Journal of Arid Environments 74 (2010) 1494–1506

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

# Channel changes in burned streams of northern Nevada

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ARTICLE INFO

*Article history:*
Received 5 March 2009
Received in revised form
18 December 2009
Accepted 8 June 2010
Available online 25 July 2010

*Keywords:*
Environmental impacts
Fire
Monitoring
Riparian ecology
Rivers/streams

ABSTRACT

In the Great Basin, frequency of large-fire is increasing. To better understand fire and riparian system interactions, we studied pre- to post-fire changes in ten riparian attributes of a randomly sampled reach of forty three streams burned within a three-year period. Post-fire data were collected four to six relatively dry years after late-summer wildfires in sagebrush dominated watersheds of the North Central Great Basin. All streams had been surveyed in the one to fifteen years prior to the fire. Five channel attributes improved; bankfull width decreased 21%, riparian width increased 79%, median dominant riparian vegetation increased by two categories (grass/sod to high brush), bank stability increased by one category, and median bank angle decreased. Four attributes did not change; bank cover, organic debris, bank undercuts, and embeddedness. An increase of sand by 19% in the dominant bottom material was considered unfavorable. Riparian vegetation and systems seem to be resilient and whether improvement was due to fire or changed management and time for recovery was not ascertained. Overall, degradation to stream channel attributes was minimal to non-existent suggesting riparian stability and/or resiliency.


## 1. Introduction

Two fire problems endanger Great Basin ecosystems. Part of the land continues to accumulate woody fuel in the absence of fire. Young and Clements (2009) state "The government's policy of excluding wildfires during the twentieth century led to greater expansion of woody vegetation in the Great Basin than had occurred since the Neoglacial period 5000 years ago". The absence of fires was also due to the lack of flammable understory herbaceous vegetation for many decades in the late nineteenth and early twentieth centuries due to overgrazing (Burkhardt and Tisdale, 1976; Miller and Rose, 1999). As shrub and tree dominated plant communities grow fuel, eventual fire becomes more certain, fires become hotter, larger, and more damaging to soil, watersheds, and plant communities that become less resilient. This first fire problem is especially damaging where juniper or pinyon pine trees become dominant (Gruell, 1999; Tausch and Tueller, 1990) and where livestock grazing management has stressed and altered the herbaceous understory of sagebrush (West, 1983). As agencies effected conservative grazing practices, herbaceous native perennials and invasive alien species, especially cheatgrass, *Bromus tectorum* L., increased and provide the continuity of fuel that often allows fires to spread rapidly between woody plants including sagebrush (Young and Clements, 2009). In the absence of a resilient understory, upland burned areas often re-vegetate to flammable annuals, especially in the arid part of the sagebrush zone (Chambers et al., 2007). This creates a second fire problem because burned areas re-vegetated with annuals often burn again. Fast moving fires can become quite large quickly and this too increases fire frequency (Miller and Narayanan, 2008). Invasive annuals now fuel dramatically increased fire frequency and fire size (Brooks et al., 2004; Young and Clements, 2009). Global increase in carbon dioxide acts to fertilize plant growth. It elevates productivity and reduces digestibility of cheatgrass which could increase fuel load and fire frequency and intensity (Ziska et al., 2005). Because fire is a natural phenomenon, areas that still retain resilience could benefit from fire or some fire surrogate that releases herbaceous perennials from competition before fire response is permanently changed (Tausch et al., 2009). Fire corrects problem one if timely, or results in problems one and two if not.

In 1999, 2000 and 2001, numerous wildfires burned over 1.1 million hectares (2.8 million acres) across northern Nevada, much of it managed by the Bureau of Land Management (BLM) and the US Forest Service (USFS). These fires of mixed severity burned across numerous riparian areas, affecting them in various ways. In 2005, 2006, and 2007, another 1.28 million hectares (3.1 million acres) burned in Nevada. The area burned annually increased by 8.5 times from before to after 1999. As wildfire frequency and size increases, land managers need tools and information about fire effects, especially in critical management areas such as riparian zones.

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doi:10.1016/j.jaridenv.2010.06.003

Past and recent policy has been to suppress fires that approach riparian zones, even though fire is often used as a management tool in upland areas (Bisson et al., 2003). This is likely due to the notion that the riparian area is a highly valuable (greater biodiversity, high anthropogenic utility, important hydrologic/geomorphic controls (Debano and Neary, 1996)) and a limited resource (one-half to two percent of the landscape) that should be protected from destruction. This paradigm is being questioned (Agee, 1998) with concerns about increased fuel loads and more homogenous landscapes leading to more severe and larger fires, potentially causing greater riparian damage. With accumulation of fuel, riparian zones may change from fuel breaks to corridors for fire movement (Pettit and Naiman, 2007). Furthermore, riparian areas, especially those dominated by woody vegetation, support greater biomass or fuel than uplands.

Riparian ecosystem diversity is maintained by natural regimes of disturbance such as fire (Naiman et al., 1993; Pettit and Naiman, 2007), potentially making suppression detrimental ecologically. Riparian zones are typically cooler and more humid than surrounding uplands (Danehy and Kirpes, 2000). This often leads to higher fuel and soil moisture content, reducing the severity of a riparian burn compared to the uplands. Riparian plants of Great Basin rangelands are generally fire adapted in that they sprout root suckers or sprout from stumps and underground stems following fire (Bartos and Campbell, 1998; Miller, 2000; Rood et al., 1994; Shepperd and Smith, 1993). These plants also produce seeds that can be delivered to downwind burned riparian areas, where burned duff provides nutrients to establishing seedlings. These conditions can lead to high plant densities on post-fire riparian sites (Havlina, 1995). Forbs and grasses often increase reproduction for some years after fire (Kauffman, 1990). Taken together, these findings suggest a strong resiliency within riparian systems (Dwire and Kauffman, 2003). This is not the case with sagebrush stands which are highly susceptible to fire, and may require thirty years or more to recover original canopy cover and height (Lesica et al., 2007; Paysen et al., 2000).

Riparian areas are known for their resiliency (Wyman et al., 2006), yet post-fire floods have at times caused significant impact (Minshall et al., 1997). Pettit and Naiman (2007) describe a great variety of possible fire effects on riparian areas depending on position in the watershed; fire adaptation of dominant riparian plant species; time since previous fire, fuel loads, and fire intensity; post-fire flows; local geomorphology and topography; and pre- and post-fire management. They emphasize the "requirement for improved understanding of the natural recovery processes of riparian areas after fire." Intense fires that burn a high percentage of watersheds around low order streams present the greatest potential for long-term effects on those streams (Minshall et al., 1997). Short-term affects of increased stream flow energy and changed hydrology, geomorphology, and riparian communities (Arno and Allison-Bunnell, 2002) are likely to affect several aspects of the drainage system for longer periods (Gresswell, 1999). Channel changes to geometry due to incision and bank erosion result in changes to aquifer recharge, subsequent base-flow, and peak-flow discharge characteristics. Fire directly affects watershed and riparian vegetation and soils, and indirectly effects stream channels by changing water and sediment supply, and channel form, roughness and integrity (Debano and Neary, 1996). While it has been found in the moister climes of coastal northwest regions that fire severity and frequency are typically lower in riparian zones than uplands (Morrison and Swanson, 1990), drier forest types have generally similar frequencies between the two (Olson and Agee, 2005). Conversely, riparian zones can burn more frequently than uplands in some southwestern riparian habitats (Busch and Smith, 1993).

Many of the effects of fire on upland and riparian systems can significantly affect aquatic ecosystems both directly and indirectly (Minshall et al., 1997). Cold-water fish often listed as threatened or endangered are sensitive to habitat changes. Land management agencies monitor condition and trend of riparian attributes important to fish habitat and consider changes as either improvement or degradation (USFS, 1989). Management goals in many riparian areas focus on improving or at least not degrading fish habitat. Other important resource values will be higher when fish habitat condition is optimized (e.g., riparian physical functionality and various ecosystem services). Therefore, this study considers improvement and degradation of riparian systems with respect to fish habitat specifically and to resource values in general. Some management goals may not define these changes as such.

With evidence of both improving and degrading effects of fire on riparian areas in other regions, questions remain about fire's general effects and the variability of those effects on Great Basin riparian systems. How the resource is affected on mid-term management scales of about five years (after the resource has been given a chance to recover and is back in use) is not widely studied and not in the Great Basin. Knowledge of mid-term management scale responses is critical as they affect long-term management options. In view of the context with shrub dominated uplands, suspected increased woody fuel loads in riparian zones, and increasing fire size, we hypothesized consistent degradation to stream attributes after fire. To test our hypothesis, we compared pre- and post-fire attributes on forty three stream riparian areas burned in late-summer over a three-year period by fires of mixed severity across northern Nevada.

## 2. Study design

### 2.1. Area description

The northern Great Basin is a temperate desert with cold snowy winters and hot dry summers. The sagebrush (*Artemisia* sp. L.) dominated landscape features numerous north–south oriented fault block mountain ranges interspersed with wide valleys or basins (horst and graben). Bryce et al. (2003) described two level III ecoregions incorporating some 14 level IV ecoregions defined by physiography, elevation, geology, climate, vegetation and landcover that encompass these streams. It is not the intent of this study to relate this variability to the effects of fire, and it is assumed that the variability among these streams represents natural and management induced variability of the northern Great Basin in Nevada.

In the rain shadow of the Sierra Nevada and Cascade mountain ranges, Nevada has the lowest average precipitation of any state (241 mm/year). Most precipitation is deposited as snow, especially at higher elevations, and snowmelt with discharge from springs is the major water source for the streams of this study. Most streams in this region terminate in a closed basin.

The numerous wildfires of 1999, 2000, and 2001 burned over 1.1 million hectares (2.8 million acres) including creeks as shown in Fig. 1. Evaluated stations range in elevation from approximately 1560 to 2230 m (5100–7300 ft), slopes are from approximately 0.5–8.0%, and stream order from 1 to 3 (Strahler, 1964). About half of the streams are of a Rosgen (1996) "B" classification (moderate entrenchment and gradient; riffle dominated with infrequently spaced pools; stable plan, profile, and banks), 40% are "A" (steep, entrenched, cascading step/pool streams), "E" (low gradient; meandering riffle/pool; low width/depth ratio; high meander width ratio) and "F" (entrenched meandering riffle/pool channel; low gradient; high width/depth ratio) streams (near evenly distributed), 8% are "C" (low gradient; meandering, point-bar, riffle/pool, alluvial channels; broad, well defined floodplains) and 2% are