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PACIFIC SOUTHWEST REGION
Restoring, Enhancing and Sustaining Forests in California, Hawaii and the Pacific Islands
Stanislaus National Forest

Topic: Environmental Degradation **March 11, 2015**

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SUMMARY: The Rim fire burned 154,430 acres of the forest and watershed lands causing degradation to soil, water, wildlife, aquatic, cultural, range, and timber resources. Not only was the infrastructure that is vital to forest management directly damaged or destroyed it is now at risk from the instability of other resources in the system such as soil and water. Some of the loss can be recovered immediately; others fall in to short term (three to five years), while others will take decades or cannot be recovered at all. This degradation has losses that are economically tangible such as loss of a road or a million board feet of timber while others have no economic valuation system such as wildlife habitat or habitat for organisms that live in the gravel beds of rivers. Many of our resources are so interdependent that the degradation of one touches or synergistically affects other resources. In an effort to describe the environmental degradation we have presented some of the impacts by resource category below as well as the economic loss to that resource where the information was available.

Natural resources

Water and Soils

Forty-four percent of the area burned at high to moderate severity. This is important to understand, because soil burn severity is different than fire severity. Soil burn severity considers above and below ground factors that relate to soil hydrologic function, run-off potential, and vegetative recovery. Loss of ground cover coupled with hydrophobic soil conditions has led to increase erosion potential of two to 15 tons per acre (One ton per acres is approximately equivalent to one cubic yard (yrd^3)). This impact will last for three to five years. The cost impacts associated with accelerated erosion are presented in the table on page 2.

67,949 acres of high to moderately burned area are at risk due to flooding, mudslides, landslides, and sedimentation affecting water quality, roads, hydroelectric power houses and private camps. Approximately 30,000 acres of soils are now hydrophobic. Potential loss of soil within the fire could range from one and one-half dump truck loads per acre to one dump truck load per ten acres.

Soil productivity has been compromised from loss of vegetative cover, consumption of organic matter and loss of top soil. Soil structure has also been altered. The organic matter component of the soil which provides for the loose granular structure can be consumed at relatively low temperatures. The loss of structure increase bulk density and reduces porosity, thereby reducing infiltration. Loss of infiltration reduces available water for vegetation recovery, percolation into ground water sources and increases run-off.

Increased erosion and loss of woody debris especially in meadows and streams has led to rills, gullies and a risk of addition down cutting of unstable systems. Downcutting stream will over time lower the water table drying the meadow and change the vegetative composition from riparian species to species that tolerate

dryer soil conditions. As the base level of the stream drops it serves to further drain the meadow system. The cost of environmental degradation for water and soil is presented in table 1.

Loss of forest cover exposed an open mine shaft creating a condition where injury or death could occur. This loss is not measurable.

Table 1) Economic Impact Environmental Degradation Soil and Water

Item or Activity	Value in Dollars	Unit of Measure	Total Units	Total Loss	Value Year	Reference
Soil Loss	$25.00	cubic yard	135898 - 1019235	$3,397,450 - $25,480,875	2015	Local Market
Clean Up of Transported Soil	1 to 10	cubic yard	135898 - 1019235	$135,898 - $10,192,350	2001	Ecological Economics
Value of Restored Riparian Areas or Economic Value of Wetland Services	$471.00	per acre	157	$73,947	2006	Benefits Calculation Methodology, David E. Gallo, Professor of Economics, CSU, Chico
Value of Accessible Stream Miles is the calculated benefits of reduced water temperature and increased summer stream flows on the affected fisheries, and, the effect of reduced sediment load and riparian habitat restoration on water quality and desirability for recreational use.	$6,416.00	per mile of stream	5	$32,080	2006	Benefits Calculation Methodology, David E. Gallo, Professor of Economics, CSU, Chico
Total Cost of Environmental Degradation	Min	$3,639,375	Max	$35,779,252		

Habitat Loss and impacts Wildlife

Impacts to wildlife species include mortality, habitat alteration, and habitat loss. Some of the species affected include the Federally Endangered Sierra Nevada yellow-legged frog, Region 5 Forest Service sensitive species including the California spotted owl, Great gray owl, northern goshawk, western pond turtle, and common species including mule deer. Significant changes in habitat availability and distribution has altered, to varying degrees, the ability of these and other species to inhabit this post-fire landscape. Approximately 32 percent (49,000 acres) of forested habitat burned at high severity and was lost and connectivity between areas of remaining suitable habitat no longer exists. Approximately 70 percent of great gray owl nest sites were lost and several spotted owl and goshawk breeding territories were lost. While it is unknown how many individuals have been lost or displaced by the fire, the fact is, this landscape can no longer support the density of wildlife that inhabited it pre-fire. This can in turn result in fewer individuals in a given population which reduces the ability of that population to sustain itself over time and provide a source of genetic variation to other populations throughout the species range. Thermal cover for deer on their critical winter range was also lost.

Without active restoration, these habitat and individual losses can be permanent. The acres that burned at high severity don't have adequate conifer seed sources. These areas will convert to chaparral without active management such as reforestation.

Fire impacts to meadows in conjunction with the loss of nest structures for raptors and other birds of prey such as the great gray owl, has also displaced individuals. Loss of basking and hiding cover for western pond turtles occurred when downed logs also known as large woody debris was consumed by the fire.

Habitat and impacts Aquatics

Impacts to aquatic systems range from beneficial underburn of riparian and upland areas to large areas of high severity fire where riparian and watershed function is greatly compromised. In watersheds with high proportions of moderate to high severity burn condition there is both short- and long-term degradation of aquatic biological resources. The primary factors adversely affecting biological function are increased sedimentation, increased flooding, and loss of riparian shading. Heavy sedimentation degrades aquatic function through the reduction of the amount and complexity of habitats, shifts in aquatic insect communities, and increases the susceptibility of stream channels to debris flows during flood events.

In streams impacted by high levels of sedimentation, trout and other aquatic dependent species (amphibians, reptiles, and aquatic macroinvertebrates) frequently experience short-term declines in abundance due to loss of key habitat elements and reduced rates of reproduction. Organisms may be restricted to fewer, suboptimal deep water habitats as a result of streambed filling which, in turn, may increase physiological stress as individuals have to more actively compete for available resources like space and food. Sedimentation also alters aquatic insect communities by reducing habitat complexity which leads to a prevalence of smaller bodied species which may not be suitable to meet the energy needs of organisms such as trout and frogs. Sediment can prevent fish from effectively spawning or inhibit the emergence of young fish as they swim up through the streambed. Heavy levels of sediment stored in channels can also be detrimental during periods of high streamflow because debris flows can occur which effectively scour the channel and kill or transport a variety of aquatic organisms downstream.

High severity fires also kill vegetation in riparian areas which can lead to a decrease in stream shading and an increase in water temperature. Water temperatures at lower elevations can exceed the thermal threshold for trout and other organisms requiring cold and cool water. Water close to a thermal maximum can also create physiological stress which, when combined with other stressors, can be lethal to individuals. Fishing is one of the primary recreational activities on the forest per the most recent National Visitor Use Monitoring data. This is tied to our local economy.

If culverts become plugged, the stream will overtop the culvert and can erode the road surface and fill slope, divert down the road, or the crossing can fail. All three situations can cause additional sediment to be delivered downstream and affect organisms and habitats.

There are losses to the economy because the forest was closed and the public could not engage in wildlife viewing, fishing or hunting. The forest does not have visitor use data for these activities. If we assume 100 people would have participated in these activities during the closure period the loss to the local economy would be over 5 million dollars. The actual loss is likely in excess of this amount.

Table 2) Economic Impact Environmental Degradation Wildlife and Aquatics

Item or Activity	Value	Unit of Measure	Days Available During Closure	Total Loss for One Person Per Day	Year Value	Reference
Loss of Wildlife Viewing	$72.48	per person per day	460	$33,341	2004	General Technical report PNW-GTR-658
Loss of Fishing	$44.36	per person per day	325	$14,417	2004	General Technical report PNW-GTR-658
Loss of Hunting	$45.49	per person per day	112	$5,095	2004	General Technical report PNW-GTR-658
Total Cost of Environmental Degradation				$52,853	There is no data on actual visitor use per day	

Range Resources

Environmental degradation can occur from the loss off-site water sources and the loss of fences that help manage the location of cattle. Thirty-three miles of National Forest System fences were damaged or destroyed (about **$18,000** per mile loss, but much higher cost to restore). Thirteen livestock water troughs were damaged or destroyed about **$1,500** each.

Recoverable Losses Include:

- One cabin, one 13 mile irrigation ditch, and unknown number of handing facilities (corrals, holding pens) and other miscellaneous privately owned range infrastructure damaged or destroyed.
- Approximately 20 miles of private fences damaged or destroyed**.**
- Unknown number of private water developments damaged or destroyed.

Permanent Losses Include:

- At least 130 cows reported killed by the fire, and unknown number of indirect losses caused by the fire (cows that later aborted or died from injuries associated with the fire).

- Permittees suffer from lost future income due to the loss of mother cows, which are critical to the economic viability of cow/calf cattle operations.

Table 3) Economic Impact Environmental Degradation Range Management

Item or Activity	Value	Unit of Measure	Total Units	Total Loss	Year value	Reference
Loss of Infrastructure FS, Fence	$18,000.00	mile	33	$594,000	2013	Internal Estimate
Loss of Infrastructure FS, Trough	$1,500.00	each	13	$19,500	2014	Local Industry Average
Loss of Infrastructure Private, Fence	$18,000.00	mile	20	$360,000	2014	Internal Estimate
Loss of Infrastructure Private,	$1,500.00	each	UnK		2014	Local Industry Average
Loss of Animal	$1,966.00	per animal	130	$255,580	2014	Farm Service
Loss from Devaluation of Animal	$900.00	per animal			2014	Local Operator
Loss from Lack of Forage	$232.00	per acre	90000	$20,880,000	2001	Ecological Economics
Total				$22,109,080		

Heritage Resources

Over 2000 historic and prehistoric sites are contained within the perimeter of the fire. The types of sites include: prehistoric sites related to food processing (bedrock milling features), stone tool processing (lithic scatters) and temporary living areas (rock shelters) associated to land use by the native inhabitants of the region; the Central Sierra Miwok. Additionally, historic site types include: railroad logging (camps, grades, trestles and associated features), mining (mines, hydraulic mining areas, water conveyance ditches), water development (dams and water conveyance ditches), grazing (structures and fence lines), homesteading (structure remains) and historic forest administrative sites (structures). Of these, approximately 87% of these sites were directly or indirectly impacted by the incident. The direct cost of monitoring and implementing protection measures was $**1,083,831**. Estimated loss of archaeological resources is $**1,807,048**.

Prehistoric sites though affected by the fire are not permanently lost. The fire burned away brush and tree cover leading to erosion problems and concerns. The heat of the fire caused spalling to occur on a small percentage of the bedrock milling stations damaging the mortars/grinding cups on the surface of the milling stations. Additionally the loss of ground cover exposes these sites to potential looting and vandalism.

Historic sites containing wooden remains were the ones most directly impacted by the fire and the value of that loss is difficult to ascertain. In most cases the loss is permanent and cannot be restored. For example:

- Camp 45- a railroad logging camp associated with the Westside Lumber Company (1920's) contained numerous standing and collapsed structures, miles of railroad grade with wooden ties in place, and wooden steam donkey sets or skids upon which heavy iron machinery rested that were lost. Though the metal remains of the camp such as can dumps , iron rails, machine parts, water pipe etc. are still there, the potential information that could have been gathered and the interpretational values are now lost. In addition the loss of surface vegetation now exposes the site to looting and vandalism.

However, there are several historic sites though lost in the fire, can be restored and utilized by the forest for both scientific studies and recreational value. These are:

- Niagara Camp and Trestle- a railroad logging camp associated with the Westside Lumber Company and listed on the National Register of Historic Places (NRHP). This camp like Camp 45 had standing and collapsed wooden structures, but also had a 225' wooden trestle spanning Niagara Creek. Based on a 2002 assessment of Bourland Trestle (identical to Niagara before it collapsed) the cost of restoration of Niagara would be **$1,443,176.**
- Jawbone Station- was a 1930's USFS Guard Station which had been restored in partnership with the California Mule Deer Foundation and utilized as a home base in winter for deer counts and other scientific endeavors. The station was eligible for but not yet listed on the NRHP. This loss was particularly significant to the heritage department as the forest has only one other original guard

station that is eligible for listing. The forest does have original plans for the structure and the estimated cost for reconstruction is **$163,873.**

Though the fire is out, the threat of loss and damage continues for heritage resources. Total environmental degradation for the Heritage Resources that can be quantified **is 4,497,928**.

Timber Resource

It will take 60 to 100 years to regrow the forest. The fire created hazard trees along road ways, trails and within 11 recreation sites making these unsafe places for employees as well as the public. Brush is already beginning to dominate sites, inhibiting conifer survival and growth. Without intervention the rapidly resprouting brush prevents the slower growing tree seedlings from reaching the sun and limited water needed for establishment. Under these situations, natural conifer regeneration resulting in a forested landscape could take hundreds of years to develop. Consumption of the organic layer and severe heating of the upper layer of soil has degraded or consumed the seed bank stored in the soil leading to a great need for reforestation. There is a cost outside of getting a system back to a stable state. There is the loss of timber value. Green trees can have a value of $20 to $100 per ccf burned trees if harvested in time only have a value of $10.

The fire has also created an excess of small diameter material called biomass. This material if left on the landscape adds to the risk of future catastrophic fire and will over time break or fall and collects on the ground creating an unnatural fuel load. This fuel build up can lead to detrimental soil impacts as the larger fuels lay in contact with the soil and burn. The greatest impacts to soils come from residence time not temperature. When these small diameter trees enter the stream network they alter the natural sediment regime. Small material decays at a faster rate; entrainment of sediments is short term as decaying logs fail. During peak events small material cannot hold sediment in place. Released sediment will affect timing, volume and character of the input. End cutting and scouring within the channel caused by heavy loading of dead and downed material will influence the timing, volume and character of sediment being transported through the system. The cost of biomass removal can be up to $1,500 per acre.

There is an ascetic loss to the public and environmental losses that can be calculated for the estimated environmental degradation loss see table 4 below. The numbers presented in the table are a subset of the number of acres impacted with in the fire. They represent areas that were or are being analyzed for management activities. If we looked at the entire foot print of the fire the numbers would be much larger.

Table 3) Economic Impact Environmental Degradation Timber

Item or Activity	Value	Unit of Measure	Total Units	Total Loss	Year Value	Reference
Cost Reforestation	$2,500.00	per acre	30065	$75,162,500	2015	complete total units is only an estimate
Value of Lost Timber Value in Timber Sales	$10 - $90	per CCF	387574	$3,875,740 $34,881,660	2015	Local Industry Average
Cost to remove Bio-mass Standing	$1000 - $1500	per acre	37647	$37,647,000 $56,470,500	2015	Local Industry Average
Cost to remove Bio-mass Decked	$25.00	per ton	20250	$506,250	2015	Local Industry Average
Total			Min	$117,191,490	Max	$167,020,910

Botanical

Rare plant species were adversely affected by the fire; most notable, the mountain ladyslipper orchid (Cypripedium montanum), the aquatic lichen, Goward's waterfan (Peltigera gowardii) and Taylor's fawnlily (Erythronium taylorii). The fire directly killed many of the ladyslipper plants and removed the conifer overstory over many of the occurrences. This species requires dense forest with Douglas-fir and well-developed organic soil layers for survival. The Goward's waterfan lives in cool, slow flowing perennial streams which are shaded by conifers and broadleaved tree species. Taylor's fawnlily is known from only

one location in the world. This site burned at a high severity resulting in a loss of as much as 80 to 90% of the population. The population had been largely hidden from public view by trees before the fire, affording it a great deal of protection from illegal collectors or rock climbers who "weed" their climbing routes and trample plants. Most of the trees hiding the population were killed by the fire, exposing the habitat and the plants.

The southernmost grove of Pacific madrone (Arbutus menziesii) in the Sierra Nevada occurs in the burned area and is designated a Botanical Special Interest Area (SIA). It survives this far south due to the locally cool moist habitat it occupies. The fire impacted the overstory in the SIA, opening it and exposing the habitat to hotter, drying conditions. The rare plants and Pacific madrone would benefit from nearly 1,000 acres of reforestation in their habitats.

Exclosures and shade structures are needed at some of the ladyslipper orchid sites for protection. The total cost of these projects would be approximately **$20,000**.

There are sun-loving rare wildflowers in the burned area. These tend to respond well to the disturbance caused by fire, growing more profusely in the year after a fire as a result of the increase in nutrients and huge, temporary decrease in competing plants. However, these habitats are vulnerable to weed invasions. The post-fire conditions in which the rare wildflowers like to grow are also very favorable for many species of noxious weeds and other non-native, invasive plants.

Invasive plants

Invasive plants respond to fire by rapidly occupying habitats previously shared with native and less invasive non-native plant species (many of the annual grasses available for cattle grazing are non-native grass species). Noxious weeds such as yellow star-thistle (Centaurea solstitialis), spotted knapweed (Centaurea stoebe spp. micranthos), barbed goatgrass (Aegilops triuncialis) and Medusahead grass (Elymus caput-medusae) are not yet widespread in the burned area. However, the fire created conditions which will favor the rapid spread of the existing infestations, if left unchecked. Loss of native plant habitat, severe impacts to plant communities and growth impeding competition for conifer seedlings are some of the serious implications for uncontrolled noxious weed infestations.

The most economically feasible approach to solving the issue of spreading noxious weeds in the burned area is to implement an integrated pest management program stressing eradication using careful herbicide applications, using selective herbicides where possible. This approach has a high chance of success. There are an estimated 5,000 acres of weeds within the burned area. Weed control using herbicides, applied twice a year for five years would total **$9,000,000**. Some weed species bank seed for up to ten years in the soil. A ten year treatment program would be about one and one-half the five year amount, since the number of weeds needed to be treated would be reduced every year.

An interim plan to treat weeds without herbicides would use alternative methods including hand pulling and digging, weed whacking with string trimmers and suppressing weeds with landscape cloth. This plan would treat 189 acres and cost about **$65,000** over a ten year period, using volunteers as the primary labor force. Total estimated environmental degradation for botanical resources is $**9,085,000**.

Infrastructure

Roads and Trails

Along the 720 miles of road, 118 miles of trails, there is increased potential for damage from rock fall, increased stream flow, debris transport(wood and sediment), and over toped culverts. The removal of the salvage logs and bio-mass coupled with the excessive use during suppression has reduced the expected life of these roads. If culverts become plugged, the stream will overtop the culvert and can erode the road surface and fill slope, divert water down the road, or the crossing can fail. Road infrastructure is a primary

investment by the forest. Since the fire we have had below average precipitation years. There is still a large quantity of sediment perched up in the watershed that will continue to impact the road system. Vegetation recovery has been slower than expected. Vegetation is key to mitigate the transport of material downslope onto roads and into culverts and waterways. Infrastructure is predicted to be at risk for another three to five years. Estimated cost for the most likely road repairs are listed in table 5 below.

Table 5) Cost of Road Repair and Maintenance

Item or Activity	Value	Unit of Measure	Year Value	Reference
Road Reconstruction Single Lane	$25,000 - $50,000	mile	2015	Internal Estimate
Road Reconstruction Double Lane	$250,000 - $500,000	mile	2015	Internal Estimate
Culvert Repalcment	$30,000 - $80,000	each	2015	Internal Estimate
Culvert Cleaning	$400 - $ 1000	each	2015	Internal Estimate
Retaining Wall replacement	$80,000 - $100,000	each	2015	Internal Estimate

Current loss of retaining walls and installation of additional drainage features to route increased run-off to protect road infrastructure is estimated at $**1,030,000**.

Infrastructure Other

Recreational Infrastructure losses included signs, picnic tables, vault toilets, and interpretive panels. The loss of this infrastructure is valued at **$493,520**.

The fire destroyed boundary placards, trees and monuments the cost to replace these items **$1,000,000**.

Vault toilets were burned, exposing human waste and melted construction materials. Hazardous materials were exposed when buildings were consumed by the fire causing risk to water quality. The immediate threats were mitigated by installing techniques that contain the hazard using BAER funds these funds do not pay for replacement or removal of the hazard and the estimated cost is **$80,000**. Total Infrastructure losses in this section are $**1,493,520.**

Recreational Uses

The Forest was under a closure order from August 24, 2013 to November 18, 2014. Evacuation of the public within the fire started as early as August 16, 2013. Loss of visitor use lasted for 460 days. This closure had a direct impact on tourism and ability for the public to recreate.

According to the 1977-2013 Tuolumne Wild & Scenic River Use, an average of 5,813 visitors are on the river per day. These are commercial and non-commercial visitors. For losses from this and other recreational uses see the Table 6 below.

Table 6) Economic Impact Environmental Degradation Recreation

Item or Activity	Value	Unit of Measure	Days Available During Closure	Visitor per Day	Total Loss	Year Value	Reference
Mountain Biking	$49.68	per person per day	370	no data availble	$18,382	2004	General Technical report PNW-GTR-658
Backpacking	$52.10	per person per day	460	no data availble	$23,966	2004	General Technical report PNW-GTR-658
Camping	$104.35	per person per day	460	no data availble	$48,001	2004	General Technical report PNW-GTR-658
General recreation	$32.35	per person per day	460	no data availble	$14,881	2004	General Technical report PNW-GTR-658
OHV Use	$40.37	per person per day	399	no data availble	$16,108	2004	General Technical report PNW-GTR-658
Picnicking	$64.22	per person per day	460	no data availble	$29,541	2004	General Technical report PNW-GTR-658
Loss of snowmobiling	$27.29	per person per day	90	no data availble	$2,456	2004	General Technical report PNW-GTR-658
Sightseeing	$20.27	per person per day	460	no data availble	$9,324	2004	General Technical report PNW-GTR-658
Loss of Floating, rafting, and canoeing	$44.36	per person per day	168	5813	$43,321,266	2004	General Technical report PNW-GTR-658 and 1977-2013 Tuolumne Wild & Scenic River Use
Item or Activity	**Value**	**Unit of Measure**	**Total Units**		**Total Loss**	**Value**	**Reference**
Loss to Campgroung Concessions		August 2014 to March 2015	NA		$175,054	2015	Internal Data
Cost of Trail Repair	$4,312	mile	25		$107,800	2014	Internal Estimate
Total					$43,766,779		
For the values with no visitor data availble if just 100 people engaged in these activities					$16,265,863		

Contact Barbara Drake at 209-532-3671 ext. 438 for more information