Restoration of Drakesbad Meadow, Lassen Volcanic National Park, California

David J. Cooper, Ph.D.

Department of Earth Resources, Colorado State University

Fort Collins, CO 80523, DavidC@cnr.colostate.edu

INTRODUCTION

Wetlands that have a water table near the soil surface for most of the year typically have very slow rates of organic matter (dead leaves and roots) decomposition, due to low soil oxygen concentrations. Under these conditions net primary production may exceed organic matter decomposition, resulting in a positive carbon balance. The result is that organic matter accumulates in the soil. If these conditions persist on a time scale of thousands of years, and if the site is isolated from the erosion and deposition processes of streams, and has low sediment influx from hillslopes, an organic soil called peat can develop. Ecosystems with peat soils are termed peatlands, and peatlands fed primarily by ground water, are fens. Peat accumulation rates in western U.S. fens are on

111/160171

the order of 20 cm per thousand years, thus peat bodies more than 1 m thick represents a very long period of site stability and soil development.

Fens occur throughout the Rocky Mountains, and are reported for Colorado (Cooper 1990, 1996), Wyoming (Cooper and Andrus 1994), Montana (Lesica 1986, Chadde et al. 1997) and Idaho (Bursik and Henderson 1995), but there are very few reports of peatlands occurring in California, Oregon or Washington. The rarity of fens in the Sierra Nevada and Cascade Mountain ranges is likely due to the dry summer climate of these regions, and wetland water tables that decline during the summer result in increased organic matter decomposition rates. However, a few locations have perennial spring complexes creating saturated soils where fens have developed. Because fens are rare, they most likely support unique biodiversity elements and deserve the utmost in protection.

One fen, Drakesbad Meadow, is known to occur in Lassen Volcanic National Park, California. It was identified as a fen during the summer of 2000 because it has organic soils more than 40 cm thick. At approximately 90 acres in size, this spring-fed complex is the largest wetland in the park, yet it has been severely degraded by a system of drainage ditches. The ditches, which were dug prior to Park establishment in 1916, likely served to dry the site to allow hay cutting and livestock grazing. However, drainage ditches continue to remove water from fens long after their intended use is no longer appropriate, and Drakesbad Meadow has been maintained in a state of drought. We have observed that the fen soils in Drakesbad Meadow are dry during the summer, indicating that it is no longer functioning like a fen. Most likely the peat is oxidizing and degrading and disturbed fens often are invaded by exotic plants (Ziegenbein and Wagner, 2000).

The cool spring water that discharges into hydrologically intact fens maintains cool soil temperatures, providing stable habitats for plant, amphibian and invertebrate species that are either endemic or disjunct from the main ranges of their populations in boreal and subarctic zones of North America (Cooper 1996, Cooper and Sanderson 1998). Drakesbad Meadow likely supports unique biodiversity elements because of its large size, complexity, diversity of water sources (springs enter the fen from several of the surrounding mountains), and because it is likely one of only a small number of fens occurring in the southern Cascade Range. Gillet et al. (1995) indicate that wetlands contain the majority of plant species in the Lassen area. Thus, the restoration of this fen is of critical importance to the biological diversity and integrity of Lassen Volcanic National Park.

There are very few examples of fen restoration projects in the western U.S. Restoration of the Big Meadows fen in Rocky Mountain National Park, Colorado, which is similar in size to Drakesbad Meadow, involved plugging a large drainage ditch with metal sheets (Cooper et al. 1998). That project provided detailed analyses of the hydrologic regime of the ditched fen area before and after restoration, documenting the hydrologic success of the project. However, changes in the vegetation, or functioning of the fen, were not documented. A restoration project in a mined fen in South Park, Colorado addressed questions about how to restore the dominant peat-forming plants (Cooper and MacDonald 2000). But mined fens lack vegetation, and this situation is not comparable with Drakesbad Meadow.

The Drakesbad Meadow restoration project would undo the physical and hydrologic changes caused by the drainage ditches. The project goal is true restoration, meaning returning the site to its pre-existing condition. This includes restoring the site hydrologic regime, flora and vegetation, and peat accumulating processes, all of which are essential for recreating the environment in which the fen biota have persisted for thousands of years. The project will also restore a critical part of the hydrological, floristic and ecological diversity of Lassen Volcanic National Park.

METHODS AND APPROACH

The proposed restoration project would include a carefully designed and implemented monitoring program to determine the net benefits of the restoration, document what aspects of the restoration were achieved, and what additional actions (if any) might be necessary to ensure that the restoration is fully successful. The functioning of all ditches on site must be completely eliminated, and the floristic composition of the vegetation restored. The approach includes monitoring the conditions of the fen prior to restoration (summer of 2002), performing the restoration (fall of 2002), and monitoring the fen post-restoration (summer of 2003). It would be desirable to locate at least one pristine fen at a similar elevation in the southern Cascade Range to use as a reference site. The reference site would be used to set goals for the restoration project and quantify the desired hydrologic regime and vegetation. (The park will continue the vegetation monitoring for at least an additional 5 years beyond the end of this project to further quantify the response of the existing vegetation and the soil seed bank to the new hydrologic conditions.)

Fen restoration approach

The restoration would be accomplished by NPS staff in September 2002, using primarily hand tools. The ditches would be backfilled with material existing in spoil piles from the original ditch excavation. Where insufficient material is available for filling the ditch, metal sheets would be installed across the ditches at a spacing of no more than every 20 m. The goal of filling and blocking the ditch is to stop all flow of water in ditches. Prior to implementation, all ditches would be marked with flagging, and the location of spoil piles that could be used to backfill the ditch would be identified. Where backfill material is lacking, the number of metal sheets needed would be determined. Sheets would be constructed from relatively inexpensive sheet steel. The location where each sheet would be installed would be marked, numbered and the ditch width and depth carefully measured so that a sheet could be prepared in the exact size needed. Installation of the steel sheets must completely stop the flow of water, and the metal must extend below the bottom of the ditch and be tied into the native soils on the edge of the ditch by pre-cutting slots in the native soil with a saw. The sheets are then driven into place with rubber mallets. In critical locations it will be necessary to import soil to backfill around the sheets to make certain that water does not flow around them.

Hydrologic Analysis

Historically, high water tables in Drakesbad Meadow were maintained by three factors, (1) the perennial flow of surface and ground water to the fen, (2) the relatively flat landscape which retarded drainage, and (3) the low hydraulic conductivity of the peat. We will quantify the existing water table depth through the snow-free season, and quantify the hydrologic inputs to the fen. A simple water budget for the fen will be calculated to determine how much water flows through the fen each year, using the methods of Drexler et al. (1999). Approximately 80-100 ground water monitoring wells will be installed in a regular grid through the fen in spring 2001, and hydrologic monitoring will begin at that time (funded by LAVO prior to beginning of this project). Each well will be constructed of slotted 1.5 inch PVC pipe, capped on the bottom, and installed into hand augured holes that extend to just above the bottom of the peat body. Piezometers, which are wells open only at the bottom, will be constructed from ½ inch diameter PVC driven into the peat soil following the methods of Cooper (1990). Piezometers are used to measure vertical components of flow, e.g., whether water is moving up or down through the peat column. Piezometers will be installed only at selected monitoring well sites, but will provide an important data set for understanding how water moves through the Meadow. Piezometers will be installed in nests of three, with one each installed to the base of the peat body, the middle of the peat body, and approximately 20-30 cm below the soil surface. Hydrologic analysis of the data will follow the methods of Cooper et al. (1998).

Ground water maps of the site will be constructed showing; (1) the elevation of the water table and directions of water flow at the water table peak in June and the water table low in late summer, and (2) the depth to the mid-summer water table. These maps will assist in identifying areas where the water table has not been completely restored.

Water and soil chemistry

Basic information on the chemical characteristics of fens in the Sierra and Cascade Ranges are lacking. We will collect enough water samples to characterize water sources so that we can classify the Drakesbad fen on the rich to poor peatland gradient (Sjörs 1950). Water pH, as well as the concentrations of major cations and anions would be analyzed.

Vegetation Analysis

The composition of the vegetation in a 10 m^2 circular plot centered on each monitoring well will be analyzed each year. All plant species (both vascular and non-vascular) in each plot will be listed and the canopy coverage for each estimated. The vegetation data will be analyzed in two ways; (1) cluster analysis to develop a community classification, and (2) direct gradient analysis to relate plant species composition to measured water table depths. It will be especially important to follow changes in vegetation composition after restoration. A randomly selected 0.25 m^2 plot within each vegetation plot will be clipped to determine annual standing crop. We will analyze vegetation change using gradient analysis relating the change in coverage or biomass production for key species on a gradient of water table change, or restored condition water table depth.

Soil seed bank analysis

The drying of Drakesbad Meadow fen by ditching most likely led to the death of plant species that are most sensitive to water levels. Thus, the existing fen vegetation may represent only a fraction of its pristine condition species composition. Since there is no pre-ditch information on species composition, the only way to determine the composition of the pre-ditch fen is to analyze the soil seed bank. Seeds of wetland plants may remain viable and germinable in the soil of drained montane wetlands for a century or more (Wenger 1996). When the soil is rewetted following restoration, a number of fen species may emerge from the seed bank and significantly affect the composition of the vegetation. It is essential to understand the composition of the soil seed bank so that we can set goals for the vegetation composition following restoration.

The seed bank composition will be analyzed by collecting soil samples representing the upper 5 cm of soil from five random locations within each vegetation plot. The five replicates will be pooled. The soil will be mixed, live rhizomes and plant parts removed by hand, and the soil spread onto a 12 x 12 cm flat. Each flat will be tagged to identify the vegetation plot from which the sample was collected. The flats will be placed outside in a fenced exclosure to prohibit grazing or disturbance by animals. The flats will be watered hourly during the summer (daylight hours only) to maintain moist or saturated soil conditions. Plants emerging from the soil will be identified to species and a table developed of the number of each species for each plot. These data will be used to set long-term vegetation goals for each plot.

Peatland Functions

The goal of this project is to restore Drakesbad Meadow from a peat oxidizing to a peat-accumulating ecosystem. This will facilitate a return of the pre-disturbance plant community. To confirm that this project goal is met will require the calculation of a simple carbon budget for the study area. A carbon budget will be developed for 10 plots, representing the range of sites occurring within Drakesbad Meadow, using the methods described by Chimner (2000). Above and below ground production will be quantified in each plot. Above ground production will be quantified using the clipping method. Below ground production will be quantified using the in-growth bag method. Carbon export will be quantified by measuring CO_2 and CH_4 efflux from the soils. Gases will be quantified by measuring changes in gas concentrations within small chambers installed in the field. CO_2 will be measured in the field with an Infrared Gas Analyzer (IRGA) borrowed from the Natural Resources Ecology Laboratory at Colorado State University. We hope to find a lab in California that can analyze our collected gas samples for CH_4, which requires a gas chromatograph (GC). It is likely that a GC exists at a nearby University of California campus, or an USDA Agricultural Research Station facility.

Topographic Surveying

All wells and the ground surface along our well transects must be surveyed to determine the location and exact elevation of each site. This information is essential for the production of water table maps, water flow maps and analyses, and for determining the location of water sources.

ANTICIPATED RESULTS

The goal of this project is to restore one of the few fens known to exist in northern California, undo damage to Lassen Volcanic National Park created by early settlers, and provide documentation of how the project has restored the hydrologic regime, vegetation, and functions of the fen. This type of information is lacking for peatland restoration projects in the U.S. Since the water sources for Drakesbad Meadow are intact, this is one of the few circumstances where true restoration of a wetland can be achieved. The pre-restoration monitoring program is aimed at providing a baseline of existing conditions, with which the post-restoration condition can be compared. Goals for the restoration will be developed using a combination of a pristine reference site, if one can be found, and information developed from the soil seed bank analysis. At the end of the post-restoration monitoring program, analyses will identify where and if additional restoration must be accomplished to meet the project goals of restoring the entire fen.

LITERATURE CITED

Bursik, R.J. and D. M. Henderson. 1995. Valley peatland flora of Idaho. Madrono: 42: 366-395.

Chimner, R. A. 2000. Carbon dynamics of southern Rocky Mountain fens. Ph.D. dissertation, Colorado State University, Fort Collins, CO.

Cooper, D. J. 1990. Ecology of wetlands in Big Meadows, Rocky Mountain National Park, Colorado. Biological Report, U.S. Fish and Wildlife Service, Washington, D.C.

Cooper, D. J. 1996. Water and soil chemistry, floristics and phytosociology of the extreme rich High Creek Fen, South Park, Colorado. Canadian Journal of Botany **74**:1801-1811.

Cooper, D. J. and R. Andrus. 1994. Patterns of vegetation and water chemistry in peatlands of the west-central Wind River Range, Wyoming. Can. J. Bot. 72:1586-1597.

Cooper, D. J., L. H. MacDonald, S. K. Wenger and S. Woods. 1998. Hydrologic restoration of a fen in Rocky Mountain National Park, Colorado. Wetlands **18**: 335-345.

Cooper, D. J. and J. Sanderson. 1997. A montane *Kobresia myosuroides* fen community type in South Park, Colorado. Arctic and Alpine Research **29**:300-303.

Cooper, D. J. and L. MacDonald. 2000. Restoring the vegetation of a mined peatlands in the southern Rocky Mountains of Colorado, USA. Restoration Ecology 8: 103-111.

Drexler, J., B. Bedford, A. DeGaetano and D. Siegel.1999. Quantification of the water budget and nutrient loading in a small peatland. Journal of the American Water Resources Association 35: 753-770.

Gillett, G.W., J.T. Howell, and H. Leschke. 1995. A flora of Lassen Volcanic National Park, California. California Native Plant Society. Sacramento, CA.

Lesica, P. 1986. Vegetation and flora of Pine Butte Fen, Teton County, Montana. Great Basin Naturalist 46: 22-32.

Sjörs, H. 1950. On the relation between vegetation and electrolytes in northern Swedish mire waters. Oikos **2**:241-258.

Wenger, S. 1996. Evaluation of an impacted riparian wetland's soil seed bank for use in restoration. Masters thesis, Colorado State University, Fort Collins, CO.

Ziegenbein, M.S. and J. Wagner. 2000. Lassen Volcanic National Park disturbed land inventory and recommendations. National Park Service, Geologic Resources Division and Water Resources Division. Denver, CO.

PROPOSED BUDGET

Salary	Year 1	Year 2	Total Year 1+2
David J. Cooper, P.I. (2 wk/yr)	$2,800	$2,528	$5,328
Graduate Student	$13,800	$14,100	$27,900
Fringe benefits for PI and Student	$979	$981	$1,960
Salary Subtotal	**$17,579**	**$17,609**	**$35,188**
Expenses			
Graduate student tuition	$2,400	$2,440	$4,840.00
Travel/Per diem (3 trips/yr)	$1,300	$1,300	$2,600.00
PVC Pipe (supplemental wells)	$100	$50	$150.00
Sample collection bottles	$100	$50	$150.00
IRGA use (supplies, calib.)	$200	$200	$400.00
Seedbank analysis material	$100	$50	$150.00
Expenses Subtotal	**$4,200**	**$4,090**	**$8,290**
CSU Indirect Costs (15%)	**$3,267**	**$3,255**	**$6,522**
Total Costs	**$25,046**	**$24,954**	**$50,000**

RESTORATION OF DRAKESBAD MEADOW, LASSEN VOLCANIC NATIONAL PARK

Evaluation Criteria Form

1. **<u>Significance of the Resource or Issue to the Park</u>: How important is the resource or issue to the park involved, relative to its other resources and issues?** Weighting Factor = 2X

Drakesbad Meadow, LAVO's largest wetland, is a popular destination for visitors seeking secluded hiking, bird-watching, and enjoyment of nearby hot springs. Despite drainage, Drakesbad still contributes unique and important biodiversity elements because of its large size, complexity, and rare fen communities. Gillett et al. (1995) found that wetlands contain the majority of LAVO's plant species, and reported over 20 sedge species, 7 rush species, and the state-listed "obtuse starwort" at Drakesbad. King (1998) described Drakesbad as highly productive breeding habitat for several songbird species. Species recorded there include Song Sparrow, Wilson's Warbler, Warbling Vireo, and Yellow Warbler (all Partners in Flight "species of concern"). The adjacent Warner Valley is a significant breeding area for Willow Flycatchers (state endangered, federal candidate), with 32-39 territories established annually. *Willow Flycatchers are captured periodically at the avian monitoring station at Drakesbad.* A parkwide peregrine falcon survey cited unconfirmed sitings, good prey availability, and potential nesting sites as reasons for considering Drakesbad potential peregrine habitat. Thus, Drakesbad's restoration is critically important to sustaining and increasing LAVO's biodiversity and visitor enjoyment.

LAVO's enabling legislation mandates preservation of natural resources in their natural condition. LAVO's NRMP ranks Drakesbad restoration as the highest priority unfunded natural resources project.

2. **<u>Severity of Resource Threat, Problem, or Need(s)</u>:** Weighting Factor= 3X

The drainage ditch network, which was installed prior to park establishment in 1916, poses a longstanding and substantial threat to the unique resources of this fen ecosystem. Once established, the ditch system became self-perpetuating because of the lack of sediment inputs and the swift perennial water flow. As a result, peat soils that took millennia to establish are quickly and continually being lost through oxidation, and exotic plants are displacing unique native fen vegetation assemblages in areas affected by drainage. Delaying restoration will therefore result in sustained artificial lowering of the water table, continued oxidation (loss) of rare peat soils that become more and more difficult to restore over time, loss of unique fen vegetation communities that develop on these soils, and loss of the fauna that are dependent on this unusual habitat type. The 2-foot deep ditches also pose a visitor safety issue because they are hidden by overgrowing vegetation and are often discovered only by accidentally falling into them.

Without restoration, Drakesbad Meadow will remain in a continually declining state, thereby compromising the park's resource protection mission, decreasing visitor enjoyment and safety, and reducing the locally and regionally important natural resource values that fen ecosystems provide.

3. <u>Problem definition and information base:</u> How well is the problem defined?
Weighting Factor= 2X

LAVO has received onsite technical assistance from Joel Wagner (wetland scientist, NPS-WRD), Mark Ziegenbein (disturbed land restoration specialist, NPS-GRD) and Dr. David Cooper (Colorado State University) in evaluating drainage impacts at Drakesbad and in developing this restoration plan. Dr. Cooper is an expert in peatland ecosystems and their restoration. His work in restoring the hydrology of the very similar Big Meadows fen in ROMO is documented in "Hydrologic Restoration of a Fen in Rocky Mountain National Park, Colorado, USA" (Cooper at al. 1998). Based on their combined knowledge and experience, we feel that the stated impacts of the ditches on hydrology, soil and vegetation community processes, the proposed restoration work, and the associated monitoring are well-defined and scientifically based.

The park NRMP states that the "...knowledge of the natural resources that make up LAVO is extremely limited..." and aquatic resources information is "spotty to nonexistent." Therefore, the collection of hydrology, soil, vegetation, topography, water quality, and seedbank data must be done to further define the problem and carry out a fully successful restoration. These data and analyses, which will be provided to LAVO in the final report, will help fill gaps in aquatic resource information for Drakesbad Meadow.

4. <u>Feasibility</u>: Weighting Factor= 3X

This project was designed with extensive input from the NPS Water Resources Division, the NPS Geologic Resources Division, and an expert in peatland (fen) ecology and restoration from Colorado State University. The proposal presents clearly defined objectives and utilizes sound restoration methods and monitoring procedures that have been field tested by the principal investigator at Rocky Mountain National Park and other locations. Jeff Connor, ROMO Resource Management Specialist, supervised installation of comparable structures for the Big Meadows fen restoration, and reports that the method was feasible, effective and long-lasting. The Big Meadows structures have been in place since 1989, and documentation of success in restoring fen water levels and flow patterns is found in Cooper et al. (1998). Although the restoration actions proposed here are similar to the Big Meadows project, this proposal goes further by using seedbank, carbon budget, and vegetation monitoring to establish feasible goals, evaluate success, and determine if any additional measures are needed to achieve full restoration. In combination, these procedures provide for improved project feasibility and a successful outcome. LAVO has also committed to funding longer-term vegetation plot monitoring (after completion of this project in 2003) to continue documenting recovery of the pre-disturbance vegetation community.

5. **<u>Problem resolution</u>: Will the proposed use of funds contribute directly to decisions or actions, which, when implemented, will meaningfully resolve a management issue?** Weighting Factor= 3X

This project implements management actions designed to resolve the longstanding issue of drainage impacts at Drakesbad Meadow. Existing condition water level monitoring, vegetation analysis, topographic data, and ditch mapping will be used to pinpoint the most effective locations for backfilling and placement of structures to achieve hydrologic restoration. Ditch dimensions at these locations will then be carefully measured to determine the appropriate size of the steel sheets needed for implementation of the restoration plan. These methods were proven effective in restoring pre-disturbance hydrology at Big Meadows in Rocky Mountain National Park (Cooper et al., 1998 and Jeff Connor, pers. comm.) and will be adapted for this project. Post-implementation monitoring at Drakesbad will go several steps beyond the ROMO project in assuring problem resolution by assessing changes in the carbon (peat) budget and vegetation plots resulting from these actions. Results of these assessments will document whether or not the goals of restoring peat-accumulating conditions and recovery of target fen vegetation are being met project-wide, and will indicate where follow-up restoration actions (if any) might be needed.

6. **Transferability: How widely will the project protocols or results be useful?** Weighting Factor= 1X

The methods, analytical techniques, results, and "lessons learned" from this wetland restoration project will have Servicewide benefits. Such transferability is demonstrated in this proposal, where the methods from a successful hydrologic restoration at Rocky Mountain NP are being adapted for this similar effort at Drakesbad. This project will build on the ROMO experience by adding seedbank, vegetation plot, and carbon balance analyses to better define project goals, evaluate project success, and recommend any further actions needed to promote complete restoration. These improved methods can then be transferred in many ways to other parks considering similar restoration projects. The final report will be made available Servicewide through publication in the WRD technical report series or through Colorado State University. The project "story" will be told and availability of the report will be announced through venues such as Park Science, the Natural Resources Year in Review report, George Wright Society presentations, and the NPS Natural Resources Bulletin Board. WRD and GRD will also continue the Servicewide technology transfer process through ongoing technical assistance to parks with similar restoration needs. The graduate student will focus his/her Masters thesis on this project, and the investigators will also publish results in refereed, internationally distributed journals.

7. **<u>Cost effectiveness</u>: Given problem statement and proposed methodology, are cost estimates realistic and commensurate with the results to be produced?** Weighting Factor= 2X

Project costs covered by this funding are clearly defined in the budget. The project provides standard support costs for a Masters level graduate student at Colorado State University for two years, which is a sufficient length of time to collect and analyze the data for the pre- and post-restoration periods. The principal investigator's salary figures had to be held quite low (2 weeks/yr) to keep costs within funding limits, but are agreeable to Dr. Cooper, who will donate an additional 1 week in 2001 and 2 weeks/yr in 2002-2003. The budget includes sufficient travel money to allow Dr. Cooper to oversee field aspects of the project. Supplies and materials are held to a minimum by borrowing the Infrared Gas Analyzer (budget shows supplies and machine calibration only) and by having the park supplement costs such as summer housing and a vehicle for the graduate student, cost of the steel sheets and their installation, and installation of much of the well network prior to the project start. The 15% CSU overhead figure is already negotiated as part of an existing CESU Agreement and is extremely competitive. The park has also agreed to continue vegetation monitoring after 2003 to assure longer-term success.

8. <u>Project Support</u>: What resources (including in-kind contributions) are the park, region or other partner(s) willing to commit to this project. A detailed description of total project costs, including contributions is required.
Weighting Factor= 1X

This project is a collaborative effort between WRD, LAVO, and Colorado State University (CSU). LAVO will provide extensive support including housing, vehicle use, and travel for the graduate student (summer 2002 and 2003), well installation and hydrologic data collection in the spring/summer of 2001, purchase and installation of the sheet metal dams, and post-project vegetation monitoring (total value = $30,000). CSU offers an extremely competitive 15% project overhead rate through the existing CESU Agreement. WRD funding will only cover Dr. Cooper's involvement for 2 weeks/yr in 2002-2003. He will donate 1 week in 2001 to guide project setup, and 2 additional weeks/yr in 2002-2003, for a total of 5 weeks donated over 3 years (value = $7000). The total project cost, including LAVO, CSU, and WRD contributions, will be $87,000. The project support portion totals $37,000 or **43%** of the total project budget (see table below for detailed documentation).

Budget Summary Including Cost-Sharing/In-Kind Services

	Pre-project Setup & Monitoring (2001)	Year 1 (2002)	Year 2 (2002)	Post-project monitoring (2003-2007)	Total
WRD Funding		$25,046	$24,954		$50,000
Well installation in 2001 - includes 4 weeks labor, materials, travel, housing, vehicle (LAVO funding)	$4,600				$4,600
Weekly well monitoring in summer 2001 (LAVO funding)	$2,000				$2,000
Sheet metal dam purchase and installation (LAVO funding)		$4,300			$4,300
Graduate student summer supplemental support (housing, gov. vehicle, travel) while at park (LAVO funding)		$3,300	$3,300		$6,600
Post-project vegetation plot monitoring @$2,500/yr for 5 years (LAVO funding)				$12,500	$12,500
PI donated salary (2 weeks/yr)	$1,400	$2,800	$2,800		$7,000
Combined Total	$8,000	$35, 446	$31,054	$12,500	$87,000