New Concepts for Meadow Restoration in the Northern Sierra Nevada

Donna S. Lindquist
Feather River Coordinated
Resource Management
P.O. Box 3880
Quincy, CA 95971
(530) 283-3739
(530) 283-5465 (fax)
donnal@plsn.com

Jim Wilcox
Feather River Coordinated
Resource Management
P.O. Box 3880
Quincy, CA 95971
(530) 283-3739
(530) 283-5465 (fax)
plumasco@psln.com

Donna Lindquist obtained a BA degree in Ecological Biology from San Francisco State University and an MS degree in Range Management from the University of California Berkeley. She is currently the watershed monitoring coordinator for the Feather River Coordinated Resource Management (FRCRM) group, and previously worked for Pacific Gas & Electric Company for 15 years in the Research and Development Department as an environmental scientist and water resources project manager.

Jim Wilcox, a long time resident of Plumas County, has served for ten years as the FRCRM project manager and steam restoration specialist. His responsibilities include development, design, implementation and administration of stream restoration projects in California's upper Feather River watershed. He has a unique familiarity with the watershed and over a decade of experience in all aspects of watershed planning, analysis and restoration.

Abstract:

The Feather River Coordinated Resource (FRCRM) group, a partnership of 21 public and private sector watershed stakeholders, has over a decade of experience in designing and implementing watershed restoration projects in California's upper Feather River basin. Due to historical land abuse, 98 per cent of the meadows in the watershed are degraded and require man's intervention to reverse current trends. Accelerated erosion, gully formation, lack of desirable riparian vegetation, habitat loss, and flashy runoff patterns are consequences of a watershed that has lost hydrologic and biologic function. The FRCRM identified degraded meadows as a high priority for restoration and several new innovative approaches to meadow restoration have been designed and tested with successful results. The Big Flat Meadow Project is an example.

The Big Flat Meadow/Cottonwood Creek Restoration Project, located in the Plumas National Forest, was initiated in 1994 by the FRCRM to restore hydrologic function to meadow resources. Historically, Cottonwood Creek maintained groundwater levels in the Big Flat Meadow that supported mesic vegetation, however, intense grazing, logging, and road building over the preceding 90 years resulted in relocation of Cottonwood Creek and the creation of a gully 10-15 feet deep. As the new channel eroded and incised, subsurface meadow aquifers drained, vegetation converted from wet meadow species to xeric species, and the pattern of surface flow was modified from perennial to intermittent. Loss of meadow function lead to a dramatic change in hydrology, diminishing subsurface water storage and flood attenuation capacity.

From a list of potential alternatives, the FRCRM selected a unique "pond and plug" restoration approach to enhance the hydrology and ecology of Big Flat Meadow. This unique geomorphic approach was the first-in-kind demonstration in California. The strategy involved moving the stream to its historic location, reconstruction of the historic channel, and filling in the existing gully with soil excavated from onsite ponds created to enhance waterfowl habitat. Preliminary results indicate that the successful reconnection of the channel to its naturally evolved floodplain has extended the period of stream flow, moderated the magnitude and duration of peak flow events, and reduced seasonal ground water fluctuation indicating increased ground water storage. Meadow vegetation is more productive and has shifted to wetter site species. The modified grazing system has encouraged vegetation establishment and minimized mechanical streambank damage along the new channel. Continued monitoring will determine whether the modified hydrologic regime will lead to long term changes in meadow vegetation, water storage capacity and the social benefits due to extended late season flow.

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Introduction

The condition of watershed resources can effect the environmental and economic stability of resource-dependent rural communities such as Plumas County, located in California's northern Sierra Nevada. Plumas County's economic welfare depends on maintaining healthy and aesthetic streams, forest and meadow lands in the Feather River watershed, which are important assets for business attraction, outdoor recreation, forest products, agriculture, and water output. The critical synergy between the environment and economy underlies the need to enhance and maintain good watershed condition, in order to preserve rural communities and their unique values, while providing products and services to meet downstream demand.

The Feather River watershed is located in Plumas County and includes 3,222 square miles of land base that drains west from the crest of the northern Sierra Nevada into the Sacramento River. Annual runoff produced from this watershed provides over 1,400 MW of hydroelectric power, and represents a significant component of the State Water Project, annually providing 2.3 million-acre feet of water for urban, industrial and agricultural consumers downstream. Timely delivery of high quality water is becoming more imperative as demand increases. Restoration and maintenance of these systems from headwaters to the San Francisco Bay/Delta is critical to meeting current and future demand. The quantity and quality of California's water supply is dependent, in part, upon the condition of source watersheds such as the Feather River basin.

Much of the Feather River watershed has been affected by 140 years of intensive human influence. Extensive mining, grazing, timber harvesting, railroad, and road construction and maintenance have contributed to watershed degradation, resulting in accelerated erosion, sedimentation in streams and reservoirs, meadow de-watering, and degraded terrestrial and aquatic habitats (Mitchell 1986). Restoration of watershed function is a key element in moderating these trends. Stable, well vegetated streams with functioning meadows, aquifers and uplands are critical to reducing erosion and modifying the destructive runoff patterns that are prevalent today.

The Feather River Coordinated Resource Management (FRCRM) group is a partnership of 21 public and private sector groups that was formed in 1985 to facilitate a broad scale watershed restoration program for the Feather River watershed. Watershed stakeholders joined forces via a Memorandum of Agreement to collectively work toward common goals for stabilizing watershed resources through leveraged financial and technical support. The FRCRM has undertaken over 50 restoration projects and watershed studies since 1985, and has demonstrated numerous innovative approaches to stabilizing degraded channels. After fourteen years of experience, the FRCRM has determined that reversing watershed degradation begins with the restoration of water and sediment retention and release functions in headwater meadows, so projects targeting such areas are high priority as limited dollars are allocated.

Mountain meadows play a key role in effecting watershed condition and water flow in the northern Sierra Nevada. Restoration of degraded meadows is the first step in improving overall watershed function and could have major effects on surface and subsurface flow regimes influencing water delivery downstream, far removed from source watersheds. This is especially important in the Feather River watershed since there are over 250,000 acres of meadow and small mountain valleys of which an estimated 98 per cent are degraded. Qualitative observation indicates that fully functioning meadows can moderate flow by storing water in soils, vegetation, streambanks and subsurface aquifers, reducing peaks and extending late season flow (Ponce and Lindquist 1990). The role of meadows in modifying hydrologic function, though, is not well quantified or documented in scientific research so the potential magnitude and duration of these effects can not be predicted with the current state of knowledge. Therefore, current FRCRM priorities include seeking new information and research opportunities to better understand meadow function, while targeting restoration dollars to degraded meadows as a means to test and evaluate new techniques.

Restoration Approach

The FRCRM restoration effort has evolved from a focus on demonstration projects located mid-level in the watershed that treat erosion and sediment supply problems, to restoring the water and sediment retention and release functions in headwater reaches. After more than a decade of experience, FRCRM partners have determined that the primary channel characteristic impacting restoration goals is the disconnection of the channel from its historic functional floodplain. This channel/floodplain disconnection is pervasive throughout the upper watershed meadows and valleys due largely to past land management practices. In response, reconnecting degraded streams to their floodplain has become is a major area of emphasis for the FRCRM. Though there is no “cookbook” as to when and where a given technique or combination of techniques should be used, the FRCRM has successfully used a new innovative geomorphic approach on several alluvial meadow projects. One such project is the Cottonwood Creek/ Big Flat Meadow project that is featured below.

Big Flat/Cottonwood Creek Project

The Big Flat Meadow/Cottonwood Creek Restoration Project, located in the Plumas National Forest, was initiated in 1994 by the FRCRM group to restore hydrologic function and improve the condition of Big Flat meadow. Big Flat, a 47-acre alluvial meadow, lies within the Cottonwood Creek watershed at an elevation of 6,000 feet. The drainage area is 10,919 acres and the average annual precipitation is 20 inches (Benoit and Wilcox 1997). Streamflow in Cottonwood Creek is seasonal, completely drying up in mid-summer.

Historically, Cottonwood Creek maintained groundwater levels in the Big Flat meadow that supported mesic vegetation including grasses, sedges and other riparian species. However, intense grazing, logging, and road building over the preceding 90 years resulted in relocation of Cottonwood Creek and the creation of a gully 10-15 feet deep. As the new channel eroded and incised, subsurface meadow aquifers drained, vegetation converted from wet meadow species to xeric species, and the pattern of surface flow was modified from perennial to intermittent. Continued heavy grazing impeded the establishment and vigor of vegetation and increased mechanical breakdown of soils on the streambank. The resulting entrenched channel was a major source of elevated sediment supply downstream. Loss of meadow function lead to a dramatic change in hydrology, diminishing subsurface water storage and flood attenuation capacity.

The primary goal of the project is to re-water the meadow by reconnecting Cottonwood Creek to its historic floodplain. Objectives include extend summer flow along Cottonwood Creek, recharge meadow aquifers, reduce erosion, flood attenuation, restore spawning and rearing habitat for rainbow trout, enhance vigor and diversity of vegetation, and demonstrate an innovative stream restoration approach which might be applied to other Sierran meadows.

Project Design

To re-water Big Flat Meadow, the FRCRM developed an new approach that combines geomorphic measures, grazing management changes, and revegetation to meet project objectives (FRCRM 1996). Figures 1-2 presents an aerial view of the project before and after implementation of the preferred design.

Geomorphology: From a list of potential alternatives, the FRCRM selected a unique “pond and plug” restoration approach to return hydrologic function to Big Flat Meadow. This strategy involved abandoning the creek’s current incised gully. The gully was filled in with soil excavated from seven onsite ponds that were created for waterfowl and wildlife habitat enhancement. The creek was diverted into a reconstructed 4,050 foot channel sited in the historic location, and rock step pools were created in the steepest sections of the new channel to protect against new head cutting (Benoit and Wilcox 1997).

Grazing Management: Plumas National Forest revised the grazing allotment plan for this meadow. The revised plan reduced the overall animal unit months by 20 per cent, reduced riparian pasture use from 2-3 weeks to 2-3 days, and modified the grazing system from a 2-pasture rotation to a 5-pasture rotation, which included 3 miles of new fencing.

Revegetation: Construction zones were revegetated using hardwoods transplanted from the gully, and were reseeded to supplement natural recolonization. Sod removed from the meadow during construction was transplanted to the edges of the new channel to expedite establishment and soil erosion protection.

Figure 1: Aerial view of Big Flat Meadow prior to restoration.

Figure 2: Aerial view of Big Flat Meadow after restoration

Monitoring Methods

The project was successfully implemented in 1995, and monitoring of surface, ground water, channel configuration and vegetation was carried out from 1993-1999 to document project effects. Baseline data was collected two seasons prior to implementation of the project to characterize the pre-project hydrology and meadow vegetation. Fortunately, data collection occurred during a relatively dry period in 1993-1994 (73 per cent of normal), to an exceptionally wet period in1994-1995 (259 per cent of normal), which enabled researchers to capture a broad range of baseline climatic, hydrologic, and vegetative data for the site (FRCRM 1996).

Stream flow data was collected both upstream and downstream of the project to show changes in flow quantity and timing. Stream stage (water level) was monitored at the upper and lower ends of the meadow with digital recorders, pressure transducers, and a stream staff gage. The digital recorders captured and stored hourly average stream stage data. Stream flow measurements were made during routine visits to the site, and these data were used to develop rating curves (Sagraves 1998).

Ground water measurements were obtained by collecting subsurface water level information from nine piezometers (wells) installed in the meadow prior to the restoration work. Six additional piezometers were installed during the filling of the abandoned gully. This data provides information on the depth of groundwater in the meadow before versus after the project was completed (DeLasaux 1999).

Channel stability, shape and structure is tracked using seven cross sectional profiles established in the project area. Photopoint stations were also established to further support interpretation of the data.

Changes in vegetation is monitored to document the change in species composition, cover, and biomass of herbaceous plant matter in response to the change in hydrology and grazing management. Three-300 foot transects were established and will be monitored every three years by the Plumas National Forest.

Preliminary Results

Monitoring results to date show alterations in flow trends for the re-routed Cottonwood Creek. Flows occur earlier and end later in the runoff period than pre-project flows. In water year 1995 (pre-project), precipitation was 279% of normal, and flow duration lasted 214 days. Post-restoration years 1996 and 1997 yielded 227 and 252 days of flow, respectively. Pre-project flow data show that meadow water storage was capable of supporting downstream flows for about one month after stream flow in the system ended (Sohrakoff 1999).

In addition to flow duration, the quantity and magnitude of peak flow events have been moderated by restoration. Extreme fluctuation of daily flow regimes occurred in 1995, before treatment, but not after treatment was completed. Incised stream systems with no flood plain area (such as the pre-treatment channel) are likely to experience extreme fluctuations in daily flows due to lack of area for peak flow dissipation (Sagraves 1998).

Established photopoints and field observation indicate a shift from a preponderance of undesirable dry site vegetation including cheat grass, sagebrush and rabbitbrush, to wet site species including sedges, hairgrass and bluegrass. Bare ground has been replaced with lush vegetative growth in most areas. Vegetation transect data will be available after the 1999 field season to quantify these observed results of the project. Figures 3-4 provides a before treatment and after treatment view of Cottonwood Creek.

Figure 3: Cottonwood Creek prior to restoration

Figure 4: Cottonwood Creek after restoration

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Conclusions

Returning Cottonwood Creek and Big Flat Meadow to full hydrologic function through this unique geomorphic approach was the first-in-kind demonstration in California. The technique has already been implemented on several other restoration projects in northeastern California, with successful results. The approach is also broadly applicable to semi-arid montane meadows in other areas. Preliminary results indicate that the successful reconnection of the channel to its naturally evolved floodplain has extended the period of stream flow, moderated the magnitude and duration of peak flow events, and reduced seasonal ground water fluctuation indicating increased ground water storage. Meadow vegetation is more productive and has shifted to wetter site species. The modified grazing system has encouraged vegetation establishment and minimized mechanical streambank damage along the new channel. Continued monitoring will determine whether the modified hydrologic regime will lead to long term changes in meadow vegetation, water storage capacity and the social benefits due to extended late season flow.

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