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Rim Recovery
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Re: Rim "Recovery" Logging Project

Dear Supervisor Skalski:

I offer the following scoping comments in response to the "Rim Fire Recovery (43033) Scoping Package" (SN) for the forthcoming EIS for the Rim Fire "Recovery" salvage logging project (Project) on the Stanislaus National Forest (SNF). My comments are based on my more than 30 years of professional experience and expertise on: a) the limits of effectiveness of fuel treatments (Rhodes and Baker, 2008[1]) and b) the cumulative effects on watershed and aquatic systems from postfire logging and associated activities (e.g., Beschta et al., 2004; Karr et al., 2004), roads,[2] livestock grazing (e.g., Rhodes et al. 1994;[3] Beschta et al., 2012) and mechanical fuel treatments (Rhodes et al., 2007).

It is critical that the SNF fully assess and disclose the many negative impacts of postfire salvage logging and associated activities, because it is well-established that these impacts significantly degrade forest ecosystems in a variety of ways that impede the postfire recovery of forested ecosystems. This has been described in Beschta et al. (1995), Karr et al. (2004), Beschta et al. (2004) and scientific work that followed (e.g., Lindenmayer et al., 2004; DellaSala et al., 2006; Donato et al., 2006; Hutto, 2006; Noss et al., 2006; Noss and Lindenmayer, 2006; Lindenmayer and Noss, 2006; Donato et al., 2013). Hutto (2006) noted:

> "Any postfire salvage logging operation that requires a consideration of the maintenance of biological diversity will have to deal with the facts associated with salvage logging, which are unprecedented in terms of how consistently negative the

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[1] Rhodes and Baker (2008) statistically analyzed of GIS data for more than 40,000 fires occurring over about 20 years in ponderosa pine forests on western USFS lands to quantitatively assess the regional probability of fire affecting treated areas during the window when fuels have been reduced in these forests, which provides an upper bound on potential fuel treatment effectiveness. Since publication, this paper has been repeatedly cited in peer-reviewed studies of: 1) fire frequency in forests (e.g., Williams and Baker, 2012), 2) the potential efficacy of fuel treatments (e.g., Price et al., 2012; Price, 2012), and 3) the impacts of wildfire and forest fuel treatments on forest carbon budgets (e.g., Law and Harmon, 2011; Campbell et al., 2011; Restaino and Peterson, 2013).

[2] The USFS's own synthesis of scientific information on roads (Gucinski et al., 2001) cites Rhodes et al. (1994) six times regarding the impacts of roads on soils, watersheds, and aquatic systems.

[3] Rhodes et al. (1994), which takes an in-depth look at grazing and road impacts on aquatic resources, was cited in USFS's scientific assessment of land management impacts on interior Columbia Basin national forests (USFS and USBLM, 1997a) more than nine times, primarily regarding the numerous aquatic and watershed impacts of roads and livestock grazing.

> ecological effects of salvage logging are…The ecological cost of salvage logging speaks for itself, and the message is powerful. I am hard pressed to find any other example in wildlife biology where the effect of a particular land-use activity is as close to 100% negative as the typical postfire salvage-logging operation tends to be."

The EIS must adequately describe proposal elements and their settings at the Project and watershed scales that affect watershed and aquatic resources and processes.

The proper disclosure and assessment of environmental impacts from proposed activities requires disclosure of the nature and location of the activities that affect their impacts. For instance, attributes that influence the duration and intensity of impacts from activities include those associated with soil types, terrain, etc. Therefore, the nature of the proposed activities and their physical contexts must be adequately described.

Roads and landings activities under the Project alternatives

The EIS must disclose the location and amount of all roads[4] and landings subject to haul, construction, reconstruction, use, and/or maintenance, including setting attributes that influence their direct, indirect, and cumulative impacts on watershed and aquatic resources and processes. It is well-established that roads profoundly affect hydrologic processes, including runoff, infiltration, water storage, and water routing to streams, soil erosion, and sediment delivery in an extremely persistent manner. Increased road use for log haul significantly elevates erosion and sediment delivery from roads, particularly when roads are wet (Reid et al., 1984; Foltz, 1996). Roads also have numerous enduring adverse effects on soils and soil processes that persistently degrade watershed hydrology. Landings impacts are akin to those of roads on a per unit area basis (Beschta et al., 2004). The USFS Region 5 Equivalent Roaded Area (ERA) model treats landing impacts as equivalent to roads on a per unit area basis (Menning et al. 1995). For these reasons, the amount of area affected by the road and landing activities must be thoroughly disclosed, including for each alternative.

The location and physical context of road and landing impacts strongly influence the ultimate impact on aquatic and watershed systems. For instance, it is well established that road and landing impacts on streams tend to increase in their severity and variety[5] with proximity to streams (USFS, et al., 1993; Rhodes et al., 1994). Therefore, these contexts of road and landing activities must be adequately disclosed for all alternatives.

The cumulative impacts of road and landing impacts accrue at the watershed scale. For this reason, road and landing activities and salient contexts must be adequately described at the scale of both the Project area and affected watersheds.

For the foregoing reasons, the EIS must disclose the following for all roads and landings subject to haul, construction, reconstruction, use, and/or maintenance at the Project and watershed scales:

- Total number and area of landings and roads affected by each activity (e.g. construction, haul, maintenance, etc.)

[4] In these comments, the term "roads" includes "temporary" roads. These roads have permanent adverse impacts. Only their use is temporary.

[5] For instance, roads within 40 feet of streams not only affect runoff and sediment delivery, but also permanently rob large woody debris and stream shading from affected streams.

- Total miles of affected roads, with landings area converted to road miles, because landings have impacts equivalent to roads on a per unit area basis
- Duration of activities (e.g. construction, use, etc); type, timing, and duration of treatment after use (e.g. abandonment, closure, long-term maintenance, etc.)
- Area and miles by burn severity class, soil type, and, erosion hazard class
- Level of hydrologic connectivity between the affected roads and landings and all perennial and non-perennial streams. If the SNF lacks field data on such connectivity for these roads and landings within the Project area, it must acknowledge this deficiency, but use a reasonable surrogate to estimate road-stream connectivity. For instance, the Clearwater National Forest (2003) noted that most roads within 300 ft of streams had some degree of stream connectivity.
- Miles and area of these roads and landings within 300 ft of all perennial and non-perennial streams due to their impacts on runoff and sediment delivery to streams
- Area and miles of these landings and roads within all RCAs due to their severe impacts on RCA functions (e.g. stream shade, coarse woody debris (CWD) provision, etc)
- Area and miles of these landings and roads within one site-potential tree height of all perennial and non-perennial streams, due to their enduring adverse impacts on CWD provision to streams
- Number and location of crossings of all perennial and non-perennial streams by affected roads

Again, it is critical that the foregoing be made known for all road and landing activities that contribute to watershed, soil, riparian, and aquatic degradation, including construction, reconstruction, haul (particularly during wet periods), and maintenance.

Proposed logging units and fuel treatment activities

The EIS must disclose the location and amount of proposed logging units and fuel treatments. These activities have numerous persistent negative effects on postfire recovery, hydrologic processes, soil conditions, erosion, and sediment delivery. Piling and burning has particularly severe impacts on soils and related hydrologic properties. These impacts vary with setting, location, and methods. For these reasons, the following must be disclosed for all logging units and fuel treatment activities at the scale of watersheds and the Project area.

- Number, location, and area of logging units and damaging fuel treatments, such as piling and burning
- Duration of logging activities and fuel treatments
- Area of fuel treatment and logging in burn severity classes, soil types, and erosion hazard classes
- Area within 300 ft of all perennial and non-perennial streams
- Area within RCAs
- Area within one site-potential tree height of all streams

- Number of and sizes of trees removed by unit and as a mean
- Volume of carbon pools and sources of wood removed due to the combined effect of fuel treatments and logging.

Postfire livestock grazing management

Livestock grazing impedes postfire recovery in numerous ways (Beschta et al., 2004; Karr et al., 2004; Dwire et al., 2006). Reducing its negative effects is one of the promising means of complementing postfire ecosystem recovery (Beschta et al., 2004; Karr et al., 2004). Livestock grazing also affects the achievement of the Purpose and Need espoused in the SNF's SN because livestock grazing adversely affects fuel conditions which alters natural fire regimes and forest structure (Savage and Swetnam, 1990; Belsky and Blumenthal, 1997; Swetnam and Betancourt, 1998; Baker, 2009; Beschta et al., 2012). Therefore, the EIS must describe and analyze postfire grazing management under the alternatives at the scale of the Project and watersheds.

- Number of years of postfire grazing rest required
- Number, location, and area of allotments
- Season of grazing and animal unit months on each allotment
- Miles of all perennial and non-perennial streams within allotments
- Area of RCAs within allotments
- Grazed area by burn severity class

The EIS must adequately make known existing conditions and ongoing activities at the project and watershed scales that cumulatively affect watershed, soil, riparian, and aquatic conditions, resources, and processes.

Roads, landings, and firelines not affected by the Project alternatives

Existing roads and landings that would not be affected by the proposed alternatives still have numerous persistent impacts that combine with those from proposed road activities to cumulatively damage a host of watershed, riparian, soil, and aquatic conditions. Firelines have significant soil, vegetation, and erosional impacts (Kattlemann, 1996; Beschta et al., 2004). Therefore, the following must be disclosed at the scale of watersheds and the Project area for all roads (whether open, closed, or temporary), landings, and firelines not subject to activities under the action alternatives:

- Number of landings; area and miles of landings, firelines and roads
- Area and miles in burn severity classes, soil types, and erosion hazard classes
- Level of hydrologic connectivity between roads, landings, and firelines and all perennial and non-perennial streams.
- Miles and area of these impacts within 300 ft of all perennial and non-perennial streams, due to their impacts on runoff and sediment delivery to streams

- Area and miles of these impacts within all RCAs, due to their severe impacts on RCA functions (e.g. stream shade, CWD provision, etc)
- Area and miles of these impacts within one site-potential tree height of all perennial and non-perennial streams because due to their enduring adverse impacts on CWD provision to streams
- Number and location of crossings of all perennial and non-perennial streams by roads and firelines

Existing aquatic conditions

Existing conditions strongly influence the overall cumulative impacts of watershed activities, particularly on aquatic biota and beneficial uses. Therefore, it is critical that the following aquatic conditions that are likely to be affected by action alternatives be properly described and analyzed at the Project and watershed scales.

- Pool volume, frequency, and quality
- Water temperatures
- CWD frequency
- Fine sediment conditions, including fine sediment levels in stream substrate, turbidity, and the fraction of pool volumes occupied by fine sediment
- Stream width/depth ratio
- Bank stability
- Stream shading
- Water quality impairments
- Beneficial uses and status
- Peak flow elevation
- Low flow/water supply issues

Existing watershed and riparian conditions

A number of watershed and riparian conditions significantly influence the cumulative impacts of alternatives on watershed, riparian, aquatic, and soil conditions and processes. These existing conditions must be adequately described and analyzed at the scale of watersheds and the Project area, including the following conditions.

- Road density, *including* landings, because numerous assessments have repeatedly found an inverse relationship between fish population status and road density, including USFS assessments (USFS and USBLM, 1997a; Gucinski et al., 2001). As the Plumas National Forest (PNF) (2010) noted: “Several studies have correlated road density or indices of roads to fish density or measures of fish diversity (Gucinski, et al. 2001). Impacts to fisheries include sedimentation of fines, changes in streamflow, changes in water temperature through loss of shade or changes in groundwater, migration barriers, introduction of exotic fish and…changes in channel geomorphology…"

- Road density, *including* landings, and past logging within RCAs, because these impacts strongly affect the functionality of RCAs
- Past logging
- Area and percent of area affected by past logging, roads, firelines, and landings within one site potential tree height of all streams, because these impacts influence aquatic CWD provision
- Area and percent of area affected by logging, roads, firelines, and landings within 300 ft of all streams, due to impacts on sediment delivery and runoff to streams
- Percentage of area grazed over the past 30 years at the scale of the Project area, watersheds, and riparian areas
- Status of grazed riparian areas
- Mining & other activities that may cumulatively affect aquatic systems
- Amount of past soil erosion and volume of wood removal over the past 30 yrs due to management activities
- Percentage of area with soils previously compacted by roads, grazing, logging, including within riparian areas

The EIS must thoroughly assess the direct, indirect and cumulative impacts due to activities under the alternatives, existing conditions, and ongoing activities on soil erosion and sediment delivery to stream systems at the scale of watersheds and the Project area.

Several aspects of the activities proposed in the SN will persistently accelerate soil erosion and sediment delivery, which is a concern for many reasons, including effects on soils, ecosystem function, postfire recovery, water quality and a wide variety of downstream beneficial uses (Waters, 1995; Reid, 1998; 1999; Beschta et al., 2004). It is critical that EIS adequately assesses all sources of management-induced erosion and sediment delivery, because these sources are the most amenable to management control.

The EIS must disclose the magnitude and duration of management-induced sources of elevated erosion and sediment from existing conditions and proposed activities in order to provide managers and the public with a notion of their combined magnitude. The EIS must provide discrete estimates of erosion and sediment delivery from existing conditions, including the existing road network and landings, firelines, and past livestock grazing, as well as sediment-generating activities proposed under action alternatives, such as road and landing activities, logging, fuel treatments, and/or grazing.

Management-induced acceleration of erosion and sediment delivery, caused by roads and landings, is enduring (Gucinski et al., 2001; Beschta et al., 2004; Robichaud et al., 2010). Livestock grazing also persistently elevates erosion and sediment delivery. In contrast, erosion and sediment delivery elevation by wildfire is relatively transient. For these reasons, the EIS must provide estimates of management-induced erosion and sediment delivery over a reasonable timeframe (e.g. 10 to 20 years) in order to reasonably elucidate the nature of impacts associated with the alternatives. For instance, the USFS's own assessment of fuel treatment impacts on watersheds (Robichaud et al., 2010) noted (emphasis added):

> "…the cumulative impacts of fuel treatments, repeated at 10-20 year intervals, when combined with the impacts of continuous road maintenance and use, may be similar to the pulse impact from wildfires."

Sediment delivery affects a wide variety of stream conditions and aquatic biota at the scale of watersheds. Sediment-related impacts at the Project scale affect not only these conditions and biota, but also downstream water uses. Therefore, the EIS must provide thorough and complete estimates of the magnitude and duration of elevated erosion caused activities under the action alternatives together with that from existing management at the scale of watersheds and the Project area.

Road and landing activities under the alternatives

A variety of road activities persistently affect erosion and sediment delivery. The construction, reconstruction, and elevated use of roads greatly increase erosion and consequent sediment delivery (Gucinski, 2001; Beschta et al., 2004; Karr et al., 2004). Road construction causes particularly profound increases in erosion and sediment delivery. Landing construction has similar impacts to those of roads in severity and persistence (Menning et al., 1996; Beschta et al., 2004). Notably, in a study of sediment plumes from roads and landings, the longest travel distance of a sediment plume was from a landing (Ketcheson and Megahan, 1996). Landings activities are critical to assess because landings affect a significant amount of logged area, typically occupying 1-2% of the area logged.

Research has consistently shown that elevated road use for timber haul significantly increases road erosion and the delivery of sediment to streams (Reid and Dunne, 1984; Beschta et al., 2004; Foltz, 1996), even when road aggregate is used in an attempt to reduce road erosion (Foltz, 1996; Luce and Black, 2001). The USFS own summary of scientific information on roads (Gucinski et al., 2001) noted: "rates of sediment delivery from unpaved roads are...closely correlated to traffic volume." Road use during wet weather significantly increases the impact of elevated road use on erosion and sediment delivery still more (Burroughs, 1990; Foltz and Burroughs, 1990; Reid, 1998; 1999; Gucinski et al., 2001). Road maintenance, such as blading and ditch cleaning, significantly elevates road erosion and sediment delivery (Luce and Black, 2001; Sugden and Woods, 2007; Robichaud et al., 2010). All of these impacts must be properly factored into the analyses of the impacts of action alternatives on erosion and sediment delivery.

The estimates of erosion and sediment delivery due to road and landing activities must also account for their connectivity with streams. Erosion from roads is delivered quite efficiently at streams at points that are hydrologically connected to streams (Kattlemann, 1996; PNF, 2010). This is significant because in most watersheds, much of the road network is hydrologically connected to streams (Kattlemann, 1996; Wemple et al., 1996; Great Lakes Environmental Center (GLEC), 2008). Sediment delivery from roads is particularly high at stream crossings, where little can be done to prevent sediment delivery (Kattlemann, 1996; Rieman et al., 2003; PNF, 2010). The fraction of roads hydrologically connected to streams tends to be greatest for roads relatively near streams (Wemple et al., 1996; Rhodes and Huntington, 2000). CNF (2003) noted that roads within

300 feet of streams likely contribute some runoff and sediment to streams. However, roads are also directly connected to streams by gullies, drainage diversions to hillslopes, and ditchlines over considerable distances (Wemple et al., 1996; GLEC, 2008), as USFS assessments have acknowledged (Gucinski et al., 2001; PNF, 2010). USFS and USBLM (1995) noted that channelized flows of water and sediment, such as those in gullies below road ditch drainage features, can travel several hundred feet downslope. This connectivity must be assessed for all streams whether perennial or non-perennial, because smaller headwater streams cumulatively supply most of the sediment to downstream reaches (CWWR, 1996).

Sediment detention below road runoff diversions is limited and quickly exhausted, resulting in the delivery of sediment to streams from road runoff diversions near streams, as noted in the USEPA-commissioned assessment of road Best Management Practices (BMPs) and the water quality impacts of roads (GLEC, 2008). Thus, efforts to disconnect roads that are relatively proximate to streams are often ineffective. Therefore, the EIS must factor in the very limited ability to hydrologically disconnect roads and landings from streams into estimates of sediment delivery from management-induced road and landing activities proposed under action alternatives.

If the SNF lacks reliable field data on hydrologic connectivity, it must clearly acknowledge this, but use some reasonable surrogate, such as CNF (2003). MacDonald and Larsen (2009) provide an approach that can be used to estimate road-stream connectivity, based on its relationship to mean annual precipitation.

The EIS must also properly assess the persistence of greatly elevated erosion and sediment delivery from all roads constructed under the alternatives, including those that are temporarily used and ultimately decommissioned. Even many decades after obliteration, erosion rates on roads remain well above natural rates, as indicated by the USFS ERA cumulative effects method coefficients (Menning et al., 1996).[6] The USFS's own research (Foltz et al., 2007) demonstrates that infiltration and vegetative recovery, which are both key to erosion and sediment delivery recovery, is exceedingly minor for several years after such treatment. Therefore, road decommissioning does not rapidly produce significant reductions in erosion and sediment delivery. Instead, over the course of a decade, reductions in these impacts are nominal on decommissioned roads. It is unknown if decommissioned roads ever fully recover the properties that affect erosion and sediment delivery (Foltz et al., 2007). As we noted in Beschta et al. (2004):

> "Accelerated surface erosion from roads is typically greatest within the first years following construction although in most situations sediment production remains elevated over the life of a road (Furniss et al. 1991; Ketcheson & Megahan 1996). Thus, even 'temporary' roads can have enduring aquatic impacts. Similarly, major reconstruction of unused roads can increase erosion for several years and potentially reverse reductions in sediment yields that occurred with non-use (Potyondy et al. 1991). Where roads are unpaved or insufficiently surfaced with erosion resistant aggregate, sediment production typically increases with increased vehicular usage (Reid & Dunne 1984)…Furthermore, the assumption that road obliteration or BMPs will offset the negative impacts of new road and landing construction and use is unsound since road

[6] USFS and USBLM (1997c) notes that the approach in Menning et al. (1996) regarding the road-related cumulative impacts to watersheds provides an index that is consistent with the USFS's experts' assessments of the sediment-related risks from these activities.

> construction has immediate negative impacts and benefits of obliteration [or decommissioning] accrue slowly."

For these reasons, the EIS's estimates of the impacts of road activities on erosion and sediment delivery must address the persistence of these impacts, including those from decommissioned roads.

Roads, firelines, and landings not affected by the Project alternatives

Elevated erosion and sediment delivery from roads and landings are extremely persistent. Whether open, closed, recently decommissioned, abandoned, or unused, the existence of these roads and landings generate accelerated erosion and sediment delivery that combines with that from road and landing activities to cumulatively affect sediment-related conditions in streams. Therefore, the EIS must assess the erosion-related impacts from these roads, firelines, and landings at the scale of watersheds and the Project area in order to properly assess cumulative impacts on sediment-related stream conditions. The estimates of erosion of sediment delivery for these roads and landings must incorporate the factors discussed in the previous section: stream proximity, stream connectivity, persistence, the limited ability to hydrologically disconnect these impacts from streams, and the nominal accrual of reductions in erosion over time with decommissioning or abandonment.

Logging and fuel treatments

Logging inevitably increases soil erosion and stream sedimentation, regardless of how carefully it is designed and implemented, as the USFS has concluded (USFS and USBLM, 1997a; c). Chase (2009) documented that postfire logging elevated sediment production considerably in the Sierra Nevada. Unsurprisingly, the prime mechanism for the increased sediment delivery was the reduction in groundcover caused by logging (Chase, 2009).

Groundcover especially that from live vegetation, is a key concern in postfire landscapes, because it strongly influences soil erosion (Kattlemann, 1996; Beschta et al., 2004). Postfire logging significantly reduces postfire groundcover by destroying live vegetation, setting back natural postfire regeneration of conifers (Donato et al., 2006), disrupting duff layers, and removing future sources of needles and woody material that ultimately fall to the forest floor and provide important groundcover after fire (USFS and USBLM, 1997a; AGU, 2003; Pankuk and Robichaud, 2003). Rhodes (2003) documented that unlogged burned areas had far higher groundcover than areas subjected to postfire logging in the Sierra Nevada (Rhodes, 2003).

Fuel treatments often elevate soil erosion. Machine piling of slash and other fuel materials has severe impacts on soil productivity via compaction, soil disruption, and removal of vegetation and groundcover. On a per unit area basis, the soil disturbance caused by impacts of machine piling are only rivaled by the construction of roads and landings, based on the Region 5 ERA model coefficients (Menning et al., 1996).

Piling and burning sets back the postfire recovery of vegetation, which is the most effective form of soil cover for reducing erosion, and thwarts revegetation by removing organic matter and nutrients, and sterilizing soils beneath the piles (Kauffman, 2004; Korb et al., 2004; DellaSala, 2006; Rhodes 2007). The soil damage under burned piles is so intense and enduring that burn scars often remain persistently unvegetated or occupied only by undesirable, and often invasive, weeds (Korb et al., 2004; Rhodes, 2007).

Activities that retard the recovery of native vegetation after fire can cause erosion that is greater than that from fire alone (Kattlemann, 1996). Due to the importance of groundcover, and, especially that from living vegetation, the EIS's estimates of logging and fuel treatment impacts on erosion and sediment delivery must reflect the degree, extent, and persistence of the loss of groundcover under any alternatives that include these activities.

Livestock grazing impacts

The effects of livestock grazing on erosion and sediment delivery must be properly assessed in the EIS because it has numerous impacts that combine with the impacts of logging, roads, and landings on soil erosion and sediment delivery (Reid, 1993; Rhodes et al., 1994; Henjum et al., 1994; Beschta et al., 2012). These impacts are significant due to the area affected by grazing: it is the most pervasive extractive land use on Sierra Nevada public lands (CWWR, 1996).
The EIS must make known that grazing persistently elevates erosion-related impacts in many ways. Livestock grazing greatly increases soil compaction, which reduces soil productivity and alters the hydrologic properties of soils (Platts, 1991; Rhodes et al., 1994; CWWR, 1996; Belsky and Blumenthal, 1997; USFS and USBLM, 1997a; b; Kauffman et al., 2004), increasing surface runoff and thereby increasing soil erosion. Such compaction is inevitable, because cattle hooves exert more than five times the pressure on soils than does a large bulldozer (Beschta et al., 2012), as the USBLM has acknowledged (Cowley, 2002).

Livestock grazing also elevates soil erosion by reducing groundcover (Platts, 1991; Fleischner, 1994; Rhodes et al., 1994; Beschta et al., 2012). Grazing impacts on sediment delivery are intense because they are typically most profound in riparian areas (CWWR, 1996; Beschta et al., 2012). Grazing in riparian areas increases bank and channel erosion and resultant sediment delivery by destabilizing banks via trampling and vegetation impacts (Platts, 1991; Belsky et al., 1999; Beschta et al., 2012). As USFS and USBLM (1997a) noted:

> "Grazing is a major nonpoint source of channel sedimentation (Dunne and Leopold 1978; MacDonald and others 1991; Meehan 1991; Platts 1991). Grazed watersheds typically have higher stream sediment levels than ungrazed watersheds (Lusby 1970; Platts 1991; Rich and others 1992; Scully and Petrosky 1991). Increased sedimentation is the result of grazing effects on soils (compaction), vegetation (elimination), hydrology (channel incision, overland flow), and bank erosion (sloughing) (Kauffman and others 1983; MacDonald and others 1991; Parsons 1965; Platts 1981a; 1981b; Rhodes and others 1994). Sediment loads that exceed natural background levels can fill pools, silt spawning gravels, decrease channel stability, modify channel morphology, and reduce survival of emerging salmon fry (Burton and others 1993; Everest and others 1987; MacDonald and others 1991; Meehan 1991; Rhodes and others 1994)...Compared to ungrazed sites, aquatic insect communities in stream reaches associated with grazing activities often are composed of organisms more tolerant of increased silt levels, increased levels of total alkalinity and mean conductivity, and elevated water temperatures..."

Postfire grazing also stunts the recovery of riparian vegetation that is vital to the recovery of sediment regulation in streams after fire (Dwire et al., 2006). For these reasons, livestock grazing effects on erosion and sediment delivery must be assessed in order to properly assess the cumulative impacts of the alternatives on erosion, sediment delivery and sediment-related aquatic impacts, including water quality.

The EIS must disclose that the ERA method often used in USFS Region 5 is inadequate with respect to accounting for the pervasive and significant cumulative watershed damage caused by livestock grazing. The ERA method does not incorporate the cumulative watershed impacts caused by livestock grazing in estimating ERA levels (Reid, 1993; Menning et al., 1996), nor does the model account for the actual contributions of grazing to erosion and sediment delivery.

Aquatic impacts of elevated sediment delivery

The EIS must fully make known the cumulative effects of the alternatives and existing conditions effects on erosion, sediment delivery, and its aquatic impacts. Elevated sediment delivery has numerous negative impacts on aquatic systems (Waters, 1995; Beschta et al., 2004). These include water quality degradation from increases in turbidity (Reid, 1999), increases in fine sediment in streams (Rhodes et al., 1994), reductions in the quality and volume of pools (Lisle and Hilton, 1992; Rhodes et al., 1994; McIntosh et al., 2000), and increases in stream width/depth ratios in depositional streams (Richards, 1982; Rhodes et al., 1994; Dose and Roper, 1994). All of these impacts negatively affect salmonids and other sediment-sensitive aquatic biota (Meehan, 1991; Waters, 1995; USFS and USBLM, 1997a; b; c; Karr et al., 2004; Beschta et al., 2004). For instance, PNF (2010) correctly noted with respect to fish, “Increases in stream sediments have been correlated with decreased fry emergence, decreased juvenile densities, loss of winter carrying capacity, and increased predation of fish.”

The persistent chronic sediment delivery from management activities typically can have greater negative effects on aquatic systems than the pulsed sediment delivery from fire accompanied by CWD recruitment, which rejuvenates aquatic habitats (Rieman et al., 2003; Karr et al., 2004). Elevated sediment delivery to streams also reduces downstream reservoir storage via sedimentation, resulting in water supply impacts.

Increases in stream width/depth ratios caused by increased sedimentation increase water temperatures even in the absence of shade loss (Bartholow, 2000; Beschta et al., 2004). Elevated sedimentation and water temperatures are some of the most pervasive problems afflicting streams draining USFS lands in the Sierra Nevada (CWWR, 1996; USFS, 2000).

For these reasons, it is critical that the EIS reasonably describes the effects of sediment delivery from the Projects’ activities on aquatic systems for each alternative at the scale of watersheds and the Project area. This must include the direct, indirect and cumulative effects of the alternatives, existing conditions, and ongoing activities on turbidity, sedimentation, fine sediment in stream substrate, pool conditions, stream width/depth ratios, water temperature, and sediment-sensitive aquatic biota based on available scientific information. As previously discussed, existing sediment-related conditions exert a strong influence on the significance of impacts, therefore EIS must describe the existing conditions of aquatic elements and processes affected by sediment delivery, including turbidity, sedimentation, fine sediment in stream substrate, pool conditions, stream width/depth ratios, water temperature, and sediment-sensitive aquatic biota status and factor these into a proper assessment of cumulative aquatic impacts.

The SNF must properly analyze and describe the impacts of the proposed alternatives, together with those from existing conditions and ongoing activities, on riparian areas and their functionality, including CWD provision to streams, water temperature and resulting impacts on watershed and aquatic systems.

Riparian areas are vital to aquatic systems in general (CWWR, 1996; Moyle et al., 1996; Erman et al., 1996; National Research Council (NRC) 2002), but they are a major postfire concern with respect to the recovery of aquatic ecosystems (Kattlemann, 1996; Lindenmayer et al., 2004; Beschta et al., 2004; Karr et al., 2004; DellaSala et al., 2006; Halofsky and Hibbs, 2009). Some of the key functions of riparian areas for aquatic ecosystems include the regulation of sediment flux and runoff, stream shading vital to water temperature moderation, maintenance of channel conditions and water quality, and the provision of CWD essential to channel complexity and instream sediment storage. The degradation of riparian areas degrades these functions and instream conditions, harming instream habitats and aquatic biota. For these reasons, the EIS must disclose that damage to riparian areas and their functions is in direct conflict with postfire recovery of aquatic conditions (Karr et al., 2004; Beschta et al., 2004; Noss et al., 2006). These significant impacts must be adequately described. The EIS must also acknowledge that in the absence of degradation from postfire management insults, riparian systems recover quickly without intervention after fire, indicating are they are fire-adapted and resilient (Halofsky and Hibbs, 2009).

Riparian areas and aquatic impacts

The scientific literature demonstrates that grazing, logging, roads, and landings in riparian zones degrade aquatic systems in many ways (Rhodes et al., 1994; CWWR, 1996; Erman et al., 1996; Moyle et al., 1996; National Research Council (NRC) 2002; Beschta et al., 2004; Karr et al., 2004). Unfortunately, riparian areas are one of the most pervasively degraded features on public lands in the Sierra Nevada (CWWR, 1996). Therefore, it is essential that EIS reasonably describe existing riparian conditions and the existing cumulative impacts on them, as well as the impacts of activities in each alternative on riparian areas and aquatic systems.

At a minimum, the EIS must describe the extent and nature of past and on-going impacts to riparian areas, including the existing road miles, area of landings, occupation by firelines, stream crossings by roads, logged area, and grazed areas in riparian zones. The EIS must properly make known all of the impacts of livestock grazing on riparian areas that combine with other impacts to cumulatively afflict riparian areas and aquatic systems, including soil compaction, loss of soil productivity, elevated erosion and sediment delivery, the spread and establishment of noxious vegetation, loss of bank-stabilizing riparian vegetation, and reduced stream shade (Platts 1991; Reid, 1993; Fleischner, 1994; Rhodes et al., 1994; Belsky et al., 1999; Beschta et al., 2004; Beschta et al., 2012).

Similarly, the EIS needs to disclose the amount of riparian area exposed to grazing, logging (by logging method), and road and landing activities under each alternative. The EIS also needs to disclose that postfire logging, livestock grazing, and road and landing construction and reconstruction activities in riparian areas are not consistent with unimpeded postfire recovery of aquatic ecosystems (Karr et al., 2004; Beschta et al., 2004).

There is compelling scientific information indicating that the width of protected areas around streams should be considerably wider than that afforded by the SNF's RCAs in order to protect aquatic systems from further degradation. In particular, the SNF's RCAs on smaller headwater streams are too narrow to reasonably protect aquatic systems from additional damage (Rhodes et al., 1994; Erman et al., 1996; Moyle et al., 1996). Headwater streams, including non-perennial ones, exert a powerful control on downstream conditions because they supply the bulk of streamflow and material transfers to downstream reaches (Rhodes et al., 1994; Erman et al., 1996; Moyle et al., 1996, USFS and USBLM, 1997a). These smaller streams are also more susceptible to degradation from upslope activities (USFS and USBLM, 1997a). Therefore, these smaller streams must be afforded adequate protection, as great as or greater than that afforded to larger streams, in order to protect downstream aquatic conditions (Rhodes et al., 1994; Erman et al., 1996; Moyle et al., 1996; USFS and USBLM, 1997a). The EIS must disclose this information regarding the inadequacy of the RCAs.

CWD

There is no question that CWD is a critical component of riparian areas and aquatic systems (USFS et al., 1993; CWWR, 1996; Moyle et al., 1996; USFS and USBLM, 1997a; b; c; Beschta et al., 2004; Karr et al., 2004). Therefore, the EIS must describe existing riparian and instream CWD levels and how they have been affected by past and on-going management activities. For instance, roads and landings within one site-potential tree height of streams permanently truncate CWD provision to streams.

The EIS must also describe how the alternatives will affect future CWD recruitment in riparian areas and to streams. This is especially critical in the postfire landscape, because burned riparian areas provide a bonanza of CWD recruitment to streams and riparian areas; removal of trees within one tree height robs streams of this periodic bonanza. Noss et al. (2006) noted “Dead wood, including large snags and logs, rivals live trees in ecological importance.” This is certainly the case in riparian areas due their importance for CWD provision (Karr et al., 2004).

Therefore, the EIS must disclose the magnitude of the loss of CWD due to logging and road and landing construction within one tree height on all streams under alternatives that propose such activities. The EIS must also disclose that such losses are irretrievable and take centuries for recovery. In the case of roads and landings, CWD is not only irretrievable, but recovery of CWD provision will never occur for as long as roads exist. Even many decades after decommissioning, recovery of CWD provision will take even longer than after logging due to the permanent loss of soil productivity.

CWD plays a major role in the creation and maintenance of pools and channel complexity. Therefore, the EIS must also examine and describe the effects of the alternatives and cumulative impacts on pool conditions and channel complexity due to CWD loss and cumulative sediment delivery impacts. The EIS must also properly examine and make known how the cumulative effects on CWD affect aquatic biota.

Water temperature

Riparian areas are important for moderating stream temperatures via shading and microclimate maintenance (USFS et al., 1993; Rhodes et al., 1994; CWWR, 1996; NRC, 2002). Therefore, the EIS must describe how existing riparian conditions that affect water temperature regulation have been affected by past and on-going management activities, including the removal of shade-providing vegetation by logging, grazing, firelines, roads and landings at the scale of watersheds.

The EIS must also describe how the alternatives are likely to affect future shade and microclimate regulation in riparian areas and resulting cumulative impacts on water temperatures via the removal of riparian trees via logging, landings, and roads.

For both existing conditions and in the assessment of the alternatives' impacts on water temperature, the EIS must also factor in the following:

- Stream temperatures are elevated by road runoff from summer rain events delivered at stream crossings and other points that are hydrologically connected to streams (NRC, 2008). Runoff from roads occurs in response to even small precipitation events and this runoff is heated by warm road surfaces during summer. Notably, this thermal pollution from roads occurs when streams are already warm due to seasonal effects, elevating the adverse impacts on salmonids (Meehan, 1991; Rhodes et al., 1994; McCullough, 1999).

- Stream crossings, particularly by fords, cause the loss of shade-providing native riparian vegetation, increasing water temperatures.

- Riparian roads reduce subsurface baseflow contributions due to the shunting of precipitation as overland flow, coupled with the loss of water storage due to compaction, together with the interception of subsurface flows (Rhodes et al., 1994; Tague and Band, 2001; Hancock, 2002). These are serious impacts because subsurface flow contributions are typically cooler than streamflows during the critical summer period and, thus, are critical to the moderation of summer high water temperatures (Rhodes et al., 1994, Moore et al., 2005; Pollock et al., 2009).

- Roads and logging within riparian areas impair their microclimatic functions that help moderate stream temperatures (USFS et al., 1993; Moore et al., 2005).

- Roads and landings within about 100 feet of streams and stream crossings also contribute to stream temperature elevation via the removal of stream shading and the prevention of recovery of shading by vegetation for even longer than roads exist due to long-term adverse impacts on revegetation after abandonment or decommissioning.

- The impacts of livestock grazing elevate stream temperatures by widening streams and the elimination and reducing stream shading by vegetation. Livestock grazing stunts postfire riparian vegetation recovery (Dwire et al., 2006) critical to water temperature recovery after fire.

- Channel widening due to elevated peak flows and/or sedimentation increases stream temperatures (Bartholow, 2000).

- Field research on the effects of road density and density of stream crossings in multiple watersheds have verified that stream temperatures increase with increasing density of roads and stream crossings (Nelitz et al., 2005). This is likely due to the combined impacts of roads and road crossings on water temperatures, including shade loss, subsurface flow disruption, channel widening, and warmed road runoff contributions.

- Increased water temperatures profoundly affect the production and survival of salmonids (McCullough, 1999) and other aquatic stenotherms.

- Water temperatures affect compliance with water quality standards.

- Water temperature impacts in streams that are upstream of occupied fish habitat cumulatively affect downstream water temperatures in occupied fish habitat (Allen and Dietrich, 2005).

The SNF must properly analyze and describe the cumulative impacts on soils from existing conditions in combination with proposed activities.

Soils are a fundamental component of forested ecosystems that strongly influence hydrologic processes, water quality, and forest vegetation (Beschta et al., 2004). Logging and associated activities, such as the use and construction of roads and landings, persistently damage soils in several ways (Karr et al., 2004; DellaSala et al., 2006). These impacts are especially serious after fire and can last for a century or more (Beschta et al., 1995; 2004; Karr et al., 2004; DellaSala et al., 2006). Therefore, it is essential that the Projects' cumulative impacts on soils be thoroughly assessed and described.

Woody material, organic matter, nutrients, soil productivity, and watershed scale soil water storage

Organic matter is a key soil component, affecting productivity and important hydrologic properties. Woody debris, especially large CWD, is a critically important source of organic matter (Beschta et al., 1995; 2004; USFS and USBLM, 1997a; b; Karr et al., 2004). Salvage logging greatly reduces CWD sources and other woody material (Beschta et al., 1995; 2004; Karr et al., 2004; DellaSala et al., 2006), as documented in the Sierra Nevada (Powers et al., 2013).[7] USFS and USBLM (1997a; b) noted that the loss of CWD from salvage logging typically has greater and more enduring negative impacts on soils than wildfire. Noss et al. (2006) noted that after fire dead trees, including large trees and snags, are ecologically important and that their removal "…is inconsistent with scientific understanding of natural disturbance regimes and short- and long-term regeneration processes."

Therefore, the EIS must reasonably quantify the magnitude of the reduction in woody material volume, including CWD, due to all activities that involve the removal of trees and other sources of organic matter, the construction of landings and roads, piling and burning, and efforts to control native brush. The long-term persistence of these impacts on soils and soil productivity must also be described. Since existing conditions are essential to reasonably assessing the significance of additional impacts, the EIS must also describe existing wood conditions and the degree to which these have been reduced by tree removal activities throughout the Project area.

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[7] Total carbon storage likely provides an index of the amount of soil organic matter sources. Powers et al (2013) found that postfire salvage logging reduced the mean magnitude of the total ecosystem carbon storage by more than 50% relative to an unlogged burned area.

As part of disclosing these effects on soils, the EIS must disclose the extent of the area with reduced soil productivity due to the removal of woody material under each alternative. It also needs to provide a reasonable estimate of the loss of nutrient capital from loss of wood by alternative.

Native brush provides an important source of soil nutrients and organic matter. A 35-year USFS study (Busse et al., 1996) of the effect of brush control on ponderosa pine showed that complete brush removal did not increase the growth of ponderosa pines older than 20 years old. Instead, soils with unmolested native brush had higher soil productivity than under soils where brush had been removed. Busse et al. (1996) concluded, "A long-term benefit to upper soil horizons is associated with maintaining understory vegetation." Beschta et al. (2004) noted, "… onsite impacts to early successional native plant species during postfire logging, where such species are nitrogen-fixers, can significantly affect a major pathway of nutrient replenishment in the postfire environment." This plainly indicates that brush removal as part of efforts to control "competing" vegetation will cause long-term damage to soil productivity. Therefore, the EIS must fully describe the loss of woody material, organic matter, and nutrients due to brush removal as part of proposed efforts to control "competing vegetation."

The EIS must disclose that the loss of soil productivity caused by the construction of landings and roads is severe and extremely enduring (Karr et al., 2004; Beschta et al., 2004), even for "temporary" roads and landings (Beschta et al., 2004). As the USFS has acknowledged, soil productivity cannot ever be completely restored in areas where "temporary" roads and landings have been constructed, even with remediation (Bitterroot National Forest, 2001; Rogue River-Siskiyou National Forest, 2003). The USFS's own research indicates that infiltration rates on decommissioned roads exhibit nominal recovery over the course of several years and that it is unknown if such roads ever fully recover (Foltz et al., 2007).

The EIS must also disclose that leaving soils undisturbed is the most effective approach to maintaining and restoring soil productivity after fire. Available scientific information clearly indicates that one of the most effective steps to restoring soil productivity after fire is to retain *all* sources of wood recruitment to soils and to leave areas *undisturbed* until they have recovered (Kattlemann, 1996; USFS and USBLM, 1997a; Beschta et al., 2004).

Organic matter sources for soils are also a major concern due to climate-related impacts on streamflow. Low flows are likely to decrease due to several climate-related impacts. Water stored in soils is the primary source of streamflow generation during low flow periods (Kirkby, 1978). Thus, maintaining and restoring water storage capacity in soils at the scale of watersheds is critical to contribute to watershed resilience under climate change, while the loss of water storage capacity in soils will exacerbate climate-induced changes to low flows. It has long been known that other factors remaining equal, soils with higher organic matter content are able to store more water than soils with lower levels of organic matter. Soil organic matter strongly influences infiltration rates, which can affect the amount of water stored in soils at the watershed scale. Therefore, the EIS must assess these impacts under the alternatives including their consistency with adaptation under climate change and the goal of resilient watersheds.

Soil compaction, disruption, and water storage capacity in soils

Salvage logging and associated activities greatly increase soil compaction and disruption. This reduces soil productivity, decreases infiltration rates, elevates surface runoff, and contributes to increased topsoil erosion. These impacts of soil compaction not only degrade forest soils, but also contribute to the degradation of aquatic systems (Kattlemann, 1996; Beschta et al., 2004; Karr et al., 2004; DellaSala et al., 2006). Therefore, the EIS must adequately assess and describe the extent and likely degree of soil compaction caused by activities under each alternative, including logging, road and landing activities, efforts to control native brush, and fuel treatments.

Soil compaction is a widespread problem on USFS lands in the Sierra Nevada (CWWR, 1996). Because soil compaction typically persists for at least 50-80 years (Beschta et al. 2004), compaction impacts are highly cumulative. Therefore, the EIS must also disclose the persistence of soil compaction caused by past activities, including the extent and intensity of existing soil compaction within the Project areas caused by past and on-going activities, such as landings, roads, past logging and past and livestock grazing, which significantly compacts soils (CWWR, 1996; Belsky and Blumenthal, 1997; Kauffman et al., 2004; Beschta et al., 2012).

Soil compaction unquestionably reduces the ability of soils to store water, which makes it a significant concern due to climate-related impacts on streamflow. As previously discussed, low flows are likely to continue to decrease due to several climate-related impacts. Because water stored in soils is the primary generator of streamflow during low flow periods, maintaining and restoring water storage capacity in soils at the scale of watersheds is critical to contribute to watershed resilience under climate change, while the loss of water storage capacity in soils will exacerbate climate-induced changes on low flows.

Compaction also significantly reduces infiltration rates. Reductions in infiltration rates can influence the amount of water stored in soils because when snowmelt or rainfall rates exceed infiltration rates that have been reduced via compaction, the water is shunted as surface runoff rather than going into soil water storage. Notably, roads and grazing cause particularly profound and enduring reductions in infiltration rates (see Figure 1). For these reasons, the EIS must assess these compaction-related impacts under the alternatives, including their consistency with adaptation under climate change and the goal of resilient watersheds. The EIS must also disclose the cumulative loss of available water storage due to existing conditions combined with the impacts of the action alternatives.

Hydrophobic soils, infiltration rates, fire, and water storage capacity in soils

Any assessment of existing or potential future occurrence of hydrophobic (aka water repellant) soils must do so within the framework of six critical contexts. First, fire, even when it is of high severity, does not consistently cause hydrophobicity (Beschta et al., 2004; Wondzell and King, 2003).

Second, field evidence demonstrates that hydrophobicity in forest soils occurrence is commonly unrelated to fire (Doerr et al., 2009). Regarding the occurrence of these soils, Doerr et al. (2009) noted:

> "…high levels of repellency have also been reported under vegetation types not affected by fire, and the question arises to what degree the water repellency observed at burnt sites actually results from fire…'Natural background' water repellency… was detected …at 75% of all sites examined irrespective of dominant tree species (*Pinus ponderosa, Pinus contorta, Picea engelmanii* and *Pseudotsuga menziesii*). These findings

> demonstrate that the soil water repellency commonly observed in these forest types following burning is not necessarily the result of recent fire but can instead be a natural characteristic. The notion of a low background water repellency being typical for long-unburnt conifer forest soils of the north-western USA is therefore incorrect. It follows that, where pre-fire water repellency levels are not known or highly variable, post-fire soil water repellency conditions are an unreliable indicator in classifying soil burn severity."

These findings indicate that burn severity is an unreliable predictor of hydrophobic soils and that the existence of hydrophobic soils after fire cannot be reliably ascribed to fire impacts.

Third, postfire hydrophobic soil conditions are transient, abating once soils are wetted, sometimes lasting only a few months, and seldom lasting more than two years. Hydrophobicity declines with time and moisture content.

Fourth, in contrast to hydrophobic soils, reductions in infiltration rates due to compaction on roads and landings are highly persistent, never recovering for as long as roads and landings exist. Even several years after subsoiling, infiltration rates remain severely reduced relative to undisturbed soils (Foltz et al, 2007). Reductions in infiltration rates due to compaction by grazing are also highly persistent (CWWR, 1996; USFS and USBLM, 1997a; Beschta et al., 2004; 2012). Infiltration rates are unlikely to begin to recover until grazing is ceased.

Fifth, available data indicate that grazing and roads not only reduce infiltration rates more persistently than fire sometimes might, but that grazing and roads cause far larger reductions in infiltration rates than do hydrophobic soils. Severe fire can temporarily reduce infiltration rates by about 50% *if* hydrophobic soils develop in response to fire (Wondzell and King, 2003). In contrast, grazing and roads persistently reduce infiltration rates by about 85% and 95-99%, respectively (Figure 1). Due to the extremely low infiltration rates on roads, they generate surface erosion and runoff in response to frequent, low-intensity rainfall and snowmelt events, for as long as the road exists, resulting in persistent and chronic degradation of water quality and aquatic habitats. This is not the consistent case when fire causes hydrophobic soils to develop temporarily (Wondzell and King, 2003) and fire does not always cause hydrophobic soils (Wondzell and King, 2003; Beschta et al., 2004; Doerr et al., 2009).

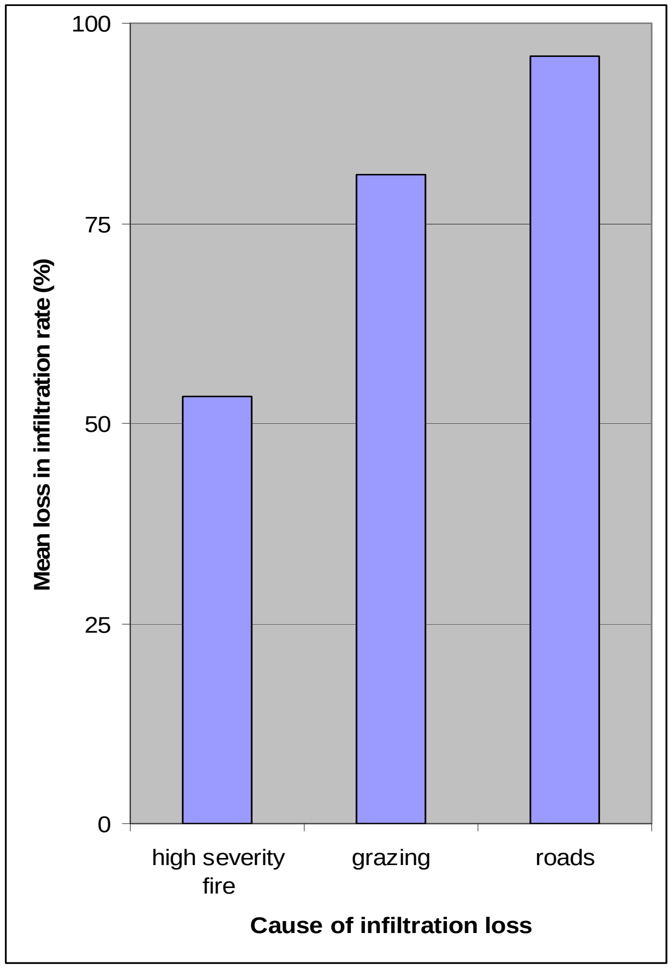

Figure 1. Measured mean reductions of infiltration rate due to hydrophobic soils ascribed to high severity fire in CO, NM, OR, and ID (Wondzell and King, 2003); grazing in OR (Kauffman et al., 2004); and several roads (Luce, 1997). The losses in infiltration rates caused by grazing and roads are far more enduring, less patchy, and less temporally variable the reduced infiltration capacity *sometimes* caused by higher-severity fire. Notably, based on Doerr et al. (2009), the infiltration rate reduction ascribed to high severity fire in this figure may not have been fire-induced.

Sixth, hydrophobicity does not reduce available water storage and infiltration rates in soils via compaction, as grazing (Kauffman et al., 2004), landings, and roads do. Full recovery from soil compaction typically requires 50-80 years after the complete cessation of impacts (USFS and USBLM, 1997a; Beschta et al., 2004). It is likely that infiltration rate and soil water storage capacity reductions related to compaction require a similar time period for full recovery.

For the foregoing reasons, if the SNF is concerned about infiltration rates, soils, and runoff in the postfire environment, as indicated by evinced concern about fire-related hydrophobicity in the SN, it is clear that the SNF should focus on foregoing road and landing construction, ground-based logging, and sharply reduce livestock grazing in the postfire landscape, as recommended in assessments of postfire watershed management that complements ecological recovery (Beschta et al., 2004; Karr et al., 2004).

Groundcover and vegetative regrowth

As discussed, groundcover, especially by live vegetation, is a major postfire concern, due to its influence on soil erosion (Kattlemann, 1996; Beschta et al., 2004). Postfire logging activities reduce groundcover in several ways (Donato et al., 2006; USFS and USBLM, 1997a; AGU, 2003; Pankuk and Robichaud, 2003). Rhodes (2003) and Chase (2009) documented that postfire logging in the Sierra Nevada reduced groundcover considerably relative to burned unlogged areas.

Due to the importance of groundcover, and, especially that from living vegetation, the EIS must estimate the degree, extent and persistence of the loss of groundcover due to all activities in the alternatives that affect groundcover and its recovery. At a minimum, the activities that require such examination include logging, road and landing reconstruction or construction, slash treatments, burning, and efforts to control native brush. The EIS also needs to reasonably consider and describe the additional effects of any other continuing and/or past activities that affect groundcover recovery, such as grazing (Beschta et al., 2004).

Planting and seeding can significantly delay or setback the postfire recovery of native vegetation that provides the most effective groundcover (Kattlemann, 1996; Beschta et al., 2004; Karr et al., 2004; Keeley et al., 2006; Noss et al., 2006). Therefore, the EIS needs to disclose the extent and nature of seeding and planting and take a hard look at its effect on the recovery of native groundcover vegetation, based on available scientific information.

Accelerated erosion and the loss of topsoil

Postfire logging and associated activities, including logging and the construction, reconstruction, and elevated use of roads and landings, significantly increase soil erosion. As stated in Beschta et al. (1995), "Soil and soil productivity are irreplaceable in human timescales; therefore, post-burn management activities that accelerate erosion or create soil compaction must be prohibited." The loss of topsoil via erosion causes significant and essentially permanent reductions in soil productivity (Beschta et al., 2004; Karr et al., 2004).

Therefore, it is essential that the EIS reasonably estimate and describe the degree, persistence, and extent of increased soil erosion caused by the Project activities and the resulting effects on soil productivity. The EIS must also disclose that the loss of topsoil and associated soil productivity is permanent. The EIS also needs to examine and describe the existing level and extent of topsoil loss caused by past and on-going activities within the Projects' areas, including logging, roads, landings, firelines, and grazing.

Unlike the pulsed, short-term erosion sometimes triggered by fire, many activities, such as road and landing construction and reconstruction, cause enduring increases in soil erosion, even if the roads and landings are subsequently obliterated (Beschta et al., 2004; Foltz et al., 2007). Therefore, the EIS must describe the cumulative effects of erosion caused by activities in alternatives over a reasonable timeframe, on the order of 10-20 years, and its effects on critical soil functions.

Ground-disturbing activities on steep slopes and sensitive soils

The effects of postfire salvage logging are especially significant on steep slopes, in erosion-prone and/or shallow soils, and soils burned at higher severities (Karr et al., 2004; Beschta et al., 2004; Lindenmayer and Noss, 2006). Therefore, the EIS needs to disclose the extent and nature of all ground-disturbing in all such areas. The EIS should describe the slopes and erosion hazard associated with all activities. The EIS should also describe the nature and extent of all land-disturbing activities in areas with thin soils and/or burned at moderate to high severity. The EIS should also note that available scientific information indicates that logging, landing and road construction and reconstruction in areas with steep soils and/or sensitive soils, such as those exposed to moderate and high severity fire, are inconsistent with the recovery of forested ecosystems after fire (Karr et al., 2004; Beschta et al., 2004; Noss et al., 2006; Lindenmayer and Noss, 2006).

Consistency of proposed activities and soil impacts with postfire ecological recovery

The EIS should identify whether or not the activities proposed under the alternatives and their impacts on soils are consistent with unimpeded ecological recovery after fire, based on available scientific information. Many of the scientific papers on the topic clearly discuss and describe activities that are inconsistent with unimpeded postfire recovery, including Beschta et al. (1995; 2004), Karr et al. (2004), Noss et al. (2006) and Keeley et al. (2006).

The SNF must reasonably analyze and describe the cumulative impacts on streamflows from existing conditions and on-going activities in combination with proposed activities.

Peak flows affect numerous channel and aquatic conditions and processes (Rhodes et al., 1994; Dunne et al., 2001). Logging and roads significantly elevate peak flows and their frequency (Rhodes et al., 1994; Jones and Grant, 1996; Bowling et al., 2000; La Marche and Lettenmaier, 2001; Gucinski et al., 2001; Alila et al., 2009). There is little dispute that available evidence indicates that the most frequently occurring peak flows (e.g. with a recurrence interval of 1-5 years) are increased in a statistically significant fashion by forest removal and roads (Bowling et al., 2000).

Dunne et al. (2001) expressly noted that it cannot be reasonably assumed that relatively small increases in peak flows do not have significant adverse impacts on stream systems, aquatic habitats, and fish populations, because relatively small increases in peak flows exponentially increase sediment transport. Increased frequency of peak flows caused by logging and roads is ecologically significant and a key attribute of peak flow alteration by roads and logging that is critical to assess (Alila et al., 2009). PNF (2010) noted: "The effects of roads and trails also include…changes to streamflow regime…streamflows have the potential to impact fish densities by affecting reproductive success and over wintering survival. High streamflow events following spawning can dislodge amphibian and fish egg masses or displace tadpoles, metamorphs, and young fry, and therefore lead to increased mortality to amphibian and fish populations."

Roads contribute to elevating peak flows by concentrating runoff and rapidly shunting it to streams via integration with the stream network (Wemple et al., 1996; Jones and Grant, 1996; Bowling et al., 2000; Gucinski et al., 2001; La Marche and Lettenmaier, 2001). The effects of roads on peak flows are estimated to be roughly equivalent and in addition to the effect of logging (La Marche and Lettenmaier, 2001). It is also well established that a significant fraction of road networks is hydrologically connected to channel networks, elevating peak flows (Wemple et al., 1996; Jones and Grant, 1996; Bowling et al., 2000; La Marche and Lettenmaier, 2001; Gucinski et al., 2001).

Therefore, the EIS needs to adequately examine and describe how the alternatives and cumulative existing and ongoing impacts are likely to affect peak flows in the Projects' areas. This analysis needs to reasonably incorporate the effects of roads, including their connectivity with stream systems (Grant et al., 2008). The analysis also needs to adequately incorporate the effects of past and on-going activities that compact soils and increase surface runoff, such as grazing (Belsky and Blumenthal, 1997; Kauffman et al., 2004; Beschta et al., 2012).

As previously discussed, low flows are a concern due to the effects of climate change and their importance to aquatic biota and downstream water supply. Existing conditions, particularly roads and grazing, have very likely diminished low flows by reducing infiltration rates and available soil moisture storage via the combined effects of compaction, loss of organic matter, and soil erosion. Roadcuts also interrupt subsurface water that generates streamflow during the low flow period. For these reasons, the EIS must assess the cumulative impact of existing conditions together with those under the alternatives on low flows and conditions that affect low flows.

The EIS must properly assess and discuss the substantial body of available scientific literature that describes the highly negative ecological impacts of postfire salvage logging and associated activities, as well as the benefits of leaving burned landscapes unmolested.

Scientific literature provides a vital context for assessing Project impacts. There is a considerable and growing body of scientific literature that shows that postfire logging is inimical to the restoration of forested ecosystems after fire. This literature must be discussed in order to provide the public with a notion of the effects of various alternatives on the recovery of burned ecosystems, including the spread of undesirable exotic vegetation, soil degradation, the loss of biodiversity, water quality degradation, the delay in forest recovery after fire, and increased postfire fuel loads (Donato et al., 2006; Donato et al., 2013).

This obligation is amplified because the postfire logging and associated activities described in the SNF's SN will have many persistent negative ecological impacts on a wide variety of conditions and processes. These impacts must be fully and adequately analyzed and disclosed to the public, based on the available scientific information that clearly demonstrates that postfire salvage logging conflicts with the ecological recovery of forested ecosystems after fire.

The EIS must also discuss that the available scientific literature documents that burned areas, if left unmolested by land management, provide many important ecosystem benefits, including those to biodiversity, forest structure, provision of downed wood, soils, postfire fuel levels, aquatic systems, even areas have been burned at high severity (Beschta et al., 1995, Karr et al., 2004; Beschta et al. 2004; Lindenmayer et al., 2004; DellaSala et al., 2006; Hutto, 2006; Noss and Lindenmayer, 2006; Lindenmayer and Noss, 2006, Noss et al., 2006; Kotliar et al., 2007; Rhodes, 2007; Odion and Hansen, 2007; Donato et al., 2006; Baker et al., 2007; Donato et al., 2013). The USFS's own research (Parks et al., 2013) indicates that in the rare event of reburn, previously burned areas reduce burn severity. As Parks et al. (2013) states "…burn severity is significantly lower in areas that have recently burned compared to areas that have not."

The SNF must reasonably assess and make known that there is little need to conduct postfire logging or mechanical fuel treatments with respect to future fire behavior

The EIS must consider and make known that there is not a compelling need to cause watershed damage in order to attempt to reduce postfire fuel levels via logging. Studies have shown that postfire logging elevates surface fuel levels (Donato et al., 2006; 2013). Even when fuels are reduced via salvage logging, its impacts elevate soil damage from subsequent fire due to groundcover impacts (Fraver et al., 2011). Donato (2013) documented that unlogged areas several years after fire had surface fuel loads consistent with commonly prescribed levels. Parks et al. (2013) documented that unlogged burned areas reduced burn severity in the rare event of reburn.

The EIS must consider and make known that it is well established that attempts to reduce fuels have relatively transient impacts on fuel levels (e.g., Kauffman, 2004; Noss et al., 2006; Rhodes and Baker, 2008; Robichaud et al., 2010). Fuel levels begin to rebound immediately after treatment and typically recover 10 to 20 years after treatment (Rhodes and Baker, 2008, Robichaud et al., 2010).

The EIS must also assess the likelihood that damaging activities undertaken under the rubric of fuel reduction can affect fire during the transient window while fuels are reduced. Fuel treatments cannot affect fire, if it does not affect treated areas during the limited period when fuels have been reduced. This can be tractably estimated by examining fire occurrence in the area under existing management (Rhodes and Baker, 2008). Such an analysis is critical to conduct properly and make known to the public in the EIS.

Several other studies of fuel treatment impacts (Law and Harmon, 2011; Campbell et al., 2011; Price et al., 2012; Price, 2012; Restaino and Peterson, 2013) have also shown: a) that analysis of the probability of fire affecting treated areas, such as that of Rhodes and Baker (2008), is essential to assessing the potential effectiveness of such treatments, and b) that the probability of fire affecting treated areas while fuels are reduced is relatively low. These findings must be made known in the EIS.

The EIS must examine and describe the impacts of the Projects' alternatives on the spread and establishment of non-native vegetation.

Noxious weeds are already a major problem on USFS lands in the Sierra Nevada (CWWR, 1996). Postfire logging activities contribute to the spread and establishment of weeds (Beschta et al., 2004; Karr et al., 2004; DellaSala et al., 2006). Riparian areas can be particularly vulnerable to invasive vegetation. Therefore, the EIS must describe existing infestations of non-native vegetation and the cumulative, direct, and indirect impacts of the alternatives on non-native vegetation.

The EIS should also examine and describe how postfire recovery will be affected by alternatives that increase the spread and establishment of non-native vegetation. The establishment of noxious weeds can delay or prevent the recovery of native vegetation, increase erosion, sediment delivery, and runoff (CWWR, 1996), reducing soil productivity and contributing to the degradation of aquatic systems.

The EIS must examine the effects of alternatives with adequate riparian protection and management aimed at restoring ecosystems after fire.

Based on available information, it is quite clear that the activities proposed in the SN will significantly impede ecological recovery after fire, in many ways. Therefore, the EIS needs to develop alternatives that are consistent with postfire ecosystem recovery after fire.

Although a no-action alternative provides some perspective, the EIS should develop an alternative that includes proactive management that actually promotes postfire ecosystem recovery. As noted in Beschta et al. (2004) and Karr et al. (2004), such measures include aggressive efforts to reduce existing management-induced impacts, such as eliminating/curtailing livestock grazing, obliterating and decommissioning roads, rehabilitating firelines, removing stream crossings and other obstructions to the connectivity of aquatic populations, while avoiding: ground based logging, all logging in riparian areas and on steep slopes and areas burned at higher severity, planting, and construction or reconstruction of landings and roads. Noss et al. (2006) also recommended avoidance of postfire logging and planting, and particularly stressed the need to retain all large dead trees. Such an alternative should also include full protection of riparian area widths along all streams based on the recommendations in Rhodes et al. (1994) and Erman et al. (1996).

The EIS must disclose that Best Management Practices (BMPs) have very limited effectiveness and do not eliminate impacts of land management activities.

There is ample evidence of the inability of BMPs to completely mitigate the adverse impacts of land management on aquatic systems (Espinosa et al., 1997; Rieman et al., 2003; Beschta et al., 2004). There are no reliable data indicating that "Best Management Practices" (BMPs) consistently reduce the adverse effects of significant soil and vegetation disturbance on aquatic resources to ecologically negligible levels, especially within the context of currently pervasive watershed and aquatic degradation (Ziemer and Lisle, 1993; Espinosa et al., 1997; Rieman et al., 2003; Beschta et al., 2004). Activities implemented with somewhat effective BMPs still often significantly contribute to negative cumulative effects on aquatic systems (Espinosa et al., 1997). Some impacts cannot be fully arrested by BMPs. Kattlemann (1996) noted that BMPs could do little to reduce sediment delivery from roads at stream crossings.

The nationwide assessment of road BMP effectiveness commissioned by the USEPA (GLEC, 2008) specifically noted that BMPs aimed at reducing road impacts are not 100% effective. In particular, attempts to prevent runoff and sediment delivery from roads and landings via drainage diversion features near streams are often unsuccessful. This is because such drainage diversion features often merely route runoff and sediment over hillslopes and into streams (GLEC, 2008). GLEC (2008) also noted that efforts to prevent road drainage to streams have considerable potential for failure. GLEC (2008) also notes "…conventional BMPs for road construction may not be sufficient to prevent adverse effects on stream channels and fish habitat." For these reasons, it is essential that EIS take a hard look at BMP effectiveness, the uncertainties regarding BMP effectiveness and implementation, and the limits of BMP effectiveness, and factor this into the assessment of the impacts of the alternatives.

The EIS must make known that the most effective BMP is to avoid damaging activities, such as road and landing construction, which causes long-term damage to soils, hydrological processes, and stream systems. It has long been known that the avoidance of ecological damage is far more tractable, efficient, and effective than attempts to limit, mitigate, or arrest and restore such damage (USFS et al., 1993; Rhodes et al., 1994; Kauffman et al., 1997; Beschta et al., 2004; Karr et al., 2004). Another effective BMP is to avoid damaging impacts in sensitive areas, such as road and landing construction near streams. As GLEC (2008) noted with respect to road impacts, "in some cases, however, control of the problem may not be feasible: location 'trumps' management practice."

The EIS must also disclose that the best available science indicates that restoration attempts that treat the symptoms rather than the causes of degraded and disturbed conditions are often largely ineffective or have very limited effectiveness (e.g. USFS et al., 1993; Rhodes et al., 1994; Kaufman et al., 1997; Beschta et al., 2004; Karr et al. 2004; Beschta et al., 2012).

The EIS must also make known that it has long been recognized that *full* protection of the area of vegetation within 200 to greater than 300 ft of the edge of *all* stream types is one of the most important and effective ways to limit the impacts from upslope disturbances, as numerous independent assessments have repeatedly concluded, including, to but not limited to, USFS et al. (1993), Henjum et al. (1994), Rhodes et al. (1994), Erman et al. (1996), Moyle et al., 1996; USFS and USBLM (1997a; b; c), Beschta et al. (2004), and Karr et al. (2004).

The EIS must properly assess and make known the alternatives compliance with salient USFS land management standards, policies, and guidelines.

Plainly, the SNF is obligated to thoroughly assess compliance with its own applicable policies, standards, and guidelines. Therefore, the EIS must thoroughly assess the compliance of the alternatives and their impacts with these obligations.

Conclusion

Because the postfire activities proposed described in the SN negatively affect a wide variety of ecological elements and processes in a persistent fashion, the EIS must reasonably describe the nature of the alternatives, existing conditions, and their numerous negative cumulative effects on watershed, riparian, and aquatic systems, based on available scientific information. The EIS also needs to develop alternatives that include a proactive approach to postfire restoration and include adequate riparian protection, based on available scientific information.

Thank you for the opportunity to comment.

Sincerely,

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EDUCATION

1989: Doctoral candidacy degree in forest hydrology at the Univ. of Wash. Completed all requirements but dissertation.

1985: M.S. in Hydrology and Hydrogeology at the Univ. of Nev.-Reno. Thesis topic: The influence of seasonal stream runoff patterns on water quality.

1981: B.S. in Hydrology and Water Resources at the Univ. of Ariz.

PROFESSIONAL HISTORY

Sept. 2001 -- present. Principal Hydrologist, Planeto Azul Hydrology. Main duties: Analysis of water and land use effects on streams and aquatic resources, including native salmonids and their habitats; diagnosis of watershed and stream conditions; stream monitoring; development of programmatic and site-specific watershed and stream protection measures; project management. Some recent projects (and clients): Analysis of potential effects of groundwater pumping on streamflow (Conf. Tribes of the Umatilla Indian Reservation, OR); diagnosis of watershed and stream conditions in an urbanized watershed (West Multnomah Soil and Water Conservation District, OR); analysis of data on sediment effects on ESA-listed salmon in the South Fork Stillaguamish River, WA (Snohomish County, WA). See list of clients at the end of the CV.

Aug. 1990 -- Sept. 2001. Consulting hydrologist for non-profit organizations. Past projects (and clients) include: hydrologic characterization of remnant marsh proposed as urban wildlife refuge/greenspace (Multnomah Co. Parks Dept, OR); review of aquatic effects of: quarry expansion (Friends of Forest Park, OR), urban construction (homeowners consortium, W. Linn, OR); forest manipulations on streamflow (Pacific Rivers Council).

Apr. 1989 -- Sept. 2001. Senior Fishery Scientist-Hydrologist, Columbia River Inter-Tribal Fish Commission. Main duties: Administration and implementation of projects monitoring channel change from land use; development of programmatic and site-specific land management plans to ensure protection of watershed integrity, water quality and aquatic resources; development of restoration plans for watersheds degraded by grazing, roads, logging, and mining; design of plans for monitoring watershed and stream erosion, sedimentation, water quality, and habitat conditions; review of land management plans for adequacy of protection of aquatic resources; field evaluation of watershed and channel conditions throughout the Columbia Basin; expert witness testimony; development of technical recommendations for policy staff for protection of natal habitat for anadromous fish; review of state and federal aquatic resource monitoring plans; report and proposal writing; and, participation in various state and federal technical work groups.

Aug. '84 -- Apr. '89. Research assistant, College of Forestry, Univ. of Wash. Main duties: analysis and interpretation of water quality-quantity data; technical report writing; design and maintenance of water chemistry and quantity monitoring network in a coastal forested watershed; training in data acquisition techniques; public presentation of findings.

July -- Oct. 1987 and May -- Oct. 1988. Consulting hydrologist, Tahoe Regional Planning Agency, CA and NV. Main duties: field delineation and mapping of riparian zones, wetlands, and erosion-prone areas.

June -- Sept. 1985 and July 1986. Research assistant, Dept. of Geophysics, Univ of Wash. Main duties: operation of field station for glacier research on Mt. Olympus, Wash.; measurement of snow and glacier melt rates; mapping of supra- and extra- glacial streams contributing to basal sub-glacial flow rates on surging and non-surging glaciers in the Alaska Range, Alaska.

Jan. 1984. Consultant with C.M. Skau, Reno, NV. Main duties: field evaluation of logging roads for erosion potential and sedimentation risk; recommendations for placement of future roads to minimize erosion and sediment delivery to fish-bearing streams in coastal Northern California.

Oct. 1983 -- June 1984. Hydrologic Tech., USGS, Carson City, NV. Main duties: aid in development and calibration of predictive water quality model for the Truckee River; statistical analysis of water quality data; identification and quantification of non-point sources of nutrients to Truckee River, NV.

Aug. 1981 -- Sept. 1983. Research Assistant, Univ. of Nev.-Reno. Main duties: design and installation of instrument network to monitor water chemistry and quantity in a small, forested alpine watershed in the Sierra Nevada; water quality sampling; data interpretation and management; preparation of reports, grant proposals, and publications, computer programming for data reduction and storage; mapping of geology, soils and runoff-producing areas; and, training of field technicians.

Feb. -- May 1981. Water Quality Intern, Pima Assoc. of Gov'ts., Tucson, AZ. Main duties: water quality sampling of agricultural production wells; mapping of groundwater levels; and, coordination of sampling efforts.

PROFESSIONAL SERVICE

May 2009 – present. Peer Reviewer for the scholarly journal, Open Forest Science Journal, for papers related to hydrology and forest and watershed responses to disturbance.

Mar. 2013. Invited Panel Speaker, Public Interest Environmental Law Conference: "Public Land Livestock Grazing and Climate Impacts on Aquatic Systems" and "The High Ecological Costs and Low Benefits of Logging Under the Rubric Of Restoration," Univ. of OR, Eugene, OR.

Feb. 2010. Invited Guest Lecturer, Lewis and Clark School of Law course on public lands law: "PACFISH and INFISH and Imperiled Salmonids on Public Lands" Portland, OR.

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Feb. 2005. Invited Guest Lecturer, Lewis and Clark School of Law course on public lands law: "Postfire Watershed Management on Western Public Lands" Portland, OR.

Mar. 2004. Invited Panel Speaker, Public Interest Environmental Law Conference: "Postfire Watershed Restoration," Univ. of OR, Eugene, OR.

April 2002. Invited Speaker, Restoring Public Lands Conference: Reclaiming the Concept of Forest Restoration, "Watersheds and Fisheries: Restoration Needs for Trout Habitats," Univ. of CO, Boulder, CO

Mar 2002. Invited Panel Speaker, Public Interest Environmental Law Conference: “Soils, Impacts and Effects on Trout Habitat,” Univ. of OR, Eugene, OR

Mar. 2001. Invited Panel Speaker, Public Interest Environmental Law Conference: “NFMA and Salmon Habitat Protection,” Univ. of OR, Eugene, OR.

May 2000. Invited speaker, 5th National Tribal Conf. on Environmental Management: "Federal Land Management's Effects on Critical Habitat for Endangered Salmon,” Lincoln City, OR

July 1998-2000. Peer Reviewer for the scholarly journal, N. Amer. J. Fish, for papers related to the sedimentation of fish habitat in response to erosion from land uses and fire.

Feb. 1998. Invited Speaker, Oregon AFS Annual meeting: "Adaptive management: Is it really adaptive?" Sunriver, OR

May 1996-2000. Guest lecturer, Oregon State Univ. graduate course on riparian and wetland ecology, Corvallis, OR

Apr.-May 1996. Peer-reviewer for Proceedings of Forest-Fish Conference: Land Management Affecting Aquatic Ecosystems, Proc. Forest-Fish Conf., May 1-4, 1996, Calgary, Alberta, Canada. Nat. Resour. Can., Can. For. Serv. Nort. For. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-356.

Apr. 1995. Invited speaker, Pacific Rivers Council Workshop on Watershed Analysis and Salvage Logging, Wenatchee, Wash.

Apr. 1995. Invited speaker, Oregon State Univ. Dept of Fisheries and Wildlife Seminar, Corvallis, OR

Apr. 1995. Invited speaker, American Fisheries Society North Pacific International Chapter, Annual Meeting, Vancouver B.C., Can.

Mar. 1995. Invited speaker, American Fisheries Society Idaho Chapter Annual Meeting, Boise, ID.

Nov. 1994. Invited speaker, President's Council on Sustainable Development Workshop, Yakima, WA.

Sept. 1994. Invited speaker, Oregon Water Resources Research Institute Streambank Restoration Conference: "Biological Methods to Stabilize Streambanks--From Theory to Practice," Portland, OR.

Mar.-April, 1994. Peer-reviewer for Henjum et al., 1994. Interim Protection for Late Successional Forests, Fisheries, and Watersheds: National Forests East of The Cascade Crest, Oregon and Washington. The Wildlife Soc., Bethesda, MD.

Jan. 1993-Sept. 1995. Member, Oregon Department of Environmental Quality's (ODEQ) Technical Advisory Committee for Triennial Review of the State Water Temperature Standard.

Mar. 1993. Invited speaker, Northwest Scientific Association Symposium: "Cumulative Effects of Land Management Practices on Anadromous Salmonids," La Grande, OR.

Aug. 1992 - Sept. 1992. Member, Ad Hoc Consultant Selection Committee for Portland Water Bureau Study of Future Water Supply Needs.

May 1992. Invited Speaker, US Forest Service, Pacific Northwest Region, Regional Workshop on Monitoring Soil and Water Resources, Bend, OR.

May 1992. Invited Speaker, Northern Arizona University, School of Forestry, Graduate Seminar Series, Flagstaff, AZ.

Jan. 1991 - Mar. 1995. Member, Technical Work Group: Upper Grande Ronde River Anadromous Fish Habitat Protection, Restoration and Monitoring Plan.

Aug. 1989 - Feb. 1990. Member, Technical Advisory Committee to ODEQ for development of definitions for level of beneficial use impairment by nonpoint sources.

May 1989 - Jan. 1991.Member, Nonpoint Source Technical Advisory Committee to Idaho Department of Environmental Quality: Coordinated Nonpoint Source Monitoring Program For Idaho.

PUBLICATIONS

Peer-Reviewed:

Rhodes, J.J., C.M. Skau, and W.M. Melgin, 1984. Nitrate-nitrogen flux in a forested watershed -- Lake Tahoe, USA. In: Recent Investigations in the Zone of Aeration, Proc. of Inter. Symp., Munich, West Germany, 1984, P. Udluft, B. Merkel, and K. Prosl (Eds), pp. 671-680.

Rhodes, J.J., 1985. A Reconnaissance of Hydrologic Transport of Nitrate in An Undisturbed Forested Watershed Near Lake Tahoe. M.S. thesis, Univ. of Nev. Reno, 254 pp.

Rhodes, J.J., C.M. Skau, and J.C. Brown, 1985. An areally intensive approach to hydrologic nutrient transport in forested watersheds. In: The Forest-Atmosphere Interaction, B.A. Hutchison and B.B. Hicks (Eds), pp. 255-270.

Rhodes, J.J., C.M. Skau, D. Greenlee, and D.L. Brown, 1985. Quantification of nitrate uptake by riparian forests and wetlands in an undisturbed headwaters watershed. US Forest Service Gen. Tech. Rept. RM-120.

Rhodes, J.J., C.M. Skau, and D. Greenlee, 1986. The role of snowcover on diurnal nitrate concentration patterns in streamflow from a forested watershed in the Sierra Nevada, Nevada, USA. In: Proc. of AWRA Symposium: Cold Regions Hydrology, Fairbanks Alaska, 1986, D.L. Kane (Editor), pp. 157-166.

Rhodes, J.J., R.L. Armstrong, and S.G. Warren, 1987. Mode of formation of "ablation hollows" controlled by dirt content of snow. J. Glaciology, **33**: 135-139.

Edmonds, R.L., T.B. Thomas, and J.J. Rhodes, 1991. Canopy and soil modification of precipitation chemistry in a temperate rain forest. Soil Soc. of Amer. J., **55**: 1685-1693.

Rhodes, J.J., McCullough, D.A., and Espinosa Jr., F.A., 1994. A Coarse Screening Process for Evaluation of the Effects of Land Management Activities on Salmon Spawning and Rearing Habitat in ESA Consultations. CRITFC Tech. Rept. 94-4, Portland, OR

Rhodes, J.J. 1995. A Comparison and Evaluation of Existing Land Management Plans Affecting Spawning and Rearing Habitat of Snake River Basin Salmon Species Listed Under the Endangered Species Act. CRITFC Tech. Rept. 95-4, Portland, OR

Rhodes, J.J. 1996. Description and Evaluation of Some Available Models for Estimating the Effects of Land Management Plans on Sediment Delivery, Channel Substrate, and Water Temperature, CRITFC, Portland, OR

Espinosa, F.A., Rhodes, J.J., and McCullough, D. A. 1997. The failure of existing plans to protect salmon habitat on the Clearwater National Forest in Idaho. J. Env. Management **49**: 205-230.

Rhodes, J.J., and Purser, M.D., 1998. Overwinter sedimentation of clean gravels in simulated redds in the upper Grande Ronde River and nearby streams in northeastern Oregon, USA: Implications for the survival of threatened spring chinook salmon, Forest-Fish Conference: Land Management Affecting Aquatic Ecosystems, Proc. Forest-Fish Conf., May 1-4, 1996, Calgary, Alberta, Canada. Nat. Resour. Can., Can. For. Serv. Nort. For. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-356, pp: 403-412.

Beschta, R.L., Rhodes, J.J., Kauffman, J.B., Gresswell, R.E, Minshall, G.W., Karr, J.R, Perry, D.A., Hauer, F.R., and Frissell, C.A., 2004. Postfire Management on Forested Public Lands of the Western USA. Cons. Bio., 18: 957-967. http://pacificrivers.org/files/post-fire-management-and-sound-science/Beschta-etal2004.pdf

Karr, J.R., Rhodes, J.J., Minshall, G.W., Hauer, F.R., Beschta, R.L., Frissell,C.A. Perry, D.A, 2004. Postfire Salvage Logging's Effects on Aquatic Ecosystems in the American West. BioScience, 54: 1029-1033. http://www.earthjustice.org/library/reports/the-effects-of-positive-salvage-logging.pdf

Rhodes, J.J. and Odion, D.C., 2004. Comment Letter: Evaluation of the Efficacy of Forest Manipulations Still Needed. BioScience, 54: 980.

Rhodes, J.J., 2005. Comment on "Modeling of the interactions between forest vegetation, disturbances, and sediment yields" by Erkan Istanbulluoglu et al. J. Geophys. Res. Earth Surf., Vol. 110, No. F1, F01012 10.1029/2004JF000240

Rhodes, J.J., 2007. The Watershed Impacts of Forest Treatments to Reduce Fuels and Modify Fire Behavior. Pacific Rivers Council, Eugene, OR http://pacificrivers.org/science-research/resources-publications/the-watershed-impacts-of-forest-treatments-to-reduce-fuels-and-modify-fire-behavior

Rhodes, J.J. and Baker, W.L., 2008. Fire probability, fuel treatment effectiveness and ecological tradeoffs in western U.S. public forests. Open Forest Science Journal, 1: 1-7. http://www.bentham.org/open/tofscij/openaccess2.htm

Beschta, R.L., Donahue, D.L., DellaSala, D.A., Rhodes, J.J., Karr, J.R., O'Brien, M.H., Fleischner, T.L., and Deacon-Williams, C. 2012. Adapting to Climate Change on Western Public Lands: Addressing the Ecological Effects of Domestic, Wild, and Feral Ungulates. Env. Manage. DOI 10.1007/s00267-012-9964-9 http://www.springer.com/about+springer/media/springer+select?SGWID=0-11001-6-1395645-0

Technical Reports:

1986. Annual Report on Watershed Studies at Olympic National Park. College of Forestry, Univ. of Wash., Seattle, Wash. (Co-authors: R.L. Edmonds, T.B. Thomas, T.W. Cundy)

1987. Annual Report on Watershed Studies at Olympic National Park. College of Forestry, Univ. of Wash., Seattle, Wash. (Co-authors: R.L. Edmonds, T.B. Thomas, T.W. Cundy)

1988. Annual Report on Watershed Studies at Olympic National Park. College of Forestry, Univ. of Wash., Seattle, Wash. (Co-authors: R.L. Edmonds, T.B. Thomas, T.W. Cundy)

1989. Annual Report on Watershed Studies at Olympic National Park. College of Forestry, Univ. of Wash., Seattle, Wash. (Co-authors: R.L. Edmonds, T.B. Thomas, T.W. Cundy)

1990. Coordinated Nonpoint Source Monitoring Program For Idaho. Idaho Dept. of Environmental Quality, Boise, Idaho. (Co-authors: B. Clark, D. McGreer, W. Reid, T. Burton, W. Low, I. Urnovitz, D. McCullough, T. Litke)

1992. The Upper Grande Ronde River Anadromous Fish Habitat Protection, Restoration and Monitoring Plan. Wallowa-Whitman National Forest, Baker, OR (Co-authors: M. Purser, P. Boehne, R.E. Gill, R.L. Beschta, J.R. Sedell, B. McIntosh, J. Zakel, J.W. Anderson, D. Bryson, S. Howes, R. George).

1992. Salmon Recovery Program for the Columbia River Basin: An Advisory Report for the US Congress, Col. Riv. Inter-Tribal Fish Comm., Portland, OR (Co-authors: P.R. Mundy, D.A. McCullough, M.L. Cuenco, T.W. Backman, D.Dompier, P. O'Toole, S. Whitman, E. Larson, B. Watson, G. James).

1993. A comprehensive approach to restoring habitat conditions needed to protect threatened salmon species in a severely degraded river--The Upper Grande Ronde River Anadromous Fish Habitat Protection, Restoration and Monitoring Plan. USFS Gen. Tech. Rept RM-226, pp. 175-179. (Co-authors: J.W. Anderson, R.L. Beschta, P. Boehne, D. Bryson, R.E. Gill, S. Howes, B. McIntosh, M.D. Purser and J. Zakel).

1993. Dante's Video Guide to Habitat Conditions for Wild Spring Chinook Salmon, Steelhead and Bull Trout in the John Day Basin, Oregon. (Video) Presented at AFS National Meeting, Portland, Or, Aug. 29-31. (Co-authors: R. Taylor and M. Purser).

1995. Wildfire and Salvage Logging: Recommendations for Ecologically Sound Post-Fire Salvage Logging and Other Post-Fire Treatments on Federal Lands in the West. Pacific Rivers Council, Portland, OR (Co-authors: R. Beschta, C. Frissell, R. Gresswell, R. Hauer, J. Karr, G. Minshall, D. Perry).

1998. Adaptive management: Is it really adaptive? Abstracts: Oregon AFS Annual Meeting, Feb. 11-13, 1998, p. 31.

1998. Thinning For Increased Water Yield in the Sierra Nevada: Free Lunch or Pie in the Sky? Pacific Rivers Council, Eugene, OR. (Co-author: M. Purser)

1999. Annual Project Report: Watershed Evaluation and Aquatic Habitat Response to Recent Storms. Bonneville Power Administration (BPA), Portland, OR. (Co-author: C. Huntington)

1999. Annual Project Report: Monitoring Fine Sediment in Salmon Habitat in John Day and Grande Ronde Rivers. BPA, Portland, OR (Co-author: M. Purser)

2000. Annual Project Report: Watershed Evaluation and Aquatic Habitat Response to Recent Storms. BPA, Portland, OR. (Co-author: C. Huntington)

2000. Annual Project Report: Monitoring Fine Sediment in Salmon Habitat in John Day and Grande Ronde Rivers. (Co-author: M. J. Greene)

2001. Annual Project Report: Monitoring Fine Sediment in Salmon Habitat in John Day and Grande Ronde Rivers. BPA, Portland, OR. (Co-author: M. J. Greene)

2001. Imperiled Western Trout and the Importance of Roadless Areas. Western Native Trout Campaign, Center for Biological Diversity, Tucson, Az. (Co-authors: J. Kessler, C. Bradley, and J. Wood)

2002. Tryon Creek Watershed: Overview of Existing Conditions, Data Gaps, and Recommendations for the Protection and Restoration of Aquatic Resources. West Multnomah Soil and Water Conservation District, Portland, OR

2002. An Analysis of Trout and Salmon Status and Conservation Values of Potential Wilderness Candidates in Idaho and Eastern Washington. Western Native Trout Campaign, Center for Biological Diversity, Tucson, AZ. (Co-authors: C. Bradley, J. Kessler, C. Frissell)

2003. Stream and Fish Habitat Conditions in Tryon Creek: Their Likely Causes and Ramifications for Salmonids. Proceedings of Urban Ecology and Conservation Symposium, January 24, 2003, Portland, OR. Portland State University, Environmental Sciences and Resources, Portland, OR

2008. Primary Sources of Fine Sediment in the South Fork Stillaguamish River. Interim progress report for Washington State Salmon Recovery Funding Board, Olympia, WA. Snohomish County Public Works Surface Water Management, Everett, WA. (Co-authors: M. Purser, B. Gaddis, S. Britton, T. Coburn, and M. Rustay)

2009. Primary Sources of Fine Sediment in the South Fork Stillaguamish River. Project completion report for Washington State Salmon Recovery Funding Board, Olympia, WA. Snohomish County Public Works Surface Water Management, Everett, WA. (Co-authors: M. Purser, B. Gaddis,)

Semi-Technical Publications:

1993. Dam the analysis--heal streams instead. The Assoc. of Forest Service Employees for Env. Ethics Inner Voice, **5**(6): 1, 4-5.

1994. Invited Preface to Northwest Science Special Issue--Environmental History of River Basins in Eastern Oregon and Washington. Northwest Sci., **68**.

PROJECT MANAGEMENT

1993-1996. Technical Assistance Contract with NMFS to produce technical guidance for ESA consultations for effects of land management on critical habitat for listed Columbia basin salmon. Main duties: Co-Primary Investigator; primary author of peer-reviewed reports including proposed ESA consultation guidelines for effects on salmon habitat (Rhodes et al., 1994), evaluation and comparison of compatibility of land management plans with protection of critical salmon habitat (Rhodes, 1995), and evaluation of models for estimating land management effects on salmon habitat (Rhodes, 1996); review and synthesis of available scientific literature; budget preparation and tracking; coordination with subcontractors and grantor representatives. Total budget: $230,000.

1998-2000. Watershed Evaluation and Aquatic Habitat Response to Recent Storms. Main duties: Primary Investigator; design and implementation of monitoring methods, coordination of technical staff in 10 watersheds with differing levels of grazing and logging in 3 subbasins in Idaho, Washington, and Oregon; technical training; data analysis; contract administration; proposal development; report preparation; budget development and tracking; coordination with grantor representatives. Total budget: $164,000.

1998-2000. Evaluation of Effects of Grazing on Rate of Salmon Habitat Recovery. Main duties: Primary Investigator; design and implementation of monitoring methods, training of field technician; data analysis and synthesis; proposal development; preparation of progress reports; budget development and tracking; coordination with grantor representatives. Total budget: $73,000.

1998-2001. Monitoring Fine Sediment Levels in Salmon Habitat in Grande Ronde and John Day Rivers. Main duties: Primary Investigator; design and implementation of methods for monitoring fine sediment levels in four rivers; field technician training; data analysis and synthesis; subcontract administration; proposal development; progress and technical report preparation; budget development and tracking; coordination with grantor representatives. Total budget: $128,000.

2001-2002. Western Native Trout Campaign, Aquatic Scientist and Coordinator. Main duties: Oversight and scientific integrity assurance for all work products; coordinate conservation efforts among campaign member organizations and other groups working to protect and restore trout habitats and populations; reporting; and, budget tracking. Total budget: ca. $1,000,000.

HONORS AND AWARDS

1996. Leadership and Excellence. Col. River Inter-Tribal Fish Comm., Portland, OR

1991. Employee of the Year. Col. River Inter-Tribal Fish Comm., Portland, OR

1984. Academic Recruitment Scholarship for Outstanding Graduate Prospect. Univ. of Wash, Seattle, Wash.

1982. Maxey Award -- Outstanding Graduate Student Paper in Hydrology. Univ. of Nev.-Reno.

1980. Winslow and Myron Reuben Scholarship for Outstanding Undergraduate in the Earth Sciences. Univ. of Ariz., Tucson, Az.

ADDITIONAL TRAINING

1993. USFWS Water Temperature Modeling via SNTEMP

1991. USFWS Introduction to IFIM Investigations