size (Hanski, 1999) due to the heightened susceptibility of small populations to the effects of genetic, demographic and environmental variability (Caughley and Gunn, 1996; Kruse et al., 2001; Fausch et al., 2006; Letcher et al., 2007). Genetic drift (the random change in allele frequencies from generation to generation) and inbreeding in small populations reduce genetic variation (Allendorf et al., 2013).

Loss of genetic variation can reduce the capability of a population to persist and evolve. This reduced capability occurs through changes in allele frequencies that may cause an increase in deleterious alleles or a loss of allelic diversity (e.g., in the major histocompatibility complex which influences immune response) that increases vulnerability.

Demographic stochasticity arises from the unpredictable variation in individual reproduction and survival. In large populations, the effect of variation in reproduction and survival among individuals is dampened by large numbers. However, in small populations the coincidence of poor reproduction or survival among its members during a single, unfortunate year may have profound effects on population size and thus the probability of population persistence. The variation in population growth rate in a constant environment depends upon population size; a halving of population size causes a doubling of the variation in growth rate. Consequently, small populations are subject to erratic swings in size due to demographic stochasticity alone and have little buffer against spiraling declines that end in population extinction (Caughley and Gunn, 1996). Small populations may be subject to depressed per capita growth rate due to reduced mating success (Allee effect) and increased emigration.

Environmental variation such as prolonged drought, scouring floods, or extended periods of favorable, stable flow conditions, may have a strong influence on population growth rate, with cascading effects on demographic stochasticity. However, the effect of environmental variation is reduced with increased size of area occupied because environmental conditions have a spatial component and are typically scale-dependent (e.g., a wildfire that affects one watershed within a contiguous, six-watershed area occupied by the species). Large, occupied areas have higher habitat heterogeneity than small areas, which provides a better chance of maintaining some favorable habitat at all times. In contrast, suitable habitat may temporarily disappear entirely from small areas resulting in population extinction (Hanski, 1999).

Fragmentation of distribution disrupts the dynamics of migration and colonization. For example, natural recolonization of stream reaches in which habitat has recovered following elimination of populations by flood, fire effects, or drought is not possible when populations are isolated from one another. Lack of immigration also may result in increased inbreeding and reduced genetic variation (Wofford et al., 2005; Neville et al., 2006; Morrissey and de Kerckhove, 2009).

Species Response

Responses of Gila trout to the threat of small population size include increased vulnerability of populations to extirpation and reduced genetic variation. Isolated populations have been extirpated by the effects of wildfire (see section on Large-Scale, High-Severity Wildfire), drought, suspected demographic stochasticity, or a combination of factors. For example, remnant populations of Gila trout were extirpated in a variety of locations as a result of wildfire in 1989, 1990, 1995, 1996, 2007, 2011, 2012, and 2012. Heterozygosity of all remnant lineages of Gila trout, with the exception of Iron Creek, has declined from 2002 to 2013 (Gila trout Recovery Team, 2014). Loss of genetic diversity has been particularly acute in the Spruce Creek lineage.

The erosion of genetic diversity in the remnant lineages is likely due to the consequence of bottlenecks and small genetically effective population size in many of the occupied streams.

Magnitude of Threat

The overall magnitude of the threat of small population size is ranked as high (Table 3). As of 2017, only the Mogollon Creek and Willow Creek drainages had dendritically structured metapopulations of Gila trout with some potential for colonization and movement dynamics. In relation to geographic extent, population isolation and small population size are a range-wide concern for Gila trout. In relation to timeframe, these stressors constitute an imminent, ongoing historical threat to the species. Intensity of the threat is ranked as moderate because even relatively small populations may persist for a decade or more. The potential negative effects of genetic drift and inbreeding depression in such small populations suggest that they may best be considered as natural refuge sites that require periodic introductions of fish to maintain genetic diversity.

Chapter 4- Conservation Efforts

Introduction

The history of actions from the early 20th century through 2015 to conserve Gila trout have been documented by Turner (1986), Propst et al., (1992), Propst (1994), Turner (1996), notes from recovery team meetings, and other sources. The following discussion of conservation measures to date was adapted from those sources. The history of each lineage and its fate (survival each year, extirpated by fire or flood, or loss from introgression) within streams from 1980 through 2021 can be found in Tables 4, 5, and 6.

See Appendix I for an account of conservation efforts prior to 2011.

2011 through Present

The 2011 Wallow Fire affected Gila trout recovery streams in the Blue River drainage. The Gila trout population in Raspberry Creek (Spruce Creek lineage) was eliminated by the fire. Several other potential recovery streams were also affected by the fire including Coleman, KP and Grant creeks. After removal of hybrid trout, KP Creek was subsequently found to be fishless. AZGFD collected eDNA samples in 2020 to confirm the fishless state of KP Creek. Manual removal of nonnative trout (using electrofishing) was conducted in Black Canyon and McKenna Creek in 2011. The entire length of perennial stream in McKenna Creek (*ca*. 1.6 km [1 mi]) was intensively electrofished five times, resulting in removal of 495 Gila x rainbow hybrid trout. Construction of a new fish barrier on Black Canyon was completed in July 2011. In August 2011, electrofishing in Black Canyon resulted in removal of 164 brown trout from the stream above the fish barrier. The new barrier, located adjacent to the existing gabion structure, was constructed of concrete, and included a splash pad on the downstream side of the barrier. The existing gabion structure had been compromised and likely was not effective in preventing upstream movement of nonnative trout into the Gila trout restoration area. Monitoring in May 2011 found no nonnative trout in the upper West Fork Gila River restoration area. In October 2011, 199 Gila trout (Main Diamond lineage) were collected from upper White Creek and were stocked in the West Fork Gila River below Packsaddle Canyon. The population of South Diamond lineage Gila trout in Frye Creek, which was established in 2009, was supplemented by stockings of 650 Gila trout in February and 150 in November 2011. Ash Creek was stocked with 5 Spruce Creek lineage Gila trout from Mora National Fish Hatchery (MNFH) in November 2011.

The naturalized rearing system at Mora National Fish Hatchery was improved in 2011 to address gas super-saturation issues, and other refinements to the system were made in water quality monitoring and maintenance, provision of live and natural feed, and regulation of photoperiod and temperature. The result was the highest hatch rate of Gila trout eggs in five years and higher survival rates of wild fish brought into the station. A program of marking members of each broodstock family was implemented using passive integrated transponder tags. Stocking of the recreational Gila trout fisheries in the West Fork Gila River near the Heart Bar Wildlife Area and Sapillo Creek was conducted in January and November 2011. A recreational fishery was also established at Frye Mesa Reservoir with stocking of 1,446 South Diamond lineage Gila trout in 2011.

Monitoring in spring of 2012 discovered brown and rainbow trout in the upper West Fork Gila River above the waterfall near White Creek Cabin, indicating that the waterfall did not constitute an effective barrier to upstream movement of nonnative trout, as previously assumed. A large boulder lodged in a narrow space below the waterfall was causing a marked increase in water surface elevation during high flows and a consequent decrease in the height of the waterfall to the point that upstream fish movement was possible.

The Whitewater-Baldy Complex Fire burned through portions of the upper Gila River and San Francisco River watersheds from May through July 2012. The wildfire burned more than 120,534 ha (465 mi^2) and was the largest wildfire in New Mexico state history. Aerial reconnaissance was conducted to assess the condition of Gila trout recovery streams in June 2012. Numerous streams were observed to have been severely affected by the fire, with the most extreme impacts occurring at Whiskey Creek, West Fork Mogollon Creek, Rain Creek, Whitewater Creek and East Fork Whitewater Creek (Figure 11; Brooks, 2012*a*).

Figure 11. Whitewater-Baldy Fire effects in the West Fork Mogollon Creek watershed, looking upstream (James Brooks, June 2012)

The fire also severely affected many other existing or potential Gila trout recovery streams including the upper West Fork Gila River, Cub Creek, White Creek, Langstroth Canyon, Spruce Creek, Big Dry Creek and Mogollon Creek, Iron Creek, Willow Creek, South Fork Whitewater Creek, and Mineral Creek (Brooks, 2012*a*). Gila trout were evacuated from Spruce Creek in June 2012, with 100 taken to Mora National Fish Hatchery and another 210 translocated to Ash Creek in Arizona (Brooks, 2012*b*), because approximately 22 percent of the watershed had burned with high to moderate severity and severe post-fire impacts were anticipated (Brooks, 2012*a*). The population in Spruce Creek was subsequently extirpated in the aftermath of the Whitewater-Baldy Complex Fire, but the Spruce Creek lineage population in Big Dry Creek persisted. Similarly, Gila trout were evacuated from Whiskey Creek in June prior to the onset of major post-fire impacts (Figure 12). Over 80 percent of the Whiskey Creek watershed had burned with high to moderate severity. Eighty-one Gila trout were captured and were transported to a naturalized rearing facility at the New Mexico Fish and Wildlife Conservation Office in Albuquerque (Brooks, 2012*c*). Approximately 60 Gila trout (Whiskey Creek lineage) were also evacuated from Langstroth Canyon in June 2012 and transported to Mora National Fish Hatchery (Brooks, 2012*c*). In July 2012, another 67 Gila trout were captured in Langstroth Canyon and translocated to McKenna Creek. Post-fire impacts subsequently caused the extirpation of the Gila trout population in Whiskey Creek.

Figure 12. Gila trout being collected for evacuation from Whiskey Creek (James Brooks, June 2012)

By the end of 2012, Mora National Fish Hatchery had 232 Whiskey Creek lineage and 96 Spruce Creek lineage Gila trout. The naturalized rearing facility at the New Mexico Fish and Wildlife Conservation Office housed 68 Whiskey Creek lineage Gila trout. KP Creek was electrofished to remove Apache x rainbow trout hybrids. Two hybrid trout were found and removed. Following electrofishing the stream was considered likely to be fishless. Electrofishing was also conducted in upper Turkey Creek, which was affected by the Whitewater-Baldy Complex Fire. Two Gila x rainbow hybrid trout and 13 rainbow trout were removed during electrofishing. Electrofishing removal of nonnative trout was continued in Black Canyon and McKenna Creek in 2012. Six electrofishing passes were made through the entire perennial reach of McKenna Creek in June 2012, and no fish were collected during the fifth and sixth passes. Consequently, hybrid trout were determined to have been eliminated from the stream. As noted above, Gila trout of Whiskey Creek lineage were subsequently translocated from Langstroth Canyon to McKenna Creek. Willow Creek was stocked with South Diamond lineage Gila trout in 2012.

Monitoring conducted in April 2013 found trout populations had been eliminated in the upper West Fork Gila River (above the waterfall near White Creek Cabin), Whiskey Creek, White Creek and Langstroth Canyon. Whiskey Creek lineage Gila trout evacuated from the stream in 2012 were stocked in McKenna Creek in May 2013. In November 2013, lower White Creek was stocked with 2,750 Main Diamond lineage Gila trout, and Cub Creek was stocked with 2,750 South Diamond lineage fish. The Silver Fire, which started in June 2013, brought about the extirpation of Gila trout populations in McKnight Creek and Black Canyon. Black Canyon was stocked in October and November 2013 with Main Diamond lineage Gila trout. Main Diamond lineage 2,750 fish were also stocked in Little Creek and Sheep Corral Canyon in September and October 2013. Gila trout were evacuated from South Diamond Creek in June as a precaution against potential impacts from the Silver Fire. The fire did not reach the South Diamond Creek watershed, so the fish were returned to the stream in October.

The Iron Creek population survived the Whitewater-Baldy Complex Fire. In May 2013, 51 fish were collected from Iron Creek and taken to Mora National Fish Hatchery. The South Diamond lineage broodstock at Mora National Fish Hatchery was augmented with 200 Gila trout collected from Mogollon Creek in May 2013. A temporary fish barrier, constructed of gabion baskets, was installed on Willow Creek in 2013, and the stream above the barrier was stocked with South Diamond lineage Gila trout.

Genetic analysis of trout from above the barrier in Iron Creek found a greater than 95 percent probability that the fish were not recently hybridized with rainbow trout (Turner, 2013), in contrast to earlier work that concluded the population was introgressed (Leary and Allendorf, 1999). It was suggested that the contradiction may have arisen from: 1) retention of ancestral polymorphism at allozyme loci; 2) retention of allozyme loci through the effect of purifying selection; or 3) past introgression and subsequent loss of rainbow trout alleles through backcrossing with pure Gila trout. Turner (2013) concluded that the Iron Creek population was essentially pure and that it represented a unique evolutionary lineage. The Iron Creek population was also found to have unique alleles at relatively high frequencies at the MHC class II β gene, and that this population had the highest diversity among Gila trout populations at the MHC locus (Turner, 2013). Subsequent analysis of single nucleotide polymorphisms found no evidence of recent hybridization in the Iron Creek population (Turner and Camack, 2017).

An analysis of natural and man-made barriers on seven recovery streams was conducted in 2014 (Gila trout Recovery Team, 2014). The analysis concluded that the man-made barriers on Little Creek, Iron Creek, and Black Canyon were effective at preventing upstream movement of fish. The man-made barrier on McKnight Creek was found to be compromised, but it was determined that the structure could be repaired. A permanent fish barrier was constructed in Willow Creek immediately upstream of the confluence with Gilita Creek in 2016, replacing the gabion structure that had served as a temporary barrier since 2014. The temporary barrier on Willow Creek was assessed to be a functional barrier to upstream movement of fish during low to moderate flows, but not during high flows. The natural waterfall barrier on White Creek was determined to be a barrier to upstream movement of fish at all flows. The waterfall on the West Fork Gila River, consisting of three drops, was determined to allow upstream movement of fish during high flows due to boulders that reduced drop height.

Genetic analysis of trout samples collected in April and July 2014 from the upper West Fork Gila River found the Gila trout populations in the West Fork Gila River and Cub Creek to be introgressed with rainbow trout. Apparently, rainbow trout or Gila x rainbow trout hybrids either survived the 2010 rotenone treatments or subsequently gained access to the restoration area either by human-assisted fish movement or by upstream movement of rainbow trout or Gila x rainbow hybrid trout past the waterfall on the West Fork Gila River located below the confluence of White Creek.

Little Creek was found to continue to support only low numbers of Gila trout likely due to the lack of pool habitat (a lingering effect of sediment input following the 2011 Miller Fire). Two thousand and fifty Main Diamond lineage Gila trout were stocked in Little Creek again in 2014. Sheep Corral Canyon was also stocked with 165 Main Diamond lineage Gila trout in 2014. Two hundred and ninety South Diamond lineage fish were stocked in both Grapevine Creek and Frye Creek. None of the Gila trout stocked in Black Canyon in 2013 survived, and the stream was stocked again in 2014 with 3,200 Main Diamond lineage fish. Monitoring in October 2014 found the stream above the barrier to be fishless. Upper White Creek was stocked with 5,300 Whiskey Creek lineage Gila trout. Two hundred Spruce Creek lineage Gila trout were stocked in Ash Creek post-Whitewater Baldy Fire in 2012. However, Gila trout were evacuated from the stream in November 2014 and moved to MNFH due to lack of reproduction, lack of genetic diversity, high relatedness, and overall vulnerable status of the lineage. South Diamond lineage Gila trout were stocked above the gabion structure in Willow Creek in 2014 to maintain a popular recreational fishery, as this creek was not considered a recovery stream due to the impermanence and possible ineffectiveness of the temporary barrier. After construction of the permanent fish barrier was completed on Willow Creek, the population was augmented with South Diamond lineage Gila trout. No nonnative salmonids were recorded in Willow Creek above the permanent barrier. Willow Creek is now considered a recovery stream, and regulated harvest is allowed under the special 4(d) rule for Gila trout (USFWS, 2006). Recreational fisheries in the West Fork Gila River, Snow Lake, and Frye Mesa Reservoir were also stocked with Gila trout in 2014.

Monitoring in 2014 indicated substantial reproduction of nonnative trout in upper Turkey Creek, indicating that mechanical removal would not suffice to renovate the stream for Gila trout. Assessment of West Fork Mogollon Creek and Rain Creek found that nonnative trout populations survived the Whitewater-Baldy Complex Fire. Assessment of Whitewater Creek found nonnative brook trout in very low numbers in the South and East forks and rainbow trout in the upper reaches of the stream. Mineral Creek was confirmed in 2014 to be fishless. However, post-fire habitat degradation rendered the stream unsuitable for restoration of Gila trout. Iron Creek was closed to angling in 2014.

Monitoring in July 2015 found that the Spruce Creek lineage Gila trout population in Big Dry Creek survived the Whitewater-Baldy Complex Fire. Main Diamond Creek lineage Gila trout were stocked into upper Langstroth Canyon in 2015. Dude Creek was stocked with 500 Main Diamond and 500 South Diamond lineage Gila trout, and Ash Creek was stocked with 500 Whiskey Creek lineage Gila trout in 2015. Dude Creek has was also stocked in 2016 and 2017. The McKenna Creek population (Whiskey Creek lineage) was monitored in May 2015 and found to consist of multiple age classes, indicating successful reproduction and recruitment. Monitoring in 2015 also confirmed persistence of Gila trout populations in Sheep Corral Canyon and Little Creek. Removal of boulders and sediment limiting the effectiveness of the waterfall barrier on the West Fork Gila River near White Creek Cabin was conducted in May 2015. The boulders were removed using explosives. The result was an increase in vertical drop to more than 2.4 m

(8.0 ft.). Trail cameras were installed to record conditions at various flows. Despite efforts to increase the height of the waterfall, spring runoff and monsoonal floods compromised its effectiveness as a barrier. Also, water-temperature dataloggers were installed at six locations in the upper West Fork Gila River drainage. Electrofishing removal of nonnative trout from upper Marijilda Creek was conducted in 2015 in an effort to make the stream suitable for restoration of Gila trout. Frye Creek was opened to angling in January 2015; however, angling was closed following the 2017 Frye Fire.

Conservation efforts currently concentrate on repatriating both streams affected by fire and streams devoid of nonnative salmonids. Unexpected benefits arose from the large-scale wildfires. Large-scale wildfires extirpated Gila trout from streams within the fire perimeter; however, post-fire effects also eliminated nonnative trout from several streams, opening the possibility for Gila trout repatriations. Mineral Creek was one stream that benefitted from post-fire extirpation of nonnative trout. Mineral Creek was subsequently stocked with Whiskey Creek lineage Gila trout from 2016-2018, with natural reproduction reported in 2018. The Whitewater Creek drainage also lost most of the rainbow and brook trout that previously inhabited the drainage. In response, the recovery team recommended a renovation of Whitewater Creek to remove the remaining nonnative trout.

NMDGF performed rotenone piscicide treatments from 2017 to spring 2020 in Whitewater Creek. After verifying success with eDNA samples and electroshocking, Gila trout stocking began in fall 2020. Stocking will continue for three years, ending in August 2022. Whitewater Creek is a stream system that fits the recovery criteria of a dendritic metapopulation (Criterion C). All five lineages were stocked in Whitewater Creek in 2020 and 2021, with a final stocking planned for 2022.

In Arizona, effects from fires eliminated populations of Gila trout from Ash Creek, Frye Creek, and Grapevine Creek in 2017. Experimental egg-outplanting occurred in Frye and Grapevine creeks. Surveys in 2019 indicated survival of outplanted eggs in Grapevine Creek. Coleman Creek was determined to be void of nonnative salmonids. Chase Creek was determined to be fishless after several removal efforts to remove nonnative Rainbow Trout from the stream. Chase Creek was stocked with Iron Creek lineage Gila trout in 2017 and 2018. Visual surveys have documented natural reproduction following these stockings, and AZGFD plans to augment Chase Creek with additional Iron Creek lineage fish or eggs in 2022 pending availability.

A visual estimate conducted in Dude Creek in 2019 documented three age classes of fish. In 2020 only adults were observed during a visual survey. In 2021 a redd survey was attempted but no redds were observed during the last week of March. However, prior to this, three years of natural recruitment were observed in the stream.

Raspberry Creek was stocked in 2019 with N = 250 Gila trout, and in 2020 with N = 250 more Whiskey Creek lineage Gila trout. A population estimate was completed in 2021 using a three pass depletion backpack electrofishing method (Dauwalter et al., 2017) at eight sites. Four adult fish were observed and the population estimate for Raspberry Creek was 26 Gila trout. The population will be monitored for the next few years. In 2020 AZGFD completed eDNA surveys of Marijilda, Gibson and Crazy Horse Creeks. The eDNA Results from 23 sites were all negative for any salmonid marker. In 2020, 250 Whiskey Creek lineage Gila trout were stocked in the upper section of Marijilda Creek, 500 South Diamond lineage Gila trout were stocked in the middle section of the stream. Coleman Creek was stocked with 94 Gila Trout (that varied in size from 56 mm to 249 mm) from Big Dry Creek (Spruce Creek lineage) in New Mexico in August 2020.

Frye Creek was stocked with 24,000 Gila trout eggs (South Diamond lineage) in April 2019. Visual surveys in May and August confirmed no survival of eggs, and 250 Gila trout (South Diamond lineage) were stocked in November of 2019. In April 2020, 16,000 Gila trout eggs were stocked. Visual surveys in May and August confirmed survival of both the 2019 fish stocked and 2020 egg stocking. Over October and November of 2020 an additional 502 Gila trout were stocked in Frye Creek. Additionally, 10,367 Gila trout Eggs were stocked in Fry Creek in April 2021. Visual surveys in May confirmed survival of the 2021 egg stocking.

Grapevine Creek was stocked with 6,000 more Gila trout eggs (South Diamond lineage) in 2020 with no survival observed during a follow up visual survey. In 2020 AZGFD salvaged and translocated 196 Gila trout ranging in length from 85 to 198 mm from a lower section of Grapevine Creek to a higher section of the stream. Grapevine Creek was again stocked with 2,240 eggs in March 2021, and young of year were observed during an August visual survey in the stream.

In 2021 KP Creek was stocked with 109 Gila trout (Iron Creek lineage), and Grapevine and Dude Creeks were open to seasonal catch and release fishing. A population estimate is planned for Dude Creek in 2022.

Table 4, 5, and 6 below provide a graphic representation of the Gila trout conservation efforts previously described in text in Chapter 4.

Table 4 - Status of Gila trout populations, pre-1980 through 1993, showing numbers of extant populations of each lineage.

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Main Diamond Creek Lineage	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**3**	**3**	**2**	**2**	**2**
Main Diamond Creek (remnant)	→	→	→	→	→	→	→	→	→	E,Xf				
McKnight Creek	B,R,S	→	→	→	→	→	→	→	→	→	→	→	→	→
Sheep Corral Canyon	S	→	→	→	→	→	→	→	→	→	→	→	→	→
Gap Creek	S	→	→	→	→	→	→	→	→	→	→	Xd		
South Diamond Creek Lineage	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
South Diamond Creek (1) (remnant)	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Mogollon Creek (2)							R	R, S	R, S	R, S	→	→	→	B, →
Whiskey Creek Lineage	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
Whiskey Creek (remnant)													→	→
Iron Creek Lineage	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**3**
Iron Creek (remnant)	→	B, R	→	→	S	→	→	→	→	→	→	→	→	→
Sacaton Creek											S	→	→	→
White Creek (upper)														R, S
Spruce Creek Lineage	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
Spruce Creek (remnant)	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Big Dry Creek					R	R, S	→	→	→	→	→	→	→	→
Total Number of Populations	**7**	**7**	**7**	**7**	**7**	**8**	**8**	**9**	**9**	**8**	**8**	**8**	**9**	**10**

1. South Diamond Creek includes the headwater stream in Burnt Canyon
2. Mogollon Creek is an interconnected stream complex that consists of Mogollon Creek and tributaries including (from upstream to downstream) Woodrow Canyon, Trail Canyon, and South Fork Mogollon Creek.

Key to Codes:
→ = extant population
X = extirpation of population (see Extirpation Causes for modifier definitions)
B = barrier construction or modification
R = removal of nonnative trout by piscicide application or electrofishing
S = initial stocking following renovation or extirpation
E = evacuation of Gila trout
F = population opened to recreational angling
H = hybridization detected

Extirpation Causes:
Xf = wildfire effects (direct and indirect)
Xd = stream drying
Xq = major flood events

Table 5. Status of Gila trout populations, 1994 through 2007, showing numbers of extant populations of each lineage.

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Main Diamond Creek Lineage	**3**	**3**	**3**	**3**	**4**	**4**	**6**	**5**	**5**	**5**	**5**	**5**	**5**	**6**
Main Diamond Creek (remnant)	S	→	→	→	→	→	→	→	→	→	→	→	→	→
McKnight Creek	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Sheep Corral Canyon	→	→	→	→	→	→	→	Xd						S
Black Canyon					B,R,S	→	→	→	→	→	→	→	→	F, →
Little Creek (lower)					R	R	S	→	→	→	→	→	→	→
White Creek (upper)							R, S	→	→	→	→	→	→	→
White Creek (lower)											R	R	R	
West Fork Gila River										R	R	R	R	R
South Diamond Creek Lineage	**2**	**1**	**0**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
South Diamond Creek (1) (remnant)	→	Xf		S	→	→	→	→	→	→	→	→	→	→
Mogollon Creek (2)	→	E, →	H, →	R, S	→	→	→	→	→	E, →	→	→	→	→
West Fork Gila River										R	R	R	R	R
Whiskey Creek Lineage	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**1**	**1**	**1**	**2**	**2**
Whiskey Creek (remnant)	→	→	→	→	→	→	→	→	E, →	→	→	→	E, →	→
Little Creek (upper)					R	R	S	→	→	Xf				
Langstroth Canyon (3)											R	R	R, S	→
Iron Creek Lineage	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Iron Creek (remnant)	→	→	→	H? →	→	→	→	→	→	→	→	→	→	F, →
Sacaton Creek	→	→	Xf											
White Creek (upper)	→	→	→	→	→	→	R							
Spruce Creek Lineage	**2**	**2**	**2**	**2**	**2**	**3**	**4**	**4**	**4**	**4**	**4**	**3**	**3**	**3**
Spruce Creek (remnant)	E, →	→	→	→	→	→	→	→	→	→	→	→	→	→
Big Dry Creek	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Dude Creek						S	→	→	→	→	→	Xq		
Raspberry Creek							S	→	→	→	E, →	→	→	→
Total Number of Populations	**11**	**10**	**8**	**10**	**11**	**12**	**15**	**14**	**14**	**13**	**13**	**12**	**13**	**14**

Footnote:
1. South Diamond Creek includes the headwater stream in Burnt Canyon
2. Mogollon Creek is an interconnected stream complex that consists of Mogollon Creek and tributaries including (from upstream to downstream) Woodrow Canyon, Trail Canyon, and South Fork Mogollon Creek.
3. Langstroth Canyon is a relatively small, interconnected stream complex that consists of the stream in Langstroth Canyon and tributaries including Rawmeat Creek and Trail Creek.

Key to Codes:
→ = extant population
X = extirpation of population (see Extirpation Causes for modifier definitions)
B = barrier construction or modification
R = removal of nonnative trout by piscicide application or electrofishing
S = initial stocking following renovation or extirpation
E = evacuation of Gila trout
F = population opened to recreational angling
H = hybridization detected

Extirpation Causes:
Xf = wildfire effects (direct and indirect)
Xd = stream drying
Xq = major flood events

Table 6. Status of Gila trout populations, 2008 through 2021, showing numbers of extant populations of each lineage.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Main Diamond Creek Lineage	**6**	**6**	**7**	**7**	**5**	**5**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Main Diamond Creek (remnant)	→	→	→	→	→	→	→	→	→	→	→	→	→	→
McKnight Creek	→	→	→	→	→	Xf								
Sheep Corral Canyon	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Black Canyon	→	→	→	→	→	Xf	S	→	→	→	→	→	→	→
Little Creek (lower)	→	→	→	→	→	→	→	→	→	→	→	→	→	→
White Creek (upper)	→	→	→	→	Xf									
White Creek (lower)		R	R			S	H							
Langstroth Canyon (upper)								S	→	→	→	→	→	→
West Fork Gila River		R	R, S	→	Xf	S	H							
South Diamond Creek Lineage	**2**	**4**	**6**	**5**	**5**	**7**	**5**	**5**	**5**	**3**	**3**	**5**	**5**	**5**
South Diamond (1) Creek (remnant)	→	E, →	→	→	→	E, →	→	→	→	→	→	→	→	→
Mogollon Creek (2)	F, →	→	→	→	→	→	→	→	→	→	→	→	→	→
Grapevine Creek		S	→	→	→	→	→	→	→	Xf		S	→	→
Frye Creek		S	→	→	→	→	→	F, →	→	Ef, S		S	S →	S →
West Fork Gila River		R	R, S		Xf	S	H							
Cub Creek			S	→	Xf	S	H							
Willow Creek					S	→	→	→	→	→	→	→	→	→
Whiskey Creek Lineage	**2**	**2**	**2**	**2**	**1**	**1**	**2**	**2**	**3**	**2**	**4**	**4**	**5**	**4**
Whiskey Creek (remnant)	→	→	→	→	E, Xf									
Langstroth Canyon (3)	→	→	→	→	E, Xf									
McKenna Creek				R	R, S	→	→	→	→	H				
White Creek (upper)							S	→	→	→	→	→	→	→
Mineral Creek									S	→	→	→	→	→
Raspberry Creek											S	→	→	→
Sacaton											S	→	→	Xd
Marijilda Creek (upper)													S	→
Iron Creek Lineage	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**3**
Iron Creek (remnant)	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Chase Creek											S	→	→	→
KP Creek														S
Spruce Creek Lineage	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**2**	**2**	**3**	**3**
Spruce Creek (remnant)	→	→	→	→	E, XI						S	→	S, →	→
Big Dry Creek	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Dude Creek								S	S	S				
Raspberry Creek	→	→	→	Xf										
Ash Creek			R	S	→	→	E, →4							
Coleman Creek													S	→

Table 7 (cont). Status of Gila trout populations, 2008 through 2021, showing numbers of extant populations of each lineage

Mixed Lineage	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**1**	**1**	**1**	**3**	**3**
Ash Creek								S, →4	→	E, Xf				
Dude Creek								S	→	→	→	→	→	→
Marijilda Creek (lower)													S	→
Whitewater Creek										R	R	R	S	S, →
Total Number of Populations	**14**	**16**	**19**	**18**	**14**	**16**	**14**	**16**	**17**	**13**	**17**	**19**	**23**	**23**

Footnotes:

1. South Diamond Creek includes the headwater stream in Burnt Canyon
2. Mogollon Creek is an interconnected stream complex that consists of Mogollon Creek and tributaries including (from upstream to downstream) Woodrow Canyon, Trail Canyon, and South Fork Mogollon Creek.
3. Langstroth Canyon is a relatively small, interconnected stream complex that consists of the stream in Langstroth Canyon and tributaries including Rawmeat Creek and Trail Creek.
4. Ash Creek was originally stocked with Spruce Creek lineage fish. In 2015 Whiskey Creek lineage fish were also stocked in the stream to create a mixed lineage population.

Key to Codes:

→ = extant population
X = extirpation of population (see Extirpation Causes for modifier definitions)
B = barrier construction or modification
R = removal of nonnative trout by piscicide application or electrofishing
S = initial stocking following renovation or extirpation
E = evacuation of Gila trout
F = population opened to recreational angling
H = hybridization detected

Extirpation Causes:

Xf = wildfire effects (direct and indirect)
Xd = stream drying
Xq = major flood events

Chapter 5- Current Condition and Species Needs

Introduction

This section describes the biological needs and situational background of the Gila trout and is intended to give a clear sense of the species' current status and inform the recommended approach to its recovery.

Current Condition and Species Needs

What the Gila trout needs to maintain viability is presented here by characterizing the status of the species in terms of its resiliency, redundancy, and representation (Wolf et al., 2015). For the purpose of this document, we define **viability** as the ability of a species to persist over the long term and, conversely, avoid extinction. We use the conservation principles of **redundancy**, **representation**, and **resiliency** (Shaffer and Stein, 2000) (together, the 3Rs) to better inform our view of what contributes to species' probability of persistence, how best to conserve them, and how to achieve recovery.

Redundancy describes the ability of a species to withstand catastrophic events. Measured by the number of populations, their resiliency, and their distribution (and connectivity), redundancy gauges the probability that the species has a margin of safety to withstand or can bounce back from catastrophic events (such as a rare destructive natural event or episode involving many populations.

Representation describes the ability of a species to adapt to changing environmental conditions. Representation can be measured by the breadth of genetic or environmental diversity within and among population and gauges the probability that a species is capable of adapting to environmental changes. The more representation, or diversity, a species has, the more it is capable of adapting to changes (natural or human-caused) in its environment. In the absence of species-specific genetic and ecological diversity information, we evaluate representation based on the extent and variability of habitat characteristics across the geographical range.

Resiliency describes the ability of a population to withstand stochastic events (arising from random factors). We can measure resiliency based on metrics on population health; for example, birth versus death rates, and population size. Highly resilient populations are better able to withstand disturbances such as random fluctuations in birth rates (demographic stochasticity), variations in rainfall (environmental stochasticity), or the effects of anthropogenic activities.

Summary of the Current Status of Gila Trout

Redundancy

Redundancy is a function not only of the number of populations (Brown et al., 2001) but also their spatial distribution across the landscape (Wolf et al., 2015). Recovery actions implemented to date have greatly improved redundancy by increasing the number of populations of Gila trout to 23. However, spatial distribution of populations is constrained by the geographical distribution of currently suitable habitat for the species.

Representation

With respect to representation, the genetic diversity of Gila trout is encompassed in the remnant lineages of Main Diamond Creek, South Diamond Creek, Whiskey Creek, Spruce Creek, and Iron Creek (see section on Genetics in Chapter 2). The Main Diamond and South Diamond lineages are relatively secure, with hatchery broodstock and production having been successfully developed and populations present in numerous streams by the end of 2016 (Table 7). The current situation of the other three lineages is less secure, and three mixed-lineage populations existed by the end of 2022. The remnant-lineage populations occurring in Whiskey Creek and Spruce Creek were extirpated following large-scale, high-severity wildfire. Spruce Creek lineage fish were restocked into Spruce Creek in 2018, which makes it the third stream representing that lineage. Whiskey Creek lineage fish are represented in four streams. The Iron Creek lineage occurred in three streams at the end of 2016, and those populations contains unique genetic variation. Finally, three mixed-lineage populations existed at the end of 2022, due to the Whitewater Creek restoration (Table 7). Genetic introgression with introduced rainbow trout or rainbow x Gila trout hybrids remains a threat to at least some of the populations due to illicit stocking or failure of fish barriers to prevent upstream movement of nonnative salmonids

Resiliency

Resiliency of Gila trout is constrained by the patchy distribution and geographic isolation of cold-water streams, many of which are single-stream systems that are relatively small, throughout its historical range (see section on Historical Range and Current Distribution). Few, if any, extant populations of Gila trout are large enough to survive extremes in environmental conditions without experiencing a severe population bottleneck (drastic reduction in population size) (Gilpin and Soulé, 1986; see section on Habitat Loss and Fragmentation). Currently, only the Mogollon and Willow creek drainages (where the South Diamond lineage has been established) have a dendritic population structure, and even the largest single-stream systems where Gila trout have been repatriated (e.g., Black Canyon) have been subject to local extirpations associated with environmental stochasticity (see section on Conservation Efforts).

Biological Constraints and Needs

The biological constraints and needs of Gila trout comprise inherent limiting factors, and therefore must be incorporated into the recovery and conservation program for the species. The threats described in the Assessment of Threats section above exert stressors on particular limiting factors, such as the potential effect of a future warmer, drier climate on water temperature. Furthermore, limiting factors place constraints on recovery planning and implementation. For example, Gila trout cannot be successfully repatriated to formerly suitable habitats within its historical range that no longer have perennial flow. Consequently, recognition of biological constraints and needs in this Recovery Plan will ensure that ecologically relevant and valid goals, strategies, and recovery actions are developed, given the current state of knowledge and understanding of the species and its habitat.

Perennial Stream Flow

Persistent, viable populations of Gila trout require perennial stream flow. Ephemeral and intermittent stream reaches may support Gila trout temporarily but not over the long term. Continuous occupation of a stream reach is possible only when flow is perennial. Additionally, stream flow must be adequate to maintain sufficient habitat diversity (see section on Diversity of Habitats below) and volume to support all life stages of Gila trout (eggs, fry, juveniles, adults). Flow regimes required to maintain sufficient habitat diversity and volume vary depending on site-specific characteristics of stream reaches (e.g., stream gradient, seepage, substrate composition, channel dimensions, watershed hydrology).

Suitable Water Temperature Regime and Water Quality

Gila trout require cold-water aquatic habitats with unimpaired water quality. Suitable water temperature regimes are characterized by maximum water temperatures that do not exceed 26^{o}C (78^{o}F). Suitable water quality for Gila trout is characterized by high dissolved oxygen concentration, low turbidity and conductivity, low levels of total dissolved solids, near-neutral pH, and low conductivity.

Diversity of Habitats

In addition to perennial stream flow and suitable water temperature and water quality, Gila trout require a diversity of habitats sufficient to sustain all life stages of the species. This includes suitable spawning habitat, habitat where fry can find shelter and food, and areas suitable for occupancy by juvenile and adult Gila trout. Specific habitat attributes required by Gila trout are described in the section on Habitat Characteristics. The two most important features with respect to population persistence are likely sufficient pool habitat (Harig and Fausch, 2002) and spawning habitat (Magee et al., 1996; Suttle et al., 2004).

Population Size and Habitat Connectivity

The threat of local extinction of native salmonid populations increases with isolation and decreasing population size (see review in Fausch et al., 2006; also Caughley and Gunn, 1996; Hanski, 1999; Fausch et al., 2009; Roberts et al., 2013). It follows that persistence of Gila trout over the long term requires combinations of sufficiently large occupied habitats and, where possible, connectivity in dendritic stream networks, not only with respect to population size but also to maintain genetic variation (Morrissey and de Kerckhove, 2009; Wofford et al., 2005) and access to suitable habitat in response to environmental variation and life history requirements (Young, 2011). Many streams within the presumed historical habitat of Gila trout in Arizona may not fully meet the requirements listed here. However, smaller stream segments in Arizona and New Mexico have been shown to support viable populations in the past (Sheep Corral Canyon, Main Diamond, South Diamond, Frye Creek, and Grapevine Creek). Considering the limited amount of available habitat, small streams, although not ideal, may be useful in meeting recovery requirements for Gila trout.

Absence of Nonnative Salmonids

A key biological need for sustaining viable populations of Gila trout is the absence of nonnative salmonids (Family Salmonidae, Figure 2). The threats of brown trout (*Salmo trutta*) predation and competition (see section on Nonnative Trout Predation and Competition) and human-mediated introgressive hybridization with nonnative *Oncorhynchus* species (see section on Human-mediated Introgressive Hybridization) result from the presence of nonnative salmonids. Viable populations of Gila trout cannot persist when nonnative *Oncorhynchus* species are present. Consequently, the absence of nonnative salmonids is a fundamental requirement for sustaining viable populations of Gila trout.

Chapter 6- Recovery Program

Introduction

This section describes the goal, strategy, objectives, and criteria for the Gila trout recovery program, and identifies the specific actions that, when implemented, would alleviate known threats to the species and restore Gila trout to long-term sustainability.

Recovery Goal

The goal of the recovery program is to improve the conservation status of Gila trout to the extent that the species is viable and no longer requires protection under the ESA. To ensure that the Gila trout will no longer meet the definition of threatened or endangered, multiple resilient populations need to be well-distributed in suitable habitats throughout the species' historical range, and threats to its existence must be eliminated or sufficiently abated.

Recovery Strategy

The primary focus of the recovery effort for Gila trout is to evolve from a crisis-management situation focused on preventing extinction to a perspective of sustainable populations established throughout the historical range that contain the breadth of genetic diversity of the species (Redford et al., 2011). This will entail incremental replacement of nonnative salmonids with Gila trout in suitable habitat throughout the historical range of the species. This strategy will be implemented by conducting actions to substantially improve redundancy, representation, and resiliency (*cf.* Haak and Williams, 2013; Wolf et al., 2015), as noted in Table 7, to the point that protections under the ESA are no longer necessary.

Table 8. Summary of the recovery strategy to address aspects of redundancy, representation, and resiliency for Gila trout.

	Current Situation	Recovery Strategy
Redundancy	Spatial distribution somewhat geographically clustered due largely to availability of suitable habitat.	Increase spatial distribution, where possible, and number of populations.
Representation	Main Diamond and South Diamond lineages are relatively secure. Status of the other three lineages is less secure. Few mixed lineage populations exist.	Maintain and conserve the genetic diversity and integrity of the species. Increase number of replicates of each genetic lineage. Increase number of mixed-lineage metapopulations.
Resiliency	Few populations have dendritic structure; most populations are relatively small and isolated.	Increase the number of large populations with dendritic metapopulation structure. Increase population size and interconnectedness.

Key Assumption

It is assumed that sufficient suitable habitat will be available in the future and that the effects of climate change will not be so severe as to preclude recovery of the species. Current information indicates that consequences of climate change are likely to be substantial for cold-water habitats within the historical range of Gila trout. However, actual changes in habitat conditions that may occur are unknown, as are actions that society may or may not take to address climate change.

Recovery Units

The previous version of the recovery plan defined two recovery units as a context for delisting criteria (USFWS, 2003). These were the Gila River Recovery Unit, consisting of three remnant lineages in the upper Gila River drainage (Main Diamond, South Diamond, and Whiskey creeks) and the San Francisco River Recovery Unit, which consisted of the Spruce Creek lineage. A recovery unit is defined as “a special unit of the listed entity that is geographically or otherwise identifiable and is essential to the recovery of the entire listed entity, i.e., recovery units are *individually necessary* to conserve genetic robustness, demographic robustness, important life history stages, or some other feature necessary for long-term sustainability of the *entire listed entity*” (National Marine Fisheries Service and U.S. Fish and Wildlife Service, 2010). Identification of recovery units is optional in recovery plans (National Marine Fisheries Service and U.S. Fish and Wildlife Service, 2010).

The use of recovery units is discontinued in this plan for several reasons. First, it imposed unnecessary constraints on recovery of the species. For example, under the use of recovery units, recovery would not be achievable if the Spruce Creek lineage were lost. While such an event would certainly be unfortunate, it would not necessarily preclude recovery and long-term sustainability of Gila trout as a biological entity. Secondly, information and knowledge of the genetics of Gila trout gained since the last recovery plan revision highlight the conservation importance of genetic exchange between lineages in mixed populations. While the recovery unit approach did acknowledge mixed-lineage populations, it only specified San Francisco River-Gila River unit combinations as contributing to recovery (USFWS, 2003). The benefit of other lineage combinations in developing mixed-lineage populations is now recognized. Consequently, it was determined that identification of recovery units is not necessary for recovery of Gila trout.

Recovery Objectives

The recovery goal is expressed by the following objectives:

1. Secure the existing genetic diversity of Gila trout through the establishment of additional populations (both single lineage stream segments and mixed-lineage metapopulations), the prevention of introgression by nonnative salmonids, the continuation of development

of broodstock and hatchery production programs, and the continuation of work on assessment of genetic diversity and detection of introgression.

2. Increase the geographic distribution of the species so that it inhabits a substantial portion of its historical range which represents the spectrum of ecological conditions present in suitable habitats (Carroll et al., 2010).
3. Increase the size, dendritic metapopulation population structure, and interconnectedness of populations through nonnative salmonid removal and the strategic installation or modification of barriers (to prevent nonnative salmonid invasion but also to improve access to diverse habitats).

These objectives can also be presented in the context of redundancy, representation and resiliency:

- Redundancy: Viable populations of Gila trout are established in watersheds throughout the historical range of Gila trout, as constrained by availability of suitable habitat.
- Representation: Genetic diversity of Gila trout is maintained by establishing viable populations that replicate remnant genetic lineages, genetic diversity is augmented through planned lineage mixing, and all recovery streams are free of and protected from invasion by nonnative trout.
- Resiliency: The combination of numbers and sizes of Gila trout populations are sufficient to maintain genetic diversity, allow for persistence, and maintain evolutionary potential.

Recovery Criteria

The following are objective, measurable criteria which, when met, may result in a determination that Gila trout be removed from the endangered species list:

Criterion A – Area of Occupancy

Gila trout occupy 280 km. (174 mi.) of stream within the historical range of the species. Occupancy, in the context of this criterion, refers to streams with suitable habitat to support all life stages of Gila trout (see Habitat Characteristics Chapter 3) being inhabited by viable populations. Criterion A explicitly addresses recovery objectives 1, 2, and 3.

Justification

Viable populations are defined as those populations that exhibit annual reproduction, size structure indicating multiple ages, and individuals attaining sufficient sizes to indicate three to seven years of survival (USFWS, 2006). An analysis of extinction probability based on results of a PVA by Brown et al., (2001) indicated that 280 km. (174 mi.) of occupied stream resulted in approximately 3% probability of extinction. Brown et al., (2001) focused on risk associated with catastrophic wildfire; however, the PVA did not account for the large-scale wildfires that have recently burned in the Gila River Basin, NM. Population viability defined as a less than ten percent extinction probability has been used in other recovery plans (USFWS, 2010) and by the International Union for Conservation of Nature as a threshold in assessing a species' vulnerability of extinction. In recognition of the severity of recent wildfires that were not evaluated by Brown et al., (2001), using stream occupancy associated with a more conservative extinction probability is prudent. Additionally, better, more precise mapping of suitable stream habitat resulted in a slight increase from 273 km. in the 2006 plan to 280 km. required in this plan, which will provide sufficient redundancy and resiliency for Gila trout recovery.

The threat of climate change and factors associated with climate change (wildfire, drought, and stream temperature) are highly variable throughout Gila trout habitat (Dennison et al., 2014, Kennedy et al., 2014; and Isaak et al., 2016). Although climate change is a threat to Gila trout, a recent analysis of vulnerability of Gila trout to future wildfire and stream temperature projections indicates that most currently occupied and unoccupied, available streams will maintain suitable temperatures into the 2080s (Dauwalter et al., 2017). The occupied length requirement (280 km.) should encompass a variety of habitats within and among streams to provide refuge for Gila trout when faced with the effects of climate change.

The previous revision of the recovery plan also included a minimum number of populations in the recovery criteria (USFWS, 2003). However, a population can be defined in a number of ways. For the purposes of Gila trout recovery and conservation, a population typically has been defined as the fish inhabiting a particular stream segment, or a short section of stream with no perennial tributaries that may be fragmented from the rest of the same stream and contains a type of barrier to fish migration (dry reach or waterfall) at the downstream end. This perspective is problematic when fragmented stream systems or “complex” dendritic systems[4] are considered (e.g., upper and lower Little Creek, Mogollon Creek and its tributaries Woodrow and Trail canyons and South Fork Mogollon Creek). For example, Brown et al., (2001) considered Mogollon Creek, Woodrow Canyon, Trail Canyon, and South Fork Mogollon Creek individual populations, as opposed to others who consider dendritic systems a single population unless impassable barriers are present (USFWS et al., 2015). Therefore, no minimum number of populations is required within this plan. Criteria B and C include additional representation, redundancy, and resiliency safeguards rather than including a minimum number of populations.

Criterion B – Remnant Genetic Lineages

Each remnant genetic lineage of Gila trout is represented by at least three geographically separate, viable populations and requires one replicate population of each lineage to be geographically separated by at least 34.0 km (21.1 mi) from the other two replicate populations of that genetic lineage. These populations and the streams they inhabit would contribute to meeting the area of occupancy threshold in Criterion A. Criterion B explicitly addresses objective 2, representation.

Justification

Conservation of genetically distinct lineages is an important component of maintaining the genetic integrity of Gila trout (Wares et al., 2004; Allendorf et al., 2013). Individual populations of each remnant genetic lineage should preferably be established in larger stream systems to maximize effective population size, thereby minimizing the loss of genetic variation through drift and inbreeding depression (Franklin and Frankham, 1998; Lynch and Lande, 1998; Rieman and Allendorf, 2001; Traill et al., 2010; Allendorf et al., 2013; Frankham et al., 2014). As described above, viable populations are defined as those populations that exhibit annual reproduction, size structure indicating multiple ages, and individuals attaining sufficient sizes to indicate three to seven years of survival. Persistent, viable populations may exist on the landscape at highly varying population sizes; therefore, specifying a number of individuals to define a viable population is not prudent, as population dynamics are a more appropriate predictor of population viability than is population size. Maintenance of genetic diversity within Gila trout lineages will be accomplished by replication of individual lineages to new streams, geographic separation between those replicated populations, and planned mixing of lineages in the remaining streams necessary to meet Criteria A and C. Planned mixing of lineages in the remaining recovery streams will ensure remnant genetic diversity is present across the range of Gila trout. Requiring a minimum distance between populations of individual lineages reduces the risk that one catastrophic event will affect all populations of that lineage. The distance of separation is based on the Whitewater Baldy Fire in 2012, which burned approximately 297,845 acres and had a maximum burn diameter of approximately 34.0 km wide (U.S. Forest Service, 2011), the largest fire in New Mexico history.

Criterion C – Dendritic Metapopulations

At least four dendritic metapopulations of Gila trout are established. These metapopulations and the streams they inhabit would contribute to meeting the area of occupancy threshold in criterion A. Criterion C explicitly addresses objective 3, and also contributes to meeting objectives 1 and 2.

Justification

Ideally, the dendritic metapopulations should support effective population sizes of at least 500 (Franklin and Frankham, 1998) and preferably over 1,000 individuals (Lynch and Lande, 1998; Traill et al., 2010; Frankham et al., 2014). Habitat fragmentation and isolation of local populations exerts a strong influence on loss of genetic diversity (Carim et al., 2016) and risk of extinction (Dunham et al., 1997). Much of the divergence among remnant genetic lineages of Gila trout likely does not reflect local adaptation but rather is the effect of drift (Wares et al., 2004). The isolation of remnant populations since widespread Euro-American settlement of the region has resulted in loss of genetic diversity and it is likely that, historically, there was genetic transfer within drainage systems (Turner et al., 2009).

As a result of the Whitewater-Baldy Fire, many isolated trout populations were eliminated; however, trout populations survived in all dendritic systems within the fire footprint, including Whitewater Creek, Willow Creek, West Fork Gila River, and Mogollon Creek. Larger dendritic systems may provide more refuge habitat during stressful environmental disturbances such as fires or floods (Nakamura et al., 2000). This demonstrates the value of dendritic systems for providing resiliency from catastrophic wildfire, floods, and drought.

The metapopulation concept is important in Gila trout recovery. As mentioned above, populations within the complex dendritic systems provided the resiliency against large catastrophic wildfire. We may not be able to produce a classical metapopulation with distinct populations, patches, or groups of individuals that experience local extinctions and recolonizations (Hanski, 1999; Rieman and Dunham, 2000). However, metapopulations can vary from the conventional definition depending upon spatial and temporal scales (Harrison and Taylor, 1997). In that regard we apply the metapopulation concept to complex dendritic systems within the suitable habitat of Gila trout. In the metapopulation concept here, any potential loss of a group of individuals (within a tributary, adjacent tributaries, or section of the mainstem) due to fire, flood, or disease may be reestablished by individuals from another portion of the metapopulation.

Additionally, increasing the genetic diversity will aid in achieving the desired representation of genetic information across lineages and resiliency of the metapopulation over time. When a dendritic system becomes available for Gila trout recovery efforts, the stocking strategy will be evaluated on a case-by-case basis in order to achieve the best representation of the available genetics given the limitations at that time (hatchery availability, habitat availability and quality, and existing genetic representation on the landscape). This strategy will contribute to attaining representation as well as realizing greater resiliency for Gila trout.

Criterion D – Absence of Nonnative Salmonid Species

Nonnative salmonids are absent from recovery streams, and measures such as barriers and eradication programs are in place to prevent re-invasion by nonnative salmonids. If non-hybridizing, nonnative salmonids persist in recovery streams, active management and suppression will occur to mitigate effects on the Gila trout recovery populations until complete eradication of nonnative salmonids is achieved. Criterion D explicitly addresses objectives 1 and 2.

Justification

A key biological need for sustaining viable populations of Gila trout is the absence of nonnative salmonids. The threats of brown trout predation and competition (see section on Nonnative Trout Predation and Competition) and human-mediated introgressive hybridization with nonnative *Oncorhynchus* species (see section on Human-mediated Introgressive Hybridization) result from the presence of nonnative salmonids. Reducing and eliminating nonnative trout from streams occupied by or potentially occupied by Gila trout is crucial to maintaining viable populations of Gila trout.

Recovery Actions and Implementation

Actions Needed

Recovery actions are the site-specific management actions needed to address threats to the species and achieve recovery criteria. For the Gila trout, implementation of the following recovery actions will involve participation from the USFWS, U.S. Forest Service, Arizona Game and Fish Department, and New Mexico Department of Game and Fish.

Recovery actions are assigned numerical priorities, as defined below, to highlight the relative contribution they may make toward species recovery.

- Priority 1: An action that must be taken to prevent extinction; or to prevent the species from declining irreversibly in the foreseeable future.

- Priority 2: An action that must be taken to prevent a significant decline in species population/habitat quality, or some other negative impact short of extinction.
- Priority 3: All other actions necessary to meet recovery objectives.

1. Repatriate Gila trout to streams within its historical range (Priority 1). Reintroduction of fish to extirpated habitats and stocking of fish to unoccupied streams will increase the number of Gila trout populations (species redundancy) across its range, thus increasing the species' ability to withstand catastrophic events such as large-scale, high intensity wildfires. Supplementing fish to increase the abundance in existing Gila trout populations will also increase the resiliency of those populations, making them better able to withstand the demographic stochasticity associated with small, isolated populations and environmental stochasticity associated with climate change.
2. Establish and maintain captive propagation methods and conservation hatchery facilities in suitable locations (Priority 1). Establishing and maintaining conservation hatcheries is directly related to recovery action 1. The hatchery stock will be used for the reintroduction to historical habitat that creates species redundancy by establishing new wild populations. It also mitigates the threat of extirpation of a genetic lineage due to catastrophic events in the remaining populations due to wildfire, climate change or introduction of a nonnative salmonid species that may hybridize with a wild population; maintaining a hatchery stock will allow for reestablishment of the genetic lineage due to these events.
3. Manage the presence of nonnative salmonids in recovery streams in Arizona and New Mexico (Priority 1). Managing and monitoring for nonnative salmonids allows the USFWS and its partners to try and prevent their establishment in streams that are home to wild Gila trout populations. Nonnative salmonids may outcompete the Gila trout and this may be exacerbated by the increased effects of climate change. Too, preventing the establishment of nonnative salmonids reduces the risk of predation on Gila trout and hybridization, which can lead to a decrease in natural genetic lineage and population abundance.
4. Monitor remnant and repatriated Gila trout populations within the Gila River drainage basin (Priority 2). Monitoring Gila trout populations provides increased data on how species are responding to environmental changes such as climate change, invasive species and wildfire. The increase in knowledge and understanding allows the USFWS to make more informed decisions regarding the recovery of Gila trout and adapt to changes in population sizes or habitat.
5. Conduct public education, involvement, and outreach in areas with an interest in Gila trout (Priority 3). Increasing public awareness and interest in restoring the Gila trout populations provides an additional resource to the USFWS for monitoring and responding to populations and changes to the environment on the local scale. An informed public can better understand how their decisions can affect the populations of Gila trout, including fire safety near native habitat and reducing the risk of introduction

of invasive species. Education on best logging and grazing practices can decrease the associated habitat fragmentation that leads to smaller populations. Maintaining healthy population sizes increases the resiliency of the Gila trout to adapt to environmental stochasticity.

6. Develop and implement rules to maintain sustainable Gila trout populations in recovery streams opened to sport fishing in Arizona and New Mexico (Priority 3). Implementing rules in recovery streams open to sport fishing will minimize the amount of unmanaged or illegal harvest by the public of the Gila trout. Managed sport fishing will create additional enthusiasm for the recovery of Gila trout, while ensuring that the size and number of fish removed will not create an additional burden on population growth.

Estimates of the cost and time required to implement these recovery actions and achieve the plan’s goal of recovering the Gila trout are outlined in Table 8 below.

Flexibility, which is essential to Gila trout recovery, can be hard to obtain with rigid timelines and schedules. Therefore, we will develop a Gila trout supplemental Recovery Implementation Strategy (RIS), which provides additional detailed, site-specific activities needed to implement the actions identified in this Recovery Plan. We intend to update the RIS as frequently as needed by incorporating new information, including the findings of future 5-year status reviews. The activities, schedules, and estimated costs identified in the RIS will be continually updated as recovery implementation progresses. Therefore, we anticipate being able to provide a greater degree of specificity in the RIS than via the recovery actions in the Recovery Plan.

Estimated Timing and Cost of Recovery

We expect the status of the Gila trout to improve such that we can achieve the delisting criteria in approximately 10 years. In other words, 2032 is the approximate date to reach the goal of recovery for the Gila trout. The time to recovery is based on the expectation of full funding, implementation of recovery actions as provided for in this Recovery Plan, implementation of activities as provided for in the RIS, and full cooperation of partners.

The total estimated cost of recovery is $15,619,030. This cost includes those borne by Federal and State governmental agencies, as well as other institutions, universities, and organizations with an interest in recovering the Gila trout.

Table 9. Annual cost estimates to implement recovery actions for the first 5 years are as follows:

Year 1	$1,494,900
Year 2	$1,381,800
Year 3	$1,552,300
Year 4	$1,895,600
Year 5	$1,725,500
Total Cost	$8,050,100

The estimated cost to implement the first 5 years of recovery actions (intermediate steps toward the goal of recovery) is $8,050,100. The calculation of the total estimated cost to recovery is included in the Recovery Action Table below. The cost of implementing the first 5 years of recovery, as well as a description of the costs for these years, is detailed in the Implementation Schedule Table of the RIS.

Implementation

The Recovery Action Table below (Table 9) lists actions and estimated costs for meeting the recovery objectives for Gila trout, as set forth in this Recovery Plan. Recovery actions are assigned numerical priorities, as defined above (see Recovery Actions section), to highlight the relative contribution they may make toward species recovery. Parties with authority, responsibility, or expressed interest to implement a specific recovery action are identified in the Recovery Action Table. When more than one party has been identified, the proposed lead party is indicated by a superscript plus symbol. As stated in the Disclaimer, recovery plans are advisory documents, not regulatory documents. A recovery plan does not commit any entity to implement the recommended strategies or actions contained within it for a particular species, but rather provides guidance for ameliorating threats and implementing proactive conservation measures, as well as providing context for implementation of other sections of the ESA, such as section 7(a) (2) consultations on Federal agency activities, development of Habitat Conservation Plans, or the creation of experimental populations under section 10(j).

Table 9. Recovery Action Table detailing the site-specific management actions needed for Gila trout recovery. Abbreviations are: **USFWS** = U.S. Fish and Wildlife Service; **USFS** = U.S. Forest Service; **AZGFD** = Arizona Game and Fish Department; **NMDGF** = New Mexico Department of Game and Fish. Increases in annual costs are meant to reflect annual inflation rates of 2.0%.

Priority #	**Action #**	**Action Description**	**Action Duration**	**Responsible Parties**	**Total Estimated Cost ($)**	**Threat(s) Addressed (ESA Listing Factor)**
1	3	Manage the presence of nonnative species in recovery streams in Arizona and New Mexico	8 years	USFWS, USFS, AZGFD, NMDGF	3,437,000	Effects of climate change (Factor A) Nonnative species predation and competition (Factor C) Human-mediated introgressive hybridization; (Factor E)
2	4	Monitor remnant and repatriated Gila trout populations within the Gila River drainage basin	10 years	USFWS, USFS, AZGFD, NMDGF	1,391,000	Large-scale, high-severity wildfire; Effects of climate change (Factor A) Human-mediated introgressive hybridization; Small population size (Factor E)
3	5	Conduct public education, involvement, and outreach in areas with an interest in Gila trout	10 years	USFWS, USFS, AZGFD, NMDGF	320,000	Large-scale, high-severity wildfire, Effects of climate change (Factor A) Small population size (Factor E)
3	6	Develop and implement regulations to maintain sustainable Gila trout populations in recovery streams opened to sport fishing in Arizona and New Mexico	10 years	USFWS, AZGFD, NMDGF	351,000	Illegal harvest (Factor B)
Total Cost					15,619,000	

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Glossary

Exon - a nucleotide sequence within a gene that becomes part of the final ribonucleic acid (RNA) produced by that gene after introns (non-protein coding nucleotide sequences) have been removed by RNA splicing.

Hadley cell - a large-scale atmospheric circulation pattern characterized by the rising of warm, moist air near the equator, loss of moisture through precipitation, poleward divergence of resulting upper troposphere air masses, and subsidence or sinking of warm, dry air in subtropical zones of high aridity.

Hyporheic groundwater - water that travels along localized subsurface flow pathways for relatively short periods of time and then reemerges into the stream channel downstream.

Metapopulation - a spatially structured population where: 1) habitat consists of discrete patches or collections of habitats capable of supporting local breeding populations; 2) the dynamics of occupied patches are not perfectly synchronous; and, 3) dispersal among the component populations influences the dynamics and/or the persistence of the metapopulation (Rieman and Dunham 2000). The metapopulation concept critical to this criterion is the establishment of spatially structured populations, in which a lost portion of the metapopulation may be repopulated by individuals from the remaining portions.

Panmixis - random mating within a population (all individuals in the population have an equal probability of paired mating).

Phreatic groundwater – the portion of an aquifer, below the water table, in which nearly all available pores and fractures and fully saturated with water.

Appendix A – Morphological Description of Gila Trout

As described by David (1976, 1998) Gila trout has 135 to 165 scales in the lateral line series, 59 to 63 vertebrae, and 25 to 45 pyloric caecae in all populations except Spruce Creek, which has a mean of 48 pyloric caecae. Gila trout from Spruce Creek (a tributary to Big Dry Creek in the San Francisco River watershed) and Oak Creek (an extinct population from the Verde River drainage) have basibranchial teeth (David, 1976). The Spruce Creek population is morphologically similar to Apache trout (*O. apache*) (David, 1976), but biochemical systematics indicate it is more closely related to Gila trout (see section 1.3; Loudenslager et al., 1986; Riddle et al., 1998). Thus, the Spruce Creek population likely represents an evolutionary unit native to the San Francisco River drainage, which includes the Blue River (David, 1998).

In addition to confusions among co-occurring nonnative trout, chubs (*Gila* spp.) have been and may continue to be locally confused with Gila trout (*cf.* allusion to “Gila trout” versus “true trout” in Dinsmore, 1924; reference to “Verde trout” and “Gila trout” as local common names for chubs in Minckley, 1973). The two fish share a similar distribution, although chubs typically occur at lower elevations than Gila trout currently occupies. The two taxa may be confused partly because chubs may be caught by anglers fishing in trout waters. Chubs (family Cyprinidae) differ from Gila trout (family Salmonidae) in both body shape and coloration. Chubs lack an adipose fin and have a narrow caudal peduncle (the segment of the body to which the tail fin is attached). Also, chubs lack parr marks, golden coloration, yellow cutthroat marks, and the salmon-pink band found on Gila trout. Chubs are typically a mottled olive or dark silver color above the lateral line. Body coloration lightens to a light silvery hue below the lateral line (Sublette et al., 1990).

Appendix B – Gila Trout Genetics

Beamish and Miller (1977) reported karyotypes for Gila trout ranging from 2n = 55 to 2n = 58, with the majority of samples having a diploid chromosome number of 2n = 56. When 2n = 56, there were 49 metacentric or submetacentric chromosomes (diploid chromosomes in which the centromere occurs approximately in the middle) and seven acrocentric or telocentric chromosomes (diploid chromosomes in which the centromere is near or at, respectively, the end of the chromosome; Beamish and Miller, 1977). The number of chromosome arms in Gila trout is 105 (Beamish and Miller, 1977).

The karyotype of Gila trout is similar to Apache trout except that Gila trout has one more acrocentric and one less meta- or submetacentric chromosome (Beamish and Miller, 1977; Table B1). Beamish and Miller (1977) suggested that this may have resulted from a pericentric inversion in only one meta- or submetacentric chromosome in Gila trout. An inversion results when a chromosome breaks at two points producing a fragment, the fragment is inverted and then reattaches. A pericentric inversion is when the two breaks in the chromosome are on opposite sides of the centromere.

Table B 1. Karyotypes of Gila, Apache, rainbow and cutthroat trout (Beamish and Miller, 1977; Gold, 1977).

Species	Chromosome Number	Number of Acrocentric or Subtelocentric Chromosomes	Number of Chromosome Arms
Gila trout	56-58	7	105
Apache Trout	56-58	6-10	106
Rainbow Trout	60	16	104
Cutthroat Trout	64-70	22-34	104-106

Although chromosome arm numbers are unequal in rainbow trout and Gila or Apache trout, alignment of haploid chromosome arms does occur as evidenced by fertile hybrids of Gila x rainbow and Apache x rainbow trout (Brown et al., 2004).

Structural genes code for RNA or non-regulatory protein products, such as enzymes. Allozymes are the various forms of an enzyme that are coded for by the different alleles at a given gene locus. Allozymes provide a means for assessing genetic variation because they are a product of the DNA base-pair sequences that compose genes. The variation in allozymes is analyzed using protein electrophoresis.

Loudenslager et al., (1986) reported five diagnostic gene loci for differentiating Gila and rainbow trout (Table B2). However, Dowling and Childs (1992) could not confirm one of these loci, dipeptidase (*PEPA**), for discrimination of Gila and Apache trout. Dowling and Childs (1992) found three diagnostic loci for differentiation of Gila trout from nonnative trout (rainbow and cutthroat trout). These three loci were alcohol dehydrogenase (*ADH**), lactate dehydrogenase (*LDH**) and tripeptidase (*PEPB**).

Leary and Allendorf (1999) analyzed allozymes translated by 48 structural genes and found fixed to nearly fixed frequency differences at eight gene loci. These eight loci were considered diagnostic for Gila trout. The eight diagnostic loci reported by Leary and Allendorf (1999) were alcohol dehydrogenase (*ADH**), creatine kinase (*CK-C2**), fumarate hydratase (*FH-1**), glyceraldehyde-3-phosphate dehydrogenase (*GAPDH-4**), L-lactate dehydrogenase (*LDH-C**), tripeptide aminopeptidase (*PEPB**), phosphoglycerate kinase (*PGK-2**) and phosphoglucomutase (PGM-1*).

Table B 2. Allele frequencies for diagnostic gene loci in Gila and rainbow trout, from Loudenslager et al., (1986). Loci are: ADH* = alcohol dehydrogenase; PEPA* = dipeptidase; PEPB* = tripeptide aminopeptidase; MDH* = malate dehydrogenase; and mMEP* = malic enzyme. Loci nomenclature follows Shaklee et al., (1990).

Gene Locus	Allele	Gila trout Allele Frequency	Rainbow Trout Allele Frequency
ADH*	-120	0.025	
ADH*	-100		1
ADH*	-80	0.975	
PEPA*	110	1	
PEPA*	1400		
PEPB*	150	1	
PEPB*	100		1
MDH-3,4*	100	0.659	0.95
MDH-3,4*	75	0.341	
mMEP-3*	100		0.956
mMEP-3*	50		0.043

Mitochondrial DNA (mtDNA) exists as thousands of copies of small (*ca*. 17,000 base pairs), circular molecules in mitochondria. Mitochondrial DNA is maternally inherited and therefore typically does not undergo recombination during meiosis (pairing of homologous chromosomes from both parents). Mitochondrial DNA is haploid and progeny generally inherit a single genotype from the mother. Therefore, the mtDNA of a species represents a single, non-recombining genealogical unit with multiple alleles or haplotypes (Allendorf et al., 2013).

Dowling and Childs (1992) reported diagnostic characteristics of mtDNA from the products of two restriction endonucleases: *Nhe*I (a six-base recognizing enzyme) and *Mbo*I (a four-base recognizing enzyme). Gila and Apache trout had the same restriction fragment pattern for *Nhe*I, which differed from the restriction fragment pattern of rainbow trout by at least one site change. All three species had distinct fragment patterns for *Mbo*I, with Gila and Apache trout distinguished by differences at one site. Cutthroat trout had numerous fragment differences from Gila, Apache and rainbow trout in both enzymes (Dowling and Childs, 1992).

Riddle et al., (1998) analyzed variable sites in the 3’ and 5’ ends of the control region of mtDNA (a region of the mtDNA that is non-coding) from samples of Gila, Apache, cutthroat, rainbow and Gila x rainbow trout. They reported eight haplotypes at the 5’ end (377 base-pair sites) and 16 haplotypes at the 3’ end (195 base-pair sites) of the mtDNA control region. Restriction-site analysis of whole-genome mtDNA revealed eight different composite mtDNA haplotypes (R.1 through R.8) that varied from one another by two to 26 restriction-site changes. The control-region and whole-genome mtDNA haplotypes differentiated Gila, Apache, cutthroat, rainbow and Gila x rainbow trout (Table 3). Gila and Apache trout are differentiated by whole mtDNA restriction-site composite haplotypes: R.5 in Gila trout and R.3 in Apache trout (Table B3). The two native trout are distinguished from rainbow trout by 5’ end haplotypes (C5.6 and C5.7 in Gila and Apache trout and C5.1 in rainbow trout) and whole mtDNA restriction-site composite haplotype (R.5 in Gila trout, R.3 in Apache trout, and R.1 or R.2 in rainbow trout). Cutthroat trout is distinguished by unique control-region and whole mtDNA restriction-site composite haplotypes (Table B3). Both rainbow trout and Gila trout mtDNA haplotypes were found in the trout population in McKenna Creek. No populations were found with both Gila and cutthroat trout mtDNA haplotypes (Riddle et al., 1998).

Wares et al., (2004) reported a single diagnostic mtDNA control-region haplotype (AF517763) from Gila trout populations in the Gila River drainage (Table B3), as in the R.5 whole-genome mtDNA haplotype reported by Riddle et al., (1998). However, Wares et al., (2004) also reported four other mtDNA control-region haplotypes (AY490781 through AY490784) found only in the Spruce Creek population (Table B3). Seven mtDNA control-region haplotypes (AF517756 through AF517762) were recovered from rainbow trout (Table B3).

Table B 3. Mitochondrial DNA haplotypes for Gila, Apache, cutthroat and rainbow trout. The asterisk (*) denotes haplotypes specific to the Spruce Creek population of Gila trout. Haplotypes from Riddle et al., (1998) are noted for the 3' end of the mtDNA control region (C3 prefix), the 5' end (C5 prefix), and whole-genome mtDNA (R prefix). The R.5 haplotype in the Spruce Creek population of Gila trout had an increase of approximately 300 base pairs at the 3' end of the control region (Riddle et al., 1998).

Taxa	mtDNA Haplotypes	No. of Unique mtDNA Haplotypes	Source
Gila trout	C3.14, C3.15*, C5.6, C5.7*, R.5	3	Riddle et al., (1998)
Gila trout	AF517763, AY490781 – AY490784*	4	Wares et al., (2004)
Apache Trout	C3.14, C5.6, R.3	1	Riddle et al., (1998)
Apache Trout	AF517764 – AF517767, AY490785, AY490786	6	Wares et al., (2004)
Rainbow Trout	C3.01 to C.3.14, C5.1, R.1, R.2	16	Riddle et al., (1998)
Rainbow Trout	AF517756 – AF517762	7	Wares et al., (2004)
Cutthroat Trout	C3.16, C5.8, R.6	3	Riddle et al., (1998)

A 768 base-pair fragment of the nicotinamide adenine dinucleotide dehydrogenase subunit 4 region of mtDNA (MT-ND4) was sequenced by Wilson and Turner (2009) in an investigation of the phylogeny of freshwater *Oncorhynchus* species. Sixteen different MT-ND4 haplotypes were found (Table B4). Gila trout had two unique MT-ND4 haplotypes, as did Apache trout (Table B4). Eleven MT-ND4 haplotypes were found in cutthroat trout with six of these occurring in the Rio Grande subspecies (*O. clarkii virginalis*; Table B4). Five MT-ND4 haplotypes were reported for rainbow trout (Table B4).

Several studies have directly examined nuclear DNA markers including microsatellites and nucleotide sequences at various loci. Microsatellites are tandemly repeated nucleotide sequences, where the repeating unit is one to four nucleotides long. The variability in the number of times the unit is repeated in a given microsatellite is analyzed. The majority of microsatellites occur in non-coding regions of the genome.

Wares et al., (2004) found that the 499 base-pair sequence at exon 13 of the transferrin gene distinguished Gila and Apache trout from rainbow, cutthroat and other trout species. The distinctiveness of the exon 13 base-pair sequence in Gila trout and Apache trout consisted of two fixed nucleotide substitutions. No diagnostic microsatellite loci were found.

Turner (2013) examined variation at 13 microsatellite loci in Gila trout and rainbow trout. Multi-locus genotype analysis indicated a high probability ($p > 0.95$) that the Main Diamond Creek, South Diamond Creek, and Iron Creek populations had genetic backgrounds consistent with Gila trout, and that these three populations were more similar to each other than to rainbow trout. However, no unique alleles for Gila trout were identified for the 13 microsatellite loci that were examined.

Table B 4. MT-ND4 haplotypes (shown along top table row) for Oncorhynchus species from Wilson and Turner (2009). Common names of trout species are: *O. gilae* = Gila trout; *O. apache* = Apache trout; *O. mykiss* = rainbow trout' *O. clarkii* = coastal cutthroat trout; *O. c. virginalis* = Rio Grande cutthroat trout; *O. c. stomias* = greenback cutthroat trout; *O. c. pleuriticus* = Colorado River cutthroat trout; *O. c. utah* = Bonneville cutthroat trout; *O. c. bouvieri* = Yellowstone cutthroat trout; *O. c. lewisii* = westslope cutthroat trout; and *O. chrysogaster* = golden trout.

Taxa	FJ813495	FJ813496	FJ813497	FJ813498	FJ813499	FJ813500	FJ813501	FJ813502	FJ813503	FJ813504	FJ813505	FJ813506	FJ813507	FJ813508	FJ813509	FJ813510	FJ813511	FJ824664	FJ824665	DQ288268	DQ288269	DQ288270	DQ288271	ONHMTC
O. gilae															X	X								
O. apache													X	X										
O. mykiss																				X	X	X	X	X
O. clarkii												X												
O. c. virginalis	X	X	X	X	X	X																		
O. c. stomias							X																	
O. c. pleuriticus								X																
O. c. utah									X															
O. c. bouvieri										X														
O. c. lewisii											X													
O. chrysogaster																			X					

Appendix C – Gila trout Lineages

Loudenslager et al., (1986) reported genetic variation at six loci among four populations of Gila trout. Gila trout from the South Diamond Creek, Main Diamond Creek and Spruce Creek populations were homozygous at the *ADH** and *PGM** loci for alleles *-80* and *100*, respectively (Table C1). In contrast, the Iron Creek population was heterozygous at these two loci, with low frequencies of two unique alleles: *ADH*-120* and *PGM*85* (Table C1). The Spruce Creek population was fixed (homozygous) at four of the six loci examined, the Main Diamond Creek was fixed at three of the analyzed loci, and the South Diamond Creek population was homozygous at two of the six analyzed loci. Only the Iron Creek population was heterozygous at all six of the loci examined by Loudenslager et al., (1986).

Table C 1. Allele frequencies at six allozyme loci in four populations of Gila trout (data from Loudenslager et al., 1986). Allozyme loci are: ADH* = alcohol dehydrogenase; sIDDH* = L-iditol dehydrogenase (sorbital dehydrogenase); MDH = malate dehydrogenase; mMEP* = malic enzyme; PA* = para albumin; PGM* = phosphoglucomutase.

Locus	**Allele**	**South Diamond Creek**	**Main Diamond Creek**	**Spruce Creek**	**Iron Creek**
ADH*	-120				0.100
	-80	1.000	1.000	1.000	0.900
sIDDH-3*	170	0.367	0.062		0.200
	140	0.333	0.938	1.000	0.733
	100	0.300			0.067
MDH-3,4*	100	0.450	0.719	1.000	0.467
	75	0.550	0.281		0.533
mMEP-3*	100	0.900	1.000	0.750	0.933
	80	0.100		0.250	0.067
PA-1,2*	105	0.500	0.167	0.417	0.500
	100	0.500	0.833	0.583	0.500
PGM*	100	1.000	1.000	1.000	0.867
	85				0.133

Leary and Allendorf (1999) found substantial genetic divergence between Gila trout populations in the Gila River and the San Francisco River drainages. The two groups were fixed for different alleles at the *PGM-1** locus, as well as having marked differences in allele frequencies at other loci (Table C2).

Unique alleles were found in Gila trout from Main Diamond Creek (*sAAT-1*null* and *sIDHP-1, 2*80*) and South Diamond Creek (*sMEP-2*115* and *sMEP-2*85*; Table C2). Two other alleles (*sMDH-B1, 2*74* and *sMEP-1*100*) were found at variable frequencies in the three remnant populations in the upper Gila River drainage (Leary and Allendorf, 1999). The Whiskey Creek population did not contain any unique alleles and was either homozygous or has allelic frequencies intermediate between the Main Diamond Creek and South Diamond Creek populations at seven loci (Leary and Allendorf, 1999; Table 2).

Riddle et al., (1998) identified an mtDNA haplotype unique to the Spruce Creek population of Gila trout. The unique Spruce Creek mtDNA haplotype had a 300 base-pair length increase at the 3' end of the mtDNA control region. In subsequent analysis of the mtDNA control region, Wares et al., (2004) found four unique haplotypes (SPR1 through SPR4) in the Spruce Creek population. The upper Gila River drainage populations all shared a single haplotype, which was absent from the Spruce Creek population.

Peters and Turner (2008) reported substantial genetic variation among remnant populations of Gila trout through analysis of exon 2 of the major histocompatibility complex (MHC) class II β gene and six microsatellite loci. No MCH alleles were unique to any remnant population (Table C3). The *Ongi-DAB*0101* and *Ongi-DAB*0102* alleles were most common in the Main Diamond Creek and South Diamond Creek populations, while the *Ongi-DAB*0201* allele was most common in the Spruce Creek population (Table 3). The populations in Whiskey Creek and McKnight Creek (a replicate of the Main Diamond Creek population) contained all five MHC alleles (Table 3).

Table C 2. Allele frequencies at seven allozyme loci in five populations of Gila trout (from Leary and Allendorf, 1999). The McKnight Creek population was established with fish from Main Diamond Creek, the Mogollon Creek population was established with fish from South Diamond Creek and the Big Dry Creek population was established with fish from Spruce Creek. Allozyme loci are: sAAT-1* = aspartate aminotransferase; sIDHP-1, 2* = isocitrate dehydrogenase; sMDH-B1, 2* = malate dehydrogenase; sMEP-1* and sMEP-2* = malic enzyme; PGM-1* = phosphoglucomutase; and sSOD-1* = superoxide dismutase.

Locus	**Allele**	**McKnight Creek (Main Diamond)**	**Mogollon Creek (South Diamond)**	**Whiskey Creek**	**Spruce Creek**	**Big Dry Creek (Spruce)**
sAAT-1*	100	0.368	1.000	1.000	1.000	1.000
	null	0.632				
sIDHP-1,2*	100	0.925	0.804	1.000	1.000	1.000
	125	0.067	0.196			
	80	0.008				
sMDH-B1,2*	100	0.833	0.510	0.643	1.000	1.000
	74	0.167	0.490	0.357		
sMEP-1*	100	0.350	0.315	0.071		
	90	0.650	0.685	0.929	1.000	1.000
sMEP-2*	100	1.000	0.442	1.000	1.000	1.000
	115		0.135			
	85		0.423			
PGM-1*	133	1.000	1.000	1.000		
	Null				1.000	1.000
sSOD-1*	100	1.000	1.000	1.000	0.957	1.000
	152				0.043	

Table C 3. Allele frequencies at exon 2 of the MHC class II β gene in four remnant populations of Gila trout (from Peters and Turner, 2008). Frequencies are shown as ranges for remnant populations with samples also taken from replicated, wild populations (number of populations sampled is shown in parentheses). Single values are the frequency of an allele that was found in only one population. A blank cell indicates that the allele was absent from the population(s).

MHC Allele	Main Diamond (4)	South Diamond (2)	Whiskey (1)	Spruce (3)
Ongi-DAB*0101	0.500 - 0.867	0.567 - 0.600	0.250	0.281 – 0.313
Ongi-DAB*0102	0.033		0.036	
Ongi-DAB*0201	0.031 – 0.067	0.033 – 0.167	0.357	0.500 – 0.700
Ongi-DAB*0202	0.033 – 0.094	0.067	0.286	
Ongi-DAB*0301	0.067 – 0.367	0.167 – 0.400	0.071	0.188 – 0.219

Variation at the MHC gene indicated modest reduction in heterozygosity due to genetic drift, with an overall fixation index (F_{ST}) value of 0.214 among populations of Gila trout. The fixation index, which ranges from 0 (no genetic divergence, panmixis) to 1 (maximum genetic divergence, complete isolation), is a measure of the proportional increase in homozygosity attributable to population subdivision. An F_{ST} value greater than 0.25 indicates substantial genetic divergence among population subdivisions. A significant excess of homozygotes (compared to that expected under Hardy-Weinberg proportions) in MHC alleles was detected in the Spruce Creek population and one of its replicates, while a significant excess of heterozygotes in MHC alleles was detected in the Whiskey Creek population (Peters and Turner, 2008). Variation at the six microsatellite loci examined by Peters and Turner (2008) showed a pattern similar to that found at the MHC class II β gene. The Whiskey Creek population had the highest average gene diversity across all six microsatellite loci while a replicate of the Spruce Creek population (Raspberry Creek) had the lowest.

Status of the Iron Creek Population

Based on analysis of allozymes coded by eight gene loci, Leary and Allendorf (1999) indicated that the Iron Creek population "appeared to contain a few individuals recently descended from rainbow trout." Samples taken in May 1997 from four sites in Iron Creek found seven fish out of a sample of 12 from the uppermost site with genotypes that included alleles characteristic of both Gila trout and rainbow trout (Table C4). The average frequency of alleles characteristic of rainbow trout in the upper Iron Creek sample was 0.021 (Leary and Allendorf, 1999). Leary and Allendorf (1999) did not identify potential rainbow trout introgression in trout collected from any of the other three downstream sample sites in Iron Creek.

In contrast to the findings of Leary and Allendorf (1999), multi-locus genotype analysis using 13 microsatellite loci concluded with assignment of the Iron Creek population to Gila trout, not rainbow trout, and that there was a low probability ($p < 0.05$) of rainbow trout introgression in the population (Turner, 2013). Further, Riddle et al., (1998), and more recent analysis by Wade Wilson (Regional Geneticist, Southwestern Native Aquatic Resources and Recovery Center, U.S. Fish and Wildlife Service) found no evidence of rainbow trout introgression in analysis of mtDNA in samples from Iron Creek.

Turner (2013) suggested that the contradiction with Leary and Allendorf (1999) could have arisen from: 1) retention of ancestral polymorphism at allozyme loci; 2) retention of allozyme loci through the effect of purifying selection; or 3) past introgression and subsequent loss of rainbow trout alleles through backcrossing with pure Gila trout. Turner (2013) also reported that the Iron Creek population represents a unique evolutionary lineage. It was found to have unique alleles at relatively high frequencies at the MHC class II β gene, and that this population had the highest diversity among Gila trout populations at the MHC locus (Turner, 2013).

Analysis of single nucleotide polymorphisms (SNPs) at 28,127 loci using nextRAD sequencing methodology concluded that "there is no evidence of recent hybridization among species in any (Gila trout) individual surveyed," which included 31 specimens from Iron Creek (Turner and Camack, 2017). The analysis also found that the Iron Creek population is at least as "pure," genetically, as any of the other remnant populations, none of which have any indication of rainbow trout introgression (Wares et al., 2004). The SNP analysis indicated that the level of alleles similar to those found in rainbow trout (genetic similarities related to common ancestry) was the same in the Main Diamond, South Diamond, and Iron Creek populations (Turner and Camack, 2017).

Table C 4. Allele frequencies in 12 trout from upper Iron Creek collected in May 1997. Alleles identified by Leary and Allendorf (1999) as characteristic of Gila trout are shown first (e.g., ADH*25) and those identified as characteristic of rainbow trout are shown second (e.g., ADH*-100). Data are from Leary and Allendorf (1999).

Locus	**Allele**	**Frequency**
ADH*	25	0.984
ADH*	-100	0.016
CK-C2*	110	0.969
CK-C2*	100	0.031
FH-1*	70	0.938
FH-1*	100	0.062
GAPDH-4*	70	0.969
GAPDH-4*	100	0.031
LDH-C*	110	1
LDH-C*	100	
PEPB*	135	0.984
PEPB*	100	0.016
PGK-2*	90	0.984
PGK-2*	100	0.016
PGM-1*	-133	1
PGM-1*	-100	
Ave. Frequency of Alleles Characteristic of Gila trout		0.979
Ave. Frequency of Alleles Characteristic of Rainbow Trout		0.021

Considering the current understanding of conservation genetics the data reported by Leary and Allendorf in 1999 may not be indicative of introgression at all. As later noted by Allendorf et al., (2013), low levels of introgression (e.g., less than five percent, as in Table B4) may be difficult to distinguish from natural polymorphisms. Seemingly diagnostic alleles identified from limited reference samples may appear to become non-diagnostic as the number of individuals tested increases (Pritchard et al., 2007) or as the level of divergence between the hybridizing groups decreases (Sovic et al., 2014). In such cases, determining whether a shared allele represents recent hybridization or ancestral polymorphism may be largely subjective (Pritchard et al., 2007). An in-depth, locus-level analysis of introgression designed to distinguish whether SNPs shared between rainbow trout and Gila trout are due to common ancestry versus more recent introgression is underway (Turner and Camack, 2017).

Appendix D – Gila Trout Ecology and Life History

Reproduction and Fecundity

Fecundity is dependent upon body size and condition (Behnke and Zarn, 1976; Behnke, 1979). Nankervis (1988) described the relationship between total length (TL in mm) and ova number (F) as:

$\log_{10}F = (-3.0738) + (2.3305 \times (\log_{10}TL))$ for Main Diamond Creek, $r^2 = 0.92$; and

$\log_{10}F = (-3.5443) + (2.6078 \times (\log_{10}TL))$ for McKnight Creek, $r^2 = 0.92$.

Growth, Somatic Statistics, Survivorship and Longevity

Condition factor of Gila trout was found to vary from 0.4235 to 1.2149 in a data set that included samples from 11 streams and that spanned seven years (Propst and Stefferud, 1997). Propst and Stefferud (1997) also reported length-weight relationships for this data set using the function $W = ((aL^b) \times 10^{-6})$ where W = mass in grams, a = ordinate intercept, L = total length in mm, and b = slope of the regression line. Changes in physical habitat that affect Gila trout density and aquatic macroinvertebrate populations may be causes of variation in condition factor (Turner, 1989).

Diseases and Pathogens

The causative bacterium (*Renibacterium salmoninarum*) of bacterial kidney disease (BKD) occurs in very low amounts in brown trout populations in the upper West Fork Gila River drainage and in the Whiskey Creek population of Gila trout. The bacterium was also detected in the Main Diamond Creek, South Diamond Creek and Iron Creek populations and rainbow x Gila trout hybrid populations in McKenna Creek and White Creek. Trout populations in the Mogollon Creek drainage, McKnight Creek, Sheep Corral Canyon, and Spruce Creek have all tested negative for BKD. In the wild, BKD is not likely a threat to Gila trout populations because of limited distribution, low occurrence within populations, and lack of any clinical evidence of the disease in Gila trout (N. Wiese, U.S. Fish and Wildlife Service, Mora National Fish Hatchery, pers. comm., 24 August 2017).

The causative bacterium of BKD was confirmed in the Brood Year 2016 lot of Gila trout at Mora National Fish Hatchery in August 2016. The presence of BKD antibodies in the hatchery Gila trout was considered a sub-clinical exposure because survival rates were at all-time highs and all tested fish appeared healthy. Origin of BKD in the hatchery was suspected to be vertical transmission from 2013 Main Diamond broodstock spawned in the spring of 2016. Mora National Fish Hatchery routinely imports wild Gila trout and *Catostomus* species for broodstock management and polyculture purposes. These imported fish are kept in isolation facilities and quarantined prior to fish culture use. During spawning operations ovarian fluid samples are taken and tested for BKD infection to identify vertical transmission to offspring. Since ovarian fluid testing is not fail-safe, there is always some risk of BKD exposure. As a result of the positive BKD finding, all Brood Year 2016 Main Diamond Gila trout and the 2013-year class of Main Diamond broodstock were destroyed. This action was necessary to reduce the risk of horizontal transmission of the disease at Mora National Fish Hatchery. In 2017, Mora National Fish Hatchery reduced the number of fish on site to reduce stress and potential BKD outbreaks. The hatchery has since tested negative for BKD and is now classified as “BKD suspect.” If testing in 2018 is again negative, the hatchery will regain its “Class A” disease status.

Whirling disease is caused by the metazoan parasite *Myxobolus cerebralis*. The disease is a serious problem in hatchery and wild populations of rainbow trout throughout the western United States. Annual fish health inspections (which include testing for whirling disease) of selected wild and hatchery stocks of Gila trout have been conducted since 2011 and all wild and hatchery populations of Gila trout have tested negative for whirling disease. There have been no documented cases of whirling disease in Arizona or New Mexico.

In April 2010, cutthroat trout virus was detected in ovarian fluid of Gila trout broodstock from Main Diamond Creek and South Diamond Creek held at Mora National Fish Hatchery (Gila trout Recovery Team, 2010). This virus of the family Hepeviridae was described in 1988 and is not known to be associated with any disease (Batts et al., 2011). Spread of the virus to wild trout populations in the western U.S. is likely associated with shipments of infected eggs from hatcheries (Batts et al., 2011). It may be intentionally introduced to captive stocks to increase their resistance to more severe viruses, such as infectious hematopoietic necrosis virus. The impact, if any, of cutthroat trout virus on native fish species and its persistence in aquatic habitats is unknown.

Table D 1. Mean total length (mm) at age (year) for Gila trout from selected populations. Back calculated mean total length at annual (mm) compiled using data from Turner (1986); Turner (1989); Hanson (1971); and Nankervis (1988).

Population	Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
Sheep Corral Canyon	1983	771	138	204	243	None	None	None	None	None
South Diamond Creek	1975	85	143	219	303	337	None	None	None	None
South Diamond Creek	1983	69	124	182	223	256	None	None	None	None
Spruce Creek	1983	77	135	180	250	None	None	None	None	None
McKnight Creek	1976	102	179	235	290	None	None	None	None	None
McKnight Creek	1983	73	131	182	223	267	None	None	None	None
McKnight Creek	1987	63	128	158	190	206	248	274	None	None
McKnight Creek	1988	69	119	162	185	204	None	None	None	None
Main Diamond Creek	1969	45	86	120	157	163	None	None	None	None
Main Diamond Creek	1986	51	81	97	126	142	None	None	None	186
Main Diamond Creek	1987	53	88	113	137	146	167	214	148	None
Main Diamond Creek	1987	44	84	107	125	142	152	170	None	None

Appendix E – Water Quality in the Gila River Drainage Basin

In 2016, the cold-water or high quality cold-water aquatic life designated use was determined to be impaired in 21 stream segments within the historical range of Gila trout in New Mexico (Table 2 of main document). Water temperature was the cause of impairment in 18 of these 21 stream segments. Water temperature is influenced by the interaction of external factors (drivers) and internal factors (structure; Poole and Berman, 2001). External temperature drivers determine heat loading and water delivery to the stream, while internal stream structure determines the resistance of the aquatic habitat to warming or cooling through insulating and buffering processes. The primary drivers, or external factors, that influence temperature are climatic variables (e.g., solar radiation, precipitation, air temperature, wind speed) while the principle structural features, or internal factors, that insulate or buffer aquatic habitat include stream morphology, groundwater influences, and riparian canopy condition (Burkholder et al., 2008; Li et al., 1994; Poole et al., 2001). Aside from anthropogenic alteration of climatic conditions, the most immediate effect of human activities on temperature arise from impacts to characteristics of the watershed and alluvial aquifers, stream morphology and riparian canopy condition (Poole and Berman, 2001).

In small streams, riparian shading and phreatic groundwater inputs have the highest influence on water temperature, while hyporheic groundwater and tributary input have a moderate influence (Poole and Berman, 2001). Riparian shading and phreatic groundwater inputs provide thermal stability in small stream systems, while coarse sediment storage (such as that provided by large woody debris) drives hyporheic flow. Tributary input can have a major effect on overall stream temperature due to relatively low discharge characteristic of small stream systems during base-flow periods (Poole and Berman, 2001). Consequently, factors that influence infiltration in uplands, such as decreased vegetation cover, can reduce phreatic groundwater discharge and result in increased water temperature. Similarly, reduced riparian shading and channel widening increase heat loading to the stream system (Amaranthus et al., 1989). Simplification of channel morphology and increased fine sediment loading reduce hyporheic flow, resulting in loss of heat-exchange buffering capacity. Potential pathways of human-caused increases in water temperature are shown in Figure E1. Riparian and upland management pathways have the highest importance in small stream systems, while the channel engineering (modification) pathway is of moderate importance with respect to influences on water temperature. Channel modifications in habitats of Gila trout most frequently result from large flood events, particularly following high-severity wildfire in cold-water stream watersheds.

Chemical or physical impairment of cold-water streams within the historical range of Gila trout in New Mexico results primarily from sediment inputs or nutrients (Table 3 of main document). Sediment-related causes, including turbidity, were implicated in 5 of the 21 impaired cold-water streams while high nutrient levels were a cause of impairment in 3 of the listed streams. Numerous probable sources of sediment input were identified for these stream segments, ranging from road and bridge runoff to grazing (New Mexico Environment Department, 2016). The presence and concentration of organic and inorganic nitrogen in surface water may be indicative of water quality degradation resulting from livestock grazing (Nash et al., 2009). Concentrations of organic nitrogen in excess of 1.0 mg/L have been recorded in streams with watersheds subject to domestic livestock grazing, such as Canyon Creek (Table E1), Mineral Creek (Table E2), and

Negrito Creek (Table E2). High aluminum concentrations resulting in impairment of the cold-water aquatic life designated use were reported in Mogollon Creek and Willow Creek (Table 3 of main document).

Table E 1. Selected water quality parameters in four cold-water streams in the Upper Gila watershed. All units are mg/L except for specific conductance (umhos/cm) and turbidity (nephelometric turbidity units [NTU]). Source: U.S. Environmental Protection Agency (2016).

Parameter	**Black Canyon**	**Iron Creek**	**Turkey Creek**	**Canyon Creek**
Total Alkalinity	41.6-58.8	37.2-49.0	45.4-72.0	46.8
Bicarbonate	50.8-71.7	45.4-59.8	55.4-87.8	57.1
Calcium	11.0-16.6	7.7-10.9	7.3-12.3	13.2-14.6
Total Organic Carbon	<5-17.0	<5	<5-9.7	8.16-8.88
Hardness	43.7-60.4	30.9-41.9	28.7-33.7	59.1-59.5
Inorganic Nitrogen	<0.1-0.15	<0.1	<0.1	<0.1-0.95
Organic (Kjeldahl) Nitrogen	<0.1-0.55	<0.1-0.23	0.14-0.30	1.15-1.20
Magnesium	3.97-4.64	<1-3.58	2.51-2.83	5.58-6.32
pH	6.45-8.09	6.90-8.02	7.10-8.90	7.28-9.16
Phosphorus	0.05-0.12	<0.05-0.09	<0.05	0.19-0.25
Potassium	<1	<1	<1	5.73
Sodium	5.47-7.59	<1-5.43	17.8-40.5	7.16
Total Dissolved Solids	146-198	92-326	136-248	180-220
Total Suspended Solids	<3-157	<3	<3	6-11
Specific Conductance	107.4-143.6	80.4-95.3	140.3-256.8	112.3-146.3
Sulfate	10.4-15.7	<10	14.8-28.5	23.5
Turbidity	1.35-61.5	0.67-5.42	0.46-5.79	5.94-14.50

Table E 2. Selected water quality parameters in four cold-water streams in the San Francisco watershed. All units are mg/L except for specific conductance (umhos/cm) and turbidity (nephelometric turbidity units [NTU]). Source: U.S. Environmental Protection Agency (2016).

Parameter	**Mineral Creek**	**Negrito Creek**	**Whitewater Creek**	**Trout Creek**
Total Alkalinity	60.4-98.8	59.6-152.0	99.8-228.0	161-181
Bicarbonate	73.7-118.0	72.7-182.0	122-270	195-219
Calcium	9.9-22.5	14.5-36.2	6.0-77.4	27.8-43.4
Total Organic Carbon	<5-5.7	<5	<5-6.48	<5
Hardness	33.9-87.8	55.3-138.0	15.2-99.5	103-149
Inorganic Nitrogen	<0.1-0.13	<0.1	<0.1-0.12	<0.1-0.19
Organic (Kjeldahl) Nitrogen	<0.1-4.77	<0.1-2.72	<0.1-0.50	<0.1-0.60
Magnesium	1.83-7.66	4.61-11.50	<1-7.82	8.03-11.8
pH	7.00-8.37	6.80-8.45	6.40-8.47	6.80-8.23
Phosphorus	<0.05-0.11	0.07-0.11	<0.05-0.16	<0.05-0.19
Potassium	<1	<1-3.47	<1-3.11	<1-2.63
Sodium	7.98-14.50	7.9-27.8	10.1-20.2	20.7-24.2
Total Dissolved Solids	118-198	134-256	111-334	218-268
Total Suspended Solids	<3	<3-40	<3	<3-59
Specific Conductance	88.4-291.4	142.3-330.7	2.18-501.0	239.3-357.0
Sulfate	<10-10.4	<10-10.4	14.1-22.0	10.1-11.7
Turbidity	1.0-6.3	1.0-6.6	0.9-12.4	0.7-48.3

Table E 3. Selected water quality parameters in three cold-water streams in the Tonto watershed. All units are mg/L except for specific conductance (umhos/cm) and turbidity (nephelometric turbidity units [NTU]). Source: U.S. Environmental Protection Agency (2016).

Parameter	**Tonto Creek**	**Christopher Creek**	**Haigler Creek**
Total Alkalinity	25.9-74.8	69-99	199-243
Bicarbonate	31-91	69-112	234-296
Calcium	20.2-21.4	30-36	49.8-72
Total Organic Carbon	Not assessed	Not assessed	Not assessed
Hardness	73	103-122	209-255
Inorganic Nitrogen	<0.10-0.21	<0.10-0.14	<0.10-0.11
Organic (Kjeldahl) Nitrogen	<0.10-0.32	<0.10-0.61	<0.10-0.37
Magnesium	5.1	6.9-8.3	16-24
pH	7.40-8.38	7.10-8.19	7.19-8.61
Phosphorus	<0.10	<0.10-0.12	<0.10
Potassium	0.70-1.01	Not assessed	0.90-1.88
Sodium	<5.0	Not assessed	4.3-6.7
Total Dissolved Solids	51-112	113-166	216-297
Total Suspended Solids	<4-8	<1-12	<4-14
Specific Conductance	56-143	189-299	380-468
Sulfate	<10	17-31	<10-29.4
Turbidity	0.43-7.81	0.25-0.75	0.18-6.10

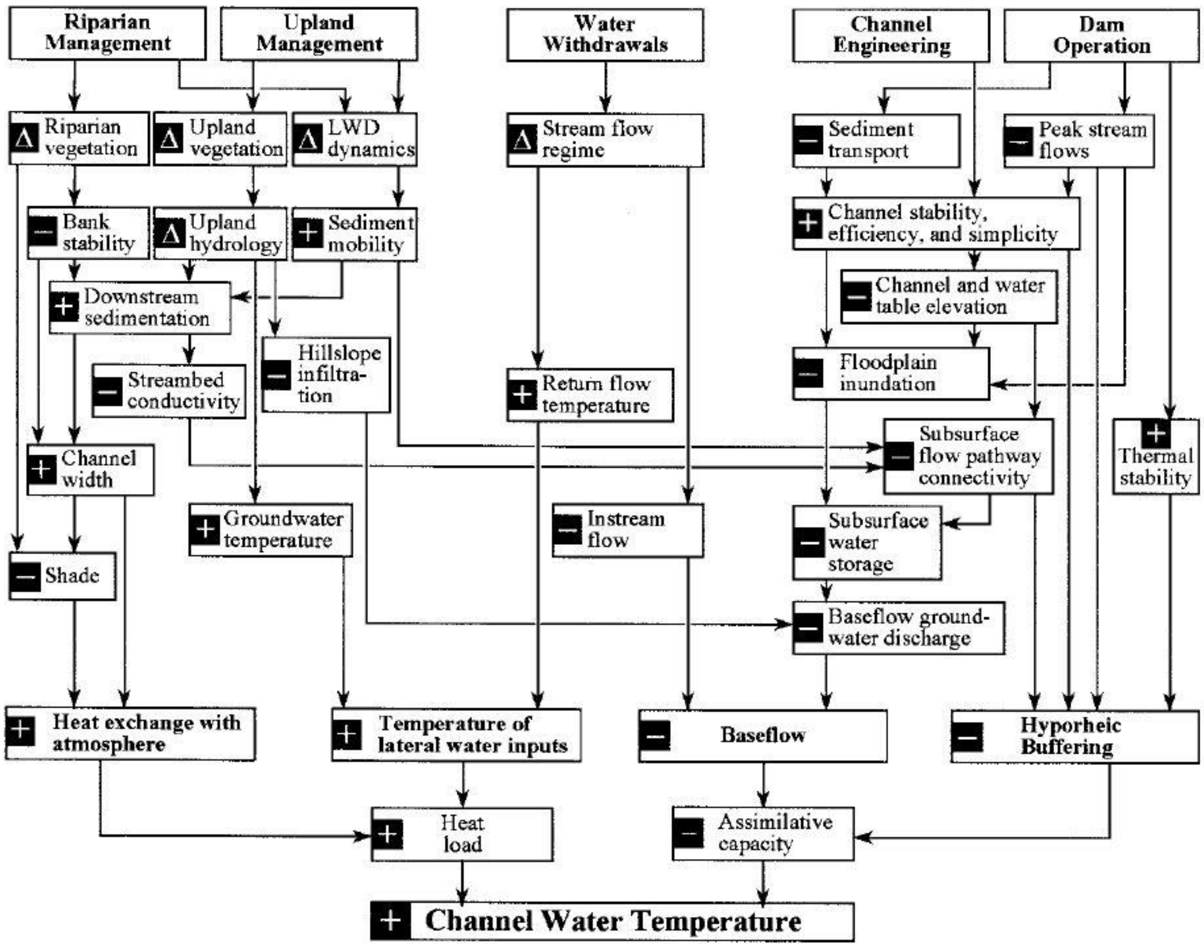


Figure E 1. Pathways of human-caused water temperature increases in stream systems. Symbols are defined as: **Δ** is a change in the state of the parameter or process (direction of change may vary); **+** denotes an increase in the parameter; and **–** denotes a decrease in the parameter. Excerpted from Poole and Berman (2001). LWD = large woody debris. The 'Riparian Management' and "Upland Management' pathways are most relevant to conservation of Gila trout.

Appendix F – Climate Change

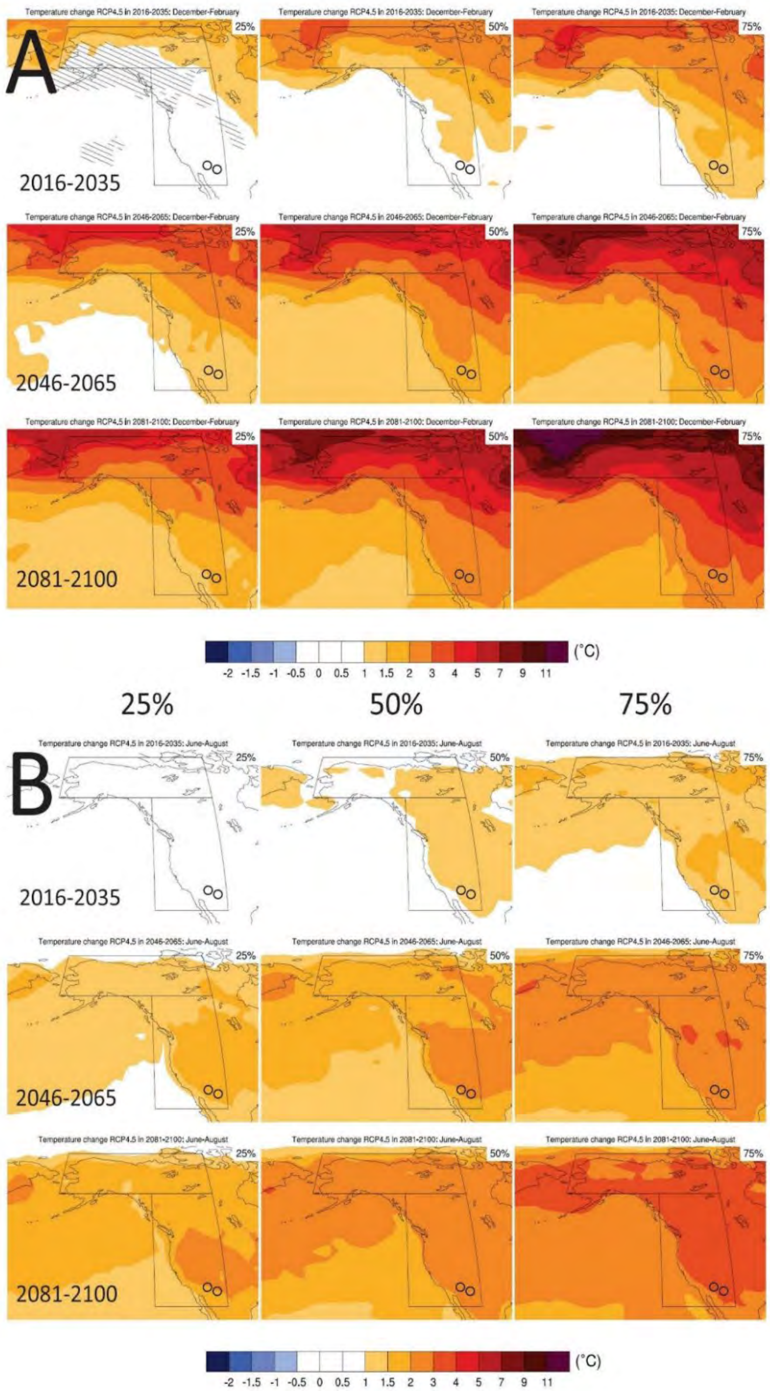


Figure F 1. Modeled temperature change during winter (A) and summer (B) months in 2016-2035, 2046-2065 and 2081-2100 (rows of figures) relative to 1986-2005. Results from the 25th, 50th and 75th percentile distribution of model runs are shown in the columns of figures. The small circles in each figure show the approximate location of the Gila R. and Verde R. headwaters for reference. Figures excerpted from van Oldenborgh et al., (2013).

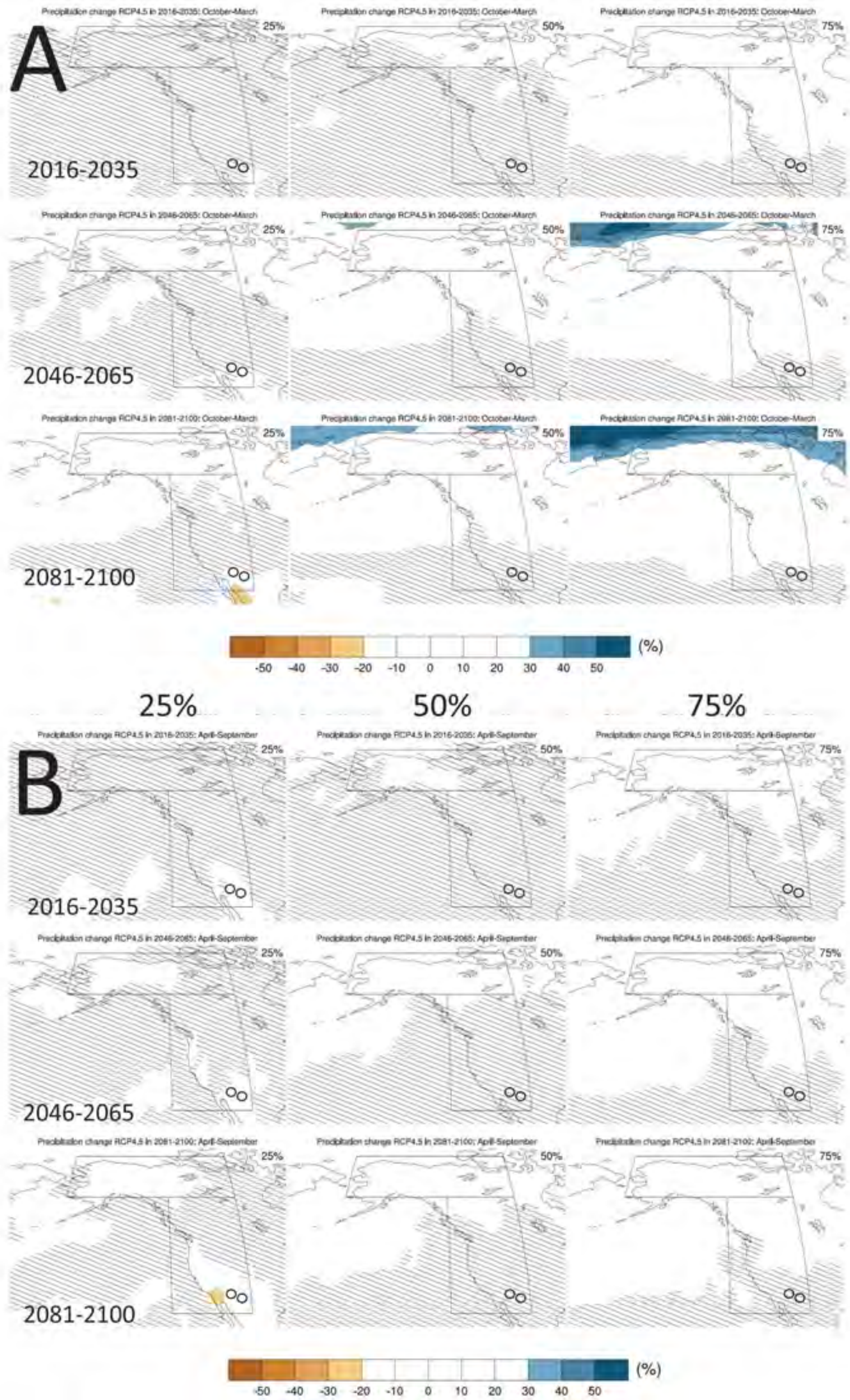


Figure F 2. Modeled precipitation change during winter (A) and summer (B) months in 2016-2035, 2046-2065 and 2081-2100 (rows of figures) relative to 1986-2005. Results from the 25th, 50th and 75th percentile distribution of model runs are shown in the columns of figures. The small circles in each figure show the approximate location of the Gila R. and Verde R. headwaters for reference. Hatching indicates conditions similar to present-day natural variation. Figures excerpted from van Oldenborgh et al., (2013).

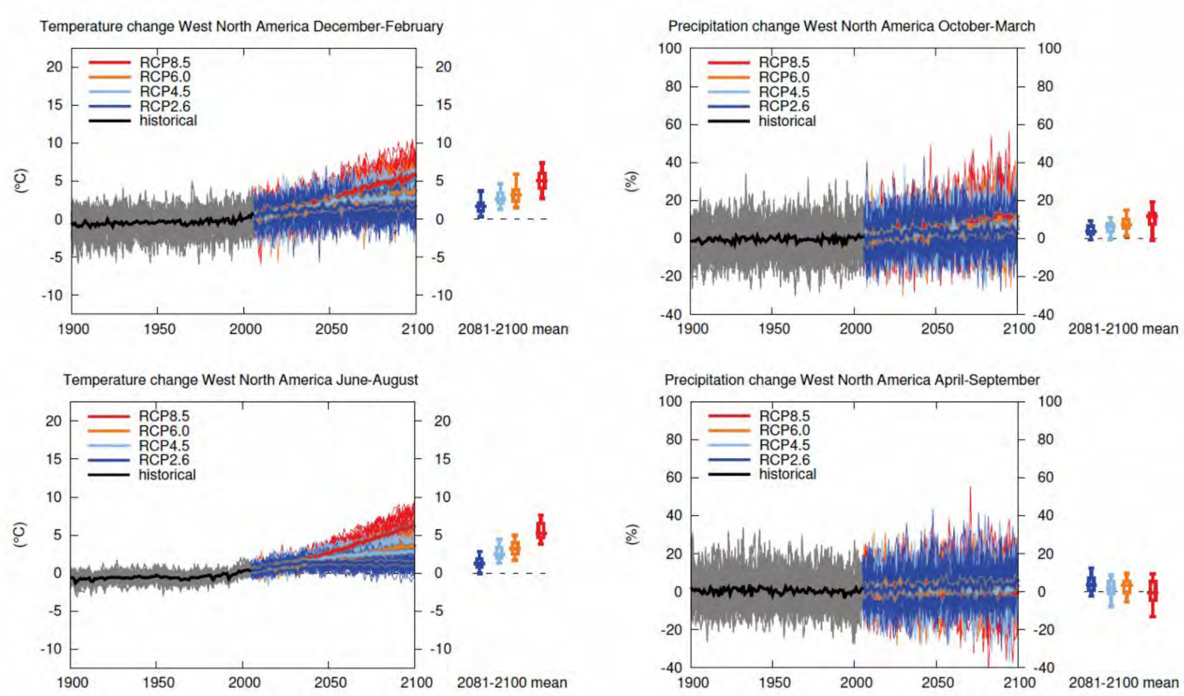


Figure F 3. Time series of temperature (left) and precipitation (right) projections relative to 1985-2005 for representative concentration pathway (RCP) scenarios (from van Oldenborgh et al., 2013). The four RCP scenarios represent radiative forcing values associated with different greenhouse gas emission rates and atmospheric concentrations. For example, RCP 8.5 is consistent with a future with no policy changes to reduce emissions, continued heavy reliance on fossil fuels, and an increasing global population growth rate whereas RCP 2.6 is based on declining use of oil, ambitious greenhouse gas emissions reductions, low energy intensity, and a slower global population growth rate.

Appendix G – Measures of Hybridization in Gila Trout

Hybridization is typically detected by analysis using molecular genetic markers (Scribner et al., 2001; Pritchard et al., 2007; Allendorf et al., 2013). Diagnostic loci that are fixed for different alleles in the two hybridizing species are identified and samples from individuals are analyzed to determine allele frequencies at the diagnostic loci. Individuals that are heterozygous for alleles at diagnostic loci from both parent species are first-generation (F_1) hybrids. Subsequent mating between hybrids or backcrosses between hybrids and parental stock produces individuals with variable genotypes composed of alleles from both parental stocks in homozygous and heterozygous combinations (Allendorf et al., 2013). The result is genetic admixture, which is defined as the “formation of novel genetic combinations through hybridization of genetically distinct groups” (Allendorf et al., 2013). A common outcome of continued crossing and backcrossing of fertile hybrids with parental stock is the production of a hybrid swarm, which is a population composed entirely of hybrid individuals (Allendorf et al.., 2013). This result of introgressive hybridization is referred to as genomic extinction because the combination of genotypes over the entire genome of the parent species is irretrievably lost (Allendorf et al., 2013).

Low levels of admixture (e.g., less than five percent) may be difficult to distinguish from natural polymorphisms (Allendorf et al., 2013). Seemingly diagnostic alleles identified from limited reference samples may appear to become non-diagnostic as the number of individuals tested increases (Pritchard et al., 2007) or the level of divergence between the hybridizing groups decreases (Sovic et al., 2014). In such cases, determining whether a shared allele represents recent hybridization or ancestral polymorphism may be largely subjective (Pritchard et al., 2007). Recent advances have improved techniques for quantifying admixture and distinguishing between recent introgression and shared ancestral variation (Durand et al., 2011; Hohenlohe et al., 2013; but see Martin et al., 2013 for qualifications).

Populations with low levels of presumed admixture may harbor unique native alleles or genetic diversity not found in other pure populations. Consequently, the presumed admixed populations may be considered to have conservation value (Campton and Kaeding, 2005). On the other hand, if a detected low level of admixture is actually the result of recent introgression, preservation of the population would perpetuate hybridization (Epifanio and Philipp, 2001). All progeny of a hybrid mating will be hybrid individuals, and the process is unidirectional. The frequency of hybrids in a local population may increase even if hybrids suffer high mortality, and parental taxa will trend toward extinction as introgression proceeds (Epifanio and Philipp, 2001). The increase in the proportion of hybridized individuals in the population may occur even when the proportion of admixture in the population is constant (Allendorf et al., 2013). From this perspective, introgressed populations may pose more of a risk than a benefit to conservation of imperiled species (Allendorf et al., 2004; Rubidge and Taylor, 2004).

Appendix H – Historical Accounts of Human-caused habitat degradation

Accounts of threats to Gila trout and habitat were recorded by USFS employees, naturalists, and residents before the mid-1800s. Those firsthand accounts described listed grazing, logging, and hydrologic alterations that shifted fish community structure and water availability. Some of those accounts are found below.

When Aldo Leopold began working in the Blue River drainage in 1908, the watershed had already been highly altered by 20 years of human use unrestrained by comprehension of the limits of productivity and ecological thresholds of the land. The historical conditions of the Blue River were described as follows (Leopold, 1921):

"All the old settlers agree that the bottoms of Blue River were, at the time of settlement in about 1885, stirrup-high in gramma grass and covered with groves of mixed hardwoods and pine. The banks were lined with willows and the river abounded with trout."

By 1900, only 15 years later, the Blue River "valley and its tributary valleys were eaten out" (Leopold, 1921). Fred Fritz, Jr., the son of one of the first settlers on the Blue River, recounted the excessive stocking of cattle and goats that occurred with settlement in the watershed, and the resulting effects on the landscape:

"During the severe drought which began in about 1899 and lasted until about 1903 ... water dried up and cattle died in great numbers ... and all ranchers took a great loss... [There] was no way to protect your range from over grazing by others, consequently there was no effort made on the part of the rancher to reduce numbers ... We all had too many cattle on the range back in those days. There was no incentive to try and save forage, you couldn't, other cattle moved in on you, consequently the range, especially around permanent waters, was abused ... In addition to the large number of cattle on the range at the turn of the century there were also thousands of goats and large numbers of horses and wild burros. On our particular range there were nine different goat outfits. Most of the goats were gone by 1910 but the scars they made are still here [1964]. It was in those early years that the country was hurt" (Stauder, 2009).

An investigation of watershed and hydrologic conditions in the Blue River drainage was conducted by the National Riparian Service Team in 2000 (Stauder, 2009), with the conclusion that "vegetation and site characteristics, along the entire length of the Blue River, appear to have been severely altered by a number of major impacts" and that "recovery to pre-disturbance conditions will necessarily take centuries if not millennia." The influence of historical overgrazing was summarized as follows:

"Continuous year long grazing was the historical norm in this area, as was common throughout most of the Southwest. Continuous year long grazing would have limited recruitment of bank stabilizing vegetation and future supplies of large wood. Overgrazing to the point of severely reducing upland vegetative cover further aggravates this by radically altering the hydrograph. The ability of the watershed to store and slowly release precipitation which falls on it is greatly reduced" (as cited in Stauder, 2009).

As recounted by Grace Johnson, who settled in the watershed in 1913:

"There used to be a lot more water in the Blue than there is now. There was enough water that at one time the miners in Clifton floated their logs down the river to Clifton from the Blue. They cut the logs up above the Box and floated them clear to Clifton" (Stauder, 2009).

Excessive grazing by domestic livestock (primarily cattle and sheep and, to a lesser extent, goats and hogs), which peaked around the turn of the 20th century, was reported to have led to severe degradation of streams on the Tonto National Forest in Arizona, as indicated in these excerpts from a 1926 paper entitled "History of Grazing on the Tonto" by Fred Croxen, a Forest Ranger on the Tonto (Tucker, 1989*a*):

"There were perennial grasses on the mesas along Tonto Creek where only brush grows at the present time. Mr. [Florence C.] Packard [who settled in the watershed in 1875] says that Tonto Creek was timbered with the local creek bottom type of timber from bluff to bluff, the water seeped rather than flowed down through a series of sloughs, and fish over a foot in length could be caught with little trouble. Today, this same creek bottom is little more than a gravel bar from bluff to bluff. Most of the old trees are gone, some have been cut for fuel, many others cut down for the cattle during droughts and the winters when the feed was scarce on the range, and many have washed away during the floods that have rushed down this stream nearly every year since the range started to deplete. The same condition applies to practically every stream of any size on the Tonto. The first real flood to come down Tonto Creek was in 1891 after it had rained steadily for 12 days and nights. At this time the country was fully stocked, the ground had been trampled hard, much of the grass was short, or gone, gullies had started and the water came rushing down."

The general condition of uplands within the watershed were described by another early settler, E. M. Watkins, who recounted that "There were no washes at all in those days [before extensive cattle stocking], where at present arroyos many feet deep are found and at places cannot be crossed." Furthermore, Fred Croxen reported that "All the men interviewed [by him] state that there was little brush in the country at the time stock was first brought in, and it was possible to drive a wagon nearly anywhere one desired." The loss of beaver in the region was reported by Mr. Vi Fuller, an early settler on the East Verde River, who stated that "... there were beaver in the streams in Tonto Basin in the early days but they were not trapped [out] by white men. The floods caused by the denuding of the ranges finally washed them out." Croxen concludes his report as follows (Tucker 1989*a*):

"The range was not only grazed out, but was trampled out as well. Moisture did not go down to the remaining grass roots and the cow trails were fast becoming gullies which drained the country like a tin roof. Sheet erosion started in many places, especially on the steep slopes and the thin soil was soon washed away and only rocks were left."

An example of how severe erosion and stream sedimentation could be at that time was provided by Leopold (1924), who reported a situation "… on the GOS cattle range in the Gila Forest, where earth-scars due to concentration of cattle along the water-courses have caused an entire trout stream to be buried by detritus."

By the time Henry Woodrow began working in 1909 as a forest ranger in the upper West Fork Gila River watershed, there were at least 13 homesteads in the "McKenna Park District" and cattle and sheep grazing was prevalent throughout the area (Tucker, 1989*b*). By that time, he noted that “The grass here was a bunch-grass type and did not have strength to keep a horse stout, so a great many of those [ranger patrol] trips were made on foot” and that “the main trails [were] ... made by stock.” Woodrow was stationed at White Creek, from where he patrolled “the fish streams and sheep camps on my way to Mogollon-Baldy and Lilly Mountain.” The widespread use of the upper West Fork Gila River drainage by sheep is attested to by Woodrow’s reports that much of his time was spent enumerating sheep on the district. He reported fighting fires, often alone or with a small group of men, which suggests that most fires at the time were quite small and easily contained, and that fuel loads were very limited. Historical coincidence of fire decline and heavy grazing, particularly by sheep, has been noted elsewhere in the Southwest (Savage and Swetnam, 1990).

Degradation of stream habitat in the upper Gila River watershed from past open-range, unregulated livestock grazing is indicated by early restoration efforts. During an inspection in August 1932, Assistant Regional Forester Hugh G. Calkins “mentioned the great improvement in grass, herbs, alders, and willows along stream courses in four areas of the Gila because of programs that reduced stocking and removed cattle from the sheep range” (Baker et al., 1988). Henry Woodrow reported working with crews in the early 1930s to construct fish “habitat improvements,” “fish dams” and fenced exclosures on streams, further suggesting that degradation of stream habitat from excessive livestock grazing was beginning to be recognized.

Appendix I – Gila Trout– Conservation Efforts Prior to 2011

The information provided in Tables I1, I2, and I3 below are graphical representations of the detailed conservation efforts provided in the text of this appendix.

Early 20th Century through 1960

Initial efforts to conserve Gila trout consisted of attempts by the New Mexico Department of Game and Fish to propagate the species in the early 1920s, when Gila trout was locally recognized as 'mountain trout' or 'speckled trout.' Propagation activities took place at Jenks Cabin Fish Hatchery starting in 1923 and at the Glenwood State Fish Hatchery beginning in 1937. These Gila trout culture programs were discontinued at the Jenks Cabin and Glenwood hatcheries in 1935 and 1947, respectively, due to low production. After the hatchery programs were abandoned, the New Mexico Department of Game and Fish implemented a policy of not stocking nonnative trout into the streams that were known to be inhabited by Gila trout. In the 1930s, the Civilian Conservation Corps constructed log stream improvement structures and fenced exclosures on streams in the Gila National Forest including Turkey Creek, Little Creek, Mogollon Creek, West Fork Gila River, Iron, Creek, White Creek, Willow Creek, and the Middle Fork Gila River (Tucker, 1989*a*). Scientific investigation of Gila trout originally came at the request of Elliot S. Barker, State Game Warden of New Mexico, and led to the description of the species from specimens taken at Glenwood Hatchery and Main Diamond Creek in 1939 (Miller, 1950). The New Mexico Department of Game and Fish closed Main Diamond Creek to fishing in 1958 (Hanson, 1971).

1960 through 1979

Gila trout was listed as endangered in the U.S. Fish and Wildlife Service "Red Book" in 1966. The species was listed as endangered in 1967 under the federal Endangered Species Preservation Act of 1966 (USFWS, 1967). A study of the ecology of Gila trout in Main Diamond Creek was sponsored by the New Mexico Department of Game and Fish in the early 1960s (Regan, 1966). A study conducted during 1969 and 1970 resulted in selection of McKnight Creek in the Mimbres River drainage as a replication site for the Main Diamond Creek population of Gila trout, and also identified populations in South Diamond, Spruce, and McKenna creeks (Table H; Hanson, 1971). After construction of a barrier and elimination of the native Rio Grande sucker (*Catostomus plebeius*) with rotenone, 307 Gila trout were transplanted from Main Diamond Creek into McKnight Creek in November 1970.

A management plan for Gila trout was developed by the Gila National Forest and New Mexico Department of Game and Fish in 1972 (Bickle, 1973). On 27 April 1972, 110 Gila trout from Main Diamond Creek were translocated into McKnight Creek to supplement the population. Also in 1972, 89 Gila trout from Main Diamond Creek were transplanted into Sheep Corral Canyon in an attempt to establish a new population in that stream (Table H; Turner, 1989). Sheep Corral Canyon above a waterfall (presumed to be a barrier to upstream fish passage) was devoid of fish prior to the transplant. The Endangered Species Act of 1973 provided protection to all species of wildlife that had been designated under the Endangered Species Preservation Act of 1966, which included Gila trout. In 1974, 65 Gila trout from Main Diamond Creek were translocated into Gap Creek, a tributary of the Verde River on the Prescott National Forest in Arizona (Minckley and Brooks, 1985; Warnecke, 1987). Stream surveys were conducted in 1974 and 1976 that established the distribution and status of Gila trout (David, 1976; Mello and Turner, 1980).

The first comprehensive taxonomic analysis of Gila trout was completed in 1970s (David, 1976), as was a cytotaxonomic study (Beamish and Miller, 1977). Methods for population estimation and habitat evaluation were tested in the late 1970s (Rinne, 1978). The first comprehensive assessment of the distribution of Gila trout was completed in the late 1970s (Mello and Turner, 1980). Replicate populations of the Main Diamond Creek lineage were established in McKnight Creek, Sheep Corral Canyon, and Gap Creek by direct transfer of fish from wild populations (Table I 1).

In 1979, the Gila trout Recovery Plan was approved by the U.S. Fish and Wildlife Service with the main objective being “To improve the status of Gila trout to the point that its survival is secured and viable populations of all morphotypes are maintained in the wild” (USFWS, 1979). An environmental assessment for Gila trout recovery projects on the Gila National Forest was approved in 1979 that authorized the stabilization and replication of indigenous populations of Gila trout involving both artificial barrier construction and piscicide application in streams within the Gila National Forest.

1980 through 1993

In 1981, a concrete and rock barrier was constructed on Iron Creek about 2.9 km (1.8 mi) downstream from an intermittent reach of the stream (Table I 1). Brown trout density was reduced with Antimycin A between the barrier and the intermittent reach after Gila trout had been removed from the area by electrofishing and placed in holding pens isolated from the toxicant. Gila trout were prematurely released into the renovated area and suffered high mortality (Coman, 1981). In 1984, 105 Gila trout were moved from the upper reach of Iron Creek downstream to the renovated area (Turner, 1989). Brown trout were removed from the renovated reach in 1985 and 12 Age II brown trout were removed in 1988.

Little Creek was selected as a site to replicate the population of Gila trout in McKenna Creek, which at the time was thought to be a genetically intact, remnant population of Gila trout. In 1982, a concrete and rock barrier was constructed on Little Creek and approximately 9 km (5.6 mi) of stream above the barrier were treated to remove nonnative trout (Table I 1). Desert sucker (*Catostomus clarki*) was also eliminated; however, speckled dace (*Rhinichthys osculus*) survived the treatment. In December 1982, 100 Gila trout were successfully transported from McKenna Creek to Little Creek.

The Gila trout Recovery Plan was revised in 1984 with the same objective as the original plan. Down-listing criteria in the plan stated that “The species could be considered for down-listing from its present endangered status to a threatened status when survival of the five original ancestral populations is secured and when all morphotypes are successfully replicated or their status otherwise appreciably improved” (USFWS, 1984).

The Spruce Creek population was replicated in Big Dry Creek in 1985 (Table I 1). A 1.9 km (1.2 mi) reach of Big Dry Creek above a 20 m (66 ft.) high waterfall was treated with Antimycin A in 1984. The first treatment did not remove all nonnative trout, so another treatment was applied in 1985. In October 1985, 97 Gila trout were translocated from Spruce Creek to the renovated reach of Big Dry Creek.

Upper Mogollon Creek and Trail Canyon were selected as sites for replicating the South Diamond Creek population of Gila trout. Trail Canyon was treated with Antimycin A in October 1986 and the stream was treated again in July 1987 to remove remaining nonnative trout (Table I 1). In September 1987, Trail Canyon was found to be fishless, and 305 Gila trout were transported by helicopter from South Diamond Creek to the stream. In October 1988, fish from South Diamond were used to supplement the Trail Canyon population (Propst et al., 1992). Mogollon Creek from its source to the confluence with Trail Canyon was initially treated with Antimycin A in July 1987 to remove nonnative trout. Nonnative trout survived the initial treatment of upper Mogollon Creek, and the stream was treated again in July 1988. At the same time Woodrow Canyon, a renovated tributary of upper Mogollon Creek, was stocked with Gila trout from South Diamond Creek. In April 1989, Gila trout brood stock were obtained from South Diamond Creek and taken to Mescalero National Fish Hatchery, and a third Antimycin A treatment was applied in upper Mogollon Creek. Eradication of nonnative trout in upper Mogollon Creek was confirmed in May 1989 and, in October 1989, the creek was stocked with 100 fingerling Gila trout from Mescalero National Fish Hatchery and 93 Gila trout from Trail Canyon.

In 1987, it appeared that down-listing criteria were rapidly being achieved, so the species was proposed for down-listing from endangered to threatened status (USFWS, 1987). In July 1989, a large portion of the 24,762 ha (61,190 ac) Divide Fire burned through the Main Diamond Creek watershed. An emergency evacuation operation during the peak of the fire removed 566 Gila trout from the stream to Mescalero National Fish Hatchery. Main Diamond Creek was sampled extensively in October 1989 and again in May 1990. The results of these surveys confirmed that the population of Gila trout in Main Diamond Creek had been extirpated. In October 1989, 200 of the evacuated Gila trout from Main Diamond Creek were stocked into McKnight Creek. The Divide Fire and loss of Gila trout prompted postponement of the down-listing proposal.

Monitoring of extant populations of Gila trout was conducted (Turner and McHenry, 1985; Turner, 1989) and numerous studies on the systematics, biology, habitat, and ecology of Gila trout were completed (Lee and Rinne, 1980; Rinne, 1980; Rinne, 1981*a*; Rinne, 1981*b*; Rinne, 1982; Mpoame and Rinne, 1984; Loudenslager et al., 1986; McHenry, 1986; Medina and Martin, 1988; Nankervis, 1988; Van Eimeren, 1988). A genetics study, including analysis of mitochondrial and nuclear DNA of all known Gila trout populations, suspected Gila trout populations, and related species was initiated in January 1988. Tissue samples for the study were collected in 1988 and 1989.

Studies on the habitat (Stefferud, 1994) and population dynamics (Propst and Stefferud, 1997) of Gila trout were completed in the 1990s. Also during this time considerable information was developed on the molecular genetics of Gila trout (Nielsen et al., 1998; Riddle et al., 1998; Leary and Allendorf, 1999; Leary et al., 1999). Stream habitat improvements were constructed and willow cuttings were planted in McKnight Creek in 1989 and 1990 by the U.S. Forest Service and New Mexico State University. The Iron Creek population of Gila trout was replicated at Sacaton Creek in May 1990, when 40 fish were stocked into the barren stream (Table I 1). A second stocking of 60 Gila trout from Iron Creek was made into Sacaton Creek in June 1991. Persistence of the brown trout population in Iron Creek, preliminary results of the 1988 and 1989 tissue sample analysis that indicated introgressive hybridization of rainbow trout in the McKenna Creek population, and extirpation of populations caused by catastrophic forest fire, resulted in a reevaluation and withdrawal of the 1987 down-listing proposal in 1991. A previously unknown population of Gila trout was discovered in an unnamed tributary to the West Fork Gila River in 1992. The tributary, referred to as Whiskey Creek, is in the upper West Fork Gila River drainage.

A fish barrier was improved on Mogollon Creek in July 1993 to prevent upstream movement of brown trout. A reach of White Creek above a waterfall barrier was renovated with three treatments of Antimycin A and 265 Gila trout from Iron Creek were transported to the stream on 21 October 1993. A second stocking was made in 1995. Evidence of illegal angling was discovered in Iron Creek in October 1993. The Gila trout Recovery Plan was revised in 1993 to incorporate new information about the ecology of the species and recovery methods obtained since the 1984 revision. Criteria for down-listing remained essentially the same as in the 1984 revision but were more specific. The 1993 plan specified that down-listing would be considered “when all known indigenous lineages are replicated in the wild” and when Gila trout were “established in a sufficient number of drainages such that no natural or human-caused event may eliminate a lineage.”

Table I 1. Status of Gila trout populations, pre-1980 through 1993. Numbers in each lineage indicate the number of extant populations of that lineage.

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Main Diamond Creek Lineage	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**3**	**3**	**2**	**2**	**2**
Main Diamond Creek (remnant)	→	→	→	→	→	→	→	→	→	E,Xf				
McKnight Creek	B,R,S	→	→	→	→	→	→	→	→	→	→	→	→	→
Sheep Corral Canyon	S	→	→	→	→	→	→	→	→	→	→	→	→	→
Gap Creek	S	→	→	→	→	→	→	→	→	→	→	Xd		
South Diamond Creek Lineage	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
South Diamond Creek (1) (remnant)	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Mogollon Creek (2)							R	R, S	R, S	R, S	→	→	→	B, →
Whiskey Creek Lineage	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
Whiskey Creek (remnant)													→	→
Iron Creek Lineage	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**3**
Iron Creek (remnant)	→	B, R	→	→	S	→	→	→	→	→	→	→	→	→
Sacaton Creek											S	→	→	→
White Creek (upper)														R, S
Spruce Creek Lineage	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
Spruce Creek (remnant)	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Big Dry Creek					R	R, S	→	→	→	→	→	→	→	→
Total Number of Populations	**7**	**7**	**7**	**7**	**7**	**8**	**8**	**9**	**9**	**8**	**8**	**8**	**9**	**10**

1. South Diamond Creek includes the headwater stream in Burnt Canyon
2. Mogollon Creek is an interconnected stream complex that consists of Mogollon Creek and tributaries including (from upstream to downstream) Woodrow Canyon, Trail Canyon, and South Fork Mogollon Creek.

Key to Codes:
→ = extant population
X = extirpation of population (see Extirpation Causes for modifier definitions)
B = barrier construction or modification
R = removal of nonnative trout by piscicide application or electrofishing
S = initial stocking following renovation or extirpation
E = evacuation of Gila trout
F = population opened to recreational angling
H = hybridization detected

Extirpation Causes:
Xf = wildfire effects (direct and indirect)
Xd = stream drying
Xq = major flood events

1994 through 2007

In May 1994, recovery team members and advisors to the team convened public meetings in Reserve, Silver City, and at Willow Creek to discuss recovery actions and address local concerns about stream renovation and the use of Antimycin A. Substantial opposition to stream renovations had been building and resulted in the postponement of removing nonnative trout from Mineral and Mogollon creeks. One-hundred and fifty Gila trout were evacuated from Spruce Creek during a forest fire in the upper watersheds of Spruce and Big Dry creeks in June 1994. The fish were transported to Mescalero National Fish Hatchery, where they suffered a high rate of mortality. The wild Spruce Creek and Big Dry Creek populations survived the fire. Monitoring of watershed condition at Main Diamond Creek indicated that the stream had recovered to the point that Gila trout could be repatriated to the stream (Wood and Turner, 1992; Wood and Turner, 1994; Jacobi, *in litt*.). In September 1994, 195 Gila trout were translocated from McKnight Creek to Main Diamond Creek to reestablish a population.

Substantial efforts were made by recovery team members, participating agencies, and team advisors to inform local government staff and concerned public about the use and effects of Antimycin A, the Gila trout recovery program, and stream renovation. These efforts included meetings, personal contacts, dissemination of fact sheets, publication of an article in New Mexico Wildlife (Propst, 1994), and publication of peer-reviewed articles that summarized recovery efforts and conservation status of the species (Propst et al., 1992; Turner, 1996). Public meetings on Gila trout recovery activities were convened in Las Cruces, Silver City, and Reserve in March 1995. The purpose of these meetings was to provide information about the recovery program. Recovery team members also met with the Grant County Commission in July and November. The November meeting was also attended by the Gila Rod and Gun Club. Gila trout recovery issues, including removal of nonnative trout and use of Antimycin A, were discussed at these meetings.

A forest fire (the Bonner Fire) caused the extirpation of the South Diamond Creek population of Gila trout in summer 1995. The fire also eliminated nonnative trout from Black Canyon. Another fire in the Mogollon Creek watershed resulted in marked reductions of Gila trout numbers in Corral and Trail canyons. About 430 Gila trout were removed from Trail Canyon and Mogollon Creek during the fire. The fish were transported to Mescalero National Fish Hatchery. Approximately 50 Age 0 Gila trout of Main Diamond lineage, which were raised at Mescalero National Fish Hatchery, were stocked into Main Diamond Creek in September 1995. Another 150 Gila trout were collected from Iron Creek and stocked into White Creek in October 1995.

Mogollon Creek, from Woodrow Canyon downstream to a waterfall, Trail Canyon, and South Fork Mogollon Creek were treated with Antimycin A in August 1996 to remove nonnative trout (Table I 2). Questions regarding the genetic purity of several Gila trout populations were raised in summer 1996. Dr. Robb Leary, University of Montana, was retained to resolve the genetics questions and conduct molecular genetics analyses of tissues taken from all extant populations. Initial results indicated that the Mogollon Creek population, which was established from the South Diamond lineage, had recently been contaminated with rainbow trout.

A memorandum of understanding between the U.S. Forest Service, New Mexico Trout, New Mexico Department of Game and Fish, and the Rio Grande Chapter of Trout Unlimited was executed in early 1997. The memorandum described a framework for cooperative efforts between the signatories to conserve native trout and their habitats. Progress on the molecular genetics work by Dr. Robb Leary indicated that the South Diamond lineage could be salvaged by conducting paired mating of Mogollon Creek fish. In November 1997, 500 Age 0 Main Diamond lineage Gila trout from Mescalero National Fish Hatchery were stocked into Main Diamond Creek to supplement that population. Two Antimycin A treatments of Mogollon Creek from the headwaters downstream to a waterfall barrier were completed in summer 1997. Prior to the first treatment, 650 Gila trout were removed from Mogollon Creek and taken to Mescalero National Fish Hatchery. These fish and Gila trout from Trail Canyon were used in paired mating to restore the South Diamond lineage. Mogollon Creek was then stocked with about 1,200 Age 0 South Diamond lineage Gila trout from Mescalero National Fish Hatchery in October. Another 500 Age 0 South Diamond lineage fish were stocked from the hatchery into South Diamond Creek in November. Results of the molecular genetics investigations indicated that both the McKenna Creek and Iron Creek populations were introgressed with rainbow trout. Rainbow trout hybridization had occurred to the point that paired mating could not be employed to restore the pure Gila trout lineage of either stream.

Introduction of rainbow trout into the McKenna Creek population was identified by Riddle et al., (1998) through analysis of mitochondrial DNA. Leary and Allendorf (1999) also reported hybridization with rainbow trout in the McKenna Creek and Iron Creek populations and hypothesized that one or two introductions of rainbow trout had likely occurred sometime between 1930 and 1950. The proportion of rainbow trout genes in these two introgressed populations was estimated to be about 10 percent. The molecular genetics investigations also identified unique genetic material in each of the other remnant populations, reinforcing the need to replicate each lineage.

A gabion waterfall barrier was constructed in June and July 1998 on Black Canyon, with considerable assistance from volunteers (Propst, 1999). Prior to completion of the barrier, brown and rainbow trout were found to have been recently introduced into the stream. Nonnative salmonids were removed by intensive electrofishing (Brooks and Propst, 1999). In November, 13,000 Age 0 Main Diamond lineage Gila trout were stocked into the stream above the barrier. Little Creek was treated with Antimycin A in November 1998 to remove the population of Gila x rainbow trout that was established in 1982 with fish from McKenna Creek. A meeting was convened in Silver City on 21 October 1998 with the New Mexico Department of Game and Fish, U.S. Fish and Wildlife Service, U.S. Forest Service, Grant County Commission, Gila Rod and Gun Club, and People for the U.S.A. to discuss the status of Gila trout recovery. Broodstock development for the extant lineages of Gila trout was initiated at Mora National Fish Hatchery.

All extant populations of Gila trout, except Whiskey Creek, were sampled in 1999 to assess density and population structure. Little Creek was treated again with Antimycin in 1999 to remove the Gila x rainbow trout hybrid population. In late September 1999, 126 Gila trout were collected from Spruce Creek and translocated to Dude Creek in Arizona, to establish a second replicate population of the Spruce lineage. The Dude Creek population was supplemented in early November 1999 with 17 Age 0 Gila trout of Spruce Creek lineage, which were raised at Mora National Fish Hatchery. About 20,000 Age 0 Main Diamond lineage Gila trout were stocked into Black Canyon on 20 October 1999.

White Creek was renovated using Antimycin A in June and July 2000 to remove the Gila x rainbow trout (Table I 2), which was established with fish from Iron Creek in 1993. The renovated stream was stocked with approximately 1,625 Gila trout of Main Diamond lineage that were produced at Mescalero National Fish Hatchery. Main Diamond lineage Gila trout were stocked from Mescalero National Fish Hatchery into lower Little Creek in April and October 2000. Also in April 2000, approximately 30 Gila trout were translocated from Whiskey Creek to upper Little Creek. Another 10 Gila trout were collected from Whiskey Creek and transferred to the Mora National Fish Hatchery. These captive fish were spawned and 13 Gila trout reared from the spawn were stocked into upper Little Creek in October 2000. In May 2000, 22 adult Gila trout were collected from Spruce Creek, spawned, and then translocated to Dude Creek. The fertilized eggs from the spawn were taken to Mescalero National Fish Hatchery. One-hundred and thirteen Age 0 fish produced from these fertilized eggs were stocked in late November 2000 into Raspberry Creek, a tributary to Blue River in Arizona. This stocking established the third replicate of the Spruce Creek lineage. White Creek was renovated in 2000 (Table I 2).

Operations at Mescalero National Fish Hatchery were suspended in September 2000 because of flood damage. All Gila trout brood stock held at the facility were transferred to the Mora National Fish Hatchery, which took over Gila trout production activities for recovery of the species.

A Memorandum of Understanding was developed in 2000 between the Apache-Sitgreaves National Forest, Arizona Game and Fish Department, U.S. Fish and Wildlife Service, Wildlife Conservation Council, Eastern Rocky Mountain Council of the Federation of Flyfishers, Old Pueblo Chapter of Trout Unlimited, and the Arizona State Council of Trout Unlimited (Arizona A.G. Contract No. KR001230-EQS, Forest Service Agreement No. 00-MU-11030121-005). The Memorandum of Understanding was developed to create a partnership for recovery of both Apache trout and Gila trout, as well as watershed restoration within the historic range of the two species on the Apache-Sitgreaves National Forest.

Monitoring in 2001 documented mixed age-class populations of Gila trout in Main Diamond Creek, South Diamond Creek, Black Canyon, McKnight Creek and Whiskey Creek. Reproduction and recruitment was documented in the South Diamond Creek population, which was repatriated to the stream in 2000. Main Diamond Creek lineage fish (Age 0) were stocked into Black Canyon on 31 October 2001 (N = 2,000), three locations in Little Creek on 1 November 2001 (N = 2,000), and White Creek on 18 November (N = 1,000; Table I 2). Mora National Fish Hatchery produced 1,690 Gila trout in 2001, primarily of Main Diamond Creek lineage (N = 1,590). The remaining 100 fish produced by the hatchery in 2001 were South Diamond Creek lineage Gila trout. A study was initiated at the hatchery to determine the feasibility and effectiveness of hatchery spawning period compression using photoperiod adjustment, temperature cues, and hormone injection.

Gila trout were confirmed present in Dude Creek in 2002, established with fish from the Spruce Creek population, but no recruitment was documented. Raspberry Creek was also confirmed to have Gila trout. It too was stocked with fish from the Spruce Creek population. Little Creek, established with Main Diamond lineage fish, was monitored and Gila trout were found to persist there. Monitoring in 2002 found the Sheep Corral Canyon population, a replicate of the Main Diamond lineage, to be extirpated. The population was likely lost as a result of drought acting in concert with habitat degradation caused by livestock grazing. Monitoring in 2002 found viable populations of Gila trout in Spruce Creek, South Diamond Creek and Mogollon Creek. Hatchery-raised Main Diamond lineage Gila trout were stocked in Black Canyon, lower Little Creek and White Creek in November 2002. The stocked fish were raised at the Mora National Fish Hatchery.

A draft emergency evacuation plan for Gila trout populations threatened by wildfire, drought, or nonnative trout invasion was developed in 2002 for review by the recovery team. The Arizona Game and Fish Department initiated efforts to allow for restoration of Gila trout to West Fork Oak Creek, tributaries to the Blue River, and Chitty Creek. Gila trout were evacuated from Whiskey Creek in July 2002 to safeguard against potential loss of the population due to the Cub Fire (Table I 2). Some of the fish were taken to the Mora National Fish Hatchery (N = 17) and the remainder (*ca*. 75) were transplanted in upper Little Creek (Brooks, 2002). The perennial section of Whiskey Creek inhabited by Gila trout was not affected or only minimally impacted by the Cub Fire.

Environmental compliance work was completed in 2003 for restoration of Gila trout to approximately 34 km (21 mi) of stream habitat in the upper West Fork Gila River drainage. The upper West Fork Gila River from Whiskey Creek confluence downstream to Packsaddle Canyon confluence was treated with Antimycin A in September and October 2003. The Cub and Dry Lake Complex fires had eliminated fish in the West Fork Gila River upstream from Whiskey Creek and from Cub Creek. Speckled dace were salvaged from the project area prior to piscicide treatment and were repatriated following completion of stream renovation.

Monitoring in 2003 confirmed the loss of the Sheep Corral Canyon population and low numbers of Gila trout in Little Creek. Black Canyon was stocked with approximately 2,500 Age 0 Gila trout (Main Diamond lineage) in November 2003. Whiskey Creek was monitored in June 2003 and the population of Gila trout there was confirmed to have survived the 2002 Cub Fire. Emergency evacuation of approximately 120 Gila trout from Mogollon Creek was conducted in July 2003 during the Dry Lakes Complex Fire. Monitoring conducted in November 2003 indicated that the population in Mogollon Creek survived the wildfire. Upper Little Creek was monitored following the Dry Lakes Complex Fire and only four Gila trout were found. These fish were taken to Mora National Fish Hatchery. Post-fire flooding and sediment input eliminated fish from upper Little Creek and rendered habitat in the reach unsuitable for trout. Naturalistic rearing methods were implemented at Mora National Fish Hatchery. These methods included placement of gravel and cobbles in rearing tanks, woody cover, painting the sides of the tanks, provision of live food, and addition of native suckers which provided a cleaning function.

Renovation treatments were continued in the upper West Fork Gila River drainage in 2004 (Propst, 2005). In June 2004, Antimycin A was applied to the West Fork Gila River from Packsaddle Canyon downstream to the waterfalls near White Creek Cabin, White Creek from the waterfall at the lower limit of Gila trout downstream to the West Fork Gila River, and Langstroth Canyon (including Rawmeat Creek and Trail Creek). Post-treatment sampling conducted in October 2004 found that both rainbow and brown trout persisted in the project area in the lower reaches of the West Fork Gila River, White Creek and Langstroth Canyon (Propst and Paroz, 2007). Thirty-one Gila trout were evacuated from Raspberry Creek during the KP Fire in 2004 and were taken to Mora National Fish Hatchery. Over half of the evacuated fish died, and the surviving 14 Gila trout evacuated were returned to Raspberry Creek in November 2004. Post-fire monitoring of Raspberry Creek found that the population survived the fire.

In August 2005, the entire West Fork Gila River drainage upstream from the waterfall near White Creek Cabin was treated with Antimycin A (Propst and Paroz, 2007). Monitoring conducted in October 2005 revealed that nonnative trout persisted in the lower portion of the West Fork Gila River in the project area as well as in lower White Creek. Mogollon Creek was stocked in July 2005 with 319 Age 0 and 53 Age I Gila trout of South Diamond lineage. In November 2005 Black Canyon was stocked with 2,815 Age 0 Gila trout of Main Diamond lineage. The West Fork Gila River at the Heart Bar Wildlife Area was stocked with 2,791 Gila trout of Main Diamond lineage (2,704 Age 0 and 87 Age I) for recreational fishing. The Gila trout population in Dude Creek was confirmed extirpated in 2005 following flooding in that drainage. The New Mexico Department of Game and Fish developed a survey for anglers with the Gila trout stamp to gather recreational fishing data.

Gila trout was reclassified from endangered to threatened in July 2006 (USFWS, 2006). The down-listing included a rule under section 4(d) of the Endangered Species Act that provided the opportunity for the states of Arizona and New Mexico to establish regulations for recreational angling for Gila trout. Renovation of the upper West Fork Gila River drainage from Packsaddle Canyon to the waterfall near White Creek Cabin was continued in June 2006 but was interrupted by the Bear Fire. Antimycin A treatment of White Creek, Langstroth Canyon and the West Fork Gila River from Cub Creek downstream to Packsaddle Canyon were completed prior to crews evacuating the project area (Propst and Paroz, 2007). Renovation resumed in July 2006 with Antimycin A treatment of the West Fork Gila River from Cub Creek downstream to the waterfall near White Creek Cabin. Langstroth Canyon was stocked with 37 Gila trout translocated from Whiskey Creek. Monitoring in 2005 and 2006 found no Gila trout in Dude Creek. The stream was stocked in 1999 and 2000, adult fish (but no young-of-year) were observed in 2002, and major flood events occurred in 2004 and 2005. Low abundance of Gila trout was documented in Raspberry Creek in 2006. An angling mortality study was conducted at Mora National Fish Hatchery using surplus brood fish. No stocking of hatchery-raised Gila trout was conducted in 2006 as a precaution arising from placement of rainbow trout and Gila trout in close proximity in the hatchery facility. Genetic testing was conducted and it was determined that integrity of Gila trout stocks at the hatchery was maintained.

In 2007 the Aspen Fire burned into the Black Canyon watershed but did not result in notable impacts to the Gila trout population. Black Canyon was opened for recreational fishing in 2007 with catch-and-release and barbless, single-hook, artificial lure regulations, and an open season of July 1 through September 30. Iron Creek was also opened to angling with a two fish limit and terminal gear restriction of a barbless, single-hook artificial lure. Anglers were required to have a free angling authorization to fish in either stream. The New Mexico Game Commission approved regulations establishing Special Trout Waters in Willow Creek, Gilita Creek, Iron Creek (downstream from the fish barrier) and Black Canyon. Black Canyon was stocked with 588 Main Diamond lineage Gila trout in August 2007. Also in August 2007, 134 Gila trout were collected from South Diamond Creek and transported to Mora National Fish Hatchery for use as broodstock. Sheep Corral Canyon was stocked with 99 Gila trout (Main Diamond lineage) in September 2007. In November 2007, catchable-size Main Diamond lineage fish were stocked in Gilita Creek (N = 350), Willow Creek (N = 1,112), East Fork Gila River at Grapevine

Campground (N = 500), West Fork Gila River near the Wilderness Visitor Center (N = 200), Sapillo Creek (N = 200), and the West Fork Gila River at the Forks Campground (N = 85). Thirty-eight Gila trout were translocated from Whiskey Creek to Langstroth Canyon.

The West Fork Gila River from Cub Creek downstream to near White Creek Cabin was treated again with Antimycin A in June 2007. Efficacy of the treatment was questionable and it was later learned that the Antimycin A formulation had less than 10 percent of label strength (Propst and Paroz, 2007). Consequently, it was determined that Antimycin A treatments made from 2005 through June 2007 involved compromised formulations. The West Fork Gila River from the falls near White Creek Cabin upstream to near Packsaddle Canyon was treated again in September 2007, but post-treatment monitoring found brown trout persisted in the project area.

Table I 2. Status of Gila trout populations, 1994 through 2007, showing numbers of extant populations of each lineage.

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Main Diamond Creek Lineage	**3**	**3**	**3**	**3**	**4**	**4**	**6**	**5**	**5**	**5**	**5**	**5**	**5**	**6**
Main Diamond Creek (remnant)	S	→	→	→	→	→	→	→	→	→	→	→	→	→
McKnight Creek	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Sheep Corral Canyon	→	→	→	→	→	→	→	Xd						S
Black Canyon					B,R,S	→	→	→	→	→	→	→	→	F, →
Little Creek (lower)					R	R	S	→	→	→	→	→	→	→
White Creek (upper)							R, S	→	→	→	→	→	→	→
White Creek (lower)											R	R	R	
West Fork Gila River										R	R	R	R	R
South Diamond Creek Lineage	**2**	**1**	**0**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
South Diamond Creek (1) (remnant)	→	Xf		S	→	→	→	→	→	→	→	→	→	→
Mogollon Creek (2)	→	E, →	H, →	R, S	→	→	→	→	→	E, →	→	→	→	→
West Fork Gila River										R	R	R	R	R
Whiskey Creek Lineage	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**1**	**1**	**1**	**2**	**2**
Whiskey Creek (remnant)	→	→	→	→	→	→	→	→	E, →	→	→	→	E, →	→
Little Creek (upper)					R	R	S	→	→	Xf				
Langstroth Canyon (3)											R	R	R, S	→
Iron Creek Lineage	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Iron Creek (remnant)	→	→	→	H? →	→	→	→	→	→	→	→	→	→	F, →
Sacaton Creek	→	→	Xf											
White Creek (upper)	→	→	→	→	→	→	R							
Spruce Creek Lineage	**2**	**2**	**2**	**2**	**2**	**3**	**4**	**4**	**4**	**4**	**4**	**3**	**3**	**3**
Spruce Creek (remnant)	E, →	→	→	→	→	→	→	→	→	→	→	→	→	→
Big Dry Creek	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Dude Creek						S	→	→	→	→	→	Xq		
Raspberry Creek							S	→	→	→	E, →	→	→	→
Total Number of Populations	**11**	**10**	**8**	**10**	**11**	**12**	**15**	**14**	**14**	**13**	**13**	**12**	**13**	**14**

Footnote:
1. South Diamond Creek includes the headwater stream in Burnt Canyon
2. Mogollon Creek is an interconnected stream complex that consists of Mogollon Creek and tributaries including (from upstream to downstream) Woodrow Canyon, Trail Canyon, and South Fork Mogollon Creek.
3. Langstroth Canyon is a relatively small, interconnected stream complex that consists of the stream in Langstroth Canyon and tributaries including Rawmeat Creek and Trail Creek.

Key to Codes:
→ = extant population
X = extirpation of population (see Extirpation Causes for modifier definitions)
B = barrier construction or modification
R = removal of nonnative trout by piscicide application or electrofishing
S = initial stocking following renovation or extirpation
E = evacuation of Gila trout
F = population opened to recreational angling
H = hybridization detected

Extirpation Causes:
Xf = wildfire effects (direct and indirect)
Xd = stream drying
Xq = major flood events

2008 through 2021

In 2008 Mogollon Creek downstream from Trail Canyon was designated as a Special Trout Water for recreational fishing from 1 July through 31 October, bringing the number of Gila trout populations open to angling to three (the other two being Black Canyon and Iron Creek). Surplus hatchery production of Gila trout was used to stock recreational fisheries in the West Fork Gila River near the Heart Bar Wildlife Area, Willow and Gilita creeks and Sapillo Creek. Approval to use rotenone to renovate the West Fork Gila River was granted by the New Mexico Water Quality Control Commission in August 2008. Monitoring in the upper West Fork Gila River project area found brown trout in Langstroth Canyon, White Creek and the West Fork Gila River (Paroz and Propst, 2008).

Monitoring in May 2009 found rainbow trout near the confluence of Trail Creek and Langstroth Canyon, and no fish in Langstroth Canyon above the Forest Trail 302 crossing (located approximately 1.3 km [0.8 mi]) upstream from the Trail Creek confluence). Brown trout were found throughout the West Fork Gila River from the waterfall near White Creek Cabin upstream to the confluence of Whiskey Creek (Paroz and Propst, 2009). Twenty-five Gila trout were collected from Spruce Creek in 2009 and taken to Mora National Fish Hatchery to develop a broodstock for that lineage. Gila trout (N = 250) were evacuated from South Diamond Creek in June 2009 to safeguard the population, which was threatened by the Meason-Diamond Fire. The West Fork Gila River drainage from the falls near White Creek Cabin upstream to the confluence of Whiskey Creek was treated with rotenone in June 2009 (Paroz and Propst, 2009). Over 1,500 brown trout, 10 rainbow trout, and approximately 950 speckled dace were enumerated following the rotenone application. Brown trout were taken from Cub Creek, the West Fork Gila River, White Creek and Langstroth Canyon. Rainbow trout were taken from White Creek and Langstroth Canyon, and one was taken from the West Fork Gila River hear the confluence of White Creek (Paroz and Propst, 2009).

Frye Creek, located in the Pinaleño Mountains in Graham County, Arizona, was assessed in 2008 and was determined to be fishless. The stream was stocked with 500 South Diamond lineage Gila trout in November 2009 (Table I 3). Grapevine Creek, another fishless stream located on the Prescott National Forest, was stocked with 160 South Diamond lineage Gila trout in November 2009. In 2009, Main Diamond lineage Gila trout were stocked in Black Canyon both above (N = 900) and below (N = 110) the fish barrier. Sheep Corral Canyon was also stocked with Main Diamond lineage fish (N = 100) in 2009. Gila trout recreational fisheries stocked in 2009 included the Gila River forks area (N = 752) and Sapillo Creek (N = 200). Stocking of nonnative trout in the Gila River drainage streams in New Mexico was ended in 2009. Sterile (all-female triploid) rainbow trout continue to be stocked in reservoirs in the drainage.

The West Fork Gila River and its tributaries upstream from the waterfall near White Creek Cabin were treated with rotenone again in August 2010. The renovation was successful and the West Fork Gila River was stocked in October with fish translocated from Main Diamond and South Diamond creeks. Main Diamond Creek fish were stocked near the confluence of Cub Creek and the South Diamond Creek fish were stocked near the confluence of White Creek. Brown trout were found to have been introduced in Black Canyon upstream from the fish barrier, and efforts were undertaken in August 2010 to manually remove the species from the stream. Mechanical removal of Apache trout was conducted in Coleman Creek, a tributary in the headwaters of the Blue River drainage, in an effort to make the stream suitable for restoration of Gila trout. Ash Creek, located in the Pinaleño Mountains on the Coronado National Forest, was treated with rotenone in October 2010 to remove nonnative trout. Post-treatment monitoring verified that the stream was fishless.

Cutthroat trout virus was isolated from ovarian fluid of Main Diamond and South Diamond lineage brood stock at Mora National Fish Hatchery in April 2010. Concerns regarding the presence of cutthroat trout virus resulted in suspension of stocking from the hatchery during most of 2010. Stocking was conducted in stream reaches known to have had previous introductions of cutthroat trout virus-positive fish. These stream reaches included the West Fork Gila River near the Heart Bar Wildlife Area, Sapillo Creek, Gilita Creek and Willow Creek, which were all stocked with Gila trout from Mora National Fish Hatchery in 2010 (Table I 3).

In Arizona, Chase Creek was determined to be fishless after several removal efforts to remove nonnative Rainbow Trout from the stream. Chase Creek was stocked with Iron Creek lineage Gila trout in 2017 and 2018. Visual surveys have documented natural reproduction following these stockings, and AZGFD plans to augment Chase Creek with additional Iron Creek lineage fish or eggs in 2022 pending availability. One hundred and nine Gila trout from the Iron Creek lineage were stocked into a portion of KP Creek downstream of its confluence with North Fork KP Creek on October 20, 2021

TableI 3. Status of Gila trout populations, 2008 through 2021, showing numbers of extant populations of each lineage.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Main Diamond Creek Lineage	**6**	**6**	**7**	**7**	**5**	**5**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Main Diamond Creek (remnant)	→	→	→	→	→	→	→	→	→	→	→	→	→	→
McKnight Creek	→	→	→	→	→	Xf								
Sheep Corral Canyon	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Black Canyon	→	→	→	→	→	Xf	S	→	→	→	→	→	→	→
Little Creek (lower)	→	→	→	→	→	→	→	→	→	→	→	→	→	→
White Creek (upper)	→	→	→	→	Xf									
White Creek (lower)		R	R			S	H							
Langstroth Canyon (upper)								S	→	→	→	→	→	→
West Fork Gila River		R	R, S	→	Xf	S	H							
South Diamond Creek Lineage	**2**	**4**	**6**	**5**	**5**	**7**	**5**	**5**	**5**	**3**	**3**	**5**	**5**	**5**
South Diamond (1) Creek (remnant)	→	E, →	→	→	→	E, →	→	→	→	→	→	→	→	→
Mogollon Creek (2)	F, →	→	→	→	→	→	→	→	→	→	→	→	→	→
Grapevine Creek		S	→	→	→	→	→	→	→	Xf		S	→	→
Frye Creek		S	→	→	→	→	→	F, →	→	Ef, S		S	S →	S →
West Fork Gila River		R	R, S		Xf	S	H							
Cub Creek			S	→	Xf	S	H							
Willow Creek					S	→	→	→	→	→	→	→	→	→
Whiskey Creek Lineage	**2**	**2**	**2**	**2**	**1**	**1**	**2**	**2**	**3**	**2**	**4**	**4**	**5**	**4**
Whiskey Creek (remnant)	→	→	→	→	E, Xf									
Langstroth Canyon (3)	→	→	→	→	E, Xf									
McKenna Creek				R	R, S	→	→	→	→	H				
White Creek (upper)							S	→	→	→	→	→	→	→
Mineral Creek									S	→	→	→	→	→
Raspberry Creek											S	→	→	→
Sacaton											S	→	→	Xd
Marijilda Creek (upper)													S	→
Iron Creek Lineage	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**3**
Iron Creek (remnant)	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Chase Creek											S	→	→	→
KP Creek														S
Spruce Creek Lineage	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**2**	**2**	**3**	**3**
Spruce Creek (remnant)	→	→	→	→	E, XI						S	→	S, →	→
Big Dry Creek	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Dude Creek								S	S	S				
Raspberry Creek	→	→	→	Xf										
Ash Creek			R	S	→	→	E, →4							
Coleman Creek													S	→

Mixed Lineage	0	0	0	0	0	0	0	2	2	1	1	1	3	3
Ash Creek								S, →4	→	E, Xf				
Dude Creek								S	→	→	→	→	→	→
Marijilda Creek (lower)													S	→
Whitewater Creek										R	R	R	S	S, →
Total Number of Populations	**14**	**16**	**19**	**18**	**14**	**16**	**14**	**16**	**17**	**13**	**17**	**19**	**23**	**23**

Footnotes:

1. South Diamond Creek includes the headwater stream in Burnt Canyon
2. Mogollon Creek is an interconnected stream complex that consists of Mogollon Creek and tributaries including (from upstream to downstream) Woodrow Canyon, Trail Canyon, and South Fork Mogollon Creek.
3. Langstroth Canyon is a relatively small, interconnected stream complex that consists of the stream in Langstroth Canyon and tributaries including Rawmeat Creek and Trail Creek.
4. Ash Creek was originally stocked with Spruce Creek lineage fish. In 2015 Whiskey Creek lineage fish were also stocked in the stream to create a mixed lineage population.

Key to Codes:

→ = extant population
X = extirpation of population (see Extirpation Causes for modifier definitions)
B = barrier construction or modification
R = removal of nonnative trout by piscicide application or electrofishing
S = initial stocking following renovation or extirpation
E = evacuation of Gila trout
F = population opened to recreational angling
H = hybridization detected

Extirpation Causes:

Xf = wildfire effects (direct and indirect)
Xd = stream drying
Xq = major flood events

Appendix J – Peer and Public Review Response

Comment: We received multiple comments requesting specific information on which streams would be repatriated in the future.

Our Response: Recovery plans are intended to provide overarching goals, objectives, and quantifiable criteria that, when met, allow for a species to no longer warrant Endangered Species Act (ESA) protections. All streams in the historical range of the Gila trout will be considered for repatriation but specifying a timeline or prioritization of specific streams is not feasible due to the presence of nonnative species or future stochastic events that may change the suitability of the habitat. This recovery plan sets forth the overarching criteria to meet recovery; however, specific activities will be described in the Recovery Implementation Strategy (RIS), which is a living document that may be updated as needed to identify and prioritize streams for stocking. A Recovery Implementation Team will be established and will write and update the RIS accordingly as we move forward with recovery.

Comment: Suggested including a list of fish barriers needed if dendritic systems are to be developed.

Our Response: Similar to the discussion for specific streams, the USFWS cannot outline or specify a list of where and when barrier placements will take place within this Recovery Plan, but will instead include those details in the RIS. Barriers are an essential need to protect the genetic integrity of Gila trout and competition/predation from nonnative trout species, but the need for a barrier will be addressed on a case-by-case basis during the implementation strategy. A Recovery Implementation Team will be established and will update the RIS accordingly as we move forward with recovery.

Comment: We received multiple comments asking for specifics regarding species monitoring methods and plans.

Our Response: Recovery plans are intended to provide overarching goals, objectives, and criteria that must be met to recover a species. The USFWS is actively working with our partners to develop a separate Monitoring Plan similar to one produced for the Apache trout, *Dauwalter, D., B. Giordano, Z. Jackson, J. Johnson, M. Lopez, and T. Stephens. 2017a. Apache trout monitoring plan: a monitoring plan for small and isolated trout populations. Arlington, Virginia.* This monitoring plan will contain the specific monitoring methodology used to reach the recovery criteria laid out in the Gila Trout Recovery Plan.

Comment: What is the trigger for when supplementation will occur? What is the genetic trigger?

Our Response: We plan to organize a Recovery Implementation Team composed of species experts from state and federal agencies and others. The purpose of the team will be to make decisions on issues such as recommending when additional supplementation to individual populations is needed.

Comment: We received multiple questions on why habitat restoration was not included in recovery criteria or recovery priorities:

Our Response: Specific recommendations for habitat restoration activities will vary substantially across the many streams in which Gila trout are found. Further, because habitat quantity and quality are dynamic and subject to changing conditions (e.g. floods, wildfires, drought) it is extremely difficult to determine in advance specifically where and what type of habitat restoration will be needed. The USFWS thinks that Recovery Criterion A appropriately addresses habitat conditions. Streams that support healthy, viable populations of Gila trout across at least 280 kilometers of habitat must have sufficiently high-quality habitat to support the species' needs.

Comment: We received comments requesting information on sport fish stocking and regulations.

Our Response: We acknowledge that the absence of nonnative fish species is vital for the recovery of the Gila trout; however, managing sport fish stocking and regulations is outside the purview of this recovery plan.

Comment: We received comments about hatchery operations, including genetic mixing, genetic rescue, and translocations.

Our Response: Hatcheries remain an important conservation tool. Mora National Fish Hatchery (MNFH) currently produces all recovery Gila trout. Under the 4(d) rule, any excess Gila trout produced can be given to NMDGF and AZGFD to be stocked for recreational take. As of March 2022, Canyon Creek Hatchery (AZ) is producing recreation fish, and Glenwood Hatchery (NM) is remodeling their facility to also produce recreational fish. Genetic monitoring is outlined in the draft RIS as an objective and will also be included in the Gila Trout Monitoring Plan. Genetic monitoring is necessary to ensure the genetic purity of the Recovery populations. It will be used to determine the genetics on the landscape and ensure that hatchery fish represent the genetics in the wild. The USFWS is revising the Gila Trout Genetic Management Plan, last updated in 2002. This will outline the process for all hatchery crosses to ensure the greatest genetic diversity and any genetic rescue that occurs. Except for controlled backcrosses (Spruce x Whiskey), all lineages are kept separate at MNFH. Translocation of wild fish between streams can occur after a recommendation from the Recovery Team and a fish health survey.

Comment: We received comments questioning whether 280 kilometers of occupied streams was achievable considering that current occupancy is less than halfway there, and in addition, whether 280 occupied kilometers was sufficient for achieving recovery.

Our Response: Since the recovery plan was drafted, the USFWS and our partners have conducted multiple reintroductions in both New Mexico and Arizona, leading to an extant population of 210.8 kilometers, and we think there is a sufficient number of cold-water streams that will remain suitable under future conditions. The 280 kilometer requirement was based on achieving an extinction probability of the species of less than 10 percent (Brown et al., 2001), which has been used in other recovery plans (USFWS, 2010) and by the International Union for Conservation of Nature as a threshold in assessing a species' vulnerability of extinction (IUCN, 2022).

Comment: We received multiple comments regarding Gila trout monitoring if the species is delisted and ESA protections are removed in the future.

Our Response: Section 4(g)(1) of the ESA specifies that “The Secretary [of the Interior] shall implement a system in cooperation with the States to monitor effectively for not less than five years the status of all species which have been recovered to the point at which the measures provided pursuant to this Act are no longer necessary...”. Therefore, a five year post delisting monitoring plan will be developed at such time that the species has been recovered and ESA protections are no longer required. Development of the post-delisting monitoring plan is a separate process, and therefore, this recovery plan does not include post delisting monitoring information.

Comment: We received comments as to whether the 4(d) rule is aiding or inhibiting recovery.

Our Response: The primary goal of the 4(d) rule is using excess hatchery fish to increase opportunities for anglers, which we think contributes to recovery overall. Specifically, recovery action 5) Conduct public education, involvement, and outreach in areas with an interest in Gila trout (Priority 3); and, 6) Develop and implement regulations to maintain sustainable Gila trout populations in recovery streams opened to sport fishing in Arizona and New Mexico (Priority 3). We think that generating interest in Gila trout angling provides additional public support when the opportunity arises for replacing a nonnative fishery with Gila trout.

Comment: “Western Watershed Protection requests that all information used as part of the decision-making process for this project be posted online on a publicly available manner, preferably on a website that allows open access for all members of the public during all comment and objection periods for this project"

Our Response: We will post the Gila Trout Recovery Plan to our Environmental Conservation Online System (ECOS) species webpage, which is accessible to the public, and provide public notice that the plan is available there. Within the Recovery Plan, we will provide citations to all sources of information used to develop the Recovery Plan. These documents and referenced literature are available upon request to the USFWS New Mexico Ecological Services Field Office.

Comment: We received multiple comments requesting additional information on the estimated costs of recovery.

Our Response: The USFWS worked with the Recovery Team and partner management agencies to estimate an accurate cost for recovery implementations activities. Management agency funds and priorities are highly variable, and we think the cost estimate is as accurate as possible when considering the time period and multiagency approach required for Gila trout recovery.

Comment: Why has this 20-year old effort not been reanalyzed with the new wildfire information/expirations and use of alternative analytical underpinnings (e.g, Bayesian modeling approaches)? This was in reference to *Brown, D. K., A. A. Echelle, D. L. Propst, J. E. Brooks, and W. L. Fisher. 2001. Catastrophic wildfire and number of populations as factors influencing risk of extinction for Gila Trout (Oncorhynchus gilae). Western North American Naturalist 61(2): 139-148.*

Our Response: While the publication (Brown et al., 2001) is 20 years old it remains the best available science for determining extinction probability for Gila trout. The paper estimated that 280 kilometers would result in an extinction probability of 3 percent, while other recovery plans have used 10 percent as the benchmark for recovery. In recognition of the severity of recent wildfires that were not evaluated by Brown et al., (2001), using stream occupancy associated with a more conservative extinction probability is prudent.

Comment: Why just the historic range? Are there any streams that are within the geographic range (HUCs) that did not historically contain Gila trout, but that may be ideal for introduction (e.g., above historic waterfalls, etc.)?

Our Response: We think recovery criteria can be met within the historical range for the Gila trout. If stream systems that are not believed to be part of the historical range become available for reintroduction, we will analyze it on a case-by-case basis to determine the effect it may have on the system.

Comment: This section [Criterion D] states that if non-hybridizing, nonnative salmonids persist in recovery streams that suppression efforts will mitigate effects 'until complete eradication of nonnative salmonids is achieved'. However, it does not address how long that scenario can or would be allowed to occur. Yet in the next paragraph the statement is made that reducing and eliminative nonnative trout is crucial to maintaining viable Gila trout population. These seem contradictory.

Our Response: We think that removal of nonnative trout is vital for a population of Gila trout to persist, but each system presents its own limitations to the effectiveness and speed at which nonnatives can be eradicated. The USFWS will continue to work with our partners to increase the number of stream kilometers that provide habitat for reintroduction of Gila trout, including the removal of nonnatives and construction of barriers that prevent their movement into Gila trout populations.

Comment: We received multiple comments questioning the limited dispersal of Gila trout in the Movement section.

Our Response: While the reported data may be low compared to movement of other salmonids, the data reported by Rinne (1982), and the data collected from White creek in 1999 and 2000 is the best available science we have for Gila trout movement. The USFWS does recognize that the research took place after increased isolation of populations due to historical land uses, but the science-based approach is more appropriate for the Recovery Plan under current conditions.

Comment: Request that critical habitat be designated.

Our Response: Designating critical habitat is outside of the purview of a Recovery Plan. The final downlisting rule published in 2006 (71 FR 40657) provides information on why the USFWS decided that designating critical habitat was unnecessary for recovery of Gila trout.

Comment: There is no discussion in the Recovery Plan of the planned strategies to recover a dendritic stream system suitable to Gila trout, one that the fish will ultimately depend on to travel, disperse, and self-maintain their population and its genetic structure.

Our Response: The specifics on recovering dendritic systems will be decided on a case-by-case basis by the Recovery Implementation Team as opportunities to establish these important metapopulations become available. In certain instances, stochastic events may provide the opportunity, and in others a plan for human assisted removal of nonnatives or barrier establishment may be the best option.

Comment: We received multiple comments asking how their organizations could help further the recovery of Gila trout.

Our Response: We appreciate the interest and commitment from organizations to help in the recovery of Gila trout. Support from these organizations will be incorporated by the Recovery Implementation Team into the RIS. Further engagement of these organizations and conservation partners will be forthcoming.

Comment: How do we know there's no hybridization in the remnant lineages? How was it tested? How are Gila X rainbows assessed? Phenotypically? How accurate is this? Which higher resolution SNP-based analyses have been performed?

Our Response: Recent studies by Wares et al., (2011) and Camak et al., (2021) indicated that it is unlikely that there has been hybridization with nonnative rainbow trout in the Recovery populations of Gila trout. Appendix B and C provided additional information regarding Gila trout genetics and lineages.

Attachment B

Presidential Documents

Executive Order 14008 of January 27, 2021

Tackling the Climate Crisis at Home and Abroad

The United States and the world face a profound climate crisis. We have a narrow moment to pursue action at home and abroad in order to avoid the most catastrophic impacts of that crisis and to seize the opportunity that tackling climate change presents. Domestic action must go hand in hand with United States international leadership, aimed at significantly enhancing global action. Together, we must listen to science and meet the moment.

By the authority vested in me as President by the Constitution and the laws of the United States of America, it is hereby ordered as follows:

PART I—PUTTING THE CLIMATE CRISIS AT THE CENTER OF UNITED STATES FOREIGN POLICY AND NATIONAL SECURITY

Section 101. *Policy*. United States international engagement to address climate change—which has become a climate crisis—is more necessary and urgent than ever. The scientific community has made clear that the scale and speed of necessary action is greater than previously believed. There is little time left to avoid setting the world on a dangerous, potentially catastrophic, climate trajectory. Responding to the climate crisis will require both significant short-term global reductions in greenhouse gas emissions and net-zero global emissions by mid-century or before.

It is the policy of my Administration that climate considerations shall be an essential element of United States foreign policy and national security. The United States will work with other countries and partners, both bilaterally and multilaterally, to put the world on a sustainable climate pathway. The United States will also move quickly to build resilience, both at home and abroad, against the impacts of climate change that are already manifest and will continue to intensify according to current trajectories.

Sec. 102. *Purpose*. This order builds on and reaffirms actions my Administration has already taken to place the climate crisis at the forefront of this Nation's foreign policy and national security planning, including submitting the United States instrument of acceptance to rejoin the Paris Agreement. In implementing—and building upon—the Paris Agreement's three overarching objectives (a safe global temperature, increased climate resilience, and financial flows aligned with a pathway toward low greenhouse gas emissions and climate-resilient development), the United States will exercise its leadership to promote a significant increase in global climate ambition to meet the climate challenge. In this regard:

(a) I will host an early Leaders' Climate Summit aimed at raising climate ambition and making a positive contribution to the 26th United Nations Climate Change Conference of the Parties (COP26) and beyond.

(b) The United States will reconvene the Major Economies Forum on Energy and Climate, beginning with the Leaders' Climate Summit. In cooperation with the members of that Forum, as well as with other partners as appropriate, the United States will pursue green recovery efforts, initiatives to advance the clean energy transition, sectoral decarbonization, and alignment of financial flows with the objectives of the Paris Agreement, including with respect to coal financing, nature-based solutions, and solutions to other climate-related challenges.

(c) I have created a new Presidentially appointed position, the Special Presidential Envoy for Climate, to elevate the issue of climate change and underscore the commitment my Administration will make toward addressing it.

(d) Recognizing that climate change affects a wide range of subjects, it will be a United States priority to press for enhanced climate ambition and integration of climate considerations across a wide range of international fora, including the Group of Seven (G7), the Group of Twenty (G20), and fora that address clean energy, aviation, shipping, the Arctic, the ocean, sustainable development, migration, and other relevant topics. The Special Presidential Envoy for Climate and others, as appropriate, are encouraged to promote innovative approaches, including international multi-stakeholder initiatives. In addition, my Administration will work in partnership with States, localities, Tribes, territories, and other United States stakeholders to advance United States climate diplomacy.

(e) The United States will immediately begin the process of developing its nationally determined contribution under the Paris Agreement. The process will include analysis and input from relevant executive departments and agencies (agencies), as well as appropriate outreach to domestic stakeholders. The United States will aim to submit its nationally determined contribution in advance of the Leaders' Climate Summit.

(f) The United States will also immediately begin to develop a climate finance plan, making strategic use of multilateral and bilateral channels and institutions, to assist developing countries in implementing ambitious emissions reduction measures, protecting critical ecosystems, building resilience against the impacts of climate change, and promoting the flow of capital toward climate-aligned investments and away from high-carbon investments. The Secretary of State and the Secretary of the Treasury, in coordination with the Special Presidential Envoy for Climate, shall lead a process to develop this plan, with the participation of the Administrator of the United States Agency for International Development (USAID), the Chief Executive Officer of the United States International Development Finance Corporation (DFC), the Chief Executive Officer of the Millennium Challenge Corporation, the Director of the United States Trade and Development Agency, the Director of the Office of Management and Budget, and the head of any other agency providing foreign assistance and development financing, as appropriate. The Secretary of State and the Secretary of the Treasury shall submit the plan to the President, through the Assistant to the President for National Security Affairs and the Assistant to the President for Economic Policy, within 90 days of the date of this order.

(g) The Secretary of the Treasury shall:

(i) ensure that the United States is present and engaged in relevant international fora and institutions that are working on the management of climate-related financial risks;

(ii) develop a strategy for how the voice and vote of the United States can be used in international financial institutions, including the World Bank Group and the International Monetary Fund, to promote financing programs, economic stimulus packages, and debt relief initiatives that are aligned with and support the goals of the Paris Agreement; and

(iii) develop, in collaboration with the Secretary of State, the Administrator of USAID, and the Chief Executive Officer of the DFC, a plan for promoting the protection of the Amazon rainforest and other critical ecosystems that serve as global carbon sinks, including through market-based mechanisms.

(h) The Secretary of State, the Secretary of the Treasury, and the Secretary of Energy shall work together and with the Export-Import Bank of the United States, the Chief Executive Officer of the DFC, and the heads of other agencies and partners, as appropriate, to identify steps through which the United States can promote ending international financing of carbon-intensive fossil fuel-based energy while simultaneously advancing sustainable development and a green recovery, in consultation with the Assistant to the President for National Security Affairs.

(i) The Secretary of Energy, in cooperation with the Secretary of State and the heads of other agencies, as appropriate, shall identify steps through which the United States can intensify international collaborations to drive innovation and deployment of clean energy technologies, which are critical for climate protection.

(j) The Secretary of State shall prepare, within 60 days of the date of this order, a transmittal package seeking the Senate's advice and consent to ratification of the Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, regarding the phasedown of the production and consumption of hydrofluorocarbons.

Sec. 103. *Prioritizing Climate in Foreign Policy and National Security*. To ensure that climate change considerations are central to United States foreign policy and national security:

(a) Agencies that engage in extensive international work shall develop, in coordination with the Special Presidential Envoy for Climate, and submit to the President, through the Assistant to the President for National Security Affairs, within 90 days of the date of this order, strategies and implementation plans for integrating climate considerations into their international work, as appropriate and consistent with applicable law. These strategies and plans should include an assessment of:

(i) climate impacts relevant to broad agency strategies in particular countries or regions;

(ii) climate impacts on their agency-managed infrastructure abroad (e.g., embassies, military installations), without prejudice to existing requirements regarding assessment of such infrastructure;

(iii) how the agency intends to manage such impacts or incorporate risk mitigation into its installation master plans; and

(iv) how the agency's international work, including partner engagement, can contribute to addressing the climate crisis.

(b) The Director of National Intelligence shall prepare, within 120 days of the date of this order, a National Intelligence Estimate on the national and economic security impacts of climate change.

(c) The Secretary of Defense, in coordination with the Secretary of Commerce, through the Administrator of the National Oceanic and Atmospheric Administration, the Chair of the Council on Environmental Quality, the Administrator of the Environmental Protection Agency, the Director of National Intelligence, the Director of the Office of Science and Technology Policy, the Administrator of the National Aeronautics and Space Administration, and the heads of other agencies as appropriate, shall develop and submit to the President, within 120 days of the date of this order, an analysis of the security implications of climate change (Climate Risk Analysis) that can be incorporated into modeling, simulation, war-gaming, and other analyses.

(d) The Secretary of Defense and the Chairman of the Joint Chiefs of Staff shall consider the security implications of climate change, including any relevant information from the Climate Risk Analysis described in subsection (c) of this section, in developing the National Defense Strategy, Defense Planning Guidance, Chairman's Risk Assessment, and other relevant strategy, planning, and programming documents and processes. Starting in January 2022, the Secretary of Defense and the Chairman of the Joint Chiefs of Staff shall provide an annual update, through the National Security Council, on the progress made in incorporating the security implications of climate change into these documents and processes.

(e) The Secretary of Homeland Security shall consider the implications of climate change in the Arctic, along our Nation's borders, and to National

Critical Functions, including any relevant information from the Climate Risk Analysis described in subsection (c) of this section, in developing relevant strategy, planning, and programming documents and processes. Starting in January 2022, the Secretary of Homeland Security shall provide an annual update, through the National Security Council, on the progress made in incorporating the homeland security implications of climate change into these documents and processes.

Sec. 104. *Reinstatement*. The Presidential Memorandum of September 21, 2016 (Climate Change and National Security), is hereby reinstated.

PART II—TAKING A GOVERNMENT-WIDE APPROACH TO THE CLIMATE CRISIS

Sec. 201. *Policy*. Even as our Nation emerges from profound public health and economic crises borne of a pandemic, we face a climate crisis that threatens our people and communities, public health and economy, and, starkly, our ability to live on planet Earth. Despite the peril that is already evident, there is promise in the solutions—opportunities to create well-paying union jobs to build a modern and sustainable infrastructure, deliver an equitable, clean energy future, and put the United States on a path to achieve net-zero emissions, economy-wide, by no later than 2050.

We must listen to science—and act. We must strengthen our clean air and water protections. We must hold polluters accountable for their actions. We must deliver environmental justice in communities all across America. The Federal Government must drive assessment, disclosure, and mitigation of climate pollution and climate-related risks in every sector of our economy, marshaling the creativity, courage, and capital necessary to make our Nation resilient in the face of this threat. Together, we must combat the climate crisis with bold, progressive action that combines the full capacity of the Federal Government with efforts from every corner of our Nation, every level of government, and every sector of our economy.

It is the policy of my Administration to organize and deploy the full capacity of its agencies to combat the climate crisis to implement a Government-wide approach that reduces climate pollution in every sector of the economy; increases resilience to the impacts of climate change; protects public health; conserves our lands, waters, and biodiversity; delivers environmental justice; and spurs well-paying union jobs and economic growth, especially through innovation, commercialization, and deployment of clean energy technologies and infrastructure. Successfully meeting these challenges will require the Federal Government to pursue such a coordinated approach from planning to implementation, coupled with substantive engagement by stakeholders, including State, local, and Tribal governments.

Sec. 202. *White House Office of Domestic Climate Policy*. There is hereby established the White House Office of Domestic Climate Policy (Climate Policy Office) within the Executive Office of the President, which shall coordinate the policy-making process with respect to domestic climate-policy issues; coordinate domestic climate-policy advice to the President; ensure that domestic climate-policy decisions and programs are consistent with the President's stated goals and that those goals are being effectively pursued; and monitor implementation of the President's domestic climate-policy agenda. The Climate Policy Office shall have a staff headed by the Assistant to the President and National Climate Advisor (National Climate Advisor) and shall include the Deputy Assistant to the President and Deputy National Climate Advisor. The Climate Policy Office shall have such staff and other assistance as may be necessary to carry out the provisions of this order, subject to the availability of appropriations, and may work with established or ad hoc committees or interagency groups. All agencies shall cooperate with the Climate Policy Office and provide such information, support, and assistance to the Climate Policy Office as it may request, as appropriate and consistent with applicable law.

Sec. 203. *National Climate Task Force*. There is hereby established a National Climate Task Force (Task Force). The Task Force shall be chaired by the National Climate Advisor.

(a) Membership. The Task Force shall consist of the following additional members:

(i) the Secretary of the Treasury;

(ii) the Secretary of Defense;

(iii) the Attorney General;

(iv) the Secretary of the Interior;

(v) the Secretary of Agriculture;

(vi) the Secretary of Commerce;

(vii) the Secretary of Labor;

(viii) the Secretary of Health and Human Services;

(ix) the Secretary of Housing and Urban Development;

(x) the Secretary of Transportation;

(xi) the Secretary of Energy;

(xii) the Secretary of Homeland Security;

(xiii) the Administrator of General Services;

(xiv) the Chair of the Council on Environmental Quality;

(xv) the Administrator of the Environmental Protection Agency;

(xvi) the Director of the Office of Management and Budget;

(xvii) the Director of the Office of Science and Technology Policy;

(xviii) the Assistant to the President for Domestic Policy;

(xix) the Assistant to the President for National Security Affairs;

(xx) the Assistant to the President for Homeland Security and Counterterrorism; and

(xxi) the Assistant to the President for Economic Policy.

(b) Mission and Work. The Task Force shall facilitate the organization and deployment of a Government-wide approach to combat the climate crisis. This Task Force shall facilitate planning and implementation of key Federal actions to reduce climate pollution; increase resilience to the impacts of climate change; protect public health; conserve our lands, waters, oceans, and biodiversity; deliver environmental justice; and spur well-paying union jobs and economic growth. As necessary and appropriate, members of the Task Force will engage on these matters with State, local, Tribal, and territorial governments; workers and communities; and leaders across the various sectors of our economy.

(c) Prioritizing Actions. To the extent permitted by law, Task Force members shall prioritize action on climate change in their policy-making and budget processes, in their contracting and procurement, and in their engagement with State, local, Tribal, and territorial governments; workers and communities; and leaders across all the sectors of our economy.

USE OF THE FEDERAL GOVERNMENT'S BUYING POWER AND REAL PROPERTY AND ASSET MANAGEMENT

Sec. 204. *Policy*. It is the policy of my Administration to lead the Nation's effort to combat the climate crisis by example—specifically, by aligning the management of Federal procurement and real property, public lands and waters, and financial programs to support robust climate action. By providing an immediate, clear, and stable source of product demand, increased transparency and data, and robust standards for the market, my Administration will help to catalyze private sector investment into, and accelerate the advancement of America's industrial capacity to supply, domestic clean energy, buildings, vehicles, and other necessary products and materials.

Sec. 205. *Federal Clean Electricity and Vehicle Procurement Strategy*. (a) The Chair of the Council on Environmental Quality, the Administrator of General Services, and the Director of the Office and Management and Budget, in coordination with the Secretary of Commerce, the Secretary of Labor, the Secretary of Energy, and the heads of other relevant agencies, shall assist the National Climate Advisor, through the Task Force established in section 203 of this order, in developing a comprehensive plan to create good jobs and stimulate clean energy industries by revitalizing the Federal Government's sustainability efforts.

(b) The plan shall aim to use, as appropriate and consistent with applicable law, all available procurement authorities to achieve or facilitate:

(i) a carbon pollution-free electricity sector no later than 2035; and

(ii) clean and zero-emission vehicles for Federal, State, local, and Tribal government fleets, including vehicles of the United States Postal Service.

(c) If necessary, the plan shall recommend any additional legislation needed to accomplish these objectives.

(d) The plan shall also aim to ensure that the United States retains the union jobs integral to and involved in running and maintaining clean and zero-emission fleets, while spurring the creation of union jobs in the manufacture of those new vehicles. The plan shall be submitted to the Task Force within 90 days of the date of this order.

Sec. 206. *Procurement Standards*. Consistent with the Executive Order of January 25, 2021, entitled, ''Ensuring the Future Is Made in All of America by All of America's Workers,'' agencies shall adhere to the requirements of the Made in America Laws in making clean energy, energy efficiency, and clean energy procurement decisions. Agencies shall, consistent with applicable law, apply and enforce the Davis-Bacon Act and prevailing wage and benefit requirements. The Secretary of Labor shall take steps to update prevailing wage requirements. The Chair of the Council on Environmental Quality shall consider additional administrative steps and guidance to assist the Federal Acquisition Regulatory Council in developing regulatory amendments to promote increased contractor attention on reduced carbon emission and Federal sustainability.

Sec. 207. *Renewable Energy on Public Lands and in Offshore Waters*. The Secretary of the Interior shall review siting and permitting processes on public lands and in offshore waters to identify to the Task Force steps that can be taken, consistent with applicable law, to increase renewable energy production on those lands and in those waters, with the goal of doubling offshore wind by 2030 while ensuring robust protection for our lands, waters, and biodiversity and creating good jobs. In conducting this review, the Secretary of the Interior shall consult, as appropriate, with the heads of relevant agencies, including the Secretary of Defense, the Secretary of Agriculture, the Secretary of Commerce, through the Administrator of the National Oceanic and Atmospheric Administration, the Secretary of Energy, the Chair of the Council on Environmental Quality, State and Tribal authorities, project developers, and other interested parties. The Secretary of the Interior shall engage with Tribal authorities regarding the development and management of renewable and conventional energy resources on Tribal lands.

Sec. 208. *Oil and Natural Gas Development on Public Lands and in Offshore Waters*. To the extent consistent with applicable law, the Secretary of the Interior shall pause new oil and natural gas leases on public lands or in offshore waters pending completion of a comprehensive review and reconsideration of Federal oil and gas permitting and leasing practices in light of the Secretary of the Interior's broad stewardship responsibilities over the public lands and in offshore waters, including potential climate and other impacts associated with oil and gas activities on public lands or in offshore waters. The Secretary of the Interior shall complete that review in consultation with the Secretary of Agriculture, the Secretary of Commerce, through the National Oceanic and Atmospheric Administration, and the Secretary of Energy. In conducting this analysis, and to the extent consistent with applicable law, the Secretary of the Interior shall consider whether to adjust royalties associated with coal, oil, and gas resources extracted from public lands and offshore waters, or take other appropriate action, to account for corresponding climate costs.

Sec. 209. *Fossil Fuel Subsidies*. The heads of agencies shall identify for the Director of the Office of Management and Budget and the National Climate Advisor any fossil fuel subsidies provided by their respective agencies, and then take steps to ensure that, to the extent consistent with applicable law, Federal funding is not directly subsidizing fossil fuels. The Director of the Office of Management and Budget shall seek, in coordination with the heads of agencies and the National Climate Advisor, to eliminate fossil fuel subsidies from the budget request for Fiscal Year 2022 and thereafter.

Sec. 210. *Clean Energy in Financial Management*. The heads of agencies shall identify opportunities for Federal funding to spur innovation, commercialization, and deployment of clean energy technologies and infrastructure for the Director of the Office of Management and Budget and the National Climate Advisor, and then take steps to ensure that, to the extent consistent with applicable law, Federal funding is used to spur innovation, commercialization, and deployment of clean energy technologies and infrastructure. The Director of the Office of Management and Budget, in coordination with agency heads and the National Climate Advisor, shall seek to prioritize such investments in the President's budget request for Fiscal Year 2022 and thereafter.

Sec. 211. *Climate Action Plans and Data and Information Products to Improve Adaptation and Increase Resilience*. (a) The head of each agency shall submit a draft action plan to the Task Force and the Federal Chief Sustainability Officer within 120 days of the date of this order that describes steps the agency can take with regard to its facilities and operations to bolster adaptation and increase resilience to the impacts of climate change. Action plans should, among other things, describe the agency's climate vulnerabilities and describe the agency's plan to use the power of procurement to increase the energy and water efficiency of United States Government installations, buildings, and facilities and ensure they are climate-ready. Agencies shall consider the feasibility of using the purchasing power of the Federal Government to drive innovation, and shall seek to increase the Federal Government's resilience against supply chain disruptions. Such disruptions put the Nation's manufacturing sector at risk, as well as consumer access to critical goods and services. Agencies shall make their action plans public, and post them on the agency website, to the extent consistent with applicable law.

(b) Within 30 days of an agency's submission of an action plan, the Federal Chief Sustainability Officer, in coordination with the Director of the Office of Management and Budget, shall review the plan to assess its consistency with the policy set forth in section 204 of this order and the priorities issued by the Office of Management and Budget.

(c) After submitting an initial action plan, the head of each agency shall submit to the Task Force and Federal Chief Sustainability Officer progress reports annually on the status of implementation efforts. Agencies shall make progress reports public and post them on the agency website, to the extent consistent with applicable law. The heads of agencies shall assign their respective agency Chief Sustainability Officer the authority to perform duties relating to implementation of this order within the agency, to the extent consistent with applicable law.

(d) To assist agencies and State, local, Tribal, and territorial governments, communities, and businesses in preparing for and adapting to the impacts of climate change, the Secretary of Commerce, through the Administrator of the National Oceanic and Atmospheric Administration, the Secretary of Homeland Security, through the Administrator of the Federal Emergency Management Agency, and the Director of the Office of Science and Technology Policy, in coordination with the heads of other agencies, as appropriate, shall provide to the Task Force a report on ways to expand and improve climate forecast capabilities and information products for the public. In addition, the Secretary of the Interior and the Deputy Director for Management of the Office of Management and Budget, in their capacities as the Chair and Vice-Chair of the Federal Geographic Data Committee, shall assess and provide to the Task Force a report on the potential development of a consolidated Federal geographic mapping service that can facilitate public access to climate-related information that will assist Federal, State, local, and Tribal governments in climate planning and resilience activities.

EMPOWERING WORKERS THROUGH REBUILDING OUR INFRASTRUCTURE FOR A SUSTAINABLE ECONOMY

Sec. 212. *Policy*. This Nation needs millions of construction, manufacturing, engineering, and skilled-trades workers to build a new American infrastructure and clean energy economy. These jobs will create opportunities for young people and for older workers shifting to new professions, and for people from all backgrounds and communities. Such jobs will bring opportunity to communities too often left behind—places that have suffered as a result of economic shifts and places that have suffered the most from persistent pollution, including low-income rural and urban communities, communities of color, and Native communities.

Sec. 213. *Sustainable Infrastructure*. (a) The Chair of the Council on Environmental Quality and the Director of the Office of Management and Budget shall take steps, consistent with applicable law, to ensure that Federal infrastructure investment reduces climate pollution, and to require that Federal permitting decisions consider the effects of greenhouse gas emissions and climate change. In addition, they shall review, and report to the National Climate Advisor on, siting and permitting processes, including those in progress under the auspices of the Federal Permitting Improvement Steering Council, and identify steps that can be taken, consistent with applicable law, to accelerate the deployment of clean energy and transmission projects in an environmentally stable manner.

(b) Agency heads conducting infrastructure reviews shall, as appropriate, consult from an early stage with State, local, and Tribal officials involved in permitting or authorizing proposed infrastructure projects to develop efficient timelines for decision-making that are appropriate given the complexities of proposed projects.

EMPOWERING WORKERS BY ADVANCING CONSERVATION, AGRICULTURE, AND REFORESTATION

Sec. 214. *Policy*. It is the policy of my Administration to put a new generation of Americans to work conserving our public lands and waters. The Federal Government must protect America's natural treasures, increase reforestation, improve access to recreation, and increase resilience to wildfires and storms, while creating well-paying union jobs for more Americans, including more opportunities for women and people of color in occupations where they are underrepresented. America's farmers, ranchers, and forest landowners have an important role to play in combating the climate crisis and reducing greenhouse gas emissions, by sequestering carbon in soils, grasses, trees, and other vegetation and sourcing sustainable bioproducts and fuels. Coastal communities have an essential role to play in mitigating climate change and strengthening resilience by protecting and restoring coastal ecosystems, such as wetlands, seagrasses, coral and oyster reefs, and mangrove and kelp forests, to protect vulnerable coastlines, sequester carbon, and support biodiversity and fisheries.

Sec. 215. *Civilian Climate Corps*. In furtherance of the policy set forth in section 214 of this order, the Secretary of the Interior, in collaboration with the Secretary of Agriculture and the heads of other relevant agencies, shall submit a strategy to the Task Force within 90 days of the date of this order for creating a Civilian Climate Corps Initiative, within existing appropriations, to mobilize the next generation of conservation and resilience workers and maximize the creation of accessible training opportunities and good jobs. The initiative shall aim to conserve and restore public lands and waters, bolster community resilience, increase reforestation, increase carbon sequestration in the agricultural sector, protect biodiversity, improve access to recreation, and address the changing climate.

Sec. 216. *Conserving Our Nation's Lands and Waters*. (a) The Secretary of the Interior, in consultation with the Secretary of Agriculture, the Secretary of Commerce, the Chair of the Council on Environmental Quality, and the heads of other relevant agencies, shall submit a report to the Task Force within 90 days of the date of this order recommending steps that the United States should take, working with State, local, Tribal, and territorial governments, agricultural and forest landowners, fishermen, and other key stakeholders, to achieve the goal of conserving at least 30 percent of our lands and waters by 2030.

(i) The Secretary of the Interior, the Secretary of Agriculture, the Secretary of Commerce, through the Administrator of the National Oceanic and Atmospheric Administration, and the Chair of the Council on Environmental Quality shall, as appropriate, solicit input from State, local, Tribal, and territorial officials, agricultural and forest landowners, fishermen, and other key stakeholders in identifying strategies that will encourage broad participation in the goal of conserving 30 percent of our lands and waters by 2030.

(ii) The report shall propose guidelines for determining whether lands and waters qualify for conservation, and it also shall establish mechanisms to measure progress toward the 30-percent goal. The Secretary of the Interior shall subsequently submit annual reports to the Task Force to monitor progress.

(b) The Secretary of Agriculture shall:

(i) initiate efforts in the first 60 days from the date of this order to collect input from Tribes, farmers, ranchers, forest owners, conservation groups, firefighters, and other stakeholders on how to best use Department of Agriculture programs, funding and financing capacities, and other authorities, and how to encourage the voluntary adoption of climate-smart agricultural and forestry practices that decrease wildfire risk fueled by climate change and result in additional, measurable, and verifiable carbon reductions and sequestration and that source sustainable bioproducts and fuels; and

(ii) submit to the Task Force within 90 days of the date of this order a report making recommendations for an agricultural and forestry climate strategy.

(c) The Secretary of Commerce, through the Administrator of the National Oceanic and Atmospheric Administration, shall initiate efforts in the first 60 days from the date of this order to collect input from fishermen, regional ocean councils, fishery management councils, scientists, and other stakeholders on how to make fisheries and protected resources more resilient to climate change, including changes in management and conservation measures, and improvements in science, monitoring, and cooperative research.

EMPOWERING WORKERS THROUGH REVITALIZING ENERGY COMMUNITIES

Sec. 217. *Policy*. It is the policy of my Administration to improve air and water quality and to create well-paying union jobs and more opportunities for women and people of color in hard-hit communities, including rural communities, while reducing methane emissions, oil and brine leaks, and other environmental harms from tens of thousands of former mining and well sites. Mining and power plant workers drove the industrial revolution and the economic growth that followed, and have been essential to the growth of the United States. As the Nation shifts to a clean energy economy, Federal leadership is essential to foster economic revitalization of and investment in these communities, ensure the creation of good jobs that provide a choice to join a union, and secure the benefits that have been earned by workers.

Such work should include projects that reduce emissions of toxic substances and greenhouse gases from existing and abandoned infrastructure and that prevent environmental damage that harms communities and poses a risk to public health and safety. Plugging leaks in oil and gas wells and reclaiming abandoned mine land can create well-paying union jobs in coal, oil, and gas communities while restoring natural assets, revitalizing recreation economies, and curbing methane emissions. In addition, such work should include efforts to turn properties idled in these communities, such as brownfields, into new hubs for the growth of our economy. Federal agencies should therefore coordinate investments and other efforts to assist coal, oil and gas, and power plant communities, and achieve substantial reductions of methane emissions from the oil and gas sector as quickly as possible.

Sec. 218. *Interagency Working Group on Coal and Power Plant Communities and Economic Revitalization*. There is hereby established an Interagency Working Group on Coal and Power Plant Communities and Economic Revitalization (Interagency Working Group). The National Climate Advisor and the Assistant to the President for Economic Policy shall serve as Co-Chairs of the Interagency Working Group.

(a) Membership. The Interagency Working Group shall consist of the following additional members:

(i) the Secretary of the Treasury;

(ii) the Secretary of the Interior;

(iii) the Secretary of Agriculture;

(iv) the Secretary of Commerce;

(v) the Secretary of Labor;

(vi) the Secretary of Health and Human Services;

(vii) the Secretary of Transportation;

(viii) the Secretary of Energy;

(ix) the Secretary of Education;

(x) the Administrator of the Environmental Protection Agency;

(xi) the Director of the Office of Management and Budget;

(xii) the Assistant to the President for Domestic Policy and Director of the Domestic Policy Council; and

(xiii) the Federal Co-Chair of the Appalachian Regional Commission.

(b) Mission and Work.

(i) The Interagency Working Group shall coordinate the identification and delivery of Federal resources to revitalize the economies of coal, oil and gas, and power plant communities; develop strategies to implement the policy set forth in section 217 of this order and for economic and social recovery; assess opportunities to ensure benefits and protections for coal and power plant workers; and submit reports to the National Climate Advisor and the Assistant to the President for Economic Policy on a regular basis on the progress of the revitalization effort.

(ii) As part of this effort, within 60 days of the date of this order, the Interagency Working Group shall submit a report to the President describing all mechanisms, consistent with applicable law, to prioritize grantmaking, Federal loan programs, technical assistance, financing, procurement, or other existing programs to support and revitalize the economies of coal and power plant communities, and providing recommendations for action consistent with the goals of the Interagency Working Group.

(c) Consultation. Consistent with the objectives set out in this order and in accordance with applicable law, the Interagency Working Group shall seek the views of State, local, and Tribal officials; unions; environmental justice organizations; community groups; and other persons it identifies who may have perspectives on the mission of the Interagency Working Group.

(d) Administration. The Interagency Working Group shall be housed within the Department of Energy. The Chairs shall convene regular meetings of the Interagency Working Group, determine its agenda, and direct its work. The Secretary of Energy, in consultation with the Chairs, shall designate an Executive Director of the Interagency Working Group, who shall coordinate the work of the Interagency Working Group and head any staff assigned to the Interagency Working Group.

(e) Officers. To facilitate the work of the Interagency Working Group, the head of each agency listed in subsection (a) of this section shall assign a designated official within the agency the authority to represent the agency on the Interagency Working Group and perform such other duties relating to the implementation of this order within the agency as the head of the agency deems appropriate.

SECURING ENVIRONMENTAL JUSTICE AND SPURRING ECONOMIC OPPORTUNITY

Sec. 219. *Policy*. To secure an equitable economic future, the United States must ensure that environmental and economic justice are key considerations in how we govern. That means investing and building a clean energy economy that creates well-paying union jobs, turning disadvantaged communities—historically marginalized and overburdened—into healthy, thriving communities, and undertaking robust actions to mitigate climate change while preparing for the impacts of climate change across rural, urban, and Tribal areas. Agencies shall make achieving environmental justice part of their missions by developing programs, policies, and activities to address the disproportionately high and adverse human health, environmental, climate-related and other cumulative impacts on disadvantaged communities, as well as the accompanying economic challenges of such impacts. It is therefore the policy of my Administration to secure environmental justice and spur economic opportunity for disadvantaged communities that have been historically marginalized and overburdened by pollution and underinvestment in housing, transportation, water and wastewater infrastructure, and health care.

Sec. 220. *White House Environmental Justice Interagency Council*. (a) Section 1–102 of Executive Order 12898 of February 11, 1994 (Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations), is hereby amended to read as follows:

''(a) There is hereby created within the Executive Office of the President a White House Environmental Justice Interagency Council (Interagency Council). The Chair of the Council on Environmental Quality shall serve as Chair of the Interagency Council.

''(b) Membership. The Interagency Council shall consist of the following additional members:

(i) the Secretary of Defense;

(ii) the Attorney General;

(iii) the Secretary of the Interior;

(iv) the Secretary of Agriculture;

(v) the Secretary of Commerce;

(vi) the Secretary of Labor;

(vii) the Secretary of Health and Human Services;

(viii) the Secretary of Housing and Urban Development;

(ix) the Secretary of Transportation;

(x) the Secretary of Energy;

(xi) the Chair of the Council of Economic Advisers;

(xii) the Administrator of the Environmental Protection Agency;

(xiii) the Director of the Office of Management and Budget;

(xiv) the Executive Director of the Federal Permitting Improvement Steering Council;

(xv) the Director of the Office of Science and Technology Policy;

(xvi) the National Climate Advisor;

(xvii) the Assistant to the President for Domestic Policy; and

(xviii) the Assistant to the President for Economic Policy.

''(c) At the direction of the Chair, the Interagency Council may establish subgroups consisting exclusively of Interagency Council members or their designees under this section, as appropriate.

''(d) Mission and Work. The Interagency Council shall develop a strategy to address current and historic environmental injustice by consulting with the White House Environmental Justice Advisory Council and with local environmental justice leaders. The Interagency Council shall also develop clear performance metrics to ensure accountability, and publish an annual public performance scorecard on its implementation.

''(e) Administration. The Office of Administration within the Executive Office of the President shall provide funding and administrative support for the Interagency Council, to the extent permitted by law and within existing appropriations. To the extent permitted by law, including the Economy Act (31 U.S.C. 1535), and subject to the availability of appropriations, the Department of Labor, the Department of Transportation, and the Environmental Protection Agency shall provide administrative support as necessary.

''(f) Meetings and Staff. The Chair shall convene regular meetings of the Council, determine its agenda, and direct its work. The Chair shall designate an Executive Director of the Council, who shall coordinate the work of the Interagency Council and head any staff assigned to the Council.

''(g) Officers. To facilitate the work of the Interagency Council, the head of each agency listed in subsection (b) shall assign a designated official within the agency to be an Environmental Justice Officer, with the authority to represent the agency on the Interagency Council and perform such other duties relating to the implementation of this order within the agency as the head of the agency deems appropriate.''

(b) The Interagency Council shall, within 120 days of the date of this order, submit to the President, through the National Climate Advisor, a set of recommendations for further updating Executive Order 12898.

Sec. 221. *White House Environmental Justice Advisory Council*. There is hereby established, within the Environmental Protection Agency, the White House Environmental Justice Advisory Council (Advisory Council), which shall advise the Interagency Council and the Chair of the Council on Environmental Quality.

(a) Membership. Members shall be appointed by the President, shall be drawn from across the political spectrum, and may include those with knowledge about or experience in environmental justice, climate change, disaster preparedness, racial inequity, or any other area determined by the President to be of value to the Advisory Council.

(b) Mission and Work. The Advisory Council shall be solely advisory. It shall provide recommendations to the White House Environmental Justice Interagency Council established in section 220 of this order on how to increase the Federal Government's efforts to address current and historic environmental injustice, including recommendations for updating Executive Order 12898.

(c) Administration. The Environmental Protection Agency shall provide funding and administrative support for the Advisory Council to the extent permitted by law and within existing appropriations. Members of the Advisory Council shall serve without either compensation or reimbursement of expenses.

(d) Federal Advisory Committee Act. Insofar as the Federal Advisory Committee Act, as amended (5 U.S.C. App.), may apply to the Advisory Council, any functions of the President under the Act, except for those in section 6 of the Act, shall be performed by the Administrator of the Environmental Protection Agency in accordance with the guidelines that have been issued by the Administrator of General Services.

Sec. 222. *Agency Responsibilities*. In furtherance of the policy set forth in section 219:

(a) The Chair of the Council on Environmental Quality shall, within 6 months of the date of this order, create a geospatial Climate and Economic Justice Screening Tool and shall annually publish interactive maps highlighting disadvantaged communities.

(b) The Administrator of the Environmental Protection Agency shall, within existing appropriations and consistent with applicable law:

(i) strengthen enforcement of environmental violations with disproportionate impact on underserved communities through the Office of Enforcement and Compliance Assurance; and

(ii) create a community notification program to monitor and provide real-time data to the public on current environmental pollution, including emissions, criteria pollutants, and toxins, in frontline and fenceline communities—places with the most significant exposure to such pollution.

(c) The Attorney General shall, within existing appropriations and consistent with applicable law:

(i) consider renaming the Environment and Natural Resources Division the Environmental Justice and Natural Resources Division;

(ii) direct that division to coordinate with the Administrator of the Environmental Protection Agency, through the Office of Enforcement and Compliance Assurance, as well as with other client agencies as appropriate, to develop a comprehensive environmental justice enforcement strategy, which shall seek to provide timely remedies for systemic environmental violations and contaminations, and injury to natural resources; and

(iii) ensure comprehensive attention to environmental justice throughout the Department of Justice, including by considering creating an Office of Environmental Justice within the Department to coordinate environmental justice activities among Department of Justice components and United States Attorneys' Offices nationwide.

(d) The Secretary of Health and Human Services shall, consistent with applicable law and within existing appropriations:

(i) establish an Office of Climate Change and Health Equity to address the impact of climate change on the health of the American people; and

(ii) establish an Interagency Working Group to Decrease Risk of Climate Change to Children, the Elderly, People with Disabilities, and the Vulnerable as well as a biennial Health Care System Readiness Advisory Council, both of which shall report their progress and findings regularly to the Task Force.

(e) The Director of the Office of Science and Technology Policy shall, in consultation with the National Climate Advisor, within existing appropriations, and within 100 days of the date of this order, publish a report identifying the climate strategies and technologies that will result in the most air and water quality improvements, which shall be made public to the maximum extent possible and published on the Office's website.

Sec. 223. *Justice40 Initiative*. (a) Within 120 days of the date of this order, the Chair of the Council on Environmental Quality, the Director of the

Office of Management and Budget, and the National Climate Advisor, in consultation with the Advisory Council, shall jointly publish recommendations on how certain Federal investments might be made toward a goal that 40 percent of the overall benefits flow to disadvantaged communities. The recommendations shall focus on investments in the areas of clean energy and energy efficiency; clean transit; affordable and sustainable housing; training and workforce development; the remediation and reduction of legacy pollution; and the development of critical clean water infrastructure. The recommendations shall reflect existing authorities the agencies may possess for achieving the 40-percent goal as well as recommendations on any legislation needed to achieve the 40-percent goal.

(b) In developing the recommendations, the Chair of the Council on Environmental Quality, the Director of the Office of Management and Budget, and the National Climate Advisor shall consult with affected disadvantaged communities.

(c) Within 60 days of the recommendations described in subsection (a) of this section, agency heads shall identify applicable program investment funds based on the recommendations and consider interim investment guidance to relevant program staff, as appropriate and consistent with applicable law.

(d) By February 2022, the Director of the Office of Management and Budget, in coordination with the Chair of the Council on Environmental Quality, the Administrator of the United States Digital Service, and other relevant agency heads, shall, to the extent consistent with applicable law, publish on a public website an annual Environmental Justice Scorecard detailing agency environmental justice performance measures.

PART III—GENERAL PROVISIONS

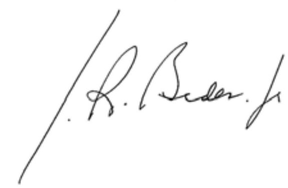
Sec. 301. *General Provisions*. (a) Nothing in this order shall be construed to impair or otherwise affect:

(i) the authority granted by law to an executive department or agency or the head thereof; or

(ii) the functions of the Director of the Office of Management and Budget, relating to budgetary, administrative, or legislative proposals.

(b) This order shall be implemented consistent with applicable law and subject to the availability of appropriations.

(c) This order is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or in equity by any party against the United States, its departments, agencies, or entities, its officers, employees, or agents, or any other person.



THE WHITE HOUSE,
January 27, 2021.

[FR Doc. 2021–02177
Filed 1–29–21; 8:45 am]
Billing code 3295–F1–P

Attachment C

CONSERVING AND RESTORING

AMERICA THE BEAUTIFUL

2021

A preliminary report to the National Climate Task Force recommending a ten-year, locally led campaign to conserve and restore the lands and waters upon which we all depend, and that bind us together as Americans.

Represented Agencies

U.S. Department of the Interior

U.S. Department of Agriculture

U.S. Department of Commerce

Council on Environmental Quality

Table of Contents

Envisioning America the Beautiful

“Positive, bipartisan, community-driven conservation efforts are already happening in our community. I pledge to continue to pull stakeholders together—recognizing this goal will take action at the neighborhood, community, state, and national level. Together, we can and must protect nature for generations to come.”**—Letter from more than 70 mayors**

“...We support 30 by 30 policies that recognize hunting and fishing as well-managed and sustainable activities that are in harmony with other management goals. Maintaining the sense of connection to our abundant resources and unrivaled natural beauty that these activities provide is essential to ensuring we have natural resource and biodiversity stewards for the next century, just as we have had in the past.”**—Hunt Fish 30x30**

“We view the intent of…30 by 30...as an opportunity to build durable conservation, outdoor recreation, equitable access to the outdoors, and climate resiliency outcomes that are crucial to our industry and our constituents.”**—Outdoor Alliance, Outdoor Industry Association, The Conservation Alliance**

"All communities should have equitable access to nearby green space, the ability to reach it, and features that honor and welcome diverse languages, inclusive histories, and uses of parkland. Natural areas and natural resources should be managed inclusively and locally, reflecting the communities they serve, with co-management by Indigenous and tribal nations."**—Hispanic Access Foundation**

“Traditional mechanisms of land protection like permanent acquisition, easement or federal designation will rightfully play a role in achieving 30 by 30. At the same time, over-reliance on these tools, or an insistence that these mechanisms are the only way to protect land fails to recognize the contributions to conservation of those already on the land. Working landscapes are the cornerstones of communities and functional ecosystems in the West. They are disappearing and taking nature with them as they go.”**—Western Landowners Alliance**

“…the Council stands ready to assist the Administration in implementing the Executive Order and engaging impacted native communities. This includes promoting fishing practices in line with sustainability and local island culture, supporting international agreements, protecting essential habitat, developing underutilized or underrepresented fisheries, allow fair and equitable access to participate in management processes, promoting a ‘bottom-up’ approach to resource management, and optimizing sustainable use of resources through its management plans.”**—Western Pacific Regional Fishery Management Council**

“We’re working to ensure 30x30 is built on the needs of the people – those who live closest to, and are most dependent on, these lands and waters, as well as those who have been disproportionately burdened by nature loss and lack of access to the benefits of nature. We must also ensure that what we protect is preserved as a network of linked habitat, including both large-scale landscapes and small parks, so species are able to migrate and otherwise move around in response to climate change and other shifts.”**—The Wilderness Society**

“Tribal Nations are key to the success of the 30x30 policy initiative in the U.S. as they are intrinsically linked, presently and historically, to existing and prospective protected areas. Tribal Nations are the original stewards of these lands and waters and have been the most effective managers and protectors of biodiversity since time immemorial….The 30x30 policy serves as a vitally important opportunity to safeguard the environment, Tribal cultural values, strengthen the Nation-to-Nation relationship, and uphold Tribal sovereignty and self-determination.”**—Letter from Tribal Leaders and Tribal organization leaders**

“...our nation’s farmers, ranchers, and foresters [are] essential allies in the effort to reach the 30x30 goals for biodiversity conservation and climate mitigation. The lands that they manage are critical for wildlife habitat, carbon sequestration, food security, clean water, and rural prosperity....To be successful, these policies must embrace USDA’s legacy of voluntary, incentive-based, and locally led conservation and be strategically targeted.”**—American Farmland Trust**

"Protecting public lands and increasing representation, meaningful participation, quality, and access to the outdoors must go hand in hand. President Biden's recent commitment to ‘30x30’ is an important step in that direction. Conserving more public lands and rivers will give more Black people a chance to reconnect and revel in nature. Protecting lands and waters near Black communities will also help ensure that Black people have cleaner air to breathe and safer drinking water. Our planet needs our collective stewardship."**—Outdoor Afro**

“To succeed requires better science and large-scale spatial planning to identify, conserve, restore and protect climate-resilient habitats. It must include sustainable resource management backed by robust public policies and funding to address systemic changes in different geographies and communities.”**—The Nature Conservancy**

“Counties recognize that comprehensive land use planning and growth management are central to our social and economic stability. How we use our land directly affects our ability to accommodate development, protect valuable natural resources, minimize pollution, preserve the cultural and historical character of our community, and maintain a high quality of life for current and future residents.”**—Chair of National Association of Counties’ Environment, Energy and Land Use Steering Committee**

"We applaud this ambitious goal and the attention it brings to the power of nature-based climate solutions. Natural resource professionals are key allies in tackling climate change and improving the overall health and resilience of ecosystems across public and private lands."**—Society of American Foresters, Association of Consulting Foresters, Society for Range Management, The Wildlife Society**

“By protecting at least 30% of the U.S. ocean by 2030—a commitment that is supported by four out of five American voters—the U.S. can ensure that our coastal communities and economies thrive, that our ocean life is protected, and that our ocean is given a chance to adapt to climate change and ocean acidification.”**—National Ocean Protection Coalition**

“Comprised of both land sector practitioners and senior advisors to the governors, the U.S. Climate Alliance would welcome the opportunity to support federal 30x30 efforts by facilitating sustained collaboration with the states – at a technical and political level – to inform robust, integrated federal and state 30x30 strategies.”**—U.S. Climate Alliance, representing a bipartisan coalition of two dozen U.S. governors**

Letter to America

As we write this, America is engaged in an all-hands-on-deck effort to defeat a deadly pandemic and tackle the climate crisis. We are proud to be a part of a team that is delivering relief to families in need, helping businesses weather the economic storm, and ensuring that millions of Americans receive vaccine shots each day.

The road to a full recovery remains steep, but President Biden is determined to lead America to new heights. He has laid out a vision and a plan for building back better that will repower America with clean energy, reduce greenhouse gas emissions at home and abroad, create millions of good-paying jobs, and—importantly—conserve and restore the lands and waters that support and sustain us.

President Biden has challenged all of us as Americans to join together in pursuit of a goal of conserving at least 30 percent of our lands and waters by 2030. The ambition of this goal reflects the urgency of the challenges we face: the need to do more to safeguard the drinking water, clean air, food supplies, and wildlife upon which we all depend; the need to fight climate change with the natural solutions that our forests, agricultural lands, and the ocean provide; and the need to give every child in America the chance to experience the wonders of nature.

The President's national conservation goal also provides an opportunity to better honor and support the people and communities who serve as stewards of our lands and waters. Rather than simply measuring conservation progress by national parks, wilderness lands, and marine protected areas in the care of the government, the President's vision recognizes and celebrates the voluntary conservation efforts of farmers, ranchers, and forest owners; the leadership of sovereign Tribal Nations in caring for lands, waters, and wildlife; the contributions and stewardship traditions of America's hunters, anglers, and fishing communities; and the vital importance of investing in playgrounds, trails, and open space in park-deprived communities. The President's challenge is a call to action to support locally led conservation and restoration efforts of all kinds and all over America, wherever communities wish to safeguard the lands and waters they know and love. Doing so will not only protect our lands and waters but also boost our economy and support jobs nationwide.

The central recommendation of this report, which we submit to the National Climate Task Force, is that the pursuit of a decade-long national conservation effort be faithful to eight core principles. These principles—which include a commitment to collaboration, support for voluntary and locally led conservation, and honoring of Tribal sovereignty and private property rights—are essential ingredients to building and maintaining broad support, enthusiasm, and trust for this effort. These principles are also indispensable to achieving durable outcomes that meaningfully improve the lives of Americans.

This report is only the starting point on the path to fulfilling the conservation vision that President Biden has outlined. Where this path leads over the next decade will be determined not by our agencies, but by the ideas and leadership of local communities. It is our job to listen, learn, and provide support along the way to help strengthen economies and pass on healthy lands, waters, and wildlife for generations to come.

Sincerely,

Deb Haaland
Secretary of the Interior

Thomas J. Vilsack
Secretary of Agriculture

Gina M. Raimondo
Secretary of Commerce

Brenda Mallory
Chair, Council on Environmental Quality

Introduction

This report and the recommendations that follow are anchored in a simple truth: nature is essential to the health, well-being, and prosperity of every family and every community in America.

Since before America's founding, the health and productivity of the continent's lands and waters supported an abundance of human life and activity. From the bounty of the Great Plains and vast coastal forests to the high deserts of the Southwest and beyond, Native peoples built some of the most enduring and advanced civilizations on Earth. Many hundreds of Indian Tribes lived sustainably on the lands for millennia.

The promise of arable and productive land fueled centuries of migration to America's shores, bringing fortune-seekers and refugees who sought a better life, and also millions of women, men, and children who were captured and forced into generations of slavery and oppression. As the Industrial Age dawned, the new nation's coal, oil, minerals, and timber powered fast-growing industries. America's rich seas—and the cod, salmon, lobster, and other seafood they supplied—became the engine for the most productive and profitable fisheries on the planet. Farmers, ranchers, and forest owners have built vibrant rural economies that supply food and fiber to the world, while also developing strong and lasting stewardship traditions that are a proud cornerstone of America's conservation heritage.

Over the past century, the breathtaking beauty of the American landscapes and coastlines emerged as their own economic engine, attracting visitors from around the globe to the Grand Canyon, Yellowstone, and the country's unparalleled parks, monuments, and public lands and waters. Outdoor recreation contributes an estimated $460 billion to the nation's economy, with mayors and local leaders recognizing parks, beaches, and open spaces as indispensable infrastructure for livable and prosperous communities, for purifying air and drinking water, and in defending against the impacts of climate change.[1]

Often, our nation's lands and waters have been venues of struggle and injustice. For well over a century, the U.S. Government waged war against Native peoples, taking their lands, killing their sacred wildlife, implementing brutal assimilation policies, and making and breaking promises. The horrors of the Civil War are still etched in the American landscape, reminders of the costs and consequences of slavery, racism, and division.

At their best, however, America's lands and waters are places where Americans find unity and forge common bonds. Over the past year, in particular, America the Beautiful has been a source of strength, comfort, and inspiration for a nation battling a deadly pandemic. Parks, playgrounds, riverfronts, and open spaces offered refuge to families seeking fresh air and a safe place to unwind.

The past year has deepened the love and appreciation that many people in our country feel for nature, and for the work that past generations have done to conserve natural places and wildlife for us to enjoy. It has also, however, brought into focus three problems that threaten the lands, waters, and wildlife upon which we depend:

- **The disappearance of nature:** Both globally and nationally, scientists are sounding the alarm about a catastrophic extinction crisis that threatens the biodiversity of our planet and the health of the natural systems that supply our food, water, and other resources.[2] In the U.S., approximately 12,000 wildlife species need conservation assistance to avoid the threat of extinction.[3] The disappearance of bees and other pollinators is reducing crop yields and threatens food security.[4] Already, there are three billion fewer birds in North America than there were 50 years ago.[5] Critical ocean habitats are declining, including an estimated 90 percent loss of live corals in the Florida Keys over the past 40 years and up to a 90 percent loss of bull kelp off of the northern coast of California in less than 10 years.[6] Roughly half of the riparian ecosystems and wetlands in the lower 48 States have already been lost, while more than 17,000 square miles of ranchland and farmland were lost to development or fragmented in the last two decades.[7]

- **Climate change:** The nature crisis is exacerbated by climate change, which is rapidly altering ecosystems on land and water. Ocean waters are warming, causing sea level rise, species migration, and altering circulation patterns.[8] Ocean acidification and deoxygenation due to climate change pose significant threats to many marine species that sustain ocean life as we know it, such as seagrasses, krill, and corals.[9] Climate change is contributing to historic droughts and floods, more frequent and intense wildfires and natural disasters, and the spread of invasive species.[10] The impacts of climate change on habitat are forcing some wildlife to new areas to survive, while squeezing other species closer to extinction.[11] These trends are predicted to continue, disrupting the balance of nature across the country.

- **Inequitable access to the outdoors:** As a result of discrimination and segregation in housing, transportation, conservation, and natural resource policy, communities of color and low-income communities have disproportionately less access to nature's benefits, such as clean water, clean air, and access to nature.[12] These same communities, meanwhile, shoulder a disproportionate share of the costs of nature's decline, including more pollution nearby, loss of subsistence fishing and hunting, and encroaching industrial development.[13] An estimated 100 million Americans do not have a park within a ten-minute walk of their home.[14] In too many neighborhoods and communities across America, families are finding too few close-to-home opportunities to safely enjoy the outdoors.

Together, these three issues pose grave risks to the abundance, resilience, and accessibility of the natural resources that are at the foundation of America's economy and well-being. These challenges, however, also present opportunities. Restoring forests to a more resilient condition creates jobs and reduces the threat of catastrophic wildfire. Restoring and maintaining healthy marine ecosystems supports fisheries and recreation. Building and improving parks in underserved neighborhoods improves public health, reduces temperatures on hot days, and creates joy and opportunity. Providing incentives for voluntary conservation practices rewards ranchers and farmers for being good stewards of working lands, waters, and wildlife habitat.

As the country works to recover and rebuild from the coronavirus pandemic and fully address the climate crisis, now is the time to develop and pursue a locally led, nationally scaled effort to conserve, connect, and restore the lands, waters, and wildlife upon which we all depend. The America the Beautiful campaign recommended and outlined by this report is inspired by President Biden's ten-year conservation challenge, builds on the nation's proud and collaborative stewardship traditions, and strives to give every person in America—present and future—the chance to experience the freedoms, joys, bounties, and opportunities that the nation's rich and vibrant lands and waters provide. Rising to meet this conservation challenge will improve the nation's resilience against climate change and strengthen the foundation of America's economy.

President Biden's Challenge

President Biden and Vice President Harris wasted no time in mobilizing their administration to confront the environmental challenges of our time, and to harness the economic opportunities that will come from addressing them.

On January 27, 2021, President Biden signed Executive Order 14008, *Tackling the Climate Crisis at Home and Abroad*, which launched an all-of-government effort to confront climate change, repower America's economy with clean energy, and create millions of jobs. The President's directive articulates a clear and powerful vision for the role that the nation's lands and waters can play in achieving these goals:

> *It is the policy of my Administration to put a new generation of Americans to work conserving our public lands and waters. The Federal Government must protect America's natural treasures, increase reforestation, improve access to recreation, and increase resilience to wildfires and storms, while creating well-paying union jobs for more Americans, including more opportunities for women and people of color in occupations where they are underrepresented. America's farmers, ranchers, and forest landowners have an important role to play in combating the climate crisis and reducing greenhouse gas emissions, by sequestering carbon in soils, grasses, trees, and other vegetation and sourcing sustainable bioproducts and fuels. Coastal communities have an essential role to play in mitigating climate change and strengthening resilience by protecting and restoring coastal ecosystems, such as wetlands, seagrasses, coral and oyster reefs, and mangrove and kelp forests, to protect vulnerable coastlines, sequester carbon, and support biodiversity and fisheries.*[15]

The President's directive recognizes the opportunities that America's lands and waters offer and outlines a historic and ambitious challenge to the nation. The U.S. should aim to conserve "at least 30 percent of our lands and waters by 2030."[16] This challenge is the first-ever national goal for the stewardship of nature in America. Notably, the President's challenge specifically emphasizes the notion of "conservation" of the nation's natural resources (rather than the related but different concept of "protection" or "preservation") recognizing that many uses of our lands and waters, including of working lands, can be consistent with the long-term health and sustainability of natural systems. The 30 percent goal also reflects the need to support conservation and restoration efforts across all lands and waters, not solely on public lands, including by incentivizing voluntary stewardship efforts on private lands and by supporting the efforts and visions of States and Tribal Nations.

The goal of conserving 30 percent of lands and waters by 2030 echoes the recommendations of scientists who encourage world leaders to work together to conserve or restore a substantial portion of our planet to stem the extinction crisis, safeguard water and food supplies, absorb carbon pollution, and reduce the risks of future pandemics and other global health emergencies.[17] As a long-standing global leader in conservation, the U.S. is among the top four countries in the world in the amount of remaining intact natural lands, has already established marine protected areas in approximately one quarter of U.S. waters, has a strong stewardship tradition on working lands among ranchers, farmers, and forest owners, and has been a pioneer in the management of fish and wildlife.[18] By supporting and accounting for existing and future conservation of public lands and waters, as well as collaborative and voluntary conservation efforts on working lands, Tribal lands, and State, local, and private lands, the U.S. is well positioned to achieve a 30 percent goal over the next decade.

Recognizing America's long-standing leadership in the conservation of our land, water, and wildlife, President Biden's E.O. 14008 directs the administration to develop and pursue strategies that reflect our nation's perspectives and priorities. In particular, E.O. 14008 directs the Secretary of the Interior—in coordination with the Secretary of Agriculture, the Secretary of Commerce, and the Chair of the Council on Environmental Quality—to deliver this report to the National Climate Task Force with input "from State, local, Tribal, and territorial officials, agricultural and forest landowners, fishermen, and other key stakeholders."[19] It also establishes the need for clear and transparent principles to steer the work, stating "the report shall propose guidelines for determining whether lands and waters qualify for conservation, and it shall establish mechanisms to measure progress toward the 30-percent goal."[20]

This report is a first step toward developing a national conservation effort that reflects the President's ambition, his determination to combat the climate crisis and address environmental injustice while also growing our economy, and his commitment to listening, learning, and supporting the extraordinary conservation work that is already underway across America.

Early Listening and Learning

Since the issuance of E.O. 14008, the U.S. Department of the Interior (DOI), U.S. Department of Agriculture (USDA), National Oceanic and Atmospheric Administration (NOAA) within the U.S. Department of Commerce, and Council on Environmental Quality (CEQ) have gathered input from a wide range of stakeholders on how to develop an ambitious and inclusive national conservation effort that honors America's conservation traditions. Senior agency officials participated in conversations with and received input from Tribal leaders, governors and their staff, Members of Congress and their staff, county officials, State elected officials, State fish and wildlife agencies, leaders on equity and justice in conservation policy, environmental advocacy organizations, hunting and fishing organizations, farming and ranching organizations, trade associations, forestry representatives, outdoor recreation businesses and users, the seafood industry, and others. The outreach conducted included virtual meetings and listening sessions, and a review of written letters and submissions.

This report is also informed by efforts in several states that are already moving forward with—or are laying the groundwork to pursue—their own conservation goals. California is embarking upon a stakeholder engagement process to inform its goal to conserve 30 percent of lands and coastal waters in California by 2030.[21] The Maine Climate Council added a goal of conserving 30 percent of the land in Maine by 2030 in its comprehensive climate change plan.[22] Hawaii launched an effort that focuses on effective management of 30 percent of nearshore waters and priority watershed forests by 2030.[23] Legislation has been introduced in South Carolina, New York, Nevada, and Michigan to pursue similar pathways.[24] More than 70 mayors from across the nation have written in support of locally led conservation efforts in pursuit of conserving 30 percent of our nation's lands and waters by 2030.[25]

In gathering input to inform this report and its preliminary recommendations, some common perspectives and values emerged across a broad range of stakeholders. There was, for example, universal appreciation of the value of America's lands and waters—in the form of working farms, ranches, and forests; freshwater and saltwater fishing areas; native hunting grounds; riparian habitats; wildlife refuges; urban parks; and more. Stakeholders described a feeling of responsibility to pass these lands and waters, traditions, cultures, and opportunities in the outdoors along to future generations.

Stakeholders also universally emphasized the importance of ongoing dialogue, engagement, and collaboration in developing approaches for conserving America's lands and waters. There was a recognition that many Americans, including communities of color, low-income communities, and Tribal nations, have often been excluded from conservation, development, and natural resource decisions and investments. There was also an emphasis on the importance of science in guiding good land and ocean management decisions, and of the value, breadth, and effectiveness of many existing conservation tools. Stakeholders across the board—from agricultural and fishing organizations to leaders who focus on equity and justice in conservation policy—also generously offered to provide ongoing input over the coming years to help guide effective, equitable, and enduring outcomes.

There were several areas in which stakeholders offered divergent perspectives or raised important questions and concerns. There were differing views, for example, of how broadly or narrowly to define "conservation" and how to measure progress toward a 2030 conservation goal. There were concerns raised about the impacts of conserving lands and waters on future abilities to mine critical minerals, conduct active forest management, harvest fish, and other activities—important considerations that underscore the value of making balanced land and ocean management decisions through public processes that are informed by the best available scientific information and accurate maps. Other discussions with stakeholders indicated the importance of working collaboratively with private landowners, Tribal Nations, State agencies, fishing communities, and others, and the need to affirm that private property rights will be honored and protected.

Input from stakeholders also conveyed important regional, State, and local considerations. Because Federal agencies manage significant expanses of public lands in the West, the Federal Government's conservation efforts and resources have, historically, been more focused on that region. Elected officials from Alaska, for example, noted that no State currently has more protected public lands. Ocean stakeholders also noted that many of the nation's marine protected areas are located in the Western Pacific. The comments spoke to a need to recognize the unique blend of priorities, threats, conservation tools, and opportunities across regions and ecosystem types, such as through the voluntary efforts of ranchers who are conserving the prairies and wetlands of the Midwest, forest owners who are conserving the rich biodiversity of the Southeast, and fishers who are conserving important fish habitats in the Pacific Northwest. Finally, the early listening and learning conducted for this report underscored the extraordinary depth of experience and passion the U.S. has demonstrated in stewarding the nation's natural resources, across regions, states, and stakeholders. This knowledge, ingenuity, and commitment offer great promise that the nation can, over the next decade, make great strides toward the President's challenge to conserve and restore the health, productivity, and connectedness of the lands and waters upon which every community depends.

Principles for a Locally Led Effort to Conserve and Restore America the Beautiful

Decades of land and water stewardship by ranchers, farmers, fishers, hunters, private property owners, conservation organizations, Tribal Nations, territories, State and local governments, and others have demonstrated that the most effective and enduring conservation strategies are those that reflect the priorities, needs, and perspectives of the families and communities that know, live, work, and care for the lands and waters.

Science can provide information about the places that are most rich in wildlife, that store the most carbon, or that are most rare or imperiled, but data alone should not be the sole guide or measure of success for how the nation protects, conserves, or restores its lands and waters. While the U.S. has a remarkable record of success in safeguarding iconic lands, species-rich waters, and at-risk wildlife, the Federal Government has also caused pain along the way: dispossessing Tribal Nations and Indigenous people of their lands and infringing upon their subsistence rights; evicting private landowners to create national parks; imposing segregationist policies on public lands and beaches; ignoring the contributions of communities of color and underrepresented communities in the preservation of national resources; and more. A renewed national commitment to land and water conservation can and must strive to honor the needs and priorities of all communities in America, help address the climate crisis, and help to strengthen the foundation of the nation's economy.

In pursuing the President's goal of conserving and restoring America the Beautiful, this report recommends adhering to eight key principles that will be critical to the success and durability of the effort. These equally important principles reflect a broad consensus of views and recommendations among the many stakeholders, agencies, and Tribes consulted in developing this report.

Principle 1: Pursue a Collaborative and Inclusive Approach to Conservation

The spirit of collaboration and shared purpose should animate all aspects of America's nature conservation and restoration efforts over the next decade. The U.S. should seek to build upon the myriad examples where collaboration and consensus-building have led to significant conservation outcomes. Just last year, Congress passed the Great American Outdoors Act on a bipartisan basis, providing the single largest investment in public lands and waters in decades. In the Crown of the Continent in Montana, the northern Everglades in Florida, the Prairie Potholes of the upper Midwest and beyond, farmers, ranchers, and sportsmen and sportswomen have teamed up to conserve some of our nation's most cherished landscapes and watersheds. From Bristol Bay, Alaska to the Northwestern Hawaiian Islands to the coral reefs in the Gulf of Mexico, fishers, Indigenous communities, and local businesses have worked together to conserve the health and productivity of unparalleled marine resources.

Principle 2: Conserve America's Lands and Waters for the Benefit of All People

The conservation and restoration of natural places in America should yield meaningful benefits in the lives of all Americans, and these benefits should be equitably distributed. The conservation value of a particular place should not be measured solely in biological terms, but also by its capacity to purify drinking water, to cool the air for a nearby neighborhood, to provide a safe outdoor escape for a community that is park-deprived, to help America prepare for and respond to the impacts of climate change, or to unlock access for outdoor recreation, hunting, angling, and beyond. Centering this effort on people also means recognizing the oversized contributions that farmers, ranchers, forest owners, fishers, hunters, rural communities, and Tribal Nations already make in safeguarding wildlife and open spaces for the benefit of the rest of the country, and therefore recognizing and encouraging these remarkable efforts.

Principle 3: Support Locally Led and Locally Designed Conservation Efforts

Every community in the United States has its own relationship with nearby lands and waters, and every community is working in some way to conserve the places that matter the most to it. The Federal Government should do all it can to help local communities achieve their own conservation priorities and vision. Locally and regionally designed approaches can play a key role in conserving resources and be tailored to meet the priorities and needs of local communities and the nation.

Conservation and restoration efforts should also be regionally balanced. For example, instead of focusing land conservation efforts primarily on western public lands—as has been a past practice of Federal agencies—agencies should support collaborative conservation efforts across the country on private, State, local, Tribal, and territorial lands. Similarly, marine conservation efforts should reflect regional priorities and seek to achieve balanced stewardship across U.S. ocean areas.

Principle 4: Honor Tribal Sovereignty and Support the Priorities of Tribal Nations

Tribal Nations have sovereign authority over their lands and waters, possess long-standing treaty hunting and fishing rights on and off reservations, and have many cultural, natural, and sacred sites on national public lands and the ocean. Efforts to conserve and restore America's lands and waters must involve regular, meaningful, and robust consultation with Tribal Nations. These efforts must respect and honor Tribal sovereignty, treaty and subsistence rights, and freedom of religious practices. Federal agencies should seek to support and help advance the priorities of American Indian, Alaska Native, Native Hawaiian, and Indigenous leaders, including those related to sustainable land management and the conservation of natural, cultural, and historical resources.

Principle 5: Pursue Conservation and Restoration Approaches that Create Jobs and Support Healthy Communities

Conserving and restoring the nation's lands and waters can yield immense economic benefits.[26] A healthy ocean, for example, supports productive fisheries and vibrant working waterfronts. Reducing wildfire risks and restoring ecological balance to the nation's forests creates jobs in rural communities. Conserving water and restoring ecosystems supports the reliability of the water supply, resiliency to drought, and resistance to flooding. Conserving fish and wildlife habitat and improving access for hunting and fishing spurs the sale of gear, boats, travel, and outfitting. Creating more parks and tree cover in cities cools neighborhoods on dangerously hot days, saves money on utility bills, and improves human health and well-being. These are among the many ways that a locally driven, nationally scaled conservation campaign over the next decade can help lift America's economy, address environmental justice, and improve quality of life.

Principle 6: Honor Private Property Rights and Support the Voluntary Stewardship Efforts of Private Landowners and Fishers

There is a strong stewardship ethic among America's fishers, farmers, ranchers, forest owners, and other private landowners. U.S. working lands and waters give our nation food and fiber and keep rural and coastal communities healthy and prosperous. They are also integral to conserving functioning habitats and connecting lands and waters across the country. Efforts to conserve and restore America's lands and waters must respect the rights of private property owners. Such efforts must also build trust among all communities and stakeholders, including by recognizing and rewarding the voluntary conservation efforts of private landowners and the science-based approaches of fishery managers. President Biden has recognized and honored the leadership role that farmers, ranchers, forest owners, and fishers already play in the conservation of the nation's lands, waters, and wildlife, and has made clear that his administration will support voluntary stewardship efforts that are already underway across the country's lands and waters. This commitment includes a clear recognition that maintaining ranching in the West—on both public lands and private lands—is essential to maintaining the health of wildlife, the prosperity of local economies, and an important and proud way of life.

Principle 7: Use Science as a Guide

Scientists have made remarkable gains in understanding the complicated natural systems that support human communities, particularly in the face of climate change. Studies of the carbon sequestration potential of lands and the ocean; of biodiversity loss, ecosystem services, and the movement and migration of wildlife; and of air and water pollution are part of a large and growing body of scientific information that can help guide decisions about how the nation should manage, connect, and conserve its lands and waters. Conservation efforts are more successful and effective when rooted in the best available science and informed by the recommendations of top scientists and subject matter experts. Transparent and accessible information will increase shared understanding and help build trust among stakeholders and the public. The use of Indigenous and Traditional Ecological Knowledge can complement and integrate these efforts.

Principle 8: Build on Existing Tools and Strategies with an Emphasis on Flexibility and Adaptive Approaches

The U.S. has long been a global innovator in natural resource conservation and stewardship, from inventing the idea of national parks to forging market-based strategies for slowing the loss of the nation's essential wetlands. Though President Biden's national conservation goal is ambitious, it can be achieved using the wide array of existing tools and strategies that Tribal Nations, territories, State and local governments, private landowners, non-profit organizations, fishing communities, Congress, and Federal agencies have already developed and deployed effectively. These tools range from grant programs for local parks and coastal restoration projects, to conservation programs on working lands, to the designation of locally crafted recreation and conservation areas on public lands and waters, to using the stakeholder-driven processes for marine fisheries management and sanctuary designations, among other examples. Agencies should support the flexible application of tools, innovation in designing new approaches, and, where appropriate, the use of adaptive management to help adjust to a changing climate, shifting pressures, and new science.

Measuring Progress for Nature and People

Executive Order 14008 sets a goal of conserving 30 percent of U.S. lands and waters by 2030 and directs DOI, in coordination with other agencies, to establish mechanisms to measure progress.[27] Each year, the Secretary of the Interior is to provide reports to the National Climate Task Force with updates on this progress.

This discussion should start with a recognition that, at its core, President Biden's conservation vision is about doing better for people, for fish and wildlife, and for the planet. There is no single metric—including a percentage target—that could fully measure progress toward the fulfillment of those interrelated goals. Similarly, there is no single database that could capture the texture and nuance of the economic and social values of every restoration or conservation action.

With these caveats, transparent and measurable goals for conservation can be a helpful tool to set a baseline, understand overall trends, and catalyze the collective action across the country that is needed to address the urgency of the climate and biodiversity crises.

The question of what should "count" came up regularly in the early listening sessions, followed by various perspectives on how to define conservation on the land and in the ocean. Many stakeholders recommended that a continuum of effective conservation measures be acknowledged, departing from stricter definitions of "protection" that do not recognize the co-benefits that working lands or areas managed for multiple use may offer. Other feedback encouraged the administration to focus on the quality and durability of conservation outcomes, noting that not every parcel of land or water is equal when it comes to enhancing nature's contributions to people, ecosystem health, biodiversity, or the sequestration of carbon.

In light of the above, this report recommends that the U.S. Government take two complementary steps to measure and report upon conservation progress in the United States: the creation of an

American Conservation and Stewardship Atlas that collects baseline information on the amount and types of lands and waters that are being managed for conservation and restoration purposes, and the publication of annual America the Beautiful updates on the health of nature in America and on the Federal Government's efforts to support locally led conservation and restoration efforts.

American Conservation and Stewardship Atlas

To develop and track a clear baseline of information on lands and waters that have already been conserved or restored, the U.S. Government should establish an interagency working group of experts to build an American Conservation and Stewardship Atlas. The Atlas would be an accessible, updated, and comprehensive tool through which to measure the progress of conservation, stewardship, and restoration efforts across the United States in a manner that reflects the goals and principles outlined in this report.

The interagency working group—led by the U.S. Geological Survey (USGS), Natural Resources Conservation Service (NRCS), and NOAA, in partnership with the Council on Environmental Quality, and other land and ocean management agencies at the Departments of Agriculture, Commerce, and the Interior—would be tasked with gathering input from the public, States, Tribal Nations, a wide range of stakeholders, and scientists to assess existing databases, and to develop an inclusive, collaborative approach to capture and reflect conservation and restoration of lands and waters. The group, for example, could consider how to reflect State- and county-presented information, how to capture conservation outcomes on multiple use lands and ocean areas, and how to protect the privacy of landowners, and sensitive or proprietary information.

The U.S. Government has existing tools to draw from in developing the American Conservation and Stewardship Atlas, including USDA's Natural Resources Inventory and Forest Inventory and Analysis programs, the USGS's Protected Area Database (PAD), and NOAA's Restoration Atlas and Marine Protected Areas Inventory, among many others, but they should be refined, coordinated, and supplemented to better reflect the state of conservation in America. For example, the PAD contains useful, but incomplete, information about the conservation status of Federal, State, and local government lands and private lands subject to conservation easements.[28] It is an aggregated database built through contributions from States and partners throughout the nation; however, the PAD does not, for example, currently include information about the conservation strategies of Tribal Nations, and many other effective conservation tools that farmers, ranchers, and other private landowners are deploying to conserve the health of working lands.

The American Conservation and Stewardship Atlas would aggregate information from these databases and others, supplement this information with information from the States, Tribes, public, stakeholders, and scientists, and provide a baseline assessment of how much land, ocean, and other waters in the U.S. are currently conserved or restored, including, but not necessarily limited to:

- The contributions of farmers, ranchers, forest owners, and private landowners through effective and voluntary conservation measures;
- The contributions of Fishery Management Councils and their conservation measures under the Magnuson-Stevens Fishery Conservation and Management Act; and
- The existing protections and designations on lands and waters across Federal, State, local, Tribal, and private lands and waters across the nation.

America the Beautiful Updates

To provide clear updates on the progress being made to support conservation and restoration efforts across the country, the Department of the Interior, in coordination with the Department of Agriculture, the Department of Commerce through NOAA, and the Council on Environmental Quality, should publish an annual, publicly available America the Beautiful report.

The first report, to be public by the end of 2021, should include:

- Progress on the areas of collaboration outlined in the next section of this report;
- An assessment of land-cover changes, including loss of open space; and
- A review of the condition of fish and wildlife habitats and populations.

Together and apart, the American Conservation and Stewardship Atlas and the America the Beautiful updates will provide a more comprehensive and inclusive accounting for the state of lands, waters, and wildlife in America, as well as document how local, State, national, and Tribal governments; private landowners; and other partners are working to conserve and restore lands and waters.

Recommendations for Early Focus and Progress in the America the Beautiful Campaign

There are hundreds of locally supported conservation and restoration efforts already underway in communities across America—in line with the principles and vision outlined above—that can be advanced over the coming decade to strengthen our economy, fight climate change, address environmental injustice, and improve outcomes for fish, wildlife, and people. Above all else, a national campaign to conserve and restore America the Beautiful should celebrate, leverage and enhance all of this remarkable work, and seek to inspire others with stories of on-the-ground collaborations and successes.

To better support and encourage locally led conservation and restoration efforts across the country, however, it will be important for Federal agencies to identify areas of priority and focus for investment and collaboration. This report identifies six recommended areas of early focus for the Biden-Harris administration's efforts to conserve and restore America the Beautiful. These areas of focus are intended to forge common purpose, support voluntary approaches to conservation, and reflect early inputs and ideas that elected officials, Tribal leaders, and stakeholders have lifted up as opportunities for successful collaboration. These recommendations are preliminary and not exhaustive. Additionally, this section primarily focuses on work that Federal agencies can do to encourage and advance locally supported conservation efforts across the nation. A successful effort will require a blend of innovative and lasting conservation work across Federal, State, local, private and Tribal lands and waters.

- **Create More Parks and Safe Outdoor Opportunities in Nature-Deprived Communities.** The Biden-Harris administration has made a historic commitment to ensure that 40 percent of the overall benefits from relevant Federal investments flow to disadvantaged communities.[29] In that spirit, the America the Beautiful campaign should support locally led conservation and park projects in communities that disproportionately lack access to nature and its benefits.

The Great American Outdoors Act, which Congress passed in 2020 on a bipartisan basis, could be among the tools used to address environmental injustice. The law provides dedicated annual funding for parks and open space projects across the country, including through Land and Water Conservation Fund (LWCF) programs, such as the Outdoor Recreation Legacy Partnership (ORLP). The National Park Service, in particular, should strengthen and expand the ORLP program, which focuses on creating new parks and access to nature in historically underserved communities.

- **Support Tribally Led Conservation and Restoration Priorities**. Tribal governments have often struggled to access Federal funding and assistance to support their conservation efforts, either because they are not written into legislation that authorizes key Federal programs, or because they may not have capacity to navigate the bureaucracy to participate in the programs for which they are eligible. Federal agencies should review their most successful conservation programs, such as the LWCF and the National Marine Sanctuaries nominations process, to determine how to better include and support Tribal governments. This may include working with Congress to revise underlying statutes, or developing technical assistance and capacity-building grants to support Indigenous-led conservation efforts.

  Additionally, Federal agencies should take steps to improve engagement with American Indians, Alaska Natives, and Native Hawaiians on the care and management of public lands and waters, particularly regarding sacred and ceremonial sites, and trust and treaty rights. The Biden-Harris administration has committed to engaging in regular, meaningful, and robust consultation with Tribal Nations; this must include land management planning and relevant decision-making for public lands and waters.[30]

  Finally, the Federal Government should prioritize restoring Tribal homelands by improving the land into trust process. Tribes have time and time again proven to be the most effective stewards of natural resources.[31]

- **Expand Collaborative Conservation of Fish and Wildlife Habitats and Corridors.** Federal agencies should take several broadly supported steps to stem the decline of fish and wildlife populations and their habitats throughout the country. First, agencies can work with States, Tribes, local communities, and private landowners to establish and expand upon promising initiatives to conserve and restore wildlife migration corridors through incentives and local collaboration. The Trump administration launched a promising effort to enhance the winter range and migration corridor habitat of elk, deer, and pronghorn on DOI-managed lands.[32] This initiative could be expanded to include other land managers, to build partnerships with working ranches and other landowners, and to conserve corridors and seasonal ranges for other species.

  Second, the U.S. Fish and Wildlife Service (FWS) should expand conservation efforts already identified through partnerships with external stakeholders, including fish passage projects in the National Fish Habitat Action Plan, conservation of at-risk species identified in State Wildlife Action Plans, and bird habitat conservation through the Migratory Bird Joint Ventures. FWS should also work with States, local communities, and others to explore where there is support to enhance the National Wildlife Refuge System, which provides important anchors for wildlife conservation throughout the nation. The Biden-Harris administration welcomes Congressional efforts to support on-the-ground habitat restoration for at-risk species through collaboration with State fish and wildlife agencies.

Third, NOAA should expand the National Marine Sanctuaries System and National Estuarine Research Reserve System. Through broad public engagement, NOAA can establish national marine sanctuaries that protect natural and cultural marine and Great Lakes resources and promote sustainable uses. The process to establish new national marine sanctuaries and accompanying management plans has already begun for sites in Wisconsin and New York, and several other sites have been nominated for potential future designation.[33] Similarly, under authorities provided by the Coastal Zone Management Act, NOAA is exploring new designations for national estuarine research reserves in Connecticut, Wisconsin, and Louisiana.[34] If approved, they would join a network of coastal sites managed in partnership with coastal states and local partners for the protection and research of estuarine systems. In addition, NOAA's Restoration Center should expand its work to conserve and restore habitats—like wetlands, rivers, and coral reefs—to boost fish populations, recover threatened and endangered species, and support resilient coastal communities.[35]

Finally, the United States boasts one of the most dynamic and innovative wild-capture fishery management systems in the world under the Magnuson-Stevens Fishery Conservation and Management Act and the Fish and Wildlife Coordination Act. The management measures that are available to fisheries management authorities, such as gear-based restrictions and habitat-based measures, could be applied to achieve improved conservation outcomes that benefit the health of fisheries as well as other marine species and habitats. NOAA should work closely with regional fishery management councils to identify areas or networks of areas where their fisheries management efforts would support long-term conservation goals.

- **Increase Access for Outdoor Recreation.** Additional conservation can and should improve access for hunting, fishing, hiking, boating, and other forms of outdoor recreation. Improved access to public lands and waters—in an equitable, well-managed and sustainable manner—can broaden and deepen connections to nature and its benefits, and encourage the next generation of outdoor stewards. Hunters, anglers, and other outdoor enthusiasts have not only played a positive role in stewarding our nation's lands, waters, and wildlife, but they also generate significant economic benefits to local communities.

  Federal land and coastal management agencies should expand support for voluntary programs that unlock access to the millions of acres of public lands that are currently inaccessible to the public.[36] The administration should also prioritize management planning that identifies lands and waters that are appropriate to be conserved and managed for outdoor recreation. In the ocean, ongoing mapping efforts will be important to managing for sustainable uses and should be continued.

  Finally, the Biden-Harris administration welcomes efforts in Congress to support outdoor recreation, including appropriate designations to improve conservation and appreciation of lands and waters.

- **Incentivize and Reward the Voluntary Conservation Efforts of Fishers, Ranchers, Farmers, and Forest Owners.** Federal agencies can and should advance conservation by supporting programs that incentivize voluntary conservation efforts and provide new sources of income for American farmers, ranchers, and forest stewards. Healthy rural economies are a key component of keeping working lands healthy, productive, and whole.

  The USDA has an array of programs that offer effective strategies for advancing conservation on working lands, such as the Working Lands for Wildlife initiative and the Conservation Reserve Program. The reauthorization of the Farm Bill in 2023 provides a tremendous opportunity for the USDA and Congress to improve the effectiveness of relevant programs to conserve working lands.

  Similarly, the FWS should enhance support for voluntary conservation efforts by private landowners through initiatives such as Conservation Without Conflict, tools such as species credit trading (conservation banking) and Candidate Conservation Agreements with Assurances, and the Partners for Fish and Wildlife Program.

  NOAA should continue its Species in the Spotlight initiative to provide immediate, targeted efforts to halt declines and stabilize populations of the species most at-risk of extinction in the near future, which could increase public awareness, marshal resources, and focus conservation actions, including through voluntary measures and public-private partnerships.

- **Create Jobs by Investing in Restoration and Resilience.** The Biden-Harris administration, through the American Jobs Plan, has proposed bold investments to restore our nation's lands, forests, wetlands, watersheds, and freshwater, coastal and ocean resources. The proposal includes putting a new, diverse generation of Americans to work through a Civilian Climate Corps that can help conserve and restore public lands and waters. The investments in restoration, reforestation, reclamation, and other activities that improve the function and form of our natural systems—from the Everglades and the Great Lakes to the Chesapeake Bay—will not only bolster our nation's resilience to extreme wildfires, sea level rise, droughts, storms, and other climate impacts, but they will also create a new pathway to good-paying union jobs and provide economic benefits to communities across the nation.

Finally, and importantly, all of these recommendations should serve as a starting point for additional public input and conversations to inform the nation's progress toward the President's goal for conservation over the next decade. Federal agencies should establish formal and informal venues by which Tribes, States, territories, stakeholders, and the American public can shape and advance these efforts. In addition to Tribal consultations and opportunities for public comment, the Biden-Harris administration should explore the formation of advisory councils, Federal-State and Federal-Tribal working groups, and other ways to engage stakeholders and the public.

Conclusion

President Biden's direction in E.O. 14008 to establish and pursue a national conservation goal over the next decade is a challenge that America is well-equipped to meet. America has had tremendous success in forging solutions to environmental problems and experience in harnessing and conserving the bounties of the natural world. The forests, rivers, coasts, deserts, mountains, and grasslands that previous generations have passed down are living testaments to the nation's collective capacity to safeguard the resources that not only power our prosperity but bind us as one people.

An America the Beautiful campaign—community-led and nationally scaled—is a fitting and needed response to the challenges of this moment. While the coronavirus pandemic inflicted tragedy, grief, and pain, the natural world offered peace, escape, and hope for many. Now, as the nation recovers and rebuilds, it is time to do right by the lands and waters that sustain every community in every part of the country: returning American wildlife to abundance; safeguarding the health and productivity of the nation's working lands and waters; giving every child the chance to play and explore in a safe, close-to-home park; honoring and supporting the natural and cultural resource priorities of Tribal Nations; and far more.

The President's goal of conserving 30 percent of America's lands and waters by 2030 is more than a number—it is a challenge to build on the nation's best conservation traditions, to be faithful to principles that reflect the country's values, and to improve the quality of Americans' lives—now and for decades to come.

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Attachment D

NEW MEXICO PUBLIC LANDS AND THEIR SIGNIFICANCE TO CLIMATE CHANGE ADAPTATION AND MITIGATION:

IDENTIFYING PRIORITIES FOR CONSERVATION AND STEWARDSHIP

EcoAdapt™
Meeting the challenges of climate change

December 2022

Acknowledgments: Thank you to the New Mexico Wilderness Alliance for funding this project, and especially to Mark Allison and Tisha Broska. Thanks also to Deb Rudnick for support with background research on New Mexico ecosystems and public lands.

Cover photo: Organ Mountains-Desert Peaks National Monument. Photo by Bob Wick/BLM via Flickr

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For more information about this report, please contact Laura Hilberg (Laura.Hilberg@EcoAdapt.org).

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Executive Summary

Scientists and policymakers are calling for the conservation of 30% of the world's lands and waters by 2030 in order to protect global biodiversity and critical ecosystem services, including those necessary for climate change adaptation and mitigation. This goal, known as the "30x30 initiative", is supported by President Biden at the national level as well as by many state governments. These include New Mexico, where the percent of protected lands managed primarily for biodiversity lags behind national levels (6.1% in New Mexico compared to 12.6% nationally) despite the relatively high proportion of public lands and rich biodiversity present in the state.

The purpose of this study was to evaluate the climate change adaptation and mitigation value of 5.9 million acres of federally-owned public lands in New Mexico that have been identified as potential priorities for additional protection as part of the 30x30 initiative. In order to accomplish this, we assessed five different indicators of climate change adaptation and mitigation: biodiversity, connectivity, site resilience, carbon storage, and greenhouse gas emissions associated with unleased fossil fuels. For each of these indicators, we identified the 25% of the study area (roughly 1.5 million acres) that represents the highest priority for additional protection based on the highest scores for that indicator. Then we overlaid these priority areas to better understand which locations might make the greatest contribution to climate adaptation and mitigation objectives across across multiple indicators.

Key Findings

Protected areas have the potential to contribute significantly to ecosystem adaptation to climate change (*1–3*) by maintaining landscape-scale ecological processes and housing larger populations of sensitive species that increase the potential for local genetic adaptation (*3, 4*) and are less vulnerable to extirpation (*5*).

- Protected areas represent a highly effective strategy to protect existing biodiversity (*5–7*), particularly when they are strategically placed to increase representation of intact, high-quality habitats across a range of environmental conditions (*2, 7, 8*). Within the study area, the 1.7 million acres with the highest presence of range-restricted imperiled species accounts for 11% of the total state biodiversity score despite accounting for only 2% of the land area. This suggests that there is high potential for targeted protection of sites with the highest value for rare species and isolated populations, which are known to be particularly vulnerable to climate change (*9, 10*).
- Protected areas that significantly increase landscape connectivity and represent a range of environmental conditions increase species movement (*11*) and gene flow (*12*), reducing the risk of extirpation in isolated populations (*13, 14*) and facilitating access to suitable habitat patches that can act as "stepping stones" to facilitate range shifts (*1, 15–17*). Portions of the study area where barriers are low and species are able to freely move across large areas primarily lie in the Chihuahuan Desert and Arizona/New Mexico Mountains ecoregions, while more concentrated movement corridors are found in

riparian areas. Expanding protection to include lands with the highest potential for maintaining species movement are likely to minimize biodiversity loss across larger spatial scales while simultaneously supporting shifts in species distribution in response to climate change (*2*, *15*, *18–20*).

- Resilient protected area networks are able to maintain the conditions necessary to sustain biodiversity and ecosystem processes as climate change occurs (*21–23*), and typically include intact, high-quality ecosystems in areas with high topographic complexity and geophysical diversity, as well as in high-elevation areas, riparian zones, and other sites with permanent sources of surface water (*24–27*). Within the study area, the most resilient sites are disproportionately located in the Arizona/New Mexico Mountains ecoregion, but many are also found in the Chihuahuan Desert in the southwest corner of the state. Strengthening protection for these sites is likely to result in the conservation of important climate refugia (i.e., areas that are buffered from exposure to rapid changes and climate extremes) that facilitate the persistence of sensitive species, buying time for adaptation over longer time scales (*17*, *28*).

Protected areas can also play an important role in climate mitigation efforts by preventing the degradation and loss of ecosystems that sequester and store carbon (*29–32*), as well as by limiting the extraction of fossil fuels that are associated with greenhouse gas emissions (*33*, *34*).

- Protection of intact ecosystems supports continued carbon sequestration and storage within plants and soils by preventing disturbances and land-use change that negatively impact the ecosystem processes that support these functions (*29–32*). By the end of the century, the study area has the potential to hold carbon stocks of 210.1 to 240.6 million metric tons of carbon, with the low end of that range occurring under the hottest, driest future scenarios. Within the study area, the amount of carbon stored per acre will be highest in the Southern Rockies ecoregion where vegetation is dominated by relatively dense montane forests, with an average density of 87 metric tons carbon per acre. Expanding protected area networks in order to maximize carbon stocks would benefit from preventing the degradation and loss of these areas to ensure continued carbon sequestration over the coming decades.
- Keeping oil, gas, and coal in the ground has the potential to significantly contribute to climate mitigation targets by preventing greenhouse gas emissions associated with fossil fuel production and end-use consumption (*35*, *36*). An estimated 2,752 million barrels of crude oil, 3,075 billion cubic feet of natural gas, and 403 million short tons of coal may remain underground in unleased portions of the study area. Together, these are associated with lifecycle greenhouse gas emissions of 2,943 million metric tons of carbon dioxide equivalent, an amount is equivalent to 5.3 months of greenhouse gas emission for the entire U.S. at 2018 levels (*37*). Strengthening protection with designations that prohibit new lease sales and fossil fuel extraction (i.e., wilderness designation) would help ensure that these fuels are permanently sequestered underground, preventing additional greenhouse gasses from entering the atmosphere.

Introduction

The 30x30 initiative, put forth by the United Nations Convention on Biological Diversity, calls for conserving 30% of the world's terrestrial and marine ecosystems by 2030 in order to protect global biodiversity and ecosystem services, including those critical for both adapting to and mitigating climate change (*38*). The United States is among many countries in support of the initiative, which was formalized on January 27, 2021 when Biden signed Executive Order 14008 "Tackling the Climate Crisis at Home and Abroad" that included a commitment to conserving at least 30% of U.S. lands and waters by 2030. While none of the 30x30 commitments have yet defined the level of protection that will count towards these goals, most existing studies evaluating 30x30 goals (*39–41*) refer to GAP status 1 and 2 lands from the Protected Areas Database of the United States (PAD-US), which are protected with the primary goal of managing for biodiversity. Currently only 12.6% of the U.S. land area are categorized as GAP 1 or 2, an area equivalent to 306.9 million acres (*42*). An additional 17.3% (421.2 million acres) is protected from conversion but open to multiple uses (GAP status 3), which may include resource extraction such as logging and mining (*42*). Generally, GAP 3 protection is assumed to be inadequate for meeting 30x30 conservation goals due to the ecosystem degradation and loss of biodiversity that can occur as a result of activities such as these.

Based on the PAD-US GAP categories, an additional 425 million acres of land must be granted GAP 1 or 2 levels of protection by 2030 in order to meet the 30x30 conservation goal at a national level. This could occur through a combination of designating new protected areas such as wilderness areas, national parks, wildlife refuges, and state parks or preserves, or by strengthening the status of existing protected areas that are currently not being managed primarily for biodiversity (e.g., GAP status 3 lands). Many of these areas are vulnerable to loss or downgrading of their protected status as a result of political pressure often related to use of natural resources (*43, 44*), such as occurred in 2017 when a review of National Monuments ordered by the Trump Administration threatened New Mexico's Organ Mountains Desert Peaks and Rio Grande del Norte National Monuments (*45*). Thus, strengthening the protected status of existing protected areas represents an important strategy to prevent the future degradation of intact, high-quality ecosystems. In particular, wilderness designation requires support from Congress for both addition and removal of lands from the National Wilderness Preservation System, making it the strongest and most permanent level of conservation protection available in the United States (*46*).

Many state governments have also committed to 30x30 goals that align with international and federal targets. This includes New Mexico, where in August 2021 Governor Michelle Lujan Grisham signed an executive order titled "Protecting New Mexico's Lands, Watersheds, Wildlife, and Natural Heritage" (Executive Order 2021-052), which calls for New Mexico to protect 30% of its land and waters by the year 2030. Currently, only 6.1% of federal, state, and private lands in New Mexico (4.8 million acres) are protected under GAP 1 or 2 status, meaning that an additional 18.6 million acres would need to be added to achieve statewide 30x30 goals (*42*). An additional 25.5% (19.8 million acres) of undeveloped land is currently managed under

GAP status 3 (*42*), highlighting ample opportunities to strengthen and extend the existing protected area network.

Climate change adaptation and mitigation benefits of 30x30 goals

Protected area designation represents a well-established and highly effective strategy to protect existing biodiversity (*5–7*, *47*), particularly when sites are strategically located to maximize connectivity and representation of ecosystem niches and habitat types for a range of species (*7*, *8*, *18*, *48*, *49*). However, climate change is already impacting biodiversity within protected areas, and climate-driven losses of native species and ecosystem functioning within protected areas are expected to continue into the future (*15*, *20*, *50*, *51*). As a result, it is critical that efforts to increase protected area networks prioritize sites that not only safeguard biodiversity and meet other conservation objectives (*9*, *39*, *40*, *52*, *53*), but also contribute to ecosystem adaptation to climate change as well as climate change mitigation efforts (*1*, *18*, *39*, *40*, *54*, *55*). To date, many of the areas with the greatest potential to support climate change adaptation and mitigation remain unprotected, including those that could serve as climate refugia, provide corridors that facilitate climate-driven range shifts, and/or sequester and store large amounts of carbon (*20*, *25*, *39*, *40*). Ensuring that these sites are protected from land-use conversion and human activities that result in degradation of these services will allow protected areas to play an important role in ecosystem adaptation to climate change as well as efforts to meet climate mitigation targets.

The goal of this study was to assess the potential climate change adaptation and mitigation value of New Mexico public lands identified by New Mexico Wild as potential candidates for additional protection. To accomplish this, we identified or created datasets to represent several critical indicators of climate change adaptation and mitigation across the landscape, including biodiversity, connectivity, landscape resilience, carbon sequestration and storage, and potential greenhouse gas emissions associated with unleased fossil fuels. Each of these five indicators was used to evaluate the relative value of protected areas considered in the study, and the top 25% of the study area for each indicator was overlaid to identify areas that may represent the highest priorities for additional protection across multiple considerations. The resulting maps and datasets are intended to assist conservation planners, land managers, and advocates in determining where strengthening existing protection of public lands may provide the greatest climate change benefits.

Study Methodology

Study area

The study area was comprised of 5,908,218 acres of federal public lands identified as having high potential for contributing to 30x30 goals (Figure 1), primarily through strengthening of their existing status (i.e., shifting protected areas from GAP 3 into GAP 1 or 2 status) and/or reducing the likelihood that their existing GAP 1–2 status will be lost or downgraded (i.e., by designating additional areas as wilderness). The areas considered include federal lands managed by the Bureau of Land Management, National Park Service, and U.S. Forest Service, and currently designated as Areas of Critical Environmental Concern (ACECs), Inventoried Roadless Areas (IRAs), Lands with Wilderness Characteristics (LWCs), and Wilderness Study Areas (WSAs). Some additional federal lands identified as having wilderness characteristics through on-the-ground surveys by New Mexico Wild were also included. Although the study area for this project focuses exclusively on federally-owned public lands, it should be noted that tribal, state trust, and private lands are part of existing GAP 1–2 areas and play an important role in effective protected area networks (*56*).

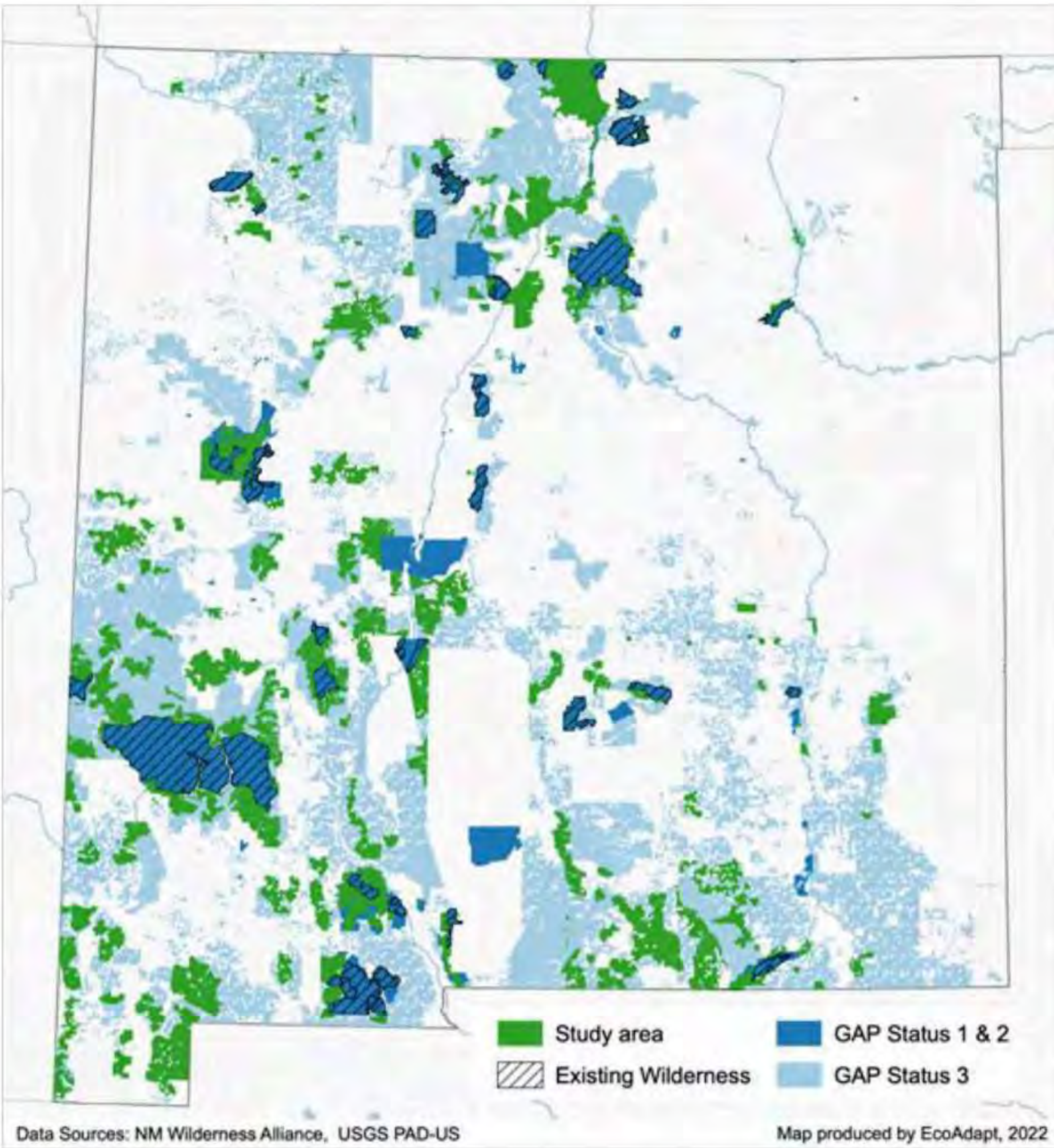

Figure 1. New Mexico study area comprised of public lands identified as having high potential for contributing to 30x30 goals (green), compared to GAP 1–2 lands (dark blue) and GAP 3 lands (light blue) that lie outside of the study area. Hatching indicates existing wilderness areas.

Because research on protected area network design has emphasized the importance of adequately representing the full range of ecological systems (*8, 49, 57*), we also considered the study area distribution among ecoregions (i.e., areas with similar physiography and landscape features). For this, we utilized the Level III ecoregion map published by the U.S. Environmental Protection Agency, which divides the U.S. into 182 ecoregions (*58*). Eight of the Level III ecoregions overlap a portion of New Mexico: the Arizona/New Mexico Mountains, Arizona/New Mexico Plateau, Chihuahuan Deserts, Colorado Plateau, High Plains, Madrean Archipelago, Southern Rockies, and Southwestern Tablelands (Figure 2; see Appendix A for a description of these ecoregions). Several of these have disproportionately little protected area, with the Colorado Plateau (0.1% of the area in New Mexico protected), Southwestern Tablelands (0.4%) and High Plains (0.7%) ecoregions particularly underrepresented within the existing network (Table 1). Within the 5.9-million-acre study area, the majority of the lands proposed for additional protection lie in the Chihuahuan Desert (31%), Arizona/New Mexico Mountains (30%), and Arizona/New Mexico Plateau (22%) ecoregions (Table 2).

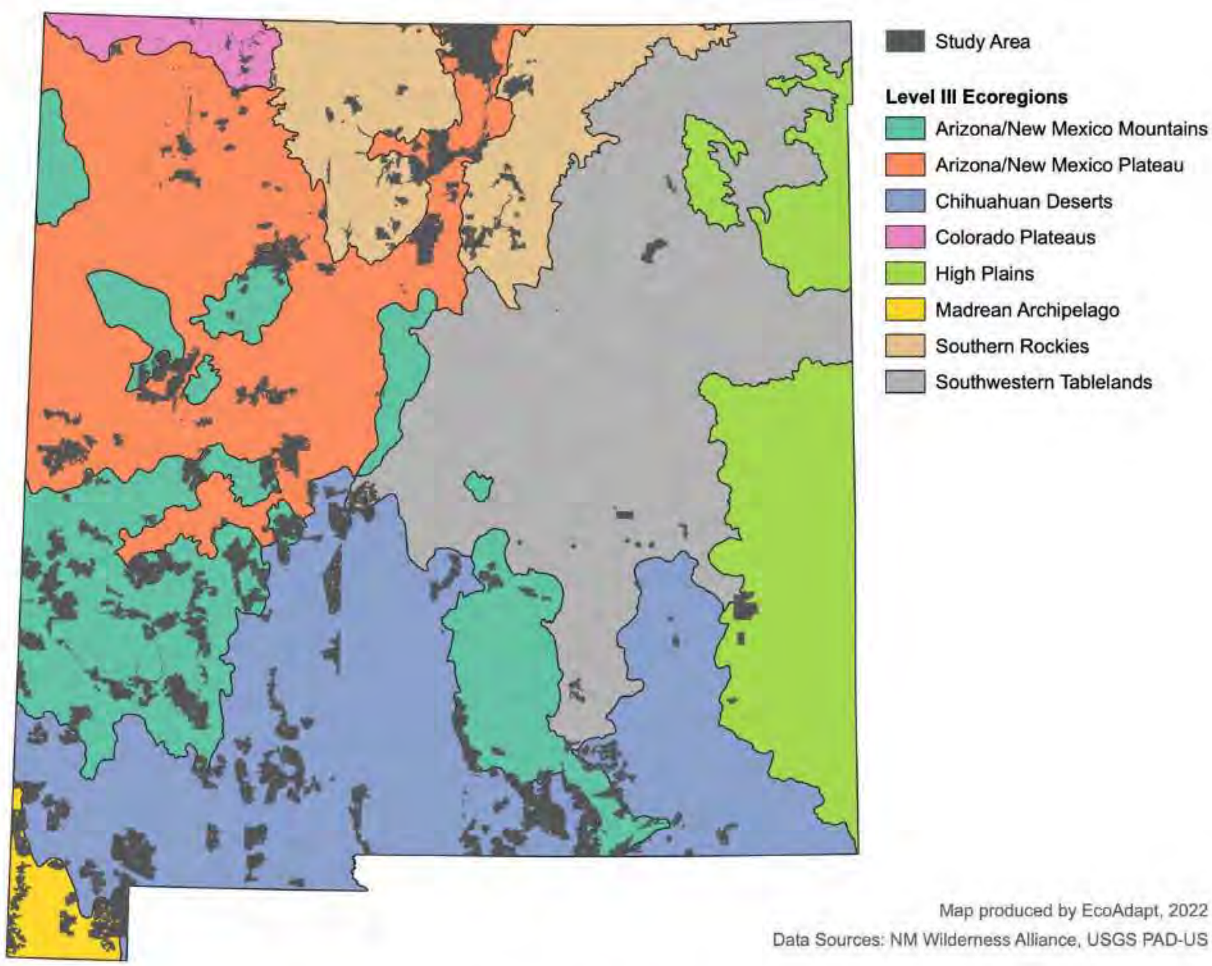

Figure 2. New Mexico study area overlaid on Level III ecoregions, which include the Colorado Plateau, Southern Rockies, Arizona/New Mexico Plateau, Arizona/New Mexico Mountains, Chihuahuan Deserts, Madrean Archipelago, Southwestern Tablelands, and High Plains.

Table 1. Acreage and percent (%) of New Mexico land area protected under GAP status 1 or 2 and GAP status 3 for each Level III Ecoregion, out of a state-wide total area of 77,819,673 acres.

Ecoregion Name	Acres GAP 1–2	% GAP 1–2	Acres GAP 3	% GAP 3
Arizona/New Mexico Mountains	1,441,867	12.5%	5,327,449	46.0%
Arizona/New Mexico Plateau	1,054,011	7.1%	2,669,760	17.9%
Chihuahuan Deserts	1,112,109	6.4%	6,572,826	38.1%
Colorado Plateau	790	0.1%	467,824	47.8%
High Plains	57,258	0.7%	626,515	8.0%
Madrean Archipelago	366,154	34.3%	268,572	25.1%
Southern Rockies	665,472	10.2%	2,415,941	36.9%
Southwestern Tablelands	69,371	0.4%	1,473,285	8.4%
TOTAL	**4,767,034**	**6.1%**	**19,822,223**	**25.5%**

Table 2. Distribution of the study area acreage and percent of the study area in each Level III Ecoregion.

Ecoregion Name	Acres	% Study Area
Arizona/New Mexico Mountains	1,776,689	30.1%
Arizona/New Mexico Plateau	1,322,867	22.4%
Chihuahuan Deserts	1,860,217	31.5%
Colorado Plateau	30,177	0.5%
High Plains	66,186	1.1%
Madrean Archipelago	310,570	5.3%
Southern Rockies	378,780	6.4%
Southwestern Tablelands	162,731	2.8%
TOTAL	**5,908,218**	**100%**

Adaptation indictors

We identified three indicators that provide information about the potential for protected lands across the study area to contribute to ecosystem adaptation to climate change: biodiversity, connectivity, and resilience. To evaluate these, we clipped state-wide datasets to include only the study area, and then we identified the roughly 1.45 million acres with the highest scores for each indicator (25^{th} percentile of the study area). These lands, referred to here as the "Top 25%", represent the portion of the study area where protection is likely to provide the greatest value for conservation of biodiversity, connectivity, or resilient sites, respectively.

Biodiversity

To evaluate biodiversity, we obtained data on range-size rarity from NatureServe's Map of Biodiversity Importance (*53*, *59*), which highlights areas with high potential for species conservation across the U.S. using habitat models for over 2,200 imperiled species including vertebrates (e.g., birds, mammals, amphibians, reptiles, freshwater/anadromous fish), vascular plants, selected aquatic invertebrates (mussels and crayfish), and selected pollinators (bumblebees, butterflies, skippers). Range-size rarity is a metric related to species richness, but is weighted to place greater emphasis on species with small range sizes that are more likely to be endemic, rare, or of significant conservation concern (*53*). Because species that are isolated or have small populations and/or limited distribution tend to be more vulnerable to extirpation as a result of extreme events and environmental changes, including climate change (*10*, *60*), using range-size rarity is considered a good indicator of where protected areas could play a greater role in protecting critical species from climate-driven declines (*9*, *53*). The NatureServe dataset sums the range-size rarity scores of all species that occur within each cell (mapped at 990-meter resolution), calculated as the inverse of the total area mapped as habitat for each of the 2,216 imperiled species considered. Thus, higher values on the map indicate where imperiled species with very small ranges and/or the presence of multiple range-restricted species occur. These areas are likely to represent locations where conservation of biodiversity is particularly critical to avoid loss of these vulnerable species.

Connectivity

To assess the value of protected areas across the study region for connectivity, we utilized the Connectivity and Climate Flow dataset from The Nature Conservancy's (TNC) Resilient and Connected Network analysis (*22*, *23*, *61*), which provides maps to assist in the identification of well-connected, climate-resilient sites representing the full range of geophysical settings. The Connectivity and Climate Flow dataset highlights permeable areas that allow species movement across sites and climate gradients, which would support migration and range shifts in response to climate change. Mapped values range from -3500 to +3500, representing areas that are blocked or have low climate flow (i.e., little movement occurs or species are deflected around impermeable features) to those with diffuse flow (i.e., intact ecosystems that facilitate high levels of dispersed movement that can follow many different pathways), and are mapped at a 30-meter resolution.

Resilience

To evaluate relative resilience across the study area, we used the Resilient Sites dataset, also from TNC's Resilient and Connected Network analysis (*22*, *23*, *61*). In this context, resilience refers to the ability of that location to maintain biodiversity and core ecosystem functioning even as climate change alters the specific species assemblages or vegetation type/structure (*21*). The Resilience score includes microclimate diversity, which is an estimate of number of microclimates created by topography and elevational gradients within a given area (*21*–*23*) and is known to be closely linked to the presence of climate change refugia that facilitate species persistence under changing conditions (*24*, *62*). It also incorporates a metric related to local connectedness, which estimates the degree to which sites are connected by natural cover that make it possible for species to access refugia and respond to changing conditions. Mapped values for the Resilience score also range from -3500 to +3500, described as the amount above or below average compared to other cells within the ecoregion (mapped at a 30-meter resolution). Within this dataset, tribal land results are not publicly available, and so these areas are excluded from the map.

Mitigation indicators

In order to evaluate the contribution of the study area lands to climate mitigation efforts, we conducted two separate analyses to estimate: a) the amount of carbon that would be sequestered (i.e., captured) and stored on these lands by the end of the century, if they remained undisturbed, and b) the amount of oil, gas, and coal resources present on the study area lands and greenhouse gas emissions associated with those resources. As with the adaptation indicators, we also identified the 25% of the study area (roughly 1.45 million acres) where additional protection is likely to result in the greatest value for climate mitigation efforts based on the amount of carbon sequestered and stored in the ecosystem or potential avoided greenhouse gas emissions.

Carbon stocks

To assess the value of protected areas for carbon sequestration and storage, we used a dataset that was produced by the MC2 dynamic vegetation model and published as part of the CONUS Climate Console (*63*), a web mapping application developed by the Conservation Biology Institute for exploring climate projections and simulated impacts. The MC2 model simulates shifts in vegetation and associated changes in ecosystem carbon stocks under future climate conditions at a 2.5 arc-minute (~4 km) spatial resolution (*64*, *65*). MC2 considers soil characteristics, climate conditions (e.g., temperature, precipitation, vapor pressure), and atmospheric CO_2 as well as wildfire and competition for soil moisture and nutrients. Then it simulates interactions between these factors by modeling primary productivity, decomposition, soil respiration, and nutrient release over time to determine the amount of carbon stored within plant and soil carbon pools. Within the CONUS Climate Console, these results are presented as the average total ecosystem carbon per decade (i.e., decadal means) for each potential vegetation class (e.g., conifer forest, cool mixed forest, deciduous forest, woodland/savannah, shrubland/woodland, grassland) expected to occur within the state by the end of the century, though these results do not take into account the modeled impacts of fire suppression on potential vegetation. Results are presented for a suite of 20 models included in the 5th Coupled Model Intercomparison Project (CMIP5) (*66*) that have been downscaled by the Multivariate Adaptive Constructed Analogs (MACA) project (*67*). The models were run using Representative Concentration Pathway 8.5, which is a high-emissions scenario representing a future where greenhouse gas emissions result in global temperature increases of 3.3–5.4°C (*68*).

For this study, we averaged decadal means for the 2070s, 2080s, and 2090s for three of the climate models to arrive at a 30-year time period representing late-century (2070–2099) climate conditions for Total Ecosystem Carbon (g C/m^2), which includes aboveground and belowground herbaceous and woody plant material as well as soil organic carbon. The three climate models we used were CanESM2, GFDL-ESM2M, and IPSL-CM5A-MR, which were chosen for this study because they capture a wide range of potential futures (e.g., 90% of the range for temperature projections among the suite of 20 models and 100% of the range for precipitation projections for the state of New Mexico; Figure 3).[1]

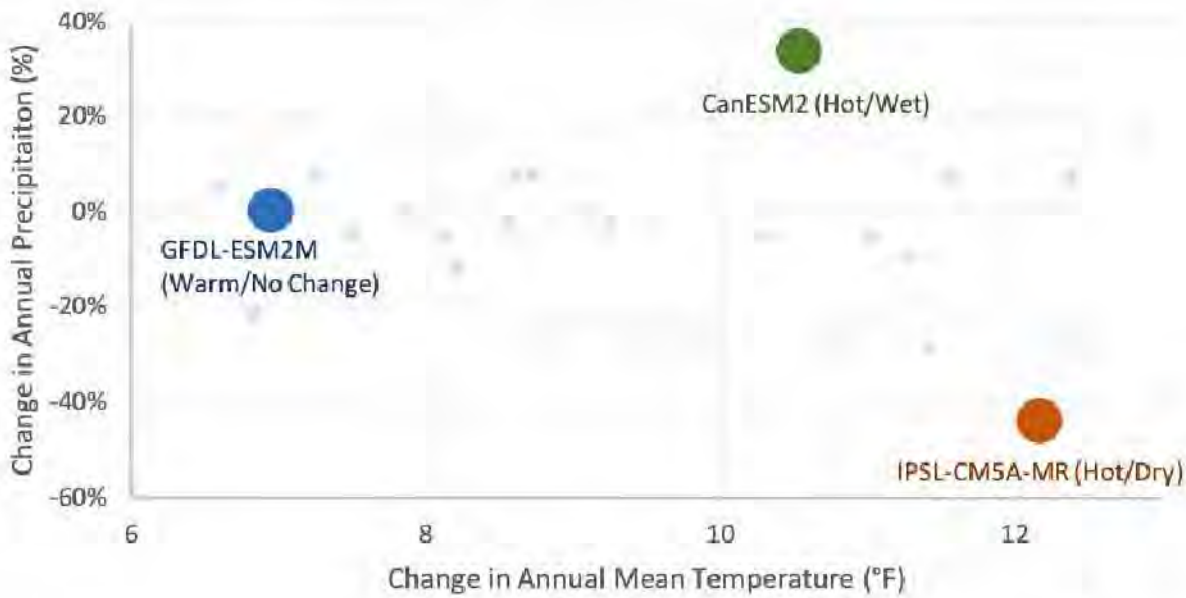

Figure 3. Comparison of change in annual mean temperature (°F) and annual precipitation (%) for the state of New Mexico across the three climate models used in this study, which are GFDL-ESM2M (representing warm temperatures with little to no change in precipitation), CanESM2 (representing large increases in both temperature and precipitation), and IPSL-CM5A-MR (representing hotter, drier conditions). Light blue dots represent the MACA-downscaled models not selected for this study, showing that the selected models span almost the entire range of potential conditions (wettest to driest; lower to higher temperature increases).

Greenhouse gas emissions associated with unleased fossil fuels

We used publicly-available data on fossil fuel resources and typical production in the region to estimate the total amount of unleased crude oil, natural gas, and coal that may remain in the study area, and then calculated the greenhouse gas emissions that would occur if all of those areas were leased and fully developed in the future. For crude oil and natural gas, we calculated the amount of the study area overlapping major basins and plays (*69–71*), and then used the average well spacing (*72*) and average Estimated Ultimate Recovery (EUR) for each well (*73*) to determine potential production. For coal, we determined the acreage of the study area that overlapped with each coalfield (*74*) and assigned the same proportion of remaining recoverable resources (*75*) to those parcels, assuming the resources were evenly distributed across the

[1] Projection ranges used were from the Scatterplot Visualization of Future Projections online tool on the MACA website, accessed on September 27, 2022 at https://climate.northwestknowledge.net/MACA/vis_scatterplot.php.

coalfield. Wherever possible, we improved the accuracy of production and remaining resource estimates by including parameters that were location-specific and/or that reflected the economic feasibility of energy development. For all fossil fuels, we then used greenhouse gas emission factors published by the Bureau of Land Management (*73*), which account for both direct emissions (resulting from exploration, development, and production) and indirect emissions (from processing/refinement, transportation/distribution, and combustion during end use). Greenhouse gas emissions are reported in units of carbon dioxide equivalent (CO_2e) based on 100-year global warming potential (a measure of how much heat a greenhouse gas traps in the atmosphere relative to carbon dioxide) for carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).
It is important to note that this analysis represents an estimate of greenhouse gases associated with fossil fuels that would remain sequestered underground if protected area status was sufficiently strong to prevent these activities (i.e., if they were designated as wilderness areas). However, it does not represent an accurate estimate of 'avoided greenhouse gas emissions' because this study was unable to account for many other factors that might prevent fossil fuel resources from being extracted and used even in the absence of protected status. These factors include multiple use conflicts (e.g., the inability to extract oil and gas resources where a coal mine is placed), land use restrictions (e.g., the presence of cultural sites or protected species), and economic and technological constraints, among other factors.

See Appendix B for a full description of the methods used for this analysis, including data sources and significant assumptions/sources of uncertainty.

Results and Discussion

Contribution of study area to ecosystem adaptation to climate change

Protected areas generally represent relatively intact, high-quality ecosystems, and it is widely acknowledged that they are an effective strategy for preserving biodiversity and large-scale ecosystem functioning that supports natural systems and human communities worldwide (*3*, *5*, *47*, *76–78*). Globally, intact ecosystems are being rapidly lost (*79*, *80*) and biodiversity continues to decline (*81*, *82*), increasing the urgent need for efforts to strengthen and expand existing protected area networks to prevent the irreversible loss of critical benefits such as support of habitat and movement corridors for endemic and/or rare species, protection of freshwater supplies and quality, carbon sequestration, and other benefits (*3*, *5*, *18*, *41*, *79*). Climate change makes these efforts even more important, as ecologically-intact protected areas that have high connectivity and represent a wide range of environmental conditions are likely to support adaptation within individual species, communities, and/or ecosystems (*2*, *3*, *18*, *77*, *78*).

Biodiversity

New Mexico is a state rich in biodiversity, due to the large climatic and elevational gradients, complex topography, and varied substrates that support hundreds of rare species and 90 state endemics (i.e., species found only within the state) (*83*, *84*). However, this biodiversity is not evenly distributed across the state; rather, it tends to be concentrated in areas such as riparian corridors and the Madrean sky islands (*53*, *59*). Nationally, a significant proportion of imperiled species (i.e., species with declining populations that are now at risk of extinction) occur outside of protected areas managed primarily for biodiversity (e.g., GAP status 1 or 2) (*9*, *39*, *52*, *53*), and this pattern holds true in many areas of New Mexico as well (*53*).

The project study area captures a disproportionate amount of statewide imperiled species richness (as measured by range-size rarity, which places greater weight on the presence of range-restricted species). Specifically, the study area captures 11% of the total range-size rarity score for New Mexico despite accounting for only 7% of the state area (about 5.8 million acres; Figure 4). Furthermore, the vast majority of the range-restricted imperiled species in the study area (99%) are found in just over a quarter of the study area acreage (1.7 million acres), representing 2% of the state (Figure 5). Within the top 25%, 1.1 million acres lies in the Arizona/New Mexico Mountains ecoregion, particularly in the western part of the state around Gila Wilderness and the smaller Blue Range and Apache Kid Wilderness areas.

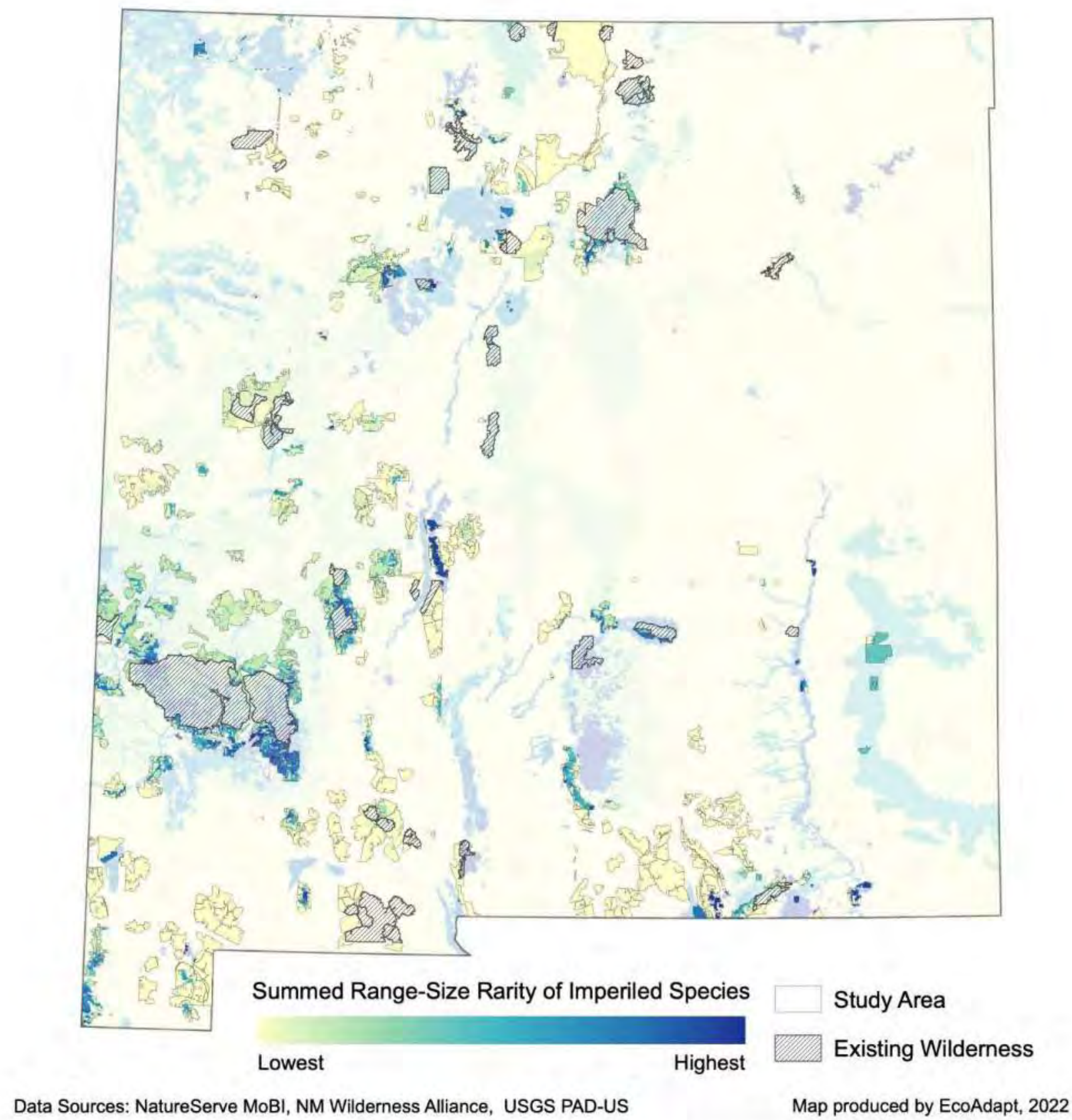

Figure 4. Range-size rarity of imperiled species in New Mexico, highlighting values for range-restricted species within the project study area.

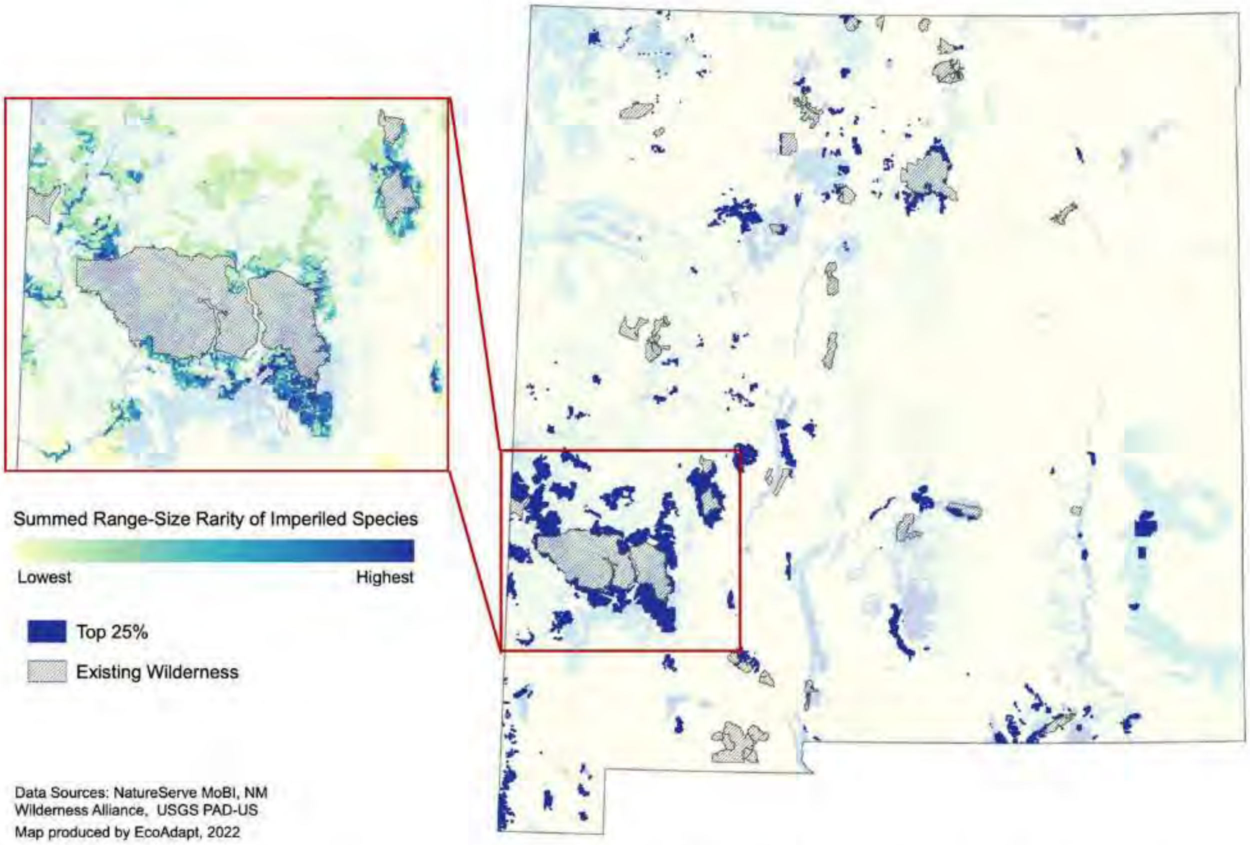

Figure 5. Twenty-five percent (25%) of the study area with the highest score for range-size rarity, representing 11% of the total range-size rarity score for the state within 2% of the land area. Inset box displays a more detailed view of the map in Figure 4 for the area where the greatest concentration of that top 25% is found, in the Arizona/New Mexico Mountains ecoregion.

It is well known that the presence of protected areas reduces extinction risk (*5*, *47*) and is associated with increased species richness (*6*, *7*). Even as climate change drives additional biodiversity loss and shifts in species distribution and community composition (*20*, *51*, *81*, *85*), protected areas are likely to play a critical role in facilitating species persistence (*1*, *6*, *7*, *47*), particularly for rare species or isolated populations that are particularly vulnerable to extreme events and stressors associated with both human activities and climate change (*9*, *10*). They may also play an important role in facilitating range shifts by providing high-quality habitat for colonization by species expanding into new regions (*1*). These results suggest that the study area represents significant opportunities for conservation of biodiversity in the context of climate change, due to the concentration of range-restricted species within the protected areas considered here. Specifically, focusing efforts to strengthen or expand the existing protected area network areas that overlap the portions of the study area with particularly high biodiversity scores would protect areas with the greatest concentrations of range-restricted imperiled species. These species represent many of those with fewer opportunities for conservation interventions (*9*, *53*), for which the well-documented benefits of protected areas are likely to support their survival as the climate continues to change and conditions become more extreme.

Connectivity

In addition to protecting current biodiversity hotspots, it is also critical to expand protected area networks to include ecologically-intact landscapes that enhance connectivity between suitable habitat patches, including those that may become suitable under future climate conditions (*15*, *18–20*, *48*). Within the project study area, regions that remain highly connected to surrounding intact ecosystems, including those in adjacent protected areas with strong protections (such as wilderness), are likely to play an important role in climate change adaptation by allowing species movement and range shifts in response to change (Figure 6). Portions of the study area allowing highly diffuse movement (i.e., few barriers to connectivity across large areas, facilitating dispersed movement) primarily lie in the Chihuahuan Desert and Arizona/New Mexico Mountains ecoregion, which together account for over 1 million acres of the 1.4 million comprising the portion of the study area with connectivity scores above the 75% percentile (Figure 7). More concentrated corridors primarily lie in riparian zones, which harbor high levels of biodiversity and facilitate movement both internally (i.e., up and down the riparian corridor) and with adjacent upland systems (*86*).

Expanding or strengthening protected areas in these locations to maintain connected landscapes is likely to increase species movement/dispersal (*11*) and gene flow (*12*), reduce the risk of extirpation in isolated populations (*13*, *14*), and facilitate access to suitable habitat patches that can act as "stepping stones" to facilitate range shifts as climate conditions change (*1*, *15–17*). Although it is unlikely that protected areas can fully prevent regional extirpation of native species and changes in community composition (i.e., presence and relative abundance of native species present in a given location) due to climate change (*15*, *20*, *50*), expanding protected area networks to include lands that maintain and enhance species movement and facilitate range shifts in response to changing conditions are likely to minimize the loss of biodiversity at larger spatial scales (*2*, *15*, *18–20*).

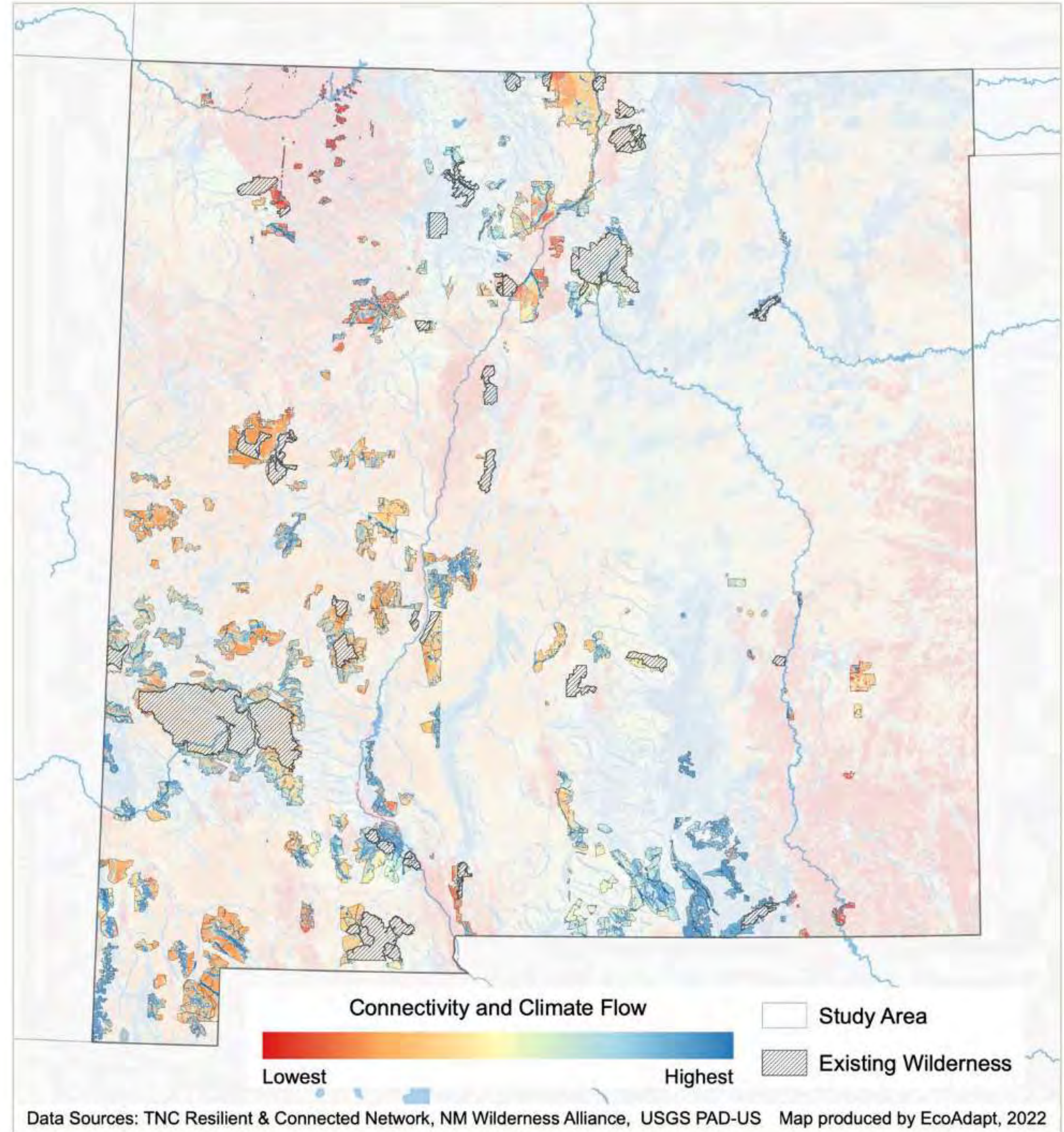

Figure 6. Connectivity and climate flow in New Mexico, highlighting connectivity values within the project study area.

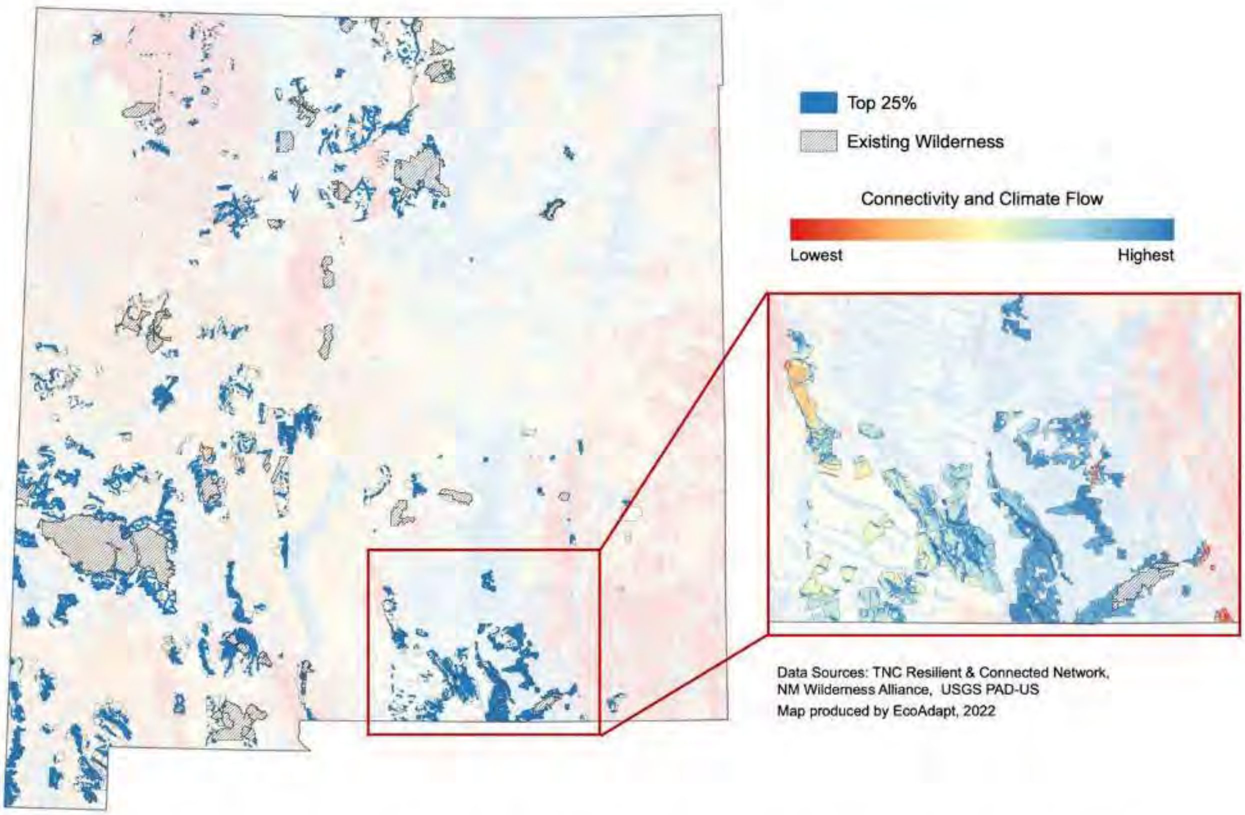

Figure 7. Twenty-five percent (25%) of the study area with the highest score for connectivity and climate flow. Inset box displays a more detailed view of the map in Figure 6 for the area where the greatest concentration of that top 25% is found, in the Chihuahuan Desert ecoregion and eastern portion of the Arizona/New Mexico Mountains ecoregion.

Resilience

Protected area networks must be able to maintain the conditions necessary to sustain biodiversity and ecosystem processes as conditions change, a characteristic often referred to as "resilience" (*21–23*). The most resilient sites typically are intact, high-quality ecosystems, particularly in high-elevation areas, riparian zones and other sites with permanent sources of surface water, and other locations where complex geophysical conditions (e.g., topography, substrate) create diverse microclimates and vegetation communities that support a wide variety of species (*24–27*). These areas may also serve as climate change refugia, which are places on the landscape that are buffered from exposure to rapid changes and climate extremes (*17*, *28*, *62*). Climate change refugia facilitate the persistence of species (particularly those with limited mobility or dispersal ability), preventing the loss of genetic diversity and buying time for adaptation over longer time scales (*17*, *62*). They also protect populations from extirpation following extreme events (e.g., severe drought or large, high-severity wildfires) (*28*, *87*), and support range shifts by providing areas where organisms from nearby regions may find suitable conditions, sometimes referred to as "stepping stones" (*1*, *16*, *26*). However, many potential climate change refugia in the most resilient areas remain unprotected, or lack the level of protection required to prevent degradation (*24–26*, *41*).

The map below (Figure 8) shows site resilience across the study area, using a dataset that considers microclimate diversity (closely linked to the presence of climate refugia) and local connectedness (tied to ecosystem integrity and species movement) to identify sites most likely to retain biodiversity and ecological function under changing climate conditions. The top 25% most resilient sites within the study area are disproportionately located in the Arizona/New Mexico Mountains ecoregion (55%), in both the southern and western portions of the state, but an additional 20% of the most resilient sites lie in the Chihuahuan Desert (Figure 9).

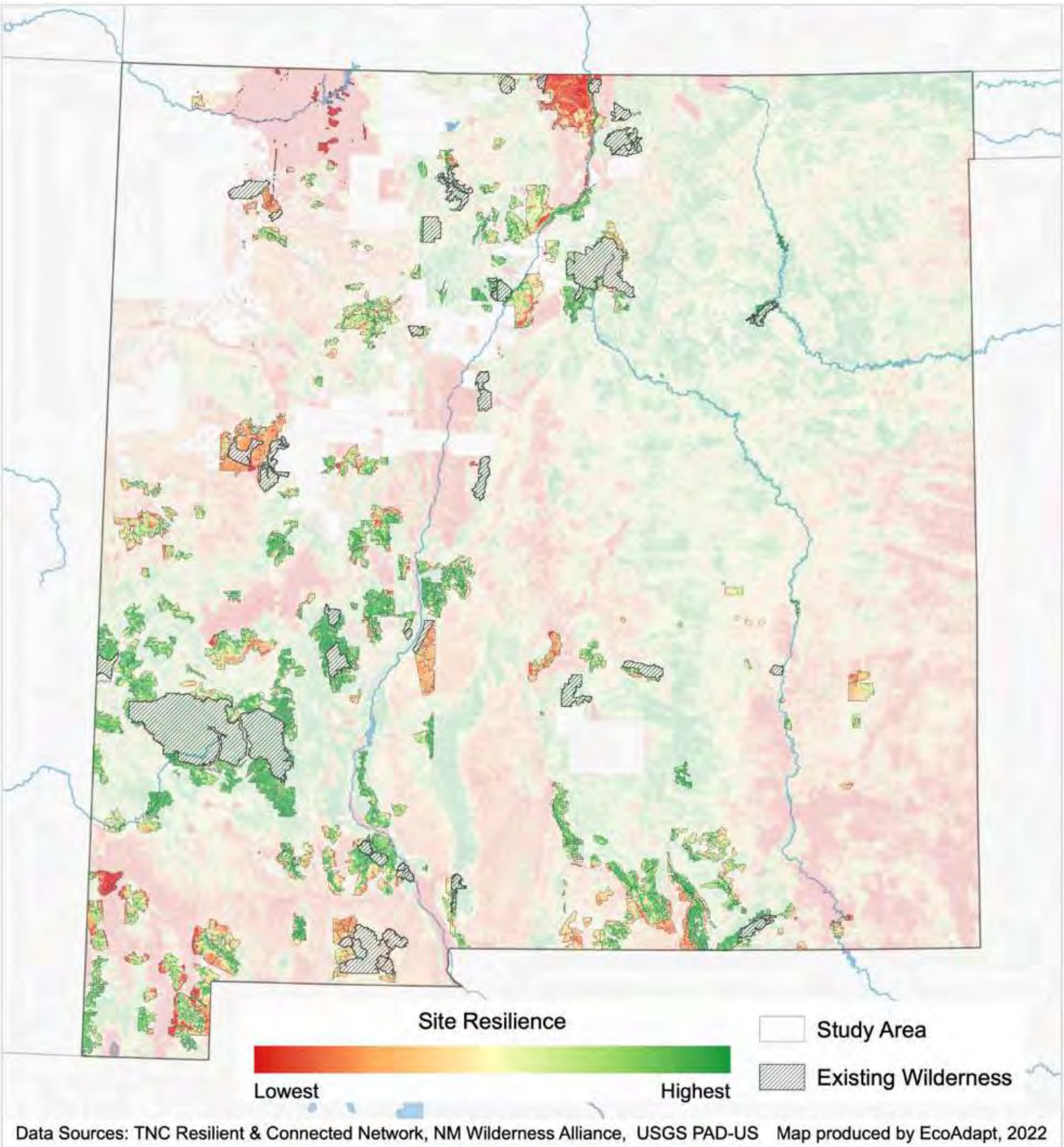

Figure 8. Site resilience in New Mexico, highlighting resilience values within the project study area.

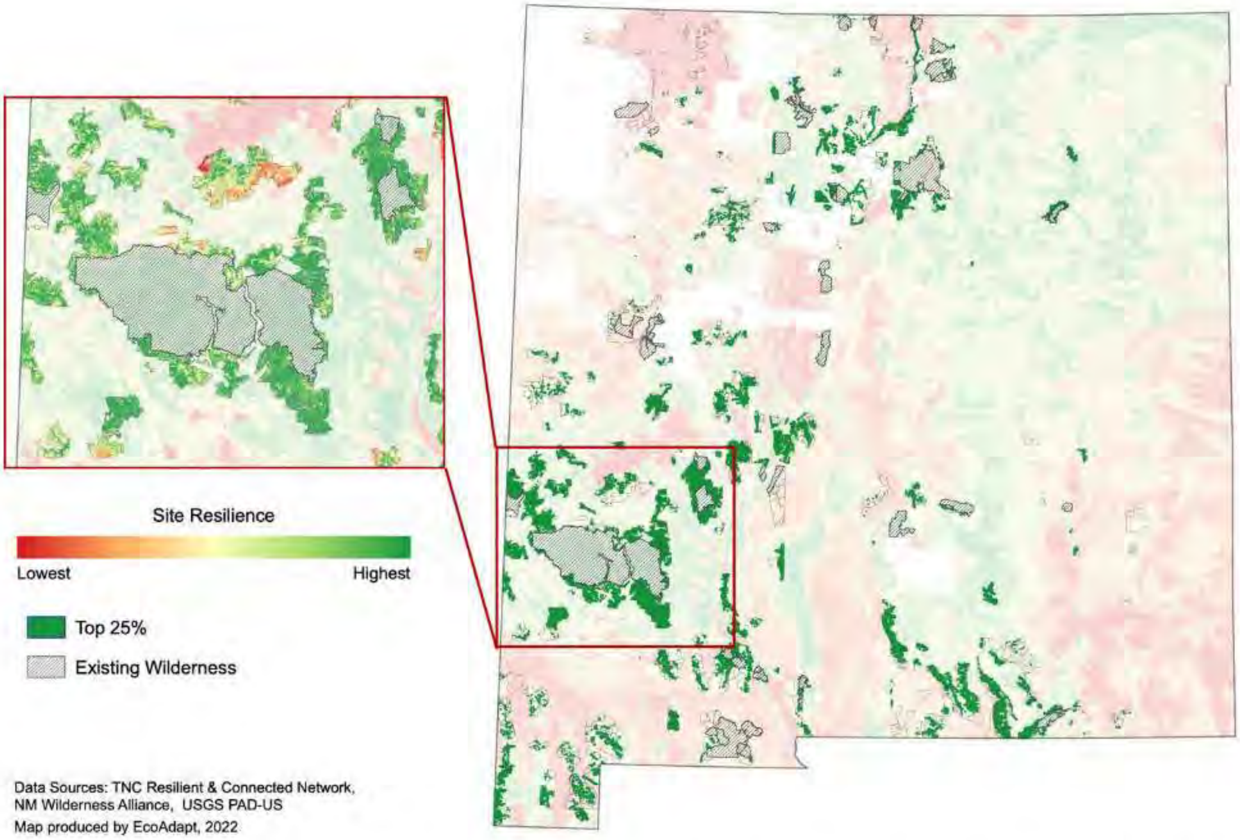

Figure 9. Twenty-five percent (25%) of the study area with the highest resilience scores. Inset box displays a more detailed view of the map in Figure 8 for the area where the greatest concentration of that top 25% is found, in the Arizona/New Mexico Mountains ecoregion.

Contribution of study area to climate change mitigation efforts

In order to meet any goal focused on climate change mitigation, it is necessary to drastically reduce greenhouse gas emissions from the production and use of fossil fuels while simultaneously increasing carbon sequestration (i.e., capture) and storage within plants and soils (*88, 89*). Protected areas can play an important role in meeting climate mitigation targets by preventing the loss of carbon sequestration and storage following land-use conversion and human activities that result in carbon losses (*29–32*). Similarly, protected area designations that prevent fossil fuel development (e.g., wilderness areas) also have the potential to reduce greenhouse gas emissions by keeping oil, gas, and coal in the ground (*33, 34*).

Carbon sequestration and storage

Maximizing carbon sequestration (i.e., the rate at which carbon is removed from the atmosphere) and carbon storage (i.e., the amount and distribution of carbon stored) within plants and soil is a critical component of climate change mitigation (*30, 78, 88*). Overall, intact ecosystems sequester and store more carbon than those that are disturbed, making the protection of these areas a critical step in meeting near-term carbon sequestration goals (*32,* *77*, *78*, *88*). Increased atmospheric carbon dioxide, warming temperatures, altered precipitation patterns, and climate-driven changes in disturbance regimes such as wildfire and beetle outbreaks are likely to significant impact carbon sequestration and storage capacity in dryland ecosystems such as those of the southwest U.S. (*65*, *90–93*). However, these changes are accelerated by anthropogenic disturbances and land-use change that results in damage or loss of plant cover and soil (*94*, *95*). Thus, strengthening protected area status to prevent the degradation or loss of intact ecosystems as a result of human activity is another important way to support the continued functioning of the processes that support carbon sequestration (*29*, *32*), along with restoration and management activities that minimize loss of existing carbon stocks (*32*, *96*).

Under future climate conditions, carbon stocks modeled using a high-emissions scenario (RCP 8.5) are projected to be between 210.1 and 240.6 million metric tons of carbon (MMt C) by the end of the century (2070–2099), depending on the climate model used (Table 3). The models chosen represent a range of potential futures (i.e., hot/dry, hot/wet, and warm/no change), with the GFDL model (warm/no change) resulting in the greatest amount of carbon stored on the landscape, at an average of 43.5 metric tons of carbon (Mt C) per acre (Table 4). By contrast, the IPSL model (hot/dry) would result in the lowest amount of stored carbon, at an average of 37.8 Mt C per acre. However, although carbon stocks vary among these models, the relative carbon density across the study area is expected to be similar (Figure 10), with the most significant carbon storage in the Southern Rockies ecoregion where vegetation is dominated by relatively dense montane forests. End-of-century carbon stocks using the average of these three models would be 226.2 MMt C, at an average density of 40.9 Mt C per acre (Figure 11).

Table 3. Total ecosystem carbon in million metric tons of carbon (MMt C) for the study area and state-wide, modeled for under end-of-century (2070–2099) climate conditions using three climate models (GFDL-ESM2M, CanESM2, IPSL-CM5A-MR) under a high-emissions scenario (RCP 8.5).

	Total Ecosystem Carbon (MMt C)			
Area	**GFDL** *(Warm/ No Change)*	**CanESM2** *(Hot/Wet)*	**IPSL** *(Hot/Dry)*	**Model Average**
Study Area	240.6	227.8	210.1	226.2
New Mexico (state-wide)	3,126.0	3,009.9	2,736.0	2,992.5

Table 4. Average carbon density (Mt C/acre) for the study area, broken down by ecoregion, and state-wide, modeled for end-of-century (2070–2099) climate conditions using three climate models (GFDL-ESM2M, CanESM2, IPSL-CM5A-MR) under a high-emissions scenario (RCP 8.5).

	Average Carbon Density (Mt C/acre)			
Area	**GFDL** *(Warm/ No Change)*	**CanESM2** *(Hot/Wet)*	**IPSL** *(Hot/Dry)*	**Model Average**
Arizona/New Mexico Mountains	47.4	44.1	40.3	43.9
Arizona/New Mexico Plateau	36.3	34.6	33.3	34.7
Chihuahuan Deserts	32.2	31.0	29.4	30.9
Colorado Plateaus	37.1	35.5	33.4	35.4
High Plains	27.4	27.2	25.8	26.8
Madrean Archipelago	33.6	31.8	30.9	32.1
Southern Rockies	94.5	92.0	74.6	87.2
Southwestern Tablelands	34.1	32.9	31.4	32.8
Study Area	**43.5**	**41.4**	**37.8**	**40.9**
New Mexico (state-wide)	**40.9**	**39.4**	**35.8**	**38.8**

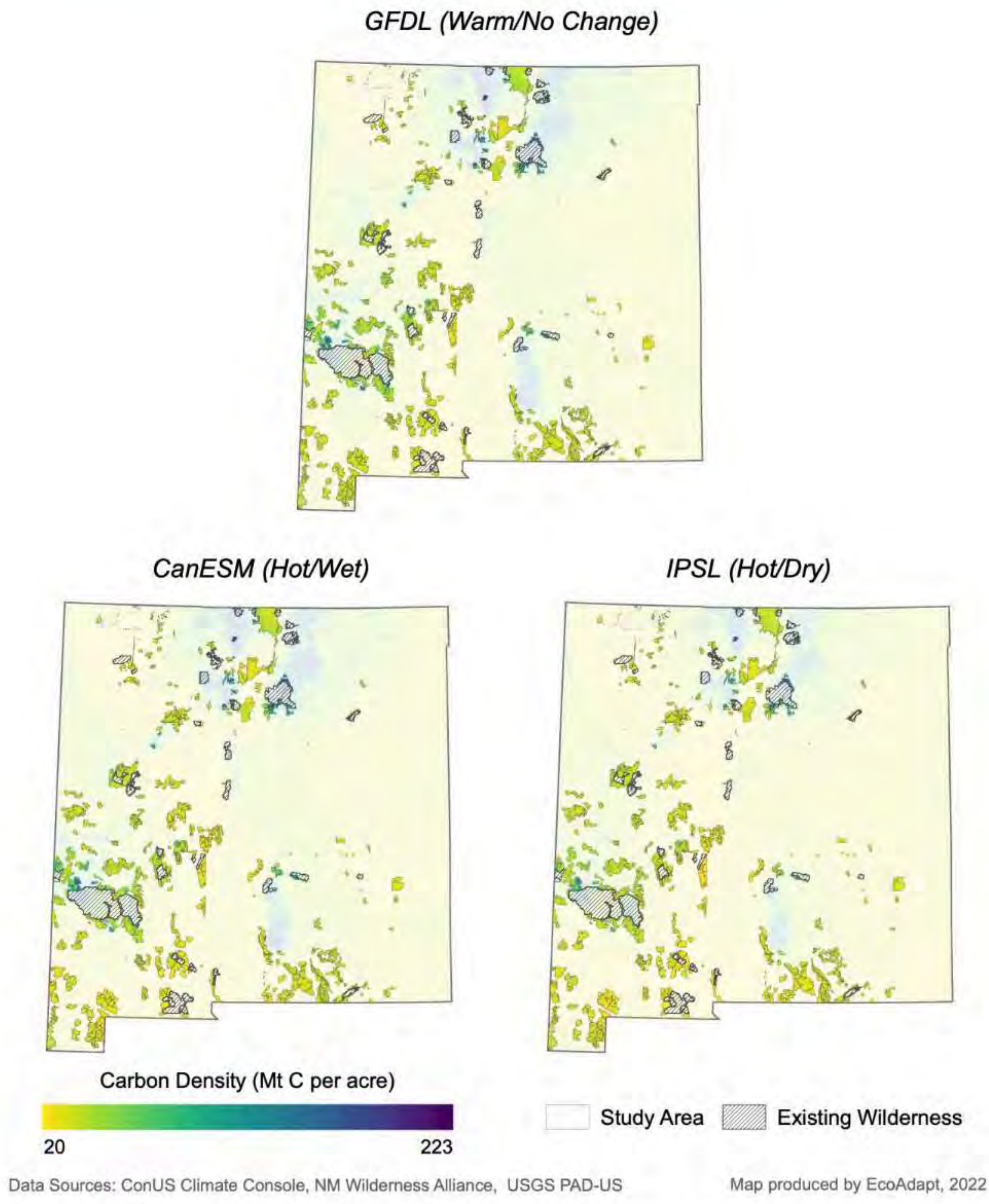

Figure 10. End-of-century (2070–2099) ecosystem carbon stocks (in Mt C/acre) for three separate climate models representing a range of potential futures, including GFDL-ESM2M (warm/no change in precipitation), CanESM2 (hot/wet), and IPSL-CM5A-LR (hot/dry) run under a high-emissions scenario (RCP 8.5).

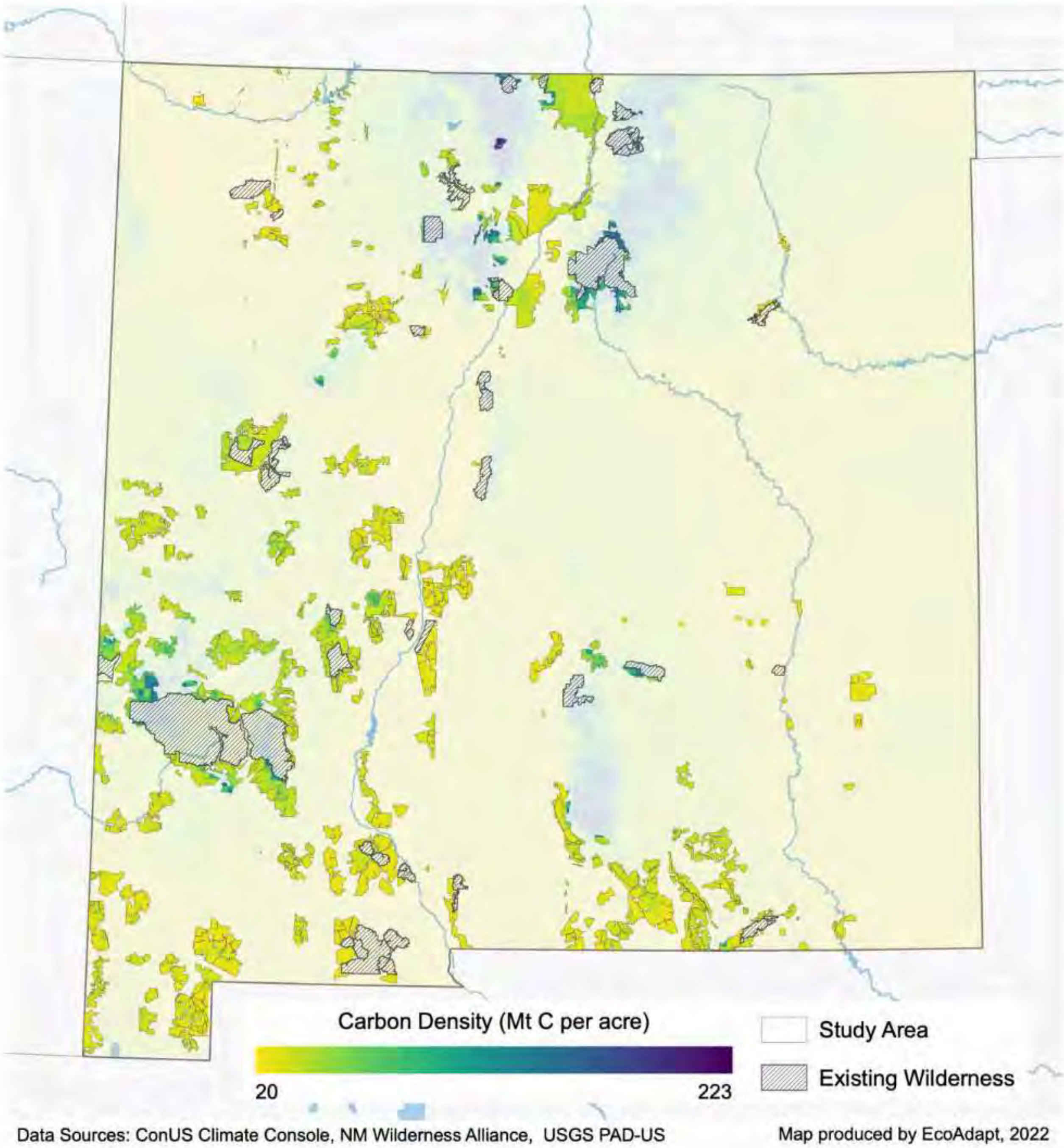

Figure 11. End-of-century (2070–2099) ecosystem carbon stocks (in Mt C/acre), using the average of three climate models (GFDL-ESM2M, CanESM2, IPSL-CM5A-LR) run under a high-emissions scenario (RCP 8.5).

Within the 5.8-million-acre study area, 38% of the carbon is found within 25% of the total acres (about 1.45 million acres; Figure 12). These areas are concentrated in more forested ecoregions where carbon density is highest, including the Southern Rockies, Arizona/New Mexico Mountains, and Arizona/New Mexico Plateau. Expanding protected area networks in order to maximize carbon sequestration and storage potential under future climate conditions would benefit from the prioritization of forested areas in the Southern Rockies such as the Canjilon

Mountain Roadless Area, which has the highest projected carbon stocks per acre (up to 49,710 Mt C per acre). Preventing degradation from human disturbances or land-use change in these carbon-dense areas is likely to play an important role in preventing loss of existing carbon stocks and ensuring continued carbon sequestration into the future, particularly if paired with climate-informed forest restoration and management (e.g., thinning, planting) designed to increase forest resilience to disturbances that result in carbon losses (*32*, *96*).

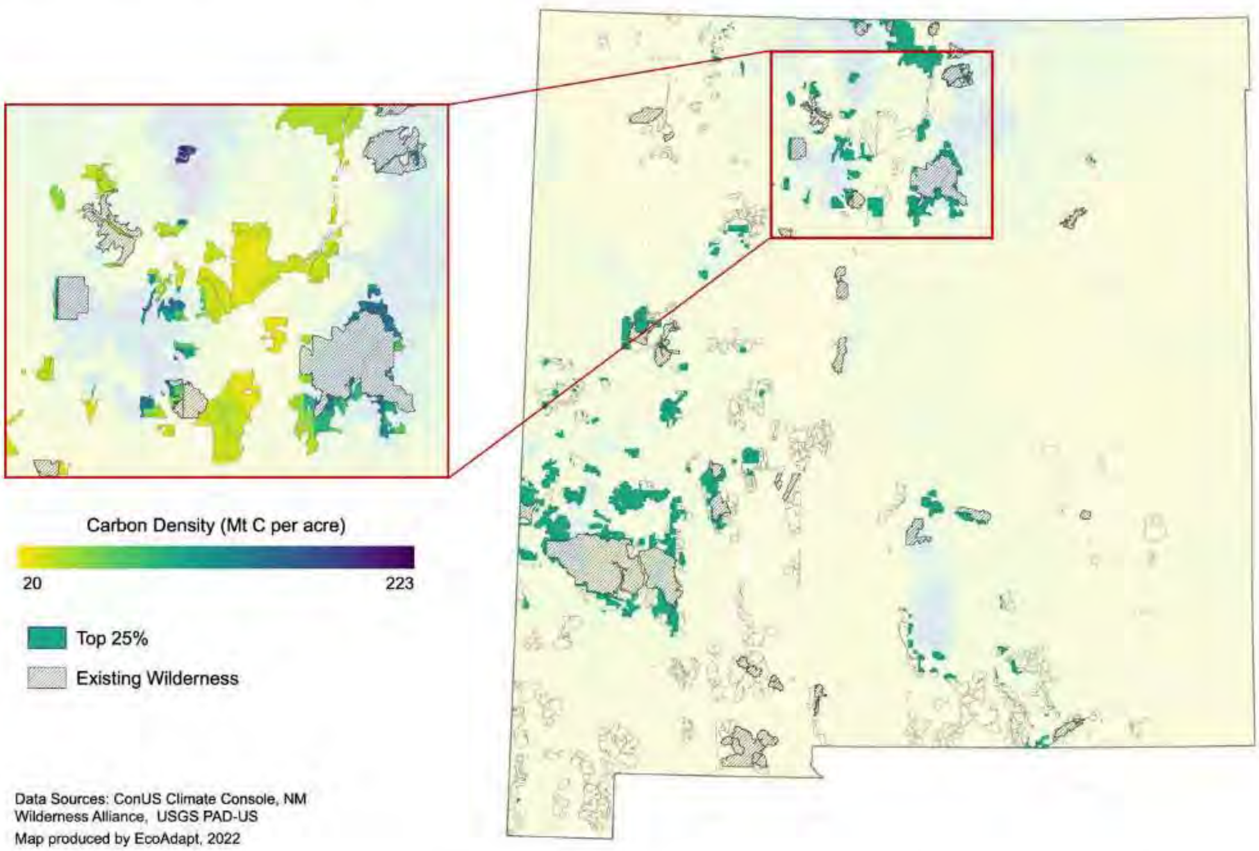

Figure 12. Twenty-five percent (25%) of the study area with the highest carbon density in metric tons carbon (Mt C) per acre. Inset box displays a more detailed view of the map in Figure 10 for the portion of the study area where carbon density is highest (up to 49,710 Mt C/acre), in the Southern Rockies ecoregion.

Greenhouse gas emissions associated with unleased fossil fuels

Nationally, a large proportion of energy production comes from public lands in the western U.S. (*97*), which are leased by federal agencies to private companies for oil, gas, and coal extraction and sale. While these leases offer a limited number of years for leaseholders to begin extraction (10 years for oil/gas or 20 years for coal), leases last indefinitely once production begins (*33*). Although federal agencies are not required to track greenhouse gas emissions associated with fossil fuel production on public lands, studies suggest that they account for over 20% of national emissions (*37*, *97*) and up to 50% of all remaining unleased U.S. fossil fuels (*33*). Multiple recent analyses (*33*, *34*) have found that unchecked production and end use consumption of remaining unleased fossil fuels in the U.S. would result in lifecycle emissions that far exceed the reductions required to avoid a 1.5°C rise in global temperature, a goal established by the United Nations and set out in the Paris Agreement (*98*). These analyses and others (*35, 36*) suggest that keeping oil, gas, and coal in the ground has the potential to significantly contribute to climate mitigation efforts.

Part of the study area for this analysis falls within the San Juan and Permian basins, which represent the most productive areas for oil and gas extraction within the state. Although most of these basins have already been leased, we estimate that fossil fuels underlying remaining unleased portions of the study area may include 2,752 million barrels of crude oil (MMBbl), 3,075 billion cubic feet of natural gas (Bcfg), and 403 million short tons of coal (MMSt; Table 5). Together, these fossil fuel resources are associated with lifecycle greenhouse gas emissions of 2,943 million metric tons of carbon dioxide equivalent (MMt CO_2e). Of these potential emissions, oil accounts for the largest proportion (57%), followed by coal (35%) and gas (8%). To put this into context, this amount of is equivalent to about 5.3 months of greenhouse gas emissions for the entire U.S. at 2018 levels, which were 6,644 MMt CO_2e annually (*37*).

Table 5. Estimates of remaining unleased oil (MMBbl), natural gas (Bcfg), and coal (MMST) resources in the study area and associated lifecycle greenhouse gas emissions (MMt CO2e) based on 100-year global warming potential for carbon dioxide, methane, and nitrous oxide.

Fossil Fuel Type	Resources	GHG Emissions *(MMt CO_2e)*
Crude oil *(MMBbl)*	2,751.5	1,680.3
Natural gas *(Bcfg)*	3,074.6	243.4
Coal *(MMSt)*	402.8	1,019.7
Total Greenhouse Gas Emissions		**2,943.4**

Within the study area, the regions where preventing additional development of unleased fossil fuels would have the greatest impact on greenhouse gas emissions is in the northwest and southeast portions of the state, which overlap the San Juan Basin and Permian Basin, respectively (Figure 13). In total, 12.8% of the 5.8 million-acre study area is estimated to have underlying fossil fuel resources that are currently unleased (738,872 acres). Forty percent (40%) of that area (just under 300,000 acres) is in the Arizona/New Mexico Plateau ecoregion, with an additional 24% and 20% in the Arizona/New Mexico Mountains and Chihuahuan Desert ecoregions, respectively.

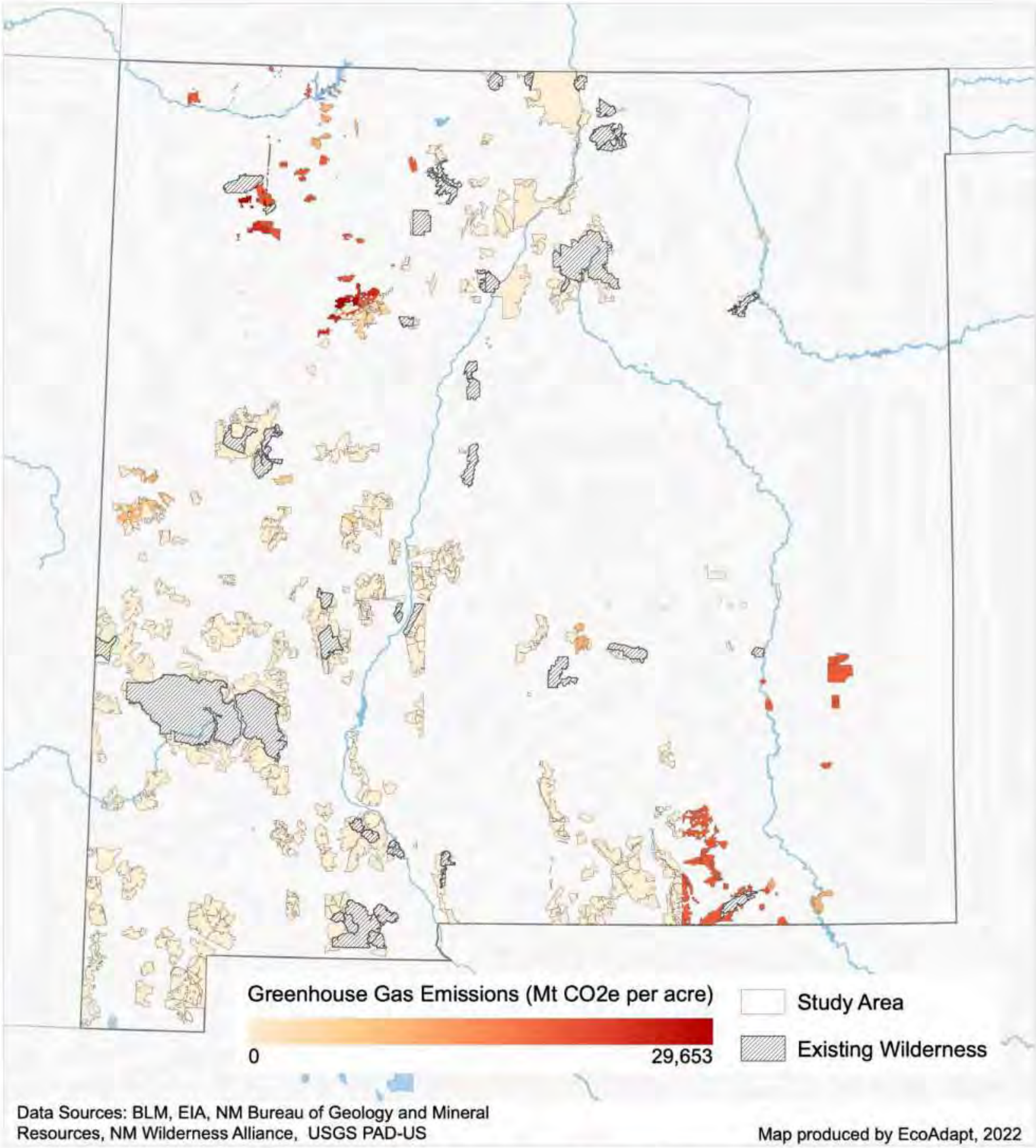

Figure 13. Greenhouse gas emissions associated with unleased fossil fuels underlying the New Mexico study area.

While it would not be possible to extract 100% of all fossil fuels on every acre of the study area (due to multiple use conflicts, economic constraints, and other factors), the results of this analysis illustrate the potential value of including unleased fossil fuels when considering the potential climate mitigation value of protected areas on New Mexico public lands. Protecting additional areas as wilderness, in particular, would ensure that new lease sales and resource extraction would be permanently prohibited, preventing the release of greenhouse gasses associated with the production and combustion of any fossil fuels underlying those lands.

Priority areas across multiple adaptation and mitigation indicators

Across the five adaptation and mitigation indicators examined in this project, several portions of the study area emerge as relatively consistent priorities for protection in the context of climate change (Figures 14 and 15). Specifically, regions that represent priorities based on their identification in the top 25% of multiple indicators are found around several existing wilderness areas, including Gila, Aldo Leopold, Apache Kid, Carlsbad Caverns, and Pecos, along with a few other portions of the study area in the Southern Rockies (Figure 16). Protected areas that were mapped as priorities for all five indicators include portions of the Guadalupe Escarpment Wilderness Study Area and the Tucson Mountains, Madre Mountain, and Carrizo Mountain Roadless Areas, among others. Prioritizing efforts to expand and/or strengthen the protected area network in these locations has the potential to deliver the greatest climate change benefits within the study area, including both support of ecosystem adaptation to climate change as well as mitigation efforts.

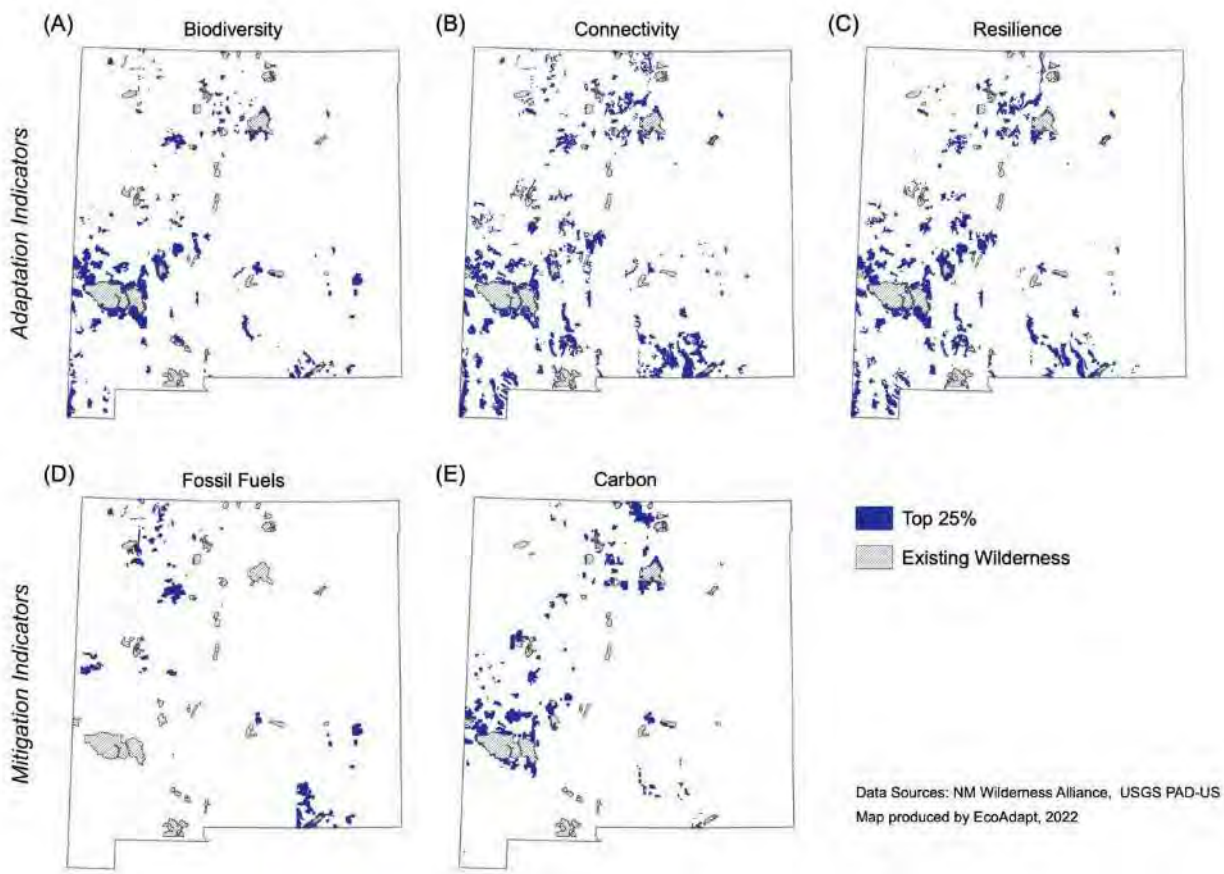

Figure 14. Twenty-five percent (25%) of the study area with the highest scores for each of five adaptation and mitigation indicators, representing priority areas for protection.

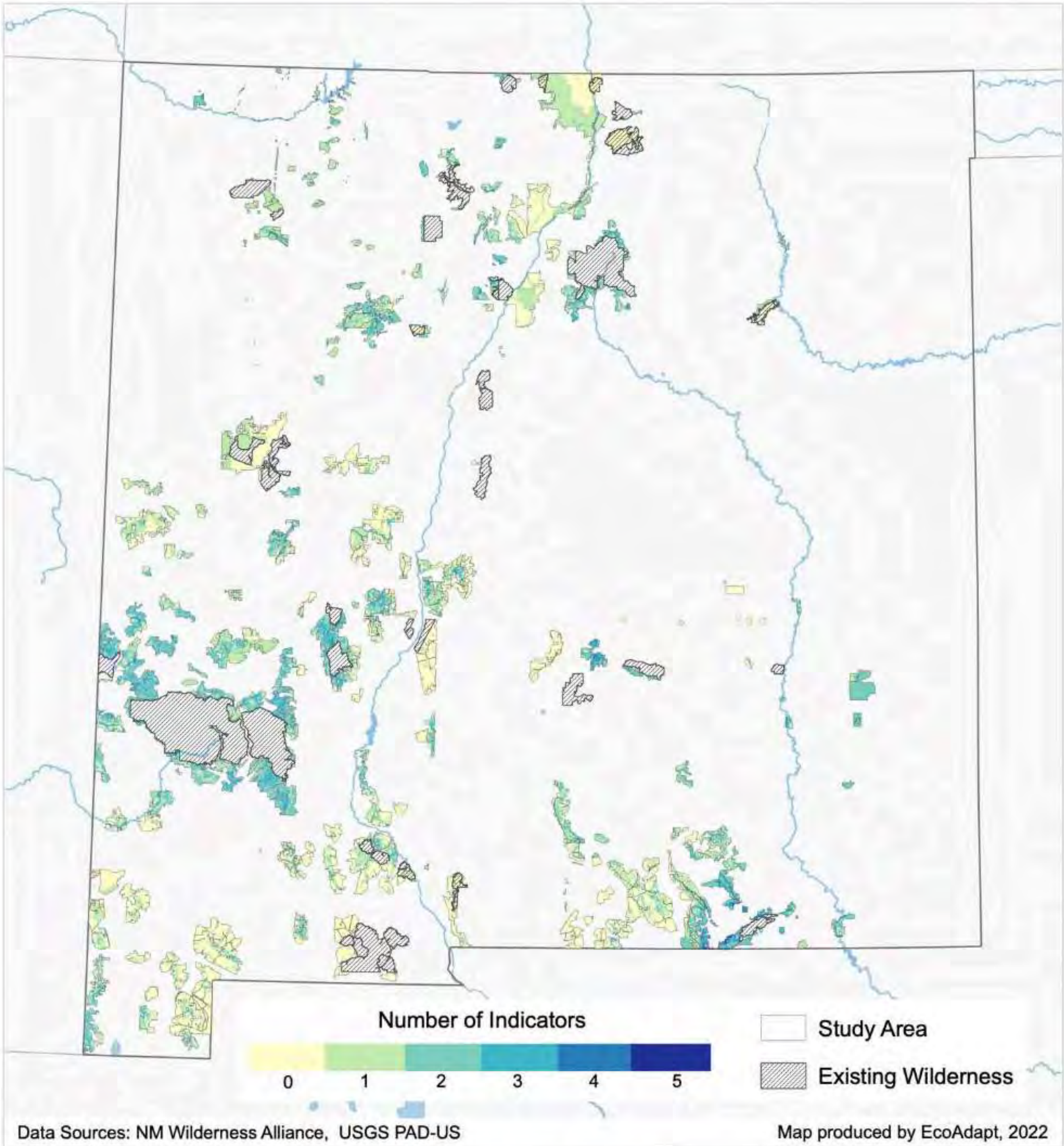

Figure 15. Priority areas based on number of adaptation and mitigation indicators for which portions of the study area have scores in the top 25%.

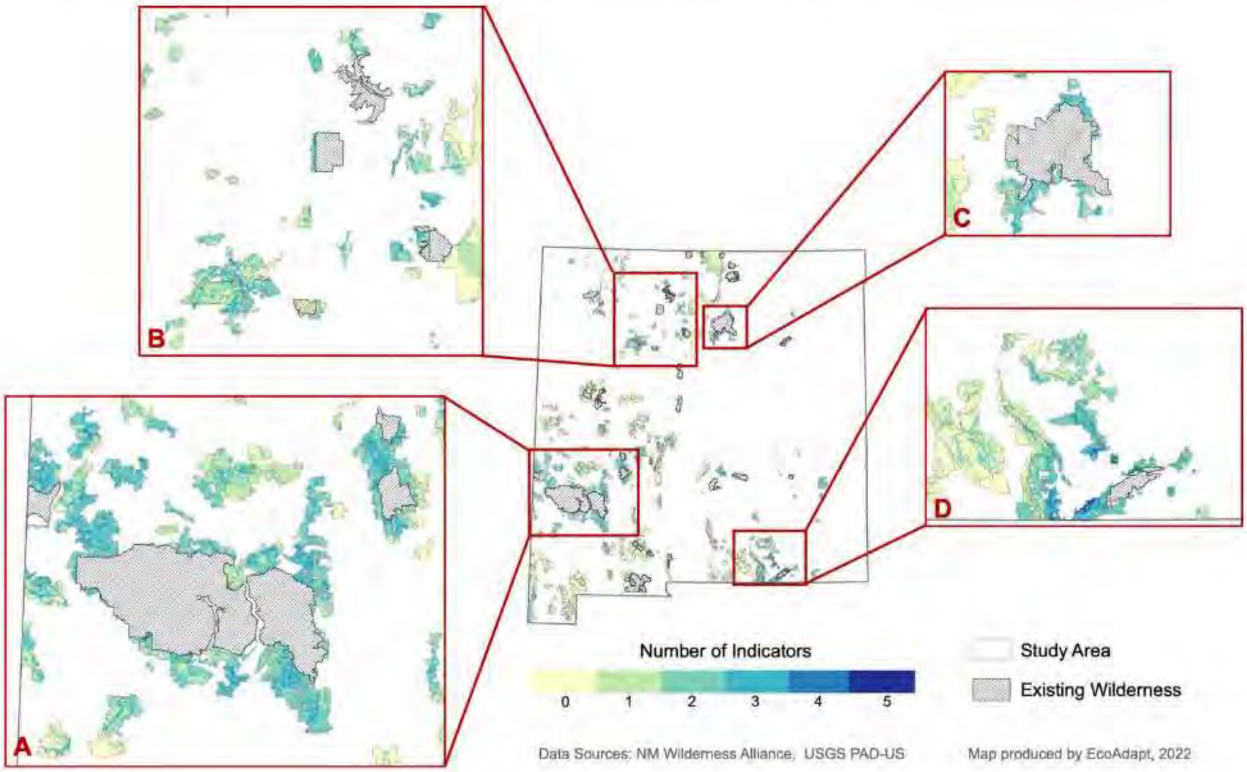

Figure 16. Detailed views of the map in Figure 15 for portions of the study area where scores for the majority of adaptation and mitigation indicators were in the top 25%. **(A)** Portions of the study area in the vicinity of the Gila, Aldo Leopold, Blue Range, Apache Kid, and Withington wilderness areas. **(B)** Portions of the study area within the Southern Rockies ecoregion, near the San Pedro Parks, Chama River Canyon, Bandelier, and Dome wilderness areas. **(C)** Portions of the study area around the Pecos Wilderness. **(D)** Portions of the study area in the vicinity of the Carlsbad Caverns Wilderness.

Conclusions

The results of this analysis provide an initial view of federally-owned public lands in New Mexico that should be considered priorities for expanding and strengthening the existed protected area network to meet 30x30 goals at both the national and state levels. While the indicators selected for this study do not provide a comprehensive evaluation of adaptation and mitigation benefits, they do represent several important climate change considerations and can act as a coarse filter for evaluating the climate benefits of protecting New Mexico public lands.

Based on the findings of this study, the following actions are recommended:

- ***Add or strengthen protected status in areas that provide the greatest benefit across multiple indicators*** (e.g., parcels that harbor range-restricted imperiled species, are resilient and have high levels of connectivity, and hold significant carbon stocks). Additional considerations might include areas with particularly high ecological integrity (such as Wilderness Study Areas or those identified as having wilderness characteristics) and those that are adjacent to or would enhance connectivity among existing protected areas.

- ***Ensure that both new and existing protected areas are protected from disturbances or human uses that would degrade the structure and function of the ecosystem***. This is particularly critical for areas such as headwaters, wetlands, and riparian zones, which harbor high levels of biodiversity and are likely to serve as climate refugia and critical movement corridors as climate change makes the surrounding areas less suitable for sensitive species. These areas will also serve an increasingly important role maintaining water supply and quality within the watershed as climate change increases water stress, both for natural and human communities.
- ***Practice climate-informed management and restoration to maximize the potential for ecosystem adaptation and mitigation***. As climate change increases environmental stress and the frequency and severity of disturbances such as wildfire and insect outbreaks, it will be critical to ensure that management practices and restoration projects in protected areas are designed to maintain biodiversity and ecosystem functioning under both present and future climate conditions. In some instances, this may result in shifts within the system (i.e., in terms of species composition or vegetation cover) that better align with future conditions. In others, management actions such as thinning to reduce forest density in areas impacted by historical fire suppression may increase the health and resilience of current ecosystems that have been degraded by human land uses or management.
- ***Ensure that tribal values and priorities are explicitly incorporated into conservation and management plans***. Protected area designation should preserve treaty rights on federal lands, such as hunting, timber harvest, and use of culturally-important sites and resources, and should seek to integrate cultural values and tribal priorities such as protection of sacred sites or restoration of culturally-important resources (*99*). Increasing opportunities for tribal co-management of federal lands and incorporating traditional ecological knowledge and perspectives into protected area management is an important step towards respecting the relationship of area tribes with their homelands, while also increasing ecosystem health and resilience.
- ***Collaborate with state, local, and tribal governments to meet 30x30 goals***. Although federally-owned lands make up a significant portion of New Mexico and other western states, the protection of federal public lands is unlikely to be adequate to meet 30x30 goals within the specified timeframe (*56*). In order to meet these goals, protected area networks must be strategically expanded to include state, local, and tribal lands that meet the criteria set for inclusion.

Appendix A

Overview of New Mexico study area

New Mexico landscapes are characterized by large gradients in precipitation, elevation and temperature as well as varied geophysical conditions (e.g., substrate, topography) that have given rise to significant biological diversity, including many endemic and rare plants and animals (*83*, *84*, *100*). New Mexico shares several major ecoregions with neighboring states (Figure 2), including:

- The southern edge of the **Colorado Plateau**, which is located in the northwestern corner of the state, is characterized by rugged topography and dominated by sparse woodlands, shrubs, and drought-tolerant grasses.
- The **Southern Rockies**, which represent the southern extent of the Rocky Mountain range and are primarily dominated by coniferous forests. Some alpine habitat also occurs on the highest peaks.
- The **Arizona/New Mexico Plateau**, which occupies much of the western portion of the state, is dominated by a combination of shrublands, grasslands, and pinyon-juniper woodlands.
- The **Arizona/New Mexico Mountains**, which are warmer and drier than their northern counterparts in the Southern Rockies. Major vegetation types include shrublands at lower elevations, pinyon-juniper and oak woodlands at lower and middle elevations, and ponderosa pine forests at higher elevations.
- The **Chihuahuan Desert**, which occupies large areas in the southern portion of the state and also extends south into Mexico, is dominated by grasslands and shrublands with higher-elevation islands of oak (*Quercus* spp.), juniper (*Juniperus* spp.), and pinyon pines (*Pinus* spp.).
- The **Madrean Archipelago** in the extreme southwestern corner of the state extends westward into Arizona and southward into Mexico. This ecoregion is characterized by "sky islands", where high-elevation pine- and oak-dominated systems are interspersed with lower-elevation grasslands and shrublands.
- The **Southwestern Tablelands**, which are dominated by sub-humid grasslands and semi-arid rangelands, with juniper-scrub oak savannah along escarpment bluffs.
- The **High Plains** in the far eastern portion of the state, dominated by native grasses where they are not converted to croplands, and containing thousands of playa lakes important to waterfowl migration (*100*).

Current uses of public lands in New Mexico are wide-ranging, and include many uses that can be compatible with conservation such as wildlife viewing, hiking, biking, fishing, camping, rafting, and horseback riding, as well as those that can have negative impacts on ecosystem integrity such as ORV use, livestock grazing, oil and gas drilling, and mining, among others. Like much of the U.S., many of New Mexico's public lands are threatened by the expansion of invasive plants that compete with and displace native species, change soil chemistry and nutrient cycling, and alter fire regimes (*101–103*). Land use changes associated with grazing and livestock movement, in particular, has facilitated the spread of many species such as mesquite (*Prosopis sp.*), and have been a driving force for shifts in community composition (*104*).

A significant challenge for protecting natural areas across much of the state is water stress. As a largely arid- and semi-arid state, New Mexico's ecosystems are adapted to relatively dry conditions, and also to temporal and geographic variability in precipitation. However, anthropogenic use of water and manipulation of water systems constitutes an additional significant stressor for the state, where nearly 500 dams have altered the natural flows in the majority of river reaches (*105*). Some parts of the state have also experienced significant aquifer declines, as groundwater makes up the majority of New Mexico's public water supply (*106*). Existing water appropriation systems further exacerbate water stress. For instance, the Rio Grande Compact of 1938, which dictates how much water must be sent from downstream to Texas, is based on hydrological conditions from 1929 and fails to take into account population growth and changing climate factors that impact water availability (*107*). Efforts to provide additional protection to riparian systems and surface water features could be undermined if problematic legal/management structures as well as issues of overallocation and overuse of surface and groundwater supplies that support natural systems are not adequately addressed.

Projected climate impacts on New Mexico public lands and associated ecosystems

Across the state, public lands are projected to experience rapid shifts in climate conditions and disturbance regimes over the coming century (see Table A1).

Table A1. Projected future changes in the primary climate stressors likely to impact New Mexico public lands. Arrows represent the trend direction (e.g., increase, decrease, or shift towards earlier timing).

Climate Stressor	Trend Direction	Projected Future Changes
Air Temperature	▲	• 7.7–15.3°F (4.3–8.5°C) projected increase in maximum annual temperature and 6.3–12.6°F (3.5–7.0°C) increase in minimum annual temperature in New Mexico by 2100 (*63*)
Precipitation	▲▼	• –24% to +42% change in mean annual precipitation in New Mexico by 2100 (high uncertainty in the direction/amount of change) (*63*) • Likely seasonal shift towards wetter winters and drier springs and summers, along with increases in interannual precipitation variability and the frequency of extreme precipitation events (*108, 109*)
Snowpack & Snowmelt	▼ ◀	• Decreased proportion of precipitation falling as snow and significant reductions in snowpack, and earlier snowmelt (*110–114*)

Climate Stressor	Trend Direction	Projected Future Changes
Streamflow	▼ ◄	• Likely reductions in annual streamflow due to increased evapotranspiration, even if precipitation increases (*114*, *115*) • Likely shift towards earlier spring peak flows and reduced volume of peak flows due to changes in snowpack and snowmelt (*111*)
Drought	▲	• Increased risk of prolonged and/or severe drought, with a >70% chance of multi-decadal drought by 2100 (*116–118*)
Wildfire	▲	• Increased fire frequency (*119*, *120*) and annual area burned (*121*) over the coming century, including a significant increase the likelihood of very large fires (*122*)

Ecological implications of climate change

Climatic changes within the region may result in:

- Increased evapotranspiration rates, driving shifts toward higher aridity even in the absence of precipitation declines (*114*, *116*, *123*, *124*).
- Reduced plant productivity and increased mortality due to greater water stress (*93*, *125–128*).
- Changes in plant functional group dynamics, leading to shifts in community composition (e.g., increased relative dominance of shrubs and invasive annual grasses over native perennial grasses) (*129*, *130*).
- Reductions in surface water availability and quality (*114*, *131*), with significant impacts for riparian vegetation (*12*, *132*) and aquatic communities (*133*).
- Increased risk of ecosystem type conversion (e.g., forests to shrubland or shrubland to non-native grassland) due to frequent and/or severe wildfires, particularly in drier areas and during periods of drought (*134–137*).
- Reduced habitat suitability/loss of core habitat and possible species range shifts towards northern latitudes and/or higher elevations (*51*, *138*), with likely loss of high-elevation montane habitat islands (*26*, *139*).
- Range contractions and/or local extirpation, particularly for range-restricted species and those that are unable to track suitable habitat (i.e., due to dispersal limitations or low landscape permeability) (*60*, *81*, *140*, *141*).
- Increased habitat fragmentation as a result of extreme events that reduce patch size, increase gaps, and/or block colonization (*142*).
- Loss of genetic diversity and species richness, particularly where species are already coping with habitat fragmentation and loss (*12*, *143*).
- Changes in carbon sequestration and storage due to reduced overall plant productivity (*93*), shifts in plant community composition (*91*), and altered soil community composition and activity (*92*, *93*).

Interactions between existing stressors and climate change

The impacts of climate change can interact with existing threats to species and ecosystems, including disturbances such as livestock grazing, ORV use, mechanical vegetation treatments, oil and gas development, and road construction, among others. On New Mexico public lands, examples of significant interactions that may occur include:

- Altered hydrology, reduced freshwater availability, and reduced water quality where human use and disturbances of public lands and adjacent areas degrade intact watersheds (*144–147*) or result in large water withdrawals and discharge of contaminated water. Warmer, drier climate conditions and more frequent extreme precipitation events are likely to exacerbate the impacts of existing water stress on native plants and animals while also increasing pressure to develop remaining water resources for human use (*114*, *148*).
- Shifts away from historical hydrologic regimes as a result of climate change results in existing water allocation systems being based on conditions that no longer exist, resulting in increasingly unsustainable practices that exacerbate current inequities (*107*)
- Increased spread and establishment of invasive plants that displace native plant species, alter ecosystem processes, and degrade critical wildlife habitat (*101*, *149*, *150*). The expansion of cheatgrass (*Bromus tectorum*), in particular, has increased wildfire frequency and annual area burned by enhancing fuel availability and continuity (*103*, *151*). Frequent fires, in turn, increase the cover of invasive grasses, creating a positive feedback loop that perpetuates altered fire regimes (*102*, *152*). Warmer temperatures and increased drought are projected to enhance wildfire risk and contribute to the spread of invasive grasses over the coming century, further strengthening invasive grass-fire feedback loops (*153*, *154*).
- Anthropogenic disturbances that reduce carbon sequestration and storage due to vegetation loss, increased erosion, and changes in soil properties. The removal of woody vegetation is generally associated with a short-term net loss of stored carbon, due to both the removal of above-ground plant biomass (*91*, *155*, *156*) as well as changes in carbon cycling that reduce soil organic carbon (*157*, *158*). However, climate-informed forest restoration focused on stabilizing long-term carbon storage may include tree removal through thinning practices designed to increase tree productivity and vigor while also reducing the vulnerability of carbon losses to wildfire (*32*, *96*).

Appendix B

Detailed methodology for fossil fuel analysis

Estimates of crude oil and natural gas and associated greenhouse gases was adapted from the methodology used in a recent report by The Wilderness Society (*34*), while coal estimates were adapted from Mulvaney et al. (*33*). All spatial data was processed and analyzed using QGIS 3.16 (*159*). Because the New Mexico study area lands are not contiguous or uniformly distributed, we were limited by the availability of parcel-level spatial data that would allow us to determine where the study area overlapped unleased fossil fuel resources.

This analysis attempts to estimate the amount of fossil fuel resources that underlie the study area in order to determine the amount of greenhouse gas emissions that would be associated with the extraction and combustion of those fuels. Because it is impossible to account for all of the complex, interacting factors that influence whether fossil fuel resources are developed, we do not attempt to account for potential competition among different fuel types (e.g., co-occurring fossil fuel deposits). However, we have utilized location-specific parameters and constraints related to technical/economic feasibility whenever possible in order to increase the accuracy of these estimates and avoid unnecessary overestimation of recoverable resources. Additional sources of uncertainty associated with greenhouse gas emissions from fossil fuels includes method of extraction (efficiency), methane leakage rates, method of well/mine abandonment, transport distance, and end-use product, among others (*33*, *37*).

Because existing leases must be honored, we excluded these from the acreage used to estimate fossil fuel resources. We also made the simple assumption that all unleased resources could be leased at some point in the future, as "no leasing stipulations" and other limitations based on current policies and land uses could be altered or eliminated in the future. Spatial data representing current leases in New Mexico was obtained from the New Mexico Bureau of Land Management for oil and gas (*160*) and from the Mining and Minerals Division of the New Mexico Energy, Minerals, and Natural Resources Department (NM EMNRD) for coal (*161*).

Crude oil and natural gas

We used basin and/or play-specific assumptions of average well densities (*72*, *162*) and estimated ultimate recovery (EUR) (*73*) for representative wells in New Mexico to estimate production separately for oil and gas wells. Spatial data and maps showing sedimentary basins (*69*) and tight oil and shale gas plays (*70, 71*) were used to determine the geographic distribution of production assumptions applied to the New Mexico study area, which were concentrated in the San Juan and Permian Basins.

Lifecycle greenhouse gas emissions were calculated using standard emission factors from the Bureau of Land Management (*73*).

Coal

In order to calculate coal resources underlying the study area lands, we utilized estimates of remaining recoverable coal resources in New Mexico based on a 2017 report published by the New Mexico Bureau of Geology and Mineral Resources and the New Mexico Geological Society (*75*), which represents the most recent estimates available for the state. We calculated the proportion of each coalfield that overlapped with the study area, and then assigned a corresponding proportion of the estimated recoverable coal resources for that coalfield. Because we lacked spatial data displaying distribution within the coalfields (e.g., location of coal seams, etc.), our estimates are made using the assumption that coal resources are evenly distributed across each field.

As for crude oil and natural gas, we utilized standard greenhouse gas emission factors from the BLM (*73*), which for coal were provided as a state-specific average including direct, indirect, and end-use emissions.

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