PROJECT GUIDELINES

ABOUT

The New Mexico Department of Game and Fish Project Guidelines provide conservation measures to minimize impacts of land use and development projects on wildlife and wildlife habitats. This set of guidelines addresses the beneficial impacts beavers have on wetlands and wildlife and strategies for beaver coexistence and relocation. For more information on this topic, please call 505-479-1269.

ERT for NM

The Environmental Review Tool (ERT) for New Mexico is a web-based system that quickly screens land use and development projects for potential impacts to wildlife and wildlife habitats. The ERT provides best management practices and guidance to mitigate these impacts. Evaluate your project with the ERT at: https://nmert.org/home.

EEP Section

The Ecological and Environmental Planning (EEP) Section's Technical Guidance Team coordinates the Department's environmental review process and works with community, private sector, state and federal government, nongovernmental organizations, and other project proponents to protect and enhance wildlife habitats. The Section implements the Share with Wildlife program and maintains BISON-M, a database of New Mexico's wildlife species. It also participates in the development and application of wildlife-related information management and planning tools.

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Beavers in New Mexico: Coexistence and Relocation

*American beaver (*Castor canadensis*). Defenders of Wildlife*

American beavers (*Castor canadensis*) are the largest rodents in North America and the second largest rodents in the world. Beavers are herbivores and will change their diet seasonally, eating more herbaceous vegetation in the summer and more woody vegetation in the winter (Pollock et al. 2023). As aquatic mammals, beavers are found in habitats with permanent surface water such as rivers, streams, ponds, and lakes.

Beavers once ranged in North America from the Arctic in the north to northern Mexico in the south (Pollack et al. 2023), existing in watersheds across the continent except for in the tip of the Florida peninsula and the Great Basin Desert (much of present-day Nevada). Before European settlement, 60-400 million beavers lived in North America (Seton 1928; Wohl 2021). Their range included the southwestern U.S. where beavers could be found in most of the perennial streams and rivers (Findley et al. 1975) in high enough numbers to support a successful fur trade (Weber 1971). However, due to unregulated historical trapping and habitat degradation, beaver numbers plummeted during the 1800s. Current beaver populations in North America are now estimated to be about 10 million (Naiman et al. 1988; Pollock et al. 2023), and in New Mexico, beaver populations were estimated to be around 6,000 in the early 2000s (personal communication, N. Forman, New Mexico Department of Game and Fish [Department]), approximately one sixth of their historic numbers (Wild 2011, WEG 2013). Beavers are now present or suspected to be present along many stream systems in every county in New Mexico except for Curry, Lea, Roosevelt, and Torrance counties, where surface water resources are limited.

Beavers are considered furbearers in New Mexico and are protected under state law (New Mexico Statutes Annotated [NMSA] 1978 § 17-5-2). It is illegal to transfer live furbearers or to capture furbearers in New Mexico without relevant permits issued by the Department (NMSA 1978 § 17-3-31). Additionally, trapping beavers on public lands (e.g., state- and federally owned land) is prohibited, with limited exceptions (19.32.2 NMAC).

Beavers' natural instincts to build structures and dam running water have been shown to greatly benefit wildlife and landscape health (outlined below), but those instincts can result in property damage, causing beavers to be seen as a nuisance by humans. Thus, coexistence strategies, outlined here and in other Department guidelines, are recommended by the Department to minimize damage to property while still allowing for the ecosystem and landscape benefits that come with beaver activity.

Importance of beavers to New Mexico's Wildlife

Fishes

Studies have found that beaver dam structures do not block up or downstream movements of fish—a common misconception (Bouwes et al. 2016, Pollock et al. 2022). In fact, ponds and backwaters created by beaver-constructed, instream structures are important to the survival and recruitment of juvenile salmonid fish (Bouwes et al. 2016) such as trout (*Oncorhynchus* spp.). Beaver ponds can also be important overwintering habitat for fish (Kemp et al. 2012), and beaver- and artificially made structures can create beneficial instream habitat for native fish (Pander et al. 2025), and provide thermal refugia for fish under warming climate conditions (Weber et al. 2017).

*Rio Grande cutthroat trout (*Oncorhynchus clarkii virginalis*). J. Caldwell*

Birds

The expansion of wetland and riparian habitat through the rise in groundwater elevation and increased surface water associated with beaver dam construction can be beneficial to wetland or riparian birds (Brown et al. 1996). Because of these effects of beaver activity, beaver reintroduction has been proposed as a management strategy for the conservation of the southwestern willow flycatcher (*Empidonax traillii extimus*; USFWS 2002), which nests in dense riparian vegetation (e.g., willows [*Salix* spp.]). Ponds also are beneficial habitat for waterfowl such as ducks (Brown et al. 1996).

*Southwestern willow flycatcher (*Empidonax traillii extimus*). K. Colgan*

Mammals

Beaver ponds and abandoned dens can provide beneficial habitat for other semiaquatic mammals such as muskrats (*Ondatra zibethicus*) and river otters (*Lontra canadensis*) (Rosell et al. 2005, Gibson and Olden 2014), as well as bats that benefit from the increased wetland and pond habitat (Hooker et al. 2024). Additionally, wetland meadows created by beavers are important habitat for the New Mexico jumping mouse (*Zapus hudsonius luteus*; Frey 2012, Chambers and Rewa 2022, NMDGF 2022), which lives only in wet riparian vegetation.

*New Mexico jumping mouse (*Zapus hudsonius luteus*). J.N. Stuart*

Reptiles and Amphibians

Many reptiles (e.g., turtles and snakes) and amphibians that prefer permanent ponds and slow-moving water benefit from the pools and backwaters created by beavers (Lovich and Halama 2016). For example, northern leopard frogs (*Lithobates pipiens*) have been found to prefer to breed in active beaver ponds (Zero and Murphy 2016). In mountainous areas, amphibians, such as the boreal toad (*Anaxyrus boreas*), are more likely to occupy beaver-influenced wetlands compared to wetlands without beavers present (Hossack et al. 2015).

*Boreal toad (*Anaxyrus boreas*). J.N. Stuart*

Pollinators and Insects

A study in the southwestern U.S. found that in areas where beavers have created a mixed stand of felled and standing trees, insect abundance and the number of insect species was higher compared to areas without beavers (Durben et al. 2021). In temperate regions, studies have found that beaver wetlands had a higher diversity and abundance of moths (Andersen et al. 2023) and beetles (Mourant et al. 2018) than areas without beavers. Additionally, actively maintained beaver dams have been shown to host a diverse community of invertebrates (Schloemer et al. 2023).

*Hoary comma (*Polygonia gracilis zephyrus*). M. Watson*

Impacts of beavers on the landscape

Wetlands

The combination of beaver dam ponds, canals dug laterally into the floodplain to access food and building resources (Grudzinski et al. 2020), and overbank flows creates a multi-channel system, rejoining into one channel downstream of beaver presence (Wohl 2021). Multi-channel systems promote wetland and riparian plant growth and habitat heterogeneity, which benefits wildlife populations. The combination of different channels and ponds created by beavers in various successional stages is referred to as a beaver meadow (Wohl 2021).

Beaver meadow and lodge. J. N. Stuart

In valley bottoms, beaver meadows can lead to a stream channel system in which the active channels are multithreaded, not cutting deep below the ground surface (i.e., not incised), and highly connected to their adjacent floodplains. This channel shape and form, referred to as Stage 0, is used as a baseline in evaluating stream channel evolution and indicates the channel system is healthy and minimally disturbed or altered (Cluer and Thorne 2014).

Surface and groundwater

By building dams, beavers can help to increase the volume of surface and groundwater on and in the local landscape. Specifically, streams with beaver dams have greatly increased surface water volume compared to those without dams (Fouty 2018), and groundwater storage can be over two times greater than surface water storage (Dittbrenner et al. 2022).

Beaver dam in Fenton Lake State Park, New Mexico. M. Watson

Water is slowly released from beaver ponds because beaver dams are “leaky” structures. This slow release, in addition to the increased groundwater storage around beaver ponds, can result in a stream segment shifting from being intermittent to perennial (Majerova et al. 2015). In other words, the period of time in a year when water flows within a stream segment downstream of beaver ponds can be extended. This is important for downstream habitats and water users that require water in later parts of the year.

Vegetation

When beaver dams cause water to flow laterally onto floodplains, the soil moisture of these former upland areas increases resulting in the formation of wetland habitats and riparian vegetation growth (Westbrook et al. 2006). The increase in vegetation creates surface roughness, which can be important in lowering the energy of overbank flows during flood events.

Beaver pond and lodge near Chimayo, New Mexico. J. Marchetti

Beaver dams can trap sediment behind them, which reduces turbidity downstream and causes sediment to build up (aggrade) in incised channels (Kramer et al. 2012, Wohl 2021). This helps to raise the channel bed closer to its floodplain, raising the water table with it. In doing so, riparian and wetland plants that require saturated soil conditions can thrive in these aggraded areas where they may have been absent before.

Wildfire resilience

A study by Fairfax and Whittle (2020) found that riparian corridors that were dammed by beavers remained green and relatively unchanged immediately following a wildfire compared to riparian corridors that were not dammed and had burned. These beaver-containing corridors can thus serve as temporary refugia for a diversity of wildlife that cannot otherwise escape spreading flames during fires. Additionally, these areas of riparian fire refugia can trap sediment and debris carried by, and lessen the flow intensity of, post-wildfire floods (Cluer and Thorne 2014). Without healthy riparian vegetation, post-fire floods can scour stream channels and cause further incision (Cannon and DeGraff 2009).

Beaver dam analog (BDA) and wet meadow in San Antonio Creek, NM. R. Whittlesey

Benefits of restoration projects for beaver relocation success

Beaver mimicry structures, such as beaver dam analogs (BDAs) and post-assisted log structures (PALS), are instream structures made of natural materials (e.g., wooden posts, tree trunks and branches, rocks, etc.) that are designed to imitate the structure and function of beaver dams. When implemented, BDAs and PALS can have the same positive impacts on a landscape as beaver dams (Lautz et al. 2019, Wheaton et al. 2019). These structures are often used in low-tech, process-based stream restoration projects.

Ideally, installing BDAs and PALS would encourage beavers to move in naturally from further up- or downstream and maintain or build upon the BDAs and PALS, or build new dam structures nearby, thus adopting the instream structures as their own. This maintenance also ensures that the structures continue to provide restoration benefits over time. However, if this does not happen, then, since these structures are designed to be temporary and will degrade and collapse over time, these structures need to be maintained in order to continue their associated habitat benefits.

BDAs and PALS can also be valuable tools when attempting beaver reintroduction and to promote beaver conservation. While beaver dams and beaver activities can help to restore a stream system, beavers are unlikely to successfully spread into a habitat if it is degraded (e.g., incised channels with fast moving water and little riparian vegetation). However, constructing BDAs and PALS can improve the quality of local stream and riparian habitats and, when combined with the planting of willows and other beaver food sources as needed, can create habitat suitable for beavers. Beavers in other parts of the focal watershed may move into this improved habitat and build upon the existing instream structures. Thus, the more aquatic and riparian habitats that are restored using BDAs and PALS (particularly in headwater reaches with slopes and other conditions suitable for beavers), the more stream reaches may become available for beavers to spread to naturally or to which beavers may be relocated with appropriate permits and permissions.

Habitat restoration may be expedited when BDAs and PALS are implemented alongside other restoration techniques, such as willow planting (mentioned above), livestock exclosures, and erosion control structures. To help beavers move into newly restored areas, BDAs and PALS should be implemented near (within 6 mi [10 km] of; Sun et al. 2000, McNew and Woolf 2005]) existing beaver colonies in habitats that are degraded. However, more research and monitoring is needed in New Mexico to determine how to successfully pair beaver mimicry structures with beaver reintroductions.

Post-assisted Log Structure (PALS) near Mancos, Colorado. J. Marchetti

Beaver dam analog (BDA) constructed on San Antonio Creek in Valles Caldera National Preserve, NM. P. Watson

Minimizing Negative Impacts of Beavers Through Coexistence Strategies

Beavers' instinct to dam running water means they can block infrastructure such as culverts and irrigation ditches (e.g., acequias), potentially leading to undesired flooding and disruption of desired flow. Additionally, a beaver dam or dams on a stream may cause flooding onto adjacent property.

- Interventions such as installing culvert fencing and starter dams are effective for preventing beavers from blocking culvert openings.
- Installation of pond-levelers and pipe-and-fence systems can be effective in preventing existing beaver dams on streams from flooding adjacent property or restricting water flow.
- In some instances, complete beaver dam removal or notching a beaver dam may be required to lower water levels or unclog water delivery systems including acequias and irrigations ditches. However, beavers may continue to build or repair dams if left in that area, making dam removal and notching temporary solutions.
- For more information regarding beaver coexistence strategies, please see Page 12 of the Department's Bridge and Culvert Construction Guidelines.
- The Department may be able to provide fencing and pond-leveler materials to private landowners with qualifying projects. Landowners interested in receiving materials should contact a member of the Department's Private Land Program staff to learn more about the program and the qualification criteria. Each proposed project must be reviewed by Private Land Program staff and approved by the Department. For qualifying, approved projects, the Department may provide materials through a materials-only contract. However, the Department cannot provide labor or funding to install these materials.

Culvert protective fencing. The Beaver Institute

A pond-leveler being floated into place prior to submersion. The Beaver Institute

Beavers will gnaw woody vegetation and cut down trees near their colony to use as food or building material.

- To protect trees and other woody vegetation of interest from beavers, fencing can be installed around the base of individual trees or tree trunks can be coated with a mix of latex paint and sand.
- For more information regarding beaver coexistence strategies, please see Page 6 of the Department's Riparian Habitat Restoration and Management Guidelines.

Trees coated with a mix of latex paint and sand. Colorado Department of Transportation (CDOT)

Protective fencing around a tree. CDOT

Minimizing Negative Impacts of Beavers Through Coexistence Strategies (continued)

The ponding of water by beaver dams can lead to partial water loss through direct evaporation from surface water or transpiration through riparian vegetation (collectively referred to as evapotranspiration, or ET), resulting in slightly lower streamflow downstream (Larsen et al. 2021). However, flow levels downstream of beaver dams are highly variable depending on local hydrology, dam attributes, and riparian habitat structure and characteristics (Larsen et al. 2021, Grudzinski et al. 2022) and remain poorly understood at an annual scale, especially in the southwestern U.S.

- Downstream area water users that are concerned about reduced water flow can install pond-levelers to ensure that water flows more freely through the dams.
- While annual water flow can be reduced by the presence of beaver dams, baseflow during drier parts of the year is often increased as a result of recharged groundwater returning to stream beds (Charnley 2019).
- Water that is lost to ET supports riparian vegetation growth and comes from wider riparian habitats typically associated with beaver dams, which can increase biodiversity and bolster local drought and fire resilience (Jordan and Fairfax 2022).
- Beaver dams can also attenuate the flow of water immediately after they are constructed, while water is rewetting the surrounding floodplains (Corday 2024), and after brief storm events. This flow attenuation can be beneficial to downstream residents in the context of flood control and sediment retention.

Beaver dam on the Rio Cebolla, New Mexico. J. N. Stuart

Beaver dam in Coyote Creek State Park, New Mexico. R. M. Cavin

Beaver Relocation

Important note: The Department encourages use of beaver coexistence strategies as described in this document and in other guidelines linked to below <u>before</u> exploring the possibility of relocating or removing beavers.

Reintroduction of any wildlife, including beavers, requires ecological, social, and government support. Not only does the landscape need to provide suitable habitat(s) for the reintroduced species to establish and thrive, but the local community must also support the release of the species into the landscape. Without neighborhood support, especially for species that can move long distances once introduced, community members may take undesirable actions such as intentionally killing reintroduced wildlife (Holmes et al. 2024). Additionally, government support is needed to create policies and programs that benefit and promote wildlife reintroductions.

In New Mexico, suitable reintroduction areas often feature low-gradient streams (< 6% slope), unconfined valleys, and areas with abundant food resources such as willows, cottonwoods, and aspens (*Populus* spp.) (Pollock et al. 2023). Beavers prefer not to eat salt cedar (*Tamarix* spp.) because of the high salt and tannin content (Gibson and Olden 2014), so areas of high salt cedar density are less suitable.

Beaver reintroductions may be possible in watersheds where beavers do not currently occur and local resources could support them (e.g., proper food resources and water availability).

Beaver Relocation (continued)

State policies and regulations in New Mexico

- The Department supports permitted and approved reintroductions and relocations as elements of a conservation strategy for beavers in New Mexico in instances where beaver coexistence approaches are not feasible.
- The Department has statutory authority to permit the capture or removal of beavers, through licenses or special permits, in cases where beavers interfere with the operation of any lawful canal, ditch, or dam or cause or threaten the destruction of private property. They can also issue permits for the capture of beavers to be transferred from one stream to another.
- Permitted removal of beavers, lethal or not, is often only a temporary solution and the least desirable option. If beavers have moved into a new area where their activities spark human-wildlife conflicts, it is likely because the conditions in that area are appealing to beavers. This means that if a beaver is removed, another may soon move in to take advantage of the empty habitat. Therefore, in instances where human safety and property are not in immediate danger, nonlethal coexistence strategies should be used.

The beaver relocation/removal process

- Department Conservation Officers are responsible for responding to depredation or other wildlife complaints in compliance with NMSA § 17-2-7.2.
- Conservation Officers will provide up to three different interventions to mitigate wildlife damage when necessary. Interventions may include an explanation of why beavers have moved into the area and a description of appropriate coexistence or removal strategies.
- In cases where the initial evaluation indicates use of coexistence materials (e.g., culvert fencing, pond levelers) may provide a viable intervention, the responding Conservation Officer may refer the wildlife complaint to a Department Private Land Program staff member for additional review.
- When coexistence is not feasible, removal and relocation may occur as a final intervention. In this case, Department biologists first assess whether there are sites available for beaver relocation. If so, Conservation Officers will set out cage traps to humanely capture the beavers and work with the landowners at the relocation site to coordinate a release.

Viable relocation sites should meet the following criteria for successful establishment:

- Approval from neighboring landowners who could be affected by the beaver(s) being relocated to that area.
- The proposed release site should have a persistent water source and suitable riparian vegetation conditions (e.g., abundant woody and herbaceous plants for use in foraging and dam building). Watersheds that do not currently have beavers present will be prioritized for relocation over those that do.

Conservation Officer Shawn Carrell assisting with capturing two beavers from a private pond. New Mexico Department of Game and Fish (NMDGF)

A beaver being released into a stream in northern Washington. M. Heim

Beaver Relocation (continued)

Important considerations before and after a beaver relocation

Before beavers are relocated to any location, Department biologists should be consulted to determine whether any state– or federally listed species are present in the release area and what impacts beavers might have on these species. Additionally, Department biologists should be consulted to determine whether the proposed beaver relocation poses any potential threat of pathogen (e.g., whirling disease, chytrid fungus [*Batrachochytrium dendrobatidis*], ranavirus, etc.) or aquatic invasive species (AIS) transmission between removal and release sites.

Monitoring and research are needed to determine the success rates of beaver releases and the effects that beaver relocations have on abiotic (e.g., hydrology and geomorphology) and biotic (e.g., vegetation and animals) factors in New Mexico and across the western U.S. (Pilliod et al. 2018). The Department has an interest in conducting short- and long-term monitoring studies at release sites in partnership with landowners and other organizations.

Limiting factors

Relocation is often limited by a lack of suitable habitat. Due to historic and current land-use practices, streams in New Mexico are often incised and fast flowing and lack abundant riparian vegetation. These conditions will prevent beavers from successfully establishing colonies. In particular, overgrazing may limit beaver relocation success. For instance, Small et al. (2016) found that beavers were mostly absent from sites within cattle allotments due to locally high grazing pressure from cattle, which reduced the abundance of riparian vegetation. Management strategies that can help riparian vegetation recover, such as rotational grazing or conservation-oriented grazing management (Fesenmyer et al. 2018) and exclosure fencing that excludes both grazing/browsing wildlife and livestock, can create favorable conditions for beavers to establish at a relocation site. The beaver meadow vegetation that can grow following beaver establishment could then improve local grazing conditions provided that livestock are appropriately managed in the riparian zone.

For more information regarding grazing management in riparian habitats, please see the Department's Riparian Grazing Guidelines.

Relocation success is also limited by predation by cougars (*Puma concolor*), coyotes (*Canis latrans*), and other medium to large carnivores and a lack of landowners and neighborhoods receptive to beaver releases.

Release of four relocated beavers in Colorado. S. Tippie

Beaver dam in the Rio Chiquito, NM. R. Whittlesey

Department Conservation Officer assisting in a beaver relocation in Bandelier National Monument, New Mexico in 2019. NMDGF

Additional Resources

Beaver Restoration Guidebook (U.S. Fish and Wildlife)

Landowners' Guide to Non-lethal Beaver Solutions (Animal Protection New Mexico).

New Mexico Department of Game and Fish Furbearer Information and Furbearer Rules

Beaver Restoration Assessment Tool (BRAT; Utah State University)

New Mexico Beaver Habitat Mapper (Defenders of Wildlife)

Beaver Coexistence Incentive Program (Defenders of Wildlife)

Low-Tech Process-Based Restoration of Riverscapes: Design Manual (Utah State University)

General Information and Beaver Mitigation/Coexistence Strategies (The Beaver Institute)

Restoring Western Headwater Streams with Low-Tech Process-Based Methods: A Review of the Science and Case Study Results, Challenges, and Opportunities (American Rivers)

Benefits of Healthy Riverscapes for Climate Resilience and Ecosystems in the West (Natural Resources Defense Council)

References

Andersen, L. H., C. Ransborg, C. Pertoldi, S. Pagh, and S. Bahrndorff. 2023. Can reintroduction of beavers improve insect biodiversity? Journal of Environmental Management **337**:117719.

Bouwes, N., N. Weber, C. E. Jordan, W. C. Saunders, I. A. Tattam, C. Volk, J. M. Wheaton, and M. M. Pollock. 2016. Ecosystem experiment reveals benefits of natural and simulated beaver dams to a threatened population of steelhead (*Oncorhynchus mykiss*). Scientific Report **6**:28581. https://doi.org/10.1038/srep28581.

Brown, D. J., W. A. Hubert, and S. H. Anderson. 1996. Beaver ponds create wetland habitat for birds in mountains of southeastern Wyoming. Wetlands **16**:127-133.

Cannon, S. H., and J. DeGraff. 2009. The increasing wildfire and post-fire debris-flow threat in western USA, and implications for consequences of climate change. Pages 117-190 *in* K. Sassa and P. Canuti, editors. Landslides— disaster risk reduction. Springer, Berlin. https://doi.org/10.1007/978-3-540-69970-5_9.

Chambers, C., and C. Rewa. 2022. NRCS outcomes webinar: what New Mexico meadow jumping mice tell us about functional riparian ecosystems. Webinar, Northern Arizona University, Flagstaff, AZ.

Charnley, S. 2019. If you build it, they will come: ranching, riparian revegetation, and beaver colonization in Elko County, Nevada. Research Paper PNW-RP-614 USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Cluer, B., and C. Thorne. 2014. A stream evolution model integrating habitat and ecosystem benefits. River Research and Applications **30**:135–154.

Corday, J. 2024. Restoring western headwater streams with low-tech process-based methods: a review of the science and case study results, challenges, and opportunities. White Paper Report. American Rivers, Washington, D. C. https://www.americanrivers.org/resource/new-report-state-of-the-science-on-restoring-western-headwater-mountain-streams/.

Dittbrenner, B. J., J. W. Schilling, C. E. Torgersen, and J. J. Lawler. 2022. Relocated beaver can increase water storage and decrease stream temperature in headwater streams. Ecosphere **13** (7):e4168. https://doi.org/10.1002/ecs2.4168.

Durben, R. M., F. M. Walker, L. Holeski, A. R. Keith, Z. Kovacs, S. R. Hurteau, R. L. Lindroth, S. M. Shuster, and T. G. Whitham. 2021. Beavers, bugs and chemistry: a mammalian herbivore changes chemistry composition and arthropod communities in foundation tree species. Forests **12**(7): 877.

Fairfax, E., and A. Whittle. 2020. Smokey the beaver: beaver-dammed riparian corridors stay green during wildfire throughout the western United States. Ecological Applications **30**(8):e02225. https://doi.org/10.1002/eap.2225.

Fesenmyer, K. A., D. C Dauwalter, C. Evans, and T. Allai. 2018. Livestock management, beaver, and climate influences on riparian vegetation in a semi-arid landscape. PLoS ONE **13** (12):e0208928. https://doi.org/10.1371/journal.pone.0208928

Findley, J. S., A. H. Harris, D. E. Wilson, and C. Jones. 1975. Mammals of New Mexico. University of New Mexico Press, Albuquerque, NM.

Fouty, S. C. 2018. Euro-American beaver trapping and its long-term impact on drainage network form and function, water abundance, delivery, and system stability. Pages 102-133 *in* R. R. Johnson, S. W. Carothers, D. M. Finch, K. J. Kingsley, and J. T. Stanley, editors. Riparian research and management: past, present, future: Volume 1. General Technical Report RMRS-GTR-377. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO. https://research.fs.usda.gov/treesearch/57373.

Frey, J. K. 2012. Survey for the New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) on Carson National Forest, New Mexico. Final Report submitted to Carson National Forest, Taos, NM.

Gibson, P. P., and J. D. Olden. 2014. Ecology, management, and conservation implications of North American beaver (*Castor canadensis*) in dryland streams. Aquatic Conservation: Marine and Freshwater Ecosystems **24**(3):391-409.

Grudzinski, B. P., H. Cummins, and T. K. Vang. 2020. Beaver canals and their environmental effects. Progress in Physical Geography **44**:189-211.

Grudzinski, B. P., K. Fritz, H. E. Golden, T. A. Newcomer-Johnson, J. A. Rech, J. Levy, J. Fain, J. L. McCarty, B. Johnson, T. K. Vang, and K. Maurer. 2022. A global review of beaver dam impacts: Stream conservation implications across biomes. Global Ecology and Conservation **37**:e02163. https://doi.org/10.1016/j.gecco.2022.e02163

Holmes, G., G. Rowland, and K. Fox. 2024. Eager about beavers? Understanding opposition to species reintroduction, and its implications for conservation. People and Nature **6**(4):1524-1537. https://doi.org/10.1002/pan3.10674.

Hooker, J., T. Foxley, E. L. Stone, and P. R. Lintott. 2024. Re-establishing historic ecosystem links through targeted species reintroduction: beaver-mediated wetlands support increased bat activity. Science of the Total Environment, **951**(15): 175661. https://doi.org/10.1016/j.scitotenv.2024.175661

Hossack, B. R., W. R. Gould, D. A. Patla, E. Muths, R. Daley, K. Legg, and P. S. Corn. 2015. Trends in Rocky Mountain amphibians and the role of beaver as a keystone species. Biological Conservation **187**:260-269.

Jordan, C. E., and E. Fairfax. 2022. Beaver: the North American freshwater climate action plan. Wiley Interdisciplinary Reviews: Water **9**(4):e1592. https://doi.org/10.1002/wat2.1592.

Kemp, P. S., T. A. Worthington, T. E. Langford, A. R. Tree, and M. J. Gaywood. 2012. Qualitative and quantitative effects of reintroduced beavers on stream fish. Fish and Fisheries **13**(2):158-181.

Kramer, N., E. E. Wohl, and D. L. Harry. 2012. Using ground penetrating radar to 'unearth' buried beaver dams. Geology **40**: 43–46.

Lautz, L., C. Kelleher, P. Vidon, J. Coffman, C. Riginos, and H. Copeland. 2019. Restoring stream ecosystem function with beaver dam analogues: let's not make the same mistake twice. Hydrological Processes **33**:174–177.

Larsen, A., J. R. Larsen, and S. N. Lane. 2021. Dam builders and their works: beaver influences on the structure and function of river corridor hydrology, geomorphology, biogeochemistry and ecosystems. Earth-Science Reviews **218**:103623. https://doi.org/10.1016/j.earscirev.2021.103623.

Lovich, R. E., K. J. Halama. 2016. Lakes, ponds, and reservoirs. Pages 132-134 *in* L. L. C. Jones, K. J. Halama, and R. E. Lovich, editors. Habitat management guidelines for amphibians and reptiles of the southwestern United States. Technical Publication HMG-5. Partners in Amphibian and Reptile Conservation, Birmingham, AL.

Majerova, M., B. Neilson, N. Schmadel, J. Wheaton, and C. Snow. 2015. Impacts of beaver dams on hydrologic and temperature regimes in a mountain stream. Hydrology and Earth System Sciences Discussions **12**:839-878.

McNew Jr., L. B., and A. Woolf. 2005. Dispersal and survival of juvenile beavers (*Castor canadensis*) in southern Illinois. The American Midland Naturalist **154**(1):217-228.

Mourant, A., N. Lecomte, and G. Moreau. 2018. Indirect effects of an ecosystem engineer: how the Canadian beaver can drive the reproduction of saproxylic beetles. Journal of Zoology **304** (2):90-97.

Naiman, R. J., C. A. Johnston, and J. C. Kelley. 1988. Alteration of North American streams by beaver. BioScience **38**:753-761.

[NMDGF] New Mexico Department of Game and Fish. 2022. 2022 Biennial review of threatened and endangered species of New Mexico. New Mexico Department of Game and Fish, Santa Fe, NM.

Pander, J., J. Otterbein, C. Nagel, and J. Geist. 2025. Nature-based fish habitat enrichment of non-damming beaver structures positively affects fish species richness and density. Ecological Engineering, **212**:107516.

Pilliod, D. S., A. T. Rohde, S. Charnley, R. R. Davee, J. B. Dunham, H. Gosnell, G. E. Grant, M. B. Hausner, J. L. Huntington, and C. Nash. 2018. Survey of beaver-related restoration practices in rangeland streams of the western USA. Environmental Management **61**:58-68.

Pollock M. M., S. Witmore, and E. Yokel. 2022. Field experiments to assess passage of juvenile salmonids across beaver dams during low flow conditions in a tributary to the Klamath River, California, USA. PLoS ONE **17**(5):e0268088. https://doi.org/10.1371/journal.pone.0268088.

Pollock, M. M., G. M. Lewallen, K. Woodruff, C. E. Jordan, and J. M. Castro, editors. 2023. The beaver restoration guidebook: working with beaver to restore streams, wetlands, and floodplains. Version 2.02. U.S. Fish and Wildlife Service, Portland, OR.

Rosell, F., O. Bozser, P. Collen, and H. Parker. 2005. Ecological impact of beavers *Castor fiber* and *Castor canadensis* and their ability to modify ecosystems. Mammal Review **35**(3-4):248-276.

Schloemer, S., T. Hörren, A. W. Lorenz, and D. Hering. 2023. The macroinvertebrate fauna of maintained and abandoned beaver dams. Hydrobiologia **850**(8):1763-1778.

Small, B. A., J. K. Frey, and C. C. Gard. 2016. Livestock grazing limits beaver restoration in northern New Mexico. Restoration Ecology **24**(5):646-655.

Seton, E. T. 1928. Lives of game animals. Volume IV, Part II, Rodents Etc. Charles T Branford Company Boston, Boston, MA.

Sun, L., D. Müller-Schwarze, and B. A. Schulte. 2000. Dispersal pattern and effective population size of the beaver. Canadian Journal of Zoology **78**(3):393-398.

[USFWS] US Fish and Wildlife Service. 2002. Southwestern willow flycatcher recovery plan. U.S. Fish and Wildlife Service, Albuquerque, NM.

Weber D. J. 1971. The Taos trappers: the fur trade in the far southwest, 1540–1846. University of Oklahoma Press, Norman, OK.

Weber, N., N. Bouwest, M. M. Pollock, C. Volk, J. M. Wheaton, G. Wathen, J. Wirtz, and C. E. Jordan. 2017. Alteration of stream temperature by natural and artificial beaver dams. PLoS One **12**(5):e0176313. https://doi.org/10.1371/journal.pone.0176313

Westbrook, C. J., D. J., Cooper, and B. W. Baker. 2006. Beaver dams and overbank floods influence groundwater–surface water interactions of a Rocky Mountain riparian area. Water resources research **42**(6):W06404. https://doi.org/10.1029/2005WR004560

Wheaton J. M., S. N. Bennett, N. Bouwes, J. D. Maestas, and S. M. Shahverdian, editors. 2019. Low-tech process-based restoration of riverscapes: design manual. Version 1.0. Utah State University Restoration Consortium, Logan, UT.

Wild, C. 2011. Beaver as a climate change adaptation tool: concepts and priority sites in New Mexico. Seventh Generation Institute, Santa Fe, NM. http://static1.squarespace.com/static/54c6efebe4b05d1a1cc71a3f/t/54d3a9c4e4b04682afea3b39/1423157700638/Beaver+As+a+Climate+Change+Adaptation+Tool+–+Concepts+and+Priority+Sites+in+New+Mexico.pdf.

[WEG] Wild Earth Guardians. 2013. Assessing beaver habitat on federal lands in New Mexico. Wild Earth Guardians, Santa Fe, NM. https://pdf.wildearthguardians.org/site/DocServer/Layman_s_Beaver_Assessment_Report_Final.pdf

Wohl, E. 2021. Legacy effects of loss of beavers in the continental United States. Environmental Research Letters, **16** (2):025010. https://doi.org/10.1088/1748-9326/abd34e.

Zero, V. H., and M. A. Murphy. 2016. An amphibian species of concern prefers breeding in active beaver ponds. Ecosphere **7**:e01330. https://doi.org/10.1002/ecs2.1330.