ASSESSMENT AND RESTORATION PLANNING FOR SELECTED STANISLAUS NATIONAL FOREST SPRINGS: 2015 FINAL REPORT

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INTRODUCTION

Springs are among the most biologically diverse, ecologically interactive, and culturally important terrestrial ecosystems, in both arid and mesic landscapes, and exist in an array of types and settings (Springer and Stevens 2008, Weixelman et al. 2011). Although often small in area, springs function as biological hotspots of aquatic, wetland and riparian diversity, and function as keystone (highly interactive) ecosystems that play disproportionally important roles in relation to adjacent uplands (Thomas et al. 1979, Fleishman et al. 2005, Perla and Stevens 2008). In addition, springs are intensively used by humans for water and other resources, and consequently springs are often ecologically impaired (Hendrickson and Minckley 1984, Shepard 1993, Sada and Vinyard 2002). Appropriate stewardship of springs is hampered by a lack of knowledge of their distribution, ecology, extent of impairment, and the generally limited scientific attention that has been paid to these remarkable ecosystems (Stevens and Meretsky 2008). Springs ecosystem restoration planning and implementation is similarly limited by the lack of assessment data and knowledge of appropriate implementation techniques (Stevens et al. in press). Among the many shortcomings of the present state of knowledge about springs has been the role of fire on springs ecosystem function. Springs may serve as regeneration hotspots following fire or other disturbances, points from which population and landscape recovery radiates across landscapes following major disturbances. However, recovery of burned springs likely varies by setting and the springs type(s) (Graham 2008; Springer and Stevens 2008).

The Museum of Northern Arizona's Springs Stewardship Institute (SSI) re-evaluated 10 springs in the Cherry Creek Project Area for potential restoration planning for the above reasons, and in response to the Rim Fire Habitat Improvement (45860) Decision Memorandum, and through a 2015 inquiry by Stanislaus National Forest (the Forest), the Sierra Nevada Conservancy, the Tuolumne River Trust, and the Yosemite Stanislaus Solutions Collaborative. That restoration evaluation involved 6 tasks, described in Table 1. SSI had visited these 10 and 107 other Rim Fire springs in August-September 2014 during an ecological inventory of springs in the Rim Fire perimeter. That inventory greatly improved understanding of springs

Table 1: Tasks associated with evaluation of 120 selected Rim Fire perimeter springs in Stanislaus National Forest, California in 2015-2016.

Task	Task Description	Due Date	Completion Date
1	Coordinate project	09/01/15	09/30/15
2	Review status and extent of background information	11/01/15	This report
3	Field reconnaissance of 10 springs	9/13-18/2015	9/18/2015
4	Integrate and report on information gathered above	12/30/15	This report
5	Develop restoration plans	02/15/16	This report
6	Revise restoration action plan	03/01/15	This report

distribution, typology, and status in the Rim Fire burn perimeter, but indicated that many springs have not been mapped or inventoried in the project area and on the Forest as a whole. SSI staff used the U.S. Forest Service Level I Springs Inventory Protocols (U.S. Forest Service 2012) to inventory Forest springs ecosystem distribution, and used an SSI assessment process to compare the ecological condition of those springs.

The Rim Fire Habitat Improvement Decision Memo contains the following guidance for proposed restoration actions at these springs in 2016 (U.S. Forest Service (2015): "Restoration of ten springs may include geomorphic restoration (spreading channelized flow), removal of encroaching conifers, planting of native species, and digging or hand pulling non-native species…Minimize cattle disturbance by creating a barrier at one site (Salvage Meadow)."

In relation to this memorandum, the Forest Service and the Tuolumne River Trust requested that the following suite of management indicator questions be addressed in this assessment:

a. *Aquifer functionality*: Does evidence suggest that the aquifer supplying groundwater to the site is being affected by groundwater withdrawal or loss of recharge?
b. *Watershed functionality*: Within the watershed, does evidence suggests upstream/up-gradient hydrologic alteration that could adversely affect the GDE site?
c. *Water quality*: Are changes in water quality (surface or subsurface) affecting the GDE site?
d. *Landform stability*: Does evidence indicates human caused mass movement or other surface disturbance affecting the GDE site stability?
e. *Runout channel*: The channel, if present, is functioning naturally and is not entrenched, eroded, or otherwise substantially altered.
f. *Soil integrity*: Soils are intact and functional. For example, saturation is sufficient to maintain hydric soils, if present; there is not excessive erosion or deposition.

g. *Vegetation composition*: Does the site include anticipated cover of plant species associated with the site environment, and no evidence suggests that upland species are replacing hydric species?
h. *Vegetation condition*: Vegetation exhibits seasonally appropriate health and vigor. Threatened, endangered, or sensitive plants are present. Invasive species are not established at the site.
i. *Flow regulation*: Flow regulation if occurring is not adversely affecting the site.

In addition, Forest managers requested information on whether anthropogenic construction and road, herbivore, or recreational activities were affecting the site, and the impacts of other disturbance factors, such as wildland fire, insect, disease, wind throw, avalanches, or other disturbances.

Here we summarize SSI's revisits and analyses to the 10 Cherry Creek Project Area springs on Stanislaus National Forest in 2015. We present data, assessments, and restoration recommendations on those 10 springs. Detailed land survey maps were made on three of the 10 springs that had somewhat higher restoration potential scores and may warrant additional management attention. We provide recommendations about potential restoration actions at all of those springs through site-specific reports (Appendix A) and report tables and mapping data for the three sites at which land survey maps were made (Appendix B).

METHODS

Study Area and Rim Fire Background

Stanislaus National Forest occupies 898,099 ac (3,632 km^2) on the west slope of the Sierra Nevada to the west of Yosemite National Park. The Sierra Nevada range is a granite batholith that has undergone both volcanic and glacial action in the recent geologic past, producing a complex terrain. Ranging in elevation from 1,500 to more than 11,000 ft (460-3,350 m), the Forest supports habitats that vary from oak savannahs to near-treeline mixed conifer forests. Lying two hours from the Great Central Valley and three hours from the San Francisco Bay Area, the Forest is an important recreation area and destination for visitors. In addition, the Forest protects the water sources and pipeline systems of the greater San Francisco metropolitan area, with several large reservoirs, such as Cherry Lake Reservoir. Yosemite National Park immediately east of the Forest contains Hetch Hetchy Reservoir, another major water source for San Francisco. The Forest occupies portions of Tuolumne and Mariposa counties, and is organized into four Ranger Districts along three highway corridors: the Groveland District is accessed on Route 120 on the south side of the Forest; the Mi-Wok and Summit Districts are accessed from Route 108 along the middle fork of the Stanislaus River; and the Calaveras District is accessed through Route 4 on the north side of the Forest. Several large in-holdings of private land exist on the Forest, with logging as a primary private use.

The Rim Fire occurred from 17 August to 24 October 2013, consuming 257,314 ac (1,041 km^2) of forest and oak woodland habitat on the Mi-Wok and Groveland Ranger Districts, and extended into Yosemite National Park to near Hetch Hetchy Reservoir (U.S. Forest Service 2014). It was the third largest wildfire in California's history and the largest wildfire in the Sierra Nevada Range. Eleven residences, three commercial buildings, and 98 outbuildings were destroyed. Although the fire burned to the edge of the town of Groveland and 10 injuries were reported, the US Forest Service prevented far more serious loss of property and no fatalities occurred. The fire cost more than $127 million to fight, and considerable expense was incurred by the local communities through loss of recreation revenues. Much funding and management attention has been devoted to restoration of the burned landscape.

Selected Springs

The US Forest Service selected 10 springs in the Cherry Creek Project Area for evaluation of restoration potential (U.S. Forest Service 2015; Table 2; Fig. 1). We planned field logistics using georeferencing data collected in 2014. Most of the 10 springs were near roadways, but several required 1-6 km roundtrip hikes. No new springs were encountered during these revisits. SSI provided all field equipment required to conduct the surveys, including a POV and field survey gear. Due to the rough terrain of the landscape and potential threats in visiting springs in a severely burned landscape, we communicated daily with Ms. Weddle as to our plans. We visited 1-3 springs/day from 9/14/2015 through 9/18/2015.

Field Methods

We followed the U.S. Forest Service's Groundwater-Dependent Ecosystems (GDE) Level I springs inventory protocols (US Forest Service 2012, as provided at: http://www.fs.fed.us/geology/GDE_Level_I_FG_final_March2012_rev1__printing.pdf. These data provide a general description of the site and qualitative management indicators; however, we sought a means to evaluate and rank restoration potential of each site. All data collected in both 2014 and 2015 have been entered into the USFS GDE Access database using the latest version (5.4, released 12/01/2015), and are available to the Forest Service.

At three sites judged to have some need for more detailed mapping, we conducted land surveys, using a CST/Berger level, stadia rod and tape. The instrument location was georeferenced and both it and the backsight were marked with a rebar stake for future reference. The instrument height was recorded, and the backsight was documented at the beginning of the survey and rechecked at the end. Survey data were recorded in a field book and entered into the SSI database in the laboratory.

Plant species were documented on each site, and any species not immediately recognized were collected. Specimens were returned to the laboratory for identification, and those taxonomic determination data were added to the database. In some cases, insufficient material existed for species-level taxonomic determination, so identifications are to the lowest taxonomic level possible. Specimens are presently stored at the Museum of Northern Arizona in Flagstaff.

Analyses

Field data were returned to the SSI laboratory in Flagstaff, AZ, and entered and quality controlled in the U.S. Forest Service Access database. Field notes on each site were recorded, and site observations were compared with conditions in 2014. Land survey data for the three springs were entered and quality controlled in the database, and incorporated into a

Table 2: Ten Stanislaus National Forest Rim Fire springs in the Cherry Lake project area that were inventoried in 2014 and evaluated for restoration potential in 2015. Mosspool and Nettle Ditch Springs sources shifted downslope between 2014 and 2015.

Site Name	Inventory Date	SSI Site ID	FS ID No.	Lat Long	T, R, Sec	Elev (m)	Springs Type
Cordulegaster	8/29/14 9/15/15	159351	S3	N 37.91781 W -119.96861	T1N, R18E, Sec 26	1097	Rheocrene
Granite Ditch	8/25/14 9/17/15	159437	S7	N 37.93236 W -119.95800	T1N, R18E, Sec 24	1333	Rheocrenic Anthro-pocrene
Hopeful	8/29/14 9/16/15	159373	S4	N 37.91715 W -119.96600	T1N, R18E, Sec 26	1068	Rheocrene
Liverwort	8/31/14 9/18/15	164152	S10	N 37.92089 W -119.92372	T1N, R19E, Sec 19	1167	Rheocrene
Mosspool	8/23/14 9/15/15	159376	S1	N 37.91740 W -119.97700	T1N, R18E, Sec 27	1187	Rheocrene
Nettle Ditch	8/22/14 9/14/15	159345	S2	N 37.91944 W -119.97210	T1N, R18E, Sec 26	1154	Anthropogenic Hillslope
Salvage Meadow	8/23/14 9/14/15	159427	S6	N 37.91839 W -119.97925	T1N, R18E, Sec 27	1187	Hillslope
Spiranthes Seep	8/24/2014 9/16/15	164143	S9	N 37.96794 W -119.908896	T1N, R19E, Sec 5	1385	Hillslope Anthro-pocrene
Tecnu Springs	9/2/14 9/17/15	159375	S5	N 37.89528 W -119.94019	T1N, R18E, Sec 36	869	Rheocrenic Hillslope
Towhee Springs	8/24/14 9/16/15	159380	S8	N 37.95635 W -119.91800	T1N, R19E, Sec 8	1364	Rheocrene

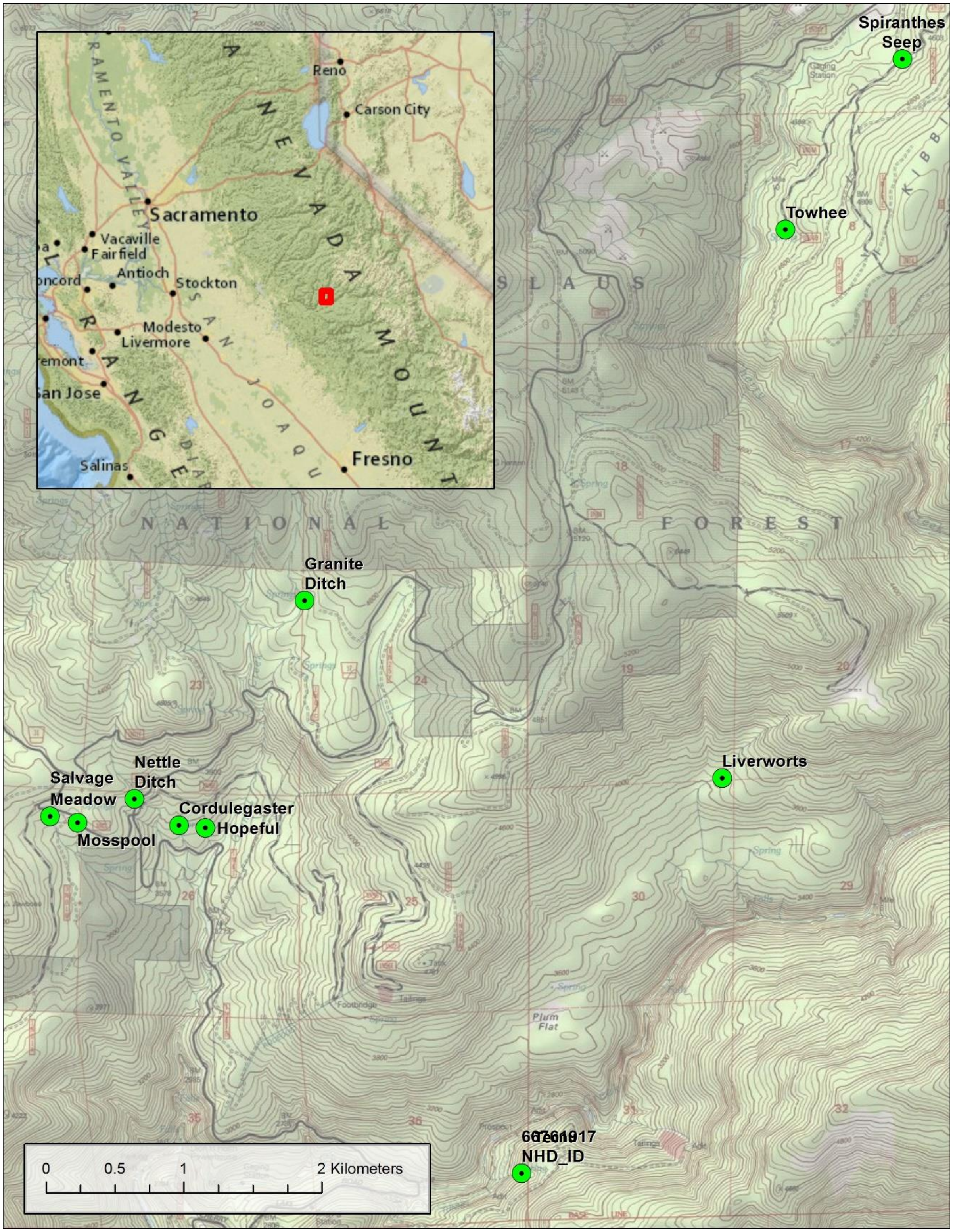

Fig. 1: Map of 10 springs selected by the U.S. Forest Service for potential restoration planning and implementation.

triangulated irregular network landscape model to produce a 0.5 m contour map of each site. Such maps may be useful for planning purposes.

The U.S. Forest Service (2012) Level 1 springs inventory protocols do not readily lend themselves to quantitative evaluation or prioritization of ecological integrity and management planning. Therefore, we generated a quantitative Forest Service management indicators (FSMI) score from the 11 criteria the Forest Service stated were of primary interest. We scored each criterion by applying expert judgment based on background data and site visits to each of the 10 springs, and using the management indicator scores generated through the Level 1 inventory protocols. Each criterion was scored from 0 (restoration was not possible) to 6 (highly restorable). The sum for each site was calculated, as was the percent score of a possible 66. For example, if the site sum was 22, the site received a FSMI total percent score of 33.3%.

We also calculated partial percent scores for geomorphology and soils by summing the five criteria (b-f) related to those characteristics and dividing by the partial total (30). Geomorphology partial percent scores were expected to be high if geomorphological restoration efforts were to be successful, with middle percent scores (e.g., 50-70%) indicating dubious potential success, and scores <50% indicating progressively lower success for restoration.

Caveats exist with regards to generating these FSMI scores prior to more detailed discussion with the Forest Service because the suite of Forest Service criteria and management indicators does not include information on factors of potential importance in restoration planning, such as ease of access (e.g., proximity to roads), which greatly influences the types, efficiency and safety of the action, as well logistical planning and the types of equipment that can be employed. In addition, the FSMI did not include consideration of faunal issues, including rare species and non-native species impacts, such as grazing. Nonetheless, the FSMI scoring process revealed important information about restoration potential of these 10 springs.

To back-check the validity of FSMI scoring, we repeated the SSI springs ecosystem assessment protocol (SEAP) analysis that we had performed on these sites in 2014. SEAP scoring is based on data and expert opinion on natural resource conditions and anthropogenic risks for each site. A site's natural resource condition score is calculated as the average score of the condition or value of the ecological integrity of the aquifer, site geomorphology, habitat quality, and population biology and status of native and non-native species in relation to the inventory team's expert opinion about deviation from the natural condition of the site. Natural resource scores range from 0 (wholly degraded natural condition) to 6 (pristine condition). Anthropogenic risk scores similarly range from 0 (no risk) to 6 (site is irretrievably degraded, with no potential for rehabilitation).

A plot of natural resource conditions in relation to human risk scores generally produces a cloud of points with a negative slope (Ledbetter and Stevens 2014: Fig. 2). Among that cloud of points, sites with low natural condition scores and high risk scores are likely too degraded to warrant management actions, while sites with high natural condition scores and low anthropogenic risk are in good condition, and many only warrant occasional monitoring. In between those two extremes, sites in moderately good ecological condition and having relatively low risk may be sites at which management attention can produce resource benefits. We generated SEAP scores for each site and compared SEAP results with the FSMI scoring results.

Information Management

The SSI springs assessment field team recorded data onto paper field sheets that were organized into folders with one site/folder. Field data sheets, plant and invertebrate specimens, observations on the sites, and mapping data were recorded and returned to our laboratory in Flagstaff for data entry, quality control, and reporting. SSI staff entered all data on field sheets, a representational photograph, and the redrawn 2014 sketchmap or land survey map into the GDE database. Senior SSI staff are conducting QA/QC using standard methods and continue to edit the final reports on each springs ecosystem that was inventoried. Taxonomic analyses of selected plant specimens also are continuing.

PROJECT PROGRESS

Task 1. Coordinate project development, logistics, information management, and project evaluation reporting with Stanislaus National Forest (the Forest)

This task was accomplished through discussion with the U.S. Forest Service and Mr. Patrick Koepele of The Tuolumne River Trust (Table 1). This collaboration set the stage for the September 2015 field site visits to the 10 springs, and allowed us to interact with several U.S. Forest Service employees and volunteers, who provided welcomed field assistance with site inventories, evaluation and mapping.

Task 2. Review the status, condition, and the extent of background information, and identify additional information needs of the selected 10 springs in the Rim Fire perimeter in Lower Cherry Creek Project.

This task was accomplished through review of the SSI 2014 report for the 10 selected springs. Our discussions with the Forest Service staff provided additional information and insight into the study site selection process, additional information needed for undertaking the task, and guidance and assistance on logistics planning and field work. This collaboration with the Forest Service was critical for the success of the September 2015 field site visits (below).

Task 3. Conduct a field reconnaissance of the 10 selected springs and evaluate aquifer and watershed functionality; water quality; landform stability; runout channel geometry; soil integrity; vegetation composition and condition; flow regulation impacts construction, road, herbivore, recreation, and other disturbance impacts; and additional management needs (e.g., wetland delineation, archeological evaluation, or land survey).

SSI staff conducted an evaluation of the restoration potential of the 10 selected sites from 14-18 September 2015, visiting each site for several hours and re-inventorying flow and water quality, geomorphological, vegetation, and management indicator status (Tables 2-4). For three sites at which some restoration potential may exist, SSI staff performed a land survey to provide better documentation of the terrain to help guide restoration planning, if so

Table 3: Physical site characteristics in 2014 and 2015 for 10 Stanislaus springs in the Rim Fire perimeter selected for evaluation of restoration potential. The source of Mosspool Springs in 2015 shifted ca. 50 m downslope in relation to the 2014 survey.

Site Name	Site Visit Date	Area (m^2)	Aspect (°True North)	% Slope	Microhabitat Cover				
					% Spring	%Channel	% Wetland	% Open Water	% Other
Cordulegaster	8/29/14	228	149	21	20	20	10	5	45
	9/15/15	same			1	14	80	5	
Granite Ditch	8/25/14	64	234	9	0	60	10	0	30
	9/17/15	49 (dry)					100		
Hopeful	8/29/14	42	151	29	2	20	10	2	66
	9/16/15	dry			1		99		
Liverwort	8/31/14	157	210	16	5	60	10	15	10
	9/18/15	same			5	50	40	5	
Mosspool	8/23/14	77	144	16	5	60	20	10	5
	9/15/15	same		10	30	40	20		
Nettle Ditch	8/22/14	248	169	9	5	60	5	5	25
	9/14/15	290		9	5	30	30	10	25
Salvage Meadow	8/23/14	300	130	19	0	0	50	0	50
	9/14/15	dry							100
Spiranthes Seep	8/24/2014	344	204	7			30		70
	9/16/15	dry					30		70
Tecnu Springs	9/2/14	47.5	300	23	5	80	15	10	0
	9/17/15	48			10	30	59	1	
Towhee Springs	8/24/14	378	235	18	10	30	30	5	25
	9/16/15	same		18	10	30	30	5	25

Table 4: Water flow and quality characteristics in 2014 and 2015 of 10 Stanislaus springs in the Rim Fire perimeter selected for evaluation of restoration potential. Flow at Liverwort Springs was measured 200 m downstream from the source.

		Flow and Water Quality						
Site Name	Inventory Date	Flow (L/s)	Domnt In-Flow Pattern	Domnt Out-Flow Pattern	H_2O Temp (ºC)	pH	Spec. Cond. (uS/cm)	DO (mg/L)
Cordulegaster	8/29/14	0.084	Surface	Surface	17.1	6.32	226.8	3.5
	9/15/15	0.036	Surface	Surface	16.5	7.06	222	2.5
Granite Ditch	8/25/14	0.000	Surface	Surface	---	---	---	---
	9/17/15	0.000	Surface	Surface	---	---	---	---
Hopeful	8/29/14	0.002	Surface	Surface	19.9	5.98	231.6	1
	9/16/15	0.000	Surface	Surface	---	---	---	---
Liverwort	8/31/14	0.440	Surface	Surface	16.6	6.31	293.3	3.5
	9/18/15	0.974	Surface	Surface	15.4	6.77	274	3.5
Mosspool	8/23/14	0.002	Surface	Surface	19.8	6.2	219	4.5
	9/15/15	0.020	Surface	Surface	18	6.53	220	3.5
Nettle Ditch	8/22/14	0.019	Mixed	Surface	16.1	6.65	226	5
	9/14/15	0.001	Mixed	Surface	19.4	6.73	200	2
Salvage Meadow	8/23/14	0.000	Surface	Surface	---	---	---	---
	9/14/15	0.000	Surface	Surface	---	---	---	---
Spiranthes Seep	8/24/2014	0.000	GDE	Surface	---	---	---	---
	9/16/15	0.000	Surface	Surface	---	---	---	---
Tecnu Springs	9/2/14	0.100	Surface	Surface	15.1	7.42	178	6.5
	9/17/15	0.003	Surface	Surface	13.3	6.89	185	5.5
Towhee Springs	8/24/14	0.370	Surface	Surface	12.6	6.11	83.8	5
	9/16/15	0.102	Surface	Surface	11.9	6.23	75	2.5

recommended pending analysis of site visit data. Field assistance provided by several Forest staff and volunteers was much appreciated in this effort. All data from these 2015 site visits, land surveys, and maps are available on the SSI website, and results are summarized in Tables 2-4.

Individual Springs Descriptions

Cordulegaster Springs: Cordulegaster Springs ecosystem is a hillslope rheocrene springs ecosystem that emerges among large granitic boulders in the channel of a steep, minor tributary of Granite Creek, into which it descends several hundred meters downstream from the Cherry Creek Road. It is located at N 37.91781°, W -119. 96861°, and at 1,097 m elevation. The springs create a flowing channel that extended downstream more than 100 m in 2014, flowing under the Cherry Creek Road, but which did not reach the road in 2015. The channel is densely vegetated with monkeyflower, Lotus, and other wetland and weedy herb species. The Cordulegaster Springs area burned with high intensity during the Rim Fire, killing all trees in the landscape. The landscape is highly unstable, with extensive erosion and much potential for debris flows due to the large area of upslope drainage and the severity of burn intensity throughout the basin. Channel and terrace vegetation regrowth was vigorous in both 2014 and 2015. Livestock impacts were everywhere abundant in 2015, with extensive trailing, trampling, pedestel formation, and feces detected throughout the steep channel in and around the springs. Cordulegaster Springs source and moist channel habitat occupied 42 m^2 in 2014, with 186 m^2 of springs-influence terrace habitat, a configuration that was unchanged in 2015. We detected a Pacific spiketail dragonfly (*Cordulegaster pacifica*) patrolling the stream in 2014. This species primarily depends on springs and springfed streams for its larval habitat.

Granite Ditch Springs: This site is an anthropogenic forest helocrene created by the excavation of an abandoned dirt roadbed that crosses Granite Creek 50 m downslope from the emergence point. The roadbed focuses seepage against the hillslope and, in 2014, created a semi-saturated zone that was dominated by wetland weeds and encroaching conifers. The site was dry in 2015, but still supported weedy and some non-native wetland plant species. The site lies at N 37.93236°, W -119.9580° at 1333 m elevation. The site was moderately intensively burned by the Rim Fire, with about half of adjacent conifers surviving the fire. The site is dominated by nonnative and wetland plants, but is being actively colonized by sapling pines. Granite Ditch Springs had been lightly grazed in 2015.

Hopeful Springs: The Hopeful Springs ecosystem is a rheocrene springs ecosystem that emerges in the channel of a steep, minor tributary of Cherry Creek approximately 150 m ESE, and slightly downslope from Cordulegaster Springs. Like that neighboring drainage, it descends about 100 m downstream to cross under the Cherry Creek Road before draining into Granite Creek. It is located at N 37.91715°, W -119.96600°, and lies at 1,068 m elevation. In 2014 the springs created a flowing channel that extended downstream, flowing under the Cherry Creek Road. However, the 2015 emergence site was dry in 2015. The channel was densely vegetated with drought tolerant *Ceanothus*, *Cyperus eragrostis*, and weedy species in both 2014 and 2015. The Rim Fire burn intensity at Hopeful Springs was high, killing all trees in the landscape. The landscape remains highly unstable, with extensive erosion and much potential for debris flows due to the large area of upslope drainage and the severity of burn intensity throughout the basin. Livestock impacts were everywhere abundant in 2015, including much trailing, trampling, and feces detected throughout this steep channel rheocrene. Hopeful Springs moist habitat had occupied 42 m^2 in 2014, with none in 2015.

Mosspool Springs: Mosspool Springs ecosystem is a rheocrene springs complex that emerges in an otherwise dry wash from unconsolidated granitic colluvium. The drainage into which the springs emerge passes under a heavily used, upslope logging road upslope, through a culvert. In 2014, the springs source lay at N 37.9180, W -119.977 at approximately 1,187 m elevation (Fig. 2). In 2015, the source had shifted downchannel 30 m to N 37.9174°, W -119.977°, at an elevation at least 10 m lower than in 2014 at approximately 1,154 m (GPS elevation error is much greater than EPE, so the precise elevation shift is unknown at this site). The downslope shift in source position indicates that the water table surface had declined since 2014, likely in response to persistent drought. The springs runout channel flows several hundred m before losing surface flow into the steep valley colluvium of the Cherry Creek drainage.

The Mosspool Springs area was intensely burned by the Rim Fire in 2013, and all coniferous and several massive California oak trees in the vicinity of the springs were killed in that fire. Many dead conifers stand over the springs, and are soon likely to fall. The presence of these dead trees makes work at the site hazardous.

Wetland vegetation regrowth in 2014 was vigorous; however, intensive cattle grazing in 2015 reduced wetland cover greatly and livestock impacts on the site were everywhere conspicuous. In 2014, the Mosspool Springs ecosystem occupied 77 m^2. In 2015, after the upper source shifted downstream, the total area affected by the springs was approximately the same, but of course lay in a different portion of the channel.

Nettle Ditch Springs: Nettle Ditch Springs ecosystem is an anthropogenic rheocrenic hillslope seepage springs complex that emerges from unconsolidated granitic colluvium on a cutbank on the side of narrow, paved, regularly used Cherry Lake Road, at N 37.91944°, W -119.97214°, and 1,142 m elevation. The seepage flows into a wetland vegetation-dominated roadside ditch, and flows 31-35 m to a stone culvert, thereafter passing under the paved Cherry Lake Road (Forest Service Road 01NO7) into a steep valley. The Nettle Ditch springs area was intensely burned by the Rim Fire, and all coniferous and oak trees in the immediate vicinity were killed. Willow and wetland vegetation regrowth was vigorous in 2014. However, cattle grazing intensity was high at the site in 2015 and an actively eroding livestock trail crossed through the site. In 2014, Nettle Ditch Springs ecosystem occupied 228 m^2. In 2015 the upper source shifted downstream 4 m and the total area was measured at 290 m^2. The increased area was due, in part to exposure of another source at this highly unstable site by roadcut erosion and livestock trail erosion, which created additional low-gradient saturated habitat. In 2015 the entire site had been mowed for roadway maintenance.

Salvage Meadow Springs: This former helocrene meadow springs ecosystem lies approximately 50 m downslope from a rather heavily used logging road on a hillslope that was intensively burned by the Rim Fire. It is located at N 37.91839°, W-19.97925° and it lies at approximately 1,187 m elevation (Fig. 3). The site is roughly rectangular in area, measuring 10 x

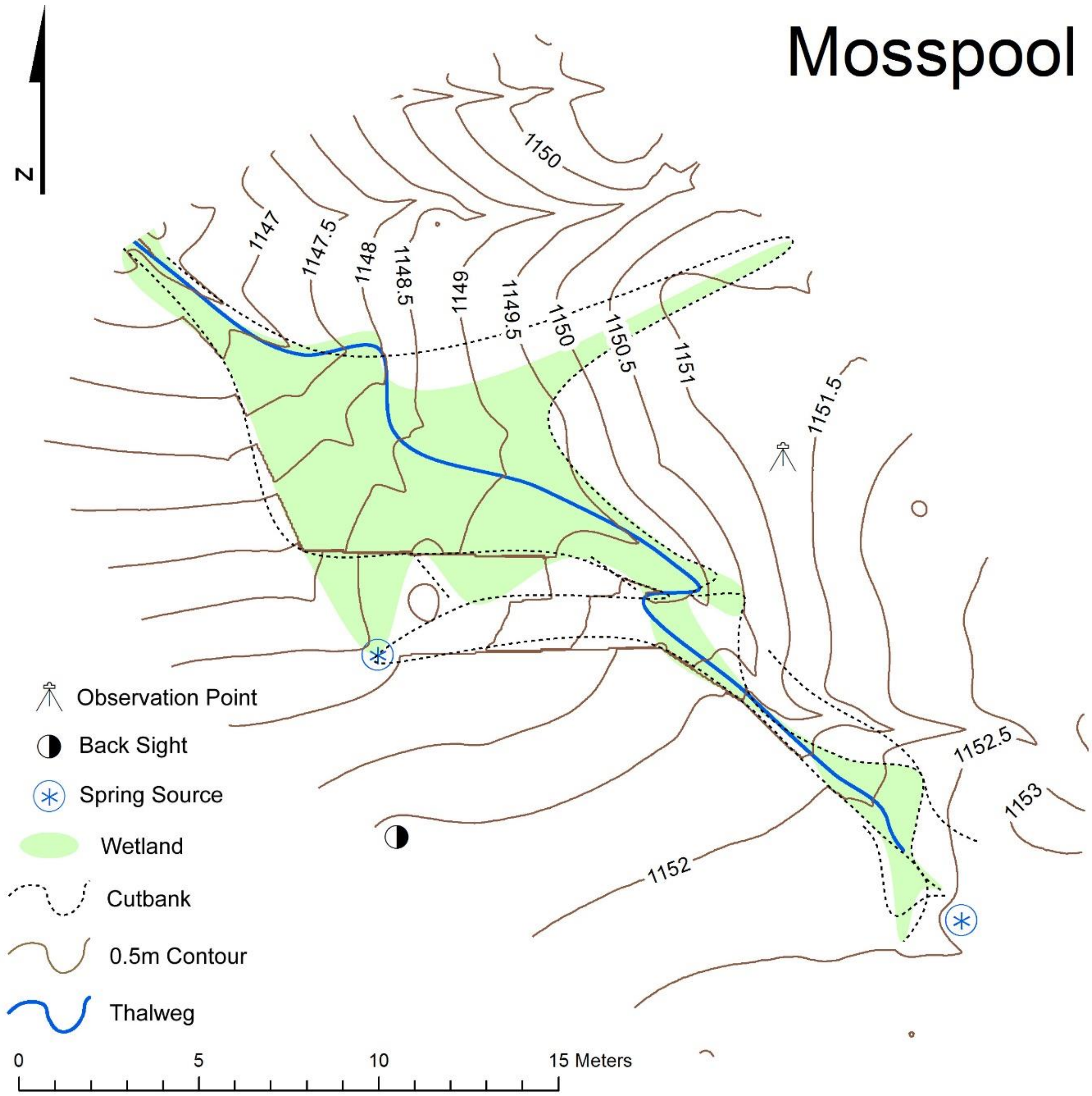

Fig. 2: Mosspool topographic map, September 2015. The Forest Service road (not depicted) lies upslope from the source in the lower right corner of the figure.

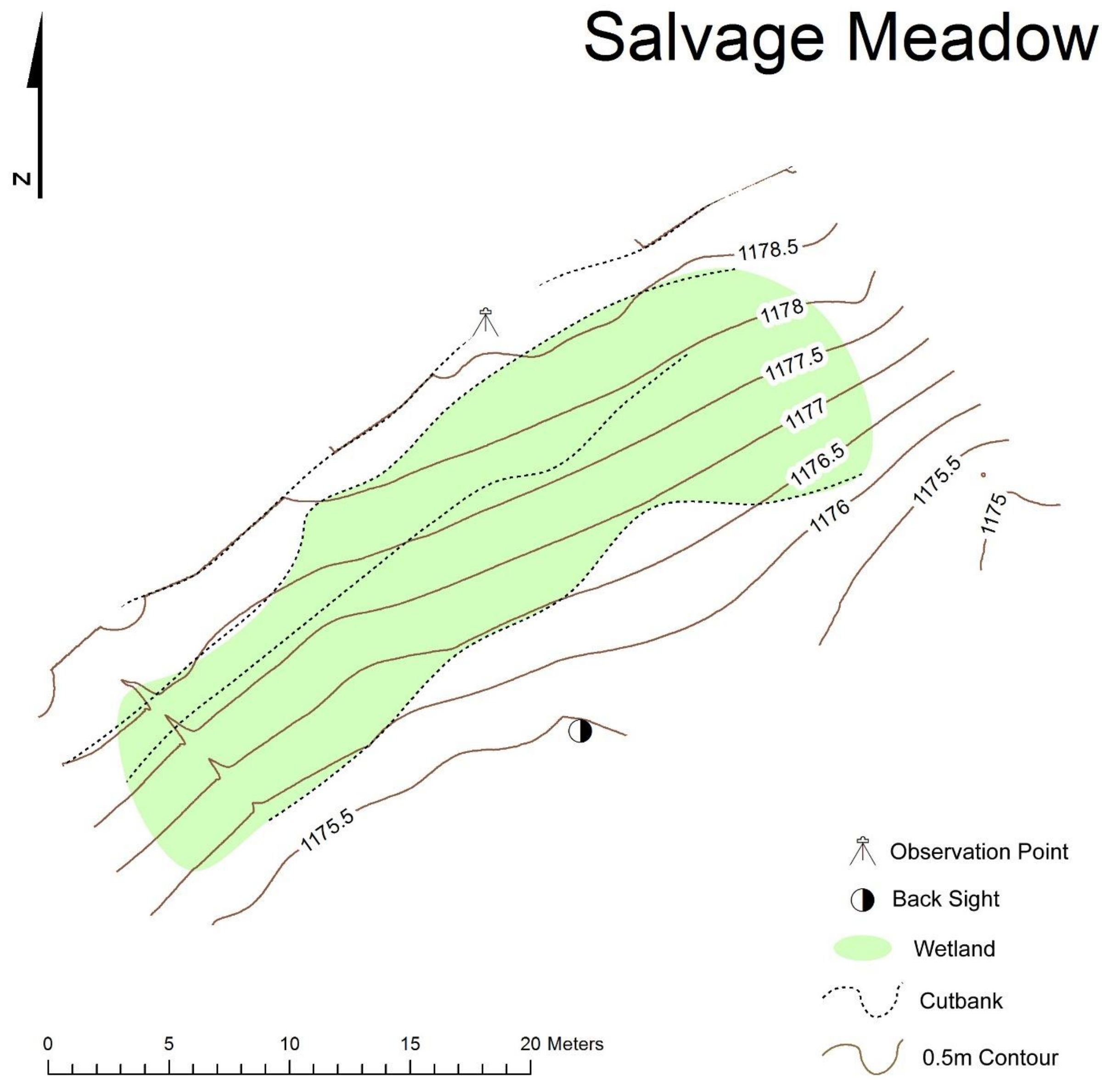

Fig. 3: Salvage Meadow Seep topographic map, September 2015.

30 m. The meadow was drying out by the time of the 2014 inventory, and by mid-September 2015 it had dried entirely. Flow formerly emerged along an upslope seepage line, wetting a meadow for a width of approximately 10 m, and creating a wet meadow approximately 300 m^2 in area that supported several wetland plant species. Livestock trampling and grazing impacts were everywhere evident. A copse of dead fire-killed conifers on the upslope and eastern side of the site threaten the safety of workers if restoration activities take place at this site.

***Spiranthes* Seep:** This site is an anthropogenic forest helocrene immediately alongside FS 1N04 south of the Cherry Valley Dam. The geomorphology is anthropogenic, created by multiple berms on this moderately heavily used dirt road, which blocks seepage and, in 2014, creating a saturated zone. The site was dry in 2015, but still supported wetland plant species, including *Spiranthes* orchids. The site lies at N 37.96794°, W -119.90890° at 1385 m elevation. The site was only lightly burned by the Rim Fire, with most of the adjacent mature incense cedars and pines surviving the fire. The site is dominated by nonnative and wetland plants, but is being actively colonized by sapling incense cedars, orchids and other wetland plant populations, which cannot persist in dense coniferous forest shade.

Tecnu Springs: Tecnu Springs ecosystem is a small rheocrene hillslope seepage complex that emerges from unconsolidated granitic colluvium in and along the channel of a steep, minor tributary on the south side of the Tuolumne River at N 37.89528°, W -119.94019°, and at 869 m elevation. The site is best accessed by descending the ridgeline to the east. The springs create moist soils that extend 7 m downstream from the channel source in a steep, bracken fern-dominated channel. The Tecnu Springs area was moderately intensely burned by the Rim Fire, with about half the trees in the landscape surviving to 2015. Channel and terrace vegetation regrowth was vigorous in both 2014 and 2015. No livestock grazing was detected in this steep, poison-oak dominated canyon. Tecnu Springs moist channel habitat occupied 48 m^2 in 2015, with 94 m^2 of associated, springs-influenced channel, and had changed relatively little between 2014 and 2015.

Towhee Springs: Towhee Springs ecosystem is a small rheocrene springs ecosystem that emerges from beneath semi-consolidated granitic alluvium in the channel of a moderately steep, minor tributary of Cherry Creek at N 37.95635°, W -119. 91800°, and at 1,364 m elevation (Fig. 4). The springs generate a small flow (0.1 L/sec) that flowed 22.5 m from the source before losing into channel alluvium in 2015. The channel becomes increasingly flat and open for the first 5 m, then drops into a deeply incised, *Actaea*-dominated channel. The springs area was a relatively open, sloping meadow and did not appear to have been burned by the Rim Fire, but a previous fire had occurred on the site. Channel and terrace vegetation regrowth was vigorous in both 2014 and 2015. No livestock grazing impacts were detected, but piping, earth movement, broken glass, and a parking lot and primitive roadway that crosses the creek attest to a long history of water extraction and recreational use. Towhee Springs supported 6 m^2 of wet channel habitat, 75 m^2 of terrace habitat, and 270 m^2 of adjacent terrace/anthropogenic habitat in 2015. The site did not change appreciably between 2014 and 2015.

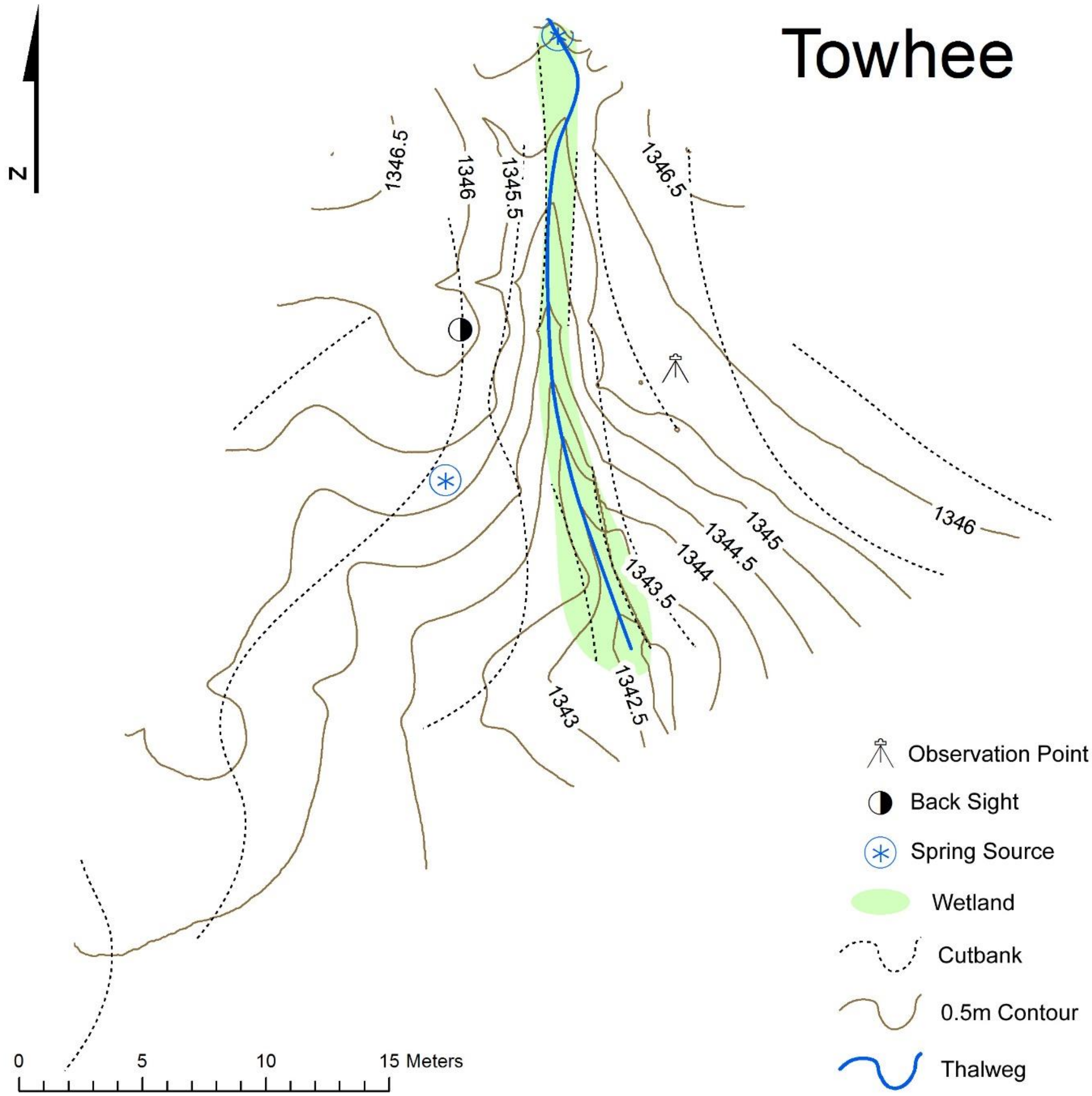

Fig. 4: Towhee Springs topographic map, September 2015.

Task 4. Integrate and report upon the information gathered in (2) and (3), including the rationale for identifying the final list of springs for rehabilitation/restoration planning.

Overview

The selected springs varied in type and configuration on the landscape (Tables 2-4): six of the 10 (60%) were rheocrene springs emerging in otherwise dry drainages, three (30%) were anthropogenic roadside helocrene (marsh-forming) springs, and one (10%) was a former wet meadow helocrene. All of the selected springs had low to zero flow in 2014 and 2015, and three (Granite Ditch, Salvage Meadow Springs, and Spiranthes Seep) were dry in 2015. Access (proximity to roads) varied greatly among sites: many of the selected springs (e.g., Nettle Ditch) lay immediately along or very near roads, while others (e.g., Liverwort Springs) lay about 2.5 km from the nearest road. Several of the springs sources documented in 2014 had shifted downslope in 2015, likely in response to drought-related declining water table depth. Sites with dynamic sources (e.g., Mosspool Springs) are particularly difficult to restore and involve management of a larger area.

We quantified FSMI scoring to evaluate restoration potential using the Forest Service's requested criteria (Table 5). We also conducted SSI SEAP analysis on the 10 springs to compare results (Table 6). Both analyses were generally in agreement, and both suggested that restoration potential and success were likely to be low at the selected sites. None of these 10 springs appear to warrant a major geomorphic restoration effort, except perhaps Towhee Springs (see below). The FSMI geomorphology partial % scores ranged from 20-40%, indicating that geomorphic restoration potential and expected success are both low. We expected that sites where intensive geomorphic restoration would result in improved ecological conditions would have partial geomorphology % scores of >66%, but none of the sites had such scores. In large part, this is because 60% of the springs are rheocrenic channel springs that, so soon after the Rim Fire remain subject to debris flow flooding, and are therefore highly geomorphically unstable. In addition, four of the selected sites proved to be ephemeral, going dry in 2015. The duration of time before flow at these sites recovers (if ever) remains unknown. Lastly, three of the selected sites are anthropogenic roadside wetlands, at which restoration attention is of questionable value.

Low FSMI and SSI SEAP condition score values, and high levels of risk and uncertainty indicates that ecological conditions among the selected springs are generally low and anthropogenic risk scores are relatively high, which indicates that restoration potential is low. Although major geomorphic restoration efforts are not recommended at these sites (perhaps except Towhee Springs - see below), several less intensive rehabilitation actions may be ecologically beneficial (Table 7). The Forest Service (2015) Decision Memo lists several options: removal of encroaching conifers, planting of native species, and digging or hand pulling non-native plant species (Table 7). Of these options, removal of encroaching conifers was identified as a threat only at the anthropogenic Spiranthes Seep, and little regeneration of conifers was detected at most other sites. Site monitoring and removal of such species can take place annually or over several-year intervals to ensure that conifer encroachment does not become a problem. Planting native species should include plugs of wetland species and seeding with

Table 5: Forest Service Management Indicator (FSMI) scores for 10 springs selected for analysis of restoration potential.

Variable No.	Variable	Scores by Springs Ecosystem									
		Cordulegaster Springs	Granite Ditch Springs	Hopeful Springs	Liverwort Springs	Mosspool Springs	Nettle Ditch Springs	Salvage Meadow Springs	Spiranthes Seep	Tecnu Springs	Towhee Springs
a.	Aquifer functionality	---	---	---	---	---	---	---	---	---	---
b.	Watershed functionality	2	2	1	1	3	3	3	3	1	3
c.	Water quality	3	0	3	2	4	2	0	0	3	3
d.	Landform stability	1	2	1	1	2	2	3	4	1	3
e.	Runout channel	1	1	1	1	2	1	3	1	1	1
f.	Soil integrity	1	1	1	1	1	1	2	2	1	1
g.	Vegetation composition	4	4	5	5	4	4	4	4	5	3
h.	Vegetation condition	3	2	2	2	2	2	3	3	2	3
i.	Flow regulation	4	2	4	4	3	1	0	1	4	2
j.	Human impacts	2	2	3	4	2	1	3	1	3	2
j1)	Construction										X
j2)	Road impacts		X			X	X	X	X	X	X
j3)	Herbivory	X	X	X	X	X	X	X			
j4)	Recreation impacts										
j5)	Other: Exotic species	X	X	X	X	X	X	X	X	X	X
k.	Disturbances	1	2	1	1	2	1	4	3	1	3
k1)	Wildland fire	X	X	X	X	X	X	X	X	X	X
k2)	Insect attack										
k3)	Disease										
k4)	Wind throw	X	X	X	X	X	X	X		X	X
k5)	Avalanche/Rockfall	X	X	X	X		X			X	
k6)	Other: Flooding	X		X	X	X	X			X	X
Total Score	**All**	**22**	**18**	**22**	**22**	**25**	**18**	**25**	**22**	**22**	**24**
Percent Score	**All**	**33.3**	**27.3**	**33.3**	**33.3**	**37.9**	**27.3**	**37.9**	**33.3**	**33.3**	**36.4**

Table 6: Comparative analysis of Forest Service management indication (FSMI) scoring and SSI SEAP scoring for 10 Stanislaus National Forest springs in the Rim Fire burn perimeter selected for potential restoration.

Site Name	Inventory Date	FSMI Scores				SEAP Scores	
		FSMI Geo-morph Partial Score	FSMI Geo-morph Partial % Score	FSMI Score	FSMI % Score	Average Natural Resource Condition	Average Anthropo-genic Risk Score
Cordulegaster	8/29/14					**2.8**	**2.5**
	9/15/15	8	26.7	22	33.3	**2.0**	**2.7**
Granite Ditch	8/25/14					**2.3**	**2.6**
	9/17/15	6	20.0	18	27.3	**2.0**	**2.7**
Hopeful	8/29/14					**2.8**	**2.4**
	9/16/15	7	23.3	22	33.3	**1.8**	**2.9**
Liverwort	8/31/14					**2.0**	**2.1**
	9/18/15	6	20.0	22	33.3	**2.0**	**2.1**
Mosspool	8/23/14					**2.3**	**2.7**
	9/15/15	12	40.0	25	37.9	**2.0**	**3.2**
Nettle Ditch	8/22/14					**1.8**	**3.3**
	9/14/15	9	30.0	18	27.3	**1.3**	**3.8**
Salvage Meadow	8/23/14					**2.3**	**2.9**
	9/14/15	11	36.7	25	37.9	**2.3**	**3.0**
Spiranthes Seep	8/24/2014					**2.3**	**2.9**
	9/16/15	10	33.3	22	33.3	**2.0**	**3.0**
Tecnu Springs	9/2/14					**2.5**	**2.5**
	9/17/15	7	23.3	22	33.3	**2.0**	**2.4**
Towhee Springs	8/24/14					**2.3**	**2.6**
	9/16/15	11	36.7	24	36.4	**2.3**	**2.9**

native grasses, but only highly selective planting of woody phreatophytes (e.g., *Cornus*, *Acer*, *Alnus*, and *Salix*) may be recommended. Restoration plantings may result in excessive evapotranspiration that reduces or eliminates surface water availability and wildlife watering value. Many sites sustained intensive invasion by invasive and non-native herbs, particularly non-native thistles, mullein, and grasses. However, non-native plant invasion is likely to vary over time, and may dissipate as the landscapes and overstory vegetation redevelop. Extensive colonization of bull thistle at Liverwort Springs in 2014 did not continue in 2015 – SSI's survey there showed it to be relatively rare in 2015. Several sites may benefit from minor management actions related to modest geomorphic stabilization, livestock exclosure, and native revegetation, and some springs may warrant such actions on the basis of road safety.

Other beneficial management actions at these sites may warrant consideration. Cutting down dead trees around these sites is needed to ensure site and personnel safety if site actions and monitoring are undertaken. Felling of dead trees will be an important safety consideration. Also, exclusion of livestock from springs sources would help limit the impacts of trampling, trailing, and foraging. However, this action has only been authorized at Salvage Meadow Springs. The use of felled dead trees for cattle exclosure is an important, lower-cost option. Lastly, occasional (annual or multiannual) monitoring of these and other valued springs in the Rim Fire perimeter and elsewhere in the Forest will help alert managers to conditions that may warrant management attention.

Below we describe management issues and potential actions at each of the springs selected for evaluation of restoration potential. In some cases, batches of springs are considered together because of similarities in potential management actions.

Restoration Potential and Options for Individual Springs

***Cordulegaster, Hopeful, Liverwort, and Tecnu Springs*:** These four springs all share share low FSMI geomorphic partial and total site percent scores, and comparably low SEAP natural resource scores, along with high anthropogenic risk scores (Tables 5, 6). None of these rheocrene sites warrant geomorphic or native planting attention until the surrounding burned landscape has stabilized. Cordulegaster and Hopeful Springs would benefit from reduction in livestock grazing, but all four sites will remain geomorphically unstable for the foreseeable future regardless of what management actions take place. Reforestation of the adjacent uplands is needed to stabilize those springs, but all have substantial upslope drainage basins that will deliver floods and debris flows through the channels until the landscape is reforested. Therefore, occasional monitoring is the only recommendation for these sites.

Hazard trees will fall across these sites and block wildlife access. Intentionally felling trees might provide the option for temporarily trapping logs parallel to the stream, but such logging actions in steep drainages are difficult and extremely dangerous, and require special training and safety precautions. Because cattle grazing is degrading the springs and surrounding landscape around the Cordulegaster and Hopeful Springs, and there is no ready way to exclude livestock from those sites, reduction of grazing intensity in those areas may warrant consideration. Hand weeding those two springs twice a year may prove useful, and such activity could be coupled with monitoring.

Granite Ditch and Nettle Ditch Springs, and Spiranthes Seep: These three springs are somewhat similar in that they are all anthropogenic landscapes, created by road construction. Variation among them is largely related to the extent of road use, which varies from road abandonment in the case of Granite Ditch Springs, to moderate use of the east Cherry Valley Dam Road that passes by Spiranthes Seep, to regular, fairly high-speed use of the paved Cherry Creek Road as it passes by Nettle Ditch Springs. Quantified FSMI and SEAP restoration assessment analyses conducted on these three springs were comparable (Tables 5, 6), both suggesting little potential success of any restoration actions at these sites. For example, Nettle Ditch Springs received a quantified FSMI score of 18 (27.3%), a low value based on its poor ecological condition and many human impacts. SSI SEAP analysis similarly provided a natural resources score of 1.3 (low rehabilitation potential in relation to a total possible score of 6) coupled with an anthropogenic risk score of 3.8. These SEAP scores indicate this springs ecosystem condition is poor, and the threats are too numerous and irreversible to warrant extensive management attention.

Unless there are major plans to alter the course of the east side Cherry Valley Dam Road or the Cherry Lake Road, we do not recommend Spiranthes Seep or Nettle Ditch Springs for geomorphic rehabilitation, fencing or revegetation. Such actions may interfere with road maintenance and traffic safety. Nettle Springs presents a special challenge, because the water there attracts cattle, which graze and browse wetland vegetation and stand on the road. Due to the steepness of the terrain, livestock have no easy escape route when traffic approaches. Persistent presence of livestock on the road is a safety issue, and signage to warn drivers coming around the tight curves at that section of the road is a minimum recommendation. A more appropriate action at Nettle Springs, and one that can be accomplished as a part of normal road maintenance would be to cover all the water, is to eliminate all wetland vegetation at the source, and entirely divert the flow without making it available to cattle. The flow can be focused into the channel downslope away from the road, where it would help ensure the stability of the road and be more safely available to livestock and wildlife. The other two sites do not warrant management attention, except for occasional monitoring to better understand aquifer responses to climate.

Mosspool Springs: The FSMI score for Mosspool was 25 of 66 (37.9%), one of the higher values of any of these 10 springs, but not a score that indicated that substantial investment in restoration would result in project success. The geomorphology and soils partial score was 40%, similarly reflecting a relatively low probability of restoration success, due to the rheocrenic nature of the site, its apparently dynamic response to climate, and the heavy impacts of both fire and livestock presence there.

The SSI SEAP scoring for this site was comparable to the FSMI analyses, with a low natural resources condition score of 2 (of a possible 6) and a moderately high anthropogenic risk score of 3.2. Elevated risk was attributed to erosion, grazing impacts, the highly degraded condition of the adjacent landscape, all of which in relation to this site as a flood-dominated rheocrene springs ecosystem, contribute to a low likelihood of restoration success.

Rehabilitation options at this site include the following:

1) Felling of the dead conifer and oak trees around the source and the upper 50 m of flowing channel – the presence of those trees presents a hazard to further work on the site.
2) Reduce flood impacts resulting from increased stream power through the upstream road (Forest Road 3N01 South) culvert. Adding boulders to the channel just downstream from the road can be accomplished as part of routine road maintenance, and would likely better protect the road by retarding floodwater velocity, reduce channel scour, and reducing incision at the sources downstream in the channel, allowing those source areas to stabilize.
3) Reconsider the option for excluding livestock from the source. Access to livestock water 50 m downslope from the source would provide ample water for cattle, and would help protect the geomorphology of the source area, allowing wetland vegetation and wildlife habitat to recover and proliferate. Without livestock exclosure, the site will continue to erode and degrade, providing little habitat value for wildlife.
4) Occasional monitoring (e.g., semiannual) to determine the extent of source shifting intra- and inter-annually.
5) Check and remove primary weed species, such as bull thistle and mullein, before they set seed.
6) If grazing and flood impacts are reduced, the site can be replanted with native wetland plugs, seeded with native grasses, planting a few strategically placed maple trees. However, without the protective measures listed above, such efforts are unlikely to be successful, and the degraded condition of the vegetation will continue to contribute to erosion and channel incision.

Salvage Meadow: The FSMI score for Salvage Meadow was 25 of 66 (37.9%), one of the higher values of the 10 springs, but not a score that indicated that substantial investment in restoration will result in project success. The geomorphology and soils partial score was only 36.7%, largely attributable to the loss of groundwater from the site between 2014 and 2015, as well as the heavy impacts of both fire and livestock on the site.

The SSI SEAP scoring for site restoration potential was more favorable, with a natural resources condition score of 2.9 (of a possible 6) and an anthropogenic risk score of 3.0. Elevated risk was attributed to grazing impacts and the highly degraded condition of the adjacent landscape, which reflect high burn intensity and the impacts of salvage logging on the soils and geomorphology of the surrounding landscape.

The Forest Service Decision Memo (2015) permits consideration of excluding livestock grazing at Salvage Meadow: "…Minimize cattle disturbance by creating a barrier at one site (Salvage Meadow)." Our land survey map of this site shows the approximate location of where livestock exclosure fencing can be placed. Such actions may be important if rains restore flow to this wet meadow; however, if flow does not return, even with fencing the site likely will continue to degrade towards the condition of the surrounding near-dysclimax rangelands. If flow does recover, and the exclosure is maintained, planting with wetland species plugs may be warranted to maintain the meadow functionality of this helocrene. We do not recommend planting phreatophytic shrubs or trees here, so as to preserve its meadow characteristics.

Rehabilitation options at Salvage Meadow Springs include the following:

1) Felling of the dead conifer trees at the upslope end – the presence of those trees presents a hazard to further work on the site.
2) Occasional monitoring (e.g., semiannual) to determine the extent of source shifting intra- and inter-annually
3) Check and remove primary weed species, such as bull thistle and mullein on an annual basis prior to seed production.
4) If grazing and flood impacts are reduced, the site can be replanted with native wetland plugs and by seeding with native grasses.
5) Use of the felled conifers to construct a barrier to livestock grazing, as permitted in the U.S. Forest Service (2015) Decision Memo. The area of exclosure can be as small as approximately 300 m^2, but a larger exclosure (400 m^2) would better enclose the area of expected seepage. The exclosure should not preclude native wildlife watering, and so should allow for access by deer and bear. If seasonal or annual increases in precipitation result in return of seepage at the site, some accommodation for flow capture outside the exclosure may be warranted to provide livestock water; however, it remains to be seen whether flow will return to this helocrene. If flow returns, excluding livestock grazing will help native wetland vegetation recover, but without livestock exclosure, the site will continue to erode and degrade, providing little habitat value for wildlife.

Towhee Springs: Towhee Springs was the only site at which geomorphic restoration may contribute to benefit wildlife habitat conditions, but several caveats exist, prominent among them being whether and the extent of contemporary flow abstraction through buried piping. This springs ecosystem has long been used as a local water source, but the SSI team could not discern whether flow abstraction continues there. Resolution of that question, and the associated water rights, is important before proceeding with ecosystem restoration.

The FSMI score for Towhee Springs was 24 of 66 (36.4%), one of the higher values of the 10 springs, but not a score that indicated that substantial investment in restoration will result in project success. The geomorphology and soils partial score was 36.7%, largely attributable to the extent of anthropogenic influences on and around the springs, as well as the impacts of roads and recreation there. The SSI SEAP scoring for site restoration potential was more favorable, with a natural resources condition score of 2.3 (of a possible 6) and an anthropogenic risk score of 2.9. Elevated risk from 2014 to 2015 was attributed to use of the formerly abandoned road and the highly degraded condition of the adjacent landscape. Thus, FSMI and SEAP scoring corroborate high levels of anthropogenic impacts at Towhee Springs.

We first recommend ensuring the source area is protected from flow abstraction, and if abstraction is no longer needed, or is only needed seasonally, that flow is recovered into the drainage. The spring runout stream extends just 22 m downstream from the source, with more than 75% of that channel in a deeply incised streambed and largely unavailable to wildlife. If flow restoration is accomplished, our land survey map of this site shows the approximate location of where a gabion composed of hand-moved large erosion barrier (LEB; woody debris) could be installed to rebuild the stream base level, and create a broader wetland area (Fig. 4).

The cost tradeoffs of such a construction project would have to be weighed against the area of wetland habitat to be created (likely <500 m^2 in addition to the existing springs wetland area).

Livestock grazing intensity does not appear to presently represent a threat at this site. However, if planting with wetland species plugs and highly selective planting of phreatophytic shrubs or trees to preserve its meadow characteristics is desired, livestock exclosure also warrants consideration.

Rehabilitation options at Towhee Springs include the following.

1) Review flow abstraction needs, and return unnecessarily abstracted flow to the site (development of a flow splitter may be used to accomplish this).
2) Occasional monitoring (e.g., semiannual) to determine the perenniality and natural range of variation in flow.
3) Check and remove primary weed species, such as bull thistle and mullein, on an annual basis and prior to seed production.
4) Construct a gabion of LEB woody debris 20 m downstream from the source to restore the stream base level, spread out the limited flow, and increase wet meadow habitat area.
5) Replant the site with native wetland plugs, seeding with native grasses, and strategic planting of phreatophyte trees.
6) Work to reduce deleterious grazing impacts on the site.

Towhee Springs have had a lengthy history of alteration and diversion through piping, and the runout channel is only 22 m long before its water sinks back into the channel floor colluvium. Therefore the expenditure of time and effort on the site may not warrant the cost of the effort. Additional monitoring would help establish whether the springs flow increases during wetter seasons and years.

Task 5. Develop draft and final plans to rehabilitate and restore, to the extent practicable, the natural ecological components, structures, and processes of springs.

Restoration Plans

Overview: In this section we present plans and draft budget for recommended restoration actions by site, including a description of the action, the time frame, the staff needed, logistics, implementation, monitoring, feedback, and outreach. The recommended actions are summarized in Table 7, and itemized by site. Costs may be reduced through condensed logistics integration, cost sharing, and the use of volunteers and Forest Service equipment and supplies. Thus these first estimates of a budget are likely to be reduced through discussions with the Forest Service, collaborators, and partners. Overhead costs are not yet fully included in the following budgets, and will depend on the partners, staffing, and time frame. If all restoration recommendations are accepted, the cost of this restoration effort may, with overhead, reach $121, 499 (Table 7; Figs. 2-4).

Whether some or all of the restoration recommendations are accepted, we strongly recommend that a brief revisit to all 10 springs be conducted prior to further consideration about restoration options. Heavy precipitation during the 2015-2016 winter are likely to have substantially changed site configuration, landscape stability, the distribution of downed trees, and perhaps site access. The costs of a 2-day site review also are not included in the overall

Table 7: Overview of components and draft budget for restoration of 10 selected springs in the Stanislaus National Forest Rim Fire perimeter.

Restoration element	Cordulegaster	Granite Ditch	Hopeful	Liverwort	Mosspool	Nettle Ditch	Salvage Meadow	Spiranthes Seep	Tecnu Springs	Towhee Springs
Cut down hazard trees					X	X	X			
Remove weeds by hand	X	X	X		X		X	X		X
Consider reduction of grazing intensity in area	X		X	X	X	X				
Consider livestock exclosure					X	X	X			X
Add native seed native plugs; add cuttings					X		X			X
Trail construction to limit erosion					X		X			X
Construct LWD gabion to rebuild stream base level										X
Eliminate exposed flow and vegetation						X				
Annually monitor flow, field WQ, and biota	X	X	X	X	X	X	X	X	X	X
Estimated Cost	*$1,253*	*$1,978*	*$1,253*	*$1,253*	*$26,280*	*$18,668*	*$17,014*	*$2,362*	*$1,253*	*$29,935*
Estimated Overhead	*$251*	*$396*	*$251*	*$251*	*$5,256*	*$3,734*	*$3,403*	*$472*	*$251*	*$5,987*
Total Estimated Cost ($121,499)	*$1,504*	*$2,374*	*$1,504*	*$1,504*	*$31,536*	*$22,402*	*$20,417*	*$2,834*	*$1,504*	*$35,922*

budget, but likely would involve Forest Service and NGO staff traveling in one vehicle for 2-3 days. Such a revisit will greatly determine realistic project options, time frames, where savings can be achieved, and refinement of cost estimation.

Cordulegaster, Hopeful, Liverwort, and Tecnu Springs: Occasional (annual-biennial) monitoring is the only management recommendation for all four of these rheocrene springs. Landscape instability limits restoration options at all of these springs. Hazard trees will fall across these sites and block wildlife access. Intentionally felling trees would provide the option for trapping logs parallel to the stream, but such logging actions are difficult and dangerous, and therefore require special training and safety precautions. Because cattle grazing is degrading the springs and surrounding landscape around the Cordulegaster and Hopeful Springs, but there is no ready way to exclude livestock from those sites, reduction of grazing intensity in those areas may warrant consideration. Hand weeding those two springs twice a year may prove useful, and such activity could be coupled with monitoring.

Table 8: Restoration actions and estimated budget for Cordulegaster, Hopeful, Liverwort, and Tecnu Springs.

Site (s)	Task	Description	Unit	Number	Unit Cost	Total Cost
Cordulegaster, Hopeful, Liverwort, Tecnu	Annual monitoring, including databasing and reporting	2 field staff @ 2 hr of site visit time each/site; 12 hr of total field travel time; 4 hr of data entry/site; 8 hr of total annual reporting	hr	52	$50	$2,600
	Hand weeding	2 crew @ 1 day/site + travel time	hr	40	$25	$1,000
	Travel	Mileage from Groveland	mi	200	$0.56	$112
		Per diem	day	8	$25	$200
		Lodging	night	8	$100	$800
	Equipment	Flow and WQ meters, field books and accessories, hand tools	all	all	all	$300
Project subtotal	***All***	***All***	***All***	***All***	***All***	***$5,012***

Granite Ditch Springs: This site is an anthropogenic forest helocrene created by the excavation of an abandoned dirt roadbed that crosses Granite Creek 50 m downslope from the emergence point. The roadbed focuses seepage against the hillslope and, in 2014, created a semi-saturated zone that was dominated by wetland weeds and encroaching conifers. The site was dry in 2015, but still supported weedy and some non-native wetland plant species. The site lies at N 37.93236°, W -119.9580° at 1333 m elevation. The site was moderately intensively burned by the Rim Fire, with about half of adjacent conifers surviving the fire. The site is dominated by nonnative and wetland plants, but is being actively colonized by sapling pines. Granite Ditch Springs had been lightly grazed in 2015.

Table 9: Restoration actions and estimated budget for Granite Ditch Springs.

Site	Task	Description	Unit	Number	Unit Cost	Total Cost
Granite Ditch	Annual monitoring, including	2 field staff @ 5 hr of site visit and travel time; 4 hr of data entry; 2 hr of total annual reporting	hr	20	$50	$1,000
	Hand weeding	2 crew @ 1 day/site + travel time	hr	16	$25	$400
	Travel	Mileage from Groveland	mi	50	$0.56	$28
		Per diem	day	2	$25	$50
		Lodging	night	2	$100	$200
	Equipment	Flow and WQ meters, field books and accessories, hand tools	all	all	all	$300
Project subtotal	***All***	***All***	***All***	***All***	***All***	***$1,978***

Mosspool Springs: The presence of many dead trees at Mosspool Springs makes work at the site hazardous. Wetland vegetation regrowth is vigorous but intensive cattle grazing in 2015 reduced wetland cover greatly and livestock impacts on the site were everywhere conspicuous. In 2014, the Mosspool Springs ecosystem occupied 77 m^2. In 2015, after the upper source shifted downstream, the total area affected by the springs was approximately the same, but of course lay in a different portion of the channel. Removing weeds and monitoring are recommended. If the site is fenced, the site can be rehabilitated with native plantings.

Table 10: Restoration actions and estimated budget for Mosspool Springs.

Site	Task	Description	Unit	Number	Unit Cost	Total Cost
Mosspool	Cut down hazard trees	6 crew, 2 vehicles for 5 days, leave stumps 4' high and fell trees parallel to creek, with stumps as fence posts; install a skirt fence across channel to allow flood debris to pass through; stall flood flow that passes through the road culvert by adding large boulders in a gabion 10 m downstream from the culvert	hr	240	$50	$12,000
	Hand weeding	2 crew @ 1 day/site + travel time	hr	20	$25	$500
	Consider reduction of grazing intensity with exclosure fencing at site	---	---	---	---	---
	Revegetation (if grazing intensity is reduced	Gather and plant native wetland plugs x 200; add 10 pole cuttings of *Salix, Acer*, etc; 2 crew 3 days + travel	hr	50	$50	$2,500
	Annual monitoring, including	2 field staff @ 5 hr of site visit and travel time; 4 hr of data entry; 2 hr of total annual reporting	hr	16	$50	$800
	Travel	Mileage from Groveland, 5 days, 2 vehicles	mi	500	$0.56	$280
		Per diem	day	40	$25	$1,000
		Lodging	night	40	$100	$4,000
	Equipment	Chain saws, gas and cans, hand tools, equipment rental, flow and WQ meters, field books and accessories	all	all	all	$4,000
	Outreach	Signage, videography, communications	hr	24	$50	$1,200
Project subtotal	***All***	***All***	***All***	***All***	***All***	***$26,280***

Nettle Ditch Springs: This spring has been subject to extensive road work, and sustains regular, moderate-speed traffic on the paved Cherry Creek Road. We do not recommend Nettle Ditch Springs for geomorphic rehabilitation, fencing or revegetation. Such actions may interfere with road maintenance and traffic safety. Nettle Ditch Springs presents a special challenge, because the water attracts cattle, which forage on wetland vegetation and stand on the road. Due to the steep terrain, livestock have no escape route when traffic approaches. Presence of livestock on the road is a safety issue, and signage to warn drivers coming around the tight curves there are needed. We recommend covering all the water, eliminating all wetland vegetation at the source by hand and entirely diverting the flow without making it available to cattle. The flow could be focused into the catchment downslope away from the road, where it could be made more safely available to livestock and wildlife. These actions can be part of normal road maintenance activities, as they are needed to ensure the stability of the road and improved road safety.

Table 11: Restoration actions and estimated budget for Nettle Ditch Springs.

Site	Task	Description	Unit	Number	Unit Cost	Total Cost
Nettle Ditch	Cut down hazard trees	6 crew, 2 vehicles, 2 days, safety signage, cones, flagmen; fall logs off roadway	hr	96	$50	$4,800
	Consider reduction of grazing intensity with exclosure fencing at site and in area	---	---	---	---	---
	Eliminate exposed flow and vegetation	4 crew, 3 days, 2 vehicles; excavate ditch, install a French drain to capture flow and direct flow to downstream concrete ditch, gravel over French drain, hand removal of weeds and other vegetation	hr	100	$50	$5,000
	Travel	Mileage from Groveland, 5 days, 2 vehicles	mi	300	$0.56	$168
		Per diem	day	12	$25	$300
		Lodging	night	12	$100	$1,200
	Equipment	Chain saws, gas and cans, hand tools, 50 m French drain; 6 yd^3 gravel; flow and WQ meters, field books and accessories	all	all	all	$6,000
	Outreach	Signage: long-term "cattle on road" signage; videography, communications	hr	24	$50	$1,200
Project subtotal	***All***	***All***	***All***	***All***	***All***	***$18,668***

Salvage Meadow Springs: If this site rewets it may be worth restoration attention; however, if it does not rewet, it likely will continue to degrade into dysclimax like the surrounding land.

Table 12: Restoration actions and estimated budget for Salvage Meadow Springs.

Site	Task	Description	Unit	Number	Unit Cost	Total Cost
Salvage Meadow	Cut down hazard trees	4 crew, 2 vehicles for 4 days, leave stumps 4' high, fell trees parallel to fall line to develop livestock exclosure with stumps as fence posts;	hr	128	$50	$6,400
	Hand weeding	2 crew @ 1 day/site + travel time	hr	20	$25	$500
	Consider reduction of grazing intensity with exclosure fencing at site and in area	---	---	---	---	---
	Revegetation in exclosure	If the site rewaters, gather and plant native wetland plugs x 200; reseed site with 100# native grass seeds; 2 crew for 3 days + travel time	hr	50	$50	$2,500
	Annual monitoring, including	2 field staff @ 5 hr of site visit and travel time; 4 hr of data entry; 2 hr of total annual reporting	hr	16	$50	$800
	Travel	Mileage from Groveland, 13 vehicle days	mi	650	$0.56	$364
		Per diem	day	26	$25	$650
		Lodging	night	26	$100	$2,600
	Equipment	Chain saws, gas and cans, hand tools, equipment rental, flow and WQ meters, field books and accessories	all	all	all	$2,000
	Outreach	Signage, videography, communications	hr	24	$50	$1,200
Project subtotal	***All***	***All***	***All***	***All***	***All***	***$17,014***

Spiranthes Seep: This is an anthropogenic helocrene, created by construction of the east Cherry Valley Dam Road, the berms of which block flow and create Spiranthes Seep. As such, we do not recommend geomorphic recontouring of the site; however, weeding, removal of cedar saplings, and annual monitoring may be warranted. Removal of the invading cedars will protect the Spiranthes and other wetland plant populations there from shading.

Table 13: Restoration actions and estimated budget for Spiranthes Seep.

Site)	Task	Description	Unit	Number	Unit Cost	Total Cost
Spiranthes Seep	Hand weeding, including removal of young cedars	2 crew @ 1 day/site + travel time	hr	20	$25	$500
	Annual monitoring, including reporting	2 field staff @ 5 hr of site visit and travel time; 4 hr of data entry; 2 hr of total annual reporting	hr	16	$50	$800
	Travel	Mileage from Groveland, 2 vehicle days	mi	200	$0.56	$112
		Per diem	day	2	$25	$50
		Lodging	night	2	$100	$200
	Equipment	Hand tools, equipment rental, flow and WQ meters, field books and accessories	all	all	all	$200
	Outreach	Signage, videography, communications	hr	4	$50	$200
Project subtotal	***All***	***All***	***All***	***All***	***All***	***$2,362***

Towhee Springs: Towhee Springs was the only site at which geomorphic restoration may contribute to benefit wildlife habitat conditions, but several caveats exist, prominent among them being whether and the extent to which contemporary flow abstraction occurs through buried piping. This springs ecosystem has long been used as a local water source, but the SSI team could not discern whether flow abstraction continues there. Resolution of that question, and the associated water rights, is important before proceeding with ecosystem restoration.

Site	Task	Description	Unit	Number	Unit Cost	Total Cost
Towhee Springs	Recontour site to raise creek base level and create a wet meadow	5 crew, 2 vehicles for 5 days; close road across stream; recontour runout channel by hand to create larger wet meadow using LEB	hr	200	$50	$10,000
	Hand weeding	2 crew @ 1 day/site + travel time	hr	20	$25	$500
	Consider reduction of grazing intensity with exclosure fencing at site	---	---	---	---	---
	Revegetation (if grazing exclosure is constructed)	Gather and plant native wetland plugs x 200; add 10 pole cuttings of *Salix, Acer*, etc; 2 crew 3 days + travel time	hr	50	$50	$2,500
	Annual monitoring, including	2 field staff @ 5 hr of site visit and travel time; 4 hr of data entry; 2 hr of total annual reporting	hr	16	$50	$800
	Travel	Mileage from Groveland, 15 vehicle days	mi	1000	$0.56	$560
		Per diem	day	35	$25	$875
		Lodging	night	35	$100	$3,500
	Equipment	Rent and transport 2 weed-whackers ; brusher, gas and cans, hand tools, equipment rental, flow and WQ meters, field books and accessories	all	all	all	$10,000
	Outreach	Signage, videography, communications	hr	24	$50	$1,200
Project subtotal	***All***	***All***	***All***	***All***	***All***	***$29,935***

Task 6. Incorporate comments into the revised restoration/rehabilitation action plan. This task will be completed by March 1, 2016.

Task 6 is accomplished by submission of this final report.

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Appendix A: Reports on 10 springs re-visited and inventoried in 2015
(Submitted in electronic format only)

Appendix B: Data compilation
(Submitted in electronic format only:
tables and mapping data for the three sites
at which land survey maps were made