Rim Fire Reforestation Project

FISHERIES REPORT*

Stanislaus National Forest

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*Adapted from Rim Fire Recovery Project fisheries report (USDA 2014)

Introduction

The purpose of this document is to describe the fisheries resource within the Rim Fire Reforestation Project (the project) area and to assess potential effects to the fisheries resource during and following project implementation. Disturbance history, recreational use, fish stocking and the existing condition serve to establish a relative quality for the fish-bearing streams potentially affected by the activities proposed by the project. A qualitative description of the physical habitat (instream and riparian) is provided, based primarily on field evaluation made during surveys for amphibian resources. A portion of the project area has been field reviewed by agency personnel allowing for more accurate analysis. The analysis for the remainder is based on past fish habitat surveys, amphibian surveys, description by other field-going Forest personnel and aerial photo interpretation. The potential for direct, indirect and cumulative effects to the fish species inhabiting the project area are addressed.

A full description of the purpose and need, location, activities, treatments, treatment units and prescriptions is contained in the Environmental Impact Statement for which this report serves as a supplement. This document addresses the potential project related effects to the fishery itself with a cursory discussion of habitat effects, specifically in relation to the fishery. A full description of the life history, distribution and habitat requirements for each trout species can be found in Meehan (1991) and for all species in Moyle (2002). Information on historic species presence and stream condition were found in the Stanislaus National Forest Fisheries Habitat Management Plan (USDA Forest Service 1971).

The Species

Six species of fish are known to occur within the project area. They include:

Rainbow trout, *Oncorhynchus mykiss* (Walbaum)
Brown trout, *Salmo trutta* (Linnaeus)
California roach, *Lavinia symmetricus* (Baird and Girard)
Sacramento sucker, *Catostomus occidentalis* (Ayres)
Riffle sculpin, *Cottus gulosus* (Girard)
Sacramento pikeminnow, *Ptychocheilus grandis* (Ayres)

Rainbow trout

The rainbow trout is the most widely distributed and, debatably, sought-after fish species on the Forest. It occurs from elevations below 900 meters to well above 2000 meters. Prior to European settlement of the region, rainbow trout and several salmon species were the only salmonid fish in the general region. Resident and sea-run populations (steelhead) historically occurred in the Merced and Tuolumne Rivers. The extent to which indigenous strains of rainbow/steelhead occupied the project area is unknown. The development of hatcheries and the proliferation of fish stocks adapted to hatchery conditions, combined with the development and alteration of downstream river reaches,

bring about the doubtful existence of the “native” rainbow genetic component (Moyle 2002).

Much of the existing rainbow trout fishery throughout the streams in the project area is the result of self-sustaining populations arising from stocked fish (holdovers) and/or stocked fish released throughout the year by California Department of Fish and Wildlife (CDFW). The fishable waters in the project area are relatively low in elevation with good access. Recreational opportunities for the species are available during the permissive fishing season. Rainbows residing in small streams rarely attain very large size, partially limited by productivity of food resources and maximum pool size.

Rainbow trout generally spawn in the spring as streamflow begins to abate from the high flow of winter. Successful spawning can occur well into the early summer and is largely dependent upon stream temperature and discharge. The pool tail and associated downstream riffle are the habitats where spawning occurs. Generally, small to medium sized gravel substrates provide for easy redd construction and permits water infiltration through the constructed redd. As fine-grained sediment supply increases in response to terrestrial changes (either suspended in the water column or involved in bedload transport), they can be deposited in the redd. If this sediment is supplied in excess, water interchange in the streambed is decreased and egg survival and subsequent fry emergence may be negatively affected.

Some of the following discussion of physical habitat is relevant to trout collectively, with specific mention made for rainbow trout. Physical instream habitats and water quality play important roles in supporting and maintaining trout populations. Physical habitat needs vary with the season and life stage of the animal. Three primary habitats are broadly defined as pool, run and riffle. Additional elements contribute “quality” factors and include depth, cover, substrate type and the interval association of habitats. Water quality elements include, but are not limited to, temperature, dissolved oxygen, turbidity and streamflow.

Habitat with deep water is important for providing thermal refuge in winter and summer. Undercut banks, woody debris, riparian vegetation and large substrates provide cover for fish. Generally, deep pools harbor the largest fish, which has been noted by personnel performing amphibian surveys. As described by Moyle (2002) and Bjornn and Reiser (1991), juveniles are most often encountered in run habitats characterized by depths of 0.5 to 1.0 meters and velocities of 0.1 to 0.3 meters/second; fry show a preference for shallow (<0.5 meter), slow (<25 centimeter/second) water, likely an adaptation for predation survivability. Runs having clean-swept bottoms comprised of larger substrates (4 to >40 centimeters diameter) provide spaces in between stones that afford escape and resting refuge. Objects providing cover improve the quality of run habitats and can influence fish abundance (Bjornn and Reiser 1991). Riffles are the primary site of instream macroinvertebrate food production, with abundance positively correlated to substrate sizes dominated by cobble, pebble, and gravel (Merritt and Cummins 1996).

Water quality parameters such as temperature, dissolved oxygen, turbidity and streamflow are crucial throughout the year for maintaining the trout fishery. The optimal temperatures for growth of rainbow trout are 15 to 18 degrees Celsius (Moyle 2002). A critical thermal maximum temperature is approached as stream temperatures exceed 25 degrees Celsius. Rainbows can tolerate short periods of temperatures exceeding 25 degrees Celsius, provided the critical maximum exceedance is gained gradually. However, there is a physiological (metabolic) cost to the fish when exposed to high temperatures.

Brown trout

Brown trout are native to Europe. They were introduced into California to provide an additional recreational species, as they are an excellent game fish and table fare. They spawn from late fall to late winter, with increasing streamflow and decreasing water temperature combining as environmental cues. Like the rainbow trout, brown trout also construct a redd at the tail end of pool, but a different strategy is employed by the latter in that the reproductive effort of the female is accomplished by the construction of multiple redds in which only a fraction of the eggs are deposited in each for fertilization (Moyle 2002). Embryos typically emerge in 7 to 8 weeks (range of 4-21 weeks), with the alevins emerging from the redd 3 to 6 weeks later (Moyle 2002). The high flows associated with winter's passage and the occurrence of rain-on-snow events makes the eggs, alevins and fry particularly vulnerable to mortality.

Fry seek slow and shallow waters along the margins of the stream. Juveniles tend to occupy habitats with increased velocity and depth, with a preference for extensive cover provided by rocks, logs and undercut banks. Fish in the fry and juvenile stages are best afforded survival if they avoid the deeper waters occupied by adults, for cannibalism is commonplace in the species. Maturity is usually reached in two to three years. Adults can attain larger maximum size in stream habitats than rainbows. Deep pools with extensive cover will generally produce the largest fish for the angler. Their ability to withstand heavy angling pressure, natural wariness and tendency toward nocturnal feeding contribute to the species' ability to maintain fishable populations (Etnier and Starnes 1993).

The brown trout is more tolerant of higher temperatures and can survive for short periods of time in waters approaching 30 degrees Celsius. Optimum growth occurs at temperatures near 18 degree Celsius (Moyle 2002). Their metabolic tolerance for high temperatures can be partially offset by increased consumption of food, which, for the brown trout, can include very large prey items. Smaller browns feed heavily on insects in drift, both aquatic and terrestrial.

California roach

The California roach is a small, native minnow (family Cyprinidae) and is commonly found throughout lower and mid-elevation habitats in the Sierra Nevada. Often thought of as a warm water fish, the roach is known to co-occur with rainbow trout in cooler waters.

The roach can occupy a wide variety of stream types, from very warm (30 to 35 degrees Celsius) intermittent streams with low dissolved oxygen to cold, turbulent trout streams (Moyle 2002). The roach also exhibits adaptation to fire-prone environments, as its persistence in streams affected by high severity fire is a testament. Given their ability to thrive in a wide range of environmental conditions and stream types, their broad distribution and ability to co-exist with other native species; the overall population status range wide is considered to be stable (Moyle et al. 1996).

California roach generally spawn in the crevices of fine gravel from April to June when water temperatures reach 16 degrees Celsius (Moyle 2002). Like most cyprinids, congregations of many individuals (up to 200) engage *en masse* in the spawn with the females releasing only a few eggs at a time accompanied by attendant males. The general commotion of the spawning activity is necessary to clear silt and sand from the interstices of gravel prior to egg deposition (Moyle 2002). The eggs hatch in only a few days, the fry emerging shortly following egg sac absorption, up to two weeks. Once free from the gravel, the young inhabit slow, shallow water feeding on midge larvae and small crustaceans. Juvenile and adult fish are opportunistic and omnivorous, taking a wide variety of prey items. Roach mature in two to three years, with a lifespan occasionally exceeding three years.

Sacramento sucker

Sacramento sucker is a highly variable, native species common and widely distributed in central and northern California (Moyle 2002). They are most abundant in clear, cool streams and rivers, but are known to occur in warm sloughs (Moyle 2002). Sacramento sucker are typically associated with native minnows, such as Sacramento pikeminnow, hardhead and California roach (Moyle 2002). Water temperature can be highly variable for this sucker, with the species found in both cold (15 to 16 degrees Celsius maximum) and warm water (29 to 30 degrees Celsius); preferred temperatures are 20 to 25 degrees Celsius (Moyle 2002).

Adult suckers are found in higher numbers in larger streams, with juveniles more numerous in tributaries or shallow reaches of large rivers near spawning areas (Moyle 2002). Microhabitat selection is related to size with larvae concentrating over detritus bottoms or among emergent vegetation in warm, protected stream edges (Moyle 2002). Juveniles utilize shallow (20-60 centimeter), slow flowing (<10 centimeters/second) water along stream margins where they forage along the stream bottom. Deeper water can be used if predators are absent. Adult and sub adult suckers spend the day in deep pools or runs, or beneath undercut banks near riffles (Moyle 2002). Sacramento suckers eat algae, detritus and small, bottom-dwelling invertebrates (Moyle 2002).

Growth of suckers is variable, with faster growth rates observed in warmer waters. Fish mature between 4 and 6 years and can live considerably longer than 10 years (Moyle 2002). Sucker populations typically have a non-uniform age structure, with reproductive success highest in wet years (Moyle 2002). Suckers can move considerable distances to tributaries to spawn over gravel riffles between late February and early June (Moyle

2002). Fertilized eggs adhere to gravel or detritus, or bounce along the bottom until they are caught in gravel or backwater areas (Moyle 2002). Embryos hatch in 2 to 4 weeks and larvae remain in the gravel; post larvae fish emerge from the gravel are washed to warm shallows or flooded vegetation where they aggregate (Moyle 2002). Sacramento sucker is able to withstand adverse environmental conditions and flood the environment with young when conditions improve (Moyle 2002).

Riffle sculpin

Riffle sculpin is a native fish most common in "permanent, cold, headwater streams where riffles and rocky substrates predominate" (Moyle 2002). Although they select shallow areas with swift water, they spend most of the time sheltered under rocks or logs where velocity is lower (8 to 9 centimeters/second) (Moyle 2002). Sculpin are most often found in water less than 26 degrees Celsius (Moyle 2002).

In general riffle sculpin are restricted to flowing water because they require oxygen levels near saturation (Moyle 2002). Presence of riffle sculpin is a good indicator of water and habitat quality, and this fish is usually found in association with rainbow trout (Moyle 2002). Sculpin eat benthic invertebrates and larger fish may occasionally eat smaller fish (Moyle 2002).

Riffle sculpin are thought to seldom live longer than 4 years, with sexual maturity reached at the end of their second year (Moyle 2002). They spawn in swift water on the underside of rocks or in submerged logs; males guard the nest (Moyle 2002). Depending on temperature, embryos hatch in 11 to 24 days and fry begin a benthic existence after absorbing the yolk sac (Moyle 2002). Dispersal is limited due to their benthic larvae. Sculpin are abundant locally and widely distributed, however population isolation is of concern (Moyle 2002). This species is particularly vulnerable to changes that reduce flows or increase temperatures; hence their presence in relatively undisturbed streams (Moyle).

Sacramento pikeminnow

Sacramento pikeminnow is a large, native minnow (family Cyprinidae) that is highly mobile and favors large streams. They are found in low- to mid-elevation streams with deep pools, slow runs, undercut banks and overhanging vegetation and are most abundant in lightly-disturbed tree-lined reaches with other native fish (Moyle 2002). Summer water temperatures range from 18 to 28 degrees Celsius with temperatures above 38 degrees Celsius lethal (Moyle 2002).

Juvenile pikeminnow school with other native cyprinids, with the smallest fish occupying the shallowest water at the stream edges (Moyle 2002). As the fish grow, deeper and faster water is used. Large pikeminnow will spend the day in loose groups swimming around in large pools and feeding on surface insects or benthos (Moyle 2002). The largest fish remain under cover until darkness falls at which time they begin to forage on small fish in runs and shallow riffles (Moyle 2002). Pikeminnows are opportunistic predators,

with type of prey taken dependent on size of the fish. Aquatic insects are taken by the smallest fish (<10 centimeters), with a switch to other fish and crayfish at 10 to 20 centimeters in size. Larger fish prey almost exclusively on fish and crayfish, although are known to take other types of prey (Moyle 2002). In areas where they co-occur, California roach, Sacramento suckers and rainbow trout use shallower or faster water to avoid predation by pikeminnow (Moyle 2002).

Pikeminnow are slow growing and long-lived, with records of 16 year old pikeminnow from the Russian River (Moyle 2002). Pikeminnow mature in the third or fourth year and are able to spawn each year, although when conditions are unfavorable they will forgo spawning (Moyle 2002). In April and May fish will move upstream to gravel riffles or shallow flowing areas at the base of pools to spawn (Moyle 2002). Water temperature at spawning is between 15 and 20 degrees Celsius (Moyle 2002). In large rivers spawning will occur in tributary streams Moyle 2002). Eggs hatch in short order (4 to 7 days) approximately 2 weeks after spawning fry begin gathering in shallow pool edges or backwaters (Moyle 2002).

The Streams

There are thirty-five named fish bearing streams within the project area, totaling approximately 300 miles of stream reaches. Table 1 lists these streams and the fish species present. The streams are arranged to show how streams flow into each other, from downstream to upstream. For example: Niagara Creek is a tributary to Reed Creek, which in turn is a tributary to the Clavey River, which is a tributary to the Tuolumne River.

Table 1: Fish bearing streams in the Rim Fire Reforestation Project Area and fish species present. Streams marked with an asterisk (*) were surveyed for stream condition between 2005 and 2012.

Streams	Fish Species Present
❖ Tuolumne River	brown trout, California roach, rainbow trout, riffle sculpin, Sacramento sucker
➢ North Fork Tuolumne River*	California roach, pikeminnow, rainbow trout, riffle sculpin, Sacramento sucker
▪ Hunter Creek*	California roach, pikeminnow, rainbow trout, riffle sculpin, Sacramento sucker
▪ Duckwall Creek*	rainbow trout
▪ Basin Creek*	rainbow trout
➢ Clavey River*	California roach, pikeminnow, rainbow trout, riffle sculpin, Sacramento sucker (brown?)
▪ Bear Springs Creek	rainbow trout
▪ Reed Creek*	rainbow trout
• Niagara Creek*	rainbow trout
• Bourland Creek*	rainbow trout
• Reynolds Creek*	rainbow trout
♦ Lost Creek*	rainbow trout

♦ Little Reynolds Creek*	rainbow trout
▪ Cottonwood Creek*	rainbow trout
• Thirteenmile Creek*	rainbow trout
▪ Hull Creek*	rainbow trout (brown?)
• Rush Creek	rainbow trout (brown?)
▪ Twomile Creek*	rainbow trout
• Camp Twentyfive Creek*	rainbow trout
• Brushy Creek*	rainbow trout
▪ Trout Creek*	rainbow trout
➢ South Fork Tuolumne River*	brown trout, rainbow trout
▪ Middle Fork Tuolumne*	rainbow trout
▪ Big Creek*	brown trout , rainbow trout
▪ Soldier Creek*	rainbow trout
▪ Rush Creek*	rainbow trout (brown?)
▪ Ackerson Creek	rainbow trout
➢ Drew Creek	rainbow trout (brook?)
➢ Corral Creek*	rainbow trout
➢ Jawbone Creek	rainbow trout
▪ Skunk Creek	rainbow trout
▪ Crane Creek	rainbow trout
➢ Cherry Creek	California roach, rainbow trout, riffle sculpin, Sacramento sucker
▪ Granite Creek*	rainbow trout
▪ Eleanor Creek*	rainbow trout (brook and brown?)

Stream condition inventories were conducted along portions of 23 streams within the Rim Fire area between 2005 and 2012. These streams are marked with an asterisk (*) in Table 1. Data is found in the Stanislaus StreamScape Inventory Database and can be summarized for baseline watershed and stream information prior to management activities. The Watershed Report summarizes the information on streams in the Rim Fire area prior to the fire and concluded that overall streambank stability was high, 16 out of 23 streams had very good condition in channel form with the remaining streams showing some evidence of accelerated incision or widening, low amounts of pool tail and pool bed sediments indicated a very stable watershed landscape, and excellent water temperatures were observed.

Table 2. Stream condition summary.

Stream Channel Indicators				Stream Habitat Indicators					
Streambank Stability		Channel Form		Pool Tail Fine Sediment		Pool Bed Fine Sediment		Water Temperature Maximum	
%	Streams	% Normal or Rejuvenating	Streams	%	Streams	%	Streams	Deg. C and (F)	Streams
>75	21	>75	16	<10	16	<10	18	<15 (59)	10
50-75	1	50-75	4	10-20	3	10-20	3	15-20 (59-68)	9
<50	1	<50	3	>20	4	>20	2	>20 (68)	4

The Rim Fire of 2013 drastically altered the landscape of the project area. As described in the Environmental Impact Statement, the Rim Fire started on August 17, 2013 in a remote area of the Stanislaus National Forest near the confluence of the Clavey and Tuolumne Rivers about 20 miles east of Sonora, California. Exhibiting high to extreme fire behavior with multiple flaming fronts, the fire made runs of 30,000 to 50,000 acres on two consecutive days. It quickly spread up the Tuolumne River watershed and its main tributaries: Clavey River, North Fork Tuolumne River, Middle Fork Tuolumne River, South Fork Tuolumne River and Cherry Creek. It also overlapped into the North Fork Merced River. Over several weeks it burned 257,314 acres, or 400 square miles including 154,530 acres of National Forest System (NFS) lands. The fire also burned within Yosemite National Park (78,895 acres), Sierra Pacific Industries private timberland (16,035 acres), other private land (7,725 acres) and Bureau of Land Management (BLM) land (129 acres).

The Rim Fire contains a mosaic of high, moderate and low soil burn severity plus unburned areas within its perimeter. Table 2 displays estimates for burn severity within Riparian Conservation Areas (RCA). Many past fires occurring within the Rim Fire perimeter have half or more of their total acreage in the low and unburned categories that resulted in minimal to negligible watershed impact. Most watershed damage occurs from high soil burn severity, and lesser from moderate soil burn severity. The actual amount of erosion from the hillslopes and the amount entering streams as sediment depends on several factors, including soil type, soil texture, hillslope steepness, ground cover quantity, and rainfall intensity. When substantial sediment enters a stream, habitat complexity is reduced (e.g., pool filling) and substrate composition change, such as abundant fine sediment, may reduce spawning suitability for many species. Observations in the Rim Fire area indicate hillslope erosion increased immediately post-fire. Post-fire erosion rates are expected to return to pre-fire rates within five to ten years. Observations made by the Forest Service personnel during 2015 and 2016 field visits indicated that many streams are already showing signs of recovery/stabilization due to rapid vegetation growth, though substantial aggradation is evident and will likely persist through a normal recovery period (5-10 years).

Table 3: Riparian Conservation Area burn severity summary (project watershed report).

HUC Level and Name	Riparian Conservation Area (RCA) (100-foot stream buffer)					Watershed (total acres)
	Soil Burn Severity % acres in RCA				Vegetation Burn Severity % acres with 75-100% Canopy Mortality	Soil Burn Severity % acres in Watershed
	High	Mod	Low	H+M		High+Mod
5 – Big Creek-Tuolumne River						
6 – Big Creek	0	0	100	0	0	0
6 – Grapevine Creek-Tuolumne River	0	11	89	11	15	27
6 – Jawbone Creek-Tuolumne River	11	38	51	49	50	70
7 – Corral Creek	41	51	9	92	88	89
7 – Lower Jawbone Creek	3	42	55	45	49	85
5 – North Fork Tuolumne River						
6 – Lower North Fork Tuolumne River	1	8	91	9	6	7
5 – Clavey River						
6 – Lower Clavey River	1	19	80	20	19	49
7 – Bear Springs Creek-Lower Clavey River	2	17	81	19	14	50
6 – Middle Clavey River	1	7	92	8	7	13
6 – Reed Creek	3	10	87	13	11	23
7 –Lower Reed Creek	12	31	56	43	41	62
5 – Cherry Creek						
6 – Lower Cherry Creek	13	34	53	47	45	53
7 – Granite Creek	35	59	6	94	91	92
6 – Upper Cherry Creek	0	0	100	0	0	1
6 – West Fork Cherry Creek	0	0	100	0	0	0
5 – Eleanor Creek[1]						
6 – Miguel Creek-Eleanor Creek	4	34	62	38	41	35
5 – Falls Creek-Tuolumne River[1]						
6 – Poopenaut Valley-Tuolumne River	5	27	68	32	32	39
5 – Middle Fork Tuolumne River[1]						
6 – Lower Middle Fork Tuolumne River	5	50	45	55	50	63
6 – Upper Middle Fork Tuolumne River	3	22	75	25	17	29
5 – South Fork Tuolumne River[1]						
6 – Lower South Fork Tuolumne River	2	23	75	25	18	46
6 – Upper South Fork Tuolumne River	4	19	77	22	17	25
5 – North Fork Merced River						
6 – Bull Creek	0	2	98	2	2	2
6 – Bean Creek-North Fork Merced River	0	2	98	2	2	4

[1] Substantial portion of the fire extends east into Yosemite National Park

Base flow and peak flow are expected to increase post-fire due to loss of vegetation and ground cover. Higher peak flows can result in scouring of the stream channel and banks, and can be a significant source of post-fire sedimentation. These higher peak flows can continue for three to five years after the fire. Base flows can increase several fold throughout the year post-fire, and can continue for several decades until vegetation recovers. Streamflow plays an important role in providing adequate velocity and water depths within each habitat type and in temperature maintenance. In spawning gravels, there is adequate streamflow to transport metabolic waste away from the eggs and alevins developing in the redd and to provide an ample supply of oxygen. During the summer, and especially when temperatures reach or exceed a preferred maximums, streamflow is

needed to create the turbulence necessary for providing dissolved oxygen. Turbulent flow can provide visual cover for feeding and escaping fish, in addition to transporting food resources. Perennial streamflow indicates the contact of surface water with ground water and provides thermal moderation (cooling influence) during the summer.

Streamflow and stream gradient determine the amount of sediment that is transported or stored in the channel. The higher the gradient the easier it is to transport fine sediments. The higher energy associated with larger streamflows moves larger quantities of sediment. Channel conditions should return to pre-fire levels within five to ten years, as evidenced by monitoring after the Stanislaus Complex Fire.

Fire-killed trees will begin to fall and will become large woody debris (LWD) in the vicinity of streams. This recruitment is highest in the 10 to 20 year period following the fire. LWD helps to stabilize streambanks, trap sediment and can result in pool creation downstream. Though some potential LWD was removed during salvage operations, many areas are expected to have ample recruitment for the foreseeable future especially with the additional tree mortality from insects exacerbated by the persistent drought in this area.

The loss of canopy cover due to the fire decreases stream shading and results in higher water temperatures. Stream temperatures can increase 5 or more degrees Fahrenheit (2.5 degrees Celsius) for several years following a fire. Temperatures will return to pre-fire conditions as stream shading returns. Obligate riparian vegetation, such as alder and willow, regrow quickly after a fire to re-shade the stream and are being promoted and protected in this project.

Post-fire effects on the fish species present are related to the predicted habitat changes. Increases in erosion led to an increase in suspended solids in the stream, which resulted in high water turbidity. This is most likely to occur during and after storms when flow is increased. Within the Rim Fire area the highest erosion rates are predicted to occur in Corral Creek, Lower Jawbone Creek, Bear Springs Creek, Lower Reed Creek, Granite Creek and the Lower South Fork Tuolumne River. Rainbow trout inhabit these streams. Brown trout also occur in the South Fork Tuolumne River. An increase in ambient turbidity levels can negatively affect sight-feeding ability and abrade the delicate tissue of the gills. This can result in poor physiological condition associated with inadequate intake of food, reduced ability to uptake oxygen and/or a combination of the two. Larger trout are sight predators and may have lower success of finding prey in highly turbid water. In highly turbid waters large trout will take refuge in deep pools. Because turbid waters are correlated with rainstorms, which in this area occur at irregular intervals, there will be pulses of turbidity with periods in between when large trout can successfully hunt. As flows decrease, turbidity will decrease both because erosion inputs to the stream lessen and sediments will settle out of the water column.

Increases in sedimentation can have reproductive and physiological effects on fish and can affect breeding success for all six fish species present. Fine sediment can reduce the quality of spawning areas by embedding the spawning substrates, reducing the capacity

for water exchange through the streambed and can effectively smother eggs. Rainbow and brown trout spawn in gravels found in pool tails and their associated riffles. Sediment present in the gravel reduces the interstitial spaces (areas between the gravels) where eggs are deposited. Trout require a good flow of water through the streambed to provide the developing eggs with adequate oxygen and to remove metabolic wastes. Excess fine sediment within the spawning gravels can adhere to the exterior of trout eggs, reduce the exchange of oxygen and metabolic waste through the egg wall and result in egg mortality. Sediment that covers eggs after spawning can reduce egg survival and emergence of fry. Brown trout reproduction is more susceptible to this as brown trout are fall and early winter spawners, before sediment inputs increase with winter storms. California roach may be able to deal with higher levels of sediment, as their spawning behavior works to clear the sediment prior to egg deposition. Effects of sedimentation on riffle sculpin spawning is expected to be less than other species, as riffles are the areas with the swiftest water flow and the last areas to show increased sedimentation. Sacramento sucker and pikeminnow are both known to withstand adverse environmental conditions and spawn when conditions improve. The sculpin, sucker, pikeminnow and roach are also found in major streams (North Fork Tuolumne River, Clavey River, Tuolumne River and Cherry Creek) where sedimentation effects are expected to be less both because of less predicted erosion and higher flows moving sediment through the system.

Sedimentation can also effect macroinvertebrate production and species composition in a stream. As summarized in the Watershed Report, benthic macroivertebrate sampling in the Clavey River and its tributaries in 2007 (Clavey River Ecosystem Project 2008) indicated macroinvertebrate at or near reference condition for the watershed. Increases in sedimentation can result in substrates becoming embedded. Embeddedness reduces the interstitial spaces between coarse substrates, which are the principal areas of colonization for macroinvertebrates that become available as drift. Sedimentation can result in a decrease in macroinvertebrate abundance and diversity as the available habitat is reduced. Species tolerant of sedimentation (i.e., oligochaetes, chironomids) would be expected to increase during the period of increased sedimentation. The duration of these effects would be expected to be relatively short, and would be dependent upon the quantity of sediment delivered to the channel and the ability of the stream to assimilate and export any excess. Macroinvertebrate recolonization of the recovering habitat would be rapid. Long-term effects would be in response to changes in the riparian and watershed vegetation. As described above, sedimentation is most likely to occur in smaller streams in the upper portions of the watersheds in the fire area. Rainbow trout are found in these streams. Changes in available prey can affect growth rate of trout in these areas.

LWD recruitment will begin to accumulate several years post fire and continue up to 20 years. Although LWD will help stabilize the streambanks and reduce scouting in the channels, most of the recruitment will occur after higher peak flows subside. Future pools created by LWD will become occupied by trout, sucker and pikeminnow, allowing larger sizes to be obtained than in creeks with an absence or limit of large, deep pools. Although this is unlikely to affect the population numbers of these species, it may provide for an increased recreational trout fishery in the future.

Temperature increases in the fire area can limit the extent of fish populations. This is most likely with rainbow trout, as they occupy the smaller creeks closer to the headwaters of the watershed. Temperature increases in these headwater areas will be more pronounced as flows are less than downstream , there are more areas of lower gradient stream and pre-fire these areas had more stream shading by trees (as opposed to the Tuolumne canyon which was primarily shrub cover). If lethal temperatures (over 25 degrees Celcius) are reached rainbow trout will contract their range. As stream temperatures decrease trout will reoccupy abandoned stream reaches.

Project effects

The implementation of the proposed project will have varying degrees of effect to the physical habitat and its relative quality. Generally, the potential for direct effects is limited as no instream activity is planned. The potential for indirect effects to individuals and populations is more likely. While the indirect effect of each type of treatment may contribute stresses that present a relatively low risk to individuals, when combined, there may be sufficient pressure to constrain populations until the project is fully implemented and the influences of project-related management are diminished by natural processes. It is expected that fish populations within the project area will incur no noticeable long-term change, especially outside of the range of what could be “normally” expected. Normal expectations primarily include natural events that affect large portions of the landscape (as in large wildland fire, flood or drought), isolated portions of a watershed or subwatershed (as in mass failure of the hillslope) or the effects of stocking.

For all of the potential effects, accurate quantification is not possible. Models developed to predict an outcome (such as sediment delivery to channels using the WEPP model) often utilize variables that may or may not represent the site-specific conditions. The variables do allow for some “tweaking” or manipulation to more closely represent actual conditions during implementation. In some cases, the modeled representations utilize a worst-case scenario and allow for disclosure in the event of an unplanned event or to predict the maximum extent of a potential effect. However, qualification of some of the potential effects is possible and descriptors such as low, moderate and high will be used to characterize the potential for an effect to occur or the risk associated with an effect.

The project consists of treatments designed to speed the rate of reforestation, including the following activities: site preparation, planting, prescribed fire, mechanical and/or chemical release, noxious weed eradication (mechanical and/or chemical) and plantation thinning. Four action alternatives were developed to meet the purpose and need of the project. Alternative 1 is the Proposed Action and involves the full complement of treatment types. Alternative 3 was developed to address issues and concerns related to herbicide use, and would require more extensive ground disturbance to accomplish site preparation, release and noxious weed eradication. Alternative 4 has reduced treatment acreage and would rely more on natural regeneration, increased use of prescribed fire over the next several decades and no herbicides for noxious weed eradication. Alternative 5 has active reforestation replacing natural regeneration treatments, and denser planting

as compared to the other alternatives. Tables 4 and 5 summarize the treatment activities by each action Alternative. A fifth alternative, the No Action Alternative (Alternative 2), was proposed to fulfill the requirements of the National Environmental Policy Act of 1969.

Table 4. Summary of Treatments

Proposed Treatments (acres)	**Alternative 1** (Proposed Action)	**Alternative 2** (No Action)	**Alternative 3**	**Alternative 4**	**Alternative 5**
Deer habitat enhancement	3,833	0	3,833	1,164	3,833
Natural regeneration	4,031	0	4,031	22,464	0
Noxious weed eradication	5,714	0	3,131	3,131	5,714
Reforestation	21,300	0	21,300	2,867	25,331
Thin existing plantations	12,769	0	12,769	12,769	12,769
Prescribed fire only	0	0	0	34,344	0

Table 5. Detailed treatment summary (outside of Deer Habitat Enhancement)

Proposed Treatments (acres)	**Alternative 1** (Proposed Action)	**Alternative 2** (No Action)	**Alternative 3**	**Alternative 4**	**Alternative 5**
Feller buncher	3,139	0	3,139	140	3,318
Feller buncher and mastication	351	0	351	0	423
Hand cut, hand pile and burn	74	0	74	0	271
Hand cut, prescribed fire (understory and jackpot)	237	0	237	51	237
Machine pile and burn	912	0	912	76	925
Mastication	1,493	0	1,493	32	1,528
Total Initial Site Preparation	6,206	0	6,206	299	6,704
Deep till and forest cultivate	5,085	0	8,893	0	5,085
Manually apply herbicides (Glyphosate)	16,215[1]	0	0	2,867	20,246
Total Site Preparation	21,300	0	8,893	2,867	25,331
Total Plant	21,300	0	21,300	2,867	25,331
Release with grubbing	0	0	21,300[2]	0	0
Release with glyphosate	21,300	0	0	4,012[3]	25,331
Total Release	21,300		42,600	4,012	25,331
Total Prescribed Fire at Year 10	21,300	0	21,300	0	0
Total Thin New Plantations	0	0	0	0	25,331[4]
Additional Prescribed Fire in First Decade				17,172	

[1] Does not include proposed 4,031 acres of natural regeneration units that may have herbicide treatment.
[2] Hand release would be required twice annually on the same acres for most competing species.
[3] Release with glyphosate acreage includes treatment of the buffer adjacent to the planted areas.
[4] Thin plantations where needed to create desired ICO structure and to meet fire and fuels structure goals.

No Action Alternative

Under the no action alternative, there would be no direct, indirect or cumulative effects associated with project activities since none would occur. The existing condition would continue to support the fishery in its current state for the short and mid-term. The recreational trout fisheries would continue to be augmented periodically through the stocking efforts of CDFW. Fish habitat would slowly improve through natural processes affecting stream habitat complexity. Additions of large woody debris would occur over time from the fire killed trees near streams.

The native fish assemblage in the project area, as described by Moyle (2002), includes California roach, Sacramento sucker, riffle sculpin, and pikeminnow. These species are found in North Fork Tuolumne River, Hunter Creek, Clavey River, Cherry Creek, and Tuolumne River. Since California roach are well adapted to the stream conditions found in the project area, populations would not likely increase or decrease noticeably. If trout stocking ceases and the trout population is diminished, roach populations could increase due to lack of competition for food and habitat resources and to decreased predation.

Sacramento sucker are adapted to withstand adverse environmental conditions, and to flood the environment with young when conditions improve. Pikeminnnow are long lived and will forgo reproduction during poor conditions. Populations are not likely to increase or decrease under the no action alternative due to effects of the Rim Fire.

Riffle sculpin live in fast moving water found in riffles. Sediment is not likely to be found in the riffles of the larger streams where sculpin are found. Effects of the Rim Fire will not result in population increases or decreases.

The trout resource in the project area may see impacts under the no action alternative. Particularly in the watersheds with high burn severity (Reed Creek, Granite Creek and Jawbone Creek) and correspondingly high predicted erosion rates. Sedimentation can result in lower reproductive success. Stocking by CDFW would lessen this impact. In addition, increased temperature in some areas may result in contracted ranges of rainbow trout for a three to five year period. As vegetation regrows temperatures will return to pre-fire levels and trout would return to their original extant.

Direct and Indirect Effects Common to All Action Alternatives

All action alternatives have the potential to increase stream sediment input. Ground disturbing treatment, such as deep tilling, is most likely to mobilize sediment. Herbicide treatments pose the lowest risk due to the lack of soil disturbance. Prescribed fire generally poses an intermediate risk, as fire intensity is kept low to prevent substantial soil exposure. Alternative 3 would likely produce an increased chance of sediment mobilization as compared to the other alternatives due to the increase in deep tilling acreage. Alternative 4 would likely produce the least chance of sediment increase due to reduced acreage of ground disturbance. Alternatives 1 and 5 would produce intermediate values. The potential for additional sediment delivery to streams is minimized by implementation of management requirements. In addition, all Alternatives would protect existing native riparian vegetation, which should maintain bank stability and provide a filter for any sediment mobilized from treatments.

Under the action alternatives large woody debris (LWD) is not expected to have any measurable change.

Little if any shade-providing vegetation is expected to be removed under any action alternatives; therefore, no measurable change in stream temperature is expected. The treatments are expected to speed the recovery and growth of shade-producing conifers as

compared to the no action alternative, so a long-term benefit to this habitat component is expected.

There is a small chance of low-concentration herbicide contamination in a few sections of stream. Risk assessments indicated that concentration will be well below those capable of measurably impacting fish. There is a chance of short-term impacts to aquatic plants and algae, which could theoretically affect food organisms (e.g., macroinvertebrates) utilized by trout. This risk is deemed very low due to project management requirements that restrict herbicide use near water along with retention of all native riparian vegetation. Therefore, the already low estimated concentrations are likely an overestimate of those that will actually occur. If indirect effects to food organisms were to occur, they would be short-term and spatially isolated. Herbicide application would not occur under Alternative 3, and would be limited to only reforestation applications (glyphosate) under Alternative 4.

Cumulative Effects

The watershed report discusses Cumulative Watershed Effects using the Equivalent Roaded Area (ERA) model used by the Pacific Southwest Region. Grazing was not included in ERA calculations as grazing effects are more of a site issue than a watershed issue.

Under this project two HUC 6 and four HUC 7 watersheds exceeded the Threshold of Concern (TOC) based on ERA percentage, almost entirely due to the contribution from previous non-project actions. These watersheds are the same watersheds that exceeded the TOC under the Rim Fire Recovery Project with the exception of the Lower Jawbone Creek HUC7 watershed that remained under TOC under this project. All of the rest of the analysis watersheds were below the TOC (Watershed Report). In nearly all watersheds, the project alternatives would contribute less than 1% to the ERA total. The main differences between the action alternatives are the percentage of ERA calculated and the length of time the TOC is exceeded; exceedance of TOC is only possible in a small minority of project area watersheds, and these few watersheds are expected to fall below TOC within a maximum of 6 years. Although there are small differences in ERA values between the action alternatives, measurable cumulative impacts on fish are expected to differ very little.

Management Requirements and Best Management Practices are expected to minimize the effects of the action alternatives on the streams. The action alternatives are not expected to result in adverse off-site cumulative effects to sediment-related water quality parameters or to watershed condition or to water temperatures. Although grazing has the potential to result in streambank disturbance and to slow recovery of riparian vegetation, effects will be localized and existing Forest and permit Standards and Guidelines should allow for riparian vegetation recovery to progress unimpeded.

Summary

The potential for effects associated with sedimentation are expected to be minimal due to the absence of instream treatments, and management requirements that will prevent most sediment from being mobilized adjacent to streams. The available spawning habitat could be degraded slightly by sediment in a minority of areas, and could slightly constrain recruitment of trout. Food resources could change in either abundance or diversity where sedimentation is high, particularly in smaller streams; similarly, herbicide application could slightly affect food organisms in the short-term. Temperatures in streams are not expected to be affected by project treatment, and project treatment should speed the recovery of shade-providing vegetation. Sediment and food resource changes could result in a slight reduction in habitat quality in select stream reaches, though a reduction in trout range is not expected. California roach and Sacramento sucker are adapted to a wide range of environments, including those dominated by fine sediments. Roach, sucker, sculpin and pikeminnow populations would not be affected significantly by increased sediment or minor changes in food resources due to herbicide use.

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