Silver Creek Watershed

An Ecological Enhancement Strategy for Silver Creek, Idaho

Prepared by:

Ecosystem Sciences Foundation

Prepared for:

The Nature Conservancy

Protecting nature. Preserving life.

Acknowledgements

Document designed, researched and developed by Ecosystem Sciences Foundation, 2010. www.ecosystemsciences.com

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Forward

"Flowing at the base of the Picabo Hills, this high-desert spring-fed creek attracts an abundance of wildlife including eagles, hawks, songbirds, waterfowl, coyotes, bobcats, mountain lions, deer and elk. Silver Creek's globally unique aquatic ecosystem features one of the highest densities of stream insects in North America, which supports the world-class fishery.

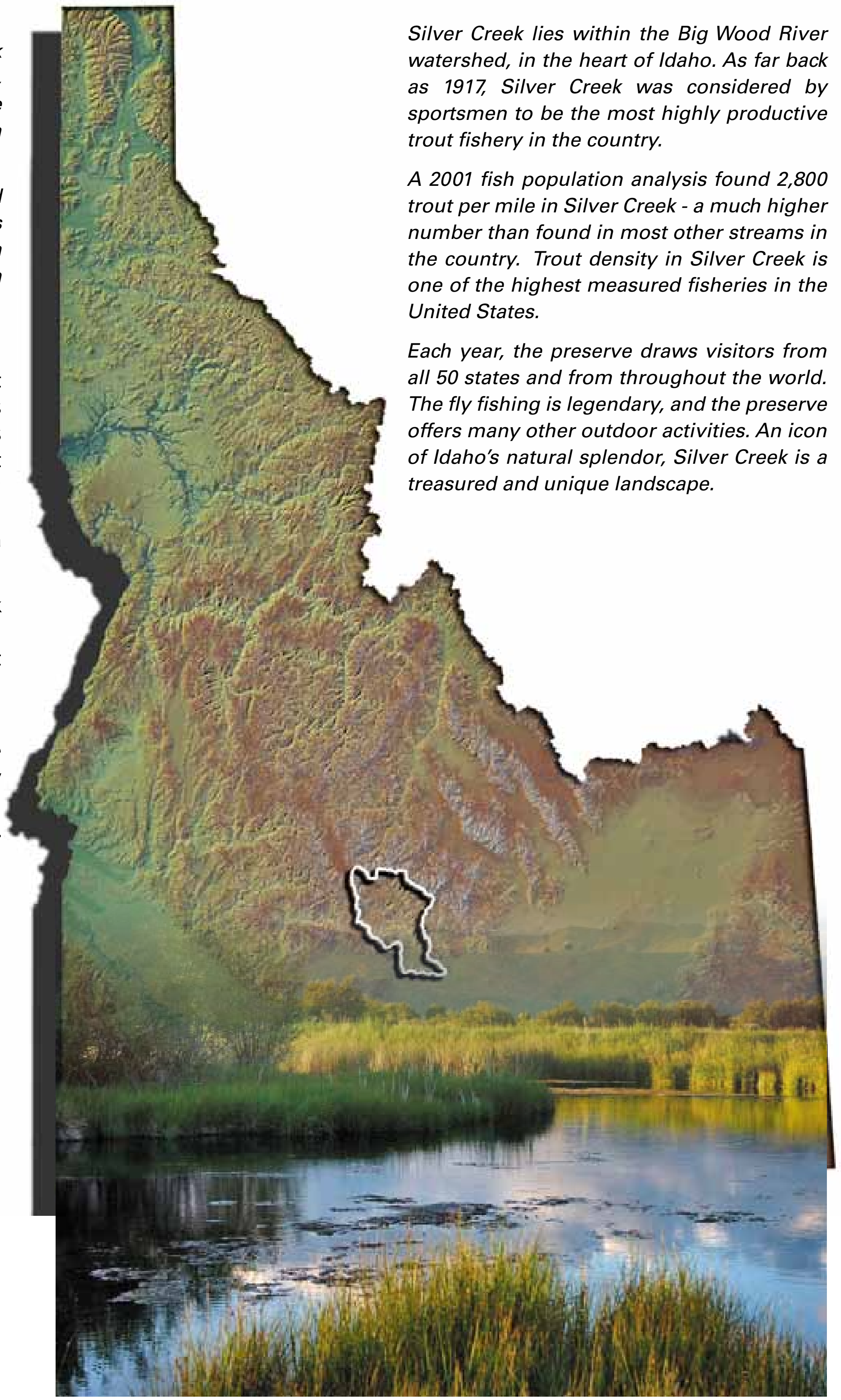
As many as 150 species of birds have been identified along the self-guided nature trail, which begins at the preserve visitor center. The Conservancy owns 883 acres along Silver Creek and has protected more than 9,500 acres through conservation easements, making this one of the most successful private stream conservation efforts ever undertaken for public benefit."

- The Nature Conservancy

This restoration and enhancement plan for the Silver Creek Preserve is the result of a partnership between The Nature Conservancy (TNC) and Ecosystem Sciences Foundation (ESF), and with valuable input from stakeholders. Funding from TNC was matched by ESF; scientists from both organizations collaborated on the development of the plan, and input from knowledgeable stakeholders was critical to understanding both current and historic land and water uses. It is hoped that this partnership will endure and continue to provide the focus and cooperation needed to implement a long-term restoration and enhancement plan.

The comprehensive plan was developed to identify areas or reaches of Silver Creek and its tributaries that most need help, and to use the restoration methods that will have the most conservation benefit. The effort will result in habitat objectives that benefit the fishery as well as many wildlife species, habitat and overall ecological health.

For the past 35 years, Silver Creek has been a successful conservation project due to community support. The enhancement plan is likewise driven by community involvement, with input from stakeholders. The public has been invited and encouraged to participate and voice their views and thoughts throughout the project.



Silver Creek lies within the Big Wood River watershed, in the heart of Idaho. As far back as 1917, Silver Creek was considered by sportsmen to be the most highly productive trout fishery in the country.

A 2001 fish population analysis found 2,800 trout per mile in Silver Creek - a much higher number than found in most other streams in the country. Trout density in Silver Creek is one of the highest measured fisheries in the United States.

Each year, the preserve draws visitors from all 50 states and from throughout the world. The fly fishing is legendary, and the preserve offers many other outdoor activities. An icon of Idaho's natural splendor, Silver Creek is a treasured and unique landscape.

Contents

Introduction

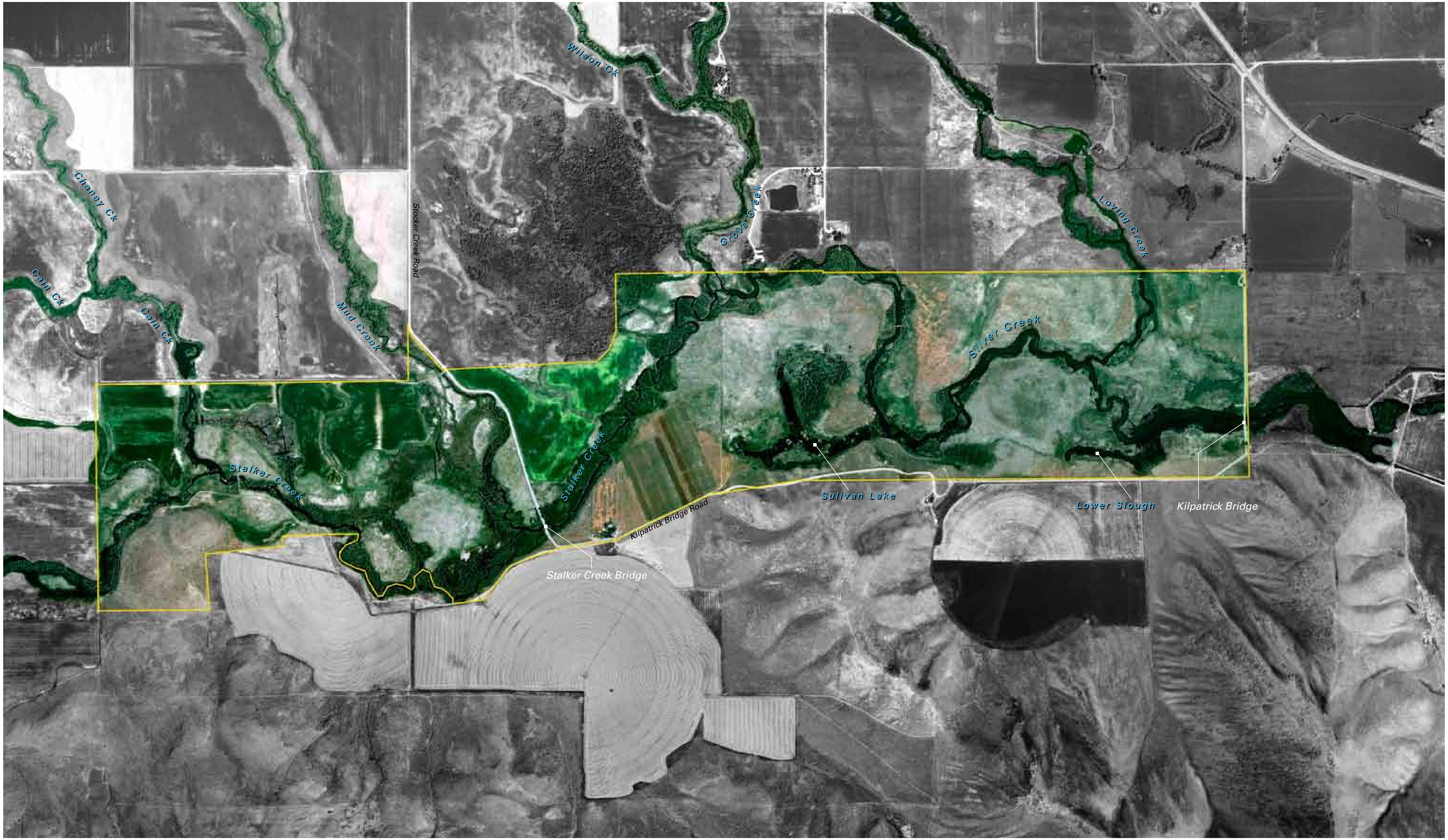
The Nature Conservancy's (TNC) Silver Creek Preserve protects one of Idaho's premier streams that is renowned for its trout fishery. The preserve is a centerpiece of TNC's presence in Idaho. Under TNC's management, the preserve has recovered from a history of degradation ranging from intensive livestock grazing to overfishing. Still problems remain, and Silver Creek, Loving Creek and other streams in the watershed suffer from elevated water temperatures and heavy accumulations of sediments.

Numerous restoration actions have been undertaken in the past to ameliorate or remove some of the most pernicious conditions. Some of these interventions were more successful than others. TNC recognizes the need to address the enhancement and restoration of Silver and Loving creeks at a watershed scale rather than simply from within the preserve boundaries. Restoration planning must take upstream influences and downstream connections as well as greater ecosystem inputs into consideration. Currently, these streams are not at the threshold or tipping point at which fish kills occur or where other traumatic biological impacts will occur. Thus, there is time to allow for nature to do some of the heavy lifting, allowing for ecological processes to develop, and allowing self-organization to be the driving force.

Time is critical to any restoration project. Restoration goals are met on biological, not political, time scales. Measuring restoration success must take into account the time needed for natural processes to achieve goals. While streams are often "engineered", the measure of success comes in time and whether the restoration actions ultimately achieve the biological goals. The goals for the restoration and enhancement of Silver and Loving creeks are, ultimately, biological. Reducing temperature inputs and sediment loading, for example, has the end goal of improving habitat and water quality conditions for the trout fishery. How well the fishery responds to temperature and sediment restoration actions will not be instantaneous, but will be measured (monitored) over time.

What makes Silver Creek and its surrounding watershed so unique is that it is largely a spring driven ecosystem. Unlike most streams in the Intermountain West, Silver and Loving creeks, and all the other streams within the subbasin, are a consequence of springs emanating from the aquifer. Irrigation and precipitation do influence the ecosystem, but the streams were created by the interplay of geologic and climatic forces long before human development.

Silver Creek is decidedly unique, and as such, will require careful planning and cautious in-channel actions. This plan identifies priority sites for restoration and enhancement and provides a three-tiered approach to intervention, with the first tier representing the least cost and least disruptive methods, and each successive tier representing more cost and more in-channel actions. Most stream restoration is undertaken as a consequence of degradation in which the fishery has been decimated or extirpated. Silver Creek is quite different in that the fishery is not only present, but is also one of the highest quality trout streams in the West. Therefore, restoration must be performed so as to cause no harm or impact to a thriving, high quality fishery.



Silver Creek Preserve

Aerial Image Mosaic

Data:
Image: June 24, 2009 USDA Farm Service Agency
Image processing by Ecosystem Sciences

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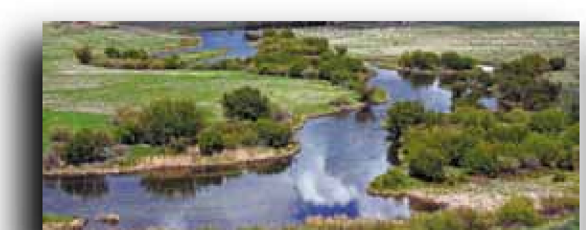
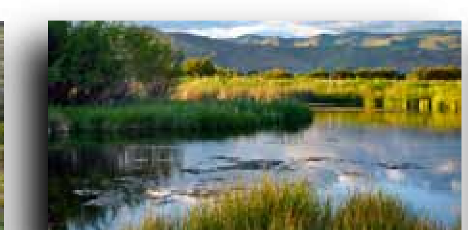
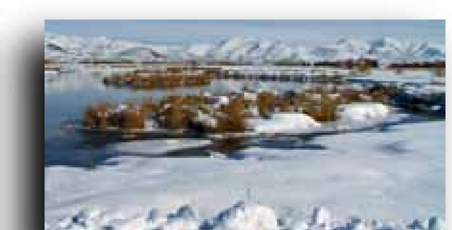






THE NATURE CONSERVANCY
Silver Creek Preserve

Mapping and analysis by:
Ecosystem Sciences Foundation

Map 1

Section 1: Purpose

Section 1: Purpose

Overview and Background

Since 1976, The Nature Conservancy (TNC) has worked with individuals and partners to protect more than 10,000 acres of working farms, uplands, wetlands and riparian areas in south-central Idaho's rich Silver Creek watershed. The watershed includes the Conservancy's 880-acre Silver Creek Preserve, a world-class fishery located at the base of the Picabo Hills.

TNC's management efforts in the watershed have benefited habitat, improved water quality and increased land values due in part to improved recreational fishing opportunities. A recent study commissioned by the Conservancy, however, suggests that Silver Creek continues to be threatened by a wide range of stressors that include high summer water temperatures, decreased flows, and invasive species (Gillian 2007).

After years of studies, research and management lessons, TNC initiated this current planning effort to develop a comprehensive enhancement plan to guide restoration efforts. The purpose is to implement a holistic management approach at the watershed scale, so that causes of degradation or impacts are addressed rather than just treating symptoms at the stream level.

The map on page 4 shows the Silver Creek Preserve and its watershed. By virtue of its position within the watershed, the preserve is heavily influenced by land and water uses outside its boundaries. Silver Creek receives sediment and thermal loading through the numerous upstream tributaries in the watershed; up-gradient surface water diversion, groundwater pumping, and reduced spring flows also influence Silver Creek's ecological condition.

A watershed scale plan recognizes that Silver Creek, Loving Creek and other tributaries are not isolated, and the conditions of one stream or area of the watershed can influence others. Therefore, this enhancement and restoration plan is intended to look beyond the Conservancy's immediate preserve boundary and work cooperatively with adjacent landowners and other watershed stakeholders to benefit all ecosystem components.

The plan is also intended to be dynamic in that it will evolve over time in response to environmental changes. The climate and land and water uses throughout the watershed will change over time, which can present new challenges to ecosystem health as well as improve current conditions. The plan must be flexible and adaptable to meet these future challenges and conditions; as a result, this plan includes a defined monitoring and adaptive management program.

Goals and Objectives

The fundamental goal is to implement a plan that will protect and enhance the Silver Creek Preserve and its greater ecosystem. Inherent in this goal is the obligation to maintain the high quality trout fishery of the preserve. Attaining this goal requires meeting immediate objectives of reducing the principal threats from sediment and thermal loading throughout the watershed, and engaging multiple stakeholders in developing a long-term vision for the management of the watershed.

Objectives to attain the goals include:

- Prioritizing sites throughout the watershed to reduce sediment and temperature loading, and address deposition and channel conditions (stability and erosion)
- Implement a three-tiered restoration program
- Initiate monitoring and adaptive management to inform and guide long-term restoration
- Encourage and foster continued stakeholder input

Approach

The approach for Silver Creek is decidedly unique and different from other stream restoration projects, and requires very careful planning and cautious in-channel actions. Most stream restoration is undertaken as a consequence of degradation in which the fishery has been decimated or extirpated. Silver Creek is different in that the fishery is not only present, but it is one of the highest quality trout streams in the West. Therefore, restoration must be performed so as to cause no harm or impact to a thriving, high quality fishery. For example, planning and implementation must be cognizant of brown trout and rainbow trout timing. Brown trout spawn in the fall and incubation occurs overwinter with fry emergence in early spring. Rainbow trout, on the other hand, are early spring spawners with incubation into early summer (temperature dependent). This leaves a relatively narrow window in which to perform instream actions and avoid impacts to trout spawning and redd incubation. This is particularly important if the restoration action is upstream from critical spawning and early rearing habitat.

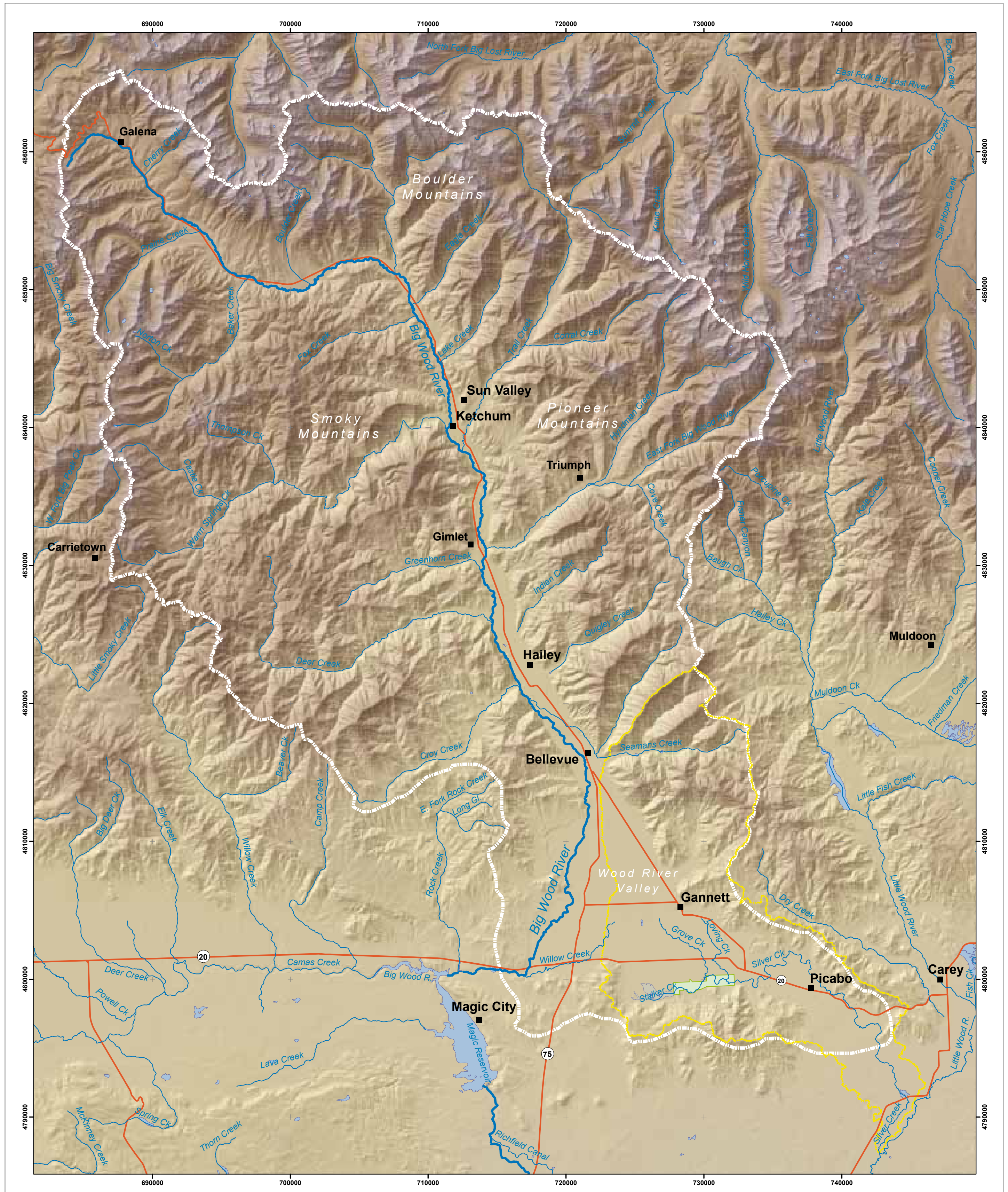
A second condition that makes Silver Creek different from other restoration projects is that it is a spring system. Silver Creek emerges as springs and inflows from Buhler Drain, Patton, Cain, Mud and Chaney creeks, which form Grove and Stalker Creeks and then Silver Creek, which is joined by Loving Creek (Brown 2000 & 2001). Silver Creek tends to rise and fall with Big Wood River flows, such that precipitation, groundwater inflow and, to some extent, irrigation, all influence the stream (Moreland 1977). Silver Creek experiences a bi-modal (two high flows) hydrograph. There is a peak in the spring (usually in March) due to snowmelt and spring rains. This is generally the high flow for the year. Except in extreme water years, high flows in Silver and Loving creeks lack the energy to modify geomorphic surfaces or cause excessive erosion or sloughing. Low flows occur in June or July. Flows rise in late summer and fall until they reach a second peak in late Fall early winter. This reflects the lag time and influence from groundwater and overland irrigation inflow. However, the rise is minor (20 to 25% increase) when compared to Intermountain West streams in which freshet flows can be 200% higher than base flows. Nevertheless, this influence from groundwater and irrigation in late summer/early fall makes Silver Creek unique among spring systems, which generally have relatively steady year-round flows, or experience only early spring highs associated with snow melt and precipitation.

Restoration planning must take upstream influences, downstream connections, as well as greater ecosystem inputs, into consideration. Passive restoration techniques (removing degrading actions or conditions) should be employed in most situations; however some situations will require more active interventions. Given the fact that Silver and Loving creeks are not isolated from the rest of the watershed, management must be done from a watershed-wide perspective. This means considering all of the influences within the watershed, including current and historical land use.

Stakeholders and Partners

The Conservancy has actively promoted developing strong ties with stakeholders throughout the watershed. Cooperation with adjacent landowners, along with the establishment of conservation easements, have been instrumental to the management of the preserve since its inception. The success of restoring and enhancing the watershed depends upon the continued goodwill and collaboration with stakeholders. Included in this effort are the various state and federal resource agencies that have provided assistance and advice over the years. Government agencies and universities have proven to be necessary and valued partners.

This plan incorporates stakeholder participation in a very meaningful and active way. Stakeholders have had opportunities to provide input on recommended restoration actions included in this plan and it is anticipated they will assist in making adaptive management decisions to ensure the success of these restoration activities. The plan does not obligate any stakeholder or landowner to comply with any elements of it; rather, it is hoped that stakeholders will recognize the value in coordinated actions that provide multiple or synergistic benefits. Funding for watershed restoration activities can often be a limiting factor—a detailed listing of funding sources for stakeholders to collectively or individually pursue is provided in the appendices of this plan. A number of private and public funding sources are identified. The USDA Natural Resource Conservation Service has many programs and cost-share opportunities to improve resource conservation on agricultural lands or restore wetlands (for example), and the U.S. Fish and Wildlife Service's Idaho Partners for Fish and Wildlife Program has funded several local projects in the watershed. Because funding priorities and deadlines can change from year to year, stakeholders are encouraged to consult the websites provided in the table for the most up-to-date funding information.



Watershed Map

Big Wood River Watershed

0 1.5 3 6 9 12 Miles

Map Data:
Delineated by IDWR
Crosses divide into Little Wood River Watershed

Legend

- City
- Rivers and Creeks
- Highway
- Silver Creek Preserve
- Big Wood Watershed
- Silver Creek Watershed

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Oblique Aerial

Big Wood River Watershed

Watershed Statistics:

The Nature Conservancy

Silver Creek Preserve

Map 2

Mapping and analysis by:
Ecosystem Sciences Foundation

Section 2: Environmental Setting and Resources

Watershed

Watersheds are bounded by a ridgeline, or elevation contour, that delimits a drainage basin, or catchment. Within each catchment ecological processes are complex and interdependent to create an ecosystem. Human intervention to divert water for agriculture, power production, flood control, etc. has altered the natural processes in many watersheds. This plus destructive land uses have degraded watersheds resulting in nonfunctioning ecosystems that increasingly are unable to provide basic and sustainable water resources.

Since water naturally flows down hill from the watershed boundary through the drainage basin, the watershed is the integrating influence for both natural and human uses and processes within each catchment. We therefore use the watershed as the natural ecosystem boundary, and the area of influence for interventions to restore ecological function and sustainable water supplies and resources. Planning and sustainable development is most effectively done at the watershed or catchment level.

Sound land use and water use management must include interventions at the watershed level, as well as at the government policy level to influence and foster improved management. Water policies must be adaptable to changing conditions and predicated on the recognition that functional watershed ecosystems are essential to sustainable development. The future of effective and sustainable water resource management demands cooperative ecosystem management by local stakeholders as well as state agencies.

The goal of sustainable watershed management is, therefore, to align human uses of resources (e.g., forestry, agriculture, water storage and diversion, hydropower, navigation) with the available water supply to sustain watershed ecological function and human activities.

Silver Creek Watershed

The Silver Creek watershed is located in south central Idaho in Blaine County. The watershed encompasses roughly 68,000 acres (USDA 1996), the majority of which supports some form of agriculture (alfalfa, barley, wheat and pasture). The Silver Creek watershed is surrounded by mountains rising 2,000 to 3,000 feet above a generally flat valley floor (USDA 1996). Elevations range from 7, 988 feet at Bell Mountain to 4,650 feet where Silver Creek confluences with the Little Wood River. Over 64% of the land in the watershed is privately-owned, while 30% is administered by the federal government (Bureau of Land Management [BLM]) and the remaining 6% lands are owned by the State of Idaho (USDA 1996).

Silver Creek is a spring driven system. The underground springs that supply the surface water in the watershed emerge primarily in the north near Gannet, Idaho, although spring vents occur throughout the watershed. Silver Creek is actually considered to be part of the Little Wood River watershed (USDA, 1996), although the waters of Silver Creek are supplied by groundwater flowing from the Big Wood River watershed. The major tributaries of Silver Creek, most notably, Loving, Grove, and Stalker creeks, merge to form Silver Creek, which then flows in a southeasterly direction towards its confluence with the Little Wood River south of Carey, Idaho.

Geology

The complex geology of the Silver Creek watershed has been influenced by volcanic eruptions, glacial activity and the Big Wood River. The watershed is located within the Big Wood River valley, which is a structural depression that has filled with sediment. More than 3 million years ago during the Pliocene Epoch the Big Wood River flowed southeast past the present town of Picabo, Idaho (USDA 1996). A basalt flow during the Pleistocene (less than 2.5 million years ago) epoch dammed the Big Wood River creating a large lake within the river valley. Over time, the lake rose in elevation, which allowed the Big Wood River to carve a new outlet to the southwest near Stanton Crossing, near its present location (USDA 1996). Subsequent basalt flows during the Pleistocene dammed the new outlet alternately causing the Big Wood River to flow to the southeast and then to the southwest. Concurrent with the basalt flows and lake formations were periods of alpine glaciation in the headwaters of the Big Wood River (USDA 1996). Glaciers advanced and retreated throughout the Pleistocene, often creating a lake in the Big Wood River Valley, and leaving coarse grained, poorly sorted materials over the valley. This sequence of events caused the deposition of alternate layers of coarse and fine grained sediments that comprise the current aquifer system (USDA 1996).

The primary soils in the Silver Creek watershed are the Little Wood – Balaam-Adamson complex, Picabo-Hapur-Bickett complex, and the Friedman-Elksel-Starhope complex (USDA 1996). The Little Wood-Balaam-Adamson complex is a very deep, well drained soil formed on alluvial slopes of 0 to 4%. This complex occurs within the northern portions of the watershed. The Picabo-Hapur-Bickett complex occurs in the southern third of the watershed and is a very deep, somewhat poorly drained soil that formed on alluvial slopes of 0 to 2%. The Friedman-Elksel-Starhope complex, found in the eastern and southern portions of the watershed, are a moderately deep soil formed in colluvium and residuum derived from volcanic rocks on slopes of 4 to 60%.

Climate

The climate in Idaho varies from west to east. Western Idaho's climate is heavily influenced by the Pacific Ocean and experiences wet winters and dry summers, while eastern Idaho experiences more Continental climatic influences, with heavier precipitation in summer than in winter (Climate of Idaho 2010). Elevation also has a major influence on Idaho's climate, with higher elevations receiving greater amounts of precipitation and lower overall temperatures.

Given the Silver Creek watershed's central location in the state, it is influenced by both the Pacific Ocean and Continental climate patterns; its higher elevations also influence the climate in the watershed (a majority of the watershed occurs above 5,000 feet). The Silver Creek watershed generally experiences a 30°F annual temperature variation, with an average low of 28°F and an average high above 57°F. Lowest temperatures occur in winter. January lows, for example, average below 10°F. High temperatures occur in July with averages over 85°F. Annually, the area receives 13 inches of precipitation, most of which falls from December to May—less than 20% of the total falls as snow during the winter months (Picabo, Idaho station 107040).

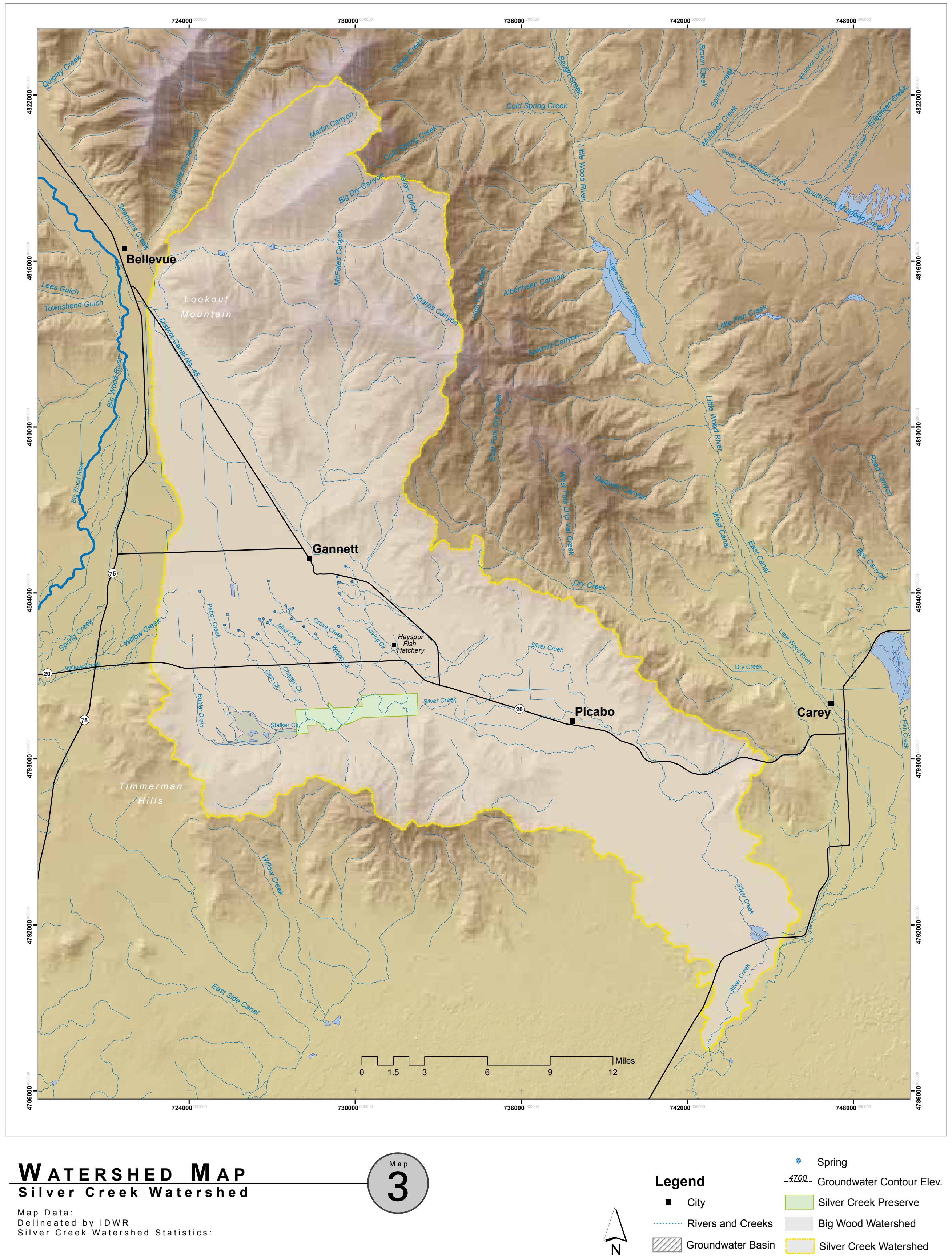
Silver Creek, Idaho

Hydrology

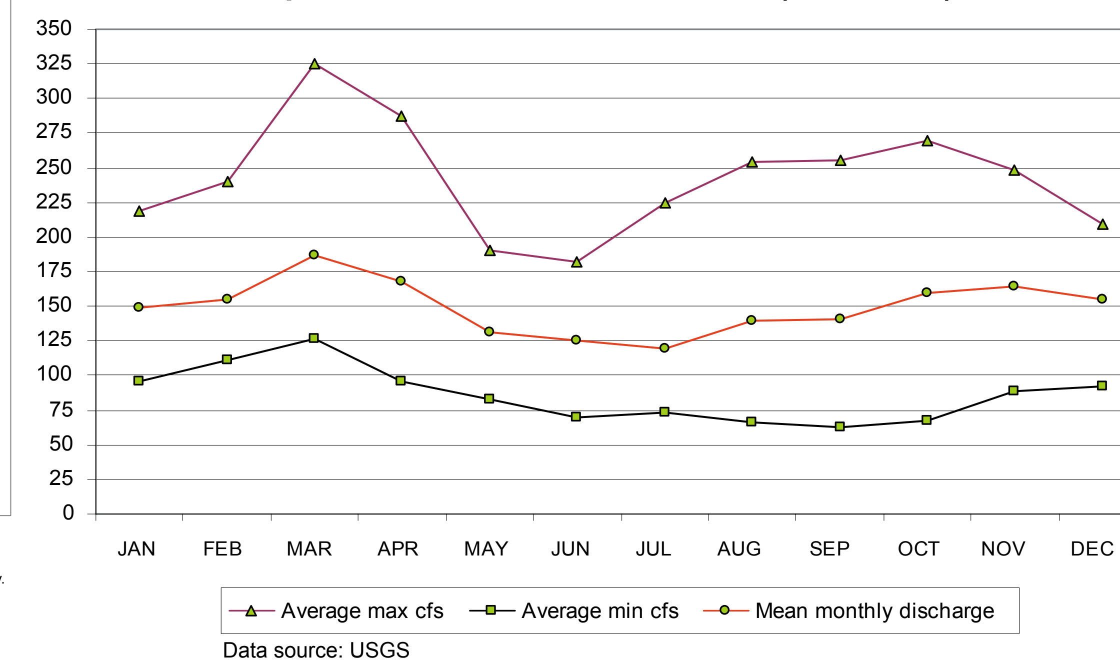
As mentioned above, Silver Creek is a spring driven system. Groundwater emerges from springs and seeps throughout the watershed to form the main tributaries of Silver Creek. Groundwater within the system is recharged by subsurface flows (which are fed from the Wood River Valley Aquifer System), as well as snowmelt, precipitation and to a large extent by irrigation. Hydrographs of the Silver Creek tributaries show flows generally rising in the early spring to the annual peak (usually in March). Flows then decline through spring and summer to the low-flow in late summer. Flows begin to rise in the late summer through the fall usually culminating in a second peak in late fall. Generally, however, the flows in Silver Creek have been observed to rise and fall in proportion to the flows in the Big Wood River, which demonstrates the hydrologic link between these two systems (Brockway and Kahlown 1994; Brown 2001).

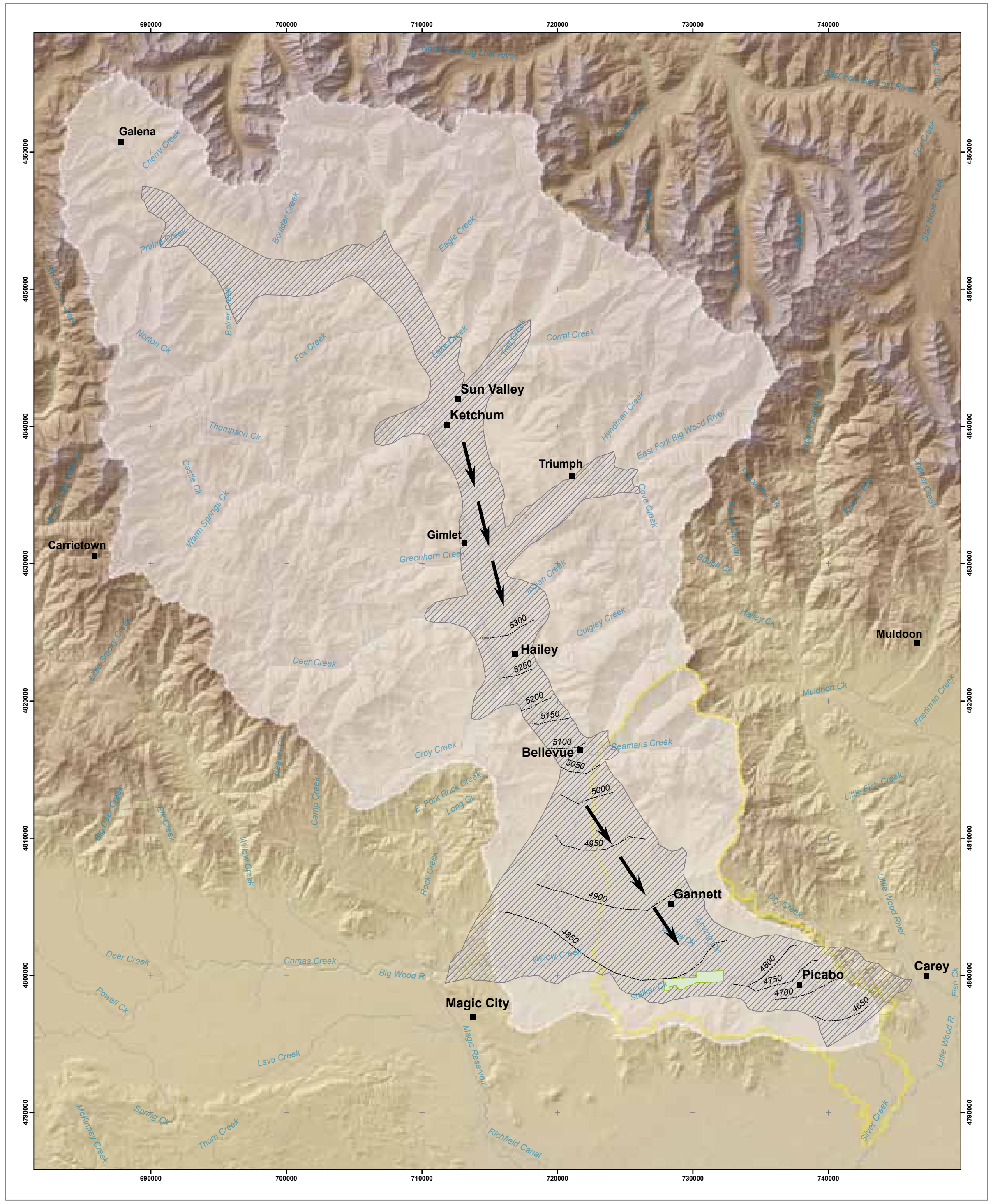
The tributaries of Silver Creek are spring-fed creeks that join to form greater Silver Creek. Stalker Creek and its tributaries Chaney and Mud creeks, emerge in the western part of the watershed and flow in a northwest-to-southeast direction. Stalker Creek encompasses roughly 52% of the overall watershed but comprises only 32% of the discharge (Perrigo 2006). Grove Creek emerges in the north part of the watershed southeast of Gannet, Idaho. Grove and its tributary Wilson Creek occupy only 26% of the Silver Creek watershed, but contribute nearly 50% of the overall flow (Perrigo 2006). Loving Creek's headwaters are located in the northern part of the watershed, where springs emerge to the east and south of Gannet. Loving Creek occupies only 22% of the watershed and contributes 27% of the overall flow in Silver Creek (Perrigo 2006).

Silver Creek and its tributaries are low gradient streams (<1%), generally dropping less than 15 feet per mile (Perrigo 2006). These low gradient streams meander through the flat Big Wood River valley at low velocities. Low gradient, low velocity streams are typical of spring driven systems in which discharge is generally constant, with only very slight seasonal changes.



Average maximum/minimum flows for Silver Creek at Sportsmans Access near Picabo (1974-2007)





Groundwater Basin Flow Contours Map

Big Wood River Watershed

Map Data:
Delineated by IDWR
Crosses divide into Little Wood River Watershed

Legend

- City
- Rivers and Creeks
- Groundwater Basin
- 4700 Groundwater Contour Elev.
- Silver Creek Preserve
- Big Wood Watershed
- Silver Creek Watershed

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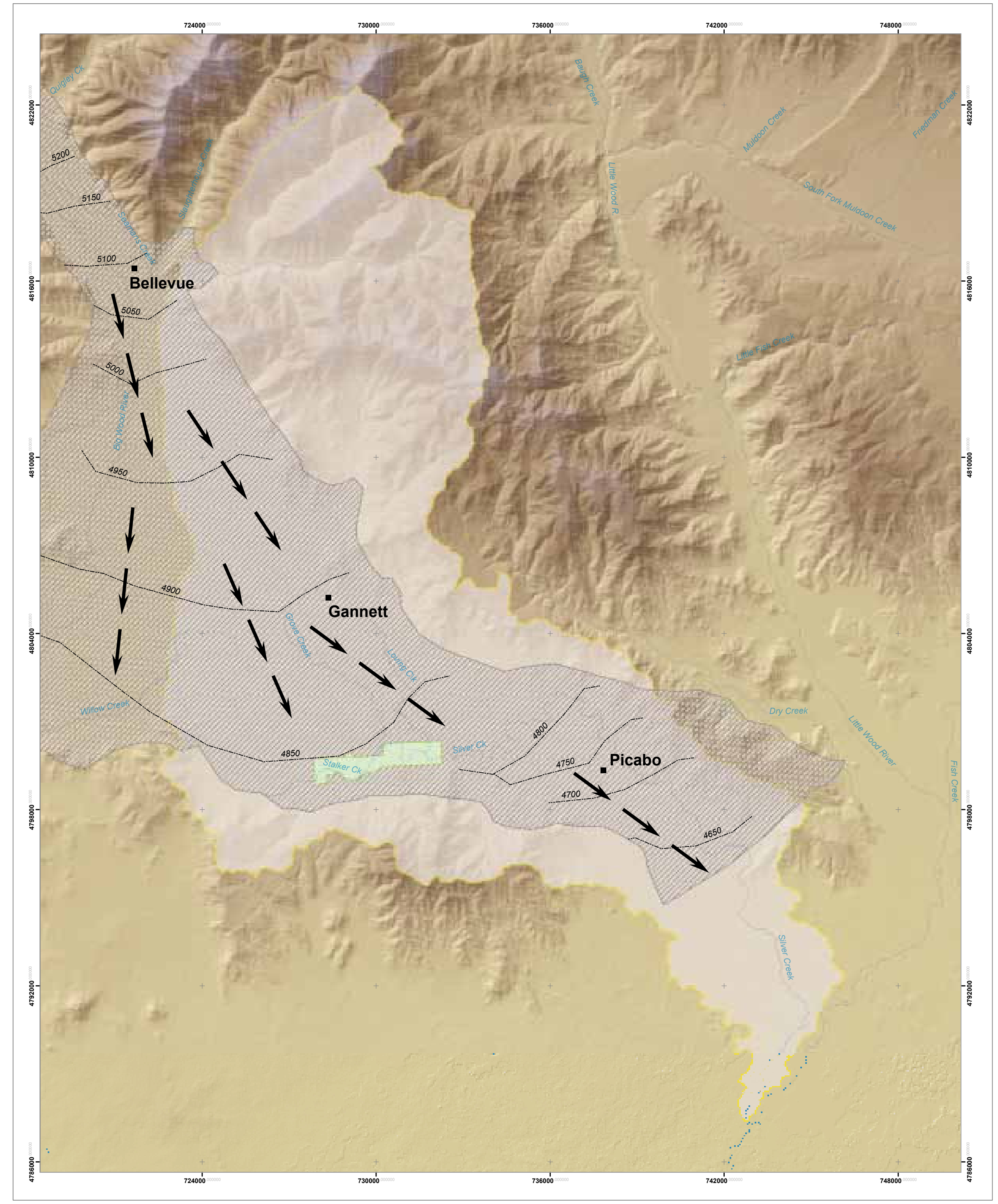


Groundwater Basin Flow Contours Map

Silver Creek Watershed

Data:

The Nature Conservancy
Silver Creek Preserve
Map 4
Mapping and analysis by:
Ecosystem Sciences Foundation

Groundwater

Groundwater is the major source of surface water within the Silver Creek watershed. Generally, this groundwater originates from precipitation in the upper Big Wood River watershed (Smith 1959). This precipitation is carried off by streams, some evaporates, and the remainder percolates into the ground. Silver Creek streamflow gain is the largest outflow from the Big Wood River aquifer system, as approximately 100,000 acre-ft/yr enters Silver Creek watershed from the Wood River Valley Aquifer system each year (approximately 37% of the aquifer outflow) (Bartolino 2009). This large volume of groundwater follows the slope of the water table south, underneath the Big Wood River valley, towards the Silver Creek watershed. Maintaining this inflow into Silver Creek from the Wood River Valley Aquifer System is critical to preserving the Silver Creek Ecosystem.

In the northern part of the Silver Creek watershed, groundwater moves in a southerly direction, where it follows the surface drainage (USDA 1996). In the southern section of the watershed, groundwater moves in a more easterly-southeasterly direction as it moves down slope at the base of the Picabo Hills.

Groundwater levels fluctuate seasonally and rise and fall in response to recharge of and discharge from the underlying aquifer. In general, water levels rise in the late spring in response to recharge from snow melt and flood flows in the Big Wood River and continue to rise through early summer as irrigation water recharges the aquifer. Groundwater levels begin to decline in July and continue to decline into fall (USDA 1996). The maximum groundwater level fluctuations occur near the Poverty Flat and Picabo areas, where 36 and 18 foot fluctuations occur, respectively. Smaller seasonal fluctuations of less than 10 feet occur throughout the southern part of the watershed.

Historic Land Use

Pre-Settlement Period

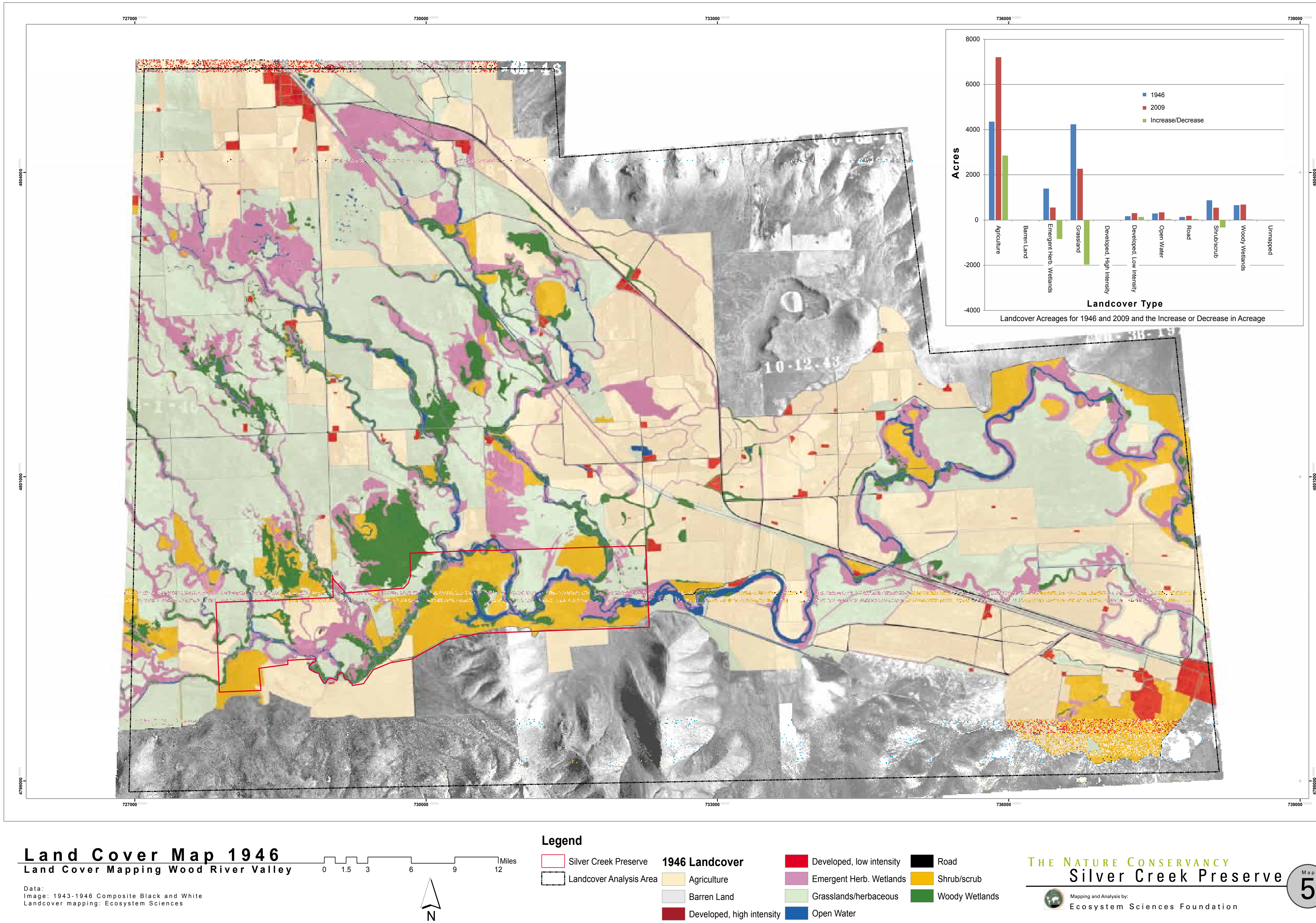
Prior to the arrival of European settlers in the latter part of the 19th century, the Silver Creek watershed is believed to have been only slightly modified by humans. Native Americans likely used the area for hunting, and utilized fire to improve habitat for their target species (Anderson et al. 1996 and Perrigo 2006). The area was likely covered in many of the same plant communities found there today (See section below), but with a higher cover and density of native species and communities (Anderson et al. 1996 and Todd 1997).

European Settlement and the Introduction of Agriculture

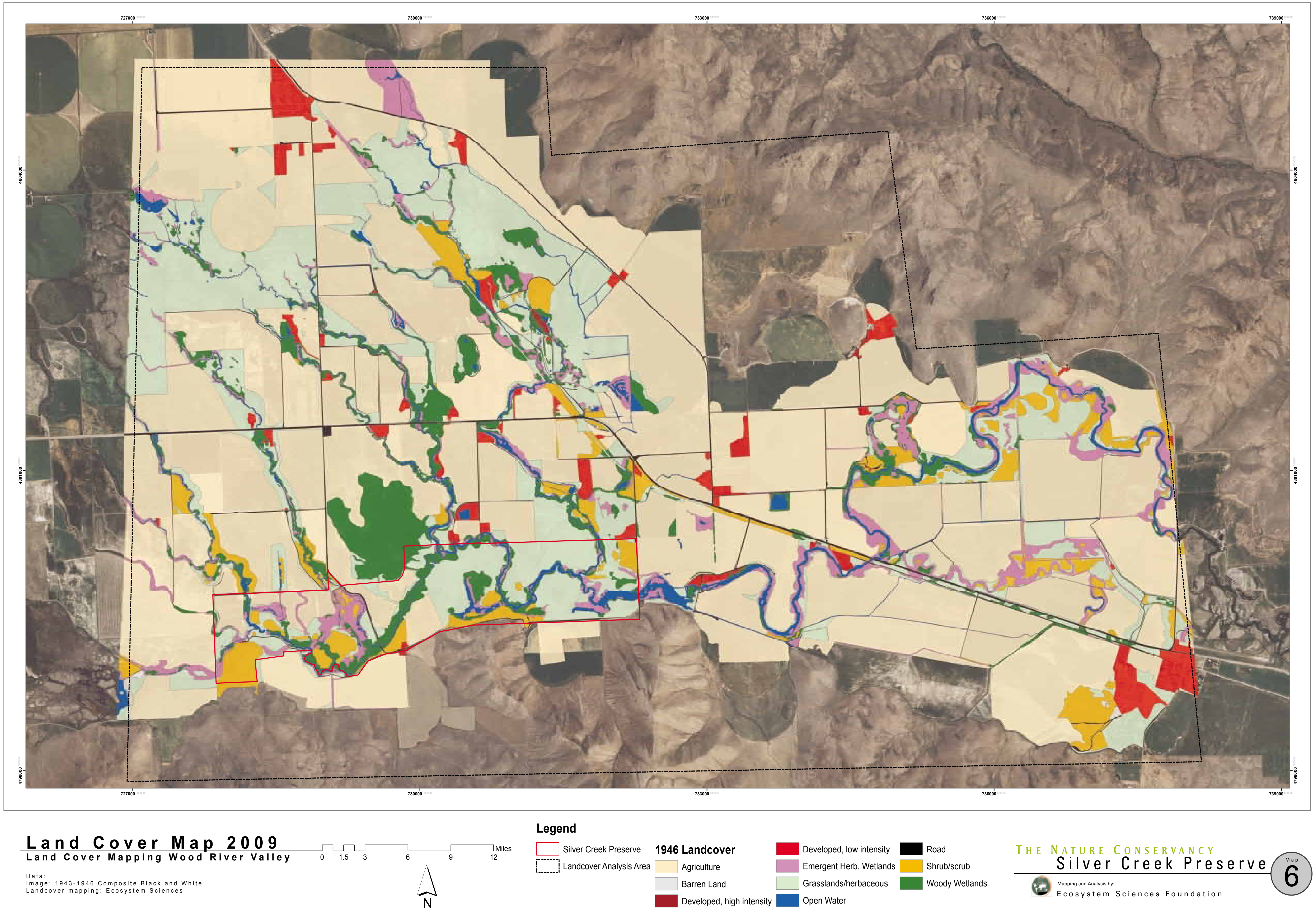
Due to investments by state and federal governments, irrigated agriculture and livestock grazing were introduced to the watershed in the 1880's (Perrigo 2006) forever changing the landscape of Silver Creek. Sheep and other livestock devastated native communities and trampled and destabilized stream banks (Anderson et al. 1996). Natural riparian communities were converted to agriculture fields, and many ditches and canals were dug across the valley. Flood irrigation was the dominant form of irrigation utilized (Brockway and Kahlown 1994). Many of the current impacts on Silver Creek and its tributaries are a legacy of these early post-European settlement land use practices (NRCS 1996).

1943-46 Conditions

As part of this watershed planning effort, land cover types were mapped using a mosaic of 1943-1946 aerial photographs based on several broad cover classes (Figure on right). Aerial photographs were not available for the entire watershed, but 12,000 acres were mapped, including the Silver Creek from its formation upstream of the TNC preserve until just north of the town of Picabo. All but the uppermost headwaters of Loving, Grove, Wilson, Mud, Chaney and Cain creeks were also mapped.



Most of Stalker Creek was not within the image area, therefore is not included in this analysis. By 1943-46, approximately one-third of the valley floor had been converted to irrigated agriculture (4351 acres). A vast network of small canals diverted water from Silver Creek's tributaries to flood irrigate these lands. Another one-third of the valley was grasslands, many of which were utilized as pasture. Springs and areas of natural vegetation had already been heavily modified from a natural condition. Human development had converted 171 acres to low-intensity urbanized areas and another 135 acres to roads. Open water covered 290 acres and the associated woody and emergent herbaceous wetlands covered 658 and 1393 acres respectively.



Current Land Use

In order to determine the current land use patterns within the watershed, land cover types were mapped using 2009 aerial photographs (NAIP 2009). The same land cover types were used for this effort as were used in the 1946 effort for ease of comparison. Unlike the 1943-46 photographs, 2009 imagery was available for the entire watershed. For comparative purposes, the 12,000 acre area covered by the 1943-46 photographs was mapped first (facing page). Within the 1943-1946 image area, 7205 acres (59%) were irrigated agriculture, an increase of 2854 acres from 1943-46 conditions. Although a large network of canals still exists, the number of small canals has decreased with the conversion from flood to sprinkler irrigation. Groundwater wells and pivot irrigation systems have contributed to the increase in irrigated lands. The main crops grown on these lands are wheat, barley, alfalfa and oats (Brockway and Kahlown 1994 and Wolter et al. 1994). These new agricultural areas were converted from emergent herbaceous wetlands (838 acre decrease from 1943-46 conditions) grasslands (1966 acre decrease) and shrub/scrub areas (327 acre decrease). Developed areas have also increased from 171 acres in 1943-46 to 307 acres in 2009. An additional 49 miles of roads have also been built. Open water areas increased between 1943-46 and 2009 by 51 acres to 342 acres. Several impoundments and water diversions have widened the stream channel and created several ponds. Because of conservation steps taken by farmers, the Nature Conservancy and other land owners in the watershed, livestock grazing within the stream channel has decreased dramatically. Many stream-side areas are fenced to prevent livestock from grazing on sensitive riparian vegetation and trampling stream banks. Several stream and riparian restoration efforts have also been undertaken. Woody wetlands have increased by 29 acres demonstrating the effectiveness of better land-use practices.

Vegetation Communities

Due to current and historic land uses, the vegetation of the Silver Creek watershed has been heavily modified from its natural state. The dominant vegetation type is agricultural fields composed primarily of wheat, barley, alfalfa and oats (Brockway and Kahlown 1994; Wolter et al., 1994). Grasslands and emergent and woody wetland areas are a mixture of native and introduced species as a consequence of past land use. Common exotic species known to occur in the drainage include Kentucky bluegrass (*Poa pratensis*), orchardgrass (*Dactylis glomerata*), common timothy (*Phleum pretense*), smooth brome (*Bromus inermis*), fowl bluegrass (*Poa palustris*), Canada thistle (*Cirsium arvense*) and tansy ragwort (*Sencio jacobaea*) (Jankovsky-Jones 1997; Gillian Associates 2007). Reed canary grass (*Phalaris arundinacea*) is common along stream banks. The origin of reed canary grass is one of debate among scientists, but its ecological impacts are not disputed: it stabilizes stream banks but forms dense monocultures decreasing species diversity.

Other common grass and herb species include sedges (*Carex* spp.), rushes (*Scirpus* spp., *Eleocharis* spp. and *Juncus* spp.), bentgrass (*Calamagrostis* spp.), and cattail (*Typha latifolia*), among many others. Trees are generally found only in wetlands or at sites where humans have planted and maintain them. Common trees and shrubs found in riparian woodlands include black cottonwood (*Populus trichocarpa*), narrow leaf cottonwood (*Populus angustifolia*), willow species (*Salix* spp.), water birch (*Betula occidentalis*), dogwood (*Cornus stolonifera*), currants (*Ribes* sp.), shrubby chokecherry (*Prunus virginiana*), and wild rose (*Rosa woodsii*). Aspen (*Populus tremuloides*) is associated with spring wetland sites. Shrubby cinquefoil (*Potentilla fruticosa*) is common on wetter scrub/shrub sites while drier shrub sites are dominated by sagebrush (*Artemisia* spp.) associations (Brockway and Kahlown 1994; Wolter et al., 1994).

Wildlife

Silver Creek Preserve protects one of the last near-intact examples of a high desert cold-spring ecosystem. The Silver Creek watershed contains and supports a large variety of wildlife, from hummingbirds to moose. Even though important wildlife populations thrive in the watershed and especially on the preserve, there is very little ecological information, to date, that describes their status and life cycle requirements.

A harsh winter condition restricts use of the area by many wildlife species. Many species are transitory to the watershed and the habitat available is very valuable in providing the requirements needed for a successful life cycle. Many wildlife species like beaver, muskrats and moose are year-round residents. Large populations of waterfowl use the watershed—ducks and trout are the principal reasons the preserve is available to recreational users today. Though wildlife appear to be doing well in the Silver Creek watershed, additional information on their status and requirements is needed and should be prioritized by the TNC in the future.

Avian Species

The most studied wildlife in the Preserve has been birds. The table in the appendices shows the results of recent surveys in which over 120 species have been observed. Eighty species are known to use the Preserve for breeding, with another 30 as possible breeders. Species include upland game birds—many of which are introduced, such as the California Quail, Chukar, Gray Partridge, and Ring-necked Pheasant—as well as numerous species of wading and shorebirds, raptors and neo-tropical migratory species.

Reed canary grass

White-faced Ibis

Bald Eagle

The list of endangered, threatened, candidate, sensitive, or special concern species that are known to use the Preserve include:

- American White Pelican
- White-faced Ibis
- Trumpeter Swan
- Long-billed Curlew
- Black Tern
- Bald Eagle
- Northern Goshawk
- Swainson's Hawk
- Ferruginous Hawk
- Merlin
- Peregrine Falcon
- Gyrfalcon
- Loggerhead Shrike

Beaver

Beaver can quickly become the Silver Creek watershed's keystone species as their dam building and use of willows affect the riparian and flow system to a greater degree than any other species. The impacts to flow and riparian habitat by beaver also dictate how many other species of fish and wildlife use the streams. Beaver alteration of stream flow and riparian habitat must be a key component of riverine-riparian ecosystem management plans today and adaptive management decisions in the future.

Beaver (*Castor canadensis*) are the largest rodents in North America, weighing up to 75 pounds. Beaver are highly specialized obligate riparian/aquatic rodents that are found in ponds, lakes, rivers and streams. They are generalized herbivores and consume a wide variety of plants (aquatics, forbs, grasses shrubs, trees), and eat many parts of the plant, including the leaves, bark, twigs, rhizomes and flowers. While beavers eat a variety of foods, they prefer and are most dependent on woody riparian species such as aspen (*Populus tremuloides*), willow (*Salix* spp.), and cottonwood (*Populus* spp.) (Jenkins and Busher 1979; Hall 1988).

Beaver provide a striking example of how animals influence ecosystem structure and dynamics in a hierarchical fashion. Initially, beaver modify stream morphology and hydrology by cutting wood and building dams. These activities retain sediment and organic matter in the channel; create and maintain wetlands; modify nutrient cycling and decomposition dynamics; modify the structure and dynamics of the riparian zone; and, influence the character of water and materials transported downstream, ultimately influencing plant and animal community composition and diversity (Naiman et al., 1988).

Beaver Influence on Wildlife

Beaver ponds and associated flooding and high water tables create habitat diversity, edge effect, and vegetative changes that attract wildlife species that are not often found in other areas. Waterfowl, shorebirds, and songbirds that feed over open water are commonly attracted to flooded areas (Neff 1957). The higher water tables often create vegetative response that provides cover, forage, or edge effects that are attractive to a variety of wildlife. In healthy riparian ecosystems, beaver ponds generally provide unique and valuable habitat for many species of wildlife. Increased structural complexity and high interspersion of unique plant communities and habitat features are important factors influencing wildlife species presence and abundance—high breeding bird density, bird species richness and diversity, and total breeding bird biomass are typically associated with beaver ponds. Perhaps the most noticeable wildlife are the large ungulates; elk and deer are commonly associated with beaver-influenced habitats and in greater densities than areas without beaver (Munther 1981).

Beaver Influence on Fisheries

Beaver can have a dramatic effect on fish habitat, depending upon the natural channel size, characteristics, and fish species. In flatter gradient streams like Silver Creek, beaver ponding covers streambed gravels, reduces habitat diversity, inhibits or blocks fish migration, and reduces fish spawning habitat (Reid 1952; Churchill 1980). On the other hand, beaver ponds often provide critical rearing habitat in steep gradient streams or in streams that cannot support much riparian habitat so that reductions in spawning success may be offset by increases in rearing space (Gard 1961).

Beaver Management

Beaver control is a necessary component of stream restoration. Beaver populations can expand so rapidly that they negate and set back riparian systems before they can be adequately established. Understanding the basic population dynamic of beaver colonization is critical.

While much research on beavers and stream ecology has been performed, the fundamental fact remains from the earliest studies on beaver biology that in the absence of predators, the primary limiting factor is the available food supply (Cook 1940). It is also a fact that beaver reproduction and colonization can out-strip the food supply, especially when riparian ecosystems are being restored, causing severe harm, even setting back restoration efforts. A real-time example of uncontrolled beaver populations and stream restoration is in the Owens Gorge, California. This 9-mile reach of the Owens River restoration project focused on restoring riparian habitat. Following years of restoration, willow and cottonwood trees had reached average heights of 15-feet and provided temperature reducing canopy over 70 percent of the stream.

Unfortunately, a beaver control program was not promulgated concurrent with riparian restoration and within three years unchecked beaver numbers had removed nearly all of the willow and cottonwood trees. Numerous dams and extensive debris in the stream has resulted in permanent inundation of riparian landforms, loss of vegetation buffering and increased stream temperatures. Beavers set the restoration back many years and negated the investment made in the riparian system.

The goal of beaver management is to protect the development and sustainability of riparian vegetation, particularly willow and other shrub species. Thus management must be a function of the allowable number of beavers per acre of willow by river reach. It is recommended that an allowable density of 1beaver/29 acres of willow initially during early seral stages of willow development and a final allowable density 1 beaver/8 acres of willow when the late seral stage is achieved (Slough and Sadlier, 1977).

Fisheries

Summer Habitat Conditions

A key indicator of a stream's health is the quality and quantity of habitat. Silver Creek is known for its first class trout fishery. Because a detailed inventory of Silver Creek's fish habitat has never been performed, Ecosystem Sciences Foundation was tasked with mapping aquatic habitat in Silver Creek on The Nature Conservancy's Preserve. Previous studies (IDFG 1976, 1978, 1993) concluded that tributaries of Silver Creek (Grove, Wilson, and Loving creeks) provide important and successful spawning grounds and nursery areas, based on the large numbers of young-of-the-year fry and fingerlings in those tributaries. Ideally, all of the fish habitat from the headwaters to the creek's confluence with the Little Wood River would be identified and mapped; however, for purposes of this project, the habitat inventory was limited to the stretch of river on the Preserve. Habitat mapping beyond the Preserve boundary will be performed in future work programs.

The fish habitat maps that follow illustrate the results of the habitat survey. The stream was floated from Stalker Creek to Kilpatrick Pond and dam. Deep runs and pools were surveyed by snorkeling. Habitat inventories focus on the primary types of fish habitat necessary for all trout life stages, including spawning and incubation, early rearing, young-of-the-year, juvenile and adult habitat. Each life stage has specific habitat requirements that are critical, including gravel size, sediment conditions, instream cover, escapement, pools and run depths.

A habitat inventory is essential in order to define the principal limiting factor(s) on a fishery. For example, while spawning habitat may be extensive in a stream, a lack of early rearing habitat may be the cause of a small adult population because young-of-the-year and juvenile trout are susceptible to predation. In addition to habitat limitations, water quality can also affect a fishery and adversely impact fish production and size.

In the case of Silver Creek, summer temperatures and sediment deposition have been cited as having the potential to impact the trout fishery. What has not been identified, to date, is the extent to which habitat and habitat availability factor into the health of the stream's fishery.

The conclusions that can be drawn from the fish habitat inventory (and shown in the following maps) are:

- With the exception of Kilpatrick Pond, all stream reaches surveyed contained some critical trout habitat feature. Spawning habitat with clean gravels is distributed throughout the stream. Early rearing and young-of-the-year habitat is juxtaposed with adult holding/rearing habitat, so that Silver Creek exhibits a mosaic of trout habitat in all reaches.
- Fish production is exceptionally high throughout the surveyed stream reaches. This is because benthic invertebrate (insects that live on the bottom of the stream) production occurs in all reaches in substrate and aquatic vegetation, providing an unlimited food base. Incubation and egg-hatch appears to be very high and redds (depressions on the stream bottom in beds of gravel where fish eggs are deposited) are little affected by sediments. In fact, successful incubation requires a certain amount of sediments to ensure an adequate protective cap develops over the redd.
- Sediment deposition is greatest at the confluence of tributaries and agriculture drains into Silver Creek. These are isolated sites of extreme sediment depth and probably contain sediments deposited years ago as a legacy of livestock grazing throughout the watershed.
- Sediment deposits are relatively thin (< 2 or 3 inches) in other stream reaches. The gravel areas covered by thin layers of fine sediments pose no problem to large trout building redds; they can easily swipe away the fines as the egg nest is dug. These sediments are also too thin to limit benthic invertebrate production.
- Pools, especially deep meander pools, are scoured of sediments. As stream flows enter outside bends, the flow velocity increases, which not only forms the pools but prevents sediment accumulation. Without these physical processes, all of the pools in Silver Creek would have vanished long ago under legacy sediments.
- Upper reaches of the stream from Stalker Creek to the Grove Creek confluence are heavily canopied and banks stabilized with riparian vegetation. The middle and lower reaches of Silver Creek within the Preserve, in contrast, lack the riparian habitat of upper reaches and are widened because of past livestock grazing. These conditions, however, do not significantly degrade instream trout habitat.
- Reed canary grass is encroaching in many places along the stream. Typically, reed canary grass begins building platforms on what were once undercut banks. In many places, undercut banks have been lost due to winter conditions exacerbated by sediment inputs. Reed canary grass easily becomes established on these disturbed sites. The long term threat from reed canary grass is in those naturally shallow channel reaches where the plant builds platforms and encroaches into the channel year-by-year.
- Fish passage is generally not an issue within the Preserve boundaries, although a beaver dam about one-quarter mile above the Stalker Creek road does inhibit trout movement into the upper watershed streams (Cain, Mud, Stalker, etc.). IDFG and TNC staff have removed some beaver and pulled down some of the dam, but the dam continues to have a backwater effect that accumulates sediments. The depth of fine sediments in this backwater area negates any positive benefits related to pool habitat; deep sediments have buried both spawning and benthic production values. The only other impairment to trout migration on Silver Creek is the Kilpatrick Dam.

Beaver

Beaver dam above Stalker Road bridge

Spawning gravels in Silver Creek

Thin sediment layer over gravel

Reed canary grass encroachment

Fisheries Continued

- Sediment movement into Silver Creek is clearly through the agriculture drains and tributaries. Significant deposition areas occur at these confluences and the solution is to attenuate, to the extent possible, sediment inputs from agriculture lands adjacent to the tributaries and from the irrigation ditches. There are also a few minor places within the Preserve that could generate sediment inputs from overland flow in the spring.
- The only place in Silver Creek that does not support high quality trout habitat and benthic invertebrate production is Kilpatrick Pond. Legacy sediments combined with annual inputs of new sediments have rendered this reach of the stream all but unusable (except at night) for all trout life stages except adult holding. Over time sediment accumulation has progressed upstream to the Loving Creek confluence. Thermal loading in the broad, shallow ponds also restricts trout use. Angling and catch effort continues to be high in the pond—mostly below the bridge and the Preserve boundary—because adult brown and rainbow trout move downstream in response to density-dependent competition, i.e., competing for space with one another. Also, trout feed on scuds and aquatic insects like midges, which are adapted to fine sediment environments.

Results from this fish habitat inventory indicate that the Silver Creek fishery not only lacks an identifiable habitat limiting factor, but habitat throughout the stream supports all life stages for all fish species. Silver Creek is a legendary fishery precisely because of the habitat quality found throughout the stream. Although physical habitat and the food base is not limiting, the fishery is adversely affected by elevated summer temperatures and sediment inputs. As temperature and sediment conditions worsen in time, it can be expected that these conditions will impose a limiting factor(s) on the fishery.

Aquatic Vegetation

The aquatic vegetation of Silver Creek and its tributaries have been surveyed over the years as part of research projects or in conjunction with fish sampling (Griffith 1979; IDFG 2001). Chara, supplemented by Veronica and Potamogeton, dominates the aquatic vegetation of all streams. Watercress is present also in headwaters, especially in Grove Creek, and downstream of Picabo. During summer and fall, these macrophyte species cover 40 to 68 percent of Silver Creek's streambed, while in winter die-off reduced coverage to about 10 percent (ICFRU, 1979). This seasonal process and extent of coverage remains relatively constant.

Research by Idaho State University (Griffith 1979; Young et al., 1997) on sediment-macrophyte-invertebrate relationships demonstrated that the removal of instream sediment leads to a shift in macrophytes, most likely from Potamegoton and/or Chara to Veronica and/or watercress. Chara and Potamegoton provide a greater biomass of aquatic invertebrates, provide better cover for trout, and attract invertebrate taxa that are selected by rainbow trout.

Aquatic vegetation as fish habitat in Silver Creek

Overhanging bank collapses in Silver Creek during winter conditions

Winter Habitat Conditions

In summer months, biological conditions and forces set the predominant ecological processes in Silver Creek and its tributaries—in winter, however, physical process dominate over biological. Winter is a stressful period for stream-dwelling organisms, especially fish. Low water temperatures slow the rate of digestion and may limit the amount of energy available for metabolism and growth, even if food is available and feeding occurs (Cunjack and Power 1987). Decreased water temperatures reduce the swimming performance of trout (Hartman 1963), which impairs their ability to escape predators. Angling is closed in Silver Creek during the winter months, but catch-and-release regulations apply in other streams in the basin.

At the onset of winter, juvenile salmonids may form aggregations in open water, especially in thermal refuges (Cunjak and Power 1987) like spring inflows, or may conceal themselves in woody debris, in interstices of the substrate, or under undercut banks (Hillman et al., 1987). Silver Creek and its tributaries offer all these conditions during winter, providing trout with ample winter cover and escapement from predators (Riehle and Griffith 1993).

Winter water temperatures in Silver Creek moderate a few degrees in comparison with most trout streams in the region, but are cold enough to induce behavioral changes in trout (Riehle and Griffith 1993). Water temperatures are warmer in the upper reaches near spring inflows, and are considerably cooler downstream. Of particular importance in spring-driven systems like Silver Creek is the effect and influence of ice. A floating ice cover can dramatically increase turbulent shear stress on the streambed, thereby causing peak annual sediment-transport events to occur during the breakup of an ice cover or the release of a breakup ice jam. These events often have high discharges, with gouging and abrasion of the bed and banks by moving ice. Ice in a stream channel can reduce the flow areas, increasing under-ice water velocity, scouring bed sediments, and possibly shifting the path of the deepest flow (thalweg). Solid ice is not the only condition that can alter a stream's structure—frazzle ice can impinge flow against the channel sides, thus contributing to bank erosion.

Ice effects can occur over varying scales, time and channel length (Scrimgeour et al. 1994). In Silver Creek, icing is more common in the lower reaches below Kilpatrick Pond than in upper reaches, because water temperatures are warmer upstream near the spring sources. At the local scale, an ice cover over a short reach may redistribute flow laterally across the reach, accentuating erosion in one place and deposition in another. Ice may dampen or amplify erosion processes locally (Beltaos et al. 2000). Dampening effects of ice include reduced water runoff from the watershed, cementing of bank materials by frozen water, and ice armoring of bars and shoreline. Amplifying effects include accelerated erosion and sediment transport, notably during the surge of water and ice consequent to the collapse of ice jams.

Surface ice occurrences on Silver Creek are seldom and occur in localized reaches. When Silver Creek experiences ice cover, the stream tends to ice from the bottom-up, by first forming anchor ice (ice sheets attached to the substrate) and then developing frazzle ice in the water column. If low temperatures persist, thin ice sheets eventually form across the channel. While surface ice generally forms for short periods, frazzle ice and anchor ice will persist much longer. Frazzle ice is like pebbles suspended in the water column, and when working against the stream bank, it acts like sandpaper and can cause significant erosion (Ettema and Daly 2004). Stream bank abrasion by icing may explain how undercut banks are formed in Silver Creek since the stream lacks the flow velocities necessary to account for undercutting.

The detrimental effects of ice formation and sediment deposition are evident in some lower reaches of Silver Creek. Sediment deposition reduces channel capacity, and icing increases the stage (height) of the water surface in deposition areas such that stream flow overtops the stream banks in local sites, as displayed in these photos downstream of the Preserve. Sediments in this area cause winter flows to overtop banks, ice then forms on top of the bank undercuts and builds-up until the overhanging bank cannot support the weight of the ice and the stream bank collapses. This results in the loss of the undercut bank and consequently, of valuable fish habitat—it also contributes new sediments to the stream and provides platforms for encroaching reed canary grass, night-shade and other invasive species.

Silver Creek habitat is adversely affected by temperature and sediments in the summer and the winter. Continued sediment inputs and winter icing conditions will have a negative effect on channel morphology, with changes in thalweg depth and location, stream bank erosion and loss of undercut banks. Consequently, although winter is the most favorable period for stream restoration work, sediment disturbance and other potential negative effects must be carefully considered.

Fish Abundance and Distribution

Pre-Settlement Period

Silver Creek in its natural condition was one of the outstanding trout fisheries in the world. According to testimonials from travelers passing through the area in 1854, Silver Creek was about 25 feet wide, two feet deep, and so full of trout they could hardly swim (Ebey 1854). At this time, all trout in the Silver Creek watershed were native redband trout, a variety of rainbow. When all the large marshes were functioning and the watershed was covered with native vegetation, its wildlife and fisheries were highly sought after by Native Americans.

1875 to 1947

With the advent of large numbers of livestock moving into the basin and the soon to follow agricultural practices, the impacts to Silver Creek were evident as early as 1903. Hauk (1947) reported a much wider stream than exists today, with heavily silted tributaries, and a dense trout population compared to other trout streams in the country. Nonetheless, Hauk believed the trout fishery to be in decline, and in response, all the Silver Creek tributaries were closed to fishing from 1934 to 1946. As far back as 1917, Silver Creek was considered by sportsmen to be the most highly productive trout fishery in the country. Even in its more degraded state, Silver Creek and its tributaries (as it is today) supports a valuable and productive trout fishery.

By the 1920s, government agencies were stocking brook trout in the Silver Creek watershed, and by 1947 their numbers made up the highest percentage of trout species in the watershed. From the 1920s to 1930s, McCloud River rainbow trout were stocked in Silver Creek. In later years, the Idaho Department of Fish and Game stocked other varieties of rainbow trout. Unfortunately, these stocking practices are the primary reason that native redband trout no longer survive in the watershed in their pure form.

1947 to 1980

During the 1950s, Silver Creek was intermittently closed to fishing because it was believed that over-fishing was causing the declining trout population. Agricultural reclamation, meanwhile, was eliminating the huge marshes in the tributaries of Silver Creek; however, no data are available to determine the impacts to the trout population from these land conversions. Over the next several decades, various sources (Gebhards 1963; Bell 1966) reported declines in the fishery. More recently (2003 and 2004) decreased catch rates and sizes were documented (Megarale 2007).

1980 to Date

In the late 1970s, brown trout was stocked in waters with direct access to the Silver Creek watershed. By 1986, brown trout made up 19 percent of the trout population in Silver Creek; by 2004, this figure increased to 60 percent and then leveled off at 55 percent in 2007. Note the concurrent decreases in the rainbow trout population as the brown trout proportion increases. Due to this indiscriminate stocking, brown trout are here to stay in Silver Creek and are now one of the important trout species in sport fishery.

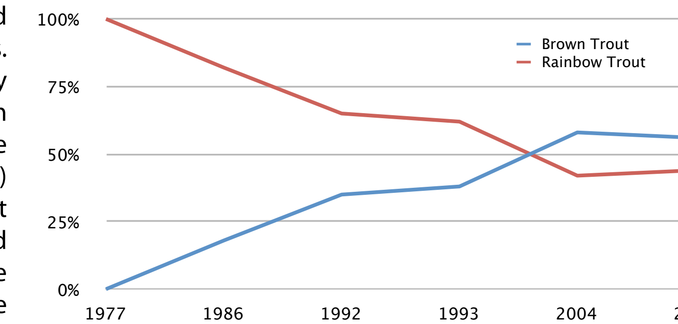
A 2001 fish population analysis found 2,800 trout per mile in Silver Creek, which is much higher than the numbers found in other trout streams in the country. In fact, trout density (1,573 rainbow/hectare) in Silver Creek was the highest measured for a mixed species salmonid fishery in the United States (Wilkinson 1996). Wiley (1977) reported 3 to 6 pound trout were regularly taken by fishermen.

In 2007, IDFG sampled Silver Creek at three locations (Stalker Creek, Cabin and Martin) to evaluate trends in population abundance and structure and estimate rainbow trout and brown trout abundance (IDFG 2007). Brown trout densities ranged from 308 to 640 fish (>100mm/km) at the Cabin and Martin sites, respectively, while rainbow trout densities ranged from 95 to 1,726 fish (>100mm/km) at the Martin and Cabin sites, respectively. IDFG sampled again in 2010; however, the results will not be available until spring of 2011. Nevertheless, some preliminary observations (Scott Stanton, personal communication) are:

- The fishery appears to be moving toward a brown trout-dominated fishery ; the upper sections of Silver and Stalker creeks are about 60% brown trout and 40% rainbow, while the lower reaches are about 80% brown and 20% rainbow.
- The shift from rainbow to brown trout dominance is a function of habitat degradation (primarily temperature because browns have a higher tolerance) as well as piscivory.
- Total abundance of trout is not much different from 2007
- Age analysis indicates no year classes have been lost; and, remarkably, some brown trout are 12 to 14 years old.
- Growth rates remain strong, about the same as in previous sampling years
- Species composition has changed with the likely extirpation of mountain whitefish

In 2000, Jack Hemmingway (personal communications) stated that Silver Creek was now better fishing than it was in the 1930s. Brook trout, however, have fewer numbers now than when they were originally stocked over a half century ago. Reports from 1952 to 1997 indicate that fishermen were averaging a catch rate of about one trout per hour. From 2001 to 2007, Gillian (2007) reported a decline in the trout population. It is doubtful that fishing success, per unit of time, in Silver Creek has decreased much over the past 75 years. Trout populations naturally have wide variations in year to year population size and could be the cause of the consistent reports of fish population declines.

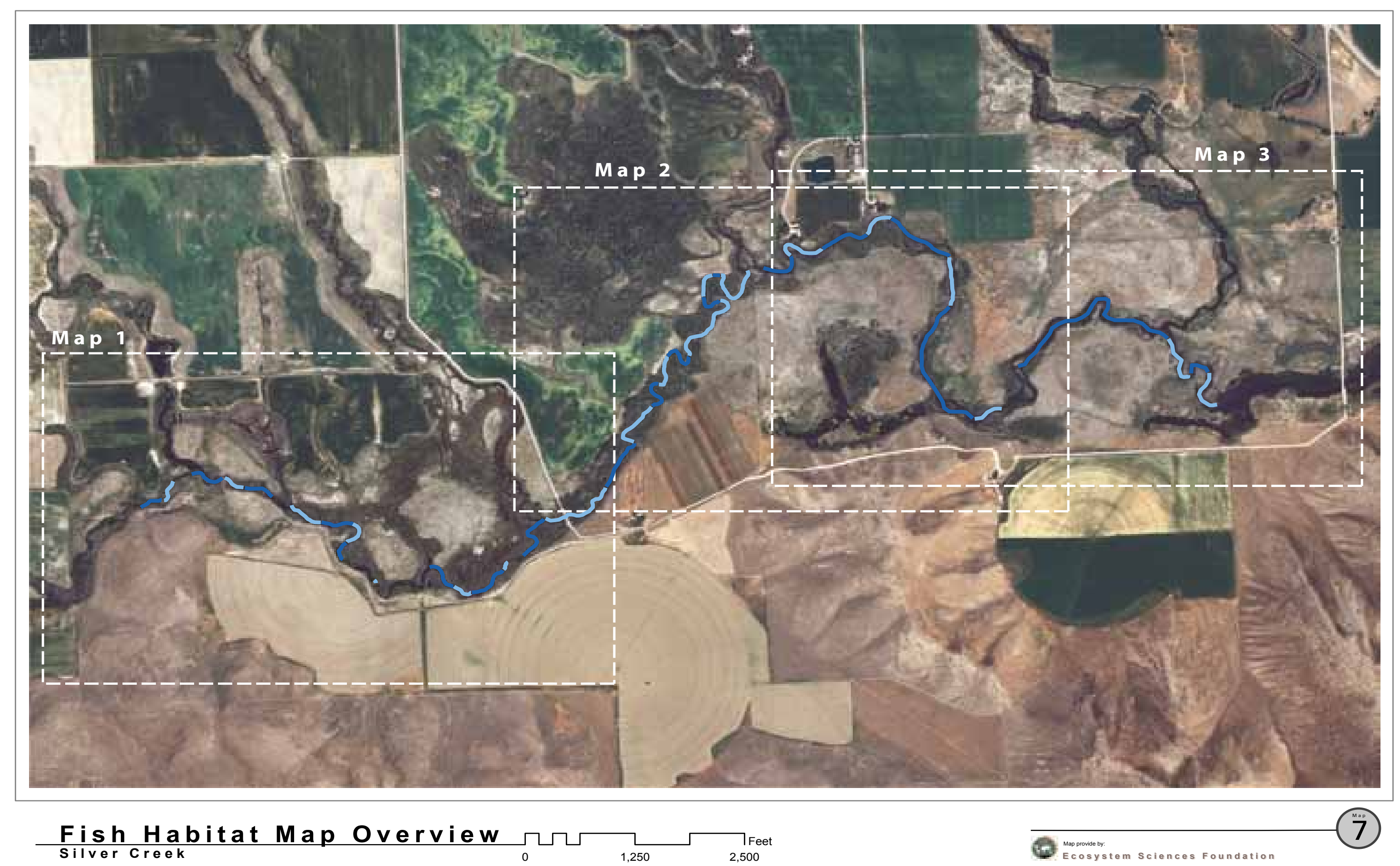
In June 1992, the first recorded trout kill occurred at "Point of Rocks" on Silver Creek. This could have been caused by low dissolved oxygen (2.5ppm), high stream temperatures, toxic inputs, a combination of these factors or unknown factors. In June 1994 a second trout kill was reported when dissolved oxygen was 3.2 ppm; however none of these isolated kills had a significant effect on the trout population. Reported fish kills in the Silver Creek watershed are quite rare to date.



Change in Silver Creek trout abundance over time

Fish Habitat Maps and Reach Description

The following maps discuss and illustrate the fish habitat of various stream segments throughout the Silver Creek Preserve. Below is an overall map of the area surveyed and the following three pages include maps that describe detailed features.



Fish Habitat Map 1

Key Notes to Stream Segments

1 Extensive ER and YOY habitat, good cover and spawning gravel; RCG growth prolific; minor sediment accumulation. Footbridge has adequate fish passage; 3-ft pools above and below

2 Excellent ER habitat, shallow pools with pronounced bank undercuts. Silt and sediment deposition deep related to backwater from Cain Creek

3 Heavy juvenile and adult use; cover primarily aquatic vegetation

4 Significant spawning area; last season redds prolific, gravel extends across stream and downstream for 20 yds; occasional 5' pools

5 Sediment depositional area, heavy aquatic vegetation but with high density of fish

6 Extensive gravel bottom with thin sediment covering; limited spawning habitat due to aquatic vegetation; banks with deep undercuts –adult habitat

7 Considerable juvenile cover in aquatic vegetation and heavily used; deep thalweg and occasional pools >3ft deep

8 Widened stream channel, shallow with minor sediment covering gravel; spawning habitat, good adult and juvenile cover with aquatic vegetation and undercut banks

9 Excellent adult holding in deep pools in outside meander bend 3 to 5' deep; pools scoured of sediments; gravel with some sediment across channel

10 Deep meander pools >4ft with gravel bottoms, undercut banks; excellent adult habitat

11 Channel encroached by RCG platforms narrowing the channel; RCG encroachment on collapsed undercut banks; deep thalweg limits RCG; good adult holding habitat; good juvenile escapement habitat in RCG margins

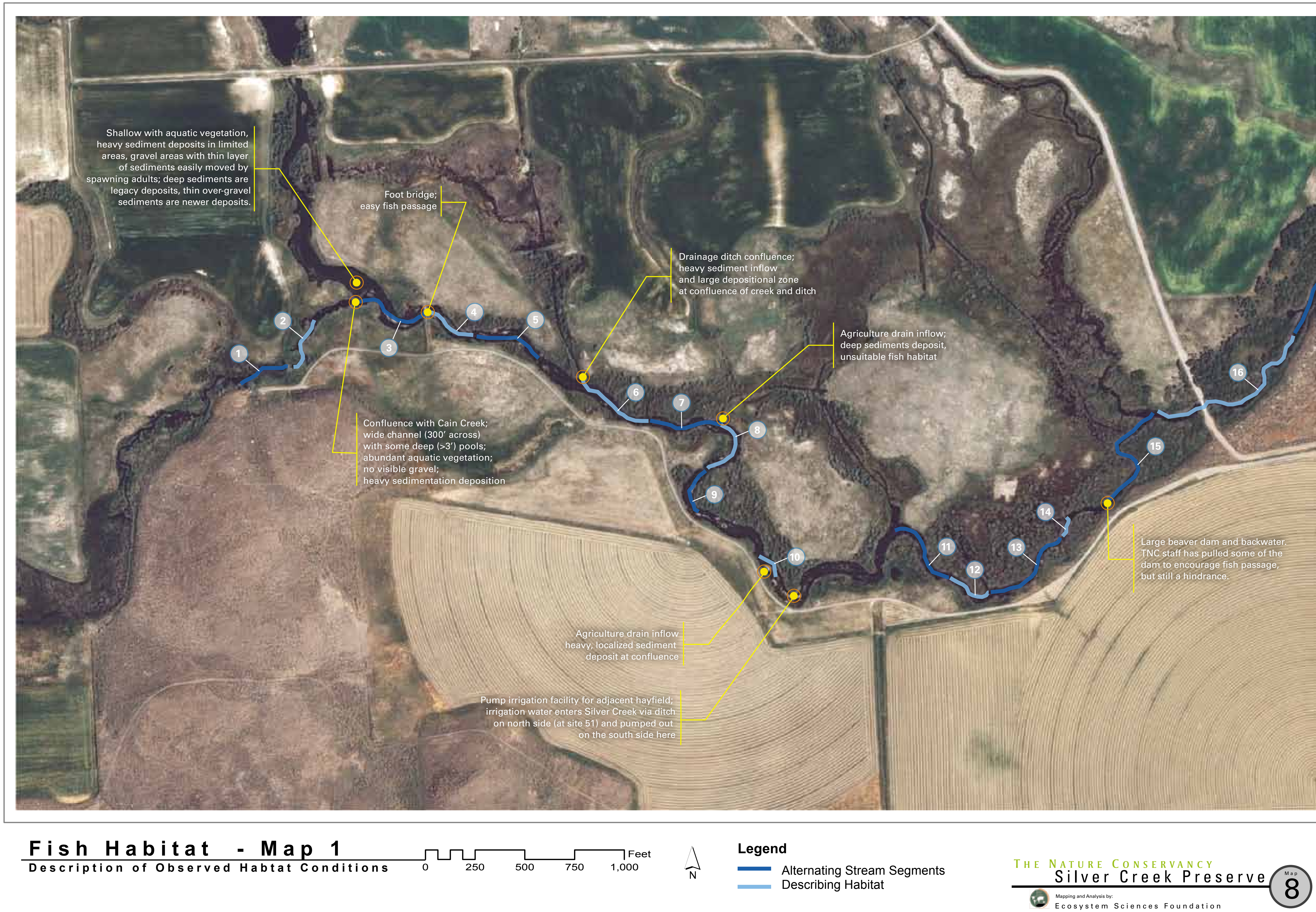
12 Moose crossing causing small, local bank degradation; deep meander pools >6'; RCG platforms; significant riparian overstory; good adult habitat

13 Ag ditch causing heavy accumulation of sediments at confluence; upper end of beaver pond influence; stream nearly blocked deadfall and deep accumulation of sediments from here to beaver dam; poor habitat for all life stages

14 Another ag drain or runoff channel; very deep channel primarily run type habitat with heavy riparian canopy but deep sediment deposits; habitat limited to adult use

15 Confluence with Mud Creek; very deep pools >5 to 6ft; stream bottom gravel; heavy riparian canopy, some RCG; no sediments from Mud Creek; excellent spawning and adult habitat to Stocker Creek bridge

16 Deep thalweg; pools >8'; pools lateral or meander scour type followed by straight runs; heavy riparian cover /canopy; excellent adult habitat w/ some sediment over gravel; does not inhibit spawning or macroinvertebrate production



Fish Habitat - Map 2
Description of Observed Habtat Conditions

0 250 500 750 1,000 Feet

N

Legend
Alternating Stream Segments Describing Habitat

The Nature Conservancy
Silver Creek Preserve
Map 9
Mapping and Analysis by: Ecosystem Sciences Foundation

Fish Habitat Map 2

Key Notes to Stream Segments

17 Very deep meander pools; heavy riparian cover with some RCG encoarchment; bank undercuts; instream vegetation provides good juvenile and adult habitat as well as food production

18 Channel narrows and current increases substantially, deep water with gravel bottom no sediments, heavy riparian cover, adult and juvenile habitat; fish abundant

19 Deep meander holes followed by shallows and natural rise in channel elevation; gravel bottom, minor sediment deposits in shallow areas, but not sufficient to have adverse affect on spawning or benthic production

20 Large spawing sites with old redds; good depth and velocity; good YOY and ER habitat; abundant small trout

21 Deep pools >8' across channel; high quality adult holding; pocket gravel and old redds; very large trout

22 Natural bottom rise with shallow area and wide channel for about 150' across followed by meander pools; dense riparian vegetation; excellent YOY and ER habitat and food production in gravels and aquatic veg

23 Natural shallow reach with elevated channel bottom, gravel with minor sediments; high quality spawning habitat with ER habitat adjacent to streambanks

24 Heavily used spawning area with old redds; insignificant sedimentation

25 Very deep meanders pool (>4') followed by runs over clean gravel beds; quality spawning habitat and benthic production

26 Series of run habitat in natural shallow area of channel followed by deep meander/scour pools; good gravel for spawing, light sediments, quality benthic production habitat

27 Old dam foundation at bed level; gravel bottom across shallow channel with minor sediment cover easily removed by redd building trout; YOY and ER habitat in aquatic vegetation; high benthic production, minimal adult habitat.

28 Very wide channel but natural shallowness; same as previous section with YOY and ER habitat in aquatic vegetation

29 Channel begins to narrow with deep meander and lateral pools good for adult holding

30 Limited spawning habitat in pocket gravel; old redds and slight sediment covering; good YOY and ER habitat in vegetation and shallow water areas

31 Excellent YOY and ER habitat in shallow water, aquatic vegetation; side channel at 80 full of juvenile trout in excellent escapement and rearing habitat

Fish Habitat Map 3

Key Notes to Stream Segments

32 Channel broad with gravel bars and aquatic vegetation; pocket gravel spawning sites, redds present; riparian veg sparse, no stream cover, RCG beginning to encroach; sediment deposition is minor; high concentration of juveniles

33 Similar to upstream reach; wide channel, no riparian cover, average depth about 2' but deeper thalweg; heavy use by juvenile trout in aquatic vegetation; minor sediment deposition

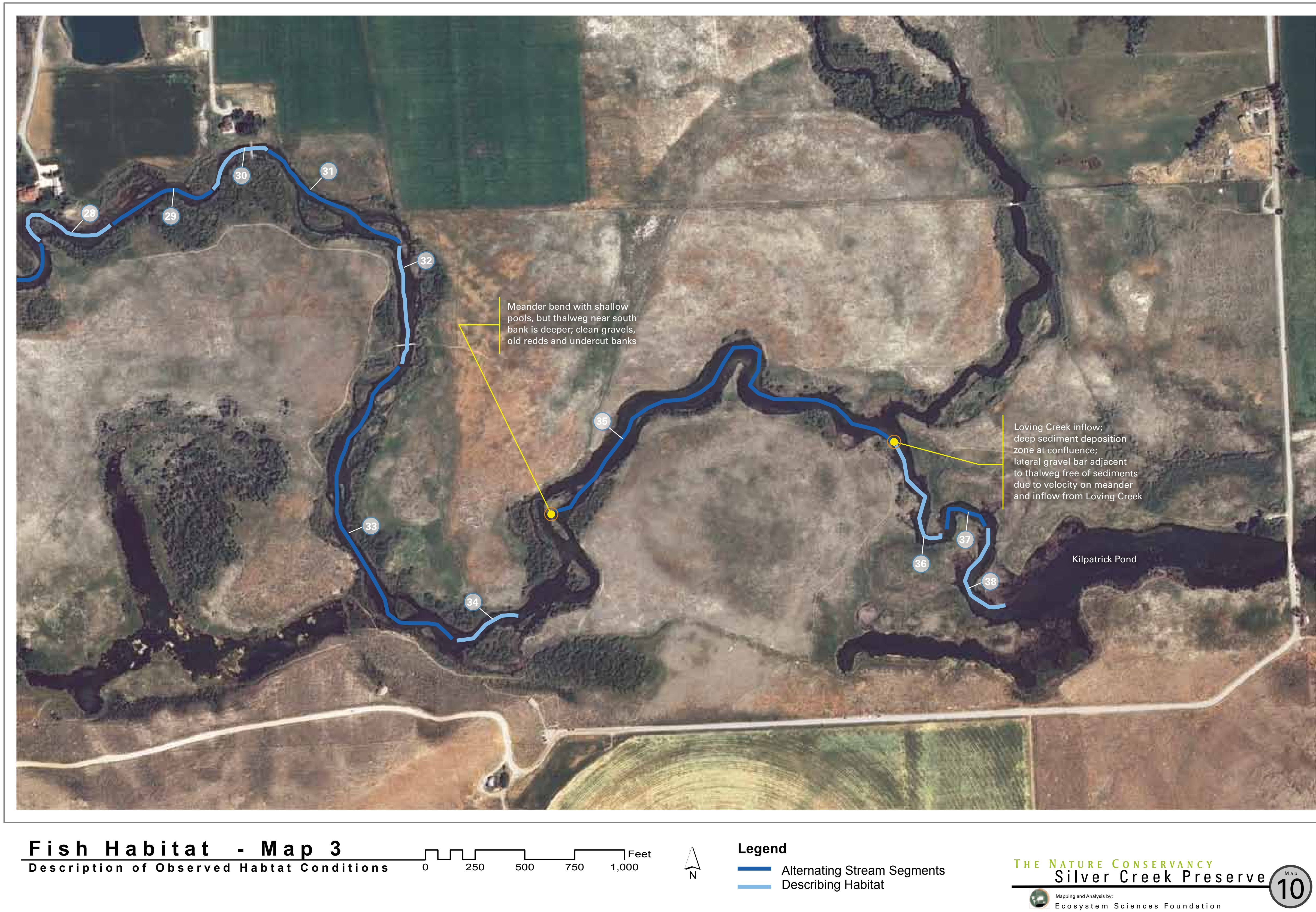
34 Channel narrows slightly; some undercut banks provide good adult habitat; clean spawning gravels; high benthic production zone; no riparian cover

35 Upper edge of sediment depositions caused by Kilpatrick dam and pond. Gravel covered by increasing sediment depths; spawning gravels heavily sedimented; some old redds but limited YOY and ER habitat

36 Wide channel with deep thalweg, heavy sediment depositions throughout channel; some pocket gravel; poor adult habitat

37 Deep sediment deposition along outside bends; thalweg deep with clean gravels and some aquatic vegetation; very deep meander pool at bottom of section– good adult holding habitat in pools and thalweg

38 Start of Kilpatrick pond and zone of influence from extreme sediment deposition. From here to dam stream is heavily impacted with very deep legacy sediments covering channel from bank to bank; extremely poor to no trout habitat



Brown trout taken from Silver Creek's legendary fishery

Section 3: Environmental Issues and Challenges

Sullivan Lake, Silver Creek Preserve

Silver Creek is located in the lower end of the watershed, and as a consequence, it is heavily influenced by up-gradient land and water uses. Silver Creek's condition on the preserve is a product of tributary inputs, which include sediments from runoff, thermal loading, nutrients, and volume (discharge). Loving Creek, a tributary of Silver Creek, is also influenced by land and water uses within its drainage area. Because Silver Creek was placed into a preserve nearly 35 years ago, the stream itself is influenced by deleterious conditions; that is to say, ecological issues in Silver Creek do not originate from within the preserve, but from the entire watershed.

This plan was developed using the available data on the tributaries, Silver and Loving creeks and other areas and ecological components throughout the watershed. While the available data is sparse and somewhat out of date, there is sufficient information (when combined with detailed analysis of current aerial imagery and mapping) to identify the sources and causes of degradation, and develop requisite restoration and enhancement interventions. The monitoring program in this plan will generate a substantial amount of data from which adaptive management decisions can be made to effectively manage the preserve into the future.

Database Summary

The database for Silver and Loving creeks was compiled by TNC and Save Silver Creek (references are provided at the end of the document). Studies have been performed in the watershed for many years and for a variety of purposes. Most studies are snapshots of conditions at a point in time; rarely were uniform studies conducted over time to provide cohesive data sets. The exception is the discharge measurements and temperature on Silver Creek, for which there are time series data.

Discharge measurements were recorded by the United States Geological Survey (USGS) at two gauging stations: Station 13150430 at the sportsman's access near Picabo from 1974 to 2002; and Station 13150500 at Highway 20 near Picabo from 1920 to 1962. The USGS has adjusted flow measurements to provide a reliable hydrologic data set since 1974. Other discharge measurements have been made by TNC at various staff gauges along Silver Creek within the preserve.

Temperature monitoring at numerous sites throughout the basin were initiated in 2004 and continued through 2009. The database was compiled from continuous data loggers at 16 locations on Wilson, Chaney, Grove, Stalker, Loving, and Silver creeks. Temperature data analysis is presented later in this document.

While sediment data are limited, sufficient work has been performed to verify the sediment budget for Silver Creek. Other data include numerous but unrelated fisheries studies conducted since 1947. The most complete fisheries data set comes from Idaho Department of Fish and Game (IDFG) surveys. Although this database is insufficient to establish trends, it does provide insight into speciation and relative abundance and distribution.

Water resources studies include occasional water quality, sediment, and groundwater evaluations and reviews. Several restoration reports are included in the database with useful transect and sediment transport data related to Kilpatrick Pond. Invasive species studies also provide valuable information on baseline conditions for New Zealand mud snail and reed canary grass.

Data Gaps

Studies for TNC on and off the preserve have frequently been done as part of graduate school research. Other studies have been done to address specific research questions. TNC will continue to cooperate with independent research projects and studies but with encouragement to fill data gaps necessary for the management of the preserve. There are numerous gaps in the database that will not necessarily be addressed with the monitoring program, because monitoring will be focused on evaluating interventions. The most important data gaps are described below.

Tributary Hydrology and Temperature

The USGS gauging sites provide the only long-term flow measurements available. Flows in the tributaries have been estimated in a variety of ways, but there are few direct, sustained measurements of discharge in most of the streams supplying Silver and Loving creeks. Staff gauges should be installed and calibrated for the upper and lower reaches of the main tributaries and read frequently each month. Without this type of data an accurate hydrologic budget of the watershed cannot be developed. Because tributaries dictate conditions in the receiving streams (Silver and Loving), knowledge of how tributary temperatures vary is also critical. Thermal data are lacking on the tributaries and receiving streams. Thermal data recorders are needed in all the tributaries to monitor existing conditions and the effectiveness of interventions to reduce temperatures.

Spring Hydrology and Temperature

There has been a substantial loss of springs over time from ponding and diversion; therefore the remaining springs play a critical role in stream discharge and temperature. Also, spring flow is an indicator of groundwater conditions—increasing groundwater extraction could reduce spring discharge throughout the watershed. Spring temperatures will change as a function of change in discharge—thermal recorders are needed on the major spring locations not only to measure these changes over time, but also to provide advance warning on any sudden temperature changes or spikes.

Pond Temperatures

The available data on water heating in ponded water are very sparse, and do not indicate that water temperatures in ponds are an issue. However, it is reasonable to suspect that ponded water does heat-up; especially those ponds open to solar heating for long periods during the day. Thermal data recordings for at least one summer in representative ponds would provide the necessary insight into how significant temperature loading is in ponds throughout the watershed.

Groundwater Balance

Numerous groundwater studies have been performed in the watershed; however, these studies were performed on a coarse scale relative to Silver and Loving creek's area of influence. Consequently, TNC, in cooperation with the University of Idaho and the Technical University of Denmark, has initiated a more detailed analysis of groundwater dynamics and how it influences Silver Creek and the preserve. This study is expected to be completed in 2011. The results will also indicate the rate at which groundwater change occurs (e.g. extraction versus recharge and depth to groundwater changes).

Fish Habitat Inventory

Before any instream work is performed on creeks, it is essential to perform a detailed inventory (qualitative and quantitative) of fish habitat if restoration interventions are to be effective. Without detailed knowledge of where spawning, early rearing and other critical fish habitat features are, any instream work could adversely affect fish distribution, recruitment or growth. A habitat inventory should also include identification of food sources.

Land Use Mapping

Traditionally, monitoring of streams and rivers was limited to the aquatic and associated riparian habitats. However, the importance and influence of land use throughout the entire watershed has become widely recognized. Measuring and monitoring land use within the watershed plays an important part of any watershed-based management plan. The land use of each parcel affects both in-stream and riparian habitat in some way. Agricultural fields contribute nutrients and change run-off patterns. Woody riparian areas filter sediments, nutrients, and solar radiation to benefit the stream. The Nature Conservancy, in its partnership with Ecosystem Sciences Foundation, has initiated a land use mapping and monitoring effort for the entire Silver Creek watershed (see Section 6 for more detail).

Muskrat/Beaver Habitat Inventory

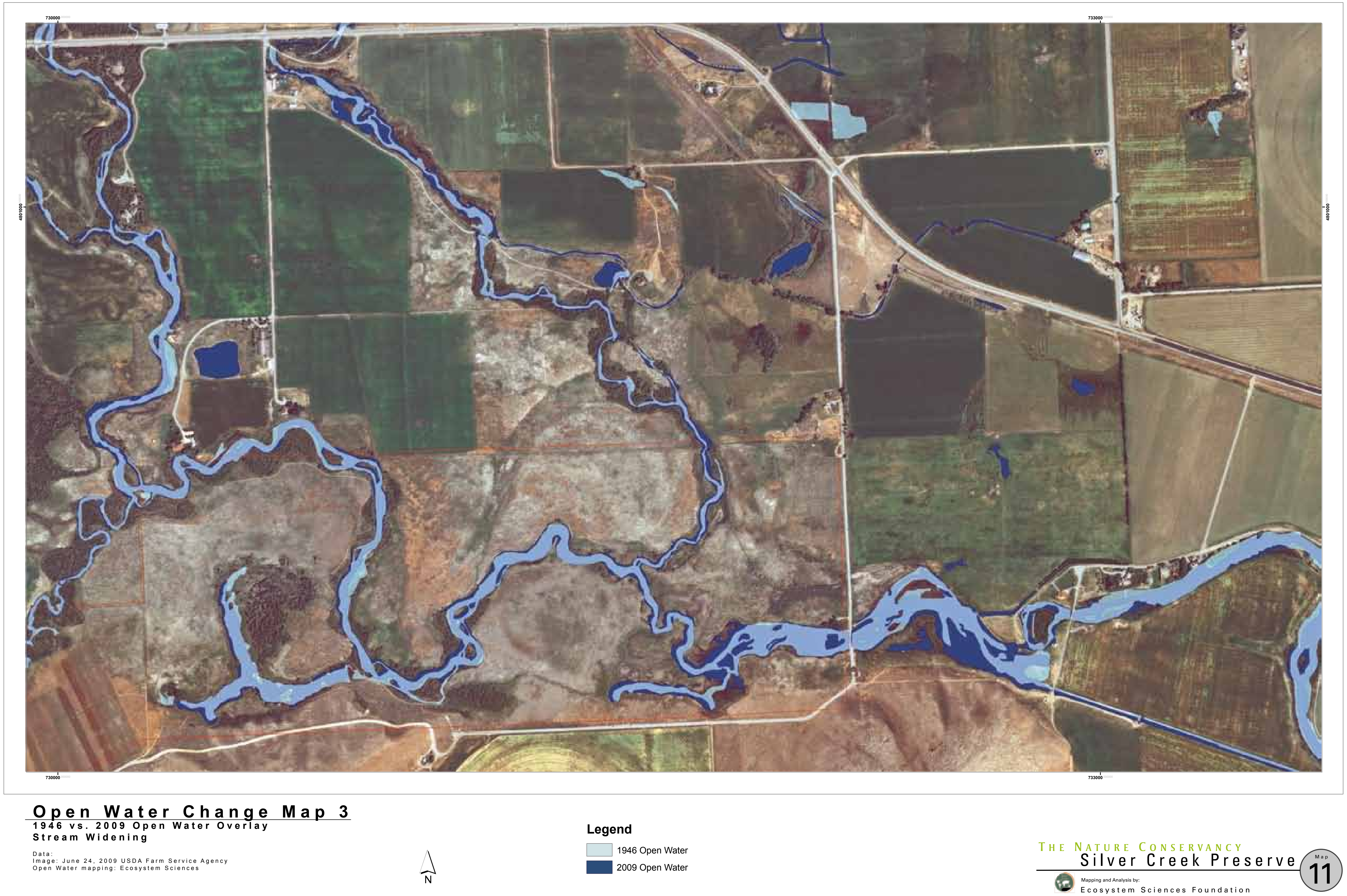
Freshwater mammals like muskrats and beavers can have a profound influence on stream dynamics that includes impacts from dam building, bank erosion and loss of riparian vegetation. Both beaver and muskrat occur in the watershed. Some stakeholders have voiced concerns that muskrats in particular are responsible for bank erosion, potential sources of sediments. While mapping has not indicated significant bank erosion in the watershed, it cannot be concluded that increasing muskrat populations will not be a future issue. These animals should be surveyed every few years to track population change. The inventory should also include changes in bank conditions and in riparian habitat attributable to beaver and muskrat.

Channel Geometry

There are a few existing cross-section transects on Silver Creek and a few tributaries. However, these are too few to provide a reliable database for stream modeling. TNC has initiated a project to collect cross channel data on 100 transects on Silver and Loving creeks and tributaries. The data will include riparian zone width, channel width, average depth, thalweg, and substrate measurements. These data will be essential for future monitoring of vegetation, channel, and substrate changes.

Ice Conditions

Winter conditions in Silver Creek have never been studied or seriously addressed; however, as discussed in other sections of this plan, icing throughout the stream has a profound influence on the stream's physical condition. Ice conditions should be examined in more detail by first mapping the location, extent and thickness of ice in winter time. Second, the kinds of icing (surface, frazzle or anchor) most common in the winter should be identified.



Channel and Open Water Comparison: 1946 to 2009

Past land use practices have had a significant impact on the current condition of Silver Creek and its tributaries. Grazing, agricultural development, and water management practices have affected the width of the stream channels within the Silver Creek Watershed for at least the last 60 years. Current land cover mapping (based on 2009 aerial images) juxtaposed with historical land cover mapping (based on 1946 georectified aerial images) identified areas within the Silver Creek watershed where stream widening has occurred.

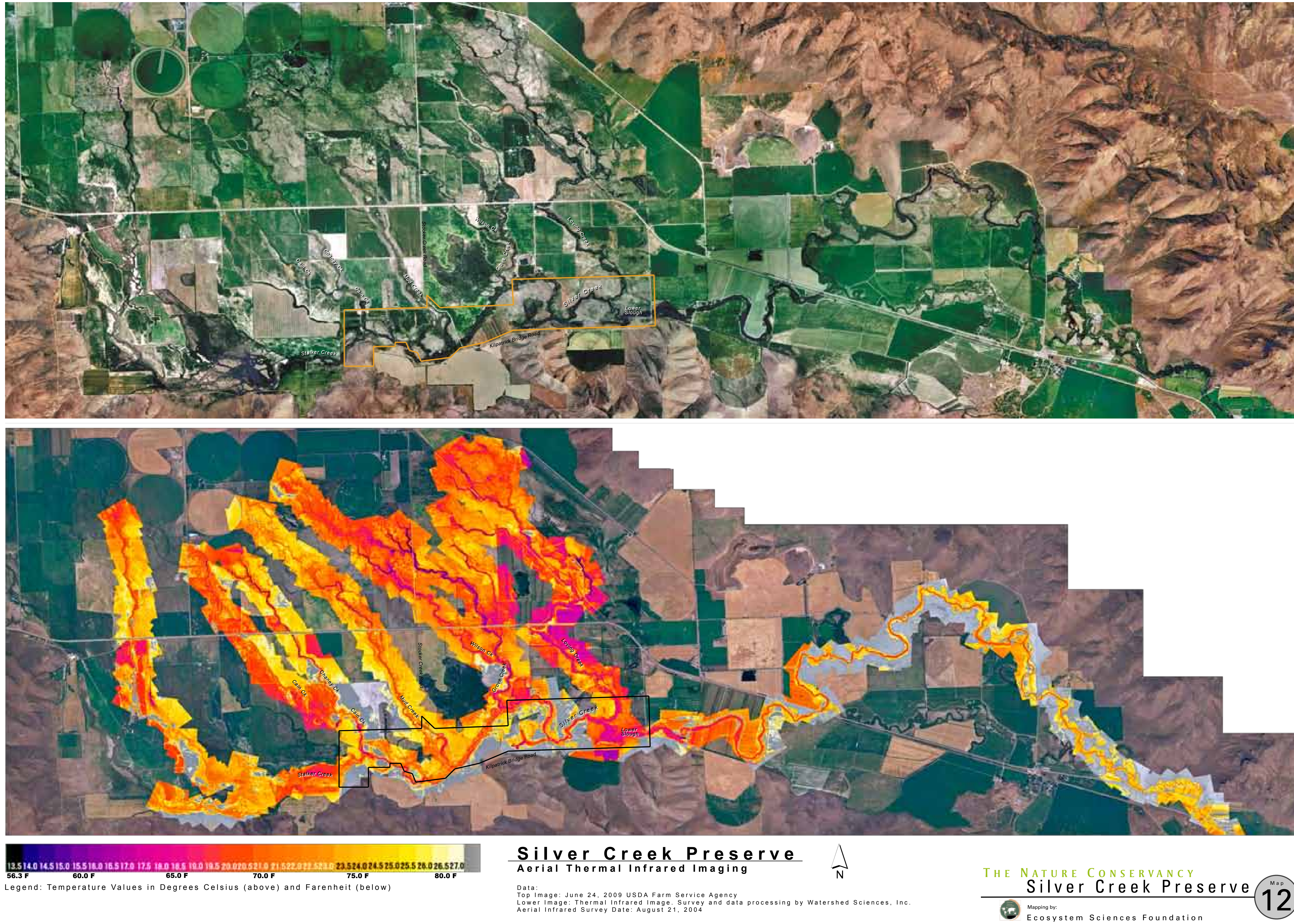
Channel widening can have deleterious effects on water quality, most notably on temperature (Gillian 2007). Wide channels often have little riparian vegetation and are thus subject to significant solar inputs, much like ponds mentioned above. These areas then become warmer than the surrounding stream channels that are narrower and support a more robust riparian canopy. Additionally, areas where channels have widened often have diminished flow velocities and therefore become depositional areas. Significant sediment deposits can hinder trout reproduction by covering gravel areas (redds) where salmonids reproduce (Grunder 1985).

Areas of the Silver Creek watershed where widening was evident based on a comparison of the 1946 and the 2009 aerial images include: Loving Creek downstream of Highway 20; Grove Creek between Highway 20 and its confluence with Silver Creek; and Chaney Creek between Highway 20 and its confluence with Cain Creek.

Thermal Loading

Sediment loading also increases stream temperatures, because soil is an effective heat sink (Colby 1963). The more sediment there is in a stream, the higher the temperatures can go. The figure to the right shows the difference in temperatures between soil (land surfaces) and water surfaces - agriculture lands absorb the greatest amount of heat. However, sediments are only a contributory factor to thermal loading in streams throughout the watershed, and direct solar heating is the primary cause of temperature issues in Silver and Loving creeks. Land cover mapping illustrates the fundamental watershed challenge to stream temperature, which is lack of shading due to a lack of riparian vegetation on tributaries. A secondary cause of elevated stream temperatures throughout the watershed is the loss of springs and ponding (Perrigo 2006). Grazing at the turn of the 20th century was the primary cause of riparian vegetation loss (Grunder and Griffith 1983). Land use practices since then have inhibited recruitment of riparian vegetation and altered springs (for irrigation purposes).

Long term monitoring of stream temperatures provides reliable data for temperature profiles (Save Silver Creek, 2006-2009). The temperature charts illustrate the summer temperatures for tributary creeks and for Silver Creek from Stalker Creek to the Susie Q Ranch. As would be expected from a spring system, minimum temperatures remain relatively constant. Average temperatures in Silver and Loving creeks and their tributaries are well below the upper threshold for brown and rainbow trout and are within the preferred temperature range for all trout life stages (Bell 1990). Only the maximum temperatures, which occur for very short time periods in the evening hours, approach trout thresholds. To date, these temperatures have not had an adverse affect on the trout population, which has remained robust and healthy. However, the concern is that stream temperatures may increase in the long-term, exceeding upper thresholds for these trout species.

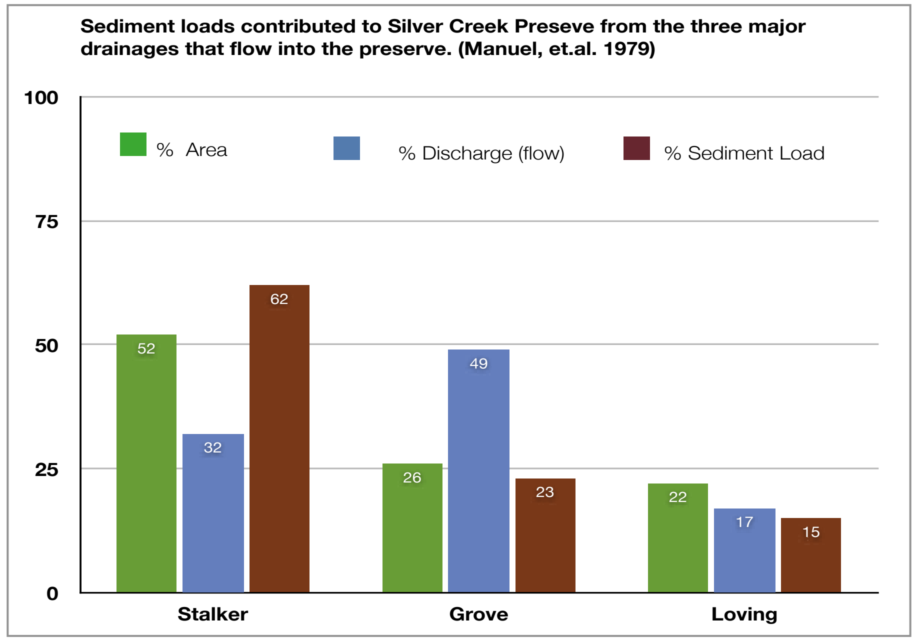


Thermal Infrared Imaging: Aerial images with and without a thermal surface temperature overlay. The thermal temperatures displayed on the bottom aerial image represent surface temperatures of water bodies and streams as well as adjacent lands. The thermal imaging only presents surface temperatures at one point in time and does not reflect any long term trends, averaging or acreages.

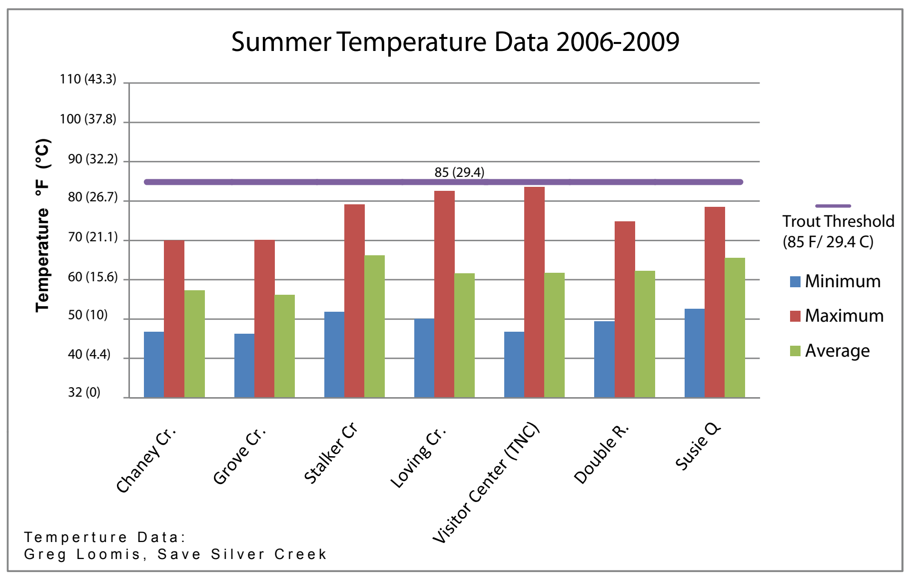
Sediment Loading

Sediment deposition in the watershed was most severe during the time of intensive cattle grazing, which spanned the 20th century (Grunder and Griffith 1983). The volume of suspended sediments entering all the tributaries and streams in those years overwhelmed the carrying or export capacity of the system, and large amounts of sediment accumulated and altered most of the stream channels from their original configurations (Perrigo 2006). Today, a major portion of the sediment depositions are a legacy of these past land use activities. Although new sediments continue to be discharged to the streams from overland runoff during snowmelt and precipitation events, the amount of sediments being exported from the system appears to balance those being imported; still the ecosystem only has sufficient export capacity to balance input with output such that legacy depositions remain in the streams (Perrigo 2006). Over time, if significant suspended sediment loading is attenuated or eliminated, sediment output will exceed input, at which point legacy sediments will begin to be exported.

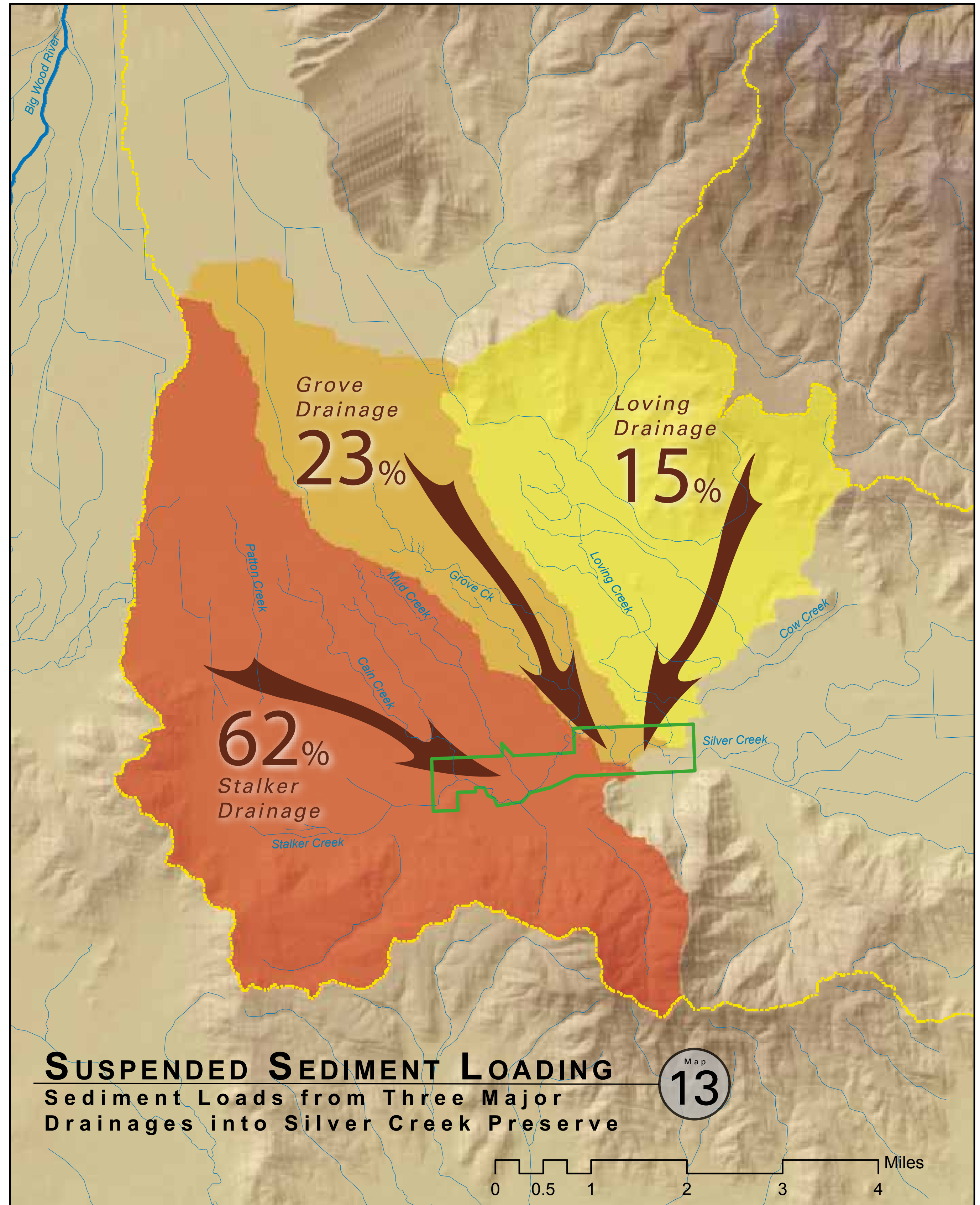
Previous investigations (1979, 1983, 2006) identified the sources of suspended sediments to the catchment or sub-basin level. The figure on the left shows the three sub-basins: Stalker, Grove, and Loving creeks. Suspended sediment loading from a sub-basin is not just a function of area and discharge. For example, Stalker sub-basin makes up 52% of the area and 32% of the discharge, but accounts for 62% of the sediment loading, which is more than the suspended sediment loading from Grove and Loving combined (Manuel et al., 1979 and Perrigo 2006). Thus, suspended sediment loading to Silver Creek is more a function of land use within a sub-basin than the size or volume of water discharged.



Suspended sediment load in relation to discharge and catchment area.



Summer temperature data from 2006 to 2009 recorded maximum temperatures in Silver Creek and its tributaries that approached but did not exceed the temperature threshold for trout.



The bulk of suspended sediment loading occurs as sheet erosion from runoff. Some sediment is from minor bank erosion and atmospheric input during wind periods, but studies indicate these are not significant sources (Manuel et al., 1979 and Perrigo 2006). Suspended sediments are transported to Silver and Loving creeks via their tributaries. Since TNC established the preserve in 1976, Silver Creek has been adequately buffered with riparian vegetation; nearly all suspended sediment loading originates in the upper watershed on tributary streams that are not adequately buffered (Grunder and Griffith 1983).

Ecological Tipping Points

Scientists have struggled to find a way to explain complex environmental changes in ways that will make them comprehensible to the layperson. The concept of tipping points is just such an explanation. An example of how tipping points can simplify the understanding of climate changes is given as:

> *A climate tipping point is a point when global climate changes from one stable state to another stable state, in a manner similar to a wine glass tipping over. After the tipping point has been passed, a transition to a new state occurs. The tipping event may be irreversible, comparable to wine spilling from the glass – standing up the glass will not put the wine back. (Hansen, J. 2008 "Tipping point: Perspective of a climatologist")*

In much the same way as you can gradually tip a glass to the side, ecological changes can accumulate slowly. Once the tipping point is reached however, gravity or some other analogous force takes control and the situation can change rapidly.

An ecological tipping point or an ecological threshold can be described as the point at which a relatively small change in external conditions causes a rapid change in an ecosystem. When an ecological threshold has been passed, the ecosystem may no longer be able to return to its state. The crossing of an ecological threshold often leads to rapid change of ecosystem health.

The adjacent figure illustrates this concept for a hypothetical trout fishery faced with increasing water temperatures. The fish population remains healthy and robust with a relative stable population over time. However, stream temperatures increase, accumulate, year after year until the point at which trout tolerance is exceeded. Once this tipping point is reached the fish population begins to precipitous decline. Reversing the decline is now not just as simple as lowering stream temperatures because other ecological conditions contribute to and accelerate the decline. Benthic macroinvertebrate production, the trout food base, also declines as a consequence of temperature change, biological oxygen demand (BOD) and chemical oxygen demand (COD) also change with temperature and redox potential increasing the amount of dissolved oxygen consumed. Other physio-chemical process are altered as well. Once the tipping point is reached and exceeded it is difficult to reset the natural ecosystem processes; i.e., standing up the wine glass will not put the wine back. There have been warning events in Silver Creek that the wine glass is slowly tipping.

The only recorded fish kills in Silver Creek occurred in June 1992 and June 1994 (IDFG personal communication, 2010). While the exact cause of the trout kills is unknown (extreme temperatures, low dissolved oxygen, nitrogen or sulfate saturation, runoff from agriculture lands), the events raised alarms about the health and condition of Silver Creek. Long term observations of sediment loading and temperature increases added to the concern that the Silver Creek ecosystem and its high value fishery might be in danger.

Analysis of the available data does not indicate that Silver or Loving creeks are in imminent danger of environmental collapse or that fish kills will become commonplace or that the fishery itself is adversely affected. However, it is clear that the ecosystem and Silver Creek in particular is under stress from watershed influences, primarily sediment and temperature loading.

The streams are approaching tipping points, or reaching the level at which additional stressors, such as extended drought periods, could cause rapid deterioration and have severe impacts on the fishery. Nevertheless, the ecosystem is currently far enough from the tipping points that there is sufficient time to address the causes and implement actions to move the ecosystem away from these thresholds. The actions included in this plan will address the threats to Silver and Loving creeks with the goal of moving the ecosystem away from the tipping points. Proper future management will ensure the long term health and sustainability of the fishery and its ecosystem.

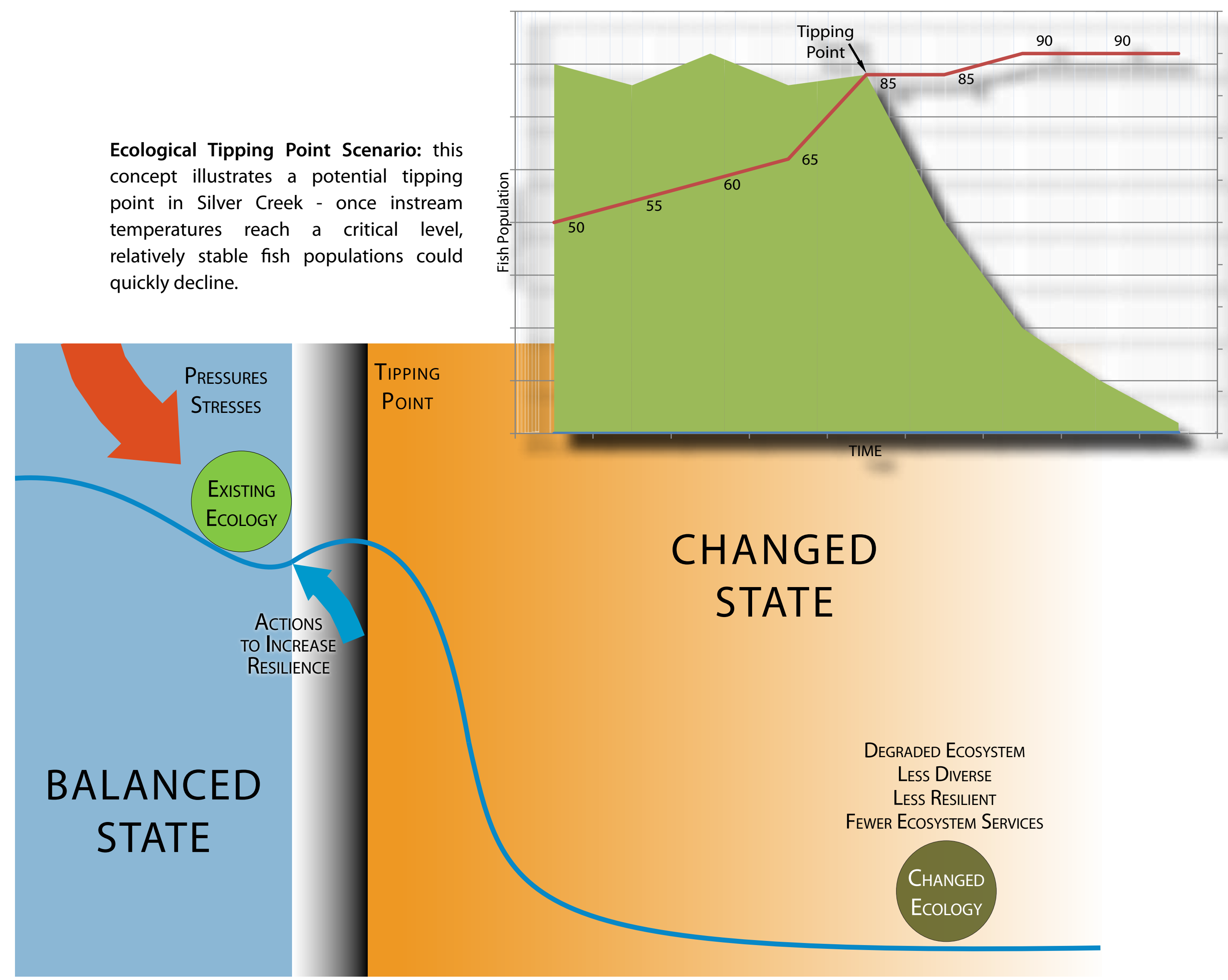
The first priority to step the ecosystem back from tipping points is the attenuation of sediment inputs. Creating and enhancing buffers between agriculture fields and streams will reduce the overall sediment loading. Since it has been shown that the nexuses between fields and streams and overland runoff are the principle sources of sediments, resources and effort can be focused to interdict sediments at the sources. It is not reasonable that all such priority sites identified in this plan can be remediated. It is to be expected that there will always be sediment inputs to the streams from overland runoff. However, it is reasonable that with enough site remediation work the total annual sediment loading will be reduced to the extent that export exceeds input throughout the ecosystem allowing annual removal of legacy sediments.

The other priority is to improve shading on key tributaries. Those tributaries to Silver Creek identified as sources of thermal loading can be planted with riparian vegetation, which can begin shading stream areas within three years with significant thermal reduction as early as five years. This period of time for development of significant riparian vegetation is well within the time frame to step the system back from the thermal tipping point.

Perhaps the ultimate tipping point and threat to Silver Creek and its watershed comes from groundwater pumping. Over-mining of the Wood River Valley aquifer system, the point at which extraction exceeds recharge, will be noticed first in the springs throughout the watershed. The groundwater levels (distance from the surface) that maintain spring flows are higher than the levels that provide groundwater inflow to streams—as groundwater levels decline, springs will begin to falter and then simply cease flowing. Since springs are the "headwaters" for Silver Creek and its tributaries, cessation or severe flow reduction would cause the ecological collapse of the streams.

The most recent study on the groundwater budget for the Wood River Aquifer (Bartolino 2009) reports that discharge or outflow from the aquifer occurs through five main sources (from largest to smallest): Silver Creek stream flow gain, groundwater pumping, Big Wood River stream flow gain, direct evapotranspiration, and subsurface outflow. Groundwater pumping for agricultural and urban development uses has increased. Although results of the study indicate that groundwater is replenished in wet years, statistical analyses by Skinner et al. (2007) suggest that such replenishment is not complete and over the long term more water is removed from storage than is replaced. In other words, despite restoration of water to groundwater storage in wet years, changes have occurred in either recharge and/or discharge to cause groundwater storage to decline over time.

At this time no one can predict the rate of decline because it is difficult to predict what additional demands will be made on the groundwater resource in the watershed and the region. It is also difficult to predict when and to what extent groundwater levels will decline, causing springs to dry up. What is known is that continued mining of the aquifer at the current rate of extraction is not sustainable, and once the groundwater tipping point is reached, the ecological integrity of Silver Creek and its tributaries will decline rapidly.



Ecological Tipping Point Scenario: this concept illustrates a potential tipping point in Silver Creek - once instream temperatures reach a critical level, relatively stable fish populations could quickly decline.

Section 4: Watershed and Landscape Influences

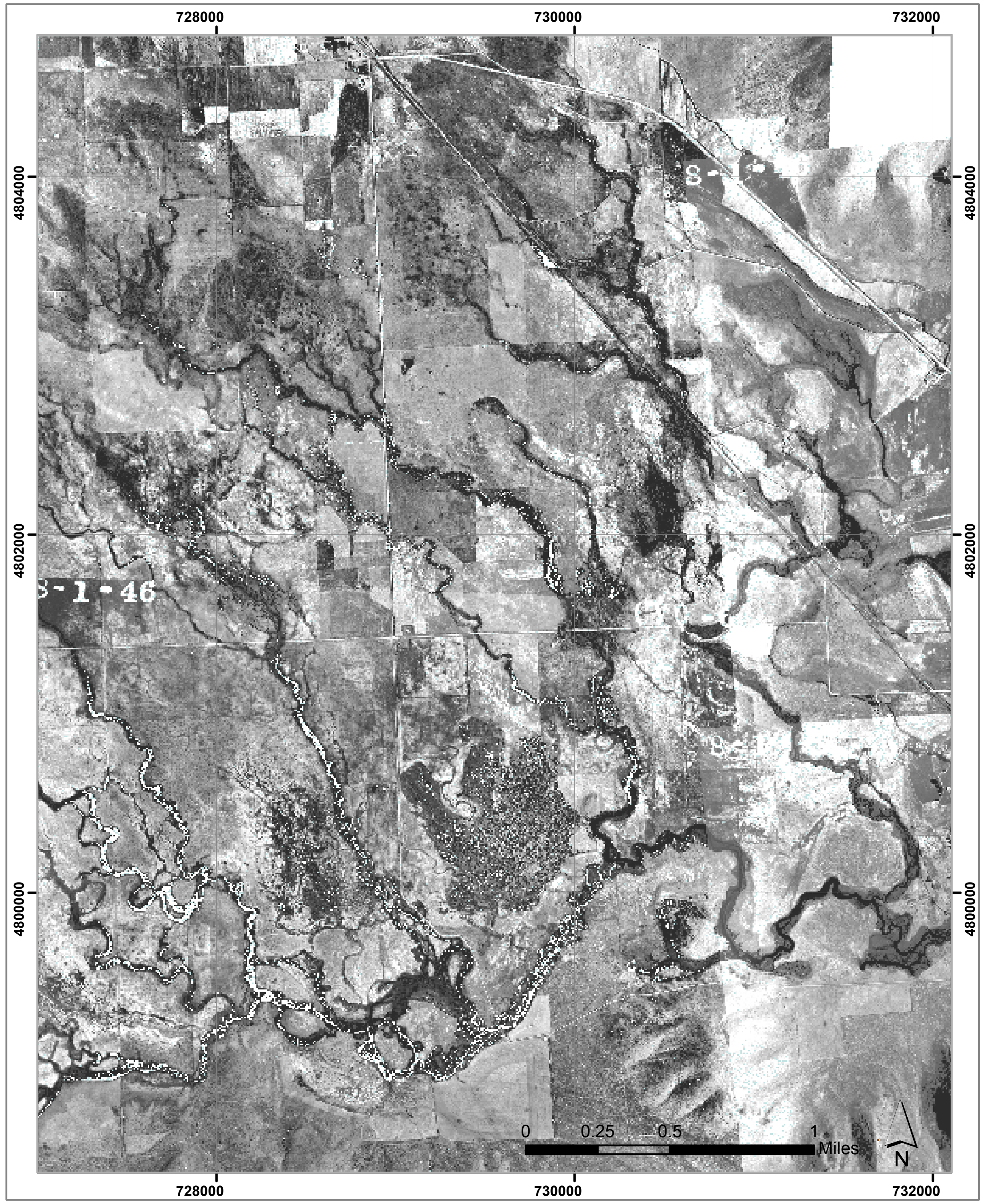
Stream conditions are a function of many ecological processes and are heavily influenced by activities within the watershed. This section identifies several watershed and landscape scale influences on the Silver Creek ecosystem. These influences should shape restoration and management priorities. Although many restoration efforts are focused on one reach or a small site within a reach, activities operating on the landscape scale influence ecosystem function. This section examines some of the land cover changes between 1943-46 and 2009 and addresses some major near term and long term threats, including exotic species, recreation, whirling disease, groundwater mining, urbanization and development, land use conversions and herbicide/pesticide accumulation. These selected influences will change through time, and management priorities and responses should adjust accordingly.

Activities within the watershed influence stream health and processes. For example, Silver Creek's bucolic setting and world class fishery make it a popular recreation destination; however, heavy fisherman traffic can reduce bank stability, mobilize instream sediments, and trample riparian vegetation. Land use patterns, especially agricultural practices, shape the landscape of the Silver Creek watershed. The conversion of lands formerly containing natural vegetation types to agricultural landscapes, influences instream temperature, sediment and nutrient levels. The method of irrigation, such as the conversion from flood to sprinkler irrigation, also influences these inputs and alters water use. Natural vegetation such as woody wetlands adjacent to streams provide shading and reduce nutrient and sediment inputs.

Landscape Change 1946 to 2009

The landscape of Silver Creek has changed dramatically through time. Because of a lack of information about the pre-European settlement and early agricultural period (prior to the 1943-46 photographs) only qualitative analyses may be made. However, land cover types can be mapped from aerial photographs and a quantitative analysis of land cover changes can be made over time (see Section 2 for a more detailed discussion). In general, over the past 50 years there has been an increase in irrigated agriculture areas, developed areas, roads, open water and woody wetlands, and a decrease in grasslands, emergent herbaceous wetlands, and shrub/scrub areas in the watershed. In its natural condition, woody wetlands, emergent herbaceous wetlands, grasslands and shrub/scrub areas were likely much higher than the 1943-46 or 2009 conditions. In this natural condition, open water was likely lower, and agriculture, developed areas, and roads did not exist.

Although mapping provides data which may be used to monitor trends and evaluate changes, a qualitative evaluation of side by side images illustrates a few of the changes the watershed has undergone that are not easily measured. The images to the right show Silver Creek and its main tributaries in black and white (1943-46) and color (2009). The conversion from grassland and emergent wetland to agriculture is clearly visible in this change pair. Examination of the two images shows a loss of overall habitat complexity and diversity. Many headwater emergent wetlands were drained for conversion to agricultural uses. Streams were impounded to create ponds or other water reservoirs for multiple uses. This loss of complexity affects habitat quality for species on a landscape scale, and influences ecosystem function. Many of the natural spring wetlands and tributary streams have been straightened or compartmentalized, reducing the connectivity of the system.

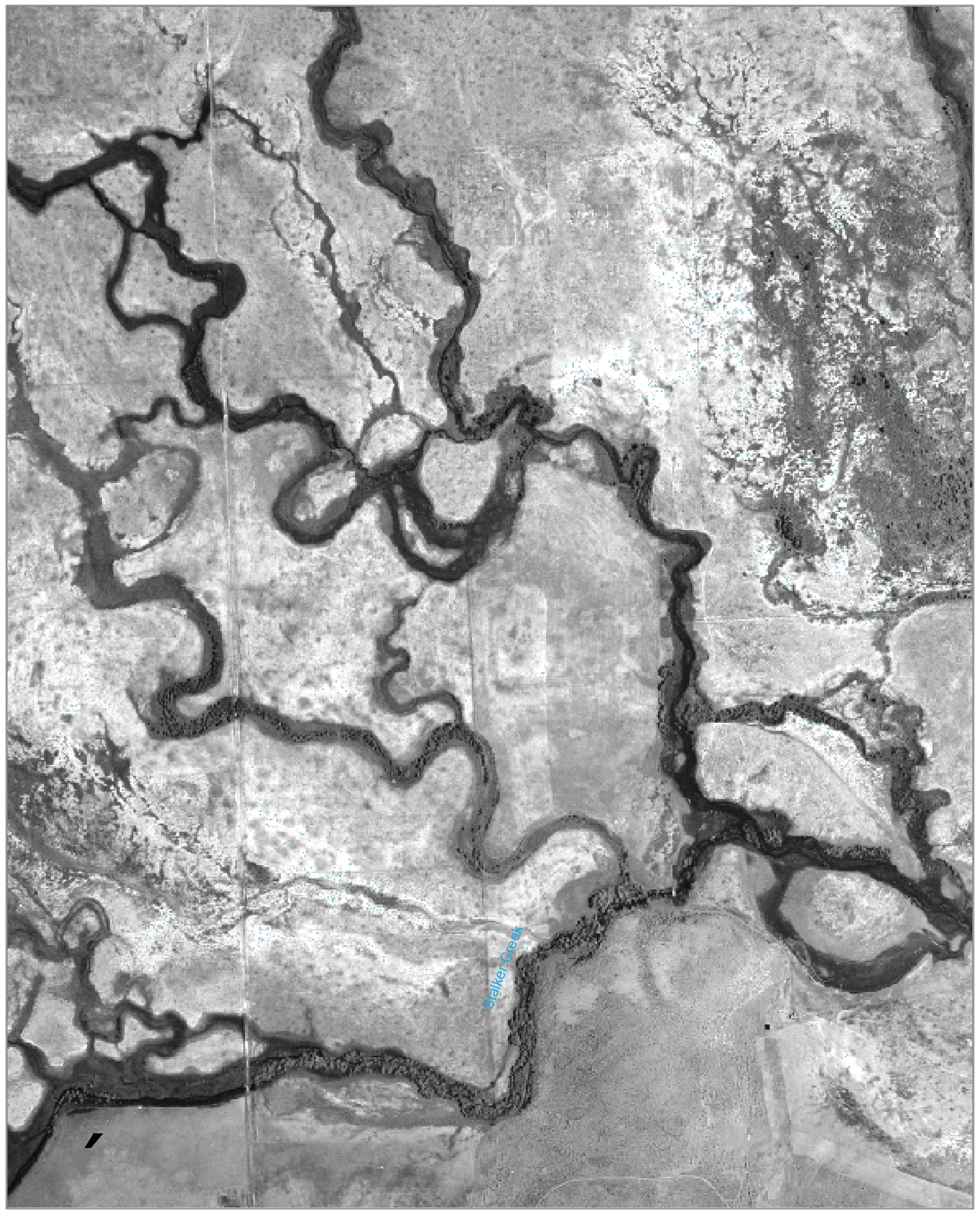


Silver Creek 1946 Conditions

Silver Creek 2009 Conditions

Though the effects of connectivity loss are difficult to directly observe, connectivity is an important watershed component that operates on a landscape scale and is vital to the overall function and value of the watershed.

Landscape Change 1946 to 2009



Silver Creek 1946 Conditions

Silver Creek 2009 Conditions

Channel straightening, narrowing and conversion of grasslands and emergent wetlands to cultivated agriculture are common changes to the Silver Creek landscape over the past 100 years.

The images to the left show portions of Stocker Creek , Chaney Creek, Cain Creek, and a small part of Mud Creek (in the upper right hand corner of each frame) in a mosaic of 1943-46 black and white images and a color 2009 image. The increase in irrigated agricultural lands is clearly visible in these finer scale images when compared to those in the figure on the opposite page. An increase in agricultural lands within the watershed results in accumulations of nutrients and pesticides, increased stream temperatures and sediment inputs. Also visible at this scale are areas where the channel has been straightened and has lost complexity. Areas covered by natural vegetation communities in the 1943-46 image were removed, and low-lying areas drained and filled to expand agriculture. This can clearly be seen on the right side of both images—a natural mosaic of shrub and grassland vegetation in a spring wetland area, visible in 1943-46, was converted to a straightened ditch with sparse wood vegetation along its edges, which is evident in the 2009 image. Road construction is also a clearly visible change between the two images, with the east-west road crossing Cain Creek; a wetland drain also resulted in a new pond north of the road. Finally, in the lower right hand corner of the 2009 image a new pivot irrigated field can clearly be seen.

Kilpatrick bridge over Silver Creek, 1939.

Additional Stresses and Constraints

Near-Term / Long-Term

Restoration and enhancement planning must consider not only the current ecological conditions and issues and challenges, but also recognize future threats to the health of the ecosystem and anticipate how to respond. TNC's preserve is already experiencing some chronic as well as new environmental stresses. These stresses either have not reached a level of significant impacts, or are still too remote to evaluate qualitatively or quantitatively. Stresses are categorized as short-term or long-term depending upon how immediate the impact or risk. While there may be innumerable possibilities in the future, planning must focus on the most likely and foreseeable threats. Identifiable short-term stresses to the Silver Creek watershed include non-native species invasions, whirling disease, and recreation impacts. Long-term stresses include groundwater extraction, urbanization and development, land use conversions, and the accumulation of herbicides and pesticides.

Exotic Species Invasions

The most immediate exotic species threat to Silver Creek comes from the New Zealand mudsnail, which is present and spreading in some reaches (Richards and Lester 2003). While the infestation is relatively confined due to cold winter water temperatures (James 2007), the distribution and abundance of mudsnails throughout Silver Creek should be periodically monitored. At high densities, mudsnails can take over invertebrate production and eliminate the trout food source. Reed canary grass (RCG) was originally introduced to the Silver Creek watershed to stabilize streambanks (August et al., 2006). This same study shows that RCG growth has been aggressive and is now affecting streamside and instream habitat in Silver Creek, and especially in Wilson Creek. So far, interventions to remove or contain RCG have not been successful. Ultimately, the best intervention for RCG in the watershed is shading. Light attenuation is a key method in reducing RCG growth (Hitchcock 1950). There are a variety of non-native, weedy plants in Idaho that include: spotted knapweed, rush skeletonweed, leafy spurge, Canada thistle, cheatgrass, meadow and orange hawkweeds and yellow starthistle. Some of these plants have probably established and spread in the Silver Creek watershed. While these plant species are ecological and economic pests, not all non-native species are undesirable. For example, brown trout are a highly prized sport fish in Silver Creek, even though the species was introduced. Rainbow trout are also non-native (Williams and Powell 2000), yet both species fill desirable ecological and recreational roles.

Recreation

Silver Creek is an exceedingly popular recreation destination, with over 7,000 visitors a year, most of them anglers who walk the streambanks and wade in the stream, impacting birds and mammals as well as the fishery. Overuse of the streambanks has caused trampling of riparian vegetation and in some places prevented recruitment of new vegetation. Intensive wading in deeper water and gravel areas where redds are less visible can damage redds and interrupt trout egg incubation; wading can also destroy aquatic invertebrates (Griffith 1988). Since the stream fishing regulation is catch-and-release, the fishery has been able to withstand intense angling pressure. However, a catch and release fishery can have high mortality and produce negative effects on growth and recruitment (Chapman 1990). Periodic fish surveys by the IDFG evaluate the fish population and age-size distribution, which guide adjustments to catch regulations. Other recreation activities such as bird watching, canoeing, and hiking have far less impact on Silver Creek's riparian system. Nevertheless, management should be aware of increased recreational uses and activities on the stream ecosystem.

Whirling Disease

Whirling disease was first detected at the Hayspur Hatchery in 1988 and in wild rainbow trout in Loving Creek in 1995. The disease is a waterborne pathogen that is deadly to trout. It is assumed that the Silver Creek trout population is infected with the disease; however, the trout population appears to be asymptomatic at this time (Wilkison 1996 and IDFG personal communication 2010).

Groundwater Mining

Groundwater pumping is a critical long term threat to the watershed and Silver Creek in particular. As the depth to groundwater increases, springs are in danger of being dried-up. A recent study by the USGS (Bartolino 2009) evaluated groundwater budgets for three periods. The study concluded that although groundwater storage is replenished in wet years, such replenishment is not complete and over the long term more water is removed from storage than is replaced. Changes have occurred in the watershed to cause a decline in groundwater storage. Causative agents include lining or abandoning canals and ditches, converting from surface water irrigation to groundwater irrigation, relocating diversion points and altering irrigation methods and efficiency.

Urbanization and Development

As the communities in the watershed grow so does water demand. Well permits have steadily climbed in relation to housing development and urbanization. Bartonlino (2009) identified increased groundwater pumping to meet urban and development demands as a contributing factor to the groundwater decline. Urbanization or growth of cities and towns in the watershed is expected to continue. While TNC's conservation easements protect the Silver Creek preserve from development, the preserve is still at risk from development throughout the watershed with its concommitment groundwater demand.

Land Use Conversions

Over time, land uses within the watershed have converted from intense livestock grazing to agriculture. Agricultural land uses have changed as well with different crops and cropping patterns. In general, the conversion of grazing to agriculture has been beneficial to the streams throughout the watershed. Nevertheless, as described in Section 5, agricultural practices in some areas of the watershed can be improved to provide greater stream protection and reduce sediment inputs and temperature loading. Land and water uses outside of the preserve have an overriding influence on conditions within Silver Creek. Consequently, land use changes throughout the watershed that involve modifications in water requirements, types of crops, or development are all important to the long term management of the preserve.

Herbicide/Pesticide Accumulation

Although there are no data to support concerns about the accumulation of herbicides and pesticides in streams throughout the watershed, both urban and agriculture runoff are recognized sources of these contaminants. Periodic monitoring of these constituents in water quality sampling would be prudent for long term management.

Section 5: Restoration and Enhancement Strategies

This section describes the actions or interventions necessary to restore and enhance Silver and Loving creeks. The critical point in achieving this restoration is time. Nature restores ecosystems in biological time, not on human schedules. Regardless of whether the intervention is active or passive, time is required to ensure natural ecological processes are established.

Restoration Concepts

To achieve success in the restoration and enhancement of the streams, there are four basic requirements: (1) to understand ecosystem function; (2) to give the system time; (3) to appreciate self-design; and (4) address the causes of degradation.

Though there is currently little scientific research on rebuilding and restoring of whole ecosystems, what works and does not work in different types of ecosystems is evident every time we rehabilitate nature's processes. Subtle ecosystem interactions are better understood when we allow nature the time to respond to the reintroduction of natural processes. Through careful monitoring of the effects of macro-scale interventions, we can then adaptively manage with confidence and use more subtle interventions at micro-scales to influence the direction of restoration efforts toward a functional and sustainable ecosystem.

Restoration and enhancement of the Silver Creek ecosystem should emphasize the "self-designing" or "self-organizing" capacity of nature to recruit species and to make choices from those species. Self-design emphasizes the development of natural habitat. Scientific knowledge in the field of ecology verifies that natural forces do ultimately self-design around habitat by choosing the most appropriate species to fill niches and establish rates of recruitment, production and growth.

Restoration Concepts, continued

Self-design allows the natural colonization of plant and animal species to attain balance and optimum biodiversity with minimal human manipulation of materials or processes. In other words, sustainable ecological restoration should not rely upon a human-built and artificially maintained ecosystem. We emphasize instead, to the greatest extent possible within the constraints of continued multiple uses, to give nature back what it needs to function and then take a hands-off approach that adapts management interventions to what nature is teaching us about what it needs to achieve a healthy balance.

Critical to any restoration project is time. Restoration goals are met on biological not political time scales. Measuring restoration success must take into account the time needed for natural processes to achieve some goals. While streams are often "engineered", the measure of success comes in time and whether the restoration actions ultimately achieve the biological goals. The goals for the restoration and enhancement of Silver and Loving creeks are ultimately biological. Reducing temperature inputs and sediment loading, for example, will meet the goal of improving habitat and water quality conditions for the trout fishery. How well the fishery responds to temperature and sediment restoration actions will not be instantaneous, but will be measured (monitored) over time.

Fortunately, Silver and Loving creeks are not at the threshold or tipping point at which fish kills or other traumatic biological impacts will occur. Thus, there is time to allow for nature to do some of the heavy lifting, allow for ecological processes to develop, and allow self-organization to occur before expensive and risky instream alternatives are proposed.

Restoration and enhancement work starts with identifying the problem(s). Too often, projects are implemented with only a focus on the symptoms, not the disease. Unless the problems that cause the degradation are addressed, restoration will have little chance of long term success. Restoration plans and actions should emphasize letting nature do the heavy lifting using as much "passive" intervention as possible. In many cases, sound water and land management actions can achieve far more benefits at considerably less cost and far less risk of doing harm than heavy in-stream construction. However, in some situations, such as incised channels or degraded steam banks, mechanical or "active" interventions may be needed. Nevertheless, these actions should be limited to the highest priority sites and designed to achieve the maximum benefit at the least cost and with minimal risk to stream biota and habitat.

Restoration Guidelines

This section describes the procedures for conducting ecological restoration in accordance with the norms of the discipline[1] as modified to reflect the experiences and conditions in the Silver Creek subwatershed.

Each procedure is stated in terms of a guideline that leads restoration proponents and project managers stepwise through the process of ecological restoration. Adherence to these guidelines will reduce errors of omission and commission that compromise project quality and effectiveness. The guidelines are applicable to the restoration of any ecosystem—terrestrial or aquatic.

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. Restoration attempts to return an ecosystem to its historic trajectory, i.e., to a state that resembles a known prior state or to another state that could be expected to develop naturally within the bounds of the historic trajectory. The restored ecosystem may not necessarily recover its former state, since contemporary constraints and conditions can cause it to develop along an altered trajectory.

The project guidelines are numbered for convenience. They do not necessarily have to be initiated in numerical order, and some may be accomplished concurrently. The guidelines are grouped into two phases of project work: planning (including feasibility assessments), and implementation.

Planning

Conceptual planning identifies the restoration project site, specifies restoration goals, and provides relevant background information. Conceptual planning is conducted when restoration appears to be a feasible option but before a decision has been made to exercise that option. Conceptual planning provides preliminary information such as observations from site reconnaissance and perhaps a few representative measurements.

1. **Identify the project site location and its boundaries.** Delineate project boundaries and portray them as maps, preferably generated on a fine-scale aerial photograph and also on soil and topographic maps that show the watershed and other aspects of the surrounding landscape. Use of GPS (Global Positioning System), land survey, or other measurement devices, as appropriate, is encouraged.

2. **Identify ownership.** Give the name and address of the landowner(s). If an organization or institution owns or manages all or part of the site, give the names and titles of key personnel. Note the auspices under which the project will be conducted—public works, environmental stewardship, mitigation, etc. If there is more than one owner, make sure that all are in agreement with the goals and methods proposed for the restoration program.

3. **Identify causes of degradation.** Critical to establish goals and objectives is understanding the causes of degradation. How the restoration will resolve or ameliorate the source of the problem is essential to successful restoration. Interventions to restore any ecosystem that does not first remove or reduce the causes of the degradation is simply a band aid without much hope of being sustainable or successful in the long run.

4. **Identify the need for ecological restoration.** Tell what happened at the site that precipitated the need for restoration. Describe the improvements that are anticipated following restoration. Ecological benefits may amplify biodiversity, improve food chain support, etc. Economic benefits are natural services (also called ecosystem services) and products that ecosystems contribute towards human wellbeing and economic sustainability.

5. **Identify restoration goals.** Goals are the ideal states and conditions that an ecological restoration effort attempts to achieve. Written expressions of goals provide the basis for all restoration activities, and later they become the basis for project evaluation. We cannot overemphasize the importance of expressing each and every project goal with a succinct and carefully crafted statement. All ecological restoration projects share a common suite of ecological goals that consist of recovering ecosystem integrity, health, and the potential for long-term sustainability.

Statements of ecological goals should candidly express the degree to which recovery can be anticipated to a former state or trajectory. Some ecosystems can be faithfully restored to a known or probable historic condition, particularly when degradation or damage is not severe and where human demographic pressures are light, plant species richness are low on account of rigorous environmental conditions, and where the ecologically young vegetation in a newly restored ecosystem tends to resemble the mature vegetation of the pre-disturbance state. Even so, the restored ecosystem will undoubtedly differ in some respects from its model, owing to the complex and seemingly random (stochastic) aspects of ecosystem dynamics. Other restorations may not even approximate a historical model or reference, because contemporary constraints or conditions prevent restoration to a former, historic condition.

Restoration can be conducted in any of five contexts. The appropriate context should be identified in the project goals in order to underscore the intent of restoration and to avoid or minimize subsequent misunderstandings, conflict and criticisms. They are:

- Recovery of a degraded (subtle or gradual changes that reduce ecological integrity and health) or damaged (acute and obvious changes) ecosystem to its former state.
- Replacement of an ecosystem that was entirely destroyed (degradation or damage removes all macroscopic life), and commonly ruins the physical environment) with one of the same kind. The new ecosystem must be entirely reconstructed on a site that was denuded of its vegetation (terrestrial systems) or its benthos (aquatic systems).
- Transformation (conversion of an ecosystem to a different kind of ecosystem or land use type) of another kind of ecosystem from the bioregion to replace one which was removed from a landscape that became irreversibly altered. This option is important for restoring natural areas in an urban context where, for example, original hydrologic conditions cannot be restored.
- Substitution of a replacement ecosystem where an altered environment can no longer support any naturally occurring type of ecosystem in the bioregion. The replacement ecosystem may consist of novel combinations of indigenous species that are assembled to suit new site conditions as, for example, at a retired solid waste disposal site.
- Substitution of a potential replacement ecosystem, because no reference system exists to serve as a model for restoration. This option is relevant in densely populated regions where many centuries of land use have obliterated all remnants of original ecosystems.

6. **Identify physical site conditions in need of repair.** Many ecosystems in need of restoration are dysfunctional on account of damage to the physical environment, such as soil compaction, soil erosion, surface water diversion, and impediments to flow. The physical environment must be capable of sustaining viable, reproductive species populations that comprise the biota of the restored ecosystem.

7. **Identify potential impacts resulting from the proposed actions.** Many restoration actions have the potential to cause environmental impacts, particularly instream construction. All impacts must be evaluated and displayed and mitigation to avoid or minimize the impacts described. This is a common requirement for state and Federal permits and in cases where there is a Federal nexus, such as Federal funds, an assessment under NEPA will be required.

8. **Identify natural processes in need of restoration.** Natural processes maintain the integrity of an aquatic ecosystem and include stable streambanks, well vegetated, natural riparian zones, multiple flow regimes, geomorphic processes, water quality, and fish and wildlife habitat. Planning must identify what natural processes have been lost and how the proposed project will replace lost, damaged, or compromised elements of the natural system.

1. Society for Ecological Restoration International: Guidelines for Developing and Managing Ecological Restoration Projects, 2nd Edition Andre Clewell, John Rieger, and John Munro. December 2005.

9. Identify and list the kinds of biotic interventions that are needed. Many restoration projects require manipulation of the biota, particularly vegetation, to reduce or eradicate unwanted species and to introduce or augment populations of desirable species. Invasive non-native species generally require extirpation. Other species, native or non-native, may be removed if they delay or arrest biotic succession.

10. Identify landscape restrictions. Population demographics of many species at a project site may be adversely affected by external conditions and activities offsite in the surrounding landscape. Land and water usage are commonly at fault. Restoration of some aquatic ecosystems depends entirely on making ecological improvements elsewhere in the catchment, and all restoration work is accomplished offsite. An example of an impact from offsite would be development of buffers to intercept sediments in runoff. Hazards elsewhere in the landscape such as these should be identified and evaluated in terms of their potential to compromise restoration efforts, and the possibility that they can be ameliorated should be assessed.

11. Identify project-funding sources. Potential external funding sources should be listed if internal funding is inadequate.

12. Identify labor sources and equipment needs. Personnel may have to be hired, volunteers invited, and other labor contracted. Determine the need and availability of special equipment.

13. Identify biotic resource needs and sources. Biotic resources may include seeds, other plant propagules, nursery-grown planting stocks, and animals for establishment at the project site. Some stocks are commercially available. Others, such as seeds of native plants, may have to be collected from other natural areas.

14. Identify the need for securing permits required by government agencies. Permits may be required for tasks such as the excavation or filling of streams and wetlands, other earthwork activities, herbicide use, and prescribed burning. Other permits may be applicable for the protection of endangered species, historic sites, etc.

15. Identify permit specifications, deed restrictions, and other legal constraints. Zoning regulations and restrictive covenants may preclude certain restoration activities. Legal restrictions on ingress and egress could prevent the implementation of some restoration tasks. If the restoration is to be placed under conservation easement, the timing of the easement must be satisfied and manipulations to the environment may have to be completed prior to the effective date of the easement.

16. Identify project duration. Project duration can greatly affect project costs. Short-term restoration projects can be more costly than longer-term projects. The longer the project, the more the practitioner can rely on natural recovery. In accelerated restoration programs, costly interventions must substitute for these natural processes.

17. Identify strategies for long-term protection and management. Ecological restoration is meaningless without reasonable assurance that the project site will be protected and properly managed into the indefinite future. To the extent possible, threats to the integrity of a restored ecosystem on privately owned land should be minimized by mechanisms such as conservation easements or other kinds of zoning. External threats can be reduced by buffers and binding commitments from neighboring landowners.

18. Appoint a restoration practitioner who is in charge of all technical aspects of restoration. Restoration projects are complex, require the coordination of diverse activities, and demand numerous decisions owing in part to the complex nature of ecosystem development. For these reasons, leadership should be vested in a restoration practitioner who maintains overview of the entire project and who has the authority to act quickly and decisively to obviate threats to project integrity. Many smaller projects can be accomplished by a single practitioner who functions in various roles—from project director and manager to field technician and laborer. Larger projects may require the appointment of a chief restoration practitioner who oversees a restoration team that includes other restoration practitioners.

19. Prepare a budget to accommodate the completion of preliminary tasks. The budget addresses labor and materials and includes funds needed for reporting. It recommends or specifies a schedule of events. Implementation plans describe the tasks that will be performed to realize project objectives. These tasks collectively comprise the project design. The care and thoroughness with which implementation planning is conducted will be reflected by how aptly implementation tasks are executed.

20. Describe the interventions that will be implemented to attain each objective. The chief practitioner designates and describes all actions, treatments, and manipulations needed to accomplish each objective. For example, if the objective is to establish tree cover with a designated species composition and species abundance on former cropland, one intervention could be to plant sapling trees of the designated species at specified densities.

Some restoration interventions require aftercare or continuing periodic maintenance after initial implementation. These tasks are predictable and can be written into the implementation plans under their respective objectives. Examples of maintenance tasks include the repair of erosion on freshly graded land and the removal of competitive weeds and vines from around young plantings.

21. Acknowledge the role of passive restoration. Commonly, some but not all aspects of an ecosystem require intentional intervention to accomplish restoration. For example, if a correction to the physical environment is all that would be needed to initiate the recovery of the biota, then the practitioner would limit restoration activities to making that correction. To ensure that all aspects of ecosystem recovery have been considered, the restoration plan should acknowledge those attributes that are expected to develop passively without intervention.

22. Prepare performance standards and monitoring protocols to measure the attainment of each objective. A performance standard (also called a design criterion or success criterion) is a specific state of ecosystem recovery that indicates or demonstrates that an objective has been attained. Satisfaction of some performance standards can be attained by a single observation—for example, to determine whether a canal has been filled. Other performance standards require a series of monitoring events to document trends towards the attainment of a specified numeric threshold for a physical parameter or for a particular level of plant abundance or growth.

Monitoring protocols should be geared specifically to performance standards. Other monitoring generates extraneous information and inflates project costs. Monitoring protocols should be selected that allow data to be gathered with relative ease, thereby reducing monitoring costs.

23. Schedule the tasks needed to fulfill each objective. Scheduling can be complex. Some interventions can be accomplished concurrently and others must be done sequentially. Planted nursery stock may have to be contract-grown for months or longer in advance of planting and must be delivered in prime condition. If planting is delayed, planting stocks may become root-bound and worthless. If direct seeding is prescribed, seed collecting sites will have to be identified. The seed must be collected when ripe and possibly stored and pre-treated. Site preparation for terrestrial systems should not be scheduled when conditions are unsuitable. For example, soil manipulations cannot be accomplished if flooding is likely, and prescribed burning must be planned and conducted in accordance with applicable fire codes. The temporary unavailability of labor and equipment can further complicate scheduling. Workdays may have to be shortened for safety during especially hot weather and in lightning storms. Wet weather may cause equipment to become mired. Schedules should reflect these eventualities.

24. Obtain equipment, supplies, and biotic resources. Only appropriate items should be procured. For example, machinery should be selected that does not compact the soil inordinately or damage it when making turns. Degradable materials such as organic mulch are generally preferable to persistent ones such as plastic ground covers. Nursery-grown plants should be accepted only in peak condition, and their potting soil should consist of all natural materials. Care should be taken to ensure that regional ecotypes of biotic resources are obtained to increase the chances for genetic fitness and to prevent introduction of poorly adapted ecotypes. However, a wider selection of ecotypes and species may be advantageous in order to pre-adapt the biota at project sites undergoing environmental change.

Restoration Guidelines continued

Implementation

Project implementation fulfills restoration plans. If planning was thorough and supervision is adequate, implementation can proceed smoothly and within budget.

25. **Mark boundaries and work areas.** The project site should be staked or marked conspicuously in the field, so that labor crews know exactly where to work.

26. **Install permanent monitoring fixtures.** The ends of transect lines, photographic stations, bench marks, and other locations that will be used periodically for monitoring are staked or otherwise marked on-site and, if possible, identified with GPS coordinates. Staff gauges, piezometer wells, or other specified monitoring equipment is installed, marked, and their locations identified with GPS coordinates.

27. **Protect the project site against vandals and herbivory.** Security of the project site should be reviewed following project implementation. Vandalism may include use of project sites for recreational activities (e.g., camp fires, dirt bike riding). Grazing animals include domestic livestock, deer, geese, muskrats and many others. Beaver can destroy a newly planted site by plugging streams and culverts. Nuisance animals may require trapping and relocation or the construction of fenced exclosures.

28. **Perform monitoring as required to document the attainment of performance standards.** Monitoring and the reporting of monitoring data are expensive. For that reason, monitoring should not be required until the data will be meaningful for decision-making. Regular reconnaissance may negate the need for frequent monitoring. Not all monitoring can be postponed. Some factors, such as water elevations and water quality parameters, are usually measured on a regular schedule to provide interpretable data. Sometimes monitoring is required to document survival of planting stock. A more effective substitute would be to require the replacement of stock that did not survive in lieu of monitoring.

29. **Implement adaptive management procedures as needed.** Adaptive management as a restoration strategy is highly recommended, if not essential, because what happens in one phase of project work can alter what was planned for the next phase. A restoration plan must contain built-in flexibility to facilitate alternative actions for addressing underperformance relative to objectives. The rationale for initiating adaptive management should be well documented by monitoring data or other observations.

Checklist for Stream Restoration Project Planning and Implementation

Map project site location and its boundaries	
Delineate ownership	
Evaluate causes of degradation	
Determine the need for ecological restoration	
Determine restoration goals and objectives	
Describe physical site conditions in need of repair	
Identify potential impacts resulting from the proposed actions	
Determine natural processes in need of restoration	
Identify and list the kinds of biotic interventions that are needed	
Evaluate landscape restrictions	
Identify project-funding sources	
Determine labor sources and equipment needs	
Describe biotic resource needs and sources	
Determine and obtain permits required by government agencies	
Identify permit specifications, deed restrictions, and other legal constraints	
Describe project duration	
Identify strategies for long-term protection and management	
Appoint a restoration practitioner who is in charge of all technical aspects of restoration	
Prepare a budget to accommodate the completion of preliminary tasks	
Describe the interventions that will be implemented to attain each objective	
Determine which aspects of the project and be performed by passive restoration	
Prepare performance standards and monitoring protocols to measure the attainment of each objective	
Schedule the tasks needed to fulfill each objective	
Obtain equipment, supplies, and biotic resources	
Mark boundaries and work areas	
Install permanent monitoring fixtures	
Protect the project site against vandals and herbivory	
Perform monitoring as required to document the attainment of performance standards	
Implement adaptive management procedures as needed	

Restoration Techniques

Stream restoration has become a multi-billion dollar industry and a diversity of techniques have been developed and practiced. In recent years, river managers and scientists have proposed the term "restoration" be used only for projects with the objective of assisting in the establishment of improved hydrologic, geomorphic, and ecological processes in a degraded watershed system and replacing lost, damaged, or compromised elements of the natural system (Wohl et al., 2005; Kauffman, 1997; Palmer, 2005; and Roni et al., 2002). Recently, Palmer et al. (2005) proposed standards for measuring and guiding restoration success, with emphasis on a watershed-scale, ecological approach. These standards were endorsed by an international group of river scientists (Jansson et al., 2005) and practitioners (Gillilan et al., 2005).

In a definitive review of stream restoration techniques applied to over 50 streams in the U.S., Roni et. al (2002) concluded; "Instream habitat enhancement (e.g., excavation, addition of wood, boulders, rocks or nutrients) should be employed only after restoring natural processes…". The common denominator among degraded streams is the loss of the natural processes that sustain a stream's biological and physical integrity. Consequently, restoration actions that ignore the fundamental ecology and natural processes that created and maintained the stream are doomed to failure, or worse, exacerbate the degradation (Platts et al., 1994).

Spring systems like Silver Creek and many of its tributaries are subject to the same conditions and causes of degradation as other types of river or creek systems. Just because spring driven systems are unique by virtue of their water source and near steady-state condition does not mean they are immune or impervious to common causes of degradation. As such, restoration actions in spring driven systems are generally the same as with non-spring systems (Roni et al., 2002). Except that when spring creeks are in need of restoration, typically stabilization is not the main problem. Habitat, water temperature, and cover are the main driving forces (Hoag, 2010).

Below are common problems in the Silver Creek watershed and restoration solutions that can be implemented to alleviate these problems (adapted from Federal Interagency Stream Restoration Working Group [FISRWG], 2001). Regardless of the scale of the restoration objectives, the decision to proceed with restoration work on a stream requires a balance between need and ability to achieve of the restoration objectives based on scientific, economic and social constraints. Furthermore, the decision must be based on an understanding of the processes that affect river morphology, hydrology, and ecology and the cause of the disturbance to these processes, emphasizing restoration of natural or ecological process and control or elimination of degrading factors.

Restoration Techniques continued

Bank Instability

Riparian plant roots penetrate and bind together channel bank soils, providing stability and resistance to stream bank erosion from the constant frictional forces of downstream moving water. Largely because of historic grazing impacts, many stream banks throughout the Silver Creek watershed are in a degraded condition. Stream bank instability is characterized by sparse riparian vegetation and excessively eroding cut banks, which may slough into the active stream channel (Skinner et al., 2000). Stream bank erosion impairs instream habitat through generation of sediment, reduction in habitat complexity, and reduction in cover provided by stream banks and vegetation (Skinner, 1983). Examples of bank stabilization techniques used to stop excessive erosion of stream banks include: 1) Riparian vegetation management to enhance riparian vegetation re-growth and associated root stabilization of bank soils; 2) Establishing buffers between agriculture fields and streams; 3) Maintaining native trees, shrubs and forbs in riparian zones; and 4) limiting livestock grazing in riparian zones.

Sedimentation

Sedimentation is one of the primary issues throughout the watershed. Bank instability and erosion frequently results in excessive sediment inputs into stream channels. Sediment increases the turbidity of a stream and may adversely affect aquatic life and fisheries in several ways. It can increase sediment deposition in pools, spawning gravels, and stream-bottom habitat for aquatic invertebrates, and restrict light penetration that is necessary for photosynthesis by aquatic plants (Skinner, 1983). Excessive sediment inputs may also alter the stream channel morphology and change the composition of aquatic habitats and associated fish and macroinvertebrate communities. Potential sources of sediment include erosion of poorly vegetated and/or disturbed areas. The source can be local — such as stream banks or beds, and irrigation canals. Other sources may be runoff from poorly vegetated upslope areas affected by natural disturbances such as landslides or fire, or by human disturbance such as poorly located or constructed roads, poorly managed timber harvest, mining, construction or agricultural practices. In stream systems with excessive erosion and sedimentation, reduction of sediment can only be effectively accomplished by addressing the source of sediment. This is typically accomplished the reestablishment of vegetation on the eroding surfaces through changing land use practices, seeding or planting. Severely eroding surfaces may also require slope regrading, decommissioning (removal) of poorly constructed roads, and/or implementation of management practices that minimize erosion from road surfaces (Roni et al., 2002).

Severe bank erosion due to grazing and loss of riparian zone.

Bank erosion on Silver Creek

Riparian plantings to control bank instability on Silver Creek.

Thin sediment layer over gravel and aquatic vegetation.

Over-widened Channels

Silver Creek has experienced channel widening in certain locations as described in Section 3.

Unhealthy riparian areas with unstable stream banks can accelerate lateral erosion of riverbanks. This increases stream width and decreases stream velocity, which causes sediment deposition. Over-widened channels are characterized by a high width-to-depth ratio (calculated from river cross-sectional data), a lack of pool/riffle habitat, and a flat channel bottom (FISRWG, 2001). Extreme sediment deposition may result in a change in channel morphology from a single channel to a braided channel (Skinner, 2000). In the most extreme cases, after passive restoration actions have proved inadequate, restoration of overwidened channels may require using excavated substrate material and importing gravel and cobble or blocks of riparian vegetation to narrow the stream channel. Log jams and log complexes may also be used in decreasing the stream's width-to-depth ratio.

Headcutting

There are a few reaches on Silver Creek tributaries where very minor headcutting is occurring. Loving Creek above the railroad trestle is experiencing some minor headcutting. Headcutting involves the initiation of channel incision at a nick point as the stream channel bed elevation adjusts to a natural or human induced disturbance. The nick point can be as subtle as an over-steepened riffle zone or as obvious as a "waterfall" or cascade. As the streambed erodes and lowers at the nick point, the active headcut will migrate upstream (Wilcox et al., 2001). Headcutting may eventually cause channel incision. Controlling a headcut is one of the most difficult challenges in stream restoration. Fortunately, in spring systems like Silver Creek and its tributaries, headcutting is very localized and stream energy is too weak to cause extensive or prolonged upstream migration. Common headcut treatments are installing check dams, or sloping the bank face and laying in fabric and rock to control continued upstream migration of the nick point.

Over-widened channel at Point of Rocks.

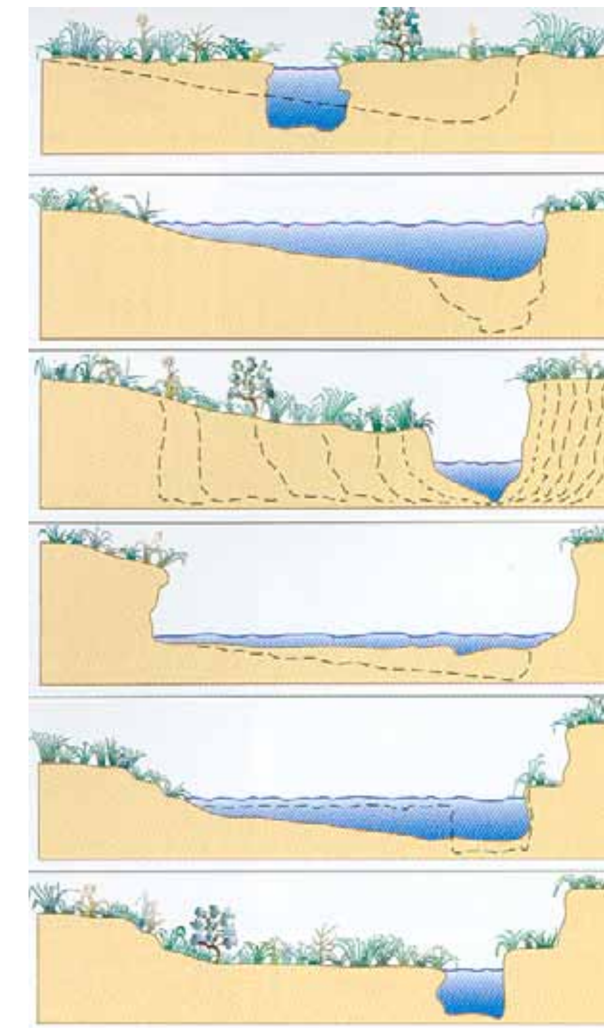


Illustration of channel geomorphology and change overtime due to watershed degradation:

A. Valley bottom stream channel

B. Loss of vegetation causes instability of banks leading to erosion

C. The channel bottom begins to erode down (headcutting) and leaves banks high and vertical

D. Steep cutbanks slough off into the channel causing increased sediment loads and bank undercuts

E. Laidback and stepped channel profile begins to stabilize as vegetation holds the streambanks

F. Inset stream channel. The stream is now functioning within the historic channel with decreased baseflow and riparian vegetation management and protection.

Restoration of riparian zones, channel sinuosity and geometry, and connecting stream and floodplain in agricultural landscapes.

Flow alteration at Kilpatrick Dam

Channel Alteration

Channel alteration from bulldozing, dredging, and construction causes severe disturbance to the channel and to riparian vegetation. An example of channel alteration is channel straightening (channelization) to maximize land use. This disturbance can result in loss of floodplain connection and significant reduction in channel complexity important for fish habitat. Historical use of tributaries in the Silver Creek watershed to transport irrigation water resulted in channel straightening in some areas. Restoration of an altered channel may require reconstructing the channel. Channel design must take into account meander geometry, channel alignment, sinuosity, channel length and slope, channel cross section at design discharge, riffle/pool spacing, and channel stability (Washington Department of Fishand Wildlife, 2003). Reconstruction goals frequently center on reconnecting the stream and floodplain and recreating more natural channel geometries (Palmer, 2005).

Flow Alteration

Because of historic and current land uses, there are many sites where Silver Creek and its tributaries' natural flow regime and sediment transport capacity have been altered. Examples are dams and irrigation diversions, which can significantly decrease downstream flow. In highly-altered flow and sediment transport regimes (such as downstream of a dam) the current flow regime, sediment loads, and social and economic constraints on the system must be factored into the restoration approach. Another factor that must be considered is the amount of time the stream has been functioning under the altered flow regime and whether it has reached a steady state (Wilcock et al., 1996). In recent years, the focus of river management has shifted from determining a minimum flow requirement to recognizing the importance of floods in maintaining the dynamic nature of the stream's riparian and aquatic ecosystem (Hill et al., 1991). Minimum stream flows below diversions or dams must incorporate a multi-flow regime to restore adequate sediment transport as well as ecological processes.

Sediment Basins

The most common areas of sediment deposition in Silver Creek are at the confluences of tributaries and behind impoundments. Suspended sediments from overland runoff are carried into Silver Creek through tributaries Cain, Chaney, Mud, Stalker and Grove creeks. Velocities are attenuated at the point where these streams enter Silver Creek and sediments are deposited. Sediments in these areas have accumulated for many years. Essentially, these areas act as sediment basins, trapping and holding sediments in one place. Restoration actions can focus on either dredging these basins if access is possible and additional environmental damage does not occur, or simply leaving the sediments in place. In the event the latter action is selected, it is necessary to attenuate or eliminate further sediment inputs from the watershed. Artificial sediment basins can be constructed in stream areas above restored sites to capture new sediment inputs and protect the restored reach.

Channel alteration and straightening on Loving Creek above the diversion. The adjacent railroad grade and the canal diversion to the fish hatchery disconnected Loving Creek from its historic channel and floodplain.

Multiple restoration actions for riparian and stream health adjacent to agricultural landscapes. Though this is a highly modified landscape these restoration actions are encouraging better ecosystem function while continuing productive agricultural practices.

Loss of Fish Habitat

In some cases, restoration efforts are directed primarily at restoring fish habitat in a particular stream. Common examples of habitat enhancement are the placement of materials, such as large pieces of wood or boulders into the stream channel, or manipulation of the channel itself to improve habitat for fish and/or other aquatic organisms. It is critical to understand habitat requirements at all seasons and for all life stages of the species of concern. In addition, habitat enhancement may be short-lived if the underlying processes causing habitat degradation are not addressed (Roni et al., 2002). Roni et al. (2002) state that habitat restoration should focus on restoring processes that form, connect, and sustain habitats. They emphasize that, by focusing on the restoration of natural processes, there is a higher probability of meeting restoration objectives and goals. It also enables the natural array of habitat types to form in all parts of a stream network. Moreover, this approach attempts to provide suitable habitats for all native aquatic species because it restores the conditions to which they are adapted.

Reduction in Riparian Vegetation or Loss of Riparian Area

Riparian vegetation is critical to the over-all stream ecosystem (Hill and Platts, 1998). Plant roots provide stability to stream banks. The vegetation filters sediment and other contaminants from runoff (Skinner et al., 2000). Overhanging vegetation provides cover for fish and shade for stream temperature control. Logs from the riparian area can also be a source of instream fish habitat. There are cases where the riparian vegetation is reduced due to natural disturbance, such as fire or flood. Examples of disturbance due to human activity are:

- Poorly located or constructed roads that negatively impact riparian zones through excess sedimentation and encroachment on the riparian zone
- Overgrazing in riparian areas that leads to a loss of bank stabilizing plants, formation of an over-widened channel and increased sedimentation (Skinner et al., 2000). Reduction in vegetation can also lead to decreased cover for fish, and reduced shade to cool the stream
- Timber harvest in riparian areas is typically no longer practiced, but effects of past logging practices in riparian areas are still apparent. A loss of stream bank stability and instream large woody debris is common in logged riparian areas, which result in an over-widened channel and loss of fish habitat
- Encroachment on the riparian area by farming, development or other land use practices

Restoration measures to address a reduction in riparian vegetation may simply require a passive restoration approach, such as a change in land use within the riparian area. For example, one might exclude livestock grazing or implement a grazing management plan in the riparian area. Active restoration might include reseeding or replanting vegetation. Roni et al. (2002) emphasize the necessity for follow-up maintenance and protection measures in riparian vegetation replanting. Some trees and shrubs are vulnerable to out-competition by other species, and trees and shrubs planted in mesh tubing or another material are less vulnerable to browsing by deer and elk. Larger trees are vulnerable to beaver use.

Fish Passage Barriers

Fish passage is critical to maintaining connectivity of habitat and/or populations. Fish passage barriers are man-made structures or natural obstacles, which are completely or partially impassable to fish. The barrier may be a velocity barrier and/or a vertical barrier based on adult or juvenile swimming and leaping capabilities (Roni et al., 2002). Barriers can inhibit fish from reaching their traditional spawning areas or colonizing areas up stream. They can also be a reason for fish mortality due to exhaustion from attempting to jump the barrier or from poaching below the structure. Barriers can also degrade fish habitat by altering or limiting the downstream movement of sediment, woody debris, and organic materials (Roni et al., 2002). Examples of man-made fish passage barriers in the Silver Creek watershed are:

- Kilpatrick Dam constructed for water storage purposes, spans the entire width of Silver Creek and blocks or inhibits fish migration in low-flow periods. The Loving Creek diversion described in this section blocks fish movement to the upper reaches of the stream.
- Road culverts, which may become a vertical barrier due to scour from a drop at the end of the culvert, or a velocity barrier during high flows if they are not constructed to accommodate bankfull flows
- Natural barriers like log jams and beaver dams

Restoration of fish passage may include removal of the obstruction, replacing the culvert, or construction of a fishway, which provides a way through or around the obstruction.

Examples of culvert replacements include bridges, open-bottom culverts or embedded (for example, countersunk) pipe-arch culverts (Roni et al., 2002).

Maintaining fish passage on Stalker Creek

Pump diversion for irrigation on Silver Creek


Diverted water for irrigation and agriculture

These structures allow continuity of the natural channel, which is important for the passage of adult and juvenile fish. Fishways generally consist of a flume with baffles or a series of stepped pools that slow the water to a velocity easily negotiated by fish. Roni et al. (2002) emphasize that habitat quality above the fish passage obstruction is a primary factor when prioritizing fish passage restoration projects.

Irrigation Canals and Diversions

It is a common practice throughout the Silver Creek watershed to divert water from streams into canals for irrigation for crop production and stock watering. In addition to decreasing instream flow, water diversions can block migration of fish as they travel up canals and become entrained in the canals, pipes, pumps, and even irrigation fields. Fish screens at the point of diversion are effective restoration practices to inhibit fish from swimming up the diversion and becoming entrained.

Stream Restoration Cost Approximations

Of course the cost of active stream restoration depends upon the amount of stream to restore, the techniques intended, equipment and materials needed, permitting and engineering required, and construction labor. There are no actual set costs for the various components; however, experience from other projects provides insight into the relative cost of individual components.

The adjacent table shows a range of cost for restoration compiled by the U.S. Forest Service (Bair, 2009). These estimates can be taken as examples and give restoration proponents in the Silver Creek watershed some idea of the magnitude of individual components.

For planning, design, and permit, costs range from $21,000 to $110,000 per river mile. The mean is about $70,000 for the planning phase. Material acquisition and material transportation to project sites can become one of the most expensive components of stream restoration. Trees and large woody debris have been primarily used for restoration related to fish habitat. Boulders and rock have also been used in certain circumstances. Obviously projects with ample on-site material cost significantly less than projects that involve extensive haul distances or helicopter transport. For material transport equipment, the use of a helicopter greatly increases the cost, to at least $64,000 per river mile and often as much as $150,000 per river mile. If material can be ground transported to the site, the cost can drop down to as low as $17,000 a river mile. If purchasing trees is necessary, the material costs may exceed $145,000/ river mile.

Labor costs are typically access-driven. Depending on the site, labor cost can range from $17,000 per mile if access is limited or drop to $112 per river mile if access to sites is not restricted.

Riparian planting and thinning is typically the most labor intensive aspect of stream restoration. Riparian planting, which is arguably always needed in conjunction with streambank stabilization, runs $4,000 to $7,000 per river mile. Maintenance of riparian and in-stream improvements are important. Monitoring of plant survival and growth plots in riparian areas along rivers and tributaries have shown that mortality of newly planted trees can approach 80%. Vegetation management is needed to control the competing vegetation and browse from ungulates.

Streams are dynamic and some level of maintenance of in-stream structures must also be maintained. Unfortunately, it is rare for most projects to receive sufficient funding for adequate monitoring or maintenance.

Another issue that can greatly affect the cost of the project is whether the equipment is rented hourly or included in a construction contract. A typical hourly equipment rental contract may include the hiring of a a tracked excavator, and bulldozer with operators. The work is directed by the designer. In contrast to hourly equipment rentals, construction contracts require extensive, detailed plans ("blueprints") for the contractor to follow. Cost for construction contracted in-stream work can significantly increase cost due to the extent of design specifications, site and contract preparation. In addition, site variances are typically the norm and not the exception which can wreak havoc with the best designs. Site variances can never be fully anticipated and typically lead to costly modifications. Experience has demonstrated that construction type contracts can cost over seven times that of equipment rental contracts and the results can be less than acceptable.

Table of Typical Restoration Costs

Item	High End (cost/river mile)	Low End (cost/river mile)	Reasonable Mean (cost/river mile)
Plan, Design & Permit	$110,400	$21,833	$68,880
Materials (trees)	$64,900	$14,747	$20,566
Mobilization	$8,200	$1,333	$2,777
Equipment	$122,000	$17,333	$20,800
Labor	$17,167	$112	$5,000
Riparian planting/maintenance	$7,646	$3,893	$5,512
Instream structure maintenance	$24,640	$4,760	$5,600
Total	**$354,593**	**$64,011**	**$129,135**

Restoration Using Buffers and Riparian Vegetation

Riparian areas provide a myriad of important ecosystem functions and services and therefore their protection, restoration and enhancement must be central to any watershed management strategy. Riparian areas are key elements in stream function and provide critical terrestrial and aquatic habitat. They provide corridors for wildlife and ecosystem processes (Hagar 1999), possess high biodiversity and biological activity (Naiman et al. 1993; Naiman and Decamps 1997) and buffer environmental impacts and protect water quality (Lowrance et al. 1997). Riparian areas, especially those with woody riparian vegetation, enhance in-stream habitat by providing inputs of large wood, stabilizing stream banks, shading the stream, and providing allochthonus inputs in the form of vegetation and insects (Kocher and Harris 2007). Healthy riparian areas reduce sediment runoff and influence nutrient processing (McLain et al 2003).

The items listed above are only a few examples of why preserving, enhancing, and restoring riparian areas are critical to ecosystem function and therefore must be a focus of efforts to enhance Silver Creek. Nearly all states now promote the protection and enhancement of riparian buffers in an effort to realize the important ecosystem services these areas provide. There are three primary issues associated with riparian areas: 1) the role of riparian areas in filtering and processing nutrients, 2) the role riparian areas in moderating stream temperatures through shading and 3) how wide riparian buffers should be to provide adequate function.

Sediment and Nutrient Processing

Riparian areas intercept, filter, and process anthropogenic nitrogen (Lowrance et al. 1984; Peterjohn and Correll 1984; Mayer et al. 2007) and phosphorous (Hoffman et al. 2009). Riparian areas also capture sediments (Liu et al. 2008). In agricultural landscapes, such as the Silver Creek watershed, riparian buffers that promote the development of healthy riparian systems are widely recommended to reduce non-point stream pollution. Given the condition of the sediment load within Silver Creek, the landscape, land use history, and future threats (e.g. increased urban development and increased fertilizer and pesticide application), the ability of riparian areas to provide these key ecosystem services is needed to preserve the long term health of the ecosystem.

Irrigated agriculture and urban areas change denitrification rates and water table dynamics. Healthy riparian areas can function as nitrogen sinks, protecting in stream biota from extreme nutrient levels and the associated impacts (e.g. algal blooms) (Watson et al. 2010). In general, wider forested riparian areas with grass understories provide better protection for streams than narrower areas with either forests or grasses only (Knight et al. 2010). Although more narrow riparian areas can provide good protection for streams, in high precipitation and runoff events, narrow riparian areas are often breached, resulting in extreme nutrient and sediment inputs into streams. How wide is wide enough to buffer streams from sediment and nutrient inputs? In a manipulated experiment, woody riparian areas approximately 16 m wide (+/- 50 ft.) with grass and/or herbaceous understories removed 97% of sediment, 94% of total nitrogen, 85% of nitrate, 91% of total phosphorous, and 80% of phosphate. Given the current level of legacy sediment and nutrient loads in Silver Creek, the filtering of current sediment and nutrient sources represents a passive yet critical enhancement technique.

Shading and Stream Temperature

In the simplest terms, intact and healthy riparian areas moderate stream temperatures through shading (Wilkerson et al. 2006). Shading and temperature control are important for maintaining healthy fish spawning habitat and reducing nuisance algal growth. Although there has been much conjecture and debate around the structure, width and height needed for riparian vegetation to function in this role, it is widely accepted within the scientific community that riparian shading is critical to controlling in-stream temperatures.

In a recently published effort to address this issue (DeWalle 2010), DeWalle presented an elegantly designed and highly inclusive model examining the light transmission and total solar input that reaches streams based on riparian width, height, and density. Due the sun's path across the sky, the influence of riparian vegetation on shading varies depending on the azimuth of the stream's course; stream courses that run north-south require higher and denser riparian vegetation to provide adequate shade than those that run east-west. The width of the stream also influences the vegetation required, as wider streams require taller riparian vegetation. Stream banks also provide varying degrees of shading; in east-west running streams, 70% of the shading is provided by the south bank and 30% is provided by the north bank.

Silver Creek streams run both north-south and east-west. Widths vary from very narrow streams to wide open impoundments. Therefore, there is no one answer to the question of how wide, tall and dense a riparian buffer is required. However, DeWalle's work provides context. He found that as buffer width increases, shading increases in a curvilinear fashion, and that buffer height and density were found to significantly increase shade. In general, buffers wider than 12 m are less important than the height and density in the first 12 m. For example, 84% of the shading provided by a 30 m wide buffer on a north-south stream was provided by the first 18-20 m of vegetation. Similarly, in an east-west stream, 68% of the shading is provided by the first 6-7 m, with the shading marginally increased by riparian vegetation further from the stream.

Of course, no stream is exactly north-south or east-west. No stream is constant in its width. Silver Creek is no different. Therefore, DeWalle suggest that overall, streams of small to moderate widths (averaging 6m width) require a minimum 12 m wide, 30m tall, dense buffer to provide adequate shading. In Silver Creek, 30 m tall trees are rare. Therefore, dense woody riparian areas, especially within 10 m of the stream are critical to provide at least a minimum amount of shading.

Recommended Riparian Buffer Widths

How wide is wide enough? Given the information above, there is no clear and simple answer. There are a number of ecological factors, management goals, and practical site-specific factors that need to be considered. In general, wide buffers are better; tall buffers are better; dense buffers are better. More diverse (woody riparian and grass/herbaceous) buffers are better. As with any natural resource area, the best management decisions are made by a team of landowners, scientists, and other stakeholders on a case by case, site-specific basis. However, a broad scale general rule can be useful. In a review of over 140 articles on the subject (Wenger 1999), Wenger recommended a minimum width of 30.5 m to provide at least adequate function for all factors. In another review (Castelle et al. 1994), Castelle et al. recommended a minimum of 15 m for the most efficient results. For Silver Creek, it depends on the landowners goals, their resources, and the site. If every mile of Silver Creek had a 15 m buffer of any kind (e.g. forested, wetland, native grasses) ecosystem function and ecosystem health would be increased. However, if every mile of Silver Creek had a 30 m buffer of native riparian forest with a dense understory of native shrubs, herbs and grasses, the system would be more robust, productive, and resilient to unknown natural and anthropogenic threats.

Existing riparian buffer on Silver Creek. Trees provide important shading and habitat, while abundant grasses work to filter sediment and nutrient inputs from overland runoff.

Natural Process Restoration and Mechanical Interventions

The restoration guidelines presented in this plan emphasize identifying and addressing the causes of stream degradation as the first step in the planning process. This is only logical since it is pointless to invest in a stream restoration project which only treats the symptoms not the causes of degradation, because, in time, and in most cases, all the investment will be wasted if the source of degradation remains unabated. For example, removing sediments by dredging or channel narrowing, or any other technique, is only a stop-gap solution if the source of the sediments are not also eliminated or dramatically attenuated. There are situations in which mechanical, instream techniques are needed in tandem with restoration techniques that restore natural processes. Following are examples from the Silver Creek sub-watershed.

Mud and Chaney Creeks

Portions of Mud, Cain and Chaney creeks have 150' buffers on both sides of the streams. This simple land management action has helped restore natural processes such that sediment inputs are minor and inputs are within the assimilation and transport capacity of the streams; and, riparian habitat has developed to increase shading. These creek provide examples of how function can be restored, in many cases, by simply creating buffers within which nature can work to restore function and balance.

A pond has been developed in the middle reach of Chaney Creek. Like many such ponds throughout the watershed, these create high quality fish habitat with deeper and cooler waters throughout the summer. Also, like most of the ponds, it was developed without addressing upstream issues, which in this case is on-going sediment inputs that requires periodic dredging or sediment removal in order to maintain the fish habitat. The immediate upstream reach of Chaney Creek is choked with legacy sediments. These depositions are extreme and cover the stream bed with up to four-feet of sediments. Consequently, the investment made in the pond to create quality habitat is at risk as these sediments continue to transport and deposit in the pond. In order to avoid the annual or periodic cost associated with dredging and clearing sediment depositions, some intervention is now needed above the pond.

Fish habitat is very limited or non-existent in the upper reach above the pond; thus, instream actions to remove this sediment source can be taken without serious risk of harm to the fishery so as long as disturbed sediments are controlled and trapped during instream work. In this case, sediments can be dredged out with heavy equipment and removed from the stream. Following sediment excavation, additional buffer zones and riparian vegetation can be established like on downstream reaches to minimize future sediment inputs and provide shading. Then, like the downstream reaches, natural processes will take hold in time to narrow the channel as riparian vegetation develops. Stream temperatures will decline and fish habitat will develop as small pools develop. Probably within three to five years, the upper reach of the stream will recover to the point that it no longer poses a threat to the pond habitat and, in fact, fish habitat connectivity will be restored as a continuum between the lower reach below the pond to the upper reach above the pond.

Point of Rocks

Point of Rocks is another example from the watershed where both natural process restoration is needed and, perhaps, mechanical instream actions as well. The issue at Point-of-Rocks is loss of fish habitat and the fishery as a consequence of sediment deposition. The channel was widened during the livestock grazing era and sediments have steadily filled the channel. The source of the sediments is from upstream as well as nearby agriculture lands. The stream banks lack riparian habitat as well.

Restoration at Point-of-Rocks should focus on four actions. First, sediments from upstream and near-stream sources must be attenuated. This can be achieved with buffer zones on tributaries to Silver Creek, holding sediments on site when doing upstream work, and establishing 150-foot setbacks on agriculture land adjacent to the Point-of-Rocks reach. Second, establish riparian vegetation with plantings (tree willow, alder) on floodplains in the inset channel. Third, give the system time to respond to the plantings and buffer interventions. During this 3 to 5-year development period monitor the reach to determine if sediment inputs are declining, vegetation is surviving and growing, and the channel is narrowing in response to the interventions. Fourth, once it is clear that natural processes have been restored but the channel has not narrowed appreciably and fish habitat remains poor, other interventions can be considered such as thalweg dredging, channel narrowing, etc.

The conventional approach would be to narrow the channel first with instream construction then plant riparian vegetation and implement buffers to attenuate sediment inputs. However, the cost and damage related to instream construction may be minimized, even be unnecessary, if natural processes are restored first. In most instances the desired results can be achieved by letting nature do the initial heavy lifting so that less intrusive actions are needed. As seen with Mud, Cain and Chaney creeks, natural processes can be restored with appropriate land management that leads to narrowed channels, vegetated streambanks, export of sediments, and development of fish habitat. In extremely widened reaches, such as Point-of-Rocks, allowing natural processes to develop over 3 to 5-years could mean significantly less channel area and stream length to artificially narrow at less labor, equipment , and materials cost if mechanical intervention is shown to be necessary.

Kilpatrick Pond

Kilpatrick Pond is an example where natural processes cannot be restored without direct mechanical intervention. Sediments from throughout the watershed have collected behind the Kilpatrick Dam for decades. Now the sediment deposition zone extends upstream beyond the bridge onto the Silver Creek Preserve. The volume of sediments is too great for natural processes to reduce or eliminate. Removal of the dam and allowing the sediments to be flushed would result in severe and unacceptable downstream environmental impacts. As described in the action section of this plan, using the sediments to build waterfowl islands within the pond retains the sediments on-sight while creating habitat for fish and wildlife. Once sediments have been stabilized in the ponds, the dam's control mechanism can be reconfigured to pass sediments in proportion to Silver Creek's capacity to assimilate and transport them, and, thus, avoid another build-up of sediments in the pond over time.

Sediments which accumulate in the pond originate from upstream sources. Concurrent with the island development in Kilpatrick Pond, buffers on agriculture-stream interface lands should be established to attenuate future sediment loading that would end-up in the pond. The ultimate goal would be to remove the accumulated "legacy" sediments choking the pond above and below the bridge, attenuate excessive annual sediment loading so that the stream's assimilation and transport capacity balances sediment imports with exports, and retrofit the dam's control structure to allow consistent sediment transport and prevent further accumulation in the pond.

In essence these actions would reestablish the natural process of sediment assimilation and transport from upstream through Kilpatrick Pond and downstream without creating deposition zones and impacts to the aquatic ecosystem. Keep in mind that some sediment input is critical to maintaining the food chains and other habitat requirements in Silver Creek and tributaries. While it is neither possible nor desirable to stop all sediment loading, the goal is to strike an input-export balance that prevents sediment accumulation in the system and, ideally, exports legacy sediments over time. Temperature reduction would be a positive benefit as a consequence of upstream shading on tributaries restored with buffers and riparian plantings, and a smaller open water surface area in the pond would reduce the overall degree of solar heating overall.


Photo credit: Ecosystem Sciences

Priority Sites

The principal causes of degradation in Silver and Loving creeks are from sediment and thermal loading. Other issues, as described in Sections 3 and 4, are the consequence of these causes (i.e., deposition and channel widening). Based on the available data, basin assessment and Total Maximum Daily Load (TMDL) studies, the only water quality issue at this time, is temperature. Therefore, restoration and enhancement efforts need to be focused on reducing the impacts of sediments and temperature before addressing deposition areas and channel widening.

Sediment Priority Sites

The source of sediments is overland runoff during snowmelt and precipitation events. Runoff is expected to be highest at those junctures between agriculture lands (crops and grazing) and streams that have inadequate buffering. Buffering refers to the distance and extent of vegetation between the stream bank and agricultural field, which prevents sediments from entering the stream during runoff events. While buffer widths vary depending upon site conditions, the preferred distance with dense riparian vegetation is 60 meters or more. As shown in the map on the facing page, a few stream reaches are adequately buffered while most streams throughout the Silver Creek watershed are not.

It is critical to recognize that Map 17 was developed from aerial imagery and has not been field verified; thus it is likely that all sites may not be accurately represented. The highest priority streams are those with (a) 10 meters or less buffering , (b) the second priority are those sites with 10 to 30 meters buffers; and (c) the lowest priority, 30 to 60 meter buffering sites.

Increasing the buffer widths at these sites will require TNC to work with stakeholders to set back agricultural practices from the steam banks to the extent practicable, restrict tilling, if necessary, and/or build additional fences.

Deposition Priority Sites

Sediment deposits occur throughout Silver and Loving creeks, but the greatest concentrations occur at the confluence of tributaries. While some of these deposits can be identified and mapped using aerial imagery, not all sites can be located and their depths and extent of sediment identified. The channel cross section work that was implemented in 2010 will provide the necessary data that cannot be obtained with remote imagery. Restoration interventions to transport or hold sediments in the ecosystem will depend upon the success of actions taken to attenuate or eliminate sediments at their source. Consequently, deposition zones will undoubtedly change in location and extent during efforts to control sources. Thus more detailed mapping and implementation of interventions should be delayed until sediment monitoring indicates additional action is required.

Temperature Priority Sites

The basin assessment and TMDL study performed by the Idaho Department of Environmental Quality (IDEQ) resulted in the listing of Loving Creek as impaired (due to temperatures). Loving Creek exhibits the greatest thermal loading and thus is the highest priority for restoration actions. The table below displays the thresholds for canopy cover by stream reach for Loving Creek, which are necessary to reduce temperatures.

IDEQ utilized the Alvord Lake TMDL to aid in selecting canopy cover targets that were based on similarities in bankfull width and vegetation type. Presumably this approach will also be suitable to define canopy cover goals for the other tributaries to Silver Creek. The thermal profiles for the tributaries and Silver Creek are shown below. Determining which streams, in addition to Loving Creek, are the highest priorities for reducing temperatures is based upon the ratio of discharge to temperature. Using the best available data, the priority tributaries for increasing canopy cover are Stalker, Cain, Wilson and Grove creeks.

Thresholds for Canopy Cover by Stream Reach for Loving Creek

Segment	Bankfull Width (meters)	Vegetation Type	Existing Canopy Cover (%)	Target Canopy Cover (%)
Headwater to Stanfield ditch	30	Grasses, willows	0	20
Stanfield ditch to highway	20	Willow, grasses, Cattails	10-40	45
Highway to ditch	65	Grasses, willows	0	10
Ditch to mouth	48	Willows, alders, Grasses	10-40	28

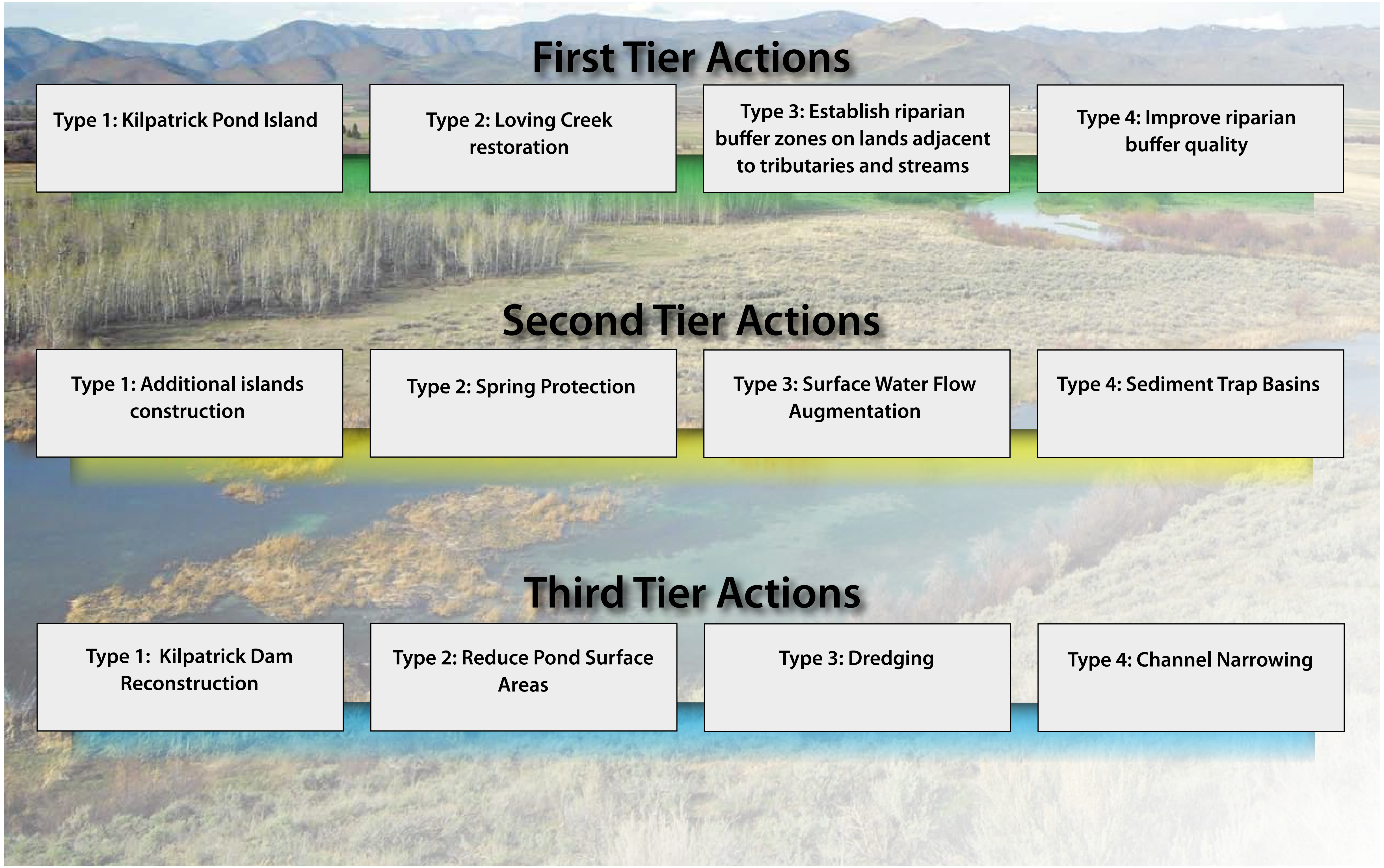
Channel Priority Sites

Over-widening of the streams within the watershed has occurred, but since 1946 channel widths have not increased dramatically. In addition, channel widening has not occurred uniformly throughout the streams. Widening of the channel most likely began with the introduction of livestock and slowed or ended with the conversion of land uses to more agriculture. The fundamental process of channel widening includes bank trampling by livestock as well as sediment inputs, which continuously raises steam bottoms, causing flows to push out stream banks. Even though these forces have been eliminated, the Silver Creek channel will not return to its original widths. As vegetation takes hold, sediments will be trapped and bank building will happen and narrowing will be more pronounced in some reaches then others; however, this is a spring driven system so bank building processes will be slow and the change will not be dramatic.

Artificially narrowing channel widths will have the salutary effect of decreasing cross-sectional area thereby increasing velocities and sediment transport and reducing temperatures. However, this is an extremely invasive technique with great risks to stream ecology. One alternative to channel narrowing is to reverse the process of rising stream beds by eliminating sediment inputs and allowing time for significant sediment exports, such that stream bottoms decline (deepen), causing stream banks to begin narrowing.

Areas of the Silver Creek watershed where widening was evident based on a comparison of the 1946 and 2009 aerial images include: Loving Creek downstream of Highway 20 and its confluence with Silver Creek; and Chaney Creek between Highway 20 and its confluence with Cain Creek.

In the event other interventions are not effective and stream narrowing is necessary, further mapping will be needed to isolate specific channel priorities. Identification of these sites will be the first step in the development of site plans to perform such in-channel work.



Restoration actions are presented in a tiered approach. Each landowner and site throughout the watershed have specific conditions, priorities, limitations and resources available. Based on environmental monitoring and analysis of results these actions and tiers can and should evolve through time.

Restoration Actions

The sites prioritized for restoration actions throughout the watershed include areas of overland runoff (as sources of sediment contribution), surface water heating, and over-widened channels. These are the principal sources of degradation in the creeks (i.e., sediment and thermal loading). Sites will be restored to minimize or eliminate these problems at the source. Restoration and enhancement will be performed systematically and for the maximum cost-benefit ratio.

Actions to restore and enhance the streams are described using a three-tier concept. Each successive tier represents both increasing cost and increasing in-channel actions. The point at which the decision is made to move to higher tier interventions will be determined from monitoring and adaptive management. If monitoring shows that an action is not effective or simply not providing the desired restoration or enhancement, using adaptive management decision-making, an intervention from the next higher tier may be warranted.

Within each of the three tiers shown there are several types of actions that can be taken depending upon resources available and adaptive management decisions. More than one type of action can be employed on a stream, such as establishing buffer zones and planting riparian vegetation. In addition, Tier 2 and 3 actions should not be implemented until the causes of degradation are addressed using Tier 1 actions. However, the most critical constraint is the willingness of stakeholders to participate in some actions. Costs need to be offset with grants and other funding sources to encourage stakeholder participation, and actions need to be agreed upon and negotiated so that stakeholder needs are met and the actions are effective.

Action: Tier 1 Type 1

Kilpatrick Pond Modification

Previous studies on Silver Creek (Gillian 2007) concluded that Kilpatrick Dam and impoundment impairs the ecological potential of the creek by disrupting natural sediment transport processes and by increasing summer water temperatures above background levels. The study resulted in the development of nine alternatives to the dam and impoundment. None of these alternatives were deemed feasible from the perspective of the dam owner. The pond created by the dam is an essential component of the Double R ranch operation to supply irrigation water to adjacent agriculture fields.

Concept and Phases

1. Construct an island from trapped sediments.

2. Create a protected buffer of 15 meters around the edge of the pond where no agriculture will occur. Plant native riparian trees along the south bank to provide shading and sediment and nutrient retention.

3. Retrofit the dam pass-through structure to allow sediments to pass in proportion to the streams capacity.

Design and Construction

To properly construct the island, construction plans should include:

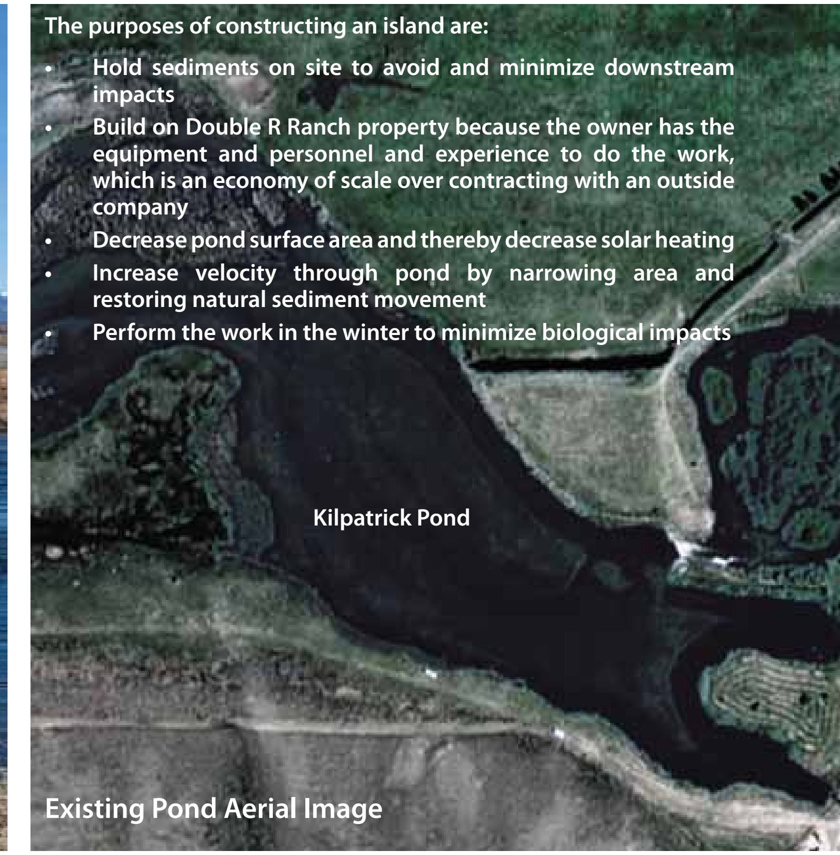
1. Construction should take place in winter to minimize biological impacts.

2. Precautions should be taken to minimize the amount of mobilized sediments that move downstream. These precautions may include but may not be limited to silt fences, etc.

3. Turbidity should be monitored before, during, and after construction to document the amount of mobilized sediment.

4. Island construction should be able to support woody vegetation and provide wildlife habitat, and have a natural shape so that it fits into its surroundings.

Existing Conditions at Kilpatrick Pond



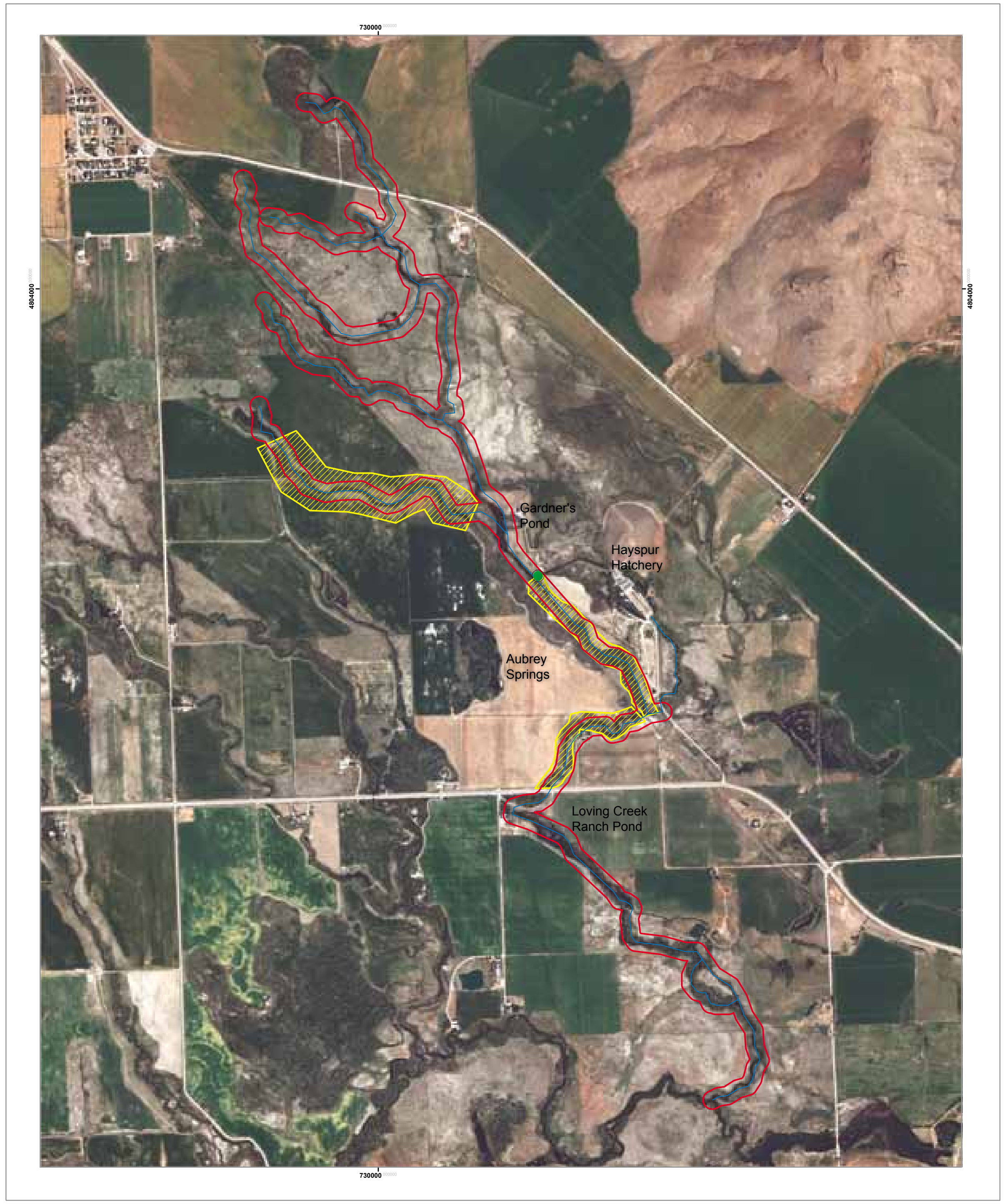
Existing Pond Aerial Image


Proposed Island at Kilpatrick Pond

Proposed Island Aerial Image

The dam owner is well aware of the adverse sediment and temperature conditions caused by the dam and has gone to great expense and effort to ameliorate impacts. In addition to projects to remove sediments via dredging, the owner opens a well at the height of summer to lower water temperatures in water discharged through downstream. The owner also allows flow-through the dam to the extent possible and simply removes the dam drop boards during non- irrigation months. The owner proposed an alternative to dam removal, bypass and other schemes previously recommended - construction of an island within the pond using the trapped sediments. The purposes of an island in the pond downstream of the Kilpatrick Bridge are several and are noted in the illustration above.

The cost of island construction is estimated between $250,000 and $350,000. Final estimates will be developed in conjunction with final, detailed construction plans.



Lower Loving Creek riparian habitat

Action: Tier 1 Type 2

Loving Creek Restoration

Loving Creek is selected for Tier 1 restoration for two reasons: first, it is a 303(d) listed stream in the Little Wood River Subbasin TMDL plan because of its elevated temperatures; second, TNC has designated Loving Creek for a pilot project to test restoration actions and assessment tools (monitoring tools). Loving Creek is an ideal stream for evaluating many restoration techniques, including connecting restored and degraded reaches, riparian plantings, buffer zones, fish passage and pool turnover.

Stream restoration work has been performed on the two upper reaches of the creek. The focus of restoration was increasing meanders and pools as well as narrowing the stream banks. Although woody riparian vegetation was planted as part of these earlier restoration efforts, tules have taken over most of the floodplain. This is because the geomorphic surfaces are too wet for willows, but provide optimal conditions for emergent marsh vegetation like bulrush and cattails. Tree willows, had they survived and grown, would have provided shading and some temperature reduction. Although the stream remains primarily marsh type habitat, the restoration efforts can be enhanced with plantings of woody riparian vegetation (willow, alder and cottonwood) on stream terraces above the saturated floodplain soils. During the initial growth years, until root depth reaches adequate soil moisture, the riparian plantings will require drip irrigation during the summer months. Drip irrigation lines from upstream would be low cost and temporary. As described in IDEQ's subbasin plan, the riparian planting goal is to create 20% canopy cover. The final restoration plan (beyond this conceptual level effort) will need to quantify the number and species of plantings as well as specific locations.

Action: Tier 1 Type 2

Loving Creek Restoration continued

The partially restored upper reaches of Loving Creek can be further improved with 150-foot buffers between the agriculture fields and the stream, on both sides. The buffer zones will be planted with native grasses and shrubs to minimize sediment input from agriculture fields from overland runoff in the spring. Buffers can also be established on the stream above Gardner's Pond to the headwaters. Sediment and nutrient inputs from crop and grazing lands would attenuate and improve overall water quality in Gardner's Pond as well as reduce sediment loading to the pond.

The next reach shown in Map 16 begins at a diversion structure. Here a portion of the flow is diverted east to the Hayspur Hatchery, south into Bill's Ditch, which parallels the road, and Loving Creek which parallels the old railroad bed. This three-way diversion also inhibits or blocks fish passage. IDFG believes there is good quality trout habitat (spawning and rearing) in the headwater reaches, which would justify fish passage at the diversion (Personal communication with Doug Mergagle, regional fish biologist). Passage can be achieved with a relatively simple ladder. The height differential is less than six feet and a six-step ladder would be adequate. Some retrofitting of the diversion structure will also be required. The final restoration plan will determine the ladder specification and configuration details.

IDFG monitors water quality conditions in the wastewater channel east of the hatchery. Water that returns to Loving Creek below the railroad trestle meets state water quality standards. Extensive tule growth and other wetland vegetation provide substantial filtration of the hatchery effluent as the flow moves through the channel. Also, there is significant shading from riparian vegetation. Given that the volume of water now coming out of the hatchery is very small and the wetlands appear to be very efficient, and some shading is present along the channel, little additional benefit would be gained expending restoration resources on this channel.

From the diversion to the railroad trestle there is state-owned land on the east side (Hayspur Hatchery) and private land (Aubrey Springs) on the west. This reach of Loving Creek is dominated by tules. Riparian vegetation is needed on the terraces above the tule choked floodplain for temperature reduction in the stream. As in the upper reaches, the final restoration plan will identify specific planting sites, number of plantings and species, as well as drip irrigation requirements. This reach will also benefit from 150-foot buffer zones on the east side agriculture lands. Mowing of the vegetation on the state lands east of the creek should be halted and native grasses and shrubs planted in the area between the road and the stream.

Buffers can be established on both sides of the stream from the trestle to the highway to reduce sediment inputs. As in upper reaches, shading and temperature reduction can be achieved with tree willow, alder and cottonwood plantings. Determination of riparian vegetation plantings and sites will be included in the final restoration plan.

Just below the highway is the Loving Creek Ranch pond. This is a man-made pond built to provide duck habitat and seasonal hunting and fishing. A control structure provides management over pond volume and elevation. The pond represents a substantial heat sink in the summer time because of its large surface area. While there is no data to indicate how much temperatures increase in the pond, it could be a significant source for temperature loading. Negotiating with the property owners to decrease the surface area by increasing the flow through in late summer months could reduce thermal loading during critical periods. The final restoration plan will include estimates on temperature reductions with different pond turnover rates.

Loving Creek below the pond is in a very different condition. As shown in the photo, this reach of the stream is heavily bordered with tree willow, alders and cottonwood and other woody riparian vegetation. The stream is somewhat widened through the lower reach, but riparian vegetation provides significant shading and temperature control. Additional riparian plantings will not improve temperature control in this reach; however, agriculture lands on both sides of the stream do contribute sediments during overland runoff and establishing 150-foot buffer zones from below the pond to the confluence with Silver Creek is the best restoration action to be taken in this reach.

Following implementation of the restoration plan, Loving Creek will need to be closely monitored to determine the effectiveness of actions. Monitoring will consist of temperature loggers located in the upper reaches (1) above Gardner's pond, (2) below the restored reaches, (3) above the railroad trestle, (4) above the highway, (5) below the pond, and (6) above the confluence with Silver Creek. Sediment change will be measured at the previously established channel cross sections. All riparian plantings will have to be examined each spring to determine survival and replacement need. Canopy cover is monitored over time as well. Monitoring data are reviewed each year to identify trends and make management changes to adapt to the trends as necessary.

Action: Tier 1 Type 3

Buffers and Riparian Zones

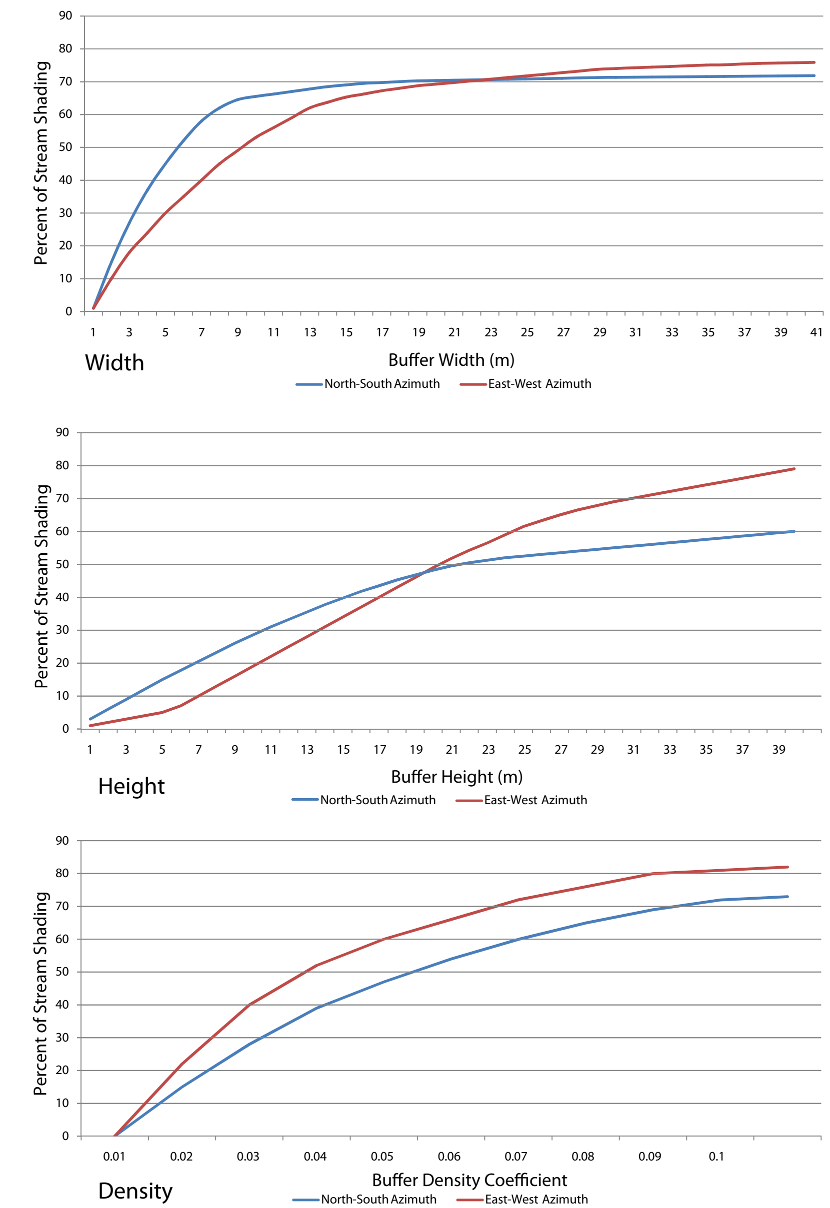
The primary source of sediment loading is from overland runoff during snow melt and precipitation. Agricultural fields adjacent to the streams without adequate vegetation buffers between the fields and stream banks are the major route for sediment movement. Buffer zones filter and block sediment movement into the streams such that if the input of sediment is significantly attenuated, the balance can be shifted to exporting greater sediment loads from Silver Creek and other streams. This shift in sediment loading will mean more of the legacy sediments are exported over time. The size of buffer zones vary from 30 to 60 meters (100 to 200 feet) depending upon site conditions, topography, existing vegetation, and other features like access roads between the field and stream.

There are three levels of priority for establishing buffers as described previously. The highest priority streams are those with (a) 10 meters or less buffering , (b) the second priority are those sites with 10 to 30 meters buffers; and (c) the lowest priority, 30 to 60 meter buffering sites. These sites are shown in Map 17. TNC will work with stakeholders with less than 10 meter buffers initially. Watershed mapping, although preliminary and subject to change with ground truthing, identifies over 50 sites primarily on Cain, Wilson, and Loving creeks. The next step is to actually visit the sites to determine if the mapping is accurate and to identify those sites' specific conditions such as slope, vegetation type and percent cover, and extent. The same approach is necessary for selecting specific sites for planting riparian vegetation, requiring site visits with landowners as the first step.

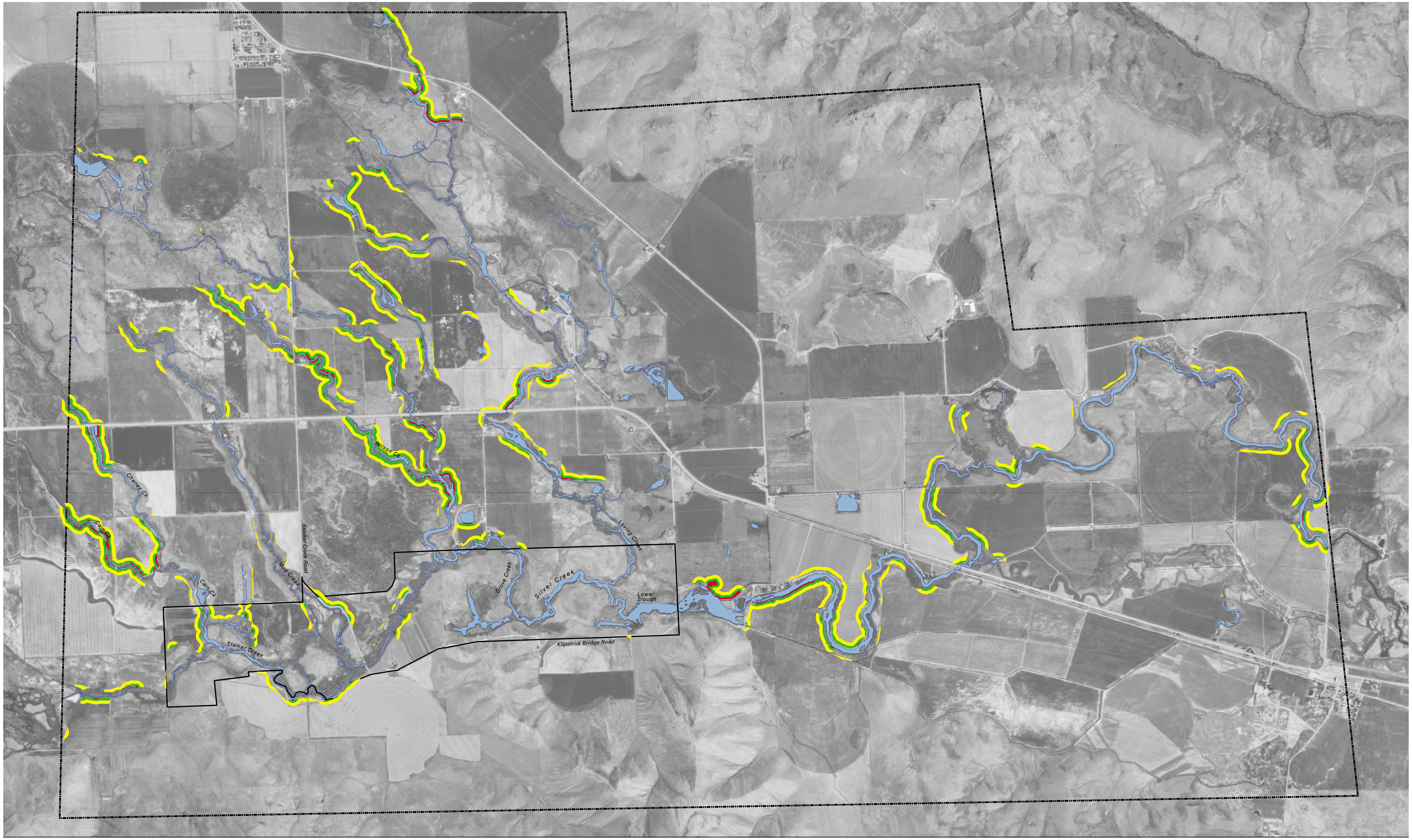
Woody riparian vegetation (willow, alder) plays a critical and highly efficient role in shading to reduce thermal loading. Increasing canopy coverage on streams tributary to Silver and Loving creeks is feasible and relatively low-cost. For the greatest cost-benefit, plant riparian vegetation on those streams with the narrowest channels and highest thermal loading. Plantings must be done in relation to the available groundwater level and soil moisture content and recognizing that short-term drip irrigation may be required.

Hoag (2010) suggests that for planting woody species, willow clumps are the best for saturated soil conditions and to provide stream function quickly. Containerized riparian woody plant species (minimum >3/8 in diameter and generally at least two litter containers) are also good especially when clumps are not available. Containerized plants that are five-gallon size or bigger (up to 2 inch caliper dbh) tend to establish faster and increase stream function much faster. Unrooted willow or dogwood cuttings in areas that have aerobic conditions for at least one month during the growing season are the best methods. In many cases, the soils along spring creeks are saturated for long periods of time. Unrooted cuttings trend to struggle to put out roots in these anaerobic conditions. So, plant the unrooted cuttings in four inches of aerobic soil above the anaerobic soil. The bottoms of the cuttings need to be in the lowest water table of the year to keep the cuttings hydrated. If aerobic soil cannot be found, plants with roots are a better choice for saturated soils.

The best planting method for herbaceous species are typically native harvested wetland sod and wetland plant plugs (no smaller than 12-15 cu in). Plugs should be planted on 18 inch centers. Different wetland plant species grow in specific hydrologic zones and should be planted only in the appropriate zone. Seeding herbaceous wetland plants is rarely very successful.



Riparian Buffer Width, Height and Density Shading
The above figures were adapted from DeWalle (2010). Blue lines are for North-South running streams, red lines are for East-West running streams. Graphs are extracted from models based upon parameters from a 3m wide stream at 40°N with 30m tall vegetation, 12 m wide buffer and an average density coefficient 0.05 m^{-1}. Not all parameters were used in each model. The density coefficient is a substitute for density of vegetation.



Prioritized Stream Buffers

Agricultural Land w/in 60m Stream Buffer

Data:
Image: June 24, 2009 USDA Farm Service Agency
Buffer mapping: Ecosystem Sciences. Note: Buffer mapping is based on remote sensing of imagery and has not been verified; inaccuracies may occur and buffers should be field verified.

0 1.5 3 6 9 12 Miles

N

Silver Creek Preserve
Landcover Analysis Area

First Priority Areas
Agriculture w/in 10m Stream Buffer
Second Priority Areas
Agriculture w/in 30m Stream Buffer
Third Priority Areas
Agriculture w/in 60m Stream Buffer

The Nature Conservancy
Silver Creek Preserve
Map 17
Mapping and Analysis by:
Ecosystem Sciences Foundation

First Tier Actions Continued

Action: Tier 1 Type 4
Improve the Quality of Riparian Buffers

Establishing riparian buffers, or excluding certain land use practices from areas close to the stream and encouraging native vegetation, is an important restoration action. Given time, these actions will promote the colonization riparian areas by dense, diverse native vegetation. However, usually following a change in land use, such as conversion from agricultural cultivation to an unmanaged riparian buffer, exotic weeds or other undesirable species will colonize riparian areas.

Riparian buffers provide a myriad of ecosystem services. However, not all riparian buffers perform the same functions. As described in Section 5, the species composition, density, and habitat type all affect the ecosystem services provided by those buffers. The ability of riparian buffers to provide those services most important to Silver Creek, primarily sediment and nutrient processing and stream shading to reduce stream temperatures, varies according to the quality of the buffer.

In general, wider and more diverse buffers perform more services. For nutrient processing, buffers more than 50 feet wide consisting of native riparian forest with grass understories provide the best filtering and retention of sediment and nutrient run off entering the stream. For shading, height, width and density all play a role in determining how much shade is provided to the stream. These factors are especially critical in the first 12-15m of buffer. Wider stream sections require taller, denser vegetation to provide adequate shade than more narrow streams.

If monitoring or site visits indicate that existing or newly established riparian buffers do not have the species composition, height, width or density to provide the desired ecosystem services (e.g. filtering or shading), then improving that buffer through native plantings, weed management, or in extreme cases more active interventions like grading and floodplain construction may be warranted. In most cases, native plantings coupled with weed management and temporary irrigation will be enough to change the trajectory of the site towards the desired state.

Second Tier Actions

Action: Tier 2 Type 1
Additional Island Construction

In the event the island restoration action in Kilpatrick Pond proves successful; i.e., monitoring shows that soils remained in place, vegetation was established with minimal (<30%) replanting, waterfowl use for breeding, nesting and rearing is evident, and downstream impacts were prevented during construction, a second island will be developed in the Preserve just upstream of Kilpatrick bridge. This island will utilize the same construction method and criteria that made the lower island successful. However, it is likely that this second island will be larger and thus require higher costs.

Action: Tier 2 Type 2
Spring Protection

Springs are the primary source of Silver Creek's flow, and their protection is fundamental to the future of the creek and the watershed. Many of the original springs have been filled, diverted, or otherwise modified. The existing springs are essential element s of the watershed and measures to directly protect the springs (such as fencing and protection) should be taken. However, spring protection also entails protecting the source of the springs: groundwater. This includes monitoring land use that may increase groundwater withdrawals and influencing policies that may reduce the groundwater supply. As noted in this plan, the Wood River Valley aquifer is probably being over-drafted and groundwater mining poses a real threat to the future ecology of Silver Creek and its tributaries.

Action: Tier 2 Type 3
Surface Water Flow Augmentation

Temperature and sediment loading can be alleviated by increasing the discharge. There may be unused water rights available for purchase on a seasonal or annual basis within the Silver Creek watershed. TNC can negotiate for unused water rights to augment tributary flows on a seasonal or even hourly basis. The volume of water needed to reduce temperatures is a function of the ratio of inflow and receiving water flow and temperature. Additional water input to tributaries during the natural high flow periods would provide greater sediment transport as well as overbank flows to benefit riparian vegetation germination and recruitment. The amount of additional water and the streams in which this would be beneficial would be determined using monitoring data.

Action: Tier 2 Type 4
Sediment Trap Basins

Sediment basins constructed within known deposition areas will trap sediments and hold them in place rather than allow sediments to distribute throughout the downstream channel. Certain tributaries are known to be the primary conveyance for sediments—specific junctions within these streams can be identified from sediment monitoring to provide the best locations for retention basins.

Third Tier Actions

Action: Tier 3 Type 1
Kilpatrick Dam Release Reconstruction

Sediment deposition above and below Kilpatrick Bridge is extensive and adversely affects the fishery and fish habitat. The cause of this deposition is Kilpatrick dam and the pond downstream. The pond is a necessary component for irrigation, but the outlet/control structure is antiquated. If replaced with an outlet structure that provides more control at different flow levels, sediment movement can be managed over time to decrease the deposition above and below the bridge. A couple of designs have been suggested from previous studies (Gillian, 2007); add a bottom release outlet structure with a 150cfs capacity at a cost estimate of $300,000, or modification of the dam to lower the outlet elevation at a cost estimate of $65,000. The cost of replacing the outlet can be significant, but it is an important action to reduce sediment deposition. The cost of constructing a new outlet could be offset with a 319 grant or other funding source to improve water quality.

Action: Tier 3 Type 2
Reduce Pond Surface Areas

Ponding of spring sources over time for irrigation and recreational (fish and duck ponds) purposes is a source of thermal loading. Ponded surface water absorbs solar radiation to a greater extent than flowing water. There is a potential for TNC to work with stakeholders to reduce or eliminate ponds that are no longer essential for irrigation or used for other purposes. To what degree this will be an effective intervention depends upon how much heating occurs in ponds—monitoring will provide the necessary data on pond temperatures.

Action: Tier 3 Type 3
Dredging

In the event monitoring indicates sediments are not being adequately reduced using Tier 1 and 2 interventions, dredging of key areas to remove sediments may be required. A detailed analysis would determine the dredge method, season, and disposition of dredge spoils as well as costs and sources of funding.

Action: Tier 3 Type 4
Channel Narrowing

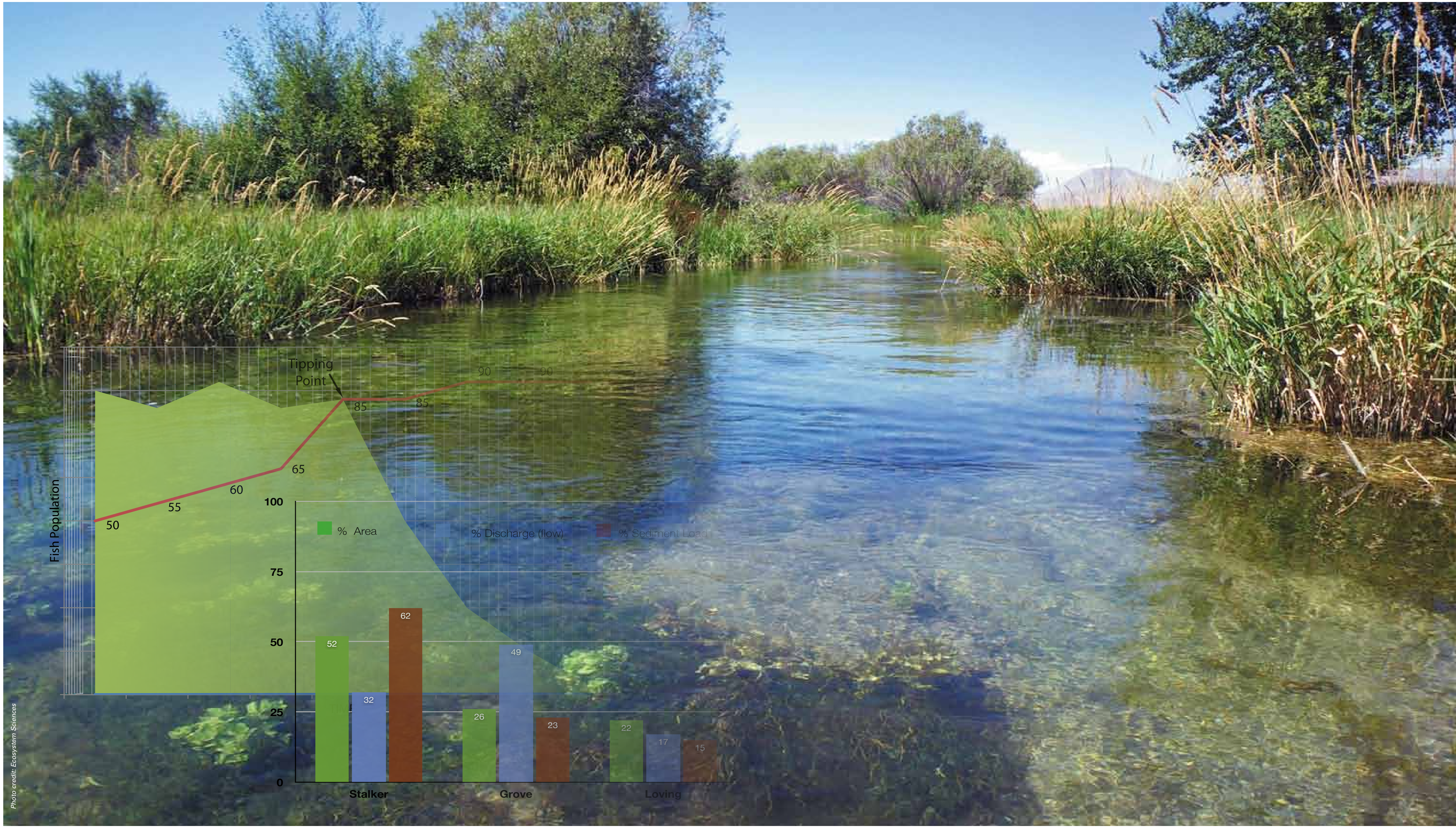
Reducing the cross-sectional area of a channel both narrows the channel and increases velocity so that sediment transport is increased and temperatures are reduced. This intervention focuses on Silver and Loving creeks and should only be implemented in combination with Type 1 and 2 interventions. Sites for the intervention are the over-widened channels described in Section 5.2. Using monitoring data, specific channel lengths would be selected. A detailed plan would determine the specific location and length of stream to provide significant benefits, construction method, seasonality, and costs and sources of funding.

Funding Sources

Appendix B identifies potential funding sources that landowners in the watershed can pursue individually, collectively, or through partnerships with organizations such as TNC. The listing includes federal, state and private funding institutions—any federal granting, such as through the Natural Resource Conservation Service (NRCS) is subject to environmental review as described in form NRCS-CPA-52 "Environmental Evaluation Worksheet". The environmental evaluation is conducted as part of the planning process and is used to identify potential long-term and short-term impacts on people and the environment and explores alternatives to the proposed action to minimize those impacts. Additional information on the environmental review process and the disclosure needed is available at: http://www.nrcs.usda.gov/technical/ECS/environment/CPA-52.doc.

Applications for projects with potentially adverse effects may need to be modified to lessen impacts to the environment, therefore it is important during the environmental review process that applicants consider alternatives in order to lessen these impacts and increase the chances of having their project funded. This environmental information is used by NRCS to determine the appropriate documentation required to comply with the National Environmental Policy Act (NEPA) and NRCS regulations. If a project is granted funding, NRCS staff will work with the selected applicants to ensure proper documentation for compliance with NEPA. The selected applicant is required to prepare and/or pay for the preparation of the appropriate NEPA document (Environmental Assessment or Environmental Impact Statement, if required). Grant funding cannot be approved until the appropriate environmental documentation showing compliance with NEPA are met. Each grant opportunity has its own application requirements and time schedule that the applicant is responsible for carefully following— specific funding priorities are described in Appendix B along with websites and contact information to assist applicants in determining the appropriate potential funding sources.

Section 6: Monitoring and Adaptive Management



Adaptive Management and Monitoring

Adaptive management is widely recognized as an intelligent, if not essential, approach to the management of natural resources under uncertainty. Adaptive management is a common element in large-scale, watershed-level, restoration projects. It can be defined as the systematic acquisition and application of reliable information to improve management over time. Thus, adaptive management depends upon monitoring to inform decision-making. How monitoring and adaptive management works is shown in the generalized model to the right. Monitoring is implemented to evaluate trends toward a specified goal. Data is collected and analyzed to identify problems, then adaptive management options are weighed and recommendations made to implement new management actions.

Monitoring and adaptive management will be critical to the on-going management of the Silver Creek Preserve because this plan is only a conceptual beginning. Too little data are available to be certain about all watershed conditions, including temperature, sediment, land use and groundwater dynamics. Many data gaps need to be filled, baseline conditions established, and monitoring programs implemented before more extensive or detailed plans can be developed.

It is important to remember that the preserve is not in an emergency state. The ecosystem does not appear to be in danger of exceeding tipping points in terms of sediment and temperature impacts, and there is time to allow first tier interventions to show results before more active and expensive interventions are considered and implemented.

Monitoring and Feedback

As shown in the figure on the right, monitoring and adaptive management is a continuous system in which information and knowledge gained is continuously fed-back into decision-making, so that over time an informed, dynamic ecosystem management program is built. Monitoring is focused on critical ecosystem elements. Partnerships with agencies or other groups will enable additional monitoring of less critical but important ecosystem components. When restoration actions are undertaken, monitoring is needed to measure the effectiveness of the restoration actions. Once adaptive management actions show desired results, it is usually possible to reduce monitoring effort. Once goals have been met and/or sustainable ecological conditions are established, fewer interventions will be required and, thus, less monitoring is needed. A detailed monitoring program will be described as part of a future task in conjunction with this plan.

Stakeholder Input

A critical part of monitoring and adaptive management is inclusion of stakeholders in the decision-making process. Stakeholders need the same information as scientists to form ideas and suggestions; however, the information must be relevant and understandable so that all participants are clear about the situations and conditions. Stakeholders often provide insight and common sense suggestions that improve adaptive management and project success. Stakeholders also usually have a vested interest in outcomes, especially if interventions directly involve their property or operations. The obvious outcome of the analysis for this plan is that the issues most affecting the preserve are outside of its boundaries. Silver Creek Preserve cannot be enhanced without the active and willing cooperation of landowners throughout the watershed.

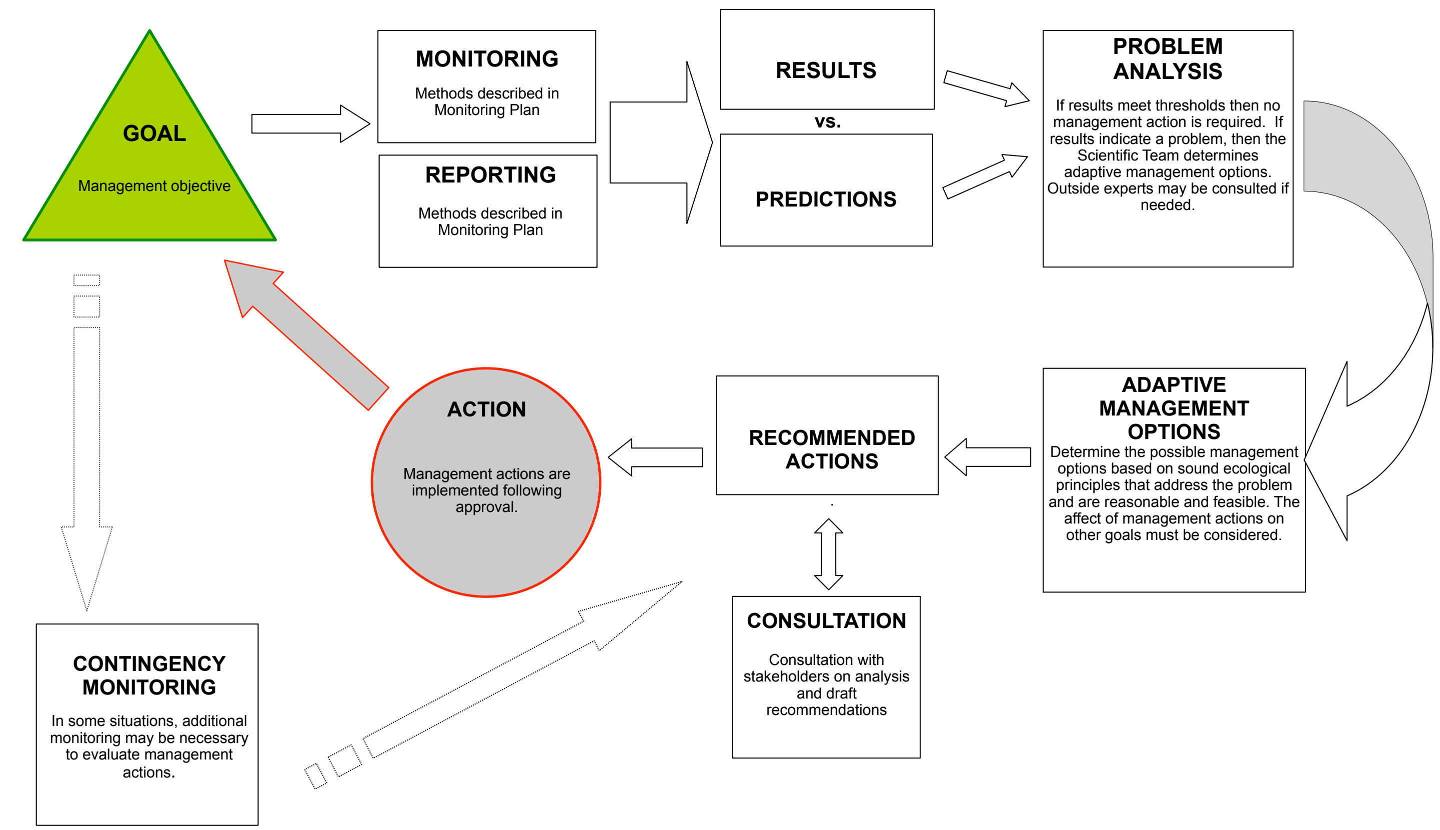
Adaptive Management Actions

Section 5 describes the potential management actions as a tiered process. As each intervention is implemented, it must be accompanied by a monitoring program to measure whether the intervention is working and whether it is a success or failure in the long-term. As shown in the figure on this page, contingency monitoring is always an option to evaluate adaptive management actions or to acquire more definitive data regarding an issue. The decision to implement an intervention must be supported by the monitoring data as necessary and the best action to take. Stakeholder input is critical and success often depends upon the willingness of stakeholders to participate, including allowing access to private lands for collecting monitoring data.

Funding

The limiting factor for monitoring and adaptive management is the availability of funds. Resource availability and competition for funds and manpower between projects is significant. Consequently, monitoring must be highly focused and the emphasis be placed on collecting pertinent data. Monitoring must be commensurate with management; it is not fiscally sound to collect data which cannot directly inform adaptive management. For example, using limited funds to monitor water quality constituents that are not a clear threat to the ecosystem when temperature monitoring is clearly needed would be a poor allocation of project funds. Also, teaming with resource agencies such as the IDFG for periodic fishery surveys, the USGS to augment flow data, or the IDEQ to assist with water quality monitoring as TNC has done in the past, is a good way to stretch limited funds. In the end, funding for monitoring and adaptive management will vary from year to year and with each funding cycle. TNC management must determine the priorities and allocate funds each year.

Monitoring and Adaptive Management Pathways: Generalized Model



General Model for Adaptive Management Pathways, Feedback and Consultation.

Implementation

Monitoring Silver's Creek health is essential to its long-term sustainability as a premier fishing, wildlife viewing and recreation destination. The four key ecosystem components addressed throughout this enhancement/restoration plan are temperature, stream flow, sediment and land use. Thus, monitoring these four key indicators of ecosystem health on Silver Creek and its tributaries will be critical to understanding the ecosystem trajectory. The map on the following page displays the suggested array of temperature, flow and sediment monitoring stations within the Silver Creek watershed. Sites were chosen to facilitate the identification of problem areas within the watershed, and for logistical reasons (e.g. sites where multiple elements can be measured at one site). Each monitoring element (temperature, flow, sediment and land use) is described below. Effective monitoring and assessment requires planning that identifies why monitoring is to be undertaken, what will be monitored, where monitoring will occur, who will perform the monitoring, and how long monitoring will will occur. The latter two points will need to be determined prior to implementing the monitoring program; all other points are addressed below.

For most of the primary elements listed in the table (location of table) baseline conditions will be established during the first year or two of monitoring. These will be the qualitative and quantitative metrics against which to measure trends. The effort has already begun; for example, some 100 transects are currently being monitored: riparian vegetation, channel depths, widths, sediment depth, and sediment distribution are being measured on Upper and Lower Silver Creek and its tributaries. In addition, TNC has initiated a cooperative groundwater monitoring and evaluation study. As described below, the land use mapping effort has been initiated, and a preliminary, watershed-wide base map has been created. In short, TNC is well on its way to developing a robust monitoring program.

Implementation (Continued)

Temperature

Temperature is an important indicator of ecological health in streams. This is especially true for Silver Creek, as it is a spring system relying on groundwater and thus should have relatively low temperatures. Increases in temperature are indicative of a problem within the system and could quickly and adversely affect Silver Creek's cold water fishery. Monitoring temperature will inform management as to the success of restoration actions to develop riparian canopy and increase turnover rates in ponds and reduce surface areas. Temperature is a well know and much discussed issue on Silver Creek, but a reliable, systematic program for measuring temperature change through time does not currently exist. The monitoring array displayed in the map on the following page enables managers to identify the source of temperature increases. For this reason, it is suggested that temperature monitoring stations be located in each tributary and along Silver Creek just downstream of each confluence with a tributary. Using an array such as this enables managers to identify the stream and potentially the reach where temperatures deviate from expected values. It is recommended that at each monitoring location, stream temperatures be recorded every half hour using commercially available automatic recorders (e.g. Optic Stow Away, Onset Computer Corporation). Temperature data can then be downloaded weekly. It is not necessary to monitor temperature during the cool months because the focus should be on surface water from May through October.

Stream Flow

Monitoring stream flow throughout the tributaries and main stem of Silver Creek enables managers to understand the hydrodynamics of the system. Understanding the hydrodynamics of a spring driven system, as complex as Silver Creek, is imperative to maintaining the pristine nature of the creek. Flow monitoring stations are arrayed in Silver Creek to capture variations within each tributary and within Silver Creek (see the map on the following page). These variations will enable managers to understand losing and gaining reaches within the system and monitor how land (agriculture and restoration) and water (groundwater and surface) management actions are affecting flow throughout the watershed. Staff gauges should be installed at each flow monitoring point on the map on the following page. Staff gauges are easy to read and less costly than in-stream flow monitoring devices. Staff gauge rating curves will need to be calibrated yearly by a certified hydrologist to ensure accurate measurements. The USGS monitors flow in Silver Creek downstream of where Silver Creek crosses Highway 20, thus staff gauges upstream could use the USGS gauge as a control. If upstream flow measurements are not in sync with USGS data then the out-of-sync gauge may need to be recalibrated. With staff gauges managers can decide how often flow monitoring should occur. Each staff gauge should be checked and flow data downloaded weekly even in winter months.

Sediment

Sediment monitoring is essential to preserving the quality fish habitat found within the Silver Creek watershed. Annual monitoring will determine if the sediment balance is moving toward more export than import relative to the baseline conditions. In this way managers will know if restoration actions to buffer stream banks and riparian plantings are being effective. Sediment monitoring stations have been established within the watershed and baseline data has already been collected (summer 2010). Subsequent sediment monitoring should be performed at minimum every two years in the summer. The Silver Creek Sediment Monitoring Protocol is found at the end of this section.

Land Cover Mapping

Land use affects stream ecosystem health from the site to the landscape scale. Changes in the predominant land use of the watershed can dramatically affect how Silver Creek functions. A prime example of these effects includes the historic cattle grazing within the stream channel and the associated impact legacy. Although currently an agricultural landscape (initial mapping results show approximately 2/3 of the watershed is dedicated to agriculture), factors such as development and conservation could change the landscape mosaic. The land use affects groundwater levels, temperature, sediment inflows and ultimately stream flow. Nutrient inputs to the stream are determined by land use – both adjacent to the stream and in the uplands. Land use mapping through time will not only track broad trends that change slowly over time, but also indicate whether restoration actions are effectively achieving their goals through stream channel and riparian mapping results. The Nature Conservancy and Ecosystem Sciences Foundation have created a base landcover map. This map was created from aerial image interpretation (unsupervised classification), and requires ground truthing and map improvement. The first task when monitoring is implemented is the ground-truthing or field verification of the mapping work that has been completed. This element, while not an extensive amount of work, will result in corrections to vegetation and channel mapping that will provide greater accuracy. During this effort the map cover classes could be further improved by adding additional attributes. For example, the agriculture cover class could also include water source (groundwater or surface water), irrigation technique (e.g. sprinkler, flood, etc.), and crop (wheat, barley, etc.). Tracking these trends through time will inform managers about groundwater and surface water dynamics, sediment, and nutrient inputs.

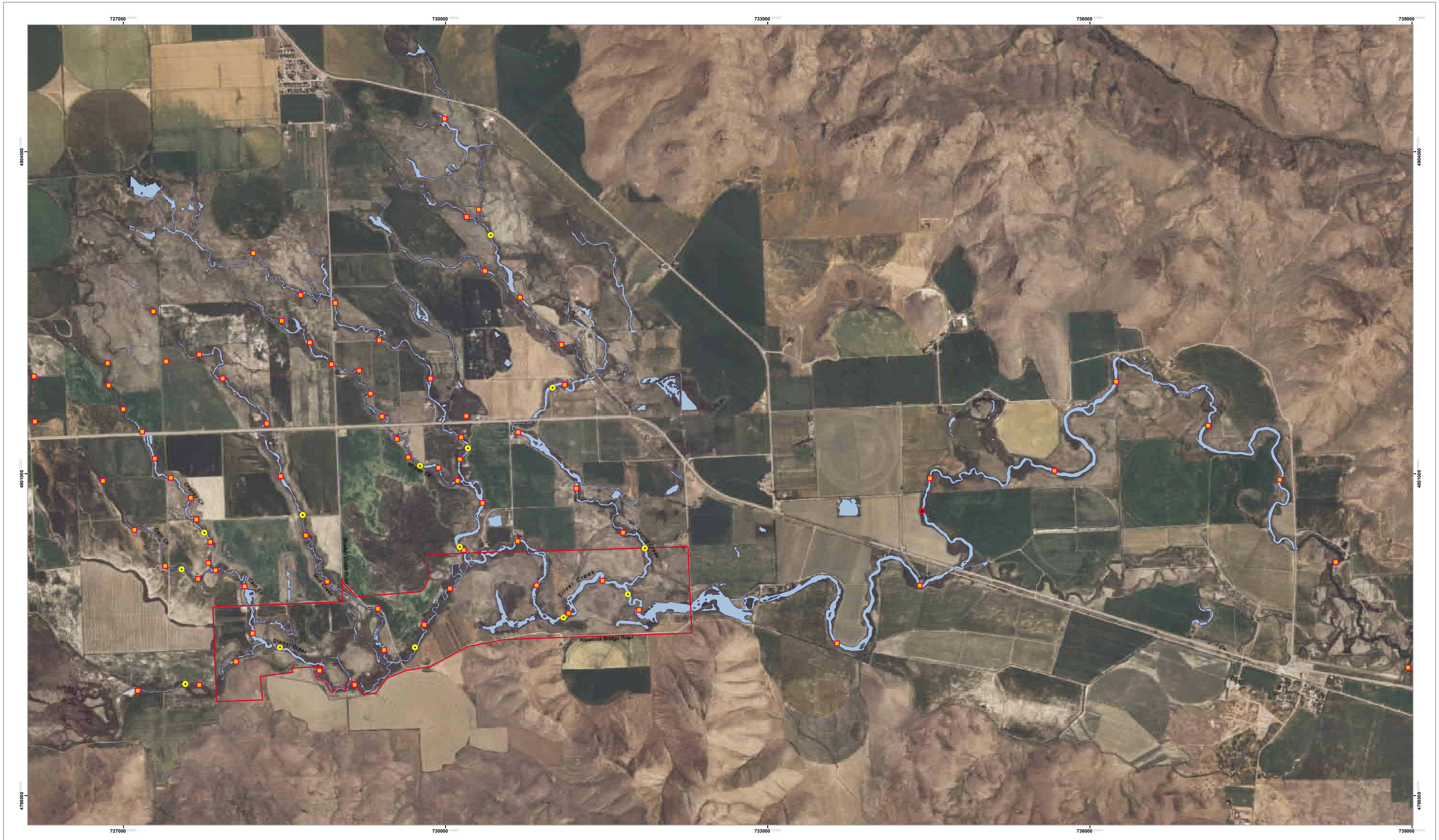
Secondary Elements

There are a myriad of different criteria and indicators of ecosystem health that can and should be monitored according to funding and need. These elements include riparian buffer quality (height, width, and density of vegetation within riparian buffers), groundwater levels and spring health, instream habitat and fish food supply, fisheries numbers and distribution, fisheries habitat, nutrients and wild life an avian populations. These elements, their indictors and metrics are described in the adjacent table. Other elements may require monitoring, based on changes in the watershed conditions.

Silver Creek

Monitoring Indicators and Elements

Ecosystem Component	Indicator	Metric/Method	Agency Partnership
Primary Elements			
Instream Habitat (Temperature)	Trends in Temperature (direct measure)	Temperature collected with data loggers at appropraite locations.	TNC
Sediment Transport Balance	Trends in Accumulated Sediment Depths	Sediment depths at established transect locations thoughout watershed mesasured in the field.	TNC
Water Supply	Trends in Stream Flow	Staff gauges read weekly and calibrated yearly	TNC/USGS
Land Use	Land Use Changes	Changes in land use patterns and location within watershed based on landcover mapping	TNC/ESF
Secondary Elements			
Ecosystem Component	**Indicator**	**Metric/Method**	
Riparian Buffer Quality	Buffer Survey Measurements	Height, width, density and species composition of buffers measured in the field using accepted obstruction pole (e.g. Robel pole).	TNC
Water Supply	Groundwater/ Springs	Groundwater levels at wells and spring condition, measured with data logggers and site visits to springs.	TNC/USGS
Instream Habitat (fish food supply)	Benthic Invertebrate Sampling	Benthic invertebrate density and species distribution measured in the field.	IDFG
Fisheries	Fisheries Surveys	Abundance, age, distribution, and size measured with electrofishing.	IDFG
Fisheries Habitat	Fisheries Habitat Inventory	A full inventory of Silver Creek and its tributaries involving all life stages made by experts in the field.	IDFG
Nutrient Levels	In-stream Nutrient Levels	Trends in nitrogen and phosphorous levels; water quality sampling at established flow and temperature sites.	IDEQ
Wildlife/Avian Populations	Avian Diversity/Abundance	Trends in avian survey numbers at existing survey locations.	TNC



Monitoring Implementation Sites

Temperature, Stream Flow, Sediment

0 1.5 3 6 9 12 Miles

N

Silver Creek Preserve

Monitoring Sites

- Temperature and Flow
- Sediment
- USGS Stream Guage

THE NATURE CONSERVANCY

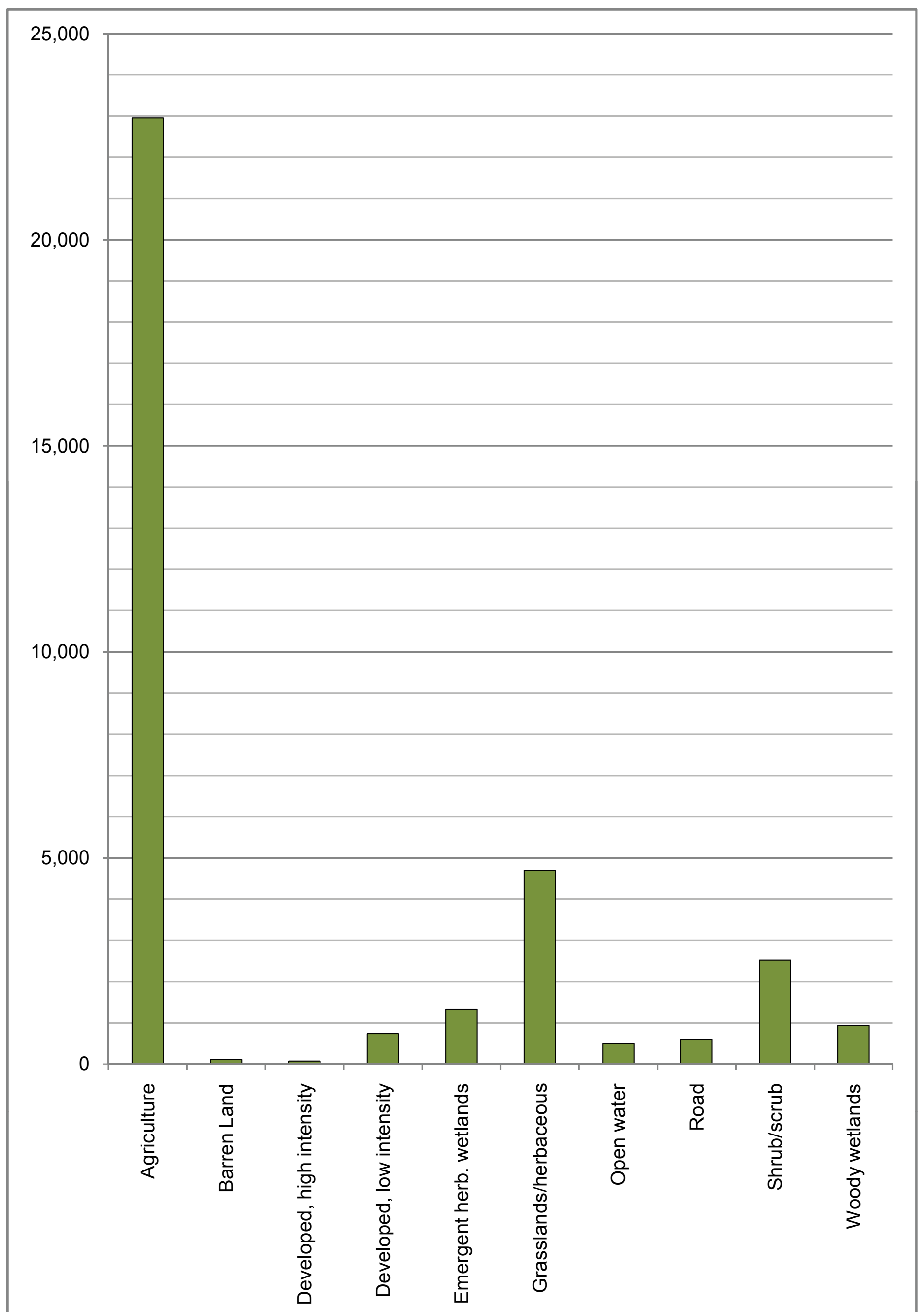
Silver Creek Preserve

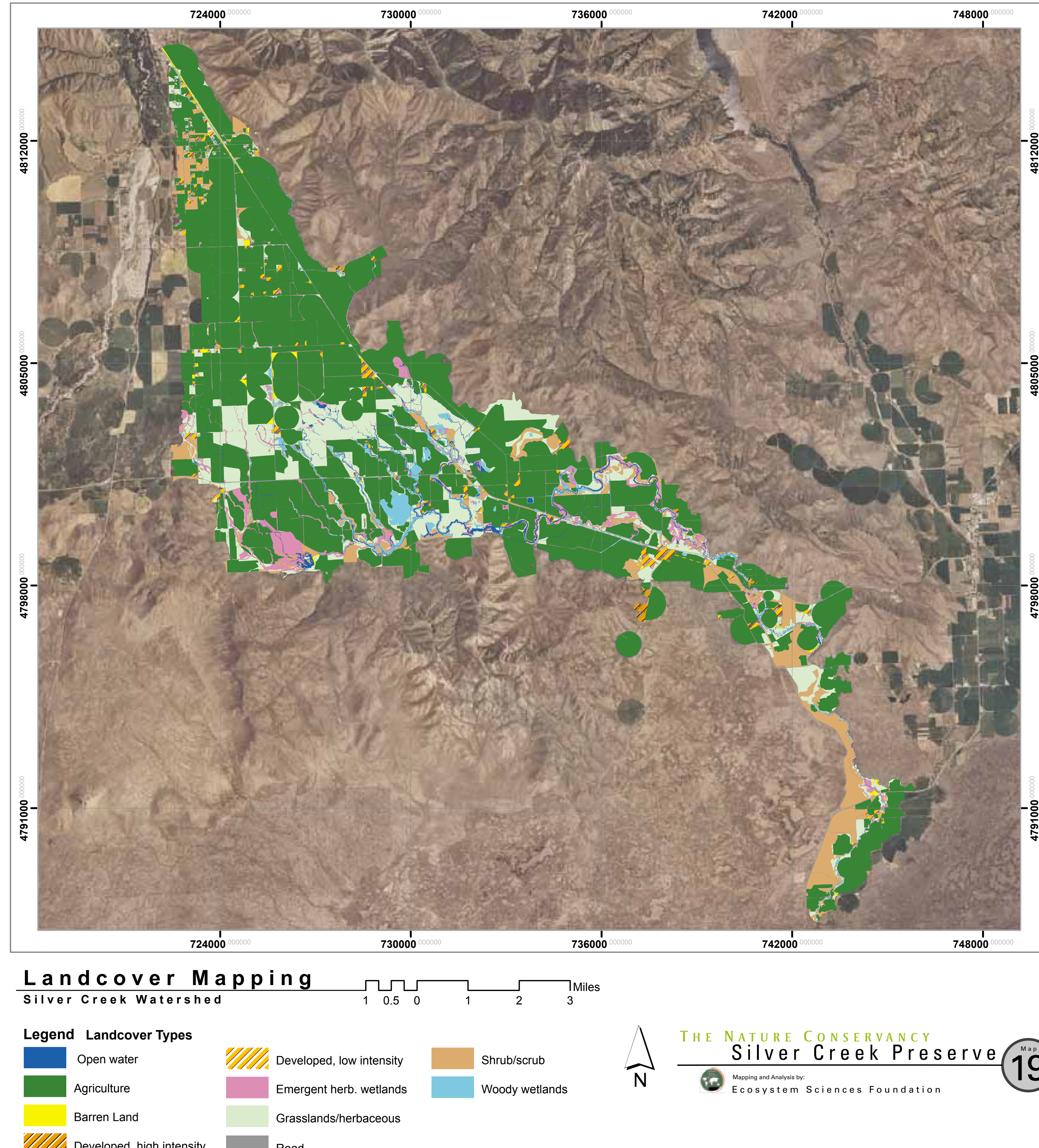
Map 18

Mapping and Analysis by:
Ecosystem Sciences Foundation

Landcover	Acres	Percent
Agriculture	22959.8	66.6
Barren Land	118.7	0.3
Developed, high intensity	80.3	0.2
Developed, low intensity	733.7	2.1
Emergent herb. wetlands	1327.1	3.8
Grasslands/herbaceous	4702.1	13.6
Open water	501.7	1.5
Road	594.9	1.7
Shrub/scrub	2518.2	7.3
Woody wetlands	943.2	2.7
Total	**34479.6**	**100.0**

Landcover for Silver Creek Watershed





Sediment Monitoring Protocol

Stream Transect Protocol

Stream Priority:

First: Loving, Grove, Stalker, Upper Silver
Second: Wilson, Chaney, Mud, Lower Silver Creek

Equipment:

GPS; Clip Board, Data Sheets, Wading Rod (5-ft pole marked off in 1-ft intervals); 200-ft measuring tape

Methodology:

Step 1: Pace off 200 feet from the streambank edge on both banks and give a general and brief description of the vegetation; e.g., willow, grass, brush, farmland; approximate the distance of each vegetation type.

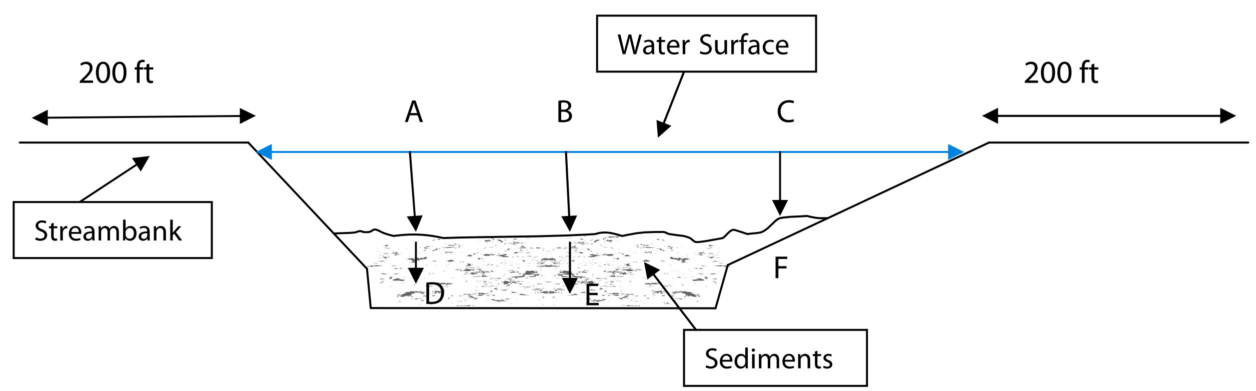
Step 2: Measure the width of the stream; streambank to streambank with the measuring tape

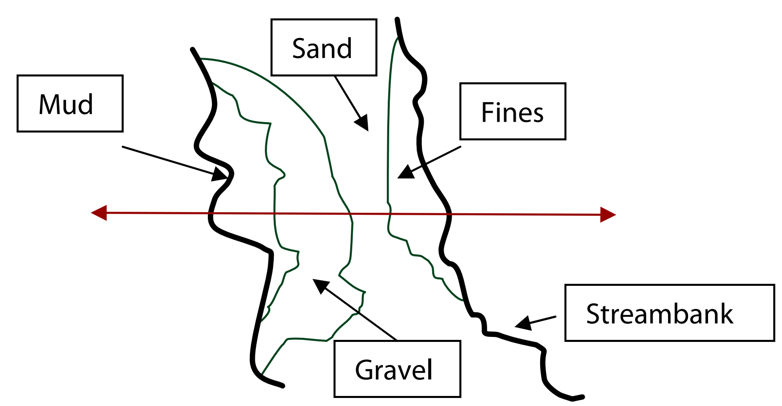
Step 3: Using the wading rod, measure depth from surface to top of sediments at points A, B, and C. Point B should be the deepest point on the transect

Step 4: Measure the sediment depths by pushing the rod in as deep as possible on points D, E, F

Step 5: Measure the distance of substrate types along the transect. The types are (1) fines (very light and easily stirred up), (2) mud, (3) sand, (4) gravel, and (5) cobble (three to four inches in diameter) – see plane view illustration below.

Step 6: Describe and estimate aquatic vegetation type and coverage.





Section 7: Studies and Background Documents

Fisheries

Bell, M. (1990). Fisheries handbook. Portland, OR: U.S. Army Corps of Engineers

Bell, R.J. (1965). Silver Creek fishery investigations- 1965. Idaho Department of Fish and Game

Bell, R.J. (1966). Silver Creek fishery investigations- 1966. Idaho Department of Fish and Game

Bjornn, T.C. (1980). Report of 1979 work at Silver Creek. Idaho Cooperative Fishery Research Unit

Born, S.M., Mayers, J., Sonzogni, W.C. and Norton, J.A. (1988). The management of exceptional trout stream systems in the United States: an analysis of State experience. Madison: University of Wisconsin

Chapman, D.W. (1990). Visiting hours only, or: catch and release revisited. Presented at Wild Trout IV, 18-19 September 1989, Yellowstone, Wyoming

Clapp, D.F. and Clark Jr., R.D. (1990). Range, activity and habitat of large, free-ranging brown trout in a Michigan stream. Transactions of the American Fisheries Society 119, 1022-1034

Gatz Jr., A.J., Sale, M.J. and Loar, J.M. (1987). Habitat shifts in rainbow trout: competitive influences on brown trout. Oecologia 74, 7-19

Gebbards, S.V. (1963). Silver Creek fishery investigations- 1963. Idaho Department of Fish and Game

Griffith, J.S. (1987). Is limited entry needed in catch and release trout fisheries? Pocatello: Department of Biological Sciences, Idaho State University

Griffith, J.S. (1979). The ecology of Rainbow Trout in Stalker and Grove Creeks. Pocatello: Department of Biological Sciences, Idaho State University

Hauck, F. (1950). Results of tagging study on Silver Creek . Idaho Department of Fish and Game

Idaho Fish and Game (2008). Fish survey 2007: Silver and Stalker Creeks. IDFG

Irving, B. and Idaho Department of Fish and Game (n.d.) History of fishing regulations on Silver Creek 1948-1973. Idaho Department of Fish and Game

Mallet, J. (1976). Silver Creek fisheries investigations: food availability and utilization by trout, quarterly coordination report. Idaho Department of Fish and Game

Mallet, J. (1978). Survey of angler use and harvest, quarterly coordination report. Idaho Department of Fish and Game

Megargle, D.J. (1999). Irrigation diversion fish loss reduction, report no. 00-02. Boise: Idaho Department of Fish and Game.

Parker, B.L. and Riehle, M.D. (1986). Silver Creek fisheries evaluation. Pocatello: Department of Biological Sciences, Idaho State University

Parker, B.L. and Riehle, M.D. (1987). Silver Creek fisheries evaluation. Pocatello: Department of Biological Sciences, Idaho State University

Parker, B.L. and Riehle, M.D. (1988). Silver Creek fisheries evaluation. Pocatello: Department of Biological Sciences, Idaho State University

Riehle, M.D. and Griffith, J.S. (1993). Changes in habitat use and feeding chronology of juvenile rainbow trout in fall and the onset of winter in Silver Creek, Idaho. Can. J. Fish Aquat. Sci. 50, 2119-2128

Riehle, M.D. and Parker, B.L. (1987). Silver Creek research. Pocatello: Department of Biological Sciences, Idaho State University

Fisheries (cont.)

Riehle, M.D., Parker, B.L., and Griffith, J.S. (1987). Rainbow trout population in Silver Creek, Idaho, following a decade of catch-and-release regulations. Presented at Wild Trout IV, 18-19 September 1989, Yellowstone, Wyoming

Riehle, M.D., Parker, B.L. and Griffith, J.S. (1989). Silver Creek fisheries evaluation, final report. Pocatello: Department of Biological Sciences, Idaho State University, in cooperation with Idaho Department of Fish and Game and Nature Conservancy

Ryce, E.K.N., Zale, A.V., MaConnell, E. and Nelson, M. (2005). Effects of fish age versus size in the development of whirling disease in rainbow trout. Diseases of Aquatic Organisms 63, 69-76

Spall, R., Foster, W. and Griffith, J. (1996). Silver Creek whirling disease: 1995 survey. Sun Valley: The Nature Conservancy.

Thurow, R. (1978). River and stream investigations, job completion report. Idaho Fish and Game

Wilkison, R.A. (1993). An evaluation of brown trout population in Upper Silver Creek, Idaho, and an evaluation of their effects on the fish community. Pocatello: Department of Biological Sciences, Idaho State University

Wilkison, R.A. (1994). An evaluation of brown trout population in Upper Silver Creek, Idaho, and an evaluation of their effects on the fish community. Pocatello: Department of Biological Sciences, Idaho State University

Wilkison, R.A. (1996). Brown trout predation in Silver Creek. M.S. Thesis. Pocatello: Department of Biological Sciences, Idaho State University.

Williams, R.N. and Powel, M.S. (2000). Genetic analysis of rainbow trout (Oncorhynchus mykiss) from Silver Creek Preserve of The Nature Conservancy, Idaho. Hagerman: Center for Salmonid and Freshwater Species at Risk, HFCES/University of Idaho

Williams, R.N. and Shiozawa, D.K. (1993). Genetic Analysis of rainbow trout from the Big Wood River and Trial Creek, Blaine County, Idaho. Idaho Department of Fish and Game

Young, M.K., Wilkison, R.A., Phelps III, J.M. and Griffith, J.S. (1997). Contrasting movement and activity of large brown trout and rainbow trout in Silver Creek, Idaho. Great Basin Naturalist 57(3), 238-244

General

Bjornn, T.C. and Francis, L.J. (1979). Aquatic resources in the Nature Conservancy portion of Silver Creek. Idaho Cooperative Fisheries Research Unit

Davidson, M. and Brown, L. (2007). Silver Creek ecological profile, Blaine County. Hailey, Idaho: The Nature Conservancy

Freedman, J.D. and Griffith, J.S. (1985). Baseline study of that portion of Wilson Creek. Pocatello: Department of Biological Sciences, Idaho State University

Griffith, J.S., Rose, F.L., Minshall, G.W. and Faler, C.Y. (1982). A baseline biological study of that portion of Chaney and Mud Creeks included Stinson Easement, Blaine County, Idaho. Pocatello: Department of Biological Sciences, Idaho State University

Griffith, J.S., Rose, F.L., Minshall, G.W., and Faler, C.Y. (1982). A baseline biological study of that portion of Grove Creel (Blaine County, Idaho) included in the McMahan Easement. Pocatello: Department of Biological Sciences, Idaho State University

Hauck, F. (1947). Preliminary observations on Silver Creek and its headwater tributaries with notes on population studies and some fishing results. Idaho Department of Fish and Game

Norman, L. (1998). Estimates of the economic impact of recreation at the Silver Creek Preserve. Pocatello: Idaho State University

General (cont.)

Simpson, J.C. (1953). Silver Creek closure report. Boise: Idaho Department of Fish and Game

The Nature Conservancy (2005). Silver Creek Preserve fact sheet. Picabo: Silver Creek Preserve, TNC

The Nature Conservancy (2009). Silver Creek: strategy effectiveness and ecological monitoring protocol. Picabo: Silver Creek Preserve, TNC

United States Department of Agriculture (1996). Preliminary investigation report: Silver Creek watershed, Blaine County, Idaho. In cooperation with Natural Resource Conservation District and Blaine Soil Conservation District

Wasser, C.J. (1993). Recreational use analysis of Silver Creek Preserve, Blaine County, Idaho. Durham: Duke University

Wiley, K. (1977). A preliminary biophysical inventory and management plan for the Silver Creek Biological Preserve. The Nature Conservancy

Invasive Species

August, E., Hook, P. and Salsbury, K. (2007). Reed canarygrass distribution at the Nature Conservancy's Silver Creek Preserve. Driggs, Idaho: Intermountain Aquatics, Incorporated

Emery, A.M. and Yensen, E. Ecological implications of and control methods for leafy spurge (Euphorbia esula L.) in Idaho. Conservation Biology 306

Forbes, V.E. and Lopez, G.R. (1990). The role of sediment type in growth and fecundity of mud snails (Hydrobiidae). Oecologia 83, 53-61

Freshwater Gastropods of North America (2005). Conference on New Zealand Mud Snail, 16-17 August 2005, Bozeman, Montana

Hall, R.O., Tank, J.L. and Dybdahl, M.F. (2003). Exotic snails dominate nitrogen and carbon cycling in a highly productive stream. Front. Ecol. Environ. 1(8), 407-411

James, C.A. (2007). Investigations of the invasive New Zealand mud snail Potamopyrgus antipodarum in Idaho: implications for temperature limitations. M.S. Thesis. Moscow: Fisheries Resources, University of Idaho

James, C.A. and Moffitt, C.M. (2004). Studies of New Zealand mud snail in Silver Creek drainage: results of 2004 survey. Moscow: Idaho Cooperative Fish and Wildlife, University of Idaho

Oregon State University (2006). Parasite causing whirling disease could be transmitted via fishing waders. Corvallis: College of Agricultural Sciences, OSU

Richards, D.C. and Lester, G.T. (2003). Survey of the invasive New Zealand Mud Snail Potamopyrgus antipodarum in the Silver Creek drainage in and around The Nature Conservancy's Silver Creek Preserve, Idaho, USA. Moscow: EcoAnalysts, Incorporated

Richards, D.C., Cazier, L.D. and Lester, G.T. (2001). Spatial distribution of three snail species, including the invader Potamopyrgus antipodarum in a freshwater spring. Western North American Naturalist 61(3), 375-380.

Richards, D.C., O'Connell, P. and Shinn, D.C. (2004). Simple control method to limit the spread of New Zealand Mud Snail Potamopyrgus antipodarum. North American Journal of Fisheries Management 24, 114-117

Schreiber, E.S.G, Lake, P.S. and Quinn, G.P. (2002). Facilitation of native stream fauna by an invading species? Experimental investigations of the interaction of the snail, Potamopyrgus antipodarum (Hydrobiidae) with native benthic fauna. Biological Invasions 4, 317-325.

Invasive Species (cont.)

Tu, M. (2004). Reed canarygrass (Phalaris arundinacae L.) control & management in the Pacific Northwest. Oregon: Wildland Invasive Species Team, The Nature Conservancy

Native Species

Griffith, J.S. (1996). Wood River sculpin (Cottus leiopomus): abundance and distribution on portions of Ketchum Ranger District of the Sawtooth National Forest and the Sawtooth National Recreation Area. Pocatello: Department of Biological Sciences, Idaho State University

Griffith, J.S. and Merkley, K. (1993). Densities and habitat utilization of Wood River sculpin (Cottus leiopomus) on three Nature Conservancy Preserves in Idaho, final report. Pocatello: Department of Biological Sciences, Idaho State University

Manuel-Faler, Y.C. (1982). Aquatic macrophytes, organic detritus and deposited sediment of upper Silver Creek, Blaine County, Idaho and its tributaries Stalker and Grove Creek. Pocatello: Department of Biological Sciences, Idaho State University

Minshall, G.W. and Manuel-Faler, Y.C. (1982). Benthic invertebrates of Upper Silver Creek, Idaho, and its tributaries Stalker and Grove Creek. Pocatello: Department of Biological Sciences, Idaho State University

Sias, D.S. (1976). The herpetology of Silver Creek, Idaho. Silver Creek Preserve

The Nature Conservancy (1981). Report of 1980-1981 Silver Creek hunting. Picabo: Silver Creek Preserve, TNC

The Nature Conservancy (2005). Birds of Silver Creek. Picabo: Silver Creek Preserve, TNC

Warren, A.D. (2000). Lepidoptera species collected by A.D. Warren at Silver Creek Nature Preserve (and adjacent parts of the Picabo Hills), Blain County, Idaho. The Nature Conservancy

Warren, M.N. and Hornaucker, M.G. (1979). Ecology of Great Blue Herons on Silver Creek, Idaho, final report. Moscow: Forest, Wildlife, and Range Experiment Station

Restoration

Gillian Associates, Inc. (2007). Kilpatrick Pond and Dam restoration feasibility study, final report. Bozeman: Gillian Associates, Inc.

Gillilan, S. and Lovell, J. (1997). Kilpatrick Pond enhancement project. Confluence Consulting, Incorporated

Hook, P. and Klausmann, J. (2008). Streamside revegetation and reed canarygrass suppression at Silver Creek Preserve. Driggs: Intermountain Aquatics, Incorporated

Irving, R.B. (1953). Silver Creek stream improvement. Boise: Idaho Department of Fish and Game.

Jankovsky-Jones, M. (1997). Conservation strategy for Big Wood River Basin wetlands. Boise: Conservation Data Center, Idaho Department of Fish and Game

Shoger, B. (2004). Stalker Creek Beaver Pond management and restoration. Picabo: Silver Creek Preserve, The Nature Conservancy

Riparian

Francis, L. and Bjornn, T.C. (1977). A study of the aquatic resources of Silver Creek and the Nature Conservancy site. Idaho Cooperative Fishery Research Unit

Grunder, S.A. (1983). Effects of trampling on stream biota in Silver Creek. Pocatello: Department of Biological Sciences, Idaho State University

Hitchcock, A.S. (1950). Manual of the Grasses of the United States. New York: Dover Publications, Incorporated

Riparian (cont.)

Hupp, C.R. (1992). Riparian vegetation recovery patterns following stream channelization: a geomorphic perspective. Ecology 73(4), 1206-1226

Mansfield, D., Emery, A.M. and Littlefield, S.L. (2001). Does distance from shore affect the degree plant cover?: Silver Creek Preserve vs. Silver Creek West. In cooperation with The Nature Conservancy, Idaho Fish and Game and U.S. Geological Survey

Meiners, W.R. (1979). A concept of natural vegetation patterns and other observations. Meridian: Resource Planning & Management Associates, Inc

Osborne, M. (1984). The affects of cattle grazing on an aquatic system. M.S. Thesis. Department of Zoology, University of British Columbia

Simpson, J.C. (1953). Observations from 1953 of aquatic vegetation in Silver Creek. Boise: Idaho Department of Fish and Game

Sediment

Brokhuizen, N., Parker, S. and Miller, D. (2001). Fine sediment effects on feeding growth in the invertebrate grazers Potamopyrgus antipodarum (Gastropoda, Hydrobiidae) and Deleatidium sp. (Ephemeroptera, Leptophlebiidae). Hydrobiologia 457, 125-132

Griffith, J. and Grunder, S. (1982). Sediment removal as means of stream habitat improvement. Pocatello: Department of Biological Sciences, Idaho State University.

Grunder, S. (1984). Mud Creek sediment removal project, silt measurement update. Pocatello: Department of Biological Sciences, Idaho State University.

Grunder, S. (1985). Biotic responses to sediment removal in a tributary of Silver Creek. M.S. Thesis. Pocatello: Department of Biological Sciences, Idaho State University.

Grunder, S. and Griffith, J. (1983). Biotic responses to removal of sediment from a tributary of Silver Creek, progress report. Pocatello: Department of Biological Sciences, Idaho State University.

Grunder, S. and Griffith, J. (1983). Stream restoration by removal of sediment. Pocatello: Department of Biological Sciences, Idaho State University.

Manuel, C.Y., Griffith, J.S. and Minshall, G.W. (1979). The sources and causes of sedimentation in Silver Creek, Blain County, Idaho, final report. Prepared for the Nature Conservancy.

Nolan, T.B. (2007). Fluvial Sediments- a summary of source, transportation, deposition and measurement of sediment discharge. Washington, D.C.: U.S. Department of the Interior

Perrigo, R. (2006). Historical sedimentation and sediment transport characteristics of Silver Creek, Idaho. Dissertation. School of Environmental Systems Engineering, University of Western Australia.

Temperature

Cox, T.J. and Rutherford, J.C. (2000). Thermal tolerances of two stream invertebrates exposed to diurnally varying temperatures. New Zealand Journal of Marine and Freshwater Research 34, 203-208

Watershed Sciences, Inc. (2005). Aerial Survey of Silver Creek, Idaho: thermal infrared and color videography, final report. Corvallis, Oregon: Watershed Sciences, Inc.

Wright, J.L. and Jensen, N.E. (1975). Evapotranspiration and climatic data for the Silver Creek-Bellevue triangle Blaine County, Idaho. Kimberly, ID: Snake River Conservation Research Center, U.S. Department of Agriculture.

Water Resources

Aronson, D. (1993). Silver Creek preserve: stream quality monitoring summary. Picabo: The Nature Conservancy

Bartolino, J. (2009). Ground-water budgets for the Wood River Valley Aquifer system, south-central Idaho, 1995-2004. U.S. Geological Survey and U.S. Department of Interior

Brockway, C.E. and Akram Kahlown, M. (1994). Hydrologic evaluation of the Big Wood River- Silver Creek watersheds, phase 1 final report. University of Idaho, Idaho Water Resources Research Institute and Kimberly Research and Extension Center

Brockway, C.E. and Grover, K.P. (1978). Evaluation of urbanization and changes in land use on the water resources of mountain valleys, research technical completion report B-038-IDA. Moscow: Idaho Water Resources Research Institute

Brown Jr., A.L. (2000). Hydrologic evaluation of the Big Wood and Silver Creek watersheds, summary report. Ketchum: Water Resources Consulting

Brown Jr., A.L. (2001). Augmented flows in Silver Creek, draft report. Ketchum: Water Resources Consulting

Brown Jr., A.L. (2002). Additional water quality data for Silver Creek. Ketchum: Water Resources Consulting

Brown Jr., A.L. (2002). Report on water quality data, and research activity in Blaine County, Idaho. Ketchum: Water Resources Consulting

Brown Jr., A.L. (2004). Silver Creek water quality monitoring protocol. Ketchum: Water Resources Consulting

Castelin, P.M. and Chapman, S.L. (1972). Water resources of the Big Wood River and Silver Creek area, Blaine County, Idaho, Water information bulletin no. 28. Idaho Department of Water Administration

Connolly, J.B., Lopez-Bernal, K.E., Shaffer, D.L. (2003). Blaine County evaluation and assessment of nitrogen sources. Williams College, Oklahoma State University and Massachusetts Institute of Technology

Frenzel, S.A. (1990). Water resources of the Upper Big Wood River Basin. Boise: U.S. Geological Survey

Meiners, W.R. and Crosthwaite, E.G. (1979). Management implications for the Stalker Creek Ranch and adjacent Silver Creek preserve, Idaho. Meridian: Resource Planning & Management Associates, Inc

Moreland, J.A. (1977). Groundwater – surface water relations in the Silver Creek area, Blaine County, Idaho. Boise: U.S. Geological Survey and Idaho Department of Water Resources

Smith, R.O. (1959). Groundwater resources in the Middle Big Wood and Silver Creek area, Geologic Survey water supply paper 1478. Washington, DC: U.S. Department of Interior

West, D. (2001). Nitrates in ground water: a continuing issue for Idaho citizens. Boise: Idaho Department of Environmental Quality

Wetzstein, A.B., Robinson, C.W. and Brockway, C.E. (1999). Hydrologic evaluation of the Big Wood River and Silver Creek watersheds, phase III. University of Idaho, Idaho Water Resources Research Institute and Kimberly Research and Extension Center

Wolter, T. and Todd, P. (1994). Silver Creek Preserve stream quality monitoring summary 1991-1994. Picabo: The Nature Conservancy

Section 8: Literature Cited

Anderson, J.E., Ruppel, K.T., Glennon, E.M. Holte, K.E. and Rope, R.C. (1996). Plant Communities, Ethonoecology, and Flora of the Idaho National Engineering Lab, Idaho Falls, Idaho. National Research Foundation

Bair, B. 2009. Stream restoration cost estimates. USDA Forest Service, Gifford-Pinchot National Forest, Carson, WA.

Bartolino, J.R. 2009. Ground-water budgets for the Wood River Valley aquifer system, south-central Idaho, 19955-2004. U.S. Geological Survey Scientific Investigations Report 2009-5016, 36 p.

Beltaos, A., R. Pomerleau, and R.A. Halliday. 2000. Ice-jam effects on Red River flooding and possible mitigation methods. Inter. Red River Basin Task Force, IJC.

Bernhardt, E.S. et al. April 2005. Synthesizing U.S. river restoration efforts. Science 308: 636-637.

Brockway, C.E. and Akram Kahlown, M. (1994). Hydrologic evaluation of the Big Wood River- Silver Creek watersheds, phase 1 final report. University of Idaho, Idaho Water Resources Research Institute and Kimberly Research and Extension Center

Castlelle, A. J., A.W. Johnson and C. Conolly. 1994. Wetland and stream buffer requirements- A review. Journal of Environmental Quality 23:878-882.

Cook, D.B. 1940 Beaver-Trout Relations. Journal of Mammalogy, Vol. 21, No. 4 (Nov., 1940), pp. 397-401

Churchill, J.E. 1980. Beaver are killing our trout streams. Trout 21:4.

Cunjak, R.A., and G. Power, 1987. The feeding and energetic of stream-resident trout in winter. J. Fish. Biol. 31:493-511.

DeWalle, D.R. 2010. Modeling stream shade: riparian buffer height and density as important as buffer width. Journal of American Water resources Association 46(2).

Dollar, E.S.J. 2000. Fluvial geomorphology. Progress in Physical Geography 24(3): 385-406.

Ebey, 1854. Oregon Trail Diary. Edited by Susan Doyle and Fred Doyle.

Ettema, R. and S.F. Daly.2004. Sediment Transport Under Ice. ERDC/CRREL USACE, Hanover, New Hampshire.

Federal Interagency Stream Restoration Working Group (FISRWG). August 2001.

Stream corridor restoration – principles, processes and practices, adopted as Part 653 of the National Engineering Handbook, USDA-Natural Resources Conservation Service. Available from: http://www.nrcs.usda.gov/technical/stream_restoration/.

Gard, R. 1961. Effects of beaver on trout in Sagehen Creek, California. J. Wildl. Manag. 25:221-242.

Gillian, S., 2007. Kilpatrick pond and dam restoration feasibility study – final report. The Nature Conservancy, Hailey, ID.

Gillilan, S., K. Boyd, T. Hoitsma, and M. Kauffman. 2005. Standards for geomorphic river restoration projects: a practitioner's response to Palmer et al.. Journal of Applied Ecology 42(2): 223-227.

Gilliam, J.L. Robinson, R.B. Brinsfield, K.W. Staver, W. Lucas, and A.H. Todd, 1997. Water Quality Functions of Riparian Forest Buffers in Chesapeake Bay Watersheds. Environmental Management 21:687-712.

Hagar, J.C. 1999. Influence of riparian buffer width on bird assemblages in western Oregon. Journal of Wildlife Mangement 63:484-496.

Hall, E.R. 1981. The Mammals of North America. John Wiley + Sons, New York, 2- 1-1181+90.

Hartman, G.F. 1963. Observations of behavior of juvenile brown trout in a stream aquarium during winter and spring. J. Fish. Res. Board Can. 20: 769-787.

Hoag, J. 2010. Planting techniques to restore vegetation in spring creek systems. Unraveling the Spring Creek Mystery, a symposium. Idaho Chapter of the American Fisheries Society, Pocotello, ID.

Hoffman, C.C., C. Kjaergaard, J. Uusi-Kamppa, H.C. Bruun Hansen, and B. Kronvang, 2009. Phosphorous retention in riparian buffers: review of the their efficiency. Journal of Environmental Quality 38:1942-1955.

Hill, M.T., W.S. Platts, and R.L. Beschta. 1991. Ecological and geomorphological concepts for instream and out-of-channel flow requirements. Rivers 2(3):198-210

Hill, M. T., and W. S. Platts. 1998. Ecosystem restoration: a case study in the Owens River Gorge, California. Fisheries 23(11): 18-27.

Hillman, T.W., J.S. Griffith, and W.S. Platts. 1987 Summer and winter habitat selection by juvenile salmonids in a highly sedimented Idaho stream. Trans. AM. Fish. Soc. 116:185-195.

ICFRU. 1979. Report of 1979 work at Silver Cree by the Idaho Cooperative Fishery Research Unit. Univ. of Idaho, Moscow.

Jankovsky-Jones, M. (1997). Conservation strategy for Big Wood River Basin wetlands. Boise: Conservation Data Center, Idaho Department of Fish and Game

Jansson, R. et al. 2005. Stating mechanisms and refining criteria for ecologically successful river restoration: a comment on Palmer et al. Journal of Applied Ecology 42(2): 218-222.

Jenkins,Stephen and Peter Busher. 1979. Castor Canadensis. Mammalian Species, 120 - 1-8.

Kauffman, J.B., R.L. Beschta, N. Otting, and D. Lytjen. 1997. An ecological perspective of riparian and stream restoration in the western United States. Fisheries 22(5): 12–24.

Kocher a, S.D., and R. Harris, 2007. Riparian Vegetation. Forest Stewardship series 10. University of California publication 8210, Oakland, Ca.

Knight, K.W., R. C. Shultz, C.M. Mabry, and T.M. Isenhart, 2010. Ability of remnant forests with and without grass filters, to buffer concentrated surface runoff. Journal of the American Water Resources Association 46(2).

Liu, X., X. Zhang, and M. Zhang, 2008. Major factors influencing the efficacy of vegetated buffers on sediment trapping: a review and analysis. Journal of Environmental Quality 37:1667-1674.

Lowrance, R., L.S. Altier, J.D. Newbold, R.R. Schnabel, P.M. Groffman, J.M. Denver, D.L. Correl, J.W., R. Todd, J. Fail, O. Hendrickson, R. Leonard, and L. Asmussen, 1984. Riparian Forests as nutrient filters in agricultural watersheds. Bioscience 34:374-377.

Mayer, P.M. S.K. Reynolds, M.D. McCotchen, and T.J. Canfield, 2007. Meta-analysis of nitrogen removal in riparian buffers. Journal of Environmental Quality 36:36:1172-1180.

McClain, M.E., E.W. Boyer, C.L. Dent, S.E. Gergel, N.B. Grimm, P.M. Groffman, S.C. Hart, J.W. Harvey, C.A. Johnston, E. Mayorga, W.H. McDowell, and G. Pinney, 2003. Biochemical hotspots and hot moments at the interface of terrestrial and aquatic ecosystems. Ecosystems 6:301-312.

Naiman, R.J., C.A. Johnston, and J.C. Kelley. 1988. Alteration of North American streams by beaver; the structure and dynamics of streams are changing as beaver recolonize their historic habitat. BioSci 38(11):753-762.

Naiman, R.J., H. Decamps, and M. Pollock, 1993. The role of riparian corridors in maintaining regional biodiversity. Ecological Applications 3:209-212.

Naiman, R.J. and H. Decamps, 1997. The ecology of interfaces: riparian zones. Annual review of Ecology and Systematics 28:621-658.

Neff, J.D., 1957. Ecological effects of beaver habitat abandonment in the Colorado Rockies. J.Wildlife Manag. 21:80-89.

NRCS (1996). Preliminary investigation report: Silver Creek watershed, Blaine County, Idaho. Natural Resource Conservation District in cooperation with United States Department of Agriculture and Blaine Soil Conservation District

Palmer, M.A. et al. 2005. Standards for ecologically successful river restoration. Journal of Applied Ecology 42(2): 208–217.

Peterjohn, W.T. and D.L. correll, 1984. Nutrient dynamics in an agricultural watershed: observations on the role of the riparian forest. Ecology 65:1466-1475.

Platts, W. S., R. L. Beschta, J. B. Kauffman, and M. T. Hill. 1994. Artificial stream restoration: an expensive success or an expensive failure? Proc. Ann. Meet. Universities Council on Water Resources, Southern Illinois University, Carbondale.

Reid, K.A. 1952. Effects of beaver on trout waters. Md. Cons 29:21-23.

Riehle, M.D., and J.S. Griffith. 1993. Changes in habitat use and feeding chronology of juvenile rainbow trout in fall and the onset of winter in Silver Creek, Idaho. Can. J. Fish. Aquat. Sci. Vol 50, 1993.

Roni, P. et al., 2005. A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds. North AM. Jour. Fish. Manag. 22:1-20

Scrimgeour, G.J., T.D. Prowse, J.M. Culp, and P.A. Chambers. 1994. Ecological effects of river ice break-up: a review and perspective. Freshwater Biology 32:261-275.

Skinner, K.D., Bartolino, J. R., and Tranmer, WA.W. 2007. Water resource trends and comparisons between partial development and October 2006 hydrologic conditions. USGS Rpt 2007-5258, 30 mpp.

Skinner, M., and M. Stone. 1983. Identification of instream hazards to trout habitat quality in Wyoming. U.S. Department of the Interior, Fish and Wildlife Service. FWS/OBS-83-13. 69 p.

Skinner, Q.D. et al.. 2000. Wyoming watersheds and riparian zones. University of Wyoming Cooperative Extension Service.

Slough, B., and R. Sadleir. 1977. A land capability classification system for beaver. Can. J. Zool. 55:1324-1335, in which numerous stream reaches were used that exhibited high variability in beaver density/colony.

Smith, B. 1980. Not all beaver are bad; or an ecosystem approach to stream habitat management. Proc. 15 Ann.Meet., Am. Fish. Soc., Bethsda, MD.

Soar, P.J., and C.R. Thorne. September 2001. Channel restoration design for meandering rivers. U.S. Army Corp of Engineers. Report ERDC/CHL.

Washington Department of Fish and Wildlife. April 2003. Riparian habitat protection and restoration. Available from: http://www.wdfw.wa.gov/hab/ahg/ispgdoc.htm.

Todd, P. 1997. Silver Creek site conservation plan and five year plan. Hailey, Idaho: The Nature Conservancy

Watson, T.K., D.Q. Kellog, K. Addy, A.J. Gold, M.H. Stolt, S.W. Donahue, and P.M. groffman, 2010. Groundwater denitrification capacity of riparian zones in suburban agricultural watersheds. Journal of the American Water Resources Association 46(2).

Wegner, S. 1999. A review of the scientific literature on riparian buffer width, extent and vegetation. Office of Public Service and Outreach, Institute of Ecology, University of Georgia, Athens, GA.

Wilcock, P.R., G.M. Kondolf, W.V.G. Matthews, and A.F. Barta. 1996. Specification of sediment maintenance flows for a large gravel-bed river. Water Resources Research 32: 2911–21.

Wilcox, J. et al., Feather River Resource Management Group. December 2001. Evaluation of geomorphic restoration techniques applied to fluvial systems. Available from: http://www.feather-rivercrm.org/publications/preports/georest/cover.html.

Wilkerson, E. J.M. Hagan, D. Siegel, and A.A. Whitman, 2006. the effectiveness of different buffer widths for protecting headwater streams temperatures in Maine. Forest Sciences 52:221-231.

Young, M.K., R.A. Wilkison, J.M. Phelps, and J.S. Griffith. 1997. Contrasting movement and acivity of large brown trout and rainbow trout in Silver Creek, Idaho. Great Basin Naturalist Vol. 7, No.3.

Appendices

Appendix A: Silver Creek Avian Species

EXPLANATION OF SYMBOLS

Seasons and Breeding Status:

S = Spring: March-May
S = Summer: June-August
F = Fall: September-November
W = Winter: December-February
B = Breeding Status:
b = confirmed breeder
? = possible breeder

Status:

* = endangered, threatened, candidate, sensitive, or special concern species.
ɵ = Introduced Species

Abundance:

a = abundant: certain to be seen
c = common: should be seen in a suitable habitat
u = uncommon: might be seen in a suitable habitat
o = occasional: seen only a few times a season
r = rare: seen at intervals of two to five years
x = accidental: fewer than five records
- = no records

	S	S	F	W	B
GREBES					
Clark's Grebe	-	r	-	-	-
Western Grebe	r	r	r	-	
Eared Grebe	-	r	-	o	
Pied-billed Grebe	c	c	c	c	b
PELICANS					
American White Pelican*	-	o	-	-	
HERONS AND BITTERNS					
American Bittern	u	u	-	-	?
Black-crowned Night Heron	o	o	o	-	
Green Heron	-	x	-	-	
Snowy Egret	-	x	-	-	
Great Egret	x	-	-	-	
Great Blue Heron	c	c	c	c	b
IBISES, CRANES					
White-faced Ibis*	-	r	-	-	
Sandhill Crane	c	u	c	x	b
DUCKS, GEESE AND SWANS					
Tundra Swan	u	-	u	c	
Trumpeter Swan*	-	-	u	u	
Snow Goose	u	-	u	-	
Canada Goose	a	c	c	a	b
Mallard	a	c	a	a	b
Gadwall	u	u	u	u	b
Green-winged Teal	u	u	o	u	b
American Widgeon	c	c	c	a	
Northern Pintail	u	u	u	c	
Northern Shoveler	u	r	u	o	
Blue-winged Teal	u	u	u	r	
Cinnamon Teal	c	c	u	r	b
Ruddy Duck	u	u	-	u	
Wood Duck	o	r	o	r	
Canvasback	o	u	o	o	b
Redhead	c	c	u	-	b
Ring-necked Duck	c	u	c	c	
Lesser Scaup	c	c	c	c	b
Barrow's Goldeneye	u	o	u	c	?
Common Goldeneye	u	o	u	c	?
Bufflehead	r	r	r	u	?
Common Merganser	u	o	u	u	b
Hooded Merganser	r	-	r	o	

	S	S	F	W	B
RAILS AND COOTS					
Virginia Rail	u	u	u	u	b
Sora	u	u	-	-	b
Yellow Rail	-	x	-	-	
American Coot	c	c	c	c	b
SHOREBIRDS					
American Avocet	u	r	u	-	
Killdeer	c	c	c	-	b
Long-billed Curlew*	c	u	-	-	b
Willet	c	c	-	-	b
Greater Yellowlegs	o	-	-	o	
Lesser Yellowlegs	o	-	-	o	
Solitary Sandpiper	u	-	-	u	
Spotted Sandpiper	u	u	o	-	b
Wilson's Phalarope	c	u	-	-	b
Long-billed Dowitcher	o	-	r	-	
Common Snipe	c	c	u	u	b
GULLS AND TERNS					
Franklin's Gull	o	u	-	-	
Ring-billed Gull	c	c	-	-	b
California Gull	c	c	-	-	b
Black Tern*	r	r	-	-	
Caspian Tern	o	c	-	-	?
Forester's Tern	o	o	o	-	
VULTURES, EAGLES, HAWKS, AND FALCONS					
Turkey Vulture	c	c	-	-	
Golden Eagle	u	o	u	u	b
Bald eagle*	o	o	o	c	?
Northern Harrier	c	c	c	c	b
Sharp-shinned Hawk	u	u	u	u	
Cooper's Hawk	o	o	o	o	
Northern Goshawk*	o	r	o	o	
Red-tailed Hawk	c	c	c	c	b
Swainson's Hawk*	u	c	-	-	b
Rough-legged Hawk	c	u	o	c	
Ferruginous Hawk*	-	r	r	-	
Osprey	u	o	u	-	
American Kestrel	c	c	c	u	b
Merlin*	-	-	r	o	
Prairie Falcon	u	o	u	u	b
Peregrine Falcon*	r	r	r	-	
Gyrfalcon*	-	-	-	o	
GALLINACEOUS BIRDS					
Blue Grouse	o	r	o	o	?
Sage Grouse	u	r	u	u	b
California Quail ɵ	-	r	r	-	
Chukar ɵ	u	u	u	u	b
Gray Partridge ɵ	u	u	u	u	?
Ring-necked Pheasant ɵ	c	c	c	c	b
PIGEONS AND DOVES					
Rock Dove	c	c	c	c	?
Mourning Dove	a	a	u	o	b
OWLS					
Short-eared Owl	r	r	r	r	b
Long-eared Owl	r	r	r	r	b
Great Horned Owl	c	c	c	c	b
Northern Saw-whet Owl	r	r	r	-	
Barn Owl	o	o	o	o	
NIGHTJARS					
Common Poorwill	u	u	-	-	?
Common Nighthawk	-	a	-	-	?

	S	S	F	W	B
HUMMINGBIRDS					
Calliope Hummingbird	u	o	-	-	
Broad-tailed Hummingbird	u	u	-	-	?
Rufous Hummingbird	u	u	-	-	
Black-chinned Hummingbird	u	u	-	-	?
KINGFISHERS					
Belted Kingfisher	c	c	c	u	b
WOODPECKERS					
Northern Flicker	c	c	c	u	b
Lewis' Woodpecker	u	c	-	-	
Downy Woodpecker	u	u	u	u	b
Hairy Woodpecker	u	u	u	u	b
Red-naped Sapsucker	u	u	u	-	b
FLYCATCHERS					
Eastern Kingbird	c	a	-	-	b
Western Kingbird	c	c	-	-	b
Western Wood-pewee	c	c	-	-	?
Willow flycatcher	c	c	-	-	b
Cordilleran Flycatcher	u	u	-	-	
Fork-tailed Flycatcher	-	x	-	-	
Olive-Sided Flycatcher	-	o	-	-	
LARKS					
Horned Lark	u	o	c	c	
SWALLOWS					
Tree Swallow	c	c	u	-	b
Violet-green Swallow	c	c	u	-	b
Bank Swallow	r	-	r	-	
Northern Rough-winged	c	c	u	-	b
Cliff Swallow	c	c	u	-	b
Barn Swallow	c	c	u	-	b
MAGPIES AND CROWS					
Black-billed Magpie	a	a	a	a	b
American Crow	a	a	c	c	b
Common Raven	c	u	u	c	b
CHICKADEES					
Black-capped Chickadee	c	o	u	u	b
Mountain Chickadee	u	o	u	u	
NUTHATCHES					
Red-breasted Nuthatch	o	o	o	o	
WRENS					
House Wren	u	u	u	-	b
Marsh Wren	c	a	c	u	b
Rock Wren	u	u	-	-	?
THRUSHES					
Mountain Bluebird	r	r	r	-	?
Varied Thrush	r	-	r	r	
American Robin	a	a	c	o	b
Hermit Thrush	u	-	u	-	
Swainson's Thrush	u	-	u	-	
MIMIC THRUSHES					
Northern Mockingbird	x	-	-	-	
Gray Catbird	u	u	-	-	b
Sage Thrasher	-	o	-	-	
KINGLETS					
Ruby-crowned Kinglet	o	r	o	r	
Golden-crowned Kinglet	o	r	o	r	

	S	S	F	W	B
SHRIKES					
Loggerhead Shrike*	o	o	-	-	?
Northern Shrike	-	-	u	u	
PIPITS, WAXWINGS					
American Pipit	u	-	u	-	
Bohemian Waxwing	-	-	o	o	
Cedar Waxwing	c	c	o	-	b
STARLINGS					
European Starling	a	a	a	a	b
VIREOS					
Plumbeous Vireo	u	u	u	-	?
Warbling Vireo	u	u	o	-	b
Red-eyed Vireo	-	r	-	-	?
WARBLERS					
Orange-crowned Warbler	o	o	-	-	?
Nashville Warbler	-	x	-	-	
Yellow-rumped Warbler	c	c	r	-	?
Townsend's Warbler	-	-	x	-	
Yellow Warbler	a	a	-	-	b
MacGillivray's Warbler	o	o	o	-	
Wilson's Warbler	u	o	u	-	?
Common Yellowthroat	u	c	u	-	b
Yellow-breasted Chat	u	u	-	-	b
GROSBEAKS AND BUNTINGS					
Black-headed Grosbeak	u	u	-	-	b
Indigo Bunting	-	x	-	-	
Lazuli Bunting	u	o	-	-	b
Evening Grosbeak	u	-	u	-	
Snow Bunting	-	-	-	u	
SPARROWS					
Spotted Towhee	c	c	u	-	b
Green-tailed Towhee	u	o	-	-	?
Vesper Sparrow	c	c	-	-	b
Savannah Sparrow	u	u	-	-	?
Song Sparrow	c	a	a	c	b
Lark Sparrow	c	o	-	-	?
American Tree Sparrow	-	-	u	u	
Chipping Sparrow	c	o	u	-	?
Brewer's Sparrow	c	c	u	-	b
Dark-eyed Junco	c	o	o	c	?
White-crowned Sparrow	c	u	c	-	b
Lincoln Sparrow	-	-	-	r	?
BLACKBIRDS AND ORIOLES					
Western Meadowlark	a	a	o	o	b
Yellow-headed Blackbird	a	a	u	u	b
Red-winged Blackbird	a	a	u	u	b
Brewer's Blackbird	c	c	c	u	b
Brown-headed Cowbird	a	a	a	-	b
Bullock's Oriole	c	c	-	-	b
TANAGERS, WEAVERS					
Western Tanager	u	o	-	-	?
House Sparrow	u	o	u	c	b
FINCHES					
Pine Siskin	o	o	o	o	?
American Goldfinch	a	a	c	c	b
Common Redpoll	-	-	-	c	
Cassin's Finch	o	r	o	u	?
House Finch	u	u	-	-	b
Grey-crowned Rosy Finch	-	-	-	r	

American Avocet (*Recurvirostra americana*)

Appendix B: Funding Sources for Restoration Initiatives and Actions

Following is a listing of potential funding sources available to landowners that can be pursued individually, collectively, or through partnerships with organizations such as TNC. Included are federal, state and private funding institutions—note that any federal granting, such as through the Natural Resource Conservation Service (NRCS) is subject to environmental review as described in form NRCS-CPA-52 "Environmental Evaluation Worksheet". The environmental evaluation is conducted as part of the planning process and is used to identify potential long-term and short-term impacts on people and the environment and explores alternatives to the proposed action to minimize those impacts. Additional information on the environmental review process and the disclosure needed is available at: http://www.nrcs.usda.gov/technical/ECS/environment/CPA-52.doc. Each grant opportunity has its own application requirements and time schedule— specific funding priorities are described below along with website and contact information to assist applicants in determining the appropriate potential funding sources. Note that deadlines and funding priorities can change from year to year.

Federal/State funding

Idaho Dept. of Environmental Quality (DEQ) Nonpoint Source Management 319 grant

DEQ is responsible for administering the EPA-funded 319 grant program. Eligible projects include goals and objectives that focus on maintaining or restoring water quality in areas affected by nonpoint sources of pollution. Grants must focus on improving water quality of lakes, streams, rivers and aquifers and address a variety of non-point source management and prevention activities, including: agriculture, stormwater runoff, transportation, habitat modificiations, etc. Most of Idaho's 319 funds are allocated for on-the-ground TMDL implementation projects. Priority projects for the 2011 grant funding cycle addressed watershed protection and surface and groundwater protection, agricultural practices, TMDL implementation or water quality plan implementation, and groundwater management.

Awarded annually- In 2010 the application deadline was August 2 for 2011 awards.

Contact: Dave Pisarski
(208) 373-0502
dave.pisarski@deq.idaho.gov

Website: http:// www.deq.idaho.gov/water/prog_issues/surface_water/ nonpoint.cfm#management

Endangered Species Act (ESA)- Farm Bill Tax Deduction

Tax Deduction-for farmers and ranchers that implement conservation actions that contribute to the recovery of T&E species. The 2008 Farm Bill established a tax deduction for expenditures paid or incurred for the purpose of achieving site-specific management actions recommended in recovery plans for species listed under the ESA. To qualify for the deduction, there must be federally threatened or endangered species in the area; there must be an approved recovery plan for the species; and the conservation actions implemented by the taxpayer must be consistent with management actions described in the approved recovery plan(s) and must occur in the location and habitat type for which the plan was written.

Information: http://www.fws.gov/partners/
See link to ESA's Tax Deduction Fact Sheet

Idaho Dept. of Fish and Game (IDFG)

State Wildlife Grants - This program provides federal monies to support conservation aimed at protecting at-risk species in focal areas identified in Idaho's Comprehensive Wildlife Conservation Strategy, which identifies species and habitats of greatest concern in the state.

Idaho Watershed Initiative - IDFG program that is directed towards on-the-ground proposals for restoring Idaho watersheds.

Habitat Improvement Program (HIP) - Provides technical and financial assistance to private landowners and public land managers who want to enhance habitat for upland game birds and waterfowl.

Landowner Incentive Program (LIP) - funded by USFWS and administered by IDFG, the purpose of this program is to provide incentives for landowners to protect or enhance habitat for at-risk species.

Idaho Grants Program - A summary of grants funded primarily by USFWS for habitat conservation and restoration projects-administered by both USFWS and IDFG.

Federal funds are matched by state dollars.

Contact: Karla Drewsen
State Wildlife Grants Coordinator
Idaho Dept. of Fish and Game
600 South Walnut, PO Box 25
Boise, ID 83707
(208) 287-2743
karla.drewsen@idfg.idaho.gov

Wildlife Action Plan
Contact: Rita Dixon
Idaho Dept. of Fish and Game
(208) 287-2735
rita.dixon@idfg.idaho.gov

Link to the IDFG's grants for landowners website:
http://fishandgame.idaho.gov/cms/wildlife/landowners/
Link to Idaho's Comprehensive Wildlife Conservation Strategy:
http://fishandgame.idaho.gov/cms/tech/CDC/cwcs_table_of_contents.cfm

USDA Natural Resource Conservation Service (NRCS)

Agricultural Water Enhancement Program (AWEP) - A voluntary conservation initiative that provides financial and technical assistance to agricultural producers to implement agricultural water enhancement activities on agricultural lands for the purposes of conserving surface and groundwater and improving water quality. Part of the EQIP program. Federal funding is paid directly to agricultural producers through individual contract agreements. Those eligible include agricultural or silvicultural associations, and other groups of producers such as an irrigation association, agricultural land trust, or other nongovernmental organization that has experience working with agricultural producers. Individual agricultural producers are not AWEP eligible however, once an AWEP project area has been approved and announced, individual producers may apply for program benefits through their local NRCS office.

Notice of Request was issued April 2010 effective until May 2010- look for the Notice of Request in early 2011.

Infromation: http://www.nrcs.usda.gov/programs/AWEP/

Contact:
State Conservationist for Idaho
Jeffrey B. Burwell
9173 West Barnes Drive
Suite C
Boise, Idaho 83709
Phone: 208/378–5700
jeffrey.burwell@id.usda.gov

USDA Natural Resource Conservation Service (NRCS)

Conservation Innovation Grants (CIG) - A voluntary program to stimulate the development and adoption of innovative conservation approaches and technologies for agricultural production- promotes sharing of skills, knowledge, technologies, and facilities among communities, governments and other institutions- uses EQIP funds to award competitive grants to non-federal governmental or NGOs, Tribes, or individuals. 2010 priorities were transitioning to organic production, wildlife habitat enhancement, pollinator habitat, cover crops and water quality trading.

Pre-proposal application due by May 24, 2010- look for this in early 2011.

Requires a 50% match with federal dollars, with a maximum of $75,000 federal dollars for each project.

Contact: Mark Weatherstone, Assistant Conservationist for Technical Services
(208) 378-5720
mark.weatherstone@id.usda.gov
http://www.id.nrcs.usda.gov/programs/cig/index.html

More information on Idaho grants in FY2010:
http://www.id.nrcs.usda.gov/programs/cig/state.html

Contacts/Forms and How to Apply Questions:
Chris Catherman, Grants and Agreements Specialist
Phone: (208) 685-6982
Chris.Catherman@id.usda.gov

Technical and Program Questions:
Mark Weatherstone, Assistant State Conservationist for Technical Resources
Phone (208) 378- 5720
Email: Mark.Weatherstone@id.usda.gov

USDA Natural Resource Conservation Service (NRCS)

Cooperative Conservation Partnership Initiative (CCPI) - a program to assist partners with focusing conservation assistance in defined project areas to achieve high-priority natural resources objectives on agricultural lands. Uses funds, policies and processes of EQIP and WHIP cost-share agreements. Partners who may enter into partnership agreements with NRCS include producer associations, farmer cooperatives, institutions of higher education, and nongovernmental organizations with a history of working cooperatively with producers to effectively address conservation priorities related to agricultural production and nonindustrial private forest land.

Look for request for proposal in early 2010 on CCPI website.

Cost-share- all eligibility requirements listed in the federal register notice on this link: http://www.id.nrcs.usda.gov/programs/ccpi/index.html

USDA Natural Resource Conservation Service (NRCS)

Conservation Security Program (CSP) - Rewards good stewardship on private land. NRCS updates the eligible watersheds (in 2008 it was the Little Lost). See the basic eligibility requirements in provided link- strict eligibility criteria.

Time line varies but usually around April/May.

Contact:
State Conservationist for Idaho
Jeffrey B. Burwell
9173 West Barnes Drive
Suite C
Boise, Idaho 83709
Phone: 208/378–5700
jeffrey.burwell@id.usda.gov
Website:http://www.id.nrcs.usda.gov/programs/csp/index.html

Appendix B: Funding Sources for Restoration Initiatives and Actions (continued)

Federal/State funding continued

USDA Natural Resource Conservation Service (NRCS)

Environmental Quality Incentives Program (EQIP) is funded through the Farm Bill- it helps agricultural producers improve resource conservation on their farms – EQIP funding helps producers improve irrigation efficiency, protect water quality, reduce erosion-These contracts provide financial assistance to help develop conservation plans and implement conservation practices. Owners of land in agricultural production or persons who are engaged in livestock or agricultural production on eligible land may participate in the EQIP program.

October 1, 2010: Generally, NRCS accepts applications for EQIP all year, with one or more ranking period set annually- sign ups are conducted at USDA Service Centers, see website. Persons interested in entering a cost-share agreement with the USDA for EQIP assistance may file an application at any time.

EQIP may provide payments up to 75% of the estimated incurred costs and income foregone of certain conservation practices and conservation activity plans (CAP).

Contact: NRCS RC&D Office, Gooding, ID (208) 934-8481
Program update for Idaho:
http://www.id.nrcs.usda.gov/programs/eqip/index.html

Idaho EQIP Program Manager:
Clint Evans (208) 378-5703

USDA Natural Resource Conservation Service (NRCS)

Farm Bill- Farm and Ranch Lands Protection Program (FRPP)- Program that helps farmers and ranchers keep their land in agriculture by providing matching funds to NGOs with existing farm and ranch land protection programs to purchase conservation easements. NGOs can acquire conservation easements from landowners- and landowners agree not to convert their land to non-agricultural uses- to participate, a landowner submits an application to a State, Tribal or local government or NGO that has an existing farm or ranch land protection program.

Time line: October 15, 2010.

Matching - landowner must be in compliance with the highly erodible land and wetland conservation and must meet the terms of the Adjusted Gross Income provisions in the Farm Bill.

Contact: Hal Swenson (208) 378-5728 or Clint Evans (208) 378-5703
Clint.evans@id.usda.gov
http://www.id.nrcs.usda.gov/news/newsreleases/frpp_0810.html

For eligibility criteria, go to FRPP link at this website:
http://www.nrcs.usda.gov/programs/farmbill/2002/products.html

USDA Natural Resource Conservation Service (NRCS)

Grassland Reserve Program (GRP) - protects valuable range and grassland through easements to maintain and restore grasslands on private property and prevent conversion to other land uses. This program emphasizes support for working grazing operations, enhancement of plant and animal biodiversity, and protection of grassland under threat of conversion to other uses. A grazing management plan is required for participants.

Time line: October 1, 2010.

Contact: Elizabeth Crane
NRCS National Program Manager
(202) 720-0242
http://www.nrcs.usda.gov/programs/GRP/

USDA Natural Resource Conservation Service (NRCS)

Small Watershed Program - provides funding to local organizations for planning and carrying out watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, and wetlands creation. Provide implementation or construction funds under PL-566 (Most projects in Idaho have been planned for the primary purpose of watershed protection).

Contact: Clint Evans (Wetlands Reserve Program) (208) 378-5703 or Karen Fullen (Wetlands Conservation) (208) 685-6986 or Mark Weatherstone (Watershed Planning) (208) 378-5720 Mark.Weatherstone@id.usda.gov http://www.id.nrcs.usda.gov/technical/small_watershed.html

USDA Natural Resource Conservation Service (NRCS)

Wetlands Reserve Program (WRP) - voluntary program that offers landowners the opportunity to protect, restore, and enhance wetlands on their property. NRCS provides technical and financial support to help landowners with their wetland restoration efforts- also improve wildlife habitat through agreements with States, NGO's and Indian tribes. WRP assistance is delivered to eligible landowners in approved project areas through easement acquisition, conservation program contracts, cooperative agreements, contribution agreements, or Federal contracts. Individual landowners may not submit WRP proposals through this submission process (NGOs may); however, once a WRP project has been approved and announced, eligible landowners may apply for WRP through their local NRCS office. As part of the agreement, approved partners may also help facilitate the submission of landowner applications, provide additional technical or financial assistance to landowners. Potential partners may submit WRP proposals for an individual landowner project, watershed, or geographic area to the appropriate State Conservationist. Once NRCS selects a partner's proposal, landowners within the selected project area may submit an application directly to NRCS.

Time line: May 2010- look for Request for Proposals around March/April 2011.

NRCS enters into agreements with eligible partners to help enhance conservation outcomes on wetlands and adjacent lands-WREP partners are required to contribute a financial match of at least 5% of the acquisition or restoration costs toward the project. Proposals that include additional partner resources (in-kind services or cash) will be given higher priority consideration in the selection process.

Contact:
State Conservationist for Idaho
Jeffrey B. Burwell
9173 West Barnes Drive
Suite C
Boise, Idaho 83709
Phone: 208/378–5700
jeffrey.burwell@id.usda.gov

http://www.nrcs.usda.gov/programs/wrp/
See the 2010 WREP Request for Proposals on above link for program specifics and land eligibility criteria

USDA Natural Resource Conservation Service (NRCS)

Wildlife Habitat Incentives Program (WHIP) - Provides technical and financial assistance to those who want to develop and improve wildlife habitat on their land (includes private agricultural land, cropland, grassland, rangeland, and pasture suitable for fish and wildlife habitat development or rural lands that have existing tree cover or is suitable for growing trees). Idaho is targeting the WHIP to specific species and locations (see the Idaho State WHIP Plan FY 2006-2011, link provided)- review the WHIP ranking summary to see if your project is a priority for the state.

Time line: Applications can be filed at any time.

Contact: Clint Evans
Idaho WHIP Program Manager
Clint.evans@id.usda.gov
(208) 378-5703

WHIP Program website
http://www.id.nrcs.usda.gov/programs/whip/index.html

USDA Farm Service Agency

Conservation Reserve Program (CRP) - voluntary program that assists farmers, ranchers and other agricultural producers to use their environmentally sensitive land for conservation benefits. Through CRP, farmers and ranchers can receive annual rental payments and cost-share assistance to establish long-term, resource conserving covers on eligible farmland. Producers enrolling in CRP plant long-term, resource-conserving covers in exchange for rental payments, cost-share, and technical assistance. CRP protects millions of acres of America's topsoil from erosion and is designed to improve the nation's natural resources base. Participants voluntarily remove environmentally sensitive land from agricultural production by entering into long-term contracts for 10 to 15 years. In exchange, participants receive annual rental payments and a payment of up to 50 percent of the cost of establishing conservation practices. To be eligible for CRP enrollment, a producer must have owned or operated the land for at least 12 months prior to close of the CRP sign-up period. To be eligible for placement in CRP, land must be either: cropland (including field margins) that is planted or considered planted to an agricultural commodity 4 of the previous 6 crop years from 1996 to 2001, and which is physically and legally capable of being planted in a normal manner to an agricultural commodity; or certain marginal pastureland that is enrolled in the Water Bank Program or suitable for use as a riparian buffer or for similar water quality purposes.

Time line: Continuous enrollment but general sign-up began August 2, 2010 and continued through August 27, 2010.

Requires a match-payment is up to 50% of the cost for establishing cover. Highest amount awarded is $50K.

USDA
Farm Service Agency Headquarters
Conservation Reserve Program
1400 Independence Ave. SW Stop 0513
Washington, D.C. 20250
(202)720-6221
info@fsa.usda.gov

See link below for additional eligibility requirements:
http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp

This program is administered by the Farm Service Agency but technical support is provided by the USDA's NRCS, Cooperative Extension Services, state forestry agencies or local soil and water conservation districts.

FSA Service Center Office
Lincoln County FSA
217 W. F Street
Shoshone, ID 83352
(208) 886-2258

FSA State Office
9173 W. Barnes Drive
Boise, ID 83709-1573
(208) 378-5650

Appendix B: Funding Sources for Restoration Initiatives and Actions (continued)

Federal/State funding continued

U.S. Fish and Wildlife Service (USFWS)
Idaho Partners for Fish and Wildlife Program (Wood River/Silver Creek/Camas Creek Partners Program Focus Area) - uses public funds to promote conservation and management of the Federal Trust Species (migratory birds, T&E species, inter-jurisdictional fish) on private lands to improve habitat through cooperative conservation programs such as the Partners Program. Focus is on restoring degraded riparian areas along streams and shallow wetland restoration by constructing riparian fencing, planting native shrubs and trees, bioengineering streambanks to control erosion and restoring wetlands through water control structures and other methods. In 2006 funds were used from this program to partner with Silver Springs Ranch to implement projects on Chaney Creek, a tributary to Silver Creek; funds were also secured to conduct work on reaches of Silver Creek that pass through Double R Ranch in partnership with Picabo Land and Livestock and Northwest Resource Information Center. In 2004, a project using these funds was conducted on Grove Creek, another tributary of Silver Creek.

Provides cost-share funding for habitat improvements. Contact the Program Manager for additional details and application deadlines.

Program Manager:
Partners for Fish and Wildlife Program in Idaho
Dennis Mackey
U.S. Fish and Wildlife Service
1387 S. Vinnell Way, Suite 368
Boise, ID 83709
(208) 378-5267

U.S. Fish and Wildlife Service (USFWS)
Division of Bird Habitat Conservation- North American Wetlands Conservation Act (NAWCA) U.S. Standard Grants Program- American Wetlands Conservation Act- Environmental protection, restoration, wetlands, upland habitat, education and outreach. Supports public-private partnerships that involve long-term protection, restoration and/or enhancement of wetlands and associated uplands habitats. Also have a U.S. Small Grants program, a matching grants program that supports public-private partnerships carrying projects to restore and enhance wetlands and associated uplands for the benefit of all wetlands-associated migratory birds.

Time line: July 30, 2010 for the standard grants and October 28, 2010 for the small grants.

Matching grants program to organizations and individuals who have developed partnerships to carry out wetlands conservation projects.

Contact:
David Buie
U.S. Standard Grants proposals
(301) 497-5870
david_buie@fws.gov
http://www.fws.gov/birdhabitat/Grants/NAWCA/Standard/index.shtm

Small Grants Program Coordinator
Rodecia Mcknight
(703) 358-2266
rodecia_mcknight@fws.gov
http://www.fws.gov/birdhabitat/Grants/NAWCA/Small/index.

U.S. Fish and Wildlife Service (USFWS)
National Fish Habitat Action Plan (NFHAP)/Western Native Trout Initiative - the USFWS provides funding to support fish habitat and fish passage projects- priority projects are identified through Fish Habitat Partnerships that target geographic and species habitat needs. The Western Native Trout Initiative operates in our region, and funds projects initiated by trout conservation and recovery teams, local native trout support groups, and interested parties to improve native trout populations- see website for information about becoming a partner.

Time line: October 1, 2010.

Contact:
Dan Shively
USFWS
Fish Passage and Habitat Partnerships Coordinator
911 NE 11th Avenue
Portland OR 97232
(503) 231-2270
dan_shively@fws.gov

Robin Knox
Western Native Trout Initiative
rknow@westernnativetrout.org
http://westernnativetrout.org/

Private funding sources

Bullitt Foundation
Private foundation that funds water resources, watershed restoration, wildlife, energy, and transportation projects. Their mission is to protect, maintain, and restore the natural and physical environment of the Pacific Northwest for present and future generations. They do no fund political organizations or individuals.

Time line: May 1 and Nov 1.

Provide continuing support, emergency funds, general operating support, capacity building, matching and challenge support.

Contact: Denis Hayes, President
1212 Minor Ave.
Seattle, WA 98101-2825
(206) 343-0807
info@bullitt.org
website: http://www.bullitt.org

Chichester DuPont Foundation, Inc.
Private foundation that provides funding for youth services, education, natural resources and the environment. Provide general operating support and building/renovation support-no grants to individuals. In Idaho, they have funded Idaho Rivers United and Snake River Alliance.

Time line: October 1

Contact: Gregory Fields
3120 Kennett Pike
Wilmington, DE 19807-3052
(302) 658-5244
gfields@chichesterdupont.org
http://www.chichesterdupont.org

Laura Jane Musser Fund
Private foundation that funds environmental and rural development projects. The environmental projects must involve a group of stakeholders and local citizens in developing environmental policies and programs. Projects must be in rural places. Primary areas of interest include community-based approaches to solving environmental problems. They support program development and seed money, not for general operating support or ongoing programs.

Time line: September 5

Contact: Mary Karen Lynn-Klimenko
318 E. 48th Street
Minneapolis, MN 55419-5649
(612) 825-2024
ljmusserfund@earthlink.net
http://www.musserfund.org

National Fish and Wildlife Foundation (NFWF)
Private foundation that grants funds on a competitive basis that sustain, restore, and enhance fish, wildlife, plants and their habitats. Have various grant programs, including the Five Star Restoration Grant Program, which provides financial assistance to support community-base wetland, riparian, and coastal habitat restoration projects that build diverse partnerships and foster local natural resource stewardship through education, outreach and training activities; and the Keystone Initiative Grants with bird, fish, wildlife and habitat conservation initiatives. Each of these keystones have a focus, ie. The bird keystone focuses on migratory and resident species and habitats that occur in the US that are identified as high priorities for the nation.

Time line: Feb 16, 2010 for the Five Star Program; and April 1 and Sept 1 for Keystone Grants.

A minimum 1:1 match is required; Foundation considers multi-year funding for important projects

Contact: Western Partnership Office
421 SW 6th Ave, Suite 950
Portland, OR 97204
(503) 417-8700
Lacy Reimer Alison
Assistant Program Director
Lacy.Alison@nfwf.org

http://www.nfwf.org/AM/Template.cfm?Section=Charter_Programs_List&Template=/TaggedPage/TaggedPageDisplay.cfm&TPLID=61&ContentID=13554

Orvis
The Orvis Conservation Grant Program at Orvis supports restoration, enhancement and long-term protection of fish and wildlife habitat. Orvis usually awards matching grants to three projects a year that focus on fishing or aquatic issues, land and water conservation or species. They prioritize projects that are dedicated to acquiring, restoring, enhancing or long-term protection of native fish and wildlife habitat. See their website for a list of previously funded projects. Matching funds required.

Time line: May 1, 2010 for 2011 projects.

Contact: James Hathaway
The Orvis Company, Inc.
178 Conservation Way
Sunderland, VT 05250
hathawayj@orvis.com

Grant submission guidelines included here:
http://www.orvis.com/intro.aspx?subject=5371

Trout Unlimited
Trout Unlimited's Embrace-A-Stream is a matching grant program that provides opportunities for government agencies, non-profits and other groups to partner with a TU chapter on TU projects that address the needs of native and wild trout. (Execution and management of the project(s) are conducted primarily by TU staff).

Time line: Annual- the past funding cycle had a December deadline.

Matching funds (average grant in 2009 was $7,200).

Program website and application form can be found here:
http://www.tu.org/conservation/watershed-restoration-home-rivers-initiative/embrace-a-stream


Photo credit: Ecosystem Sciences

Silver Creek Watershed

An Ecological Enhancement Strategy for Silver Creek, Idaho

The Nature Conservancy
Protecting nature. Preserving life.