California Red-legged Frog Habitat Expansion Project
Tahoe National Forest

California red-legged frog

Wetland constructed on the Eldorado National Forest

Thomas R. Biebighauser

Prepared December 24, 2015

Updated December 19, 2019

Contents

Executive Summary

The Forest Service plans to establish 18-naturally appearing and functioning wetlands on National Forest System land near Michigan Bluff in El Dorado County, California. The wetlands would contain shallow water and be designed to provide breeding habitat for the federally threatened California red-legged frog, and for a diversity of animal and plant species. The wetlands would be built to appear natural, and require little, if any maintenance. This would be a partnership project involving Save The Frogs!, the Sheltowee Environmental Education Coalition, U.S. Fish and Wildlife Service, and the USDA Forest Service.

Introduction

The California red-legged frog is listed as a Threatened Species by the U.S. Fish and Wildlife Service. One breeding population is known to exist in the Sierra Nevada region of California. The population is located on private land owned by Westervelt Ecological Services, near the community of Michigan Bluff. The species is breeding in 3 of 7 historic mining ponds on the property known as the Big Gun Conservation Bank. Unfortunately, water levels in the ponds will drop from 4 to 5 feet under drought conditions. The ponds are likely to dry in a long drought, leaving the population of California red-legged frogs no place to breed.

Tom Biebighauser worked with Kary Schlick (U.S. Forest Service Wildlife Biologist), Dan Teater (U.S. Forest Service Fisheries Biologist), and Jann Williams (Volunteer, U.S. Forest Service Fisheries Biologist-retired) to design 20-wetlands that may be built to provide breeding habitat for the California red-legged frog on National Forest System land. The wetlands would be constructed within 1-mile of the Big Gun Conservation Bank near Michigan Bluff. The USDA Forest Service is planning to build 18 of the wetlands that were designed.

Wetlands would be built to provide breeding habitat for the California red-legged frog

Ephemeral wetlands or vernal ponds would be built within tree canopy gaps that are surrounded by forested land on the Tahoe National Forest. The author has built similar wetlands that are being used by the California red-legged frog on the Eldorado National Forest, Plumas National Forest, and on BLM land within the Tahoe National Forest at Michigan Bluff. Techniques would be used to build the wetlands that have proven effective under severe drought conditions in California, and arid regions of Arizona, Nevada, New Mexico, and British Columbia, Canada.

The wetlands would be built on areas containing slopes of 6-percent or less. The percent slope was measured on each possible wetland area using a laser level, and a clinometer. Each site was chosen to have no more than a 3-foot change in elevation from upper to lower edge. A small number of pine trees would be removed to build some of the wetlands. These trees are generally of small diameter. The trees to be felled would be placed as woody debris in the completed wetlands to provide habitat for the California red-legged frog. Oak trees growing near some of the wetland construction sites would not be damaged or removed by the project. The oaks can be expected to drop their acorns into the water, providing valuable foraging habitat for the Wood Duck.

Soil texture, and the presence or absence of groundwater at each proposed wetland location was determined using a 48-inch long tile probe, and a 52-inch long open-face soil auger. Plastic ribbons were tied to trees and shrubs to mark the perimeter of each planned wetland. A tape measure was used to mark the size of each possible wetland project. A GPS was used to record the center of each planned wetland. A detailed *Wetland Design Form* was prepared for each wetland project.

The National Forest System land near Michigan Bluff is well suited for building wetlands for the California red-legged frog:

1. The proposed wetland sites are within 1-mile of a breeding population of the California red-legged frog on the Big Gun Conservation Bank.
2. The proposed wetland sites are located on public land where they would be protected.
3. There is a high probability that the California red-legged frog would occupy the new habitats. The species is known to move one mile, and occasionally up to 2 miles, from permanent or seasonal aquatic habitats without apparent regard to topography, vegetation type, or riparian corridors.[1]
4. Similar wetlands built by the author on the Eldorado National Forest, Plumas National Forest, and on BLM land since 2014 are being used by the California red-legged frog.
5. The proposed wetland sites are physically suited for building wetlands, being located in tree canopy gaps, areas of deep soils, and on gradual slopes. Three large wetlands would be built on sites containing soils that are high in clay.
6. The wetlands may be built at a relatively low cost, less than 10-percent of the cost of wetlands built for compensatory mitigation by engineering companies.
7. The wetlands can be protected from unauthorized motor vehicle and horse use.
8. No pumps, pipes, water control structures, dams, or diversions would be used to maintain water in the wetlands.

[1] USDI U.S. Fish and Wildlife Service. 2002b. Recovery Plan for the California Red-legged Frog (Rana aurora draytonii). U.S. Fish and Wildlife Service, Portland, Oregon. Viii + 173 pp.

9. Wetlands of various shapes, sizes, and water depths may be built to provide breeding habitat for the California red-legged frog, in both wet and dry years.
10. The wetlands would improve habitat for a diversity of hunted and non-hunted wildlife species.
11. The wetlands can be built to develop planned hydro-periods in times of drought.
12. The wetlands would be built on land not being farmed or grazed.
13. Areas containing nonnative invasive plants would be changed into habitat for rare native species.
14. The wetlands would not fill with sediment from possible future wildfires.

This wetland is one of seven built on the Eldorado National Forest in October 2014. The wetland is 14-months old in this photo.

Big Gun Conservation Bank

The Big Gun Conservation Bank is owned by Westervelt Ecological Services Company. The land area is a historic gold mine adjacent to the town of Michigan Bluff. The Big Gun Conservation Bank contains 7-ponds. These formed when deep holes were dug for gold, and then filled with water. The California red-legged frog breeds in three of these ponds.

Westervelt Ecological Services manages the Big Gun Conservation Bank. The company built a fence around the property and closed the access roads with gates. Personnel work continuously to keep trespassers out who are trying to mine gold. Westervelt Ecological Services works to control erosion on the land, and teaches classes on how to survey and handle the California red-legged frog. Westervelt uses the property to sell conservation credits to businesses and agencies that are required by the U.S. Fish and Wildlife Service to mitigate potential damage to California red-legged frog habitat.

The Big Gun Conservation Bank was visited by Tom Biebighauser, Peggy Cranston (BLM), Kary Schlick (U.S. Forest Service), Dan Teater (U.S. Forest Service), and Jann Williams (Volunteer) on December 8, 2015. The group was led by Matt Gause and Mark Young with Westervelt Ecological Services. It was explained that four of the ponds dry on a regular basis, two of the ponds dry in times of drought, and one pond has never dried.

The elevation of water in the Big Gun Conservation Bank ponds used for breeding by the California red-legged frog has dropped from 4 to 5-feet. The normal elevation of water is shown by the red line.

The ponds used for breeding contained many places where the California red-legged frog could lay its eggs and remain hidden from predators. The roots of willow trees formed a maze along the edge of the water. There was an abundance of logs, branches, boards and piles of rock in and out of the water. The ponds looked messy, giving the frogs and their larvae many places to hide.

A drought in the region had a great impact on water levels at the Big Gun Conservation Bank. The elevation of water in the ponds used for breeding dropped from 4 to 5-feet. The breeding ponds are likely to dry in a prolonged drought, leaving no place for this population of California red-legged frogs to breed. Westervelt is not planning to build more wetlands at the Big Gun Conservation Area. Therefore, there is a sense of urgency in building wetlands on nearby public lands that the California red-legged frog can use for breeding.

The roots, branches, and logs in the ponds at the Big Gun Conservation Bank provide places for the California red-legged frog to hide when they are filled with water.

The ponds used for breeding by the California red-legged frog contain an abundance of roots, logs, and rock piles used by the adults and larvae. The red line shows the normal water level.

Bear Creek Area

The Forest Service built 9-wetlands on the Eldorado National Forest in 2014. Seven of these are located within one-mile of Lake of the Cross and Bear Creek. Lake of the Cross is the only known breeding site for the California red-legged frog on the Georgetown Ranger District of the Eldorado National Forest. Lake of the Cross is a ranch pond that was built years ago on private land, and is surrounded by the Eldorado National Forest.

Many individuals expressed concern that the wetlands the Forest Service built near Bear Creek in 2014 would not be successful. They said the wetlands would not fill with water, and would dry too soon because of the severe drought. A number of professionals who helped build the wetlands for training urged the Forest Service to make them deeper so they would contain water long enough for California red-legged frog larvae to develop.

Fortunately, the seven-wetlands built in 2014 near Bear Creek filled with water naturally, despite the continuation of drought. Surveys were conducted on July 16 and on October 9, 2015 of six of the seven constructed wetlands. The surveys found that California red-legged frogs were using the new habitats.[2] Three of the six wetlands were dry when the surveys were done. It is not known if the wetland not surveyed, and the three wetlands containing water when surveyed, dried between October 9 and December 6, 2015. By the time the wetlands were visited on December 6, rains had begun filling the basins.

Tom Biebighauser inspected the wetlands built near Bear Creek on Sunday, December 6, 2015. He was accompanied by Jennifer House (USFS Wildlife Biologist), Vince Pacific (USFS Hydrologist), Maura Santora (USFS Aquatic Ecologist), Jann Williams (USFS Retired Fisheries Biologist), and Neil Keung (USFS Volunteer). The wetlands appeared natural and were filling with water. No erosion was occurring, motor vehicles had not damaged the wetlands, and there was no need for maintenance. The group was not able to discern how heavy equipment accessed the sites, or where soils removed to build the wetlands had been spread.

This is one of the wetlands built in October, 2014 on the Eldorado National Forest.

The Forest Service is planning to build two more wetlands on National Forest System land near Lake of the Cross in October, 2015. The agency is also analyzing the possible construction of 4-more wetlands near Bear Creek in 2017.

[2] Keung, Neil. Georgetown Red-Legged Frog Restoration Project Annual Report. 2015.

Purpose and Need

Implementing the California Red-legged Frog Habitat Expansion Project would help meet the objectives of the Tahoe National Forest Land and Resource Management Plan by improving habitat for threatened, endangered, and sensitive species of plants and animals. The Forest Plan provides management direction to identify and protect wetlands, identify and protect areas that contain threatened, endangered, and sensitive species of plants and animals, improve habitats for listed threatened, endangered, or sensitive species of plants and animals and other species as they become threatened or endangered. Construction of the proposed wetlands would not adversely affect existing habitat for rare plants and animals.

The proposed project would help implement direction provided by Executive Order 11990 for federal agencies: *Each agency shall provide leadership and shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; and (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.*

Wetlands are areas of shallow water that provide habitat to many species of plants and animals. One is likely to see mule deer, wild turkey, turtles, and dragonflies while visiting a wetland. Wetlands may contain water all year, or for only part of the year. Wetlands are considered to be the most biologically diverse of all ecosystems. Forty-three percent of all species listed as threatened or endangered in the United States by the U.S. Fish and Wildlife Service depend on wetlands for their survival. Experts report that less than one-half of the wetlands in the contiguous 48 United States remain. Over 91-percent of the wetlands in California were lost to drainage from the 1780s to 1980s.[3]

The wetland shown in this photo was built by people attending a wetland restoration workshop on the Eldorado National Forest near Bear Creek in 2014.

[3] Dahl, T.E. 1990. Wetlands losses in the United States 1780's to 1980's. U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C. 21pp.

The American River Ranger District contains few wetlands. Most of the natural wetlands were eliminated by historic mining activities, with others being converted to deep ponds for hydraulic mining, and for use by livestock. The majority of these constructed deep ponds are no longer holding water. This lack of water affects the distribution and abundance of many wildlife species, including the California red-legged frog.

In consideration of how many wetlands have been drained and filled in California it may not be possible to build *too many* wetlands on public or private land. The majority of wetlands that were destroyed historically are located where people live, work, and grow crops. These lands are generally not available for wetland restoration. One the contrary, public lands making the Tahoe National Forest are where few people live, and are often suitable for wetland construction. Some well-intentioned people claim that one must prove a wetland existed on a location before a successful wetland can be built there. Here is why their statement is not correct:

1. The majority of wetlands in California were destroyed in the 1800's, and there is are no records of how they were destroyed.
2. There are few, if any signs that a wetland has been destroyed when someone does a complete job destroying the wetland.
3. We now have the technology to build wetlands that appear and function like natural wetlands on sites that may or may not have been historic wetlands.
4. Animals and plants readily use both constructed and restored wetlands.
5. The California red-legged frog readily uses constructed wetlands.
6. There is no regulation that requires one to prove a wetland existed on a site before a wetland is constructed on that location.

The California red-legged frog is a Federally Threatened species that depends on wetlands for its survival. The California red-legged frog is found in few locations in the Sierra Nevada Mountains. Increasing breeding habitat is a critical step needed to save the species from extinction. The Tahoe National Forest contains large tracts of land that are suitable for use by the California red-legged frog. These lands are largely unoccupied by the species because there are no wetlands available for breeding. The California Red-legged Frog Habitat Expansion Project would build 18-wetlands on National Forest System land that the California-red legged frog could use for breeding.

The drainages where wetlands may have occurred on National Forest System land near Michigan Bluff were changed greatly by mining activities. Hydraulic mining practices caused head-cuts, or waterfalls to form in the streams. Erosion from head-cuts filled historic wetlands and streams with massive amounts soil. These head-cuts started in the 1800's continue to cause erosion today. The head-cuts have lowered the elevation groundwater, and have drained and filled the wetlands once present in riparian areas.

It is not recommended that wetlands be built in drainages for these reasons:

1. The wetlands would be very small because of steep slopes
2. The cost of building the wetlands would be high because of the large quantity of soil to move
3. The wetlands would soon fill with soil from erosion occurring upstream

4. Many permits would be needed for their construction
5. A large number of trees would need to be removed
6. The wetlands may not look natural or function like natural wetlands
7. The wetlands would require regular maintenance

Therefore, naturally appearing and functioning wetlands would be built on higher ground, above the drainages, for these reasons:

1. The wetlands would be much larger in size
2. The wetlands may be built at a lower cost as there would be less soil to move
3. Few permits would be needed for their construction
4. Few trees would need to be removed
5. The wetlands would appear and function like natural wetlands
6. The wetlands would not require maintenance

This small wetland was built on higher ground in only one-half day near a tributary to Bear Creek on the Eldorado National Forest in 2014.

The Forest Service is interested in establishing naturally appearing and functioning wetlands to benefit the California red-legged frog and other species. Returning wetlands to the landscape would also reduce erosion, clean run-off, and control flooding. Wetlands would provide nesting habitat for waterfowl and shorebirds, stopover habitat for migratory birds, breeding and foraging habitat frogs and toads, foraging habitat and water for bats, breeding and foraging habitat for aquatic insects, and drinking water for many other species of wildlife. The project would improve habitat for the western pond turtle, and western toad. Hunters would be thrilled to see how deer, black bear, and Wild Turkey make great use of constructed wetlands.

The wetlands would be built so that most dry in the fall season. This way they would not support bullfrogs or fish. The wetlands would be built to contain water for varying lengths of time, so that in wet or dry years, at least one of the wetlands would provide conditions suitable for successful breeding of California red-legged frogs. The wetlands are likely to benefit the California red-legged frog, which can successfully breed in wetlands that contain water

seasonally. These seasonal wetlands are called ephemeral wetlands, or vernal ponds, and are some of the rarest habitats in California.

The California red-legged frog uses wetlands of all size for breeding. This small wetland was built in a tree canopy gap near Bear Creek on the Eldorado National Forest in 2014.

The wetlands to be built would be resistant to the detrimental effects of wildfire. Tremendous amounts of erosion occurs after a wildfire. The soil washing off the mountains following a wildfire is responsible for completely filling wetlands located in drainages and riparian areas. The wetlands to be built for this project are located on higher ground, not in drainages or riparian areas. These wetlands would not fill with soil after a wildfire.

Project Objectives

Implementing the California Red-legged Frog Habitat Expansion Project would help meet these objectives:

1. Increase breeding habitat for the California red-legged frog.
2. Increase habitat for a diversity of native animals and plants.
3. Establish ephemeral wetlands (vernal ponds)
4. Establish wetlands on the landscape that would function in times of drought
5. Increase opportunities to view and hunt wildlife
6. Clean runoff
7. Establish naturally appearing and functioning wetlands that require little, if any maintenance

Proposed Action

The Forest Service plans to establish 18-naturally appearing and functioning wetlands on National Forest System land near Michigan Bluff in El Dorado County (Figure 1). The wetlands would contain shallow water and be designed to provide breeding habitat for the California red-legged frog, and for a diversity of animal and plant species. The wetlands would be built using the techniques described in the book written by Thomas R. Biebighauser *Wetland Restoration*

and Construction – A Technical Guide.[4] The wetlands would appear natural, and require little, if any maintenance.

The wetlands would be built to contain water for varying lengths of time. Techniques would be used to allow the wetlands to fill with water in times of drought, with small watersheds. Wetlands would be built of various depths so that at least one wetland in an area would have a suitable hydro-period for California red-legged frog egg and larvae development, whether precipitation is above or below average for the year.

This wetland constructed on the Eldorado National Forest in 2014 is supplied with groundwater.

The slopes surrounding the wetlands would be made gradual. No dams, diversions, pumps, or pipes would be used. The wetlands would be supplied naturally with rainwater, and would fill following heavy rain events. Construction of the wetlands would not damage existing trails, roads, or improvements. The wetlands would not flood roads, trails, buildings, lawns, or gardens, and would require no maintenance. The shrubs and trees removed to build the wetlands would be placed in the wetlands to provide habitat for the California red-legged frog, and to prevent motor vehicles from damaging the sites. Techniques described in the book *Restoration of Forests, Grasslands, and Wetlands Damaged by Off-Highway Vehicles* would be used to manage motor vehicles use near the wetlands.[5]

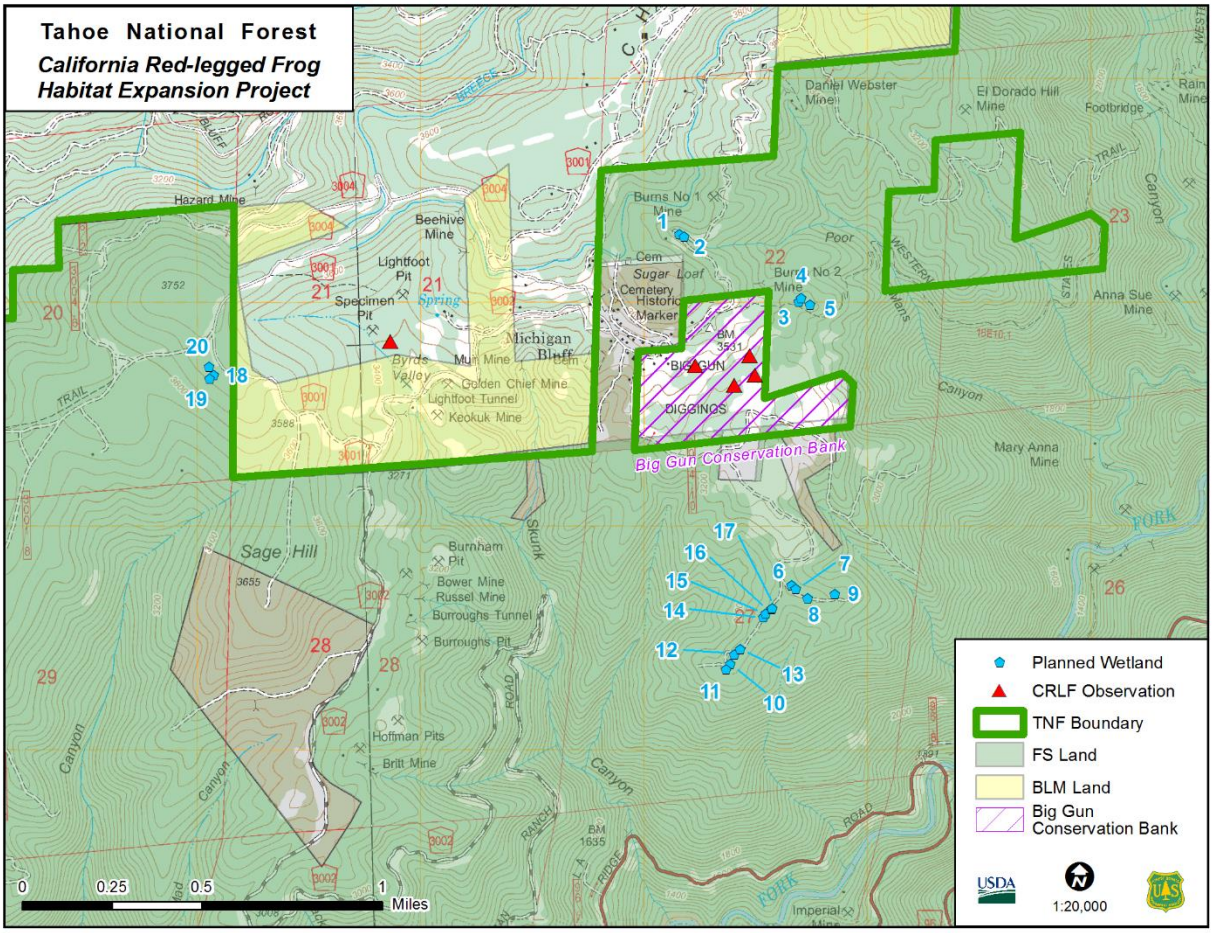
The wetlands would be built with heavy equipment, and using hand labor. Roads would not be built to access the wetland construction sites. The heavy equipment would be "walked" carefully on dirt roads, and through the woods between trees and over and around shrubs to each wetland

[4] Biebighauser, Thomas R., 2011. Wetland Restoration and Construction – A Technical Guide. The Wetland Trust, New York, 186pp.

[5] Eubanks, Ellen and Thomas Biebighauser. September 2014. Restoration of Forests, Grasslands, and Wetlands Damaged by Off-Highway Vehicles. 238 pages. USDA Forest Service. National Technology & Development Program, San Dimas, California. U.S. Government Printing Office: 2015-576-483/24032 Region No. 10.

construction site. Shrubs and small trees may be run over if needed for access, but not removed. Many of these trees and shrubs can be expected to spring back and continue to grow.

Figure 1. Location of the Tahoe National Forest California Red-legged Frog Habitat Expansion Project.



The heavy equipment would generally not disturb the ground while accessing the wetland areas. It would be difficult to see where the heavy equipment has traveled after the project is completed.

Heavy equipment would be cleaned prior to construction to avoid introducing non-native plants. The heavy equipment and operators would remove any nonnative invasive plants from the planned wetland construction site. These plants would be buried, and their carbon sequestered.

The heavy equipment and operator would remove trees and shrubs from the area where the wetland would be built and place them outside of the perimeter marked by plastic ribbons for temporary storage. This organic material would later be placed in and around the completed wetlands to provide habitat for the California red-legged frog and other species.

The heavy equipment and operator would shape a shallow basin for each wetland. The wetland would be made deepest in the center, and have gradual slopes. The wetlands would be shaped to appear natural, with no straight lines or steep banks.

The heavy equipment would be used to save any clumps of desirable plants for transplanting in and around the completed wetlands. These plants would be removed and replanted in stages as each wetland is built.

Topsoil and a portion of the mineral soil removed to build the wetland would be saved in temporary piles and later spread in and around the finished wetland. The topsoil would not be compacted, and would be spread using the rough and loosen technique.

A wide spillway would be created for each wetland and placed over a gradual slope to prevent erosion. Water would flow over the spillways in a sheet-like pattern. The spillways may become a wet-meadow wetlands. It would not be necessary to place rock on the spillways.

Native plant species such as sedges, rushes, and wildflowers may be planted and sown in and around the wetlands following construction.

California red-legged frog

The wetlands would be built specifically to provide breeding habitat for the California red-legged frog. What has been learned from observing California red-legged frog use at Lake of the Cross on the Eldorado National Forest, the Big Gun Conservation Bank on the Tahoe National Forest, and similar projects completed on the Plumas National Forest would be used to guide the construction of these wetlands.

The following features would be added to the wetlands to provide breeding habitat for the California red-legged frog:

1. Shallow water areas in full sunlight.
2. Piles and ridges of topsoil and mineral soil, loosely spread and not compacted. Some of these piles would be placed under water, others partially in water, and some out of water.
3. Piles of organic material in and out of the water. The organics would include root masses, shrubs, branches, leaves, and forest floor duff.
4. Large diameter logs and branches, broken off with fractured trunks.
5. Piles of rock of various sizes and with varying spaces between the rocks. The rock piles would be placed both in and out of the water.
6. Sedges and rushes would be planted or seeded in and around the new wetlands to provide egg attachment sites and hiding cover.

The author has found that it does not work to place these features on an engineering plan and expect the contractor to add them to a wetland under construction. A person who knows about the California red-legged frog and its habitat requirements should be on site at all times working with the heavy equipment operators to create the wetlands and add the features. This person must tactfully work with the heavy equipment operators to shape the habitat while construction is

underway. Tom Biebighauser is available to be onsite working with the heavy equipment operators to build these wetlands for the California red-legged frog.

The wetlands are expected to be used by the California red-legged frog because they are being built in close proximity to where the species is found. The species may move one mile, and occasionally up to 2 miles, from permanent or seasonal aquatic habitats without apparent regard to topography, vegetation type, or riparian corridors.[6] The wetlands would all be built within 1-mile of the Big Gun Conservation Bank, which is occupied by the California red-legged frog. The California red-legged frog rapidly colonized the new wetlands built on BLM land near Michigan Bluff.

Conditions for the development of California red-legged frog larvae in the new wetlands should be ideal for development because the wetlands would be supplied with surface water, not groundwater. Rainfall and runoff would help keep the temperature of water in these wetlands warm for egg and larvae development. The northern red-legged frog, a related species, is most successful breeding in surface water wetlands, compared to groundwater wetlands, and this could be true for the California red-legged frog.

Clay and compaction

The surface water-compacted clay liner technique, as described by Biebighauser[7], would be used to build Wetlands #18-20. This involves reshaping and compacting soils onsite that are high in clay, and then placing topsoil and organics that are not compacted, and woody debris, in the finished wetlands.

The wetlands would be built shallow so they would dry in late summer or fall, depending on rainfall for the year. The slopes surrounding the wetlands would be made gradual. No dams would be built. The wetlands would be supplied naturally with rainwater, and would fill following heavy rains.

Shrubs and small trees removed to build the wetlands would be placed in the wetlands, and between the wetlands and the road to prevent motor vehicles from damaging the wetlands. Logs would be placed in and around the completed wetlands to provide habitat, and to control motor vehicle access to the wetlands.

The main construction steps that would be taken to build Wetlands #18-20 include:

1. Marking the perimeter of the planned wetlands using plastic ribbons in advance of construction.
2. Contracting, by the hour, experienced professional heavy equipment operators to build the wetlands. The work would be done when soil moisture is at the optimum for construction.

[6] USDI U.S. Fish and Wildlife Service. 2002b. Recovery Plan for the California Red-legged Frog (Rana aurora draytonii). U.S. Fish and Wildlife Service, Portland, Oregon. Viii + 173 pp.
[7]Biebighauser, Thomas R., 2011. Wetland Restoration and Construction – A Technical Guide. The Wetland Trust, New York, 186pp.

3. Ensuring that heavy equipment is cleaned prior to construction to avoid introducing non-native plants.
4. Directing heavy equipment operators as they build the wetlands. Tom Biebighauser would be working onsite in this capacity. A laser level would be used to monitor elevations during construction and a penetrometer would be used to monitor soil compaction.
5. Ensuring that no roads are built to access the wetland construction sites. The heavy equipment would be "walked" carefully to each work site. It would be difficult to see where the heavy equipment has traveled after the projects are completed.
6. Removing any desirable plants growing within the planned wetland areas using heavy equipment and saving these plants for later replanting.
7. Removing small trees and shrubs from the planned wetland areas and placing them outside of the planned wetland area for temporary storage. These organic materials would be placed back in the completed wetlands to improve habitat for the California red-legged frog and other species.
8. Removing topsoil from within the planned wetland area. The topsoil would be saved for spreading back in the finished wetland.
9. Digging basins for the wetlands that are deepest in the center, with gradual slopes. Excess soil removed to form the basins would be placed outside of the planned wetland areas. This soil would be spread out in a fan like pattern, away from the basins being dug.
10. Digging the basins at least 18-inches deeper than the planned final depth of the wetland to make room for compacted clay. Soil that is high in clay, with suitable moisture content, would be saved for later spreading and compacting in each basin.
11. Constructing a groundwater dam along the lower edge of each basin. A trench would be dug for the groundwater dam that extends down through roots, permeable layers of soil, and possible buried drainage structures. The groundwater dam would be based on bedrock, or a compacted layer of clay.
12. Placing soil that is high in clay in the trench and compacting it to form a groundwater dam.
13. Compacting the excavated basin to 300lbs/inch^2 before layers of clay are added.
14. Spreading layers of soil that are high in clay, with suitable moisture content, in the basin. Each layer would be compacted to 300lbs/inch^2, until 24-inches of compacted clay is obtained.
15. Shaping the basins to appear natural, with no straight lines or steep banks.
16. Spreading topsoil in the wetland basin, over the compacted clay. The topsoil would not be compacted, and would be spread using the rough and loosen technique.
17. Spreading and shaping the topsoil to form mounds, ridges, tufts, and peninsulas. These features would not be compacted.
18. Spreading excess soil in a way to form wet-meadow wetlands surrounding the ephemeral wetlands being built. The soil would be spread to create shallow scrapes and low elevation mounds and ridges so that water would pool, and not runoff. The rough and loosen technique would be used to promote pant survival and growth, and to provide burrowing sites for wildlife species.
19. Creating a wide spillway over a gradual slope to prevent erosion, and to make wet-meadow wetlands. Water would flow over the spillway in a sheet-like pattern, so it

would not be necessary to embed rock on the spillway. The existing low edge of the planned wetland would generally be used as a natural spillway. Soil, rocks, or logs would not be placed in the spillway.

20. Planting desirable plants saved earlier, in and around the wetland following construction.
21. Large woody debris and shrubs would be placed in and around the new wetlands to provide habitat for the California red-legged frog, for birds, and invertebrates. Woody debris would be placed to prevent motor vehicles from damaging the wetland.
22. Native plant species such as sedges, rushes, and wildflowers may be sown or planted in and around the wetlands following construction. Wheat would be sown for erosion control, and to reduce colonization by nonnative plants. Straw would be spread on exposed soil to prevent erosion, and to reduce possible colonization by nonnative plants.

Aquatic safe liners

Liners are needed to build designed wetlands #1-17 for this project. The texture of soil on these sites is a mixture of sand, silt, gravel, and rock. The clay content of the soil is too low to shape and compact so it would hold water. This conclusion is based on the authors' experiences building over 2,500 wetlands, and examining hundreds of wetlands other people have built that have not held water as planned.

Soil high in clay is not present nearby, so it cannot be hauled by truck to make wetlands #1-17. Even if clay were present, roads would have to be built to transport the clay to the worksites. In addition, transporting clay to build a wetland generally costs ten times more than using a liner to build a wetland. Groundwater cannot be used to fill the wetlands, as the elevation of the water table is far below the surface at these sites.

People often suggest using bentonite to build wetlands on permeable soils. Their suggestion is generally based on hearsay and tradition, not from experience building wetlands. *The use of bentonite to build or repair wetlands is not recommended.* The author has had no success over 34-years using bentonite to build or repair leaking wetlands and wetlands. He has examined hundreds of sites where other people have tried to repair leaky wetlands using bentonite, and never with success. Bentonite is very expensive, and almost impossible to mix with water and compact on the large scale needed for wetland construction. Tom Biebighauser recently examined a failed wetland near Amado, Arizona where an individual spent over $30,000 on bentonite in an attempt to repair a leaky wetland, unfortunately, without success.

A major problem associated with using bentonite is how it causes and maintains high turbidity in the water. The author has spread bentonite in wetlands and has observed how the water becomes gray with suspended particles. It is likely that the turbid water is toxic to fish and aquatic animals.

Aquatic-safe liners would be used to build wetlands #1-17. The liners would be made from PVC, 30-mil or thicker, or EPDM, 45-mil or thicker, certified fish-grade & aquatic safe, one piece and factory seamed for each wetland, according to measurements listed on each Wetland Design Form. The majorities of liners available are treated with fungicides and algaecides, and if used, would kill aquatic life in the new wetlands. This is why it is critical that only liners certified as

aquatic-safe be purchased for this project. Tom Biebighauser has used aquatic-safe liners with success to build over 300-wetlands on permeable soils across North America.

Geo-textile fabric would be used to protect the top and bottom of each liner. Thick 16oz geo-textile pads would be placed over and under each liner because of the sharp-edged rocks present in the soil. The geo-textile pads would measure the same size as the liners, and also be factory seamed. *The importance of ordering one-piece, factory seamed materials cannot be over emphasized.* These materials are expensive and almost impossible to join outdoors. It is critical that the liners and geo-textile pads be ordered from the factory in one piece, and in matching sizes.

It is much less expensive to use geo-textile to protect the liner compared to removing the rock and placing sand under and over the liner, or ordering a thicker liner. The liners and matching geo-textile pads should be ordered from:

Fabseal Industrial Liners, Inc.
42404 Moccasin Trail
Shawnee, OK 74804
(800) 874-0166
http://www.fabseal.com

Here a liner, sandwiched between layers of geo-textile pads, is ready for covering with soil by the excavator. It is critical that the liner and geo-textile pads be ordered one piece, and factory seamed.

The author contacted Fab-Seal Industrial Liners, Inc. for a quote to supply the liners and geo-textile pads needed to build these wetlands. This estimate was used to prepare the budget for this project. Many organizations across the United States and Canada have taken bids on liners and geo-textile pads, and have found that Fab-Seal consistently offers the best quality and lowest

price. When ordering, please allow at least three-weeks for manufacture and delivery of the liners and geo-textile pads.

Please note that each liner and matching set of geo-textile pads would be placed on a wood pallet and delivered by a large semi-truck. One must let Fab-Seal know in advance if a large semi-truck cannot access the delivery location when ordering. Fab-Seal would then request that delivery be made using a smaller truck, with a lift gate.

Each liner and set of geo-textile pads can weigh up to 1,300lbs, so it's best to use a fork-lift to unload the pallets from the truck. Each liner comes wrapped in geo-textile, and is sandwiched between two geo-textile pads for protection. The entire package is bound by metal straps. The straps may be cut with a metal snips, and each layer of material unloaded by hand, with at least 4-people helping, if a fork-lift is not available.

Each liner and pads should be kept wrapped on the pallet and stored indoors, or in a shelter where animals cannot cause damage. Mice and squirrels can be expected to build their homes in the liners and geo-textile pads when stored outdoors. Once these mammals move in to the package, they quickly chew holes in the materials. Fortunately, this has not been a problem after the liners and geo-textile pads are installed.

A 4WD pickup should be used to transport one liner and matching set of geo-textile pads, on one pallet, to the worksite each day. A forklift should be used to load the pickup truck, and the materials would then be unloaded by hand adjacent to the depression being dug for the wetland that day.

A crew of up to 30-individuals may be utilized to install each liner and set of geo-textile pads. A minimum of 5-laboreres are needed to install a 40 x 40-foot liner, with 20 or more needed to install a 50 x 50-foot liner. There is a considerable amount of hand raking, shoveling, lifting, and pulling needed to build a wetland using a liner. This work is often accomplished by workshop participants, agency personnel, and by volunteers. The agency is asked to organize the number of people needed to build the wetland each day. Tom Biebighauser is available to direct construction, and would work with personnel to place the liners and geo-textile pads.

It is essential that a laser level and survey rod be used to monitor elevations for installing each liner and geo-textile pads. A 100-foot tape measure, along with wire flags are also needed for marking and dry-fitting the liners and geo-textile pads

The liners and geo-textile pads should be anchored by driving spikes along the top edge before covering with soil. This prevents the materials from shifting when being covered with soil. The corners and excess liner and geo-textile fabric should be trimmed before covering with soil. The materials should not be anchored by rolling them over and placing them in a narrow trench.

It takes careful measuring and takes time to prepare the wetland depression for placement of the liner and geo-textile pads. A person familiar with wetland construction and survey techniques must be onsite at all times monitoring and assisting with the construction of the wetland.

The landscape spikes used to anchor the liners can be twisted or smooth. They must be 12-inches long. Landscape spikes are available from major hardware stores such as Lowes and the Home Depot. Shorter nails will not work. One washer is needed for each landscape spike. Please make sure the washers fit over the spikes before purchasing. Purchase small diameter washers, not the more expensive, larger diameter washers.

The excavator is used to place soil over the liner and geo-textile pads. Heavy equipment must be kept off of the liner at all times to protect it from damage.

Bentonite liners

Bentofix® Thermal Lock GeoSynthetic Clay Liners and Bentomat® Geosynthetic Clay Liners combine geo-textile outer layers and a core of high swelling powdered sodium bentonite clay, or high-density polyethylene (HDPE) geomembrane with a spun-bonded geotextile and powdered sodium bentonite clay to form a *low-permeable* barrier to water. Please note that the manufacture does not claim the material is impermeable to water, or aquatic-safe.

The bentonite liners are sold in rolls that are 17-feet 8-inches wide by 210-feet long. One roll can weigh 2,650lbs. A roll can be expected to cost $5,000.00, plus shipping. The liner is placed in a constructed basin in strips, with overlapping edges. The material is very difficult to unload and install. The manufacture does not recommend using the material for wetlands containing water more than 12-inches deep, due to leakage along the seams. The material is also not recommended for wetlands that may dry, such as ephemeral wetlands. The material is not labeled as Aquatic-Safe or Fish-Grade.

The author performed a biological toxicity test of Bentomat® Geosynthetic Clay Liner material by filling two, 5-gallon buckets with water from a wetland (built from soils high in natural clay) on the author's farm. Green frog tadpoles (6), and dragonfly larvae (4) were placed in each bucket. The animals had been captured in the same wetland where water was removed to fill the buckets. A piece of Bentomat® Geosynthetic Clay Liner material, measuring 4 x 4-inches, was placed in one of the buckets. The buckets were placed in the shade, near the edge of the wetland.

The contents of the buckets were examined 24 and 48-hours after preparation. One-half of the green frog larvae died in the bucket containing the Bentomat® Geosynthetic Clay Liner material

after 24-hours. All of the green frog larvae died in the bucket containing the liner material within 48-hours. Two of the dragonfly larvae died in the bucket containing the liner material after 24-hours, a third dragonfly larva died the next day. None of the green frog larvae or dragonfly larvae died in the bucket that did not contain liner material after 48-hours.

It should be assumed that any liner is toxic to fish and aquatic-life unless it is specifically labeled and tested to be fish grade and aquatic-safe. The author has found that if a liner is fish-grade, then the liner is advertised as being fish-grade and safe for aquatic organisms. *One should assume that liners contain toxins if they are not specifically labeled as fish grade, or aquatic-safe. This information comes from the Engineers that work at liner companies.* The author has observed wetlands where non-fish-grade/aquatic safe liners were used in their construction at schools. These wetlands did not support fish or aquatic life.

The author recommends that liner materials made with Bentonite not be used to build wetlands that would be used by animals. It is very possible the bentonite liner material is manufactured for landfills and industrial waste containment, and would poison amphibians and invertebrates.

This photo shows a roll of bentonite liner material being stored in a garage. It took 15-people to unroll the material 4-feet. The roll is lifted and moved using a long pipe, chain, and backhoe

A 4-inch square piece of bentonite liner material was placed in the bucket on the left (notice the dead green frog larvae floating on the surface after 24-hours). The bucket on the right does not contain the bentonite liner material

The author recommends using fish-grade and aquatic safe, one-piece, factory-seamed EPDM liners to build wetlands instead of bentonite liners for these reasons:

1. Lower unit purchase price
2. Lower shipping cost
3. One is able to move and install the liner by hand
4. Installation is faster, requires fewer pieces of heavy equipment, and no specialized attachments or long pipe
5. Lower cost installation
6. The materials are certified fish-grade and aquatic safe
7. The materials would not leak if the water is deeper than 12-inches
8. The materials would not leak if the wetland dries
9. Wetlands built using the materials should last 100's of years

Large & Small Woody Debris

Large logs, branches, and root masses would be placed in the wetlands to improve habitat for the California red-legged frog, invertebrates, and a diversity of plants and animals. Branches of various diameters and lengths would be placed in the wetlands to provide egg attachment sites for amphibians, and improved habitat for invertebrates.

Logs would be placed in the wetlands to provide loafing sites for waterfowl.

Planting

The wetlands and soil surrounding the wetland does not have to be planted for the projects to be successful. The wetlands would hold water and provide habitat for the California red-legged frog even if planting is not done. Aquatic plants can be expected to naturally colonize the soil in and around the wetlands over time without seeding and planting.

However, seeding and planting the soil in and around the new wetlands with native species is recommended as a way of reducing the possibility of nonnative plants colonizing the sites, and to increase animal and plant diversity. Any compacted soils surrounding the new wetlands would be loosened as part of wetland construction, providing ideal conditions for plant establishment and survival. The seeds from a diversity of sedges and rushes may be sown in the wetland basins to provide egg attachment sites and hiding cover for the California red-legged frog.

It is highly recommended that exposed soils surrounding each wetland be seeded to wheat, and mulched using straw. Wheat is inexpensive, germinates within 3-days after rain, and grows and dies in one season. Wheat provides excellent erosion control, and helps make the new project look attractive to forest visitors. Wheat is not invasive or persistent, and has been used by Tom Biebighauser and botanists as a nurse crop for establishing native plants on thousands of wetland projects across North America. Wheat is different from rye. Rye has allopathic properties and can be persistent, wheat does not.

Straw should be spread by hand on exposed soil above the water level in the new wetlands to control erosion, and to suppress nonnative plants. The straw can be from wheat, oats, barley, or rice. Straw rarely contains weeds or nonnative plant species. Hay should not be used. Hay is cut grass that often contains weeds and nonnative plants. However, hay that is cut from native species of grasses provides ideal mulch and should be used where it’s available. Native wildflowers may also be seeded on exposed soil in addition to wheat as a way to benefit pollinators, including the monarch butterfly.

Each wetland should be seeded with wheat, native species of plants, and mulched using straw the same day the wetland is completed. These supplies should be stored on site so they are available to use as soon as the wetland is built.

Mosquitoes

The wetlands can be expected to lower mosquito populations. The dragonfly larvae, damselfly larvae, water boatman, water striders, frogs, toads, and salamanders living in the new wetlands would control mosquito eggs and larvae. Swallows, bats, and adult dragonflies flying near the wetlands would consume adult mosquitos. The wetlands can be expected to become population “sinks” for mosquitoes.

Wheat and native plants are sown, and straw is spread for mulch the same day each wetland is built to prevent erosion, and reduce colonization by nonnative plants.

Cattails & Reed Canary Grass Control

Actions would be taken to prevent cattails and reed canary grass from dominating the new wetlands. Techniques would be used to prevent any one plant from taking over the wetland sites.

Here's a summary steps that would be taken to prevent only a few species of plants from dominating the wetlands:

1. The excavator would be used to remove nonnative plants.
2. Nonnative plants would be buried so they do not spread.
3. The excavator would be used to remove topsoil from within each marked area.
4. The bottom of the finished wetland would contain uneven areas of topsoil, and mineral soil.
5. The elevations within the wetland would be varied to include deep and shallow zones.
6. Ridges, mounds, tufts, and scrapes would be created within and surrounding each wetland.
7. Exposed soils would be seeded to a diversity of sedges, rushes, and wheat, the same day the wetland is completed.
8. Exposed soils that are above the water level would be mulched using straw, not hay.

The wetlands would be monitored for cattail colonization following restoration. Young cattails growing in the new wetlands should be removed for 3-years following construction. This would facilitate a diversity of sedges and rushes colonizing the new habitat.

Heavy Equipment Requirements

Heavy equipment with skilled operators should be used to build the wetlands. A Service Contract is recommended for hiring heavy equipment and operators to do the work. Under a Service Contract, the machines and operators are hired by the hour to build the wetlands. The award of the contract is based on a combination of factors that include: ability to provide the required heavy equipment, performance operating heavy equipment, experience restoring wetlands, and price. The heavy equipment should be the size and type needed for restoring wetlands. Tom Biebighauser is available to help manage this project, which can include preparing a RFP (Request for Price) Service contract package.

Wetlands built using the compacted clay liner technique (Wetlands #18-20)

Recommendations for heavy equipment are based on experiences restoring similar wetlands across North America. Three types of heavy equipment are recommended to build the wetlands, a dozer, excavator, and wheel loader. All pieces of heavy equipment should be onsite working at the same time. Each should be operated by an experienced individual who is interested in restoring wetlands for wildlife.

Dozer
CAT D5 (equivalent or larger)
95HP or greater
20,000lbs or greater
6 or 7-way blade

Job: Removing and spreading topsoil, removing and spreading clay, shaping ridges and mounds.

Excavator
John Deere 210G
Minimum 42-inch wide bucket (1.0yd^3) or larger
159HP or greater
52,09lbs minimum operating weight
Working thumb attachment (important for moving logs, woody debris, and rocks)
No more than 10-years old (less likely to leak oil and breakdown)

Job: Removing and replanting desired species, making groundwater dams, digging wetland depressions, loosening compacted soils, placing large and small woody debris.

Wheel loader or equivalent compactor
CAT 924G (or equivalent)
Bucket capacity = 2.5 cubic yards or greater
140HP or greater
28,000lbs or greater
4WD

Job: Compacting clay soil and moving soil greater distances.

Wetlands built using liners (Wetlands #1-17)

An excavator with operator would be needed to build the wetlands. The excavator may be accompanied by a skid-steer and operator to speed progress. The excavator should meet the following specifications:

John Deere 210G
Minimum 42-inch wide bucket (1.0yd^3) or larger
159HP or greater
52,09lbs minimum operating weight
Working thumb attachment (important for moving logs, woody debris, and rocks)
No more than 10-years old (less likely to leak oil and breakdown)

An excavator and a skid steer working together is an effective way of building wetlands that require the use of liners

Here are some advantages of using a 200-Series excavator for building wetlands, instead of using a smaller machine known as a *mini-excavator*:

1. The excavator can stay in one place and reach a large portion of the work area. This saves destroying surrounding vegetation because the machine does not have to move over and around the entire work area to move soil.
2. The excavator does not have to pick up and move the soil a number of times, greatly speeding progress. A small excavator must pick up and move the soil a number of times across a work area. This take a very long time and costs more money.
3. The excavator has a long enough reach to place soil over the entire liner, greatly reducing the need for hand shoveling and raking.
4. The unit cost of moving soil is less for using a large excavator compared to a small excavator.
5. The project is completed faster with fewer trips to and from the jobsite.

Long-reach Excavators are available for hire in some regions. These excavators are made with a very long boom, and are often used for cleaning deep ditches. The long reach excavator is not as efficient as a standard reach excavator, as it takes much longer to move the same quantity of soil.

Buried Utilities

From a safety perspective, a check for buried utilities prior to construction of the wetlands should be conducted. All buried utilities that are in the area must be marked so they can be avoided. The wetlands cannot be built unless this critical step is completed. The wetlands should not be built over buried electric, gas, phone lines, water lines, or drain-lines.

Project Scheduling

Tom Biebighauser is available to assist with the implementation of the California Red-legged Frog Habitat Expansion Project. Tom would work with heavy equipment operators and help train agency personnel how to design and complete wetland projects.

Budget

An estimated budget was prepared for completing the California Red-legged Frog Habitat Expansion Project. The prices listed are based on completing similar wetland projects. These prices may change depending on when and how the project is completed.

Estimated budget for the California Red-legged Frog Habitat Expansion Project, Wetlands #3-17 requiring the use of liners and geo-textile pads.

Wetland Number	Liner Length (ft)	Liner Width (ft)	Liner Area (ft^2)	Excavator Hours	Excavator Cost	Liner & geotextile cost	# of 12-inch landscape spikes & washers	Cost 12-inch landscape spikes & washers	Construction Supervison	Wheat (50lb bags)	Wheat cost	Straw bales	Straw cost	Misc. Supplies	Total Cost
1	Conflict with other resources-will not be built														
2	Conflict with other resources-will not be built														
3	50	50	2500	13.0	$2,210	$4,065	105	$110	$1,690	3	$78	23	$136	$50	$8,340
4	50	50	2500	13.0	$2,210	$4,065	105	$110	$1,690	3	$78	23	$136	$50	$8,340
5	40	40	1600	8.0	$1,360	$2,654	84	$88	$1,040	2	$50	15	$87	$32	$5,312
6	40	40	1600	8.0	$1,360	$2,654	84	$88	$1,040	2	$50	15	$87	$32	$5,312
7	40	40	1600	8.0	$1,360	$2,654	84	$88	$1,040	2	$50	15	$87	$32	$5,312
8	40	40	1600	8.0	$1,360	$2,654	84	$88	$1,040	2	$50	15	$87	$32	$5,312
9	50	50	2500	13.0	$2,210	$4,065	105	$110	$1,690	3	$78	23	$136	$50	$8,340
10	40	40	1600	8.0	$1,360	$2,654	84	$88	$1,040	2	$50	15	$87	$32	$5,312
11	38	38	1444	8.0	$1,364	$2,400	80	$84	$1,043	2	$45	14	$87	$29	$5,051
12	30	30	900	6.0	$1,020	$1,560	63	$66	$780	1	$28	8	$49	$18	$3,521
13	30	30	900	6.0	$1,020	$1,560	63	$66	$780	1	$28	8	$49	$18	$3,521
14	40	40	1600	8.0	$1,360	$2,654	84	$88	$1,040	2	$50	15	$87	$32	$5,312
15	40	30	1200	7.0	$1,190	$1,998	84	$88	$910	2	$38	11	$65	$24	$4,313
16	40	30	1200	7.0	$1,190	$1,998	84	$88	$910	2	$38	11	$65	$24	$4,313
17	40	30	1200	7.0	$1,190	$1,998	84	$88	$910	2	$38	11	$65	$24	$4,313
Total				128.0	$21,764	$39,634	1275	$1,339	$16,643	30	$748	219	$1,314	$479	$81,921

Estimated budget for the California Red-legged Frog Habitat Expansion Project, Wetlands #18-20, requiring the use of the Surface water-compacted clay liner technique for construction.

Wetland Number	Area (ft^2)	Excavator Hours	Excavator Cost	Dozer Hours	Dozer Cost	Wheel-loader or Compactor Hours	Wheel-loader or Compactor Cost	Construction Supervison	Wheat (50lb bags)	Wheat cost	Straw bales	Straw cost	Total Cost
18	18000	18.0	$2,700	18	$2,700	18.0	$2,700	$2,340.00	5	$113	26	$154	$10,707
19	14520	14.5	$2,178	15	$2,178	14.5	$2,178	$1,887.60	4	$91	21	$124	$8,637
20	16000	16.0	$2,400	16	$2,400	16.0	$2,400	$2,080.00	4	$100	23	$137	$9,517
Total	48520	48.5	$7,278	49	$7,278	48.5	$7,278	$6,307.60	12	$303	69	$416	$28,861

Total budget for building Wetlands #3-20 = $110,782

Wetland Photos

Photographs showing wetlands and streams built on public and private lands are available for viewing at www.wetlandrestorationandtraining.com . Detailed information describing how wetlands were drained and streams were moved can found in the book *Wetland Drainage, Restoration, and Repair* by Thomas R. Biebighauser[8]. Instructions concerning how wetlands may be restored are available in his book: *Wetland Restoration and Construction – A Technical Guide.*

Training

The construction of the wetlands may be accomplished in conjunction with Hands-on Wetland Restoration Workshops. Tom Biebighauser would work in partnership with the Forest Service and Save The Frogs! to instruct training where participants learn about wetlands and how to restore them by becoming involved in the actual establishment and planting of wetlands. He has taught a number of these training sessions with success across California. Please contact Tom for a link to a Dropbox Folder containing a PowerPoint Presentation, Agendas, and Announcements for hosting a Hands-on Wetland Restoration Workshop in your community.

[8] Thomas R. Biebighauser, Wetland Drainage, Restoration, and Repair, Lexington, KY, University Press of Kentucky, 2007.

A wetland workshop was held in 2014 where participants helped with the construction of 3-wetlands on the Eldorado National Forest.

Summary

Eighteen-wetlands may be built on National Forest System land near Michigan Bluff on the Tahoe National Forest to benefit the California red-legged frog and other wildlife species. The wetlands would be built to appear and function like natural wetlands, requiring little if any maintenance. Features would be added to the wetlands to improve habitat for the California red-legged frog, western pond turtle, and western toad. The wetlands may be built at a low cost, and would greatly improve wildlife viewing opportunities, conserve water, and clean runoff. The wetlands could be built in conjunction with training sessions that would help and encourage others to consider wetland restoration.

Recommendations

1. Please review this report to help with the planning and implementation of the project.
2. Work to obtain approvals needed to complete the California Red-legged Frog Habitat Expansion Project.
3. Request funding for the California Red-legged Frog Habitat Expansion Project.
4. Identify skilled heavy equipment operators to help build the wetlands.
5. Schedule Tom Biebighauser to supervise the construction of the wetlands.
6. Order supplies and contract heavy equipment needed in advance of construction.
7. Ask Tom Biebighauser if you have any questions.

About the designer

Tom Biebighauser has restored over 2,500 wetlands and streams across Canada, in 26-States, New Zealand, Puerto Rico, and Taiwan since 1979. He retired in 2013 after working 34-years for the USDA Forest Service as a Wildlife Biologist, where he started wetland and stream restoration programs across the United States. Tom has served as an instructor for the British Columbia Wildlife Federation Wetlands Institute for 16-years, restoring over 250-wetlands and streams across Alberta and British Columbia since 2003. Having built over 1,400-dams, he has since decommissioned over 300 -dams. Tom learned about drainage and irrigation from contractors who spent their lives destroying wetlands. Tom has developed highly effective and low-cost techniques for building wetlands and streams for rare species across North America. He builds habitats that require little, if any maintenance, and do not involve the use of diversions, dams, dikes, pipes, or pumps. Tom has written 4-books about wetland restoration, and instructs online college and field courses on the topic. He received the United States National Wetlands Award for Conservation and Restoration in 2015.

Prepared by:

Thomas R. Biebighauser
Wildlife Biologist and Wetland Ecologist
Wetland Restoration and Training LLC
3415 Sugar Loaf Mountain Road
Morehead, KY 40351 USA

Phone: (606) 784-6175
Cell: (606)356-4569
www.wetlandrestorationandtraining.com
tombiebighauser@gmail.com