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Riparian Ecology in The Henry's Fork Watershed

Abstract

Differences in hydrology between spring-fed and runoff-dominated streams strongly influence riparian characteristics in the Henry's Fork watershed, Idaho. Overbank deposition of sediment is largely responsible for maintaining riparian characteristics along runoff-dominated streams, whereas perennially high water tables and organic matter inputs support distinctly different riparian communities along spring-fed channels. Human activities also influence riparian characteristics, with roads, hydrologic alterations, and grazing causing the most widespread changes. Rehabilitation of degraded riparian areas is well underway in the Henry's Fork watershed, but ongoing rapid development and extensive hydrologic alterations present significant challenges to future rehabilitation efforts. We synthesize existing information to describe patterns of riparian ecology in the Henry's Fork watershed, discuss obstacles and opportunities for riparian rehabilitation, and present indicators to help determine if riparian health problems exist.

Key words: riparian ecology, spring-fed streams, riparian vegetation, geomorphology.

Introduction

A diverse array of riparian plant associations exists in the Henry's Fork watershed (HFW). Multi-layered *Salix geyeriana/Carex utriculata* communities along runoff-dominated streams in the Centennial Mountains contrast with single-layered monocultures of *Carex aquatilis* occurring along spring-fed streams flowing from the Yellowstone Plateau (Fig. 1). High-elevation *Salix planifolia* willow carrs in the Henry's Lake Mountains differ from *Salix exigua* stands along the Henry's Fork near Ashton. Not surprisingly, the ecological attributes of HFW riparian areas vary, depending on what factors are important in maintaining their presence. The purpose of this article is to review what is known about HFW riparian areas and place that knowledge in the context of existing riparian literature. The geographic area covered by this paper is the Henry's Fork watershed upstream of the Teton River confluence (not including the Teton subwatershed). Following reviews of riparian ecology and literature specific to riparian and wetland areas of the HFW, we describe probable pre-settlement riparian conditions in the watershed, overlay human impacts onto that template, and discuss opportunities and obstacles for riparian rehabilitation.

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Riparian Ecology

Riparian characteristics are determined by interactions of abiotic and biotic factors (Gregory *et al.* 1991, Hupp and Osterkamp 1996). Important abiotic factors include the processes and results of stream flow and sediment transport, and the influence of riparian soil characteristics (Rood and Mahoney

Figure 1. *Multi-layered (top) and single story (bottom) riparian plant associations in the Upper Henry's Fork Basin.*

1990, Carter *et al.* 1994, Scott *et al.* 1996). Biotic factors, including vegetation colonization and succession and activities of wildlife and humans are similarly important in determining riparian characteristics (Patten 1968, Smith 1976, Kovalchik and Elmore 1992).

Factors operating at different spatial scales may influence riparian characteristics (Martin and Bouchard 1993, Bendix 1994, Whiting and Stamm

1995). For example, regional climate patterns and geology may affect stream flow characteristics (Whiting and Stamm 1995, Benjamin this issue). The influence of factors operating at different spatial scales and interdependence among biotic and abiotic factors typically results in potential for complex responses to changes in on- and off-site factors (Schumm 1977). As a result, determining the causes of degraded riparian and stream conditions is often difficult.

Riparian assessments usually begin with characterization of the hydrologic, edaphic (soil), and vegetative conditions found at a particular site (Pfankuch 1975, Gebhardt *et al*. 1989, Thompson *et al*. 1998). Hydrologic conditions can be further dissected to components of stream flow and sediment transport. Stream flow and the timing, duration, and frequency of inundation affect riparian conditions by influencing such processes as streambed and bank scour, sediment deposition, soil oxygenation and biological activity (Dionigi *et al*. 1985, Rood and Mahoney 1990, Carter *et al*. 1994, Fetherston *et al*. 1995, Whiting and Stamm 1995, Scott *et al*. 1996). Sediment transport is strongly related to stream flow and velocity, but is also a function of particle size (related to geologic parent material), stream gradient, channel roughness, and other hydraulic variables (Leopold *et al*. 1964).

Sediment transport phenomena (erosion and deposition) may influence riparian characteristics by removing and adding bank and floodplain material, initiating plant successional cycles, and preventing colonization by disturbance-intolerant plant species. By providing new material, deposition of sediments also influences soil characteristics, which are frequently used to characterize riparian areas.

Five forming factors operate to determine soil characteristics. Climate, biologic activity (or lack thereof), and chemical reactions operate on geologic parent materials through time to produce the edaphic conditions found at a particular site (Buol *et al*. 1989). Because of frequent erosion and deposition and reduced biologic activity caused by inundation, riparian soils are usually quite young and poorly developed (typically categorized as Entisols or Inceptisols; Buol *et al*. 1989, Megonigal *et al*. 1993). Soil characteristics may influence water-holding capacity and drainage, vegetation growth media and nutrient availability, and bank erodibility, all of which play important roles in determining riparian characteristics (Noble 1979, Carter 1986, Cooper and Van Haveren 1994).

Vegetation is often the most visually dominant and easily assessed riparian feature. Riparian vegetation composition may be a function of hydrologic conditions, light and soil moisture regimes, successional stage, and other factors (Knighton 1981, Carter 1986, Cordes *et al*. 1997). In turn, riparian plants may provide organic material, shade riparian and stream areas, remove soil water via evapotranspiration, influence bank stability and sediment deposition patterns, and attract wildlife, all of which are important determinants of overall riparian conditions (Smith 1976, Groeneveld and Gripentrog 1985, Johnston and Naiman 1990, Foster and Smith 1991).

In the absence of channelization, sedimentation, fire, heavy grazing, or other major disturbances, riparian areas will typically cycle through a series of successional stages that relate to the hydrologic, edaphic, and vegetative conditions present (Stromberg *et al*. 1991, Bornette and Amoros 1996). Feedback loops between related site factors (abiotic and biotic factors listed previously) are usually responsible for moving the successional cycle along. For example, gravel recently deposited on a point bar along a meandering stream may be colonized by willows (*Salix* spp.). As the willows grow and mature, they may stabilize the point bar and add organic material to the soil, both of which may facilitate colonization by other plant species. Increased roughness from vegetation establishment may cause more sediment deposition, building what may become the streambank and floodplain as time progresses and the channel meanders further away. Eventually, the channel might migrate back toward the built up streambank and established plant community, eroding the bank and removing plant material, thus restarting the successional cycle.

Successional cycling across adjacent, similar sites often creates a mosaic of early to late-successional stage riparian communities. The most mature successional stage that other seres tend toward through time is often referred to as the climax or potential natural community (PNC) (Barbour *et al.* 1987, Prichard *et al.* 1993). Human-caused and natural disturbances may prevent riparian communities from reaching their potential or even shift the potential toward a different plant association (Kovalchik and Elmore 1992, Patten 1968, Johnston and Naiman 1990). Similarly, it follows that riparian potential will be expressed where major disturbances have not altered the suite of factors (abiotic and biotic) determining riparian characteristics.

As previously noted in the point-bar example, successional characteristics in riparian areas are often strongly related to hydrologic processes including erosion, sediment deposition, and riparian moisture regimes. Where cycles in these processes are muted, in spring creeks for example, successional cycling may be driven by mechanisms more dominant in upland areas, be substantially reduced, or not be evident at all. More extensive reviews of stream dynamics and riparian ecology are provided by Heede (1980) and Gregory *et al.* (1991).

Riparian Studies in the HFW

Numerous studies have explored riparian areas in the HFW. Platts *et al.* (1989) described efforts to reduce deleterious effects of cattle on streambanks along the Henry's Fork in Harriman East. Several vegetation classifications, mapping efforts, and fisheries-related studies also have included riparian and wetland areas throughout the HFW (Youngblood *et al.* 1985, Bowerman *et al.* 1997, Gregory 1997, Hall and Hansen 1997).

The National Wetland Inventory (NWI) for the HFW is partially complete, with digital maps available in both final and draft form. The NWI maps wetlands by vegetation cover class and can be used to provide broad-scale information on wetland extent and types (Cowardin *et al.* 1979). Information from the NWI is included in Jankovsky-Jones (1996), which incorporates many earlier studies and riparian classifications to summarize HFW riparian and wetland resources, list riparian and wetland plant associations, and discuss management of rare, high priority wetlands. Riparian and wetland information may also be indirectly obtained from aerial photographs, historic photos and journal accounts, old maps, and basin residents. Additional sources of Henry's Fork riparian information are listed in Van Kirk (this issue).

Pre-settlement Riparian Conditions

Although natural causes may prevent riparian communities from reaching their potential, human activities frequently create the major disturbances that reset or shift riparian potential (Kauffman *et al.* 1997). Working on the assumption that large-scale physical factors (regional climate, geology, species availability, etc.) have not changed substantially in the past 200 years, current riparian potential is often assumed to represent pre-settlement conditions (Hutchinson 1988, Galatowitsch 1990). Where historic documents, photos, or aerial photographs are not available, current riparian potential may be determined from comparison of disturbed and undisturbed reference sites and examination of hydrologic, edaphic, and vegetative conditions (Prichard *et al.* 1993). Speculation on the effects of past management activities, and knowledge of plant ecology and stream geomorphology may also provide useful information.

As a prelude to description of riparian conditions, we first provide background information on the set of abiotic and biotic factors determining pre-settlement riparian characteristics and current riparian potential in the HFW.

Hydrology

Three general stream types based on hydrology and gradient were identified by Anderson (1996) in the upper HFW; Bezzerides (1999) used these to stratify his riparian sampling efforts. We incorporate stream order (Strahler 1957) as an additional descriptor for riparian habitat characterization. Low-order, high-gradient, runoff-dominated stream types flow from headwater areas in the Centennial and Henry's Lake mountains. Lower down, these streams may develop into or feed low-order, low-gradient, runoff-dominated streams, or feed the Henry's Fork River above Island Park Reservoir, run directly to the reservoir, or into the Warm River. High-order, low-gradient, runoff-dominated streams are found lower in the watershed. Fall River and the Henry's Fork downstream of Fall River are the two streams in the HFW falling into this category. Low-order, low-gradient, spring-fed streams typically flow from the Madison and Pitchstone plateaus and feed the Henry's Fork above Island Park Reservoir (see Benjamin this issue).

Flow characteristics of runoff-dominated streams in the HFW include a strong snowmelt runoff peak in late spring (about 10:1 ratio of peak to base flow; Whiting and Stamm 1995), gradual base flow recession during the summer, and a long period of low flow through autumn, winter, and early spring. Spring-fed streams also exhibit a snowmelt runoff peak (about 2:1 peak to base flow ratio), but because of the potentially complex recharge-discharge dynamics in HFW spring systems, this peak is attenuated and occurs later than in nearby runoff-dominated streams (Benjamin 1997, Benjamin this issue). As a result of this attenuation, spring-fed streams typically flow at bankfull stages longer than runoff-dominated streams (Whiting and Stamm 1995).

Other hydrologic differences between spring-fed and runoff-dominated streams include reduced sediment dynamics in spring-fed streams and greater floodplain formation along runoff-dominated streams (Whiting and Stamm 1995, HabiTech, Inc. 1997). Spatio-temporal differences in HFW riparian areas (disturbance patterns, floodplain and soil development, vegetation type and diversity, etc.) correlate with presence of spring-fed and runoff-dominated flow regimes, further supporting existing documentation of the importance of hydrology in determination of riparian characteristics (Whiting and Stamm 1995, Bezzerides 1999).

Soils

Hydrologic type, stream gradient, and parent material interact to determine the materials available for riparian soil formation in the HFW. Spring-fed streams generally have only gravel and smaller materials available because of the weathering characteristics of rhyolite and basalt parent materials and the inability of spring-fed streams to transport larger cobble and boulder-sized material from source areas (Whiting and Stamm 1995).

Near spring sources, soil formation is dominated by organic matter inputs (litterfall and woody debris) and the influence of a perennially high water table. Downstream, some overbank deposition of fine sediment may occur, but pedogenic processes continue to be dominated by organic matter contributions and reduced redoximorphic conditions caused by long periods of inundation. Common characteristics of soils along spring-fed streams include high organic matter content caused by low rates of decomposition, gleyed or mottled redoximorphic features caused by reduced soil conditions, fine textures resulting from limited overbank deposition of coarse materials, and poor drainage and high water holding capacity because of high organic matter content and fine texture (USDA Soil Conservation Service 1981, Whiting and Stamm 1995, Bowerman *et al.* 1997, Bezzerides 1999).

Runoff-dominated streams in the watershed exhibit a different and much more obvious longitudinal sequence of soil development. Riparian pedogenesis at upper elevations is extremely limited and soil characteristics are more similar to the alfisols of adjacent forested upland areas than the entisols and inceptisols traditionally found in riparian areas (Buol *et al.* 1989, Bowerman *et al.* 1997). Downstream, where floodplain development occurs, dynamic sediment transport processes create younger, poorly developed, well-drained soils with coarse texture and low organic matter content. As gradient decreases, overbank deposition of coarse materials is reduced and floodplain soils become finer and higher in organic matter content (USDA Soil Conservation Service 1993).

Soil-forming factors that strongly contribute to development of riparian characteristics in the HFW are related to hydrologic type and include saturated conditions along spring-fed streams and frequent inputs of sediment on runoff-dominated systems (USDA Soil Conservation Service 1981, 1993, Bowerman *et al.* 1997). Soil saturation and deposition of sediment both strongly influence patterns of riparian vegetation.

Vegetation

Factors influencing riparian vegetation in the HFW are less well studied than those affecting hydrologic and edaphic conditions. Bezzerides (1999) investigated environmental factors associated with riparian vegetation communities in the HFW and found hydrologic type (spring-fed vs. runoff-dominated) to significantly correlate with presence of the riparian community types sampled (ten different types). The most obvious pattern observed was the dominance of sedges along spring-fed streams (Bezzerides 1999). However, long-term grazing disturbance by domestic cattle and moose (*Alces alces*) may have altered riparian vegetation potential toward dominance by sedges along several of the spring-fed streams examined (Bezzerides 1999).

Henry's Fork Watershed Riparian Plant Associations and Ecology

Review of existing classifications (Youngblood *et al.* 1985), gray literature (Moseley *et al.* 1991, Layser 1993, Bowerman *et al.* 1997), ongoing surveys (Hall and Hansen 1997), and site specific surveys were used by Jankovsky-Jones (1996) to generate a list of plant associations occurring in the Henry's Fork and Teton basins. Plant associations known to be present in the study area appear in Appendix A. Additional Latin and common plant names are listed in Appendix B. Stream types, where the associations occur, were inferred based on field surveys (Anderson 1996, Jankovsky-Jones 1996, Bezzerides 1999) and review of classifications (Youngblood *et al.* 1985, Bowerman *et al.* 1997, Hall and Hansen 1997). The reader should note that a limited number of plant associations at a limited number of locations are known to be at their potential. Additional research and comparison among sites is needed to further establish successional relationships and define human and natural, disturbance-induced states. Riparian communities are broadly described below.

Needle-leaved forests occur on low-order, high-gradient, runoff-dominated streams. Fluvial landforms are frequently absent because of restrictive valley types and stream gradients that limit lateral channel migration. Riparian vegetation is thus confined to narrow streamside bands of facultative upland and wetland species whose life histories are not tightly linked with fluvial processes.

In valley bottoms at upper elevations, forested communities are dominated by *Picea engelmannii*, *Abies lasiocarpa*, *Pseudotsuga menziesii*, or *Pinus contorta*. Where gradient lessens and floodplain development occurs, *Salix*- and *Carex*-dominated wetlands may be present. Understory species in these riparian associations may include *Cornus stolonifera*, *Lonicera involucrata*, *Urtica dioica*, and *Fragaria virginiana* (Bezzerides 1999). Increased floodplain development and factors such as elevation, gradient, valley width, and sediment particle size are apparent in the transition from coniferous-tree dominated to deciduous-shrub-and-tree dominated riparian associations (Baker 1989, Patten 1998).

Riparian vegetation along low-order, low-gradient, runoff-dominated streams in the HFW can be characterized as willow shrublands along low-order streams at upper elevations (Fig. 2). At mid-to-upper elevations, riparian habitats are a mosaic

Figure 2. *A mixed willow/sedge community along a low-order, low-gradient, runoff-dominated stream.*

of *Salix*-dominated shrublands and *Carex* meadows along low-gradient, meandering channels. Common willow species include *Salix geyeriana* and *S. boothii* with lesser amounts of *S. drummondiana, S. lemmonii, S. bebbiana* var. *bebbiana, S. eastwoodiae,* and *S. planifolia* var. *planifolia*. The graminoids *Carex utriculata, C. aquatilis,* and *Eleocharis palustris* are frequently present as monocultures in wetter areas (Jankovsky-Jones 1996). Somewhat drier areas may support the graminoids *Carex nebraskensis, Juncus balticus,* and *Deschampsia cespitosa* and the shrubs *Artemisia cana* and *Potentilla fruticosa*.

Broad-leaved deciduous forests occur on well-established floodplains along high-order, low-gradient reaches of the Henry's Fork below the confluence with the Fall River and along moderate gradient tributaries to the Henry's Fork at lower elevations. The forests are most commonly dominated by the balsam cottonwoods, *Populus trichocarpa* or *P. balsamifera*, with lesser amounts of *P. angustifolia, P. acuminata* and *P. tremuloides*. The HFW is unique in that it lies at the northern limit of the range of *Populus angustifolia* and the western limit of the range of *P. balsamifera*. The distribution of the balsam cottonwoods in the watershed is not clear, and they have been included with *Populus trichocarpa* for the purpose of describing plant associations. Shrublands dominated by tall willows including *Salix exigua, S. lutea,* and *S. lasiandra* ssp. *caudata*, or non-willows *Alnus incana, Betula occidentalis, Crataegus douglasii,* or *Cornus stolonifera*, and grasslands dominated by *Agropyron smithii* may occur within the cottonwood mosaic.

Riparian and wetland habitats along low-gradient, spring-fed streams (see the sedge-dominated site in Fig. 1) in the HFW are predominantly peatlands, where organic matter accumulates because perennially high water tables limit decomposition (Moseley *et al.* 1991). Intact peatlands are among the most floristically significant wetlands providing habitat for over half of the rare wetland plant species in the watershed (Moseley *et al.* 1991). Common graminoids occurring in spring-fed wetlands include *Carex utriculata* and *Carex aquatilis*, and the less common species *Carex lasiocarpa, Carex limosa,* and *Dulichium arundinaceum*. Though willows such as *Salix boothii* and *Salix geyeriana* may be present, these spring-fed habitats frequently have stands of inundation-tolerant, low-growing willows such as *Salix wolfii, S. brachycarpa, S. planifolia* var. *monica*, and *S. candida* along with non-willows *Betula glandulosa* and *Potentilla fruticosa* (Moseley *et al.* 1991, Jankovsky-Jones 1996). Forested peatland habitat dominated by *Picea glauca* is also present in the watershed and found exclusively at Henry's Lake (Jankovsky-Jones 1996).

Human Impacts to Henry's Fork Riparian Areas

Riparian communities may not be at their full potential because of natural or human-caused reasons. The concepts of riparian health and proper functioning condition (PFC) often are used to describe the range of successional and disturbance states, from early seral, disturbed, or limited, to late seral and PNC (Prichard *et al.* 1993). It is important to remember that riparian health and PFC are derived concepts with several assumptions related to human conceptions of what stream systems should look like.

Riparian health often is determined by comparing streams or stream reaches with similar flow regime, substrate, and position on the landscape (valley bottom type, gradient, and aspect). Assessments of riparian functions such as dissipation of hydraulic energy, filtration of sediment from overbank flows, maintenance of aquatic habitat, and support of upland forage production can be used to provide relative comparisons of riparian health. Streams or specific reaches supporting comparatively fewer or less robust riparian functions are described as unhealthy in comparison to similar streams that support more, and more robust riparian functions. As elsewhere in the western U.S., riparian functions in the HFW have been affected by a long history of human land use (Platts *et al.* 1989, Green 1990).

Over-use by ungulates and lowered water tables were cited as the main ecological concerns for riparian areas on the Targhee National Forest (USDA Forest Service 1997). Gregory (1997) cited channelization, willow removal, and overgrazing as the main factors leading to degraded fish habitat in the watershed above Island Park Dam. Other effects on riparian habitats in the HFW include hydrologic alterations, timber harvest, development, introductions of noxious weeds, overuse by native wildlife, and recreation (Jankovsky-Jones 1996, Gregory 1997, USDA Forest Service 1997, Gregory and Van Kirk 1998, Benjamin and Van Kirk 1999, Bezzerides 1999). Many human effects are site specific, but a few are widespread and significant across the entire HFW. Road networks can affect riparian areas by increasing stream peak flows and decreasing hydraulic response times, especially in combination with clearings created by timber harvest (Harr *et al.* 1975, King 1989, MacDonald and Hoffman 1995). Roads also intercept surface and groundwater flow, concentrating hydraulic energy in ditches and culverts, increasing upland erosion and sediment delivery to streams (Fig. 3, Jones and Grant 1996). Roads have been identified as the main source of sediment to streams in the upper watershed (USDA Forest Service 1997), but their effects on peak flows have not been studied. In many locations, roads and bridges constrain channel migration (Bezzerides 1999), thereby increasing flow velocities and potential for downstream bank erosion and channel

Figure 3. *A headcut associated with the Old Yale Kilgore Road near Sheridan Creek contributed large quantities of sediment to the stream channel in summer 1998.*

incision (Heede 1980).

Numerous dams, diversions, and channelizations directly affect HFW riparian areas by altering hydrograph characteristics and sediment transport processes (Benjamin and Van Kirk 1999, Bezzerides 1999). Diversion structures and channelization can increase stream sedimentation by increasing channel instability and bank erosion (Heede 1980). Channel incision below dams and in channelized streams usually results in lowered water tables and changes in plant species composition to those more tolerant of drier conditions (Smith *et al.* 1991, Van der Valk *et al.* 1994). Reduced sediment transport and deposition below dams also may affect vegetation composition by limiting seedling recruitment of willows and other sediment requiring species (Rood and Mahoney 1990).

Many of the valleys in the HFW are used for hay pastures and livestock grazing. Pasture development typically includes removal of woody vegetation, seeding with non-native grasses, and development of irrigation systems (Krueper 1993, Mancuso 1995). Livestock use may reduce vigor and reproduction of woody species along riparian corridors and physically degrade channel banks, contributing sediment to the stream channel (Platts *et al.* 1989). Decreases in palatable plant species and increases in less palatable native and non-native species are associated with heavy and long-term grazing and have also been observed in the watershed on Henry's Lake Flat, along the Henry's Fork in Harriman State Park, and in the Shotgun Valley (Mancuso 1995, Jankovsky-Jones 1996, Bezzerides 1999).

Historic and ongoing human activities in the HFW affect hydrologic, edaphic, and vegetative components of riparian systems. These effects present significant opportunities for increasing riparian, fishery, rangeland, and watershed health (Jankovsky-Jones 1996, Gregory 1997, Gregory and Van Kirk 1998, Bezzerides 1999).

Obstacles and Opportunities for Riparian Rehabilitation

Interest in riparian rehabilitation in the HFW has increased over the past several years because of improved understanding of the fisheries and watershed benefits provided by healthy riparian areas. Projects to date in the HFW primarily have focused on improving riparian health by eliminating grazing effects along the Henry's Fork and Sheridan Creek in Harriman State Park, and along the Henry's Lake Outlet at The Nature Conservancy's Flat Ranch. Numerous organizations have helped organize or fund riparian improvement projects, and support for additional projects only seems to be growing.

Obstacles

Growing momentum seems to favor successful development and implementation of future projects, but several social and environmental obstacles may become evident as work progresses. All lands within the watershed are important for maintaining riparian and stream health, whether they provide groundwater recharge areas, filter sediment from upland runoff, or contribute large woody debris to the channel for habitat. Construction of roads, housing, and other developments continues at a rapid rate in Last Chance, Shotgun Valley, and Henry's Lake Flat (Sperry 1999). These activities may affect water quality, change local and watershed drainage patterns, and facilitate spread of noxious weeds, all of which are factors that can decrease riparian and stream health. Education, restrictive planning and zoning, monitoring of development activities, and enforcement of current regulations (Section 404 of the Clean Water Act) should help minimize potential impacts.

Time is needed to implement conservation strategies and allow them to take effect. Current social conditions (politics, economics, landowner attitudes) may allow for resource banking, but times can change rapidly. Riparian improvement efforts should maintain a holistic approach and work to restore and maintain systems that are socially and ecologically sustainable over the long term.

In certain locations, environmental obstacles are more daunting than social ones. The interruption of sediment transport phenomena by Henry's Lake and Island Park dams has direct implications for establishment and maintenance of riparian communities along the Henry's Lake Outlet and the Henry's Fork. Reduced recruitment of cottonwoods and willows is well documented along many tailwater systems (Rood and Mahoney 1990), and Bezzerides (1999) hypothesized that reduced sediment transport below Island Park Dam is in part responsible for poor willow recruitment along the Henry's Fork in Harriman State Park. Monitoring of riparian exclosures should help provide information on factors affecting willow seedling recruitment along the Henry's Lake Outlet (Mancuso 1995), but additional work is needed to establish baseline information for riparian vegetation recruitment patterns along the Henry's Fork in Harriman State Park.

Noxious weeds present another significant obstacle to maintenance and improvement of riparian health. In combination with disturbances such as grazing and road construction, noxious weeds can spread into riparian areas and reduce forage palatability, bank stability, and other attributes of riparian and stream health. Common noxious weeds in the Henry's Fork watershed include musk thistle *(Carduus nutans)*, spotted knapweed *(Centaurea maculosa)*, Canada thistle *(Cirsium arvense)*, leafy spurge *(Euphorbia esula)*, and yellow toadflax *(Linaria vulgaris)* (USDA Forest Service 1993, Callihan and Miller 1994, Gregory and Van Kirk 1998). Complete eradication of these species is impossible, but through improved management practices it should be possible to control their spread and deleterious effects on riparian and stream health.

Opportunities

Social and environmental opportunities for riparian rehabilitation and management are equally abundant. Government agency interest and cooperation in conservation efforts in the HFW is increasing, and large amounts of public land in the HFW should ensure a constant source of future projects and the ability to take a broader, landscape view of the watershed. In addition, interest in multiple-use management of natural resources in the HFW is growing in all sectors, as evident by the broad participation in the Henry's Fork Watershed Council (Weber this issue). Finally, many riparian systems are naturally resilient. Disturbance mechanisms such as flooding, erosion, and sediment deposition serve to rejuvenate riparian areas by providing material for seedling establishment, building banks, and reestablishing floodplain connections. Rehabilitation efforts that incorporate these disturbance processes can be successful in a short time.

Conclusions and Recommendations

Sport fishing, timber harvest, off-road vehicle use, potatoes, golf, and water for irrigation are but a few of the human uses supported by the landscape of the upper Henry's Fork watershed. Management of the watershed to ensure compatibility of these uses with maintenance and recovery of ecosystem function and natural values is challenging. For land managers and owners alike, the interdependence of hydrologic, edaphic, and vegetative factors in riparian areas provides a useful magnification system for detection of riparian health problems. Because of this interdependence, diagnosis of problems can be difficult. Causative factors need to be systematically ruled out before management actions or rehabilitation efforts are initiated. There is no substitute for time spent in the field observing riparian and stream conditions. Naturally occurring seasonal and year-to-year variations in riparian conditions further emphasize the need to spend time on the ground getting to know the riparian area of interest.

The following conditions can be used as indicators that riparian function may be in jeopardy:

- Decreases in riparian plant vigor.
- Changes in riparian vegetation composition that reflect increases in grazing-tolerant or more xeric species. *Carex nebraskensis, Potentilla gracilis, Fragaria virginiana, Taraxacum officinale, Cirsium arvense, Achillea millefolium, Poa pratensis,* and *Rosa woodsii* often increase with grazing. *Deschampsia cespitosa* and many *Salix* species can decrease under improper grazing regimes. *Artemisia tridentata* commonly encroaches on inactive floodplains, but its presence, along with *Juniperus scopulorum*, on the active floodplain signifies a potentially detrimental change in the riparian moisture regime.
- Declines in fish abundance.
- Declines in aquatic macroinvertebrate diversity, including loss of indicator taxa.
- Increases in bare ground or sediment.
- Rapid channel adjustment and bank erosion.
- Changes in the frequency of floodplain inundation.

Annual documentation of riparian characteristics (hydrology, soils, and vegetation) is valuable not only from a property management standpoint, but also is very useful for communication purposes if technical assistance is required. In the HFW, numerous government and private organizations are available for riparian consultation. For managing agencies and private landowners, specific goals and objectives for riparian management or rehabilitation or both should guide actions and help determine if results meet expectations. The outlook for successful management and rehabilitation of riparian areas in the HFW is good if a holistic, watershed approach is maintained and activities up and downstream are accounted for. Monitoring and communicating results of management and rehabilitation activities will provide valuable project feedback and help others learn from the experiences gained.

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Appendix A. *Plant associations and stream types in the Henry's Fork watershed. Stream type designations are as follows: I = Low-order, high-gradient, runoff-dominated; II = Low-order, low-gradient, runoff-dominated; III = High-order, low-gradient, runoff-dominated; IV = Low-gradient, spring-fed.*

		Stream Type			
Plant association	**Common name**	**I**	**II**	**III**	**IV**
Palustrine Forested Associations					
Needle-leaved evergreen		X	X		
Abies lasiocarpa/Calamagrostis canadensis	subalpine fir/bluejoint reedgrass	X			
Abies lasiocarpa/Streptopus amplexifolius	subalpine fir/claspleaf twistedstalk	X			
Picea engelmannii/Cornus stolonifera	Engelmann spruce/red-osier dogwood	X			
Picea engelmannii/Equisetum arvense	Engelmann spruce/common horsetail	X			
Picea engelmannii/Galium triflorum	Engelmann spruce/sweetscented bedstraw	X			
Picea glauca/Carex disperma	white spruce/softleaf sedge			X	
Picea glauca/Carex utriculata	white spruce/bladder sedge			X	
Picea glauca/Equisetum arvense	white spruce/common horsetail			X	
Broad-leaved deciduous					
Populus tremuloides/Calamagrostis canadensis	quaking aspen/bluejoint reedgrass	X			
Populus tremuloides/Cornus stolonifera	quaking aspen/red-osier dogwood	X		X	
Populus trichocarpa/Cornus stolonifera	black cottonwood/red-osier dogwood			X	
Populus trichocarpa/Crataegus douglasii	black cottonwood/black hawthorne			X	
Populus trichocarpa/herbaceous	black cottonwood/herbaceous			X	
Populus trichocarpa/recent alluvial bar	black cottonwood/recent alluvial bar			X	
Populus trichocarpa/Symphoricarpos albus	black cottonwood/common snowberry			X	
Palustrine Scrub-Shrub Associations					
Broad-leaved deciduous					
Alnus incana/Cornus stolonifera	mountain alder/red-osier dogwood				X
Alnus incana/Ribes hudsonianum	mountain alder/northern blackcurrent	X			
Artemisia cana var. viscidula/Deschampsia cespitosa	silver sage/tufted hairgrass		X	X	
Artemisia cana var. viscidula/Festuca idahoensis	silver sage/Idaho fescue			X	X
Betula glandulosa/Carex simulata	bog birch/short-beaked sedge				X
Betula glandulosa/Carex utriculata	bog birch/bladder sedge				X
Betula occidentalis	water birch			X	
Cornus stolonifera	red-osier dogwood			X	
Cornus stolonifera/Galium triflorum	red-osier dogwood/sweetscented bedstraw	X			
Cornus stolonifera/Heracleum lanatum	red-osier dogwood/common cowparsnip	X			
Crataegus douglasii/Rosa woodsii	black hawthorne/Wood's rose			X	
Potentilla fruticosa/Deschampsia cespitosa	shrubby cinquefoil/tufted hairgrass		X		X
Rosa woodsii	Wood's rose			X	
Salix boothii/Calamagrostis canadensis	Booth's willow/bluejoint reedgrass		X		X
Salix boothii/Carex utriculata	Booth's willow/bladder sedge		X		X
Salix boothii/Equisetum arvense	Booth's willow/common horsetail		X		X
Salix boothii/mesic graminoid	Booth's willow/mesic graminoid		X		X
Salix boothii/Smilacina stellata	Booth's willow/starry false Solomon's seal		X		X

Appendix A. (con.t)

Plant association	Common name	Stream Type I	II	III	IV
Salix drummondiana/Calamagrostis canadensis	Drummond's willow/bluejoint reedgrass		X		
Salix drummondiana/Carex utriculata	Drummond's willow/bladder sedge				X
Salix exigua/barren	sandbar willow/barren			X	
Salix exigua/mesic forb	sandbar willow/mesic forb			X	
Salix exigua/mesic graminoid	sandbar willow/mesic graminoid			X	
Salix geyeriana/Calamagrostis canadensis	Geyer's willow/bluejoint reedgrass		X		X
Salix geyeriana/Carex aquatilis	Geyer's willow/water sedge		X		X
Salix geyeriana/Carex utriculata	Geyer's willow/bladder sedge		X		X
Salix geyeriana/Deschampsia cespitosa	Geyer's willow/tufted hairgrass		X		X
Salix geyeriana/mesic forb	Geyer's willow/mesic forb		X		
Salix lasiandra/bench	whiplash willow/bench			X	
Salix lasiandra/mesic forb	whiplash willow/mesic forb			X	
Salix lutea	yellow willow	X			
Salix lutea/Calamagrostis canadensis	yellow willow/bluejoint reedgrass			X	
Salix lutea/Carex utriculata	yellow willow/bladder sedge			X	
Salix planifolia var. monica/Carex utriculata	planeleaf willow/bladder sedge		X		
Salix wolfii/Carex aquatilis	Wolf's willow/water sedge		X		X
Salix wolfii/Carex nebraskensis	Wolf's willow/Nebraska sedge		X		X
Salix wolfii/Carex utriculata	Wolf's willow/bladder sedge		X		X
Salix wolfii/mesic forb	Wolf's willow/mesic forb		X		X
Symphoricarpos occidentalis	western snowberry			X	
Palustrine Emergent Associations					
Persistent					
Agropyron smithii	bluestem wheatgrass		X	X	
Artemisia ludoviciana	Louisiana sagewort			X	
Calamagrostis canadensis	bluejoint reedgrass		X		
Carex aquatilis	water sedge		X		X
Carex atherodes	awned sedge				X
Carex buxbaumii	Buxbaum's sedge				X
Carex lanuginosa	woolly sedge		X	X	
Carex lasiocarpa	slender sedge				X
Carex limosa	mud sedge				X
Carex microptera	smallwing sedge		X		
Carex nebraskensis	Nebraska sedge		X	X	X
Carex praegracilis/Carex aquatilis	clustered field sedge/water sedge				X
Carex simulata	soft-leaved sedge		X		X
Carex utriculata	bladder sedge		X	X	X
Carex vesicaria	inflated sedge				X
Deschampsia cespitosa	tufted hairgrass		X		X
Dulichium arundinaceum	threeway sedge				X
Eleocharis acicularis	needle spikerush		X	X	X
Eleocharis palustris	common spikerush		X	X	X
Eleocharis pauciflora	fewflower spikerush				X
Elymus cinereus	basin wildrye			X	
Glyceria borealis	northern mannagrass				X
Juncus balticus	baltic rush		X	X	X
Nuphar polysepalum	Rocky Mountain pond lily		X	X	
Polygonum amphibium	water ladysthumb			X	
Scirpus acutus	hardstem bulrush			X	X
Typha latifolia	broadleaf cattail		X	X	X

Appendix B. *Additional Latin and common names of plants used in the text and not listed in Appendix A.*

Latin name	Common name
Fragaria virginiana	Virginia strawberry
Lonicera involucrata	twinberry
Pinus contorta	lodgepole pine
Populus acuminata	lanceleaf cottonwood
Populus angustifolia	narrowleaf cottonwood
Populus tremuloides	quaking aspen
Pseudotsuga menziesii	Douglas fir
Salix bebbiana	Bebb's willow
Salix brachycarpa	short-fruited willow
Salix candida	hoary willow
Salix eastwoodiae	mountain willow
Salix lemmonii	Lemmon's willow
Urtica dioica	stinging nettle