

**A Biological Assessment of Impacts to Aquatic Threatened Species
for the Annual Routine and Non-Routine Road Maintenance
Program
in Redwood National and State Parks (RNSP)**

**Amendment
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INTRODUCTION

The purpose of this biological assessment is to determine the effects of the proposed annual routine and non-routine roads maintenance program's actions on threatened salmonids and their habitats (see Appendix D). RNSP intends this biological assessment prepared in accordance with legal requirements set forth under Section 7 of the Endangered Species Act (19 U.S.C. 1536 (c)), to satisfy the Essential Fish Habitat consultation under the Magnuson-Stevens Act (16 U.S.C. 1801) with the National Marine Fisheries Service (NMFS).

CONSULTATIONS WITH NATIONAL MARINE FISHERIES SERVICE (NMFS)

Redwood National and State Parks obtained a list from the Arcata Fish and Wildlife Service Office website, identifying the endangered, threatened, and candidate species that may be present or may be affected by park activities, dated February 23, 2005 (Document Number 209695292-15265). This list included 23 species currently listed as threatened or endangered and four species that are candidates for listing in Humboldt and Del Norte Counties. Of the 23 species listed for the two counties, three federally listed as threatened anadromous fish occur in Redwood National and State Parks. The three anadromous fish are the Southern Oregon/Northern California Coasts (SONCC) coho salmon (*Oncorhynchus kisutch*), the California Coastal (CC) chinook salmon (*Oncorhynchus tshawytscha*) (formerly part of the Southern Oregon/Northern California Coasts ESU for chinook salmon during the original consultation for the 1998 BA of Impacts to Aquatic Threatened and Proposed Species from the Watershed Restoration Program) and Northern California (NC) steelhead trout (*Oncorhynchus mykiss*). All proposed actions are located on federal lands within RNSP.

Informal and formal consultation on RNSP annual routine and non-routine road maintenance program resulted in a Biological Assessment and Biological Opinion (dated March 4, 2003 Ref. No. 151422-SWR-02-AR-6347) on the action. It was determined the projects proposed under the batch may affect, but were not likely to jeopardize the continued existence of SONCC coho salmon, CC Chinook salmon, or NC steelhead, nor is it likely to destroy or adversely modify the designated critical habitat of SONCC coho salmon. The bases for the determination were 1) reducing the amount of sediment entering Redwood Creek in the long-term and 2) increasing the amount of available spawning and rearing habitat, resulting in increased distribution for SONCC coho salmon, CC Chinook salmon, and NC steelhead. The trigger for reinitiating consultation and amending the BA is the need to include Mill Creek Horse Trail Road and Geneva Road for consultation coverage. Both roads were not listed in the original BA.

MANAGEMENT DIRECTION

Please refer to the September 26, 2002 BA for a detailed summary of RNSP management direction.

DESCRIPTION OF PROPOSED PROGRAM

To ensure public and administrative safety, RNSP proposes to implement the Park-wide Routine and Non-Routine Road Maintenance Program that provides for safety of Park visitor and operation and maintenance of roads in accordance with regulations implementing the Highway Safety Act (23 U.S.C. sections 401-410), while also addressing barriers to fish passage, drainage diversion, slope failure problems that can potentially result from general road use and preventing sedimentation and contaminants from entering stream courses.

Road maintenance activities are often necessary as a result of drainage problems. Drainage structures are constructed in locations to minimize impacts of roads on watersheds. Most park roads are designed and constructed in a manner, which requires regular drainage structure maintenance.

In addition to maintaining drainage structures, the proposed actions will allow the Park to meet its responsibilities under the Highway Safety Act (23 U.S.C. sections 401-410). The proposed projects will remove obstacles and repair damaged road surfaces, increasing traveler safety.

The proposed projects can be divided into two categories of periodic maintenance or prescribed treatments for roads: 1) routine maintenance of the road surface, the cut bank and the fill slope, and 2) non-routine maintenance at stream crossings to reduce erosion potential on roads. The work detailed in this proposal is planned to occur over the next 5 years. At that time, RNSP will re-initiate consultation to continue periodic road maintenance.

Routine maintenance

Routine maintenance is a preventive measure to help reduce erosion along roads that are not currently scheduled for removal and to provide safe vehicular access to park areas for public and park staff. A negligible amount of erosion is expected during these activities, and the amount of road-related erosion will be reduced once the roads are properly maintained. This work is planned to continue until such time as the roads are removed, which may be as much as 20-40 years from now. All ground disturbing actions associated with the Program are expected to occur between June 1 and October 15. If RNSP determines that a limited amount of actions could be implemented after October 15 then RNSP may proceed, in coordination with NMFS, so long as work is not initiated if precipitation is anticipated within 48 hours or where saturated ground conditions exist. RNSP will have all erosion control materials necessary to winterize each work site within 24 hours for all work occurring after October 14. RNSP will monitor weather forecasts daily after October 14 to determine when wet weather conditions are likely and when to cease operations for the year.

The following listed activities incorporate mitigation guidelines as stated in the Project Design Criteria for Routine Road and Non-Routine Road Maintenance for Redwood National and State Parks.

1. Blading - This work consists of surface blading native or aggregate roadbeds to a condition to facilitate traffic and provide proper drainage. Blading includes shaping the crown or slope of the traveled way, berms, and drainage dips. Excess roadbed width shall be shaped only as needed to provide drainage away from the traveled way. The work would be generally be accomplished by a motor grader.

Sidecasting- Sidecasting at times, is unavoidable in many instances when cleaning inboard ditches. Great care will be taken not to sidecast near any stream channel. When approaching a stream crossing, the operator pulls the material on to the road surface and use a loader to move the materials offsite. Redwood National and State Parks eventually will eliminate inboard ditches anywhere possible, which will reduce or eliminate the need to sidecast. The procedure for blading the actual road surface is different as the operator works the material back and forth, retaining as much as possible. Blading is not performed during periods of rain or runoff.

2. Dust abatement – This work consists of applying dust palliatives to native and aggregate-surfaced roads. A non-petroleum-based product, magnesium chloride, is the material utilized. It is a product approved by the Environmental Protection Agency. The only road in the park where this procedure is performed, in the South Operations Access road, which is a .75 mile long road. This work would generally be accomplished with a water truck. To prevent impacts to riparian resources, water will be drawn from designated drafting sites with a screened intake.
3. Spot surfacing – This work consists of placing surface aggregate as designated. It includes preparing the area, and furnishing, hauling, and placing all necessary materials to blend with the adjacent road cross-section. This work would generally be accomplished with a dump truck, motor grader, and a small roller.
4. Asphalt pavement patching – This work consists of patching potholes, skin patching of asphalt surfaces, and patching asphalt berms. Generally this work will be accomplished using a grader, dump truck, small paver, and small roller. A backhoe will be used if the damaged area requires digging out. RNSP has approximately 17 miles of paved road (See Maps). Occasional pothole patching is done on an annual basis, but there is no runoff of petroleum base products during this procedure. We have identified several parking lots and Alder Camp road to receive an overlay. The procedure does require tack oil to bond the existing pavement with the new, but these projects are only performed during the dry season. The equipment utilized by contractors allows for the oil to only be applied on the existing surface.
5. Maintenance of unpaved shoulders – This work consists of reshaping unpaved shoulders adjacent to a paved traveled way to their original configuration. This would generally be accomplished with a motor grader with attachments. There will be no sidecasting anywhere that there is likelihood that the sidecast material will reach a channel.
6. Ditch maintenance – This work consists of removing rock, wood, soil, and other materials and re-shaping all types of drainage ditches to provide a waterway which is unobstructed.

During the operation, care shall be taken to retain existing low growing vegetative cover in the ditches. This work would generally be accomplished with a motor grader and/ or backhoe. **This activity occurs only during the dry season.**

7. Remove and end haul materials – This work consists of loading, hauling, and placing debris or excess materials (such as rock, soil, and vegetation) to designated disposal sites such as old landings. This work would normally be accomplished with a wheel loader and dump truck when excess materials are hauled to a disposal site. If materials are used to fill slumps in the road compaction will be required. Generally a wheel loader, dump truck, compactor, motor grader, and backhoe would be used.
8. Drainage structure maintenance – This work consists of cleaning and reconditioning culverts and other drainage structures such as catchbasins, inlet and outlet channels, and ditchline transition areas. Usually accomplished by hand, or in extreme cases, with a backhoe and hauled off to a NPS designated areas away from streamcourses. Work does not include cleaning totally plugged culverts or replacing all or part of the drainage structure.
9. Roadway drainage maintenance – This work consists of proving drainage on roads that have been physically closed to traffic. At completion of drainage work the road will not necessarily be passable to vehicles.
10. Drainage dip maintenance – This work consists of maintenance of existing drainage dips, including rolling dips on native, aggregate, and paved roads, and maintenance of special outlet structures to provide for a smooth flow of water from the traveled way. Generally, this work would be accomplished with a motor grader with attachments. Note: Dips are designed to function only when the culvert plugs or is overtopped. They may carry minor amounts of road surface runoff, which is somewhat unavoidable. But the full stream flow should not run thru the unless there's culvert/humboldt problems.
11. Vegetation establishment - This work consists of applying seed, and mulch, and planting roadways and disposal areas that have been disturbed by maintenance activities. This work would usually be accomplished by hand. The Park does not use fertilizers in any maintenance operation.
12. Cutting roadway vegetation – This work consists of cutting all vegetation, including hazard trees, less than 12" in diameter at six inches above the ground in order to improve sight distance and provide overhead clearance. With approximately 180 miles of roadside vegetation to maintain this procedure is done on a year-around basis. This work would be performed by hand using chainsaws or with a mechanical brush cutter. The objective is to manage roadside vegetation over time to maintain slope stability through vegetation cover while providing for sight distance and drainage needs. All of the work would occur within the road prism.
13. Windstorm Clearance – This work consists of removing down trees from roadway surfaces. This work is intended to open roads closed by minor windstorm debris or other natural

occurrences. The woody debris is collected for park use or put back into the forest. It is not put into any stream channels.

14. Maintenance of cattleguards – This work consists of cleaning and restoring cattleguards and appurtenances. Work would normally be accomplished by hand, although heavy equipment may be used to raise the deck grid.
15. Sign Maintenance – This work consists of cleaning, replacing, and reconditioning signs, posts and markers. Park Service personnel would normally accomplish this work by hand.

Non-routine maintenance

Paved surface cleaning – this work consists of removing loose material from a paved traveled way, including bridge decks and paved shoulders. Use of hydraulic flushing will not be permitted within a horizontal distance of 200 feet of a live stream, unless approved by the Fish and Wildlife Branch of RNSP. Other cleaning should be accomplished using power broom or blowers, truck with rock blade, and grader. **Note-** Hydraulic Flushing occurred only twice in the past ten years as a last ditch effort to unplug culverts.

Culvert Replacement/Upgrading

Each stream crossing on all roads not currently scheduled for removal will be evaluated for erosion control needs and treated as appropriate to reduce future erosion. The options include replacing or repairing culverts, installing arch culverts, installing additional culverts, constructing rolling dips and removing completely. This work will help minimize erosion until such time as these roads can be removed.

This work includes the removal of existing undersized, leaking or worn out culverts. Culverts will be replaced and additional culverts will be installed where needed and none now exist. Old culverts and any buried woody debris will be removed, exposing the original channel bed. The size of the excavation will vary depending on the size of the culvert and the amount of woody debris found in the fill. The sizing of a new culvert will be based on hydrologic modeling of the watershed, stream size, stream gradient (see Figure 1) and estimated 100 year cfs. A new culvert would be set below stream grade to allow stream bed material settle out in the culvert bottom. The new culvert shall be installed to maintain a uniform flow line from inlet to outlet channel. The backfill is compacted around the pipe using vibratory compaction equipment. Culverts at locations requiring dewatering and have fish passage issues will be replaced under the non - routine maintenance portion of this BA and will be required meet NMFS “Guidelines for Salmonid Passage at Stream Crossings. Additional fill is added to bring the road up to grade. Where appropriate, a rolling dip may be incorporated into the reconstruction of the crossing. Backhoes, excavators, bulldozers, loaders, dump trucks and compaction equipment will be used. Rolling dips are basically a large, gently sloped waterbar constructed at or just down slope (along the road) from stream crossings. In the event of drainage structure failure, the rolling dip directs the stream flow across the road and back into its natural flow course. Rolling dips are not installed on an annual basis. Rolling dips are installed to prevent mass wasting where there is a

risk of culverts and humboldt crossing plugging up on non-public roads. If funding was not an issue, the Park could conceivably replace a large number of culverts through multiple contracts. Because of noise restrictions, the Park, realistically could only replace and/or 10 to 15 culverts or rolling dips per year.

Culverts presently schedule for replacement that may have listed fish issues directly or indirectly are as follows:

2003 – Off-Highway, Cloquet, Miller, Cole, Streelow and 44 Creek

2004 – Bridge and Streelow Creek

2005 – Bridge, McArthur and Mill

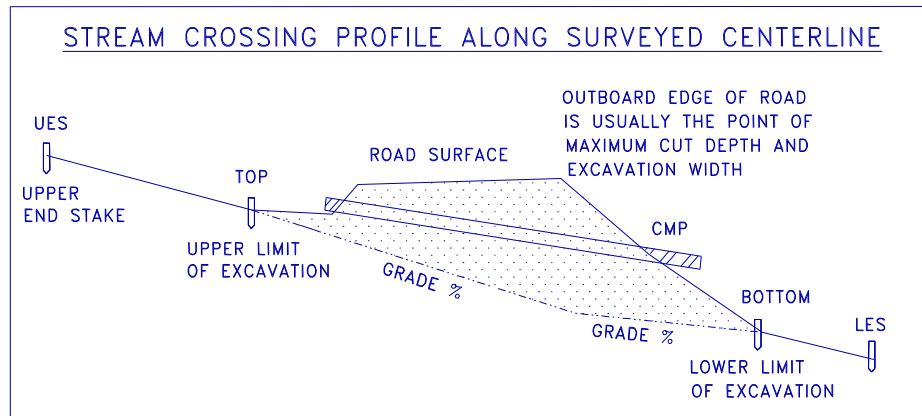
2006 – Tom McDonald

2007 – Lost Man

Methods for Replacing and Upgrading Culverts

Stream crossing excavations to replace and/or upgrade culverts (see Figure 1 & 2) involve the removal and disposal of road (crossing) fill, culverts, and organic debris from a stream channel. If the crossing has water flowing, it will be diverted around the worksite. Small trees and vegetation are removed from the work area and stocked piled. Fill is removed by an excavator and either hauled by truck or pushed by a dozer to a site where the woody debris can be separated. All logs or Humboldt crossings are removed and every attempt is made to install the new pipe on the original stream channel. The new culvert will be sized to meet a 100-year event is then installed with a flared inlet. The outlet is placed beyond the fill site as much as possible. Rock riprap is placed at the outlet to dissipate water and prevent erosion during heavy flows. Material from the site that is reusable is then compacted around the culvert. If there is not a sufficient amount of reusable material, clean $\frac{3}{4}$ minus gravel is purchased and hauled to the site. The material is compacted in one-foot increments utilizing a whacker packer and a sheepsfoot. After the compaction is complete, the site is mulched with preferably a rice straw and vegetation that has been stock piled is spread across the site. The same process would take place for a “culvert upgrade”. During a culvert replacement, any banks upstream of the inlet which pose a threat of collapsing and depositing sediment, will be excavated to a 2:1 slope.

The large woody debris that was uncovered during excavation will be placed near the restored channel area providing both sediment control and habitat complexity. Bare soils adjacent to live channels will be treated for surface erosion as prescribed in the Watershed Restoration Erosion Control and Monitoring Plan (Klein et al., 2002).



Newly placed culverts may experience minor adjustments, mostly during the first winter following excavation and placement. The remaining road fill, wedged in the interstices of the original stream bed may be mobilized; small portions of channel sidebanks may settle or slide; the original channel bed armor may adjust in response to the logging slash up and downstream of the excavation site; decaying logging slash or natural organic debris may collapse, causing a small chain reaction up and downstream; etc.

Project Design Criteria to Minimize Impacts to Threatened Salmonid Species for Routine Road and Non-Routine Road Maintenance for Redwood National and State Parks.

Applicable to All Actions

1. All non-emergency project work will be completed during the □normal operating season□ (NOS), that is, between June 1 and October 15 of each year. If more than 0.5 inches of rain is forecast during the □dry season,□ project operations will temporarily cease and sites will be winterized. If periods of dry weather are predicted outside of the NOS, additional small work items may be done, if they can be completed within the window of predicted dry weather. Only those repairs needed to reduce risks from active erosion will be undertaken outside of the NOS, in coordination with NMFS.
2. Equipment, both hand tools and heavy equipment, will be inspected daily to check for leaks. Equipment that may leak lubricants or fuels into a drainage will not be used until leaks are repaired. All equipment will be stored, serviced and fueled outside of Riparian Reserves and away from stream crossings. Heavy equipment will be cleaned (e.g., power washed, steam cleaned) prior to use below the ordinary high water mark.
3. A spill plan and materials for spill containment will be available to onsite personnel and all personnel shall know how to use them. In the event of a spill, work shall be stopped immediately, clean up shall begin and the appropriate authorities will be notified.
4. Petroleum products, chemicals, fresh cement, deleterious materials, or water contaminated by

the aforementioned shall not be allowed to enter flowing waters.

5. Disruption of natural hydrologic flow paths, including diversion of streamflow and interception of surface and subsurface flows, shall be minimized.
6. Adequate erosion control supplies (gravel, straw bales, shovels, etc.) shall be kept at all construction sites and during all maintenance activities to ensure materials are kept out of water bodies.
7. Sediment delivery to streams from roads shall be minimized. Outsloping of the roadway surface is preferred, except in cases where outsloping would increase sediment delivery to streams or where outsloping is unfeasible or unsafe. Road drainage shall be routed away from potentially unstable channels, fills, and hillslopes. Sidecasting shall be restricted as necessary to prevent the introduction of sediment into streams.
8. Vegetation trimming or removal conducted in Riparian Reserves will be completed in such a fashion as to not retard attainment of Aquatic Conservation Strategy (ACS) objectives. Specifically: (1) Downed woody material in Riparian Reserves will not be removed and will be moved only to the extent necessary to provide for safe road use. (2) Conifers exceeding twelve inches in diameter will not be cut from Riparian Reserves unless it is absolutely necessary for safe use of the road segment. If a conifer exceeding twelve inches diameter must be cut, it may not be moved from the Riparian Reserve or stream corridor without review from a fishery biologist.

Routine Road Maintenance

1. Diesel will be eliminated as a releasing or cleaning agent and environmentally sensitive cleaning and releasing agents will be used during surface work.
2. Water drafting will be conducted only at sites approved by a fisheries biologist. Operations are restricted to one hour after sunrise to one hour before sunset. Streams and pools shall be used where water is deep and flowing, as opposed to streams with low flow and small isolated pools. Vehicle approaches will be inspected by agency personnel or designee to insure damage to riparian areas is minimized.
3. Each pumping operation shall use a fish screen. The screen face should be oriented parallel to flow for best screening performance. The screen shall be designed and used such that it can be submerged with at least one-screen-height-clearance above and below the screen. Pumping rate shall not exceed 350 gallons per minute and shall not exceed 10 percent of the stream flow. Operators shall keep a log on the truck containing the following information: Operator Name, Date, Time, Pump Rate, Filling Time, Screen Cleaned (Y or N), Screen Condition, and Comments. These guidelines should be included as instructions in a logbook with serially numbered pages. This assures each truck operator easy access to this information.

4. Dust palliatives will never be applied during rain, and requires a clear 2 day forecast following the projected completion of application. During preparation for application of dust palliatives, gravel berms will be constructed at the low shoulders of the roadway to inhibit liquid palliatives from entering waterbodies. Methods of materials shall be applied in a manner that is not detrimental to either water or vegetation. A 1-foot buffer zone on the edge of gravel will be used if the road width allows. Adequate spill protection will be carried on trucks during application. Environmentally sensitive cleaning agents will be used.
5. The use of chlorides and lignins should be restricted within 8 meters (25 feet) of body of water. In areas of shallow groundwater determine if significant migration of the chloride would reach the groundwater table. Palliatives containing petroleum should not be applied within riparian zones.
6. Material removed from a ditch will be disposed of outside of any waterway or wetland. Erosion control devices such as check dams, silt fences, and other acceptable techniques, shall be used when the potential exists to have sediment or other materials entering waterbodies. Drainage ditches and steep slopes shall be reseeded with native plants.
7. Chip Seal (Asphalt Emulsion) will not be applied in a manner that will create runoff or product delivery into streams. Chip Seal will not be applied during rain and requires a clear 2 day forecast following the projected completion of application. Treated surfaces will not be washed.

Non-routine Road Maintenance

1. Any disturbed ground must receive appropriate erosion control treatment (mulching, seeding, planting, etc.) prior to the beginning of the wet season. Operations will use all feasible techniques to prevent any sediment from entering a drainage system.
2. Fine sediment cleaned out from the inside of culverts shall be removed to an upland location, where it cannot enter stream networks or road drainages that are hydrologically connected to a stream, and stabilized.
3. For each stream crossing replacements, and rolling dip installations, disturbance to Riparian Reserves will be minimized. Materials used for culvert replacements, or creating rolling dips must minimize the possibility of introduction of fine sediment or toxins into the drainage system.
4. New culverts, and other stream crossings shall be constructed to accommodate at least the 100-year flood, including associated bedload and debris. Priority for upgrading will be based on the potential impact and ecological value of the riparian resources affected. Fish passage shall be provided and maintained at all road crossings of existing and potential fish-bearing streams in a manner which meets NMFS standards and guidelines. Crossings will be constructed and maintained to prevent diversion of streamflow out of the channel and down the road in event of a crossing failure.

5. Culvert replacements will be conducted only during times of low streamflow but prior to upstream migration of adult anadromous salmonids. The streamcourse shall not be dewatered when eggs or alevins are present. Replacement activities will avoid, to the maximum extent feasible, removal of any riparian vegetation. Temporary low water crossings will be designed, and inspected daily, to insure fish passage.
6. Streamflow, on all live streams, must be diverted around culvert construction sites. The diverted flows shall be returned to their natural streamcourse as soon as construction is complete and prior to the rainy season. Any wastewater from project activities and dewatering is disposed of off-site in a location that will not drain directly into a stream channel or carry sediment laden water into a stream channel. Installation of hay bales and silt fences will be completed before flow is restored to its natural stream channel. All disturbed areas shall be winterized as well as stabilized prior to the rainy season and as needed and shall be restored to pre-work conditions. Note: Presence of alevins or eggs will be determined by a RNSP Fishery Biologist prior to dewatering.
7. Listed salmonids that would be in the area under construction shall be removed prior to and during stream flow diversion and dewatering and relocated to a suitable instream location immediately up or down stream of the work area. **This will be done by RNSP a Fishery Biologists by using an electroshocker and netting methods.** RNSP Fishery Biologists will follow NMFS guidelines. All efforts shall be taken to neither exhaust nor kill listed salmonids during collection and relocation.
8. **Effective erosion control measures shall be in place at all times during construction activities. Construction within the 5-year floodplain does not begin until all temporary erosion controls (e.g., straw bales, silt fences that are effectively keyed in) are in place, downslope of project activities within the riparian area. Erosion control structures shall be maintained throughout, and possibly after, construction activities. Sediment shall be removed from sediment controls once it has reached on-third of the exposed height of the control. Whenever straw bales are used, they shall be staked and dug into the ground 12 cm. Catch basins shall be maintained so that no more than 15 cm of sediment depth accumulates within traps or sumps.**
9. Culvert and dip construction shall take place from the bank, if possible, or on a temporary, removable pad underlain with filter fabric.

Annual Reporting of Affects

RNSP will report annually, in writing, to identify the amount of work accomplished under this programmatic consultation and provide information that may reduce the amount of incidental take authorized by a biological opinion. A brief report will be provided to NMFS by the end of the January following project completion, listing the miles of road treated, the number of stream

crossings treated, and the number of those stream crossings that carried significant stream flow during excavation.

STATUS AND DISTRIBUTION OF LISTED FISH SPECIES

1. Coho Salmon (*Onchorynchis kisutch*) Threatened

Coho salmon were historically distributed throughout the North Pacific Ocean from central California to Point Hope, Alaska, through the Aleutian Islands, and from the Anadyr River, Russia, south to Hokkaido, Japan (USDI 1997a). The species probably inhabited most coastal streams in Washington, Oregon and northern California.

Coho salmon have shown substantial decreases throughout their range (Konkel and McIntyre 1987). In the U.S. Pacific Northwest, they are now extinct in the eastern half of their former range, and badly depleted over most of the western half (Frissell 1993). At least 33 populations have been identified by agencies and conservation groups for being at moderate or high risk of extinction. Overall a geographic trend for the West Coast Coho salmon stocks has developed with the southernmost and easternmost stocks in the worst condition. In California, including hatchery stocks, current abundance could be less than 6% of estimates for the period 1940 to 1949. Populations now are at least 70% lower than during the 1960s (CDFG 1994). Two contiguous ESUs including the southern Oregon/northern California ESU (where RNSP is located) of coho salmon were designated as threatened (USDI 1997a).

The anadromous fish populations of Redwood Creek have experienced a substantial reduction during the last 30 years, in part due to severe flood events that moved large amounts of sediment from highly eroded hill slopes to the stream channels of the Redwood Creek basin. Current fish runs are far below those that occurred 70-80 years ago. News accounts and recollections of longtime residents of the Redwood Creek watershed suggest that both the size and numbers of salmonids have declined in recent decades (Van Kirk 1994). The total population in the Redwood Creek system may still number more than 2,000 adult coho, but most occur in the Prairie Creek drainage and probably originate from the Prairie Creek Hatchery (D. Anderson field notes). With the closure of the hatchery in 1992, those numbers are probably now much lower.

After hatching, juvenile coho salmon generally spend one full year rearing in freshwater before entering the ocean. Downstream migration of coho to the ocean from upstream Redwood Creek rearing areas occurs in early spring (March-April). Survey data from RNSP indicate that these young salmon presently move directly into the ocean, spending a minimal amount of time in the Redwood Creek Estuary (Anderson 1995). Adult migration through the Redwood Creek estuary is dependent upon the mouth being open to the ocean. Whether or not the mouth is open depends on a combination of wave action on the sand berm, the volume of water in the estuary, and the flow of water in the stream. Adult coho typically run upstream to spawn from late October to early March depending on access through the estuary (Anderson 1995). Recent data suggest that the peak of the spawning run begin in late November (Anderson 1998).

Coho salmon distribution in the Redwood Creek basin is limited (see Appendix) to the mainstem and the larger low gradient tributaries. The park conducted general stream surveys of the basin in 1980 and 81 to describe and characterize the salmonid rearing habitat and distribution of juvenile salmonids (Anderson 1988, Brown 1988). Migration barriers were identified during these surveys. No coho were found during these early electrofishing surveys above the barriers.

However, subsequent surveys in the 1990's have detected coho in streams that did not have coho in 1980-81. Whether these barriers still exist, have changed to allow fish passage, or new barriers have been created is unknown. Based on these data, RNSP has estimated that coho can be found occupying 26 miles of stream within the Lower Redwood Creek Basin (RNSP unpub. data).

Coho Critical Habitat

Critical habitat is defined in Section 3(5) A of the Endangered Species Act as "...the specific areas within the geographical area occupied by the species... on which are found those physical or biological features (a) essential to the conservation of the species and (b) which may require special management considerations or protection". In designating critical habitat NMFS considers habitat elements and conditions required for all life stages of the species. In addition, NMFS also focuses on the known physical and biological features (primary constituent elements) within the designated areas that are essential to the conservation the species. These essential features may include, but are not limited to, spawning sites, food resources, water quality and quantity, and riparian vegetation. Structurally complex streams containing stones, logs, brush, and aquatic macrophytes support larger numbers of rearing coho juveniles (Scrivener and Andersen 1982) than do streams that lack these structural features.

In southern Oregon and northern California, NMFS has designated critical habitat for this ESU between Cape Blanco, Oregon and Punta Gorda, California. The critical habitat unit is all stream and estuarine reaches accessible to the species and includes water, substrate, and the adjacent riparian zone. Accessible reaches are those within the historical range of the ESU that can still be occupied by any life stage of coho. The adjacent riparian zone is the area that provides shade, sediment transport, nutrient or chemical regulation, streambank stability, and input of large woody debris or organic matter. Habitat quality in this zone is related to the quality of riparian areas, upland areas and inaccessible or headwater or intermittent streams that provide key habitat elements, such as large woody debris and gravel, that are crucial for coho in downstream reaches (USDC 1999b). Thus, the width of the riparian zone included as critical habitat is variable depending upon consideration of these factors.

2. Chinook salmon (*Oncorhynchus tshawytscha*) Threatened

Chinook salmon populations have declined along the Pacific coast to the degree that certain evolutionarily significant units (ESUs) were listed as threatened by the National Marine Fisheries Service (NMFS) under the Endangered Species Act (USDC 1999a). Based on the best biological and commercial information available NMFS identified 19 ESUs from populations in Washington, Idaho, Oregon, and California. Genetic data were the primary evidence considered for the reproductive isolation criterion, supplemented by inferences about barriers to migration, human-induced changes resulting from artificial propagation, and harvest. Chinook salmon historically ranged as far south as the Ventura River, California, and north as far as the Russian Far East (USDC 1999a and citations therein).

Chinook typically return from the ocean to rivers, larger streams, and larger tributaries to spawn between November and early January. Winter-run chinook constitutes the main chinook runs in park streams. These fish begin their upstream migration around November, if access through the Redwood Creek estuary is possible, and have spawned and died by January. Adult spring-run chinook were observed in only one season since 1981, when the park began summer steelhead

surveys, but are not typically considered to use the Redwood Creek watershed. Stream barriers may impede Chinook salmon spawning in the RNSP tributaries, but they may be able to surmount some barriers that may impede the smaller coho salmon.

In spring, chinook salmon fry migrate downstream to rear in the Redwood Creek estuary before entering the ocean in the fall. Reimers (1973) documented the role estuary play in fall chinook salmon production. From scale analysis of spawning fall chinook, he determined that the majority of returning adults spends June, July, and August as juveniles within the estuaries before completing their seaward migration. His investigations determined that juvenile chinook spending less than three months in the estuary seldom returned to spawn in the natal stream. Reimers (1973) concluded that these fish did not survive as well in the ocean as the fish that had spent three months in the estuary. Apparently a survival advantage was conferred upon the fish that remained in the estuary and grew to a larger size before entering the ocean. Chinook salmon usually return to freshwater after three to four years in the ocean, although two year old male spawners are commonly observed.

Juvenile chinook salmon in Redwood Creek do not spend time rearing in upstream areas (Anderson and Brown 1982), but instead, utilize the Redwood Creek estuary. Thus, the Redwood Creek estuary is important as the sole rearing habitat for chinook salmon in the park. Park research shows that if given the opportunity the juveniles will spend an extended period (to late summer) rearing in the estuary before entering the ocean. Prior to 1978 most young chinook salmon were released from Prairie Creek Fish Hatchery in the early spring. These were fish hatched from eggs taken only four or five months earlier. Capturing sufficient numbers of chinook to obtain their eggs was difficult because of the low numbers of returning adult fish. The low numbers of returning adult chinook salmon, a species that relies totally on the estuary during its brief juvenile freshwater rearing period, are probably related in part to the summer/fall conditions in the Redwood Creek estuary. Construction of the flood control project in the estuary has resulted in degraded rearing habitat. Winter spawning/carcass counts in RNSP continue to indicate low numbers (D. Anderson pers. comm.).

Chinook Critical Habitat

Critical habitat is defined in Section 3(5) A of the Endangered Species Act as "...the specific areas within the geographical area occupied by the species... on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection". In designating critical habitat NMFS considers habitat elements and conditions required for all life stages of the species. In addition, NMFS also focuses on the known physical and biological features (primary constituent elements) within the designated areas that are essential to the conservation of the species. These essential features may include, but are not limited to, spawning sites, food resources, water quality and quantity, and riparian vegetation (USDC 2000). Riparian areas form the basis of healthy watersheds; they are essential to the conservation of the species. Vegetation in the riparian zone shades the stream, stabilizes banks, and provides organic litter and large woody debris. Additionally, the riparian zone plays a significant role in nutrient recycling, stream hydraulics, and controlling microclimate (FEMAT 1993).

In RNSP, NMFS has designated the Redwood Creek basin as critical habitat for this ESU. The critical habitat unit is all stream and estuarine reaches accessible to the species and includes water, substrate, and the adjacent riparian zone. Accessible reaches are those within the

historical range of the ESU that can still be occupied by any life stage of chinook. The adjacent riparian zone is the area that provides shade, sediment transport, nutrient or chemical regulation, streambank stability, and input of large woody debris or organic matter (USDC 2000). The width of the riparian zone considered critical habitat is variable depending upon the channel type. For example, constrained reaches could include a one site-potential tree height zone whereas a braided or shifting channel could include a zone consisting of the entire floodplain. In any case, riparian zones considered critical habitat must be wide enough to allow riparian processes to occur (Spence et al. 1996).

3. Steelhead (*Oncorhynchus mykiss*) Threatened

Historically, steelhead were distributed throughout the North Pacific Ocean from the Kamchatka Peninsula in Asia to the northern Baja peninsula. Presently, the distribution extends from the Kamchatka Peninsula, east and south along the Pacific Coast of North America, to at least Malibu Creek in southern California. Steelhead likely inhabited most coastal streams in Washington, Oregon and California as well as many inland streams in these states and Idaho.

During this century, over 23 indigenous, naturally reproducing stocks of steelhead are believed to have been extirpated, and many more are thought to be in decline in numerous coastal and inland streams in Washington, Oregon, California and Idaho. Forty-three stocks have been identified by as being at moderate or high risk of extinction. Steelhead have recently been listed as endangered in two ESUs and threatened in four ESUs. The Northern California ESU falls within the boundaries of RNSP.

Steelhead are found in most small order, high gradient tributaries to Redwood Creek. They are able to leap above barriers that might impede coho salmon (D. Anderson pers. comm.). Whether logjams are barriers to movement depends upon stream dynamics such as the size of the logjam and the stream discharge as well as the timing and duration of the steelhead migration. These events change from year to year.

Steelhead are the last of the anadromous salmonid species to return to freshwater in the annual cycle, generally between January and April. Juveniles rear in the streams for one to four years before their downstream migration to the ocean. The majority of juvenile steelhead in Redwood Creek spend their second year of life in the estuary and lower part of Redwood Creek (Anderson 1988). They reside in marine waters typically for two or three years prior to returning to the natal stream to spawn. Unlike other pacific salmon, steelheads are capable of spawning more than once before they die.

RNSP began summer steelhead surveys in 1981 and survey data indicate a continuous decline. Forty-four adult fish is the highest total number observed during summer surveys of portions of the mainstem of Redwood Creek. No adult fish were seen in 1989. No other park streams in the Redwood Creek basin have been surveyed for summer steelhead; these streams do not have pools large enough to support fish during the warm summer months.

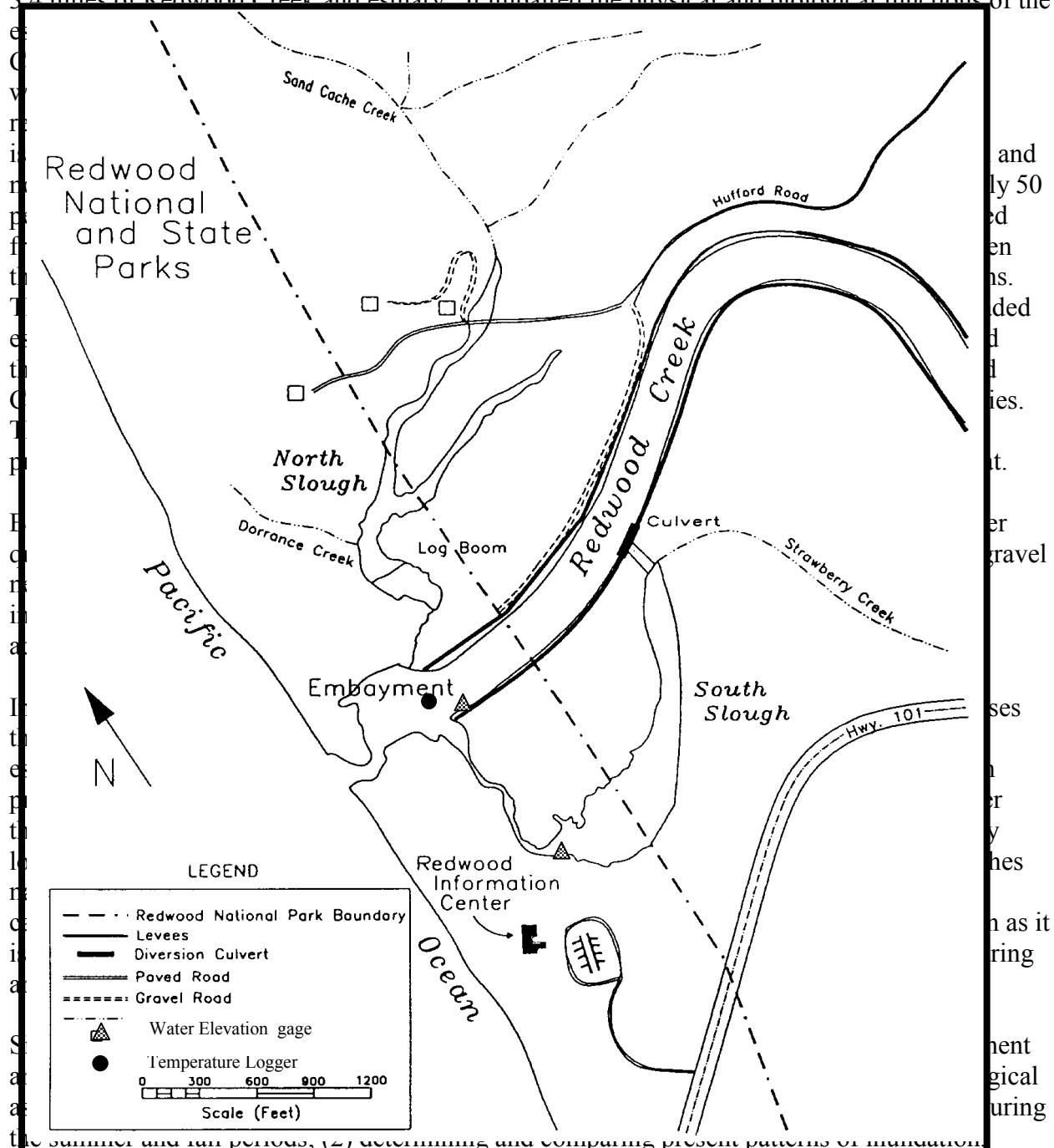
Winter steelhead numbers are much higher. Juvenile steelhead are the most common and widely distributed fish in the Redwood Creek basin. During sampling efforts in the summers of 1980 and 1981, steelhead occurred in 57 of the 111 tributaries surveyed.

EXISTING ENVIRONMENT

The Redwood Creek watershed drains a 280-square-mile watershed in the mountainous, coastal region of northwestern California. The creek begins near an elevation of 5,000 feet and flows northwest for 55 miles until it empties into the Pacific Ocean near Orick. The watershed is characterized by high relief, steep unstable slopes, and narrow valley bottoms. Average basin shows evidence of past or present mass movement (U.S. Department of the Interior, Geological Survey [USDI, GS] 1976b). The mouth of Redwood Creek is located 2.5 river miles west of Orick, California. Downstream from its confluence with Prairie Creek, Redwood Creek flows westerly through a widening valley to the ocean.

Estuary

The estuary at the mouth of Redwood Creek (shown below) is degraded because flood control levees bisect the estuary. The 1968 construction of the U.S. Army Corps of Engineers flood control project (levees and channelization) drastically altered the aquatic resources of the lower 3.4 miles of Redwood Creek and estuary. It impaired the physical and biological functions of the



seasonal morphological changes, and sediment sources with historic information, and; (3) determining fish abundance, distribution and seasonal timing within the estuary.

Figure 1. Map of the Redwood Creek Estuary, Humboldt County, California, including the embayment, north and south sloughs, and location of water elevation gages and temperature logger.

Geology

The Redwood Creek basin is underlain by rocks of the Franciscan assemblage, which is a Mesozoic to early Cenozoic accumulation of weakly indurated and pervasively sheared

continental margin deposits which are highly susceptible to fluvial erosion and mass wasting. The Grogan Fault, expressed as a well-defined, NNW-trending lineament, roughly bisects the basin and juxtaposes unmetamorphosed and slightly metamorphosed clastic sedimentary rocks to the east against metamorphic schistose rocks to the west. Tributary streams are nearly equally divided between those draining sedimentary rocks and those draining metamorphic rocks. They have high infiltration capacities but possess little cohesion and very low shear strength.

The course of Redwood Creek is structurally controlled by the Grogan Fault and the unusually elongate geometry of the basin is a strong reflection of this. As a result, there are no major tributary forks to Redwood Creek and only a few tributaries are larger than the majority. In all there are 74 tributary basins drained by second order or higher streams flowing directly into Redwood Creek. Most tributaries are characteristically low order, high gradient streams draining small watersheds. Their channels are, in general, deeply incised and have narrow, discontinuous flood plains. Average stream gradients range from .05 to .30 meters/meter. Average hillslope gradients within the basins range from .25 to .35 meters/meter. Topographic relief and average stream gradient is greater in tributaries draining the eastern portion adjacent to channels and more moderate gradients at middle and upper slope positions. This incised inner valley is particularly susceptible to mass wasting by shallow debris slides and debris avalanches.

Roads

Roads are a major cause of accelerated erosion (Kelsey and others, 1981b; Hagans and Weaver, 1987; Best and others, 1995). The erosion potential of roads is related to maintenance, location, and design (Janda and others, 1975; Best, 1984; Klein, 1987). Common erosion problems associated with roads include washouts and stream diversions at stream crossings, mass wasting of unstable fills and oversteepened cutbanks, and interception of surface and subsurface water by cutbanks and inboard ditches.

About 1,200 miles of forest roads and 5,400 miles of skid trails were built within the Redwood Creek watershed as of 1978 (Best, 1984). About 445 miles of roads and 3,000 miles of skid trails (Steensen and Spreiter, 1992) were included within present park boundaries as a result of park expansion in 1978. In addition, about 20 miles of state highway and county roads cross the watershed, including several miles of abandoned state highway.

The logged areas included within the park in 1978 and private timberlands upstream of the park had similar road densities in 1978. Since that time, watershed restoration efforts have reduced road miles within the park while timber harvesting and residential construction have increased road miles upstream.

Roads upstream of the park boundary as of 1992 totaled about 1,110 miles, based on analysis of aerial photographs. About 66% of these road miles were constructed before 1964, 14% were constructed between 1964 and 1978, and 20% were constructed between 1978 and 1992 (fig. 9). Most of the upper- and middle-basin road network, therefore, was built before enactment of current forest practice rules as amended in 1983 that required new roads to be built without potential to divert streamflow..

Of the total 1,110 miles of roads upstream of the park, about 340 miles were determined to be unmaintained and abandoned as of 1992. Another 180 miles were classified as unmaintained but still driveable. Almost half of the road network is therefore unmaintained in the upper basin.

These unmaintained roads are more likely than the maintained roads to fail during a large storm as a result of plugging and rusting of culverts, rotting of organic debris, and diversion of groundwater and streamflow.

Road locations particularly susceptible to failure include steep (>65%) hillslopes on erosion-prone bedrock and soil. About 75 miles of road in the upper basin were constructed on slopes greater than 65%. Of these, about 50 miles are in inner gorge areas adjacent to stream channels, where the impacts of failures are most serious. Roughly 335 miles of the road network upstream of the park were constructed on unstable bedrock units such as the incoherent unit of Coyote Creek and the sandstone and melange unit of Snow Camp Mountain. About 180 miles were constructed on soils units particularly susceptible to landslides and fluvial erosion.

Based on records of Timber Harvest Plans (THPs) filed for commercial timber lands in the the Redwood Creek watershed, 127 miles of new and 111 miles of rebuilt roads were used for logging within THP units between 1978 and 1992 (table 3). In addition, 236 miles of existing roads were used for access and hauling. Rebuilt roads therefore represent almost one-quarter of total logging road mileage used during this period. Although some roads may have been classified as “rebuilt” owing to vegetation encroachment, this classification was commonly used to denote roads that required earthmoving to be made driveable. The high proportion of roads that required rebuilding suggests that road failures have been frequent. Roads and skid trails used for timber harvest during this period included over 1,400 stream crossings (table 4). Most of these were on small headwaters (Class III) streams, and many required rebuilding.

Under the current FPR’s, logging haul roads are likely to remain a significant source of sediment during future large storms because the FPR’s cease to apply once logging has been completed and the logged area has met conifer stocking requirements. The current maintenance period for roads and erosion-control structures is based primarily on the time required to complete the harvest operation. Typically, road maintenance is required for a period of two to four years: one to three years during the harvest operation plus one year following harvest for stocking. As a result, long-term maintenance of roads, culverts and erosion-control structures has been rare. Unless planned road abandonment and construction of temporary roads (that is, the intentional construction of roads that will be treated to reduce erosion after timber harvests are completed) are encouraged or required by the FPR’s, perhaps through a more rigorous assessment of cumulative watershed impacts, roads will remain a significant source of sediment during future large storms.

A new section of U.S. Highway 101 was constructed partially within the Prairie Creek watershed between 1985 and 1992 (fig. 1). This highway section, known as the Redwood Park bypass, has caused substantial sediment delivery to tributaries of Prairie Creek (Meyer, 1994). The most notable impacts occurred during a heavy rainstorm in October, 1989. Suspended-sediment loads of Prairie Creek and its tributaries increased as a result (Meyer and others, 1994). Park staff are currently monitoring streamflow, sediment transport, and aquatic habitat conditions at several locations downstream of the bypass.

During bypass construction, about 350,000 tons of gravel were removed from the channel of Redwood Creek near Orick for highway construction. Bed elevations between the flood-control levees lowered by roughly 1.5 feet as a result.

Timber Harvest

Logging for ship's masts began as early as the 1850's, but commercial harvesting to supply markets outside the local area started in the 1930's. Early logging operations were clearcuts. Yarding was done with steam donkeys, and logs were transported by rail.

Large-scale logging began after the Second World War, when both tractors and gasoline-powered chain saws became widely available, and when the expanding post-war economy created a high demand for lumber (Janda and others, 1975). Logging during the 1950's was generally done by selective cutting, but clearcutting became the dominant silviculture in the 1960's as timber companies experienced poor success with thinning and natural reseedling (Janda and others, 1975). Tractor yarding has been used much more commonly than cable yarding. Intensive logging was concentrated in the upper-basin stands of Douglas-fir in the 1940's and 1950's but shifted to redwood groves of the middle and lower basins in the 1960's as redwood became more popular for home construction.

Only about 5 percent of the watershed area upstream of the confluence of Prairie and Redwood Creeks had been logged as of 1948 (Best, 1984; 1995), whereas approximately 62 percent of this area had been logged as of 1978 (Best, 1984; 1995). Logging was most intensive between 1949 and 1962, when about 31 percent of this area was logged (Best, 1984; 1995).

Timber harvesting continues to be the primary land use on private lands upstream of the park. Most timber harvests in recent years have been in second-growth stands. No timber is harvested on park lands, but pilot projects to thin second-growth redwoods and douglas-fir were initiated in 1979 and again in 1995. This program may eventually be expanded to large areas of second-growth forest in the park.

Forest practices on private lands are regulated by the California Department of Forestry and Fire Protection. Timber harvest regulation by the state began in 1945, but became more effective following passage of the Z'berg-Nejedly Forest Practice Act of 1973. This act provided the Board of Forestry with authority to develop rules and guidelines for management of non-federal forest lands in the state. On August 25, 1975, following hearings and modifications of initial rules, Forest Practice Rules (FPR's) that would guide timber harvest practices for nearly a decade became effective.

Currently, the FPR's (California Department of Forestry and Fire Protection, 1994) provide stream and riparian protection through Watercourse and Lake Protection Zones (WLPZ's), which are areas immediately along the sides of streams, lakes, or springs. The WLPZ rules are important for protection of park resources because streamside areas provide both sediment and woody debris to the channel system. The roots of streamside trees increase streambank stability, and removal of trees along streams can therefore increase bank erosion. Woody debris naturally contributed by riparian trees acts to store sediment within the channel, thereby reducing downstream sediment loads. Falling and yarding along streams can disrupt ground cover and increase sediment delivery to streams. Removal of streamside trees also reduces riparian shading and can elevate stream temperatures.

The width of a WLPZ and the level of protection that it offers depend primarily on the steepness of streamside areas, the proposed yarding method and the type or "class" of stream that will be affected by timber harvest operations. Class I streams support fish, Class II streams contain aquatic habitat for non-fish species, and Class III streams contain no aquatic life but are capable of sediment transport to Class I and II streams.

The WLPZ provisions of the FPR's were not implemented until 1983, when the vast majority of private timberlands in the Redwood Creek basin, including riparian areas, had already been harvested and after the recent large floods had disrupted riparian zones. As a result, alder and other hardwood species now dominate most streamside areas, which contain far fewer large conifers than existed under natural conditions.

Management of riparian areas under current WLPZ provisions is based on existing conditions rather than natural conditions, and the existing riparian conditions can be further compromised if previously logged areas are re-entered. Although the FPR's are intended to protect the beneficial and restorable uses of water, they allow the continued reduction of critical riparian elements - large and old coniferous trees. For example, WLPZ protection is rarely extended to Class III streams. Class III streams are the biological and physical extensions of Class I and II streams and, in some cases, are still recovering from impacts of early forest practices and large storms. For Class I and Class II streams, requirements for the composition of overstory species within streamside areas are satisfied when only 25 percent of the existing overstory conifers are retained during timber harvest. The requirements for future recruitment of large woody debris are also met by retaining only 2 conifers per acre that are at least 16 inches in diameter and 50 feet tall. Clearly, this approach to management of streamside areas may have the net effect of eliminating nearly all large or senescent conifers from riparian areas.

Under the current FPR's, riparian areas managed for timber production in the Redwood Creek watershed are unlikely to ever provide the function they provided before the advent of logging. Although the current rules provide protection for some streamside areas, vertical stand diversity, species composition, recruitment of large woody debris and shading for stream temperature control are greatly compromised. The biological importance of large trees for shade and large woody debris recruitment beyond the riparian zone is also largely ignored.

Mining

Mining within the Redwood Creek watershed has been limited to gravel mining within the channel of Redwood Creek and rock quarries and borrow pits used for road construction. Gravel has been mined between the flood-control levees, near the mouth of Prairie Creek, at the mouth of Tom McDonald Creek, and near Highway 299 (Janda and others, 1975). Gravel extraction by the Georgia-Pacific Lumber Company between 1951 and 1958 near the Tall Trees Grove totaled between 200,000 and 800,000 tons (Kelsey and others, 1979). This gravel removal at the Tall Trees Grove was not significant relative to total sediment discharge in Redwood Creek, but may have served to decrease the threat of bank erosion by lowering the channel bed locally (Milestone, J.F., Redwood National Park, written commun., 1979).

Livestock Grazing

The prairies of the Bald Hills and nearby grasslands were heavily grazed by sheep and cattle between 1860 and 1980. Grazing was eliminated on park lands in the early 1980's. Cattle grazing continues on grasslands in the middle and upper basins and in the Orick Valley, where several dairies are located.

In other areas of the western United States, livestock grazing has been associated with increased runoff and erosion. Although similar effects may have occurred in Redwood Creek, we consider them to be insignificant in comparison to high natural rates of runoff and erosion and the effects of logging and roadbuilding. Cattle affect water quality in Redwood Creek and its estuary, however, both through the introduction of nutrient-rich waste and reduction of riparian shading.

An accurate determination of the effects of past and present grazing would require additional research.

Erosion and Sediment Yield

Erosional Processes

Erosional processes in the watershed range from the removal of individual soil particles by raindrops to extensive landslides that cover entire hillslopes. In general, erosion caused by obvious large-scale earth movement has been better documented than erosion caused by dispersed small-scale processes. The smaller-scale processes, however, may also be of great importance in generating sediment because they are more widespread. Past studies indicate that streamside landsliding and fluvial hillslope erosion may be the most important processes delivering sediment to Redwood Creek (Harden and others, 1978; 1995; Kelsey and others, 1981a; 1981b).

Landslides

Streamside landslides are clearly an important source of sediment in the Redwood Creek watershed, because of their number and volume, and because they deliver sediment directly to channels. Streamside landslides include debris slides, debris avalanches, and earthflows; however, debris slides account for most of the streamside landslide volume (Kelsey and others, 1995). The erosional landform map of Nolan and others (1976) shows streamside landslides along most of the mainstem and major tributary channels in the upper and middle basins. Streamside landslides may be caused in part by channel aggradation (Janda and others, 1975). Sediment deposited in the channel raises water levels during storms, resulting in undercutting of steep hillslopes that subsequently fail as debris slides.

The temporal distribution of streamside landslides was studied by Harden and others (1978; 1995). Using aerial photographs, they determined that the numbers of streamside landslides increased from 100 in 1947 to 415 in 1976. The increase was due mostly to debris slides. Many streamside landslides occurred between 1962 and 1966, probably during the 1964 flood. Between 1970 and 1976, the number of new streamside landslides decreased in the upper basin, but increased in the middle and lower basins. Few streamside landslides have been initiated during the relatively dry period since 1975.

The most really extensive mass movement features in the watershed are earthflows (Nolan and others, 1976; Harden and others, 1978). The total area covered by active earthflows represents about 9% of the Redwood Creek watershed, and very active earthflows comprise 2% of the watershed area (Harden and others, 1978). The earthflows classified as “very active” can be considered streamside landslides because they deliver sediment directly to major channels.

Earthflows may be largely natural erosional features. Kelsey (1978), however, suggested that livestock grazing and subsequent conversion of prairie vegetation from perennial long-rooted native bunch grasses to annual short-rooted exotic grasses may have accelerated or triggered earthflow instability within the past century. In addition, road construction has accelerated gully erosion on earthflows (Walter, 1986), and, through interception of subsurface flow, may have altered streamflow peaks, patterns of groundwater flow, and hence earthflow movement. Earthflow activity may also have been initiated or accelerated by fluvial erosion where earthflow “toes” protrude into stream channels.

Landslides other than streamside landslides include debris avalanches and debris flows (Harden and others, 1978; LaHusen, 1985), slumps (Nolan and others, 1976; Harden and others, 1978), forested block slides (Sonnevill and others, 1985), and some large and relatively inactive earthflows. These landslides are much less significant as sediment sources than are streamside landslides.

Fluvial Hillslope Erosion

Fluvial hillslope erosion in the Redwood Creek watershed is apparent in both natural and disturbed settings (Janda and others, 1975). On unlogged forested hillslopes, fluvial erosion is related to interactions between subsurface piping through root channels and gully and rill development (Janda and others, 1975; Ziemer, 1992). On logged hillslopes, extensive networks of rills and gullies have developed from streamflow diversions and washouts at road and skid trail stream crossings, from ditches and cutbanks, and from interception of subsurface flow along roads and trails (Janda and others, 1975). Surface erosion of logged areas may also have increased as a result of decreased interception of rainfall by the forest canopy following harvest. Prairies are particularly susceptible to gully erosion, and road runoff has carved numerous large gullies in the Bald Hills area.

Fluvial hillslope erosion is much more difficult to quantify at the watershed scale than mass movement processes because fluvial features are smaller, more widely dispersed, and difficult or impossible to measure on aerial photographs. As a result, basinwide estimates of fluvial erosion based on field data are lacking.

Previous studies have documented large increases in fluvial erosion on lands where timber has been harvested or where roads have been constructed (Janda and others, 1975; Nolan and others, 1976; Walter, 1985; Hagans and Weaver, 1987). Kelsey and others (1981a) estimated from sediment-budget calculations that fluvial erosion from hillslopes contributed 68 percent of total sediment mobilization in the upper basin. Hagans and Weaver (1987) found that fluvial hillslope erosion in the lower basin between 1954 and 1980 produced about as much sediment as mass movement processes, including streamside landslides. Although considerable uncertainty is associated with these estimates, they indicate that fluvial hillslope erosion represents a significant sediment source in the watershed.

Channel storage

Massive amounts of coarse sediment were deposited in tributaries and the upper and middle reaches of the mainstem during the flood of 1964. During subsequent floods, particularly in 1972 and 1975, coarse sediment was scoured from tributaries and the upper mainstem and re-deposited in lower reaches (Varnum, 1984; Madej, 1995; Varnum and Ozaki, 1986).

Sediment stored within the channel system continues to move in wave-like fashion downstream (Madej and Ozaki, 1996). As of 1990, peak aggradation was about 5 miles downstream from the Tall Trees Grove and about 4 miles upstream of Orick (fig. 3-5). Channel cross section surveys in 1995 indicated that, for the first time since measurements began in 1973, the channel bed between the Tall Trees Grove and Orick was scouring. The sediment wave, therefore, may have become completely attenuated in the lower reach as a result of particle attrition and selective transport.

Sediment storage in the numerous small tributaries is controlled in part by woody debris. The effects of timber harvest on the recruitment of woody debris, and hence on sediment storage, are discussed below.

Sediment Budget

A sediment budget is a useful tool for assessing the relative importance of erosional processes. Conceptually, a sediment budget balances inputs (sediment mobilization or erosion) against outputs (fluvial sediment discharge from the watershed), after accounting for changes in sediment storage. In the case of Redwood Creek, we are interested in comparing large landslides that may occur naturally and are difficult to prevent to widespread, small-scale processes that are often related to land use and are more easily addressed with erosion-control efforts. Previous studies in and near the Redwood Creek watershed have provided a basis for estimates of fluvial sediment discharge, changes in channel sediment storage, and sediment production by mass-movement and fluvial processes between 1954 and 1980 (table 1; sediment-budget calculations and supporting information are provided in Appendix C).

The Redwood Creek sediment budget (table 1) is not a “balanced” budget because sediment discharge and additions to channel sediment storage exceed erosional inputs. The imbalance of 19,536,000 tons (35% of sediment discharge plus net storage) indicates that we cannot account for the sources of all of the sediment delivered to the channel system, and it provides a rough measure of the overall accuracy of the sediment budget.

Sediment production by fluvial erosion of roads and hillslopes (roads, surface erosion of bare ground, and gullies on table 1) accounted for 46% of sediment production (table 1). Most of this erosion was related to land use, and could have been prevented with erosion control and road maintenance measures. Of these sources, gullies produced by far the greatest amount of sediment (table 1). Most gullies resulted from streamflow diversions at road-stream crossings (Best and others, 1995; Weaver and others, 1995). The large amount of sediment eroded from gullies could have been greatly reduced if stream crossings had been built without potential to divert streamflow (Best and others, 1995; Weaver and others, 1995).

Sediment production by mass-movement processes and streambank erosion are less clearly related to land use, and also more difficult to control, than fluvial processes on roads and hillslopes. Landslides and streambank erosion contributed a total of 19,677,000 tons, equivalent to 54% of sediment production.

In summary, two significant conclusions can be made on the basis of the sediment budget analysis. First, a large amount of erosion and channel deposition is likely in the next large storm, since we know that about half of total sediment production in past storms was not clearly related to land use, and the sources of a significant amount of sediment cannot be determined with confidence. Second, treatments to remove diversion potentials from road-stream crossings are likely to be effective in reducing sediment delivery to channels from roads built before current (since 1983) forest practice rules required that crossings be built without diversion potential. Given the increasing probability of a major storm in the next few years, treatments of diversion potentials may be the only practicable means of reducing erosion related to land use in the next major storm, because such treatments can be completed quickly and inexpensively and leave roads passable to vehicles.

Recent Trends in Sediment Loads

Fluvial sediment loads are affected by land-use practices and, in turn, affect channel stability, alluvial redwood groves, and aquatic habitat. Because of the importance of sediment to resources in the Redwood Creek basin, the following sections include detailed analyses of trends in recent sediment transport rates in Redwood Creek. These analyses rely on data collected by the U.S. Geological Survey and Redwood National Park between 1971 and 1992.

Annual sediment loads are highly dependent on annual streamflow. Trends in sediment loads resulting from changes in land use are difficult to detect unless variations in sediment loads that result from streamflow fluctuations are removed from the analysis. We mathematically removed the effects of streamflow variations by computing logarithmic least-squares linear regression equations using 1) annual suspended-sediment loads and streamflow and 2) annual bedload and streamflow at both Orick and O’Kane. The regression equations minimize the variation in sediment loads resulting from streamflow variations, and the regression residuals (the differences between the observed and predicted values of suspended-sediment loads or bedloads, in logarithmic units) are therefore a measure of the variations in sediment loads due to other factors (Helsel and Hirsch, 1992). In the case of Redwood Creek, land use is the only likely factor, other than streamflow, to have substantially affected sediment loads. The regression residuals were plotted against time (figs. 6 and 7) to provide an overall picture of trends. The presence or absence of significant trends was determined using the Mann-Kendall test (Helsel and Hirsch, 1992). Suspended-sediment and bedload data were analyzed separately to more accurately assess cause-and-effect relations for any trends detected.

If streamflow was affected by land use during the study, regression residuals will not accurately represent sediment-transport trends attributable to land use. Streamflow in Redwood Creek was probably increased as a result of logging and roadbuilding by about 20% during the 1970’s (Nolan and Janda, 1981). A comparison of streamflow at the Orick and O’Kane stations with streamflow in an unlogged tributary indicates that effects of land use on streamflow were minimal after 1980. In order to determine if land-use effects on streamflow could have prevented the detection of significant trends, or could have caused false detections of artificial trends, we reduced the values of measured annual streamflow by 20% for the years 1971-80 and repeated the regression residuals analysis. The reduced streamflow data are estimates of streamflow under natural conditions unaffected by land use.

Suspended Sediment

Suspended sediment consists of sand, silt, and clay particles distributed throughout the water column. Fine sediment carried in suspension is of concern primarily because of its effects on aquatic habitat. Large proportions of suspended-sediment loads remain in suspension and are transported to the ocean once they enter the channel system. Fluctuations in suspended-sediment loads are therefore more closely related to short-term changes in watershed conditions than to long-lasting effects of major storms.

Suspended-sediment loads have been computed for about 20 years at the Orick and O’Kane stations. At Orick, annual suspended-sediment loads have ranged from 18,184 to 3,799,775 tons (table 2a), with a mean annual load of 914,821 tons. Annual suspended-sediment yields (loads per unit of contributing watershed area) at Orick have ranged from 65 to 9,888 tons per square

mile. At O’Kane, annual suspended-sediment loads have ranged from 1,217 to 695,296 tons (table 2b), with a mean annual load of 165,059 tons. Annual suspended-sediment yields have ranged from 18 to 10,378 tons per square mile.

Residuals for suspended-sediment loads at Orick show a significant ($p<0.001$) downward trend (fig. 6a). This trend indicates that rates of suspended-sediment transport have declined relative to streamflow over the past two decades. When the analysis was repeated using annual streamflow for water years 1971-80 reduced by 20%, the same result was obtained.

Residuals for suspended-sediment loads at O’Kane show no significant ($p=0.250$) trend (fig. 6b). For similar streamflow conditions, suspended-sediment loads have neither increased nor decreased significantly. The second analysis, using estimated natural streamflow for water years 1971-80, resulted in the detection of a significant downward trend. This result indicates that the combined effects of land use on streamflow and erosion caused a larger increase in sediment transport during the 1970’s than indicated by the regression residuals computed from measured streamflow and sediment data. The downward trend in suspended-sediment transport in relation to estimated natural streamflow is more significant than the original analysis using measured streamflow volumes indicates.

Table 1: Sediment budget, Redwood Creek watershed, 1954-80

<i>Sediment Source</i>	<i>Mass (tons)</i>	<i>% Total Contribution</i>
Roads:		
Haul road cutbanks	430,000	1.0
Surface erosion -Haul roads	1,377,000	3.8
-Skid trails	122,000	<1
Inboard ditches	363,000	1.0
Haul road crossings	2,000,000	5.5
Skid trail crossings	335,000	1.0
Surface erosion on bare ground	3,500,000	9.6
Gullies	8,500,000	23.4
Streambank erosion		
Tributaries	1,650,000	4.5
Mainstem	164,000	<1
Mass movement:		
Mainstem Streamside Landslides	7,100,000	19.6

Tributary Streamside Landslides (sampled, n = 16)	3,900,000	10.7
Tributary Streamside Landslides (unsampled, extrapolated data)	4,400,000	12.1
Earthflows	1,300,000	3.6
Forested Blockslides	263,000	<1
Debris Torrents	900,000	2.5
Total Sediment Input	36,304,000	100
Additions to Sediment Storage		
Main channel storage	10,400,000	
Tributary channel storage	440,000	
Sediment Output (Orick)	45,000,000	

Bedload

Bedload consists of sand, gravel, and cobbles that roll and slide over the streambed. Bedload is of concern because almost all of the coarse sediment that threatens alluvial redwood groves is transported in this manner. Large amounts of coarse sediment, delivered from hillslopes during the flood of 1964, remain stored in the channel system (Madej, 1995). Landslides and other processes have continued to provide coarse sediment to the channel, but at lower rates over the past 25 years than during the 1953-75 period that included large floods. Hence, bedload movement in Redwood Creek in the past three decades has been largely a re-distribution of coarse sediment deposited in 1964.

Table 2: Annual streamflow, suspended-sediment loads, and bedloads at daily sediment stations, 1971-92 [data from annual reports of the U.S. Geological Survey]

a. Orick				b. O’Kane			
Water Year	Streamflow (cfs-days)	Suspended Sediment (tons)	Bedload (tons)	Water Year	Streamflow (cfs-days)	Suspended Sediment (tons)	Bedload (tons)
1971	514,592	2,177,712	--				
1972	536,198	3,799,775	--				
1973	281,843	757,634	--	1973	70,264	184,689	--
1974	629,915	2,228,626	371,804	1974	149,725	657,618	301,502
1975	476,089	2,768,664	251,070	1975	124,160	695,296	243,860
1976	308,627	745,314	100,551	1976	67,873	81,189	21,295

1977	70,117	22,567	2,277	1977	16,117	1,217	724
1978	425,877	948,518	330,195	1978	95,406	122,233	65,950
1979	231,035	292,989	52,100	1979	51,081	54,296	28,436
1980	404,268	704,585	190,778	1980	98,573	162,674	36,152
1981	235,647	187,877	174,021	1981	50,793	46,873	7,143
1982	584,833	1,276,880	377,890	1982	132,041	255,056	74,039
1983	600,462	1,329,818	370,806	1983	131,297	373,940	85,292
1984	458,970	625,810	279,372	1984	120,542	173,401	56,666
1985	265,181	280,541	139,376	1985	63,422	81,351	8,956
1986	362,162	1,010,226	148,237	1986	83,886	239,826	24,563
1987	201,675	103,782	61,790	1987	44,747	12,310	3,654
1988	176,750	156,514	62,255	1988	37,076	28,769	5,623
1989	353,450	463,771	60,950	1989	82,174	89,666	6,385
1990	184,274	191,317	62,215	1990	41,912	32,804	1,618
1991	127,467	34,965	22,967	1991	25,986	5,108	420
1992	102,919	18,184	10,884	1992	22,294	2,870	176

Bedload accounts for roughly 20 to 25 percent of the total sediment load (commonly computed as the sum of suspended-sediment load and bedload) of Redwood Creek, based on data presented in table 2.

The percentage of the total sediment load transported as bedload is slightly higher at Orick than at O’Kane. Annual bedload has ranged from 2,277 to 377,890 tons at Orick (Table 2a). Bedload per unit watershed area at Orick has ranged from 8 to 1,350 tons per square mile. Annual bedload at O’Kane has ranged from 176 to 301,502 tons (Table 2b), and bedload per unit area at O’Kane has ranged from 3 to 4,500 tons per square mile.

Residuals for bedload at Orick show no significant ($p=0.108$) trend (fig. 7a). This result indicates that bedload transport rates at Orick have not changed much since the mid 1970’s. No trend was detected when annual streamflow data reduced by 20% were substituted for measured streamflow in the analysis.

In contrast, residuals for bedload at O’Kane show a highly significant ($p<0.001$) downward trend (fig. 7b). This trend indicates a shift to reduced rates of bedload transport relative to streamflow. Field observations indicate that much of the upper mainstem channel has scoured to bedrock or boulders. This trend was also detected when the reduced values of streamflow for water years 1971-80 were used.

Table 3: Roads utilized for timber harvest in the Redwood Creek watershed, 1978-92

Year	New (mi)	Rebuilt (mi)	Existing (mi)
1978	13	2	32
1979	7	4	16
1980	7	5	22
1981	1	0	5
1982	5	4	8
1983	6	0	26
1984	15	9	16
1985	5	9	6
1986	6	15	20
1987	7	11	8
1988	21	13	24
1989	14	14	24
1990	6	9	13
1991	4	4	4

1992	10	12	12
TOTAL	127	111	236

Table 4: Streams and stream crossings within timber harvest boundaries in the Redwood Creek watershed, 1978-92

Year	Streams (mi)	Number of Stream Crossings
1978	38	108
1979	33	88
1980	33	91
1981	6	17
1982	16	55
1983	32	98
1984	21	107
1985	12	66
1986	39	125
1987	18	72
1988	36	198
1989	30	137
1990	26	108
1991	11	39
1992	30	112
TOTAL	381	1,421

Watershed Restoration

The legislation expanding Redwood National Park in 1978 (PL 95-250) authorized a major watershed restoration effort. Congress directed that this work focus on minimizing erosion from past land uses, re-establishing native vegetation, and protecting aquatic and riparian resources along park streams (Spreiter and others, 1995).

Early experimental projects in the first few years of the watershed restoration program (1977-81) utilized a variety of channel and hillslope measures designed to reduce surface and channel erosion and landsliding. These included contour trenches, wooden terraces, willow wattles, mulching, check dams, and channel armoring. Many of these techniques were found to be either ineffective or prohibitively expensive (Weaver and others, 1987). The most effective treatments were removal of road fill at stream crossings and other locations using heavy equipment (Weaver and others, 1987).

Since 1981, former log-haul roads have been the primary focus of the watershed restoration efforts within Redwood National Park. About 175 miles of logging roads have been treated since 1978. The total volume of sediment excavated from roads is roughly 1,300,000 cubic yards. Projects have involved correction of stream diversions, excavations of stream crossings, road outslipping, removal of perched debris, and road decompaction and waterbar construction (Steensen and Spreiter, 1992).

Roughly 270 miles of logging haul roads remain on park lands. Recent surveys located about 1,200 sites with potential or existing erosional problems along old haul roads in the park (Spreiter, 1996). These sites, and appropriate intervening road segments, will be treated in future watershed restoration projects.

Private landowners are currently cooperating with the parks and other agencies to improve hillslope stability and aquatic habitat in the Redwood Creek watershed. Initial erosion control projects on Bureau of Land Management and Stover Ranch roads were completed between 1991 and 1994. In 1995, the parks and all major landowners in the watershed signed Memorandums of Understanding that formalized the intent of all parties to work cooperatively to reduce erosion in the upper basin. Later that year, the parks received a grant from the U.S. Fish and Wildlife Service for erosion control and habitat improvement projects. This first project, on Simpson Timber Company land, was completed in September, 1995, through an agreement with the Humboldt County Resource Conservation District. A second project is scheduled on Stover Ranch property for the summers of 1996-97. In early 1996, an inventory of erosion problems along roads in the upper basin was completed by park geologists on lands managed by Sierra Pacific Industries, Simpson Timber Company, Natural Resources Management, Inc., Western Timber Services, Louisiana-Pacific Corporation, and the U.S. Forest Service. Information collected during the inventory will be used to plan road maintenance and erosion control projects.

EFFECTS OF THE PROPOSED PROJECT TO LISTED SALMONID SPECIES

Redwood National and State Parks inherited many miles of roads when it was initially created and later expanded. Forest roads have been identified as significant sources of sediment (Best et al. 1995). Forest roads interrupt natural drainage patterns and contribute to changes in sediment production and transport rate that can impact aquatic ecosystems and species. Forest road impacts can generate off-site effects that extend from headwaters to mainstem reaches and the estuary, adversely affecting aquatic habitats throughout the Redwood Creek watershed.

Not Likely to Adversely Affect

Effects of Routine Road Maintenance

The routine road maintenance activities included in this proposed action in total have the potential to produce a negligible amount of fine sediment into anadromous salmonid habitat. The routine road maintenance consists of road grading and reshaping, brushing road corridors, surface treatment, maintenance of unpaved shoulders, inboard ditch cleaning and maintenance, culvert inlet cleaning, removal and end haul of materials, drainage structure maintenance, roadway drainage maintenance, and drainage dip maintenance.

Routine road maintenance activities mention in above paragraph may result in minimal amounts of fine sediment delivered to stream channels within RNSP and in downstream areas. However, it is the opinion of the fishery biologist, that by following the guidelines in the Protect Criteria Section of this BA, the potential for adverse effects to coho salmon, steelhead and chinook salmon habitat due to this minimal fine sediment input is negligible and, in turn, the probability of affecting survival of coho salmon, steelhead and chinook freshwater life history stages is negligible.

Road maintenance activities benefit listed and proposed Pacific salmonids by helping to prevent slope failures from improperly maintained drainage structures that divert water down roads.

Likely to Adversely Affect

Effects of petroleum and non-petroleum based products

The routine road maintenance activities that may affect individuals, and likely to have an adverse affect on the survival of coho salmon, steelhead and chinook freshwater life history stages because of the use of petroleum and non-petroleum based products include, dust abatement, spot surfacing, asphalt pavement patching, paved surface cleaning.

The routine road maintenance activities mention in above paragraph may result in minimal amounts of petroleum and non-petroleum based products being delivered to stream channel within RNSP and in downstream areas. However, the level of contamination will be short-term in duration and low in intensity. The application of these products will only occur in the dry seasons and in a manner that complies with the project design criteria section of this BA.

Effects of Non-Routine Road Maintenance

Non-routine road maintenance activities which include, culvert replacements and installations, rolling dip installations, and large crossing replacement have the potential to deliver fine sediment to streams. Generally, most of the proposed non-routine maintenance activities will result in the correction of existing and potential erosion problems and mass wasting events, and these activities are expected to result in net benefits to aquatic habitat over time. Although these types of projects may result in a short-term delivery of fine sediment into stream channels either during the project or during the first storm event after completion of the project, long-term benefits are also expected as a result of these actions.

Improperly placed culverts can create barriers to upstream migration by fish. Inadequately sized culverts can restrict stream flows and can result in major contributions of sediment to streams if they become plugged or overflow. Benefits realized from replacement or upgrading of culvert at stream crossings include restoration of fish, flood flow and bedload passage. Culverts should accommodate at least the 100-year flood, including associated bedload and debris (USDA-FS and USD_BLM, 1994). Furniss et al. (1991) summarizes other important considerations for culvert design and installation.

Earth moving activities related to culvert removal or replacement can result in short-term fine sediment pulses to streams. RNSP's particular methods for stream crossing excavations fully minimize, to the extent possible, off-site sediment movement. For example, streams with surface flows capable of sediment transport off-site are diverted around excavation areas. Or, when a culvert is present, water is kept flowing through the culvert until fill is excavated and culverts are removed in pieces so that water is only allowed to flow on finished stream channel excavations are put back into the active channel to augment natural channel armor and to provide additional sediment storage capacity. The relative short-term effects of culvert removal or replacement are generally considered to be minimal, compared to continuing long-term adverse effects caused by existing culverts that are improperly placed or sized. Projects will be carefully designed, timed, and implemented to minimize adverse effects to listed pacific salmonids.

Loss of Riparian Vegetation at Stream Crossing Excavations

The vast majority of the trees removed during these program activities are relatively young alder, redwood and Douglas Fir. After excavating small watercourse crossings, no vegetation will remain on the newly established stream bank. In many locations, none exists currently because the roadbed material is too compacted or unstable. Loss of riparian vegetation will result in a short-term loss of nesting habitat for terrestrial species and decreased water quality for aquatic species. Vegetation recovery at recently completed stream crossing excavations reveal a dense canopy of alders 6-10 feet tall will exist on virtually all disturbed surfaces within 4 years.

Water temperature will not experience significant increase as a result of stream crossing excavations. The precise amount of riparian vegetation to be removed is unknown. The duration of direct sunlight is generally limited to a few hours daily, due to steep topography and surrounding overstory trees. Many of the stream crossings and stream courses are located in steep terrain so water velocities are relatively fast. Thus, water will not pool up along areas of excavation. The projected slope of the streams will range from 15 to 40 percent. Additionally, re-vegetation rates usually allow for rapid re-colonization of alder within a short period of time after excavation. Vegetation recovery at recently completed stream crossing excavations projects reveal a dense canopy of alders 6-10 feet tall will exist on all disturbed surfaces within 4 years. Second growth or old-growth forest canopy typically exists between proposed projects and habitat occupied by threatened anadromous fish. This canopy provides suitable shade to prevent changes in water temperature as a result of the proposed actions.

Cumulative Effects

Future state, local and private actions that are reasonably certain to occur within this action area under consideration are as follows: Humboldt County continual maintenance of levees which requires the removal of riparian vegetation and gravel, negatively affect listed fish, their habitat and water quality. The past land use practices (logging, roads, mining and cattle) of private has contributed to the increase sediment load which, also, negatively affect the estuary, its aquatic resources, wetlands and riparian vegetation. Recently, private landowners have worked cooperating with RNSP and other agencies to improve hillslope stability and aquatic habitat in the Redwood Creek watershed.

DETERMINATIONS

Based on the size, nature and duration of these proposed actions, it is the determination of the fishery biologist, that the proposed projects listed as routine road maintenance in this Biological Assessment may affect individuals, but are not likely to adversely affect Southern Oregon/Northern California coho, California Coastal chinook salmon, and Northern California steelhead trout and their critical habitat or Essential Fish Habitat.

Based on the size, nature and duration of these proposed actions, it is the determination of the fishery biologist, that the proposed projects listed as routine maintenance which uses petroleum and non-petroleum based products in this Biological Assessment may affect individuals and likely to adversely affect Southern Oregon/Northern California coho, California Coastal chinook

salmon, and Northern California steelhead trout and their critical habitat or Essential Fish Habitat.

Based on the size, nature and duration of the proposed actions, it is the determination of the fishery biologist that the culvert replacement portion of this BA may affect and is likely to adversely affect Southern Oregon/Northern California coho, California Coastal chinook salmon, and Northern California steelhead trout and their critical habitat and Essential Fish Habitat, however, the short term adverse affects will be outweighed by the long-term benefits to the species and their habitats.

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Appendix A: Road Listings and Maintenance Schedules

Twenty-five roads are annually maintained in RNSP (Table 1 of Appendix A). The Coastal Drive, Newton B. Dreary Memorial Parkway and the entrance road to Mill Creek campground are the only paved roads. All other roads are maintained as dirt surfaced roads. The state of California (Caltrans) maintains highways 101 and 199. Humboldt County maintains the Bald Hills road and Del Norte County maintains the access road to the Requa maintenance facility, Alder Camp road and the Klamath River road. **Note: Downed trees are removed from roads as needed.**

Table 1. Road systems that require annual maintenance in RNSP. Bolded names indicate vehicular access is available for the public on the noted road.

Road Name	Length of road	Type of routine maintenance
West side access	16.5 miles	brushing, grading, and down tree removal
Lost man Creek /Holler Ridge	11.5 miles	brushing, grading, and down tree removal
Tall Trees Access	6.3 miles	brushing, grading, and down tree removal

Road Name	Length of road	Type of routine maintenance
M line (west side)	6.5 miles	brushing, grading, and down tree removal
Davison	4 miles	brushing, grading, and down tree removal
K&K	4.5 miles	grading, and down tree removal
Coyote Creek Roads	15 miles	brushing, grading, and down tree removal
Skunk Cabbage (North and South)	2 miles	brushing, grading, and down tree removal
South Operations Center Road	0.75 miles	brushing, grading, and down tree removal
Redwood Creek Trail head	0.62 miles	brushing, grading, and down tree removal
Crescent Beach Road	2.25 miles	brushing, ditch clearing, and down tree removal
A-9-9	3 miles	brushing, grading, and down tree removal
A-9	2 miles	brushing, grading, and down tree removal
A-9-7	2 miles	brushing, grading, and down tree removal
B-line	5 miles	brushing, grading, and down tree removal
Newton B. Drury Memorial Parkway	9.2 miles	brushing, and down tree removal
Coastal Drive	5.5 miles	brushing, grading, and down tree removal
Alder Camp	2.2 miles	brushing, grading, and down tree removal
Howland Hill	6.63 miles	brushing, grading, down tree removal
Cal Barrel	4 miles	brushing, grading, and down tree removal
Pacamo	1 miles	brushing, grading, and down tree removal
Gold Bluffs Beach	4 miles	grading, and side removal
Walker	3 miles	brushing, grading, and down tree removal
Peacock	4 miles	brushing, grading, and down tree removal

	<i>Routine Maintenance</i>				
	Proposed action = Clean inboard ditch and culvert inlet and grade road surface to remove ruts when necessary				
	Equipment used = Grader, excavator, bulldozer, dump truck, slope mower, chainsaw and backhoe				
	Periodicity of these actions = Once per four years				
	Determination – May affect, but not likely to adversely affect all listed or proposed anadromous fish species				
Watershed Name	Total Length of Road	# of stream X-ings	Duration of Field Work	Time of year action is planned <i>(All projects planned to be completed by 1 Nov)</i>	
Prairie Creek					
200	2.0	13	2 days	> 10 Jul	
205	3.5	21	7days	> 15 Sep	
230	0.6	4	1 day	> 10 Jul	
240	1.9	4	2 days	> 10 Jul	
300	0.8	6	1 day	> 10 Jul	
305	0.3	1	.5 day	> 10 Jul	
310	0.4	2	.5 day	> 10 Jul	

	<i>Routine Maintenance</i>				
	Proposed action = Clean inboard ditch and culvert inlet and grade road surface to remove ruts when necessary				
	Equipment used = Grader, excavator, bulldozer, dump truck, slope mower, chainsaw and backhoe				
	Periodicity of these actions = Once per four years				
	Determination – May affect, but not likely to adversely affect all listed or proposed anadromous fish species				
Watershed Name	Total Length of Road	# of stream X-ings	Duration of Field Work	Time of year action is planned <i>(All projects planned to be completed by 1 Nov)</i>	
May Creek					
130	1.8	15	3 days	> 10 Jul	
B-Line (North)		16		> 10 Jul	
Lower May Creek Road	0.2	0	.5 day	> 15 Sep	
Lostman Creek					
A100	6.8	42	3 weeks	> 10 Jul	
A100/A140 Connector	0.3	2	1 Day	> 10 Jul	
A110	1.1	7	3 days	> 10 Jul	
A111	0.7	4	2 days	> 10 Jul	
A112	1.6	1	5 days	> 10 Jul	
A120	1.9	13	8 days	> 10 Jul	
A121	1.1	0	3 days	> 10 Jul	
A130	0.6	7	2 days	> 10 Jul	
A131	0.5	2	2 days	> 15 Sep	
A140	2.9	14	12 days	> 10 Jul	
A141	1.8	5	8 days	> 10 Jul	
A142	0.6	5	3 days	> 10 Jul	
A150	1.2	8	4 days	> 15 Sep	
A160	2.0	1	5 days	> 15 Sep	
A170	1.3	2	7 days	> 15 Sep	
A200	2.1	6	9 days	> 10 Jul	
A300	1.9	3	8 days	Jun	
A333 (A400)	0.4	4	1 day	> 10 Jul	
A350	0.4	4	1 day	Jun	
540	0.3	3	1 day	Jun	
550 (B550)	3.1	4	12 days	> 15 Sep	
551	0.1	1	.5 day	Jun	
552 (B-552)	0.6	3	1 day	Jun	
553	0.4	2	1 day	> 10 Jul	
554	1.0	2	2 days	Jun	
560	2.0	13	4 days	> 10 Jul	
B-Line (North)	1.0	33	2 days	Jun	
B200	0.6	2	1 day	> 10 Jul	
Lower B500	3.2	4	12 days	Jun	
Upper B500	1.2	1	3 days	> 10 Jul	
530 (B-530)	0.4	2	.5 day	> 15 Sep	
B200/B500 Connector	1.1	7	2 days	> 10 Jul	
Shangri La Road	1.0	6	2 days	> 10 Jul	
Spur	0.1	0	.5 day	> 15 Sep	

	<i>Routine Maintenance</i>				
	Proposed action = Clean inboard ditch and culvert inlet and grade road surface to remove ruts when necessary				
	Equipment used = Grader, excavator, bulldozer, dump truck, slope mower, chainsaw and backhoe				
	Periodicity of these actions = Once per four years				
	Determination – May affect, but not likely to adversely affect all listed or proposed anadromous fish species				
Watershed Name	Total Length of Road	# of stream X-ings	Duration of Field Work	Time of year action is planned <i>(All projects planned to be completed by 1 Nov)</i>	
Little Lostman Creek					
A150	0.1	6	.5 day	> 15 Sep	
A160	1.1	4	.5 day	> 15 Sep	
A170	0.7	2	1 day	> 10 Jul	
Bald Hills Spur	0.1	0	.5 day	> 15 Sep	
McArthur Creek					
A-9-7		8	2 days	Aug-Sep	
A-9-7-1	4.3	15	4 days	> 1 Aug	
A-9-7-2	1.1	11	2 days	> 1 Aug	
L-Line	1.0	?	1 day	> 1 Aug	
L-2-1	1.0	0	.5 day	> 1 Aug	
L-2-2		6	1 day	> 1 Aug	
L-2-2-1	2.7	4	5	> 1 Aug	
Elam Creek					
L-Line	2.0	9	3 days	> 1 Aug	
L-1 (East)	1.5	9	.5 day	> 1 Aug	
L-1 (west)		7	1 day	> 1 Aug	
L-1-1 (South)	1.2	6	3 days (once per 3 years)	> 1 Aug	
L-1-1 (North)	2.1	3	3 days	> 15 Sep	
L-2	1.4	7	2 days	> 1 Aug	
L-2-1	1.0	0	2 days	> 1 Aug	
L-2-3-1	0.6	1	1 day	> 1 Aug	
Bond Creek					
L-1 (east)	1.5	9	2 days	> 1 Aug	
M-11	0.8	4	1 day	> 15 Sep	
M-11-1		?	3 day	> 15 Sep	
M-11-1-1		1	1 day	> 15 Sep	
Forty-Four Creek					
A-9-6	2.0	7	3 days	> 1 Aug	
A-9-6-1	1.6	4	2 days	> 1 Aug	
C-12		0	1 day	> 1 Aug	
M-11-1		1	3 days	> 15 Sep	
Tom McDonald Creek					

	<i>Routine Maintenance</i>				
	Proposed action = Clean inboard ditch and culvert inlet and grade road surface to remove ruts when necessary				
	Equipment used = Grader, excavator, bulldozer, dump truck, slope mower, chainsaw and backhoe				
	Periodicity of these actions = Once per four years				
	Determination – May affect, but not likely to adversely affect all listed or proposed anadromous fish species				
Watershed Name	Total Length of Road	# of stream X-ings	Duration of Field Work	Time of year action is planned <i>(All projects planned to be completed by 1 Nov)</i>	
C-Line	5.8	14	11 days	> 10 Jul	
Upper G-Line		4	1 day	> 10 Jul	
Bridge Creek					
G-4	0.6	5	.5 day	> 10 Jul	
M-5	0.2	0	.5 day	> 10 Jul	
M-5/G-4 Connector	0.4	0	.5 day	> 10 Jul	
M-7		1	2 days	> 15 Sep	
M-7-1		1	2 days	> 15 Sep	
M-7-1 1/2		1	2 days	> 15 Sep	
M-2.5		?	7 days	> 15 Sep	
Devils Creek					
M-2	0.1	?	.3 day	> 15 Sep	
M-2.5		0	2 days	> 15 Sep	
M-2-1	0.6	2	.5 day	> 15 Sep	
M-2-1-1	2.1	8	4 days	> 15 Sep	
Y-Line	2.5	5	5 days	> 15 Sep	
Coyote Creek					
Boundary Road	0.1	6	.5 day	June	
Bridge Road	0.2	2	.5 day	June	
Coyote Creek Road	0.6	8	1 day	June	
Coyote Peak Road		1	1 day	June	
Coyote Peak Spur	0.1	0	.5 day	June	
High Prairie Road	0.7	9	1 day	June	
Long Ridge Road	0.8	13	1 day	June	
Lookout Road	Annual	0		June	
Lower Rock Fork Road	0.4	5	.5 day	June	
Main Stem Road	1.0	3	2 days	June	
Upper Mid Basin Road	0.4	0	1 day	June	
Lower Mid Basin Road		3		June	
Ranch Road		7	.1 day	June	
Ranch Spur	0.2	17	.5 day	June	
Rock Fork Road		0	2 days	June	
Schoolhouse Loop	0.3	0	.5 day	June	
Spring Road		0	.5 day	June	
Spring Spur	0.6	1	.5 day	June	

	<i>Routine Maintenance</i>				
	Proposed action = Clean inboard ditch and culvert inlet and grade road surface to remove ruts when necessary				
	Equipment used = Grader, excavator, bulldozer, dump truck, slope mower, chainsaw and backhoe				
	Periodicity of these actions = Once per four years				
	Determination – May affect, but not likely to adversely affect all listed or proposed anadromous fish species				
Watershed Name	Total Length of Road	# of stream X-ings	Duration of Field Work	Time of year action is planned <i>(All projects planned to be completed by 1 Nov)</i>	
T. Bear Road	0.7	2	.5 day	June	
Upper Coyote Peak Road	0.4	?	.5 day	June	
Upper Lyons Road	0.7	5		June	
Redwood Creek Eastside (Other)					
C-Line (East) lower	0.7	1	.5 day	> 15 Sep	
C-10		3	.5 day	> 10 Jul	
C-30		2	.5 day	> 10 Jul	

	NON-ROUTINE MAINTENANCE				
	Replacement of culverts and installation of rolling dips				
	Periodicity of these Actions = Once (RNSP creates dips and/or upgrade culverts where there is a risk of crossings plugging, or when fish passage is an issue)				
	Equipment = Excavator, Backhoe, Bulldozer, Loader, Grader, Compaction Equip., Dump Trucks and chainsaws				
	Determination – May affect, and is likely to adversely affect all listed or proposed anadromous fish species				

Watershed Road Name	Total Length of Road	# of stream X-ings	Time of year action is planned <i>(All projects planned to be completed by 15 Oct)</i>	Estimated number of culverts to replace	Estimated number of rolling dips to be installed
Prairie Creek					
200	2.0	13	> 15 Sep	13	
205	3.5	21	> 15 Sep		12
240	1.9	4	> 15 Sep		3
300	0.8	6	> 15 Sep		1
Off- Highway				6	6
May Creek					
130	1.8	15	> 10 Jul		8
Lostman Creek					
A100	6.8	42	> 10 Jul		24
A100/140 Connector	0.3	2	> 10 Jul		2
A110	1.1	7	> 10 Jul		2
A112	1.6	1	> 10 Jul		1
A120	1.9	13	> 10 Jul		9
A130	0.6	7	> 10 Jul		1
A131	0.5	2	> 10 Jul		1
A140	2.9	14	> 10 Jul		6
A142	0.6	5	> 10 Jul		4
A150	1.2	8	> 10 Jul		3
A160	2.0	1	> 10 Jul		1
A170	1.3	2	> 10 Jul		1
A200	2.1	6	> 10 Jul		2
A350	0.4	4	> 10 Jul		2
540	0.3	3	> 10 Jul		1
550 (B550)	3.1	4	> 10 Jul		9
552 (B-552)	0.6	3	> 10 Jul		1
560	2.0	13	> 10 Jul		3
B200	0.6	?	> 10 Jul		2
Lower B500	3.2	4	> 10 Jul		5
B200/B500 Connector	1.1	7	> 10 Jul		2
Shangri La Road	1.0	6	> 10 Jul		1
Little Lostman Creek					
A160	1.1	4	> 10 Jul		1
McArthur Creek					
L-2-2		6	> 10 Jul	8	0
Elam Creek					
L-1 (East)	0.6	9	> 10 Jul	10	0
L-1 (west)		7	> 10 Jul	8	0
L-2	1.4	7	> 10 Jul	3	0
Bond Creek					

NON-ROUTINE MAINTENANCE					
Replacement of culverts and installation of rolling dips					
Periodicity of these Actions = Once (RNSP creates dips and/or upgrade culverts where there is a risk of crossings plugging, or when fish passage is an issue)					
Equipment = Excavator, Backhoe, Bulldozer, Loader, Grader, Compaction Equip., Dump Trucks and chainsaws					
Determination – May affect, and is likely to adversely affect all listed or proposed anadromous fish species					
Watershed Road Name	Total Length of Road	# of stream X-ings	Time of year action is planned <i>(All projects planned to be completed by 15 Oct)</i>	Estimated number of culverts to replace	Estimated number of rolling dips to be installed
M-11/M-11-1	0.8	4	> 15 Sep	8	0
Forty-Four Creek					
A-9		9	> 1 Aug	8	0
A-9-9		15	> 1 Aug	14	12
Tom McDonald Creek					
C-Line	5.8	14	> 10 Jul		7
Upper G-Line		4	> 10 Jul		0
G-6-1	1.4	7	> 1 Aug	10	0
B-5		9	Jun		0
Bridge Creek					
M-7-1 1/2		1	> 15 Sep		0
Rodger's Peak			> 10 Jul		0
B-5 (WSA)		14	Jun	1	0
M-Line	6.5	44	Jun	43	0

Appendix B: Checklist For Documenting Environmental Baseline and Effects of Proposed Action (s) on Relevant Indicators

**Redwood National and State Parks
Environmental Baseline and Effects of Proposed Routine and Non-Routine Road
Maintenance Actions on Relevant Watershed Indicators in the Redwood Creek Watershed**

Indicators	Environmental Baseline			Effects of the Action(s)		
<u>Water quality</u> Temperature Sediment Chem contamin.	Properly Functioning	At Risk	Not Functioning	<i>Restore</i>	<i>Maintain</i>	<i>Degrade</i>
	PC		RC	Long-term		Short-term
		PC	RC	Long-term		Short-term
	Lower RC At risk-Agriculture; PC, no info			Long-term		
Habitat Access Barriers	Properly Functioning	At Risk	Not Functioning			
	RC	PC		Long-term		
<u>Habitat elements</u> Substrate LWD Pool Frequency Pool Quality Off-channel habitat Refugia	Properly Functioning	At Risk	Not Functioning			
		PC	RC	Long-term		Short-term
	PC		RC	Long-term		
	PC		RC	Long-term		
	PC	RC		Long-term		
	PC		RC	Long-term		
	PC		RC	Long-term		
Channel condition Width/Depth Bank cond. Floodplain	Properly Functioning	At Risk	Not Functioning			
	PC		RC	Long-term		
	PC		RC	Long-term		
	PC	RC	RC-at levees	Long-term		
<u>Flow/hydrology</u> Peak flow/base* Increase drainage network*	Properly Functioning	At Risk	Not Functioning			
	PC		RC	Long-term		
	PC		RC	Long-term		
Watershed condition Road density Road location Dist. History Riparian Reserves	Properly Functioning	<i>At Risk</i>	Not Functioning			
		PC**	RC	Long-term		
		PC	RC	Long-term		
		PC	RC	Long-term		
	PC		RC	Long-term		Short-term

RC=Redwood Creek and tributaries

PC=Prairie Creek and tributaries

* Includes effects from remaining watershed upstream of park lands

** Includes roads in Lost Man drainage, tributary to Prairie Creek

Appendix C: Sediment-Budget Calculations and Supporting Information

SEDIMENT BUDGET FOR THE REDWOOD CREEK WATERSHED, 1954 - 1980

A sediment budget was constructed for the Redwood Creek watershed for the purpose of documenting the location, timing and volumes of major sources of sediment (both natural and management-related), the volume of sediment storage and the sites where that sediment is stored in stream channels, and the net sediment output from the Redwood Creek basin at Orick, California. The budget was based on a combination of fieldwork, monitoring and stream gaging, interpretation of aerial photographs and extrapolation of results from other studies. The time period chosen (1954-1980) encompasses four large floods in the basin (in 1964, 1972 [two floods], and 1975), and was bracketed by the availability of air photos in 1954 and 1978. Field mapping in 1980 filled in many gaps in the air photo interpretation. In the following sections are descriptions of how each item in Table 1 was estimated. Various investigators in studies spanning many years used many different measurement units. We tried to list the original measurements along with the appropriate conversions. All estimates for this sediment budget were converted to English tons, based on measurements of bulk densities of soil, colluvium and alluvium (listed below). This sediment budget does not differentiate sediment according to particle size, and both bedload and suspended sediment-sized particles are considered. We recognize that many of the items listed are rough estimates, and are based on extrapolations of data from small study sites to large areas. Nevertheless, we feel this method is adequate to show the relative importance of various erosional processes even if the exact volumes of sediment cannot be measured.

SEDIMENT PRODUCTION ASSOCIATED WITH ROAD NETWORKS:

Unpaved logging roads are commonly a source of sediment to streams channels. Roads contribute sediment through several processes: cutbank erosion and failures, surface erosion from unpaved roads, erosion of inboard ditches, road fill failures, landing failures, and erosion of road fill at stream crossings. Although not as large as haul roads, skid roads and skid trails are more numerous and also contribute sediment to stream channels. In addition to those sources of sediment listed below, there are several unmeasured sediment sources: cutbank and road fill failures that were not included under other mass movement categories, landing failures that feed into a stream, and sheetwash and cutbank erosion from skid trails. As more data are collected from field studies, these categories may be added to the budget.

Cut bank erosion:

Ten grids of nine erosion pins each were installed on the east side C-line in Redwood National Park in 1979 (Madej, unpublished data). Pins were 9-inch steel nails that were painted orange, and they were driven into the cutbank perpendicular to the ground surface until they were flush with the ground. Pins were spaced 18 inches horizontally from each other, above the talus pile at the toe of the cutbank. Data covers period from Nov. 1979 to June 1986 (seven winters, with moderate intensity rains) at 10 sites, on both schist and sandstone terrain. Only 48 pins remained undisturbed for the seven-year period. For the 48 erosion pins that remained intact for seven years, mean depth of erosion was 1.12 inches. ($1.12 \text{ in}/7 \text{ years} = 0.16 \text{ inch/year}$, or 1.6 inches (0.13 ft) in 10 years.) There was no significant difference between sandstone and schist terrain.

Many assumptions and simplifications were used to estimate a sediment yield from cutbanks:

- 1) Based on erosion pin data, a rate of 0.13 ft. of cutbank retreat in ten years was applied to all haul roads in the basin. On abandoned roads, it was assumed that 10 years after road construction, a combination of revegetation and the cessation of road grading and ditch cleaning would protect cutbanks from further significant erosion and contribution of material into inboard ditches. Without road grading and ditch cleaning, a debris apron forms at the base of cutbanks and stores material eroded from upslope cutbanks. Cutbank slides would contribute sediment over and above that recorded by erosion pins, but this factor was not measured in the field.
- 2) Haul roads were assumed to have only one cut bank (no throughcuts were considered), with an average height of 10 ft. Skid trails were assumed to have negligible cutbank erosion.
- 2) All material eroded from the cutbank was assumed to reach the inboard ditch. Based on a road inventory in Redwood National Park (Spreiter, 1995) of more than 700 culverts, 70% of culverts draining inboard ditches feed into stream channels (the remainder were ditch relief culverts or drained springs). This value is considerably higher than Raines and Kelsey's value for Grouse Creek, an adjacent watershed. However, most of the 1,400 miles of roads in the Redwood Creek basin are abandoned or unmaintained, with few functioning waterbars or ditch relief culverts. Therefore, we assumed that about 70% of sediment reaching the inboard ditch were delivered to a stream during the first ten years after road construction, with no contribution to streams after 10 years.
- 3) About 1400 miles of road were constructed in the Redwood Creek basin by 1978.
- 4) A bulk density of 100 lbs/ft³ (1.6 g/cm³) based on soil surveys (Popenoe, 1987) was used to convert volumes of eroded cutbank material to mass. (This bulk density was used for all hillslope erosion calculations, unless noted otherwise).

The calculation used was:

10 ft. high cutbanks x 0.13 ft. retreat in 10 years x 5280 ft/mile = 6864 ft³ for each mile of haul road over 10 years x 70% delivery = 4805 ft³/mile
 4805 ft³/mile = 240 tons/mile of haul road over a 10-year period.
 240 tons/miles of road x 1400 miles = **336,000 tons** from cutbank erosion

This estimated yield of 240 tons/mile of road is similar to that of Reid and Dunne's measurement of cutbank erosion of 15 metric tons/km of road per yr (=26.6 tons/mile of road per yr or 266 tons/mile of road in 10 years) for logging roads on the Olympic Peninsula, but greater than Raines and Kelsey's 1991 estimate of 13.5 tons/mile/yr or 135 tons/mile per 10-year period for Grouse Creek, a 170 km² basin adjacent to Redwood Creek.

Surface Erosion from Unpaved Roads:

Estimates of surface erosion were based on Reid and Dunne's work (1984) on logging roads in the Clearwater River, Olympic Mountains, Washington. There, under 3900 mm/yr of rainfall on sandstone and graywacke bedrock, the sediment yields from unpaved roads varied by use level:

Heavy use	500 tonnes/km/yr
Moderate use	42 tonnes/km/yr
Abandoned	0.51 tonnes/km/yr

These values need to be adjusted for conditions in the Redwood Creek basin. For Redwood Creek, the amount of surface erosion is probably less than in the Olympics because rainfall totals and rainfall intensities are less. Raines and Kelsey accounted for the difference in precipitation between Grouse Creek and the Clearwater basin by multiplying sediment yield rates by 0.76 (the ratio of the Grouse Creek R factor (a rainfall and runoff factor) to the Clearwater R factor). Redwood Creek has about the same R value as Grouse Creek, so the same method was used. Also, the average width of haul roads in the Redwood Creek basin is six meters (20 ft.) (based on road inventories of more than 150 miles of roads), which is 1.5 times the average width of roads in the Clearwater basin. Finally, only the sediment washed off from roads that drains into stream channels (via inboard ditches and culverts) should be counted in this sediment budget. From road inventories in the Redwood Creek basin (Spreiter, 1995), 70% of road drainage structures feed into stream channels. Thus, the adjustment factor for Redwood Creek is $0.76 \times 1.5 \times 0.70 = 0.80$.

Erosion from road surfaces is very sensitive to traffic levels (Reid and Dunne, 1984), which in turn is dependent on the type of timber harvest, length of the harvest plan, and post-harvest activities. It was assumed that during the time period 1954-1980, all roads in the Redwood Creek watershed had heavy use for one year during timber harvest, moderate use for three years, and were abandoned the remainder of the time.

1400 miles of road constructed by 1978 = 2250 km of road.

1) Heavy use:	2250 km x 500 tonnes/km/yr x 1 yr =	1,125,000 tonnes
2) Moderate use:	2250 km x 42 tonnes/km/yr x 3 years:	283,500 tonnes
3) Abandoned:	2250 km x 0.51 tonnes/km/yr x 23 years =	<u>26,400 tonnes</u>
Total =	1,434,900 tonnes from surface of roads from 1954 -1980. (= 1,581,000 English tons)	

Adjustment factor applied to roads: $0.80 \times 1,581,000 \text{ tons} = \mathbf{1,265,000 \text{ tons}}$.

If roads were actually heavily used for two years instead of one (which depends on the harvest history and log hauling routes), the total amount eroded over the 23-year period would be:

2.2×10^6 tonnes (2,400,000 English tons) or adjusted sediment production of
1,920,000 tons.

In Table 1, the smaller amount is listed because the level of road use is not well known.

Skid Trails

Little quantitative information is available for erosion from skid trails. Best and others (1995) determined erosion due to rilling and water diversions on skid trails in the Garrett Creek watershed (this value does not include skid trail stream crossing failures or general surface lowering from sheetwash). There, on about 5 km² of lands with logged coniferous forests, 29,182 tonnes of sediment came from erosion on skid trails, or 5836 t/km². Best (1984) stated that 348 km² of the Redwood Creek basin was tractor yarded. An additional 20.5 km² in Lost Man Creek was logged, and mostly tractor yarded. We applied the erosion rate from skid trails in Garrett Creek to all tractor-yarded lands (142 mi²) in the Redwood Creek basin:

$$368.5 \text{ km}^2 \times 5836 \text{ t/km}^2 = 2,150,566 \text{ tonnes} = \mathbf{2,400,000 \text{ tons}}$$

Erosion from Inboard Ditches

Based on a study of Garrett Creek, a tributary of Redwood Creek (Best and others, 1995), 2086 tonnes of road material eroded from inboard ditches along 12.7 km of road, or 165 tons of material/km of road, from 1956 to 1980.

This erosion rate was applied to the 2250 km of haul roads in the Redwood Creek basin:

$$2250 \text{ km} \times 165 \text{ tonnes/km} = 371,000 \text{ metric tonnes} = \mathbf{410,000 \text{ tons.}}$$

Erosion from Haul Road Stream Crossings

Stream crossing failures contribute significant amounts of road fill into stream channels. Various inventories have produced several estimates of this type of erosion in different terrains. The older the road and the more storms it has weathered, the higher the probability that a crossing will have failed. Eighty percent of the roads in the Redwood Creek basin were built before the large storms in 1972 and 1975, and 66% of them were built before the 1964 flood. Many crossings failed and were rebuilt, only to fail again. Weaver and Hagans (1987) measured failures of crossings in haul roads and skid trails on 2214 ha in Redwood National Park, and the average crossing failure volume was 48 m³. Measurements for skid trail crossings were not distinguished from haul road crossings, and this value is considered to be low for the watershed as a whole. Best (unpublished data) measured erosion at 140 stream crossings. He found the average failed crossing volume (n = 51) was 208 yd³ (160 m³). The Redwood National Park inventory of more than 900 stream crossings (Spreiter, 1995) listed the average volume eroded from **all** stream crossings as 230 yd³, which **includes** crossings with no failure volume. In Garrett Creek (Best and others, 1995) 111 crossings were inventoried. Of these, about 50% of the crossings failed during the study period, and the average **failure** volume was 74 - 186 m³ (97 - 243 yd³). There are several sets of road inventory data that have not been finalized yet, and so the appropriate value for sediment derived from failed stream crossings will be revised as new data become available. This value will also be refined as failure rates are stratified by age of road and slope position. In the present version of the sediment budget, we assumed a failure rate of 50% during the study period (1954 to 1980) and used a value of 200 yd³ an estimate of erosion from failed stream crossings in the Redwood Creek basin.

The next task was to estimate the number of stream crossings in the Redwood Creek basin. Field mapping and air photo interpretation during various studies (Bundros, Klein, Alpert; Redwood

National Park, unpublished data) inventoried the number of stream crossings on 90 mi² of the Redwood Creek basin (one-third of the basin area). The number of crossings ranged from 21 to 45 crossings/mi². For this budget the value of 30 crossings/mi² was used.

Upstream of park boundaries: 162 mi² x 30 crossings/mi² = 4860 crossings
Park lands: 116 mi² - [24,315 acres of old growth, or 38 mi²] = 78 mi²
78 mi² x 30 crossings/mi² = 2348 crossings

For this basin, a total of 7200 crossings is equivalent to about 5 crossings/mile of haul road. The estimated sediment input from haul road crossing failures during this time period is:

7200 crossings x 50% failure rate x 200 yd³/failed crossing = 720,000 yd³
720,000 yd³ x 1.62 tons/yd³ = **1,166,400 tons** from 240 mi² of roaded land.

This value is lower than that for the nearby upper mid-Grouse Creek basin measured by Raines and Kelsey (2.79 m³/ha, or 7800 t/mi²), but higher than that for upper Grouse Creek and Cow Creek (900 to 1000 t/mi²) (Raines and Kelsey, 1991).

Skid Trail Crossings

Various road and hillslope inventories (Best, Alpert, Spreiter; unpublished data) documented average skid trail crossings to be 25 to 50 yd³ in size. Several assumptions were used to estimate an erosion rate from skid trail crossing failures on tractor logged hillslopes:

- 1) **Skid trail density** is 16 to 42 km/km² (Best, unpublished data), which is two to five times the haul road density. Some areas have skid trail densities 7.5 times haul road densities (Redwood National Park, 1981). So, we assumed skid trail **crossing density** is four times that of haul road crossings, or 120 crossings/mi² of tractor-logged terrain.
- 2) Assume average crossing failure volume is 25 yd³.
- 3) Assume 75% of skid trail crossings failed during this time period (field observations seem to bear out a higher failure rate in skid trail crossings than in haul road crossings)
- 4) Best's land use report says about 35,000 ha of the Redwood Creek basin was tractor yarded, and an additional 2050 ha were cut in the Lost Man area, or 37,050 ha (= 143 mi²) 143 mi² x 120 crossings/mi² x 25 yd³ x 75% = 321,750 yd³ = **521,000 tons** from failures of skid trail crossings.

Surface Erosion from Disturbed Ground

Weaver and Hagans (1987) estimated the mass of sediment eroded from bare ground based on sediment trough data (0.05 to 0.1 cm of ground surface lowering during the first winter following

ground disturbance.) That rate of ground lowering was roughly similar to what Marron and others (1995) measured from erosion pins installed on bare ground (0.03 cm to 0.46 cm/yr). Weaver and Hagans stated that only 3600 ha of bare ground (1/3 of the harvested area of 10,770 ha) would actually contribute sediment from surface erosion to streams. The mass of sediment reaching streams can be calculated by using their mean lowering rate of 0.075 cm x 3600 ha = 270,000 m³ = 477,000 tons.

Next, this value was extrapolated to the remaining area of the drainage basin. Best (1995) states that between 1949 and 1978, 25,445 ha (62849 ac) of the Redwood Creek watershed was logged upstream of Redwood National Park boundaries. This figure only includes the original logging of old-growth forests, and does not include later reentries and harvest of second-growth. By 1970, 65 percent of the original coniferous forests of the basin had been logged, and practically all of that was tractor-yarded. Cable logging became more common in steep areas adjacent to streams between 1970 and 1978, but less than 6% of the watershed was cable yarded (Best, 1984). For this rough estimate of surface erosion, erosion from disturbed lands on cable yarded cuts is treated the same as on tractor-yarded areas. The assumption is that only one-third of the disturbed ground contributed sediment to a stream channel (Weaver and Hagans, 1987).

$$\begin{aligned} 0.33 \times 62849 \text{ ha} &= 20740 \text{ ha} = 207.4 \text{ km}^2 \\ 207.4 \text{ km}^2 \times .0075 \text{ m of surface lowering} &= 1,555,500 \text{ m}^3 = 2,750,000 \text{ tons} \end{aligned}$$

The Lost Man Creek basin was not included in Best's 1995 study. There, approximately 2050 ha were logged:

$$20.5 \text{ km}^2 \times .0075 \text{ m} = 154,000 \text{ m}^3 = 271,500 \text{ tons}$$

Total amount of surface erosion:

272,000 -Lost Man Creek

477,000 - Redwood National Park lands

2,750,000 - Land upstream of Redwood National Park boundaries.

3,499,000 tons

GULLIES

A) Prairie gullies:

From field measurements and air photo interpretation Walter (1985) estimated the sediment production from gullies on all prairies in the Redwood Creek basin, including both natural and road-related gullies (248,411 m³, or **440,000 tons**) between 1954 and 1978.

B) Forested lands:

Gullies are a common erosional feature on lands that have had timber harvest and road construction. Most gullies are caused by stream diversion. Such diversions are commonly caused by plugged or misplaced culverts. Stream diversions on roads produced most of the largest gullies and the bulk of hillslope erosion from the roaded areas. For example, Weaver and

others (1995) documented that 94% of the total volume of hillslope erosion in the South Copper Creek study site was caused by diversions. In addition, Best and others (1975) found that 66% of road-related fluvial erosion in the Garrett Creek watershed was caused by stream diversions.

- 1) Within Redwood National Park boundaries: Weaver and Hagans (1987) extrapolated field measurements of gully erosion on 22 km² of logged lands to all logged lands within the park. Their estimate of sediment derived from gully erosion is 1,200,000 (2,100,000 tons).
- 2) Upstream of Redwood National Park's boundary: Weaver and Hagans's extrapolation (1987) used soil classifications to define high, moderate and low yield terrains for gully erosion. Popenoe (personal communication) categorized Hugo and Masterson soils as those most susceptible to fluvial erosion. In the Park Protection Zone and upper basin 15,272 acres (6183 ha) are underlain by these soil types, so the high yield rate of Weaver and Hagans (260 m³/ha) was applied to this area. Stable soils, in terms of gully erosion, are Trailhead and Orick soil types (Popenoe, personal communication). Upstream of park boundaries only 476 ac (193 ha) are underlain by these soils. In the remainder of the upper basin (25620 ha), soils were considered to be at moderate risk from gully erosion, and we applied Weaver and Hagans' value for moderate yields (64 m³/ha.) The estimate of gully erosion for lands upstream of the park and for the Lost Man Creek basin (excluding prairies), is:

3 ha x 260 m ³ /ha =	1,608,000 m ³
193 ha 3 m ³ /ha =	579 m ³
25,620 ha x 64 m ³ /ha =	1,640,000 m ³
2,045 ha x 64 m ³ /ha =	<u>131,000 m³</u>
(estimate for Lost Man basin)	3,379,579 m ³ = 5,967,000 tons

Total gully yield for Redwood Creek basin:

440,000 tons-prairies
 2,100,000 tons-in Redwood National Park
5,967,000 tons - upstream of park, and Lost Man
8,507,000 tons

STREAMBANK EROSION

Streambank Erosion along tributaries

The length of stream channels of various stream orders was determined by using Redwood National Park's geographic information system, based on blueline streams shown on USGS 1:24,000 topographic maps, with extensions of small channels based on contour crenulations. Raines and Kelsey (1991) extrapolated the amount of streambank erosion for each order stream

from measurements in the adjacent basin of Grouse Creek. Field observations in tributary basins of Redwood Creek and cross-sectional survey data in third- and fourth-order streams (1974 to 1988, unpublished data) support these extrapolated values. These values of streambank erosion in tributaries do not include streamside landsliding (which is documented in a later section). The time frame of streambank erosion is difficult to pinpoint exactly. Undercutting of young tree roots and the prominence of bare banks suggest recent erosion, but not precise timing. The value of sediment production from tributary streambank erosion for Redwood Creek could be refined by stratifying tributaries by bedrock and land use, and by making more intensive field measurements, but this step has not been completed yet.

Stream Order	Miles of Channel (Length in Meters)	Streambank Erosion (m ³ /m)*	Sediment Production (m ³)	Sediment Mass (tons)
1	1529 (2.46 x 10 ⁶)	0.17	418,296	600,000
2	473 (761,000)	1.63	1,240,000	1,780,000
3	183 (295,000)	1.57	463,571	664,100
4	86.2 (139,000)	0.20	27,740	40,000
5	61.2 (98,500)	0.31	30,500	44,000
			TOTAL	3,130,000

* Based on Raines and Kelsey (1991) streambank erosion values for Grouse Creek.

Mainstem Bank Erosion

The width of bare or sparsely vegetated gravel bars and the low flow channel of Redwood Creek defined the active channel width of Redwood Creek. The active channel width increased greatly in several reaches of Redwood Creek during the 1964 flood, and to a lesser extent, during the 1972 and 1975 floods (Nolan and Marron, 1995). Channel widening does not automatically translate into bank erosion, however, because much of the channel widening was due to an excessive amount of gravel being deposited on surfaces that were formerly covered with trees and shrubs. Also, streamside landslides were tabulated separately, and erosion of the toes of such slides was included under that category. Although cross section measurements yield the most accurate values for bank erosion, cross section data are not available to assess the effects of the 1964 and 1972 floods. In addition, cross section monuments were commonly established on stable points, such as bedrock outcrops, so cross section surveys may not be representative of typical bank conditions in a reach.

Bank erosion along Redwood Creek was documented in two ways. The first was by field mapping of erosion features. Field evidence of bank erosion included undercut tree roots and toppled streamside trees. This estimate is a minimum, however, because once the tree is washed away, little evidence for the amount of lateral retreat remains. The second method used sequential aerial photographs from 1954, 1958, 1965 and 1978 to measure bank erosion. The problem with using air photos is that determining accurate scales from older air photos was difficult. The exact location of streambanks was commonly obscured by shadows from large streamside conifers. It was also difficult to determine accurate bank heights. Bank height information was gleaned from the recent cross section surveys and field mapping. Channel widening through the erosion of three large gravel bars during the 1964 flood accounted for 25%

of the total mainstem bank erosion. Although the alluvium in these bars originally was derived from upslope erosion processes, these were stable bars that had been deposited prior to 1954. Thus, counting erosion of these bars as sediment production during this time period is not double counting the volume of sediment. The mass of sediment derived from streambank erosion along Redwood Creek between 1954 and 1980 is **2,070,000 tons**.

MASS MOVEMENT

Streamside landslides along mainstem of Redwood Creek

Kelsey and others (1995) determined the volume of material contributed by streamside debris slides and earthflows along the mainstem of Redwood Creek. Landslide volumes were measured in the field, with supplemental measurements from air photos. Between 1954 and 1980, 4,000,100 m³ (**7,100,000 tons**) of sediment entered Redwood Creek from these slides.

Landslides in tributary basins:

Pitlick (1995), through a combination of field mapping and air photo interpretation, determined the contribution of streamside debris slides in 16 tributary basins in the Redwood Creek. Almost 90% of the slides occurred post-1954, and these slides contributed **3,900,000 tons** of sediment to tributary channels. He also classified tributary basins and their associated contribution of landslide material during the period 1954-1978 as:

Redwood dominated vegetation, Low relief:	5,000 t/km ²
Redwood dominated vegetation, High Relief:	13,800 t/km ²
Douglas fir dominated vegetation, High Relief:	26,100 t/km ²

We extrapolated those rates of sediment production from streamside landslides to tributary basins, which were not sampled and mapped during Pitlick's study.

Douglas fir, High Relief basins:	142 km ² x 26,100 t/km ²	= 3,706,200 tonnes
Redwood, Low Relief basins:	42.5 km ² x 5000 t/km ²	= 212,500 tonnes
Redwood, High Relief basins	2.9 km ² x 13,800 t/km ²	= 40,020 tonnes
Lost Man Creek, also Redwood, Low Relief:	(4089 ha x 5000 t/km ²	= 204,450 tonnes
Total debris slide input from unsampled tributaries: 4,163,000 tonnes (4,600,000 tons).		

Earthflows

The most extensive mass movement features in the watershed are earthflows (Nolan and others, 1976; Harden and others, 1978). The total area covered by active earthflows represents about 10% of the Redwood Creek watershed upstream of the confluence of Redwood and Prairie Creeks and very active earthflows comprise 2% of this area (Harden and others, 1978). The earthflows classified as "very active" can be considered streamside landslides in that they deliver sediment directly to major channels.

Earthflows are slow-moving (0 to 20 feet per year) persistent landslides. They are generally grass-covered rather than forested, and are often gullied (Gully erosion on these features was counted under "Prairie gullies"). Studies in and near the Redwood Creek watershed by Kelsey

(1978; 1980), Harden and others (1978), Nolan and others (1979a), Iverson (1984) and Iverson and Major (1987) have shown that earthflows deliver sediment to stream channels through both mass movement and fluvial processes and that earthflow movement is related to annual rainfall and patterns of groundwater flow. These previous studies have found that earthflows, despite their

large areas, contribute relatively little sediment to Redwood Creek. Long-term data collection at the Minor Creek earthflow supports this interpretation. The Minor Creek earthflow contributes sediment directly into Minor Creek, a major tributary channel. The average volume of material contributed annually to Minor Creek by the landslide can be computed as the product of width, depth, and annual movement rate. Approximate width of the landslide near its toe is 260 feet. Depth to the failure surface is about 16 feet, and the long-term average rate of movement is about 1.6 feet per year (Iverson and Driedger, 1993). The annual average sediment volume transported downslope to the channel is therefore about 250 cubic yards. Assuming a bulk density of 1.59 tons per cubic yard, based on data of Iverson (1984), the average mass of sediment contributed to the stream annually is about 400 tons.

If the 25-acre Minor Creek earthflow is considered representative of the 3,050 acres of very active earthflows in the entire Redwood Creek watershed (Harden and others, 1978), total earthflow sediment production can be estimated at approximately 50,000 tons per year, or **1,350,000 tons** from 1954 to 1980. The estimate of annual sediment production is about 3% of the average annual sediment load of the creek. This calculation supports earlier findings that earthflows are not major sediment-producing features in the Redwood Creek watershed.

Forested Blockslides:

Sonnevil and others (1987) estimated 64,150 m³ (113,300 tons) of sediment was derived from blockslides from schist terrain within the park between 1954 and 1980. The area of park lands underlain by Redwood Creek schist is about 14,500 ha, or 145 km². (64,150 m³/145 km² = 442 m³/km²)

We assumed that the same rate of blocksliding occurs on the schist terrain upstream of the park boundary: 3846 ac of South Fork Mountain schist and 42,481 ac of Redwood Creek schist. We also assumed that forested blockslides will deliver sediment directly into stream channels.

$$\begin{array}{rcl}
 46,327 \text{ ac} & = & 18,755 \text{ ha} = 187.6 \text{ km}^2 \\
 187.6 \text{ km}^2 \times 442 \text{ m}^3/\text{km}^2 & = & 83,000 \text{ m}^3 = \quad 147,000 \text{ tons from upstream of park} \\
 & & \underline{\quad \quad \quad + 113,300 \text{ tons} \quad - \text{ park lands}}
 \end{array}$$

260,300 tons

Debris torrents

The estimate of sediment production from landslides in the above section only considered those slides adjacent to high order (third to fifth order) channels. In some parts of the basin, especially those underlain by the Incoherent Unit of Coyote Creek (44,673 ac or 181 km²), debris torrents are common higher on the hillslopes and contribute sediment into lower order stream channels. The Garrett Creek study (Best et al, 1995) reported a rate of 4021 t/km² of sediment from road-related debris torrents from 1956 to 1980, and in the adjacent basin of Grouse Creek Raines and Kelsey (1991) reported a similar rate for debris torrents of 4830 t/km² during the same time period.

Based on the above values, an estimated yield from debris torrents for the Redwood Creek basin is:

$$181 \text{ km}^2 \text{ of susceptible terrain} \times 4500 \text{ t/km}^2 = 814,500 \text{ tonnes} = \mathbf{900,000 \text{ tons}}$$

CHANGE IN CHANNEL-STORED SEDIMENT

Change in Sediment Storage in Tributaries:

Pitlick (1995) estimated the total amount of sediment stored in 74 tributaries to be 2×10^6 tonnes (2.2×10^6 tons). But this is not a **change** in storage, and the tributaries had already stored some sediment behind log jams and in gravel bars before the large floods of 1964, 1972 and 1975 occurred. We have no data on pre-1954 tributary sediment storage. Madej (1987) reported that 60-100% of recent flood deposits in tributaries were flushed out within 10 years of the flood, based on an analysis of tributary cross section data from 1974 to 1986. So, in this sediment budget we estimate that 80% of the amount of sediment that Pitlick measured in the tributaries was there before the flood, because the “excess” flood deposits would have been quickly flushed out of the steep tributary channels.

$$2,200,000 \text{ tons} \times 20\% = \mathbf{440,000 \text{ tons}} = \text{Net addition to storage in tributary stream channels from 1954 to 1980}$$

Change in Sediment Storage in RedwoodCreek

Based on field measurements and air photo interpretation, Madej (1995) estimated that there was a net increase of 9.4×10^6 tonnes (**10,400,000 tons**) of sediment stored in the channel of Redwood Creek from 1947 to 1980. Most of this sediment was deposited during the 1964 flood. Details of field methodology and locations of sediment storage are listed in the 1995 report.

SEDIMENT OUTPUT

Bedload and suspended sediment have been measured near the mouth of Redwood Creek at the Orick gaging station since 1971. The U.S. Geological Survey publishes yearly summaries of these gaging efforts in their annual Water Resources Data reports. In addition, Knott (USGS, unpublished memo, 1981) estimated the probable sediment yields before gaging stations were established, for the period of 1954 to 1971. The total sediment output for Redwood Creek, including both bedload and suspended sediment discharge, for the period 1954 to 1980 was **45,000,000 tons**.

Appendix D: Fish Presence Maps



**UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration**

NATIONAL MARINE FISHERIES SERVICE
Southwest Region
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Long Beach, California 90802-4213

AUG 14 2008

In response reply to:
2007/09110

Mr. Bill Pierce
Superintendent, National Park Service
United States Department of the Interior
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Ms. Marilyn Murphy
Superintendent, California State Parks
California Dept. Parks and Recreation
Redwood National and State Parks
1111 Second Street
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Dear Mr. Pierce and Ms. Murphy:

This letter transmits NOAA's National Marine Fisheries Service's (NMFS) final biological opinion (Enclosure 1) and Essential Fish Habitat (EFH) consultation (Enclosure 2) for Federal agency actions pertaining to Redwood National and State Parks' (RNSP) Annual Routine and Non-Routine Road Maintenance Program (RNSP Roads Program). This letter also serves as consultation under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act of 1934 (FWCA), as amended.

The National Park Service proposes to conduct routine road maintenance on all the roads in the park, and to conduct non-routine road maintenance on three roads and one trail. Routine road maintenance consists of the following: blading, spot surfacing, asphalt pavement patching, maintenance of unpaved shoulders, ditch maintenance, removal and end hauling of materials, drainage structure maintenance, drainage dip maintenance, vegetation establishment, windstorm clearance, cutting roadway vegetation, maintenance of cattle guards, and sign placement. Non-routine road maintenance is limited to paved surface cleaning, rolling dip installation, and culvert replacement.

The enclosed biological opinion is based on NMFS' review of information provided with RNSP's January 31, 2006, request for an amendment to the 2003 biological opinion for the RNSP Roads Program, as well as telephone conversations and site visits that occurred during consultation. The biological opinion addresses potential adverse effects on the following listed species (Evolutionarily Significant Unit [ESU]) and designated critical habitat in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. §1531 *et seq.*):

Southern Oregon / Northern California Coast coho salmon ESU
(*Oncorhynchus kisutch*)
Threatened (June 28, 2005, 70 FR 37160)
Designated critical habitat (May 5, 1999, 64 FR 24049)



California Coastal (CC) Chinook salmon ESU*(O. tshawytscha)*

Threatened (June 28, 2005, 70 FR 37160)

Designated critical habitat (September 2, 2005, 70 FR 52488)

Northern California (NC) steelhead Distinct Population Segment (DPS)*(O. mykiss)*

Threatened (January 5, 2006, 71 FR 834)

Designated critical habitat (September 2, 2005, 70 FR 52488)

Based on the best scientific and commercial information available, NMFS concludes that implementation of the proposed RNSP Roads Program is not likely to jeopardize the continued existence of SONCC coho salmon, CC Chinook salmon, or NC steelhead, or result in the destruction or adverse modification of designated critical habitat for these species. However, NMFS expects replacement of four of the culverts is likely to result in incidental take of these species. An incidental take statement is included with the enclosed biological opinion. The incidental take statement includes non-discretionary terms and conditions that are expected to further reduce incidental take of SONCC coho salmon, CC Chinook salmon, and NC steelhead occurring as a result of the RNSP Roads Program.

The enclosed EFH consultation (Enclosure 2) was prepared pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). The RNSP Roads Program includes an area identified as EFH, specifically as spawning and rearing habitat for Chinook salmon and coho salmon, species managed under the Pacific Coast Salmon Fishery Management Plan. Based on our review, NMFS concludes that the Project has the potential to adversely affect EFH, and one EFH conservation recommendation is provided in the EFH consultation. The MSFCMA and Federal regulations (50 CFR 600.920) to implement the EFH provisions require Federal action agencies to provide a written response to EFH Conservation Recommendations within 30 days of receipt. The final response must include a description of measures proposed to avoid, mitigate, or offset the adverse impacts of the activity. If the response is inconsistent with the EFH Conservation Recommendations, an explanation of the reasons for not implementing them must be included.

NMFS has no additional FWCA comments to provide. If you have any questions regarding these consultations, please contact Julie Weeder of my staff at (707) 825-5168.

Sincerely,



Rodney R. McInnis

for Rodney R. McInnis
Regional Administrator

cc: Copy to File: 151422SWR2005AR00575

BIOLOGICAL OPINION

ACTION AGENCY: National Park Service

ACTION: Redwood National and State Parks Road Maintenance Program

**CONSULTATION
CONDUCTED BY:** National Marine Fisheries Service, Southwest Region

FILE NUMBER: 151422SWR2005AR00575

DATE ISSUED: AUG 4 2008

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I. CONSULTATION HISTORY

Redwood National and State Parks (RNSP) submitted a biological assessment (BA) addressing the impacts of their Watershed Restoration Program on June 2, 1998. NOAA's National Marine Fisheries Service (NMFS) issued a Biological Opinion (Opinion) on the RNSP Watershed Restoration Program on July 7, 1998. On July 18, 2001, RNSP requested consultation for the addition of California Coastal (CC) Chinook salmon (*Oncorhynchus tshawytscha*) and Northern California (NC) steelhead (*O. mykiss*) to the 1998 RNSP Program Opinion. NMFS staff and RNSP staff discussed the effects of the proposed actions on anadromous fish species throughout the following months. On January 16, 2002, staff discussed splitting the actions covered in the 1998 BA and Opinion into two consultations - one for road maintenance and repair, and a second for watershed restoration actions. Staff from NMFS and RNSP agreed the magnitude of effects of the two programs is different. Consulting on the programs separately would also be more consistent with the organizational structure of RNSP. On January 30, 2002, RNSP received a letter from NMFS responding to RNSP's request for consultation on the Watershed Restoration Program. The letter summarized the listing status of relevant salmonid Evolutionary Significant Units (ESUs) and their critical habitats relevant to the 1998 Watershed Restoration Program consultation, and provided a detailed list of additional changes. On July 1, 2002, NMFS received a final BA (Holden 2002) and a request to initiate informal and formal consultation on the effects of RNSP's road maintenance activities on Southern Oregon/Northern California Coast (SONCC) coho salmon (*O. kisutch*) CC Chinook salmon, NC steelhead, and designated critical habitat for SONCC coho salmon. On March 4, 2003, NMFS issued an Opinion to RNSP (NMFS 2003).

On September 21, 2005, RNSP submitted a request to amend the 2003 Opinion to include Mill Creek Horse Trail Road in the Mill Creek Watershed and Geneva Road in the Lost Man Creek Watershed. On January 31, 2006, RNSP submitted a request to further amend the Roads Program to consult on newly designated critical habitat for CC Chinook salmon and NC steelhead. RNSP also requested a 5-year extension of the proposed action. These three requests constituted reinitiation of consultation.

On March 13, 2007, staff from NMFS and RNSP visited Mill Creek Horse Trail Road and Geneva Road. NMFS discovered that previously proposed culvert work on these two roads had been completed. These two roads are therefore not included in the non-routine section of this Opinion. Routine road maintenance will occur on both these roads.

NMFS based the subject Opinion on the information in RNSP's July 1, 2002, BA and on information obtained from RNSP staff, as described below. After the March 13, 2007, visit, NMFS requested clarification on information that had changed since the original BA was submitted. On May 10, 2007, RNSP provided an updated list of the non-routine Road maintenance projects (Appendix A in Holden 2002) that were completed under the 2003 Opinion, along with the projects that are proposed to be covered under this Opinion. On October 31, 2007, RNSP answered clarifying questions sent by NMFS and provided information on environmental condition for the Smith Creek and Mill Creek watersheds.

The objective of this Opinion is to determine the effects of RNSP's Annual Routine and Non-Routine Road Maintenance Program (Roads Program) on SONCC coho salmon, CC Chinook salmon, NC steelhead, and their designated critical habitats. A complete administrative record for this consultation is on file at the NMFS Arcata Area Office.

II. DESCRIPTION OF THE PROPOSED ACTION

Section 7(a)(2) of the ESA requires Federal agencies to insure that their actions are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat that has been designated for those species. To comply with this section of the ESA, Federal agencies are required to "consult" with NMFS on effects to listed species and critical habitat under NMFS' jurisdiction.

NMFS' role in consultations is to identify the direct and indirect effects of a federal action to determine if the action is likely to contribute to the endangerment of threatened and endangered species by appreciably reducing their likelihood of both surviving and recovering in the wild. NMFS must also assess whether the action is likely to result in the destruction or adverse modification of designated critical habitat. The action addressed in the Opinion is the National Park Services' implementation of the Roads Program. Appendix A of the Roads Program BA (Holden 2002) provides a list of the watersheds and roads scheduled for routine and/or non-routine road maintenance. RNSP proposes to update this list under this Opinion as follows. Routine road maintenance is now planned to occur once every four years on Mill Creek Horse Trail Road and Geneva Road. The M-line road in the Bridge Creek watershed and the Off-Highway road in the Prairie Creek watershed will be switched from a non-routine maintenance schedule to a routine maintenance schedule. Four roads or trails are scheduled for culvert replacements: L-2-2 Road near McArthur Creek, L-1 East Road near Elam Creek, 205 Spur Road near Skunk Cabbage Creek, and Streelow Creek Trail near Streelow Creek (Figure 1). The type of culvert and characteristics of each creek are shown in Table 1.

Table 1. Number and type of proposed culvert replacements, and creek characteristics relevant to likelihood of fish presence.

	Ditch Relief Culverts			Stream Crossing Culverts				
Creek	Number Culverts	Culvert Size		Number Culverts	Culvert Size	Stream Width	Fish Bearing?	Ephemeral or Perennial?
McArthur	3	12 inches		2	18 inches	-	No	Perennial
Elam	6	18 inches		3	24 inches	-	No	Ephemeral
Elam	1	12 inches				-	No	Ephemeral
Elam	1	24 inches				-	No	Ephemeral
Skunk Cabbage	1	12 inches		1	12 inches	-	No	Ephemeral
Skunk Cabbage				2	24 inches	12 inches	No	Perennial
Streclow	13	12 inches		4	24 inches	15 inches	Yes	Perennial

A. Description of the action area

The action area includes “all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action” (50 CFR § 402.02). The action area for the routine maintenance portion of the Roads Program includes approximately 105,516 acres, which consists of all of RNSP, located along the northern California coast. The action area for the non-routine maintenance portion of the Roads Program (other than culvert replacements) is those roads identified in Appendix A of the BA (Holden 2002). The action area for culvert replacements is existing culverts under the roads or trails described in the *Description of the Proposed Action* section of this Opinion. The action area for the entire Roads Program includes much of the Redwood Creek watershed.

B. Description of project activities

1. Routine road maintenance

Routine road maintenance consists of the following: blading, spot surfacing, asphalt pavement patching, maintenance of unpaved shoulders, ditch maintenance, removal and end hauling of materials, drainage structure maintenance, drainage dip maintenance, vegetation establishment, windstorm clearance, cutting roadway vegetation, maintenance of cattle guards, and sign placement. Descriptions of these activities can be found in the BA (Holden 2002). Blading and brushing occur annually on 25 roads (approximately 122 miles). Inboard ditches and culvert inlets are cleaned once every 4 years on approximately 117 miles of road. All other activities described occur on RNSP roads as needed. Coastal Drive, Newton B. Drury Memorial Parkway and the entrance road to Mill Creek campground are the only paved roads (approximately 17 miles, including parking lots); all other roads are maintained as dirt-surfaced roads. The RNSP maintains 2.2 miles of Alder Camp Road by brushing and removing downed trees.

2. Non-Routine Road Maintenance

Proposed non-routine road maintenance activities are as follows: paved surface cleaning, rolling dip installation, and culvert replacement. Full descriptions of the first two activities can be found in the BA (Holden 2002). Culvert replacement (or repair) is described below. As the impacts of culvert replacement are expected to be greater than those of a repair, this opinion will assume all culverts will require replacement.

Culvert replacements are scheduled to occur as follows. All replacements will occur in the Redwood Creek watershed as shown in Figures 1, 2, and 3.

2008 - Replace culverts under L-2-2 road
2009 – Replace culverts under L-1 East Road
2010 – Replace culverts under 205 Spur Road
2011 – Replace culverts under Streelow Creek Trail

This work includes repairing and replacing culverts. New culverts and other stream crossings will be constructed to accommodate at least a 100-year flood, including associated bedload and

debris. Priority for upgrading will be based on the potential impact and ecological value of the riparian resources affected. Fish passage will be provided and maintained at all road crossings of streams in a manner which meets NMFS' "Guidelines for Salmonid Passage at Stream Crossings" (NMFS 2000). Crossings will be constructed and maintained to prevent diversion of stream flow out of the channel and down the road in event of a crossing failure. Stream crossing excavations to implement these actions may require the removal and disposal of road (crossing) fill, culverts, and organic debris from a stream channel. Small trees and vegetation will be removed as necessary from the work area and stock piled. Fill will be removed by an excavator and either hauled by truck or pushed by a dozer to a site where the woody debris can be separated. All logs or Humboldt crossings will be removed, and every attempt will be made to install the new pipe on the original stream channel. If the channel has natural irregularities that make pipe placement on grade prohibitive, the inlet will be installed to grade (capturing the flow within the natural channel above the rebuilt crossing) and the pipe will be cased with engineered back-fill to prevent piping of flow around the pipe itself.

New culverts will be installed with a flared inlet. The outlets will be placed beyond the fill site. Each new culvert will be set below stream grade to allow stream bed material to settle out in the culvert bottom. The new culvert will be installed to maintain a uniform flow line from inlet to outlet channel. Rock riprap will be placed at the outlet to dissipate water and prevent erosion during heavy flows. Reusable material from the site will then be compacted around the culvert.

If there is an insufficient amount of reusable material, clean 3/4 inch minus gravel will be hauled to the site. The material will be compacted in 1-foot increments with vibratory compaction equipment such as a whacker packer or a sheepsfoot. After compaction, the site will be mulched and stockpiled vegetation will be spread across the site. During a culvert replacement, any stream bank upstream of the inlet which is at risk of collapsing and depositing sediment will be excavated to a 2:1 slope. Backhoes, excavators, bulldozers, loaders, dump trucks and compaction equipment will be used. Where appropriate, a rolling dip may be incorporated into the reconstruction of the crossing. Any large woody debris that was uncovered during excavation will be placed near the restored channel area to provide both sediment control and habitat complexity. Bare soils adjacent to live channels will be treated for surface erosion as prescribed in the Watershed Restoration Erosion Control and Monitoring Plan.

3. Timing of activities

RNSP will carry out ground-disturbing Roads Program work within the normal operating season (NOS) of June 1 through October 15. If more than 0.5 inches of rain is forecast during any 24 hour period during the NOS, Roads Program operations will temporarily cease until the rain has passed. If periods of dry weather are predicted outside of the NOS, repairs needed to reduce risks from active erosion may be undertaken, in coordination with NMFS, so long as repairs can be completed within the window of predicted dry weather. Work will not be initiated if precipitation is anticipated within 48 hours or where saturated ground conditions exist. RNSP will monitor weather forecasts daily after October 14 and will cease operations if more than 0.5 inches of rainfall is forecast. After October 14, RNSP will have all erosion control materials necessary to winterize each work site within 24 hours of forecast rainfall.

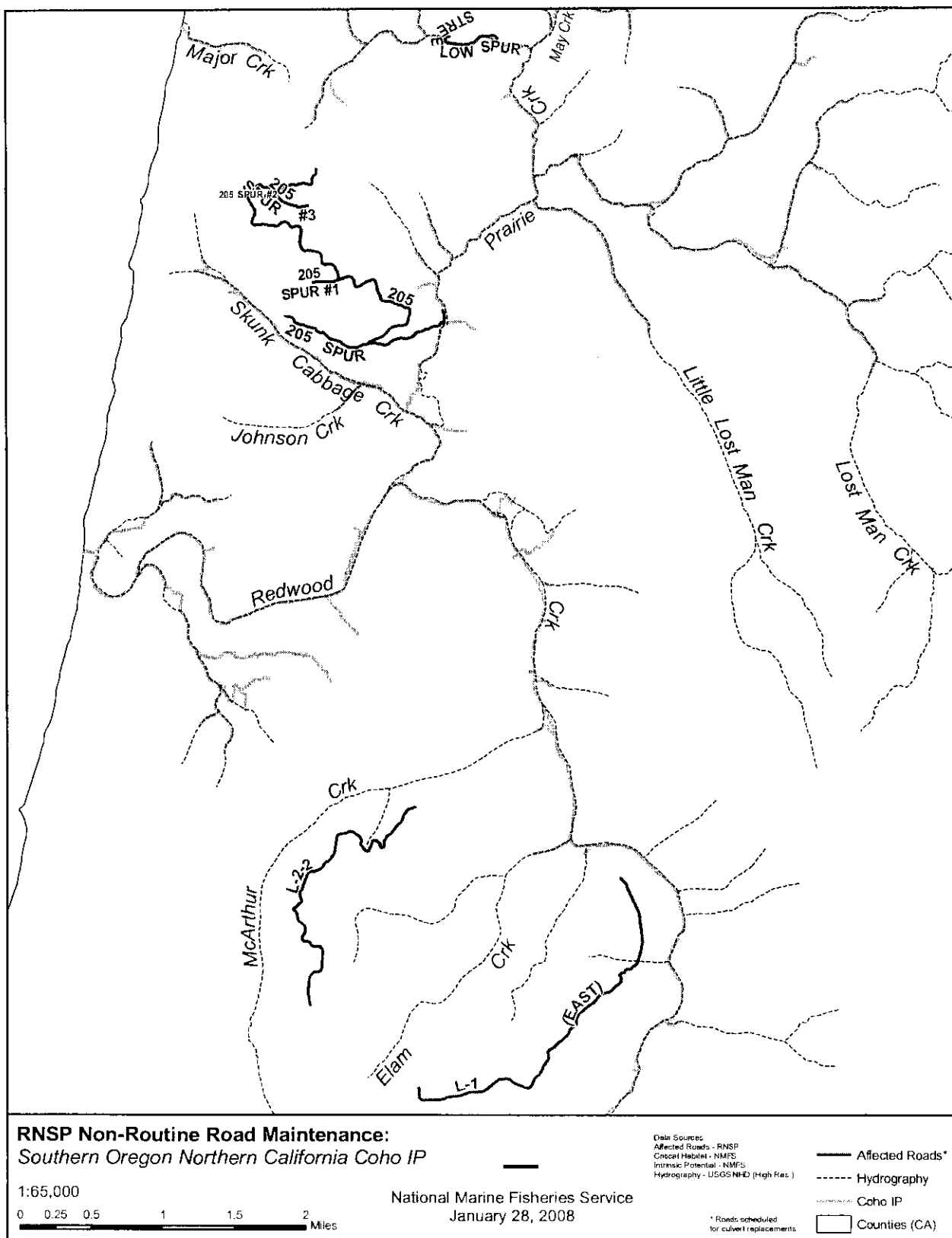


Figure 1. Roads slated for culvert replacement under the Roads Program, and habitat with intrinsic potential as favorable habitat for SONCC coho salmon (IP rating > 0).

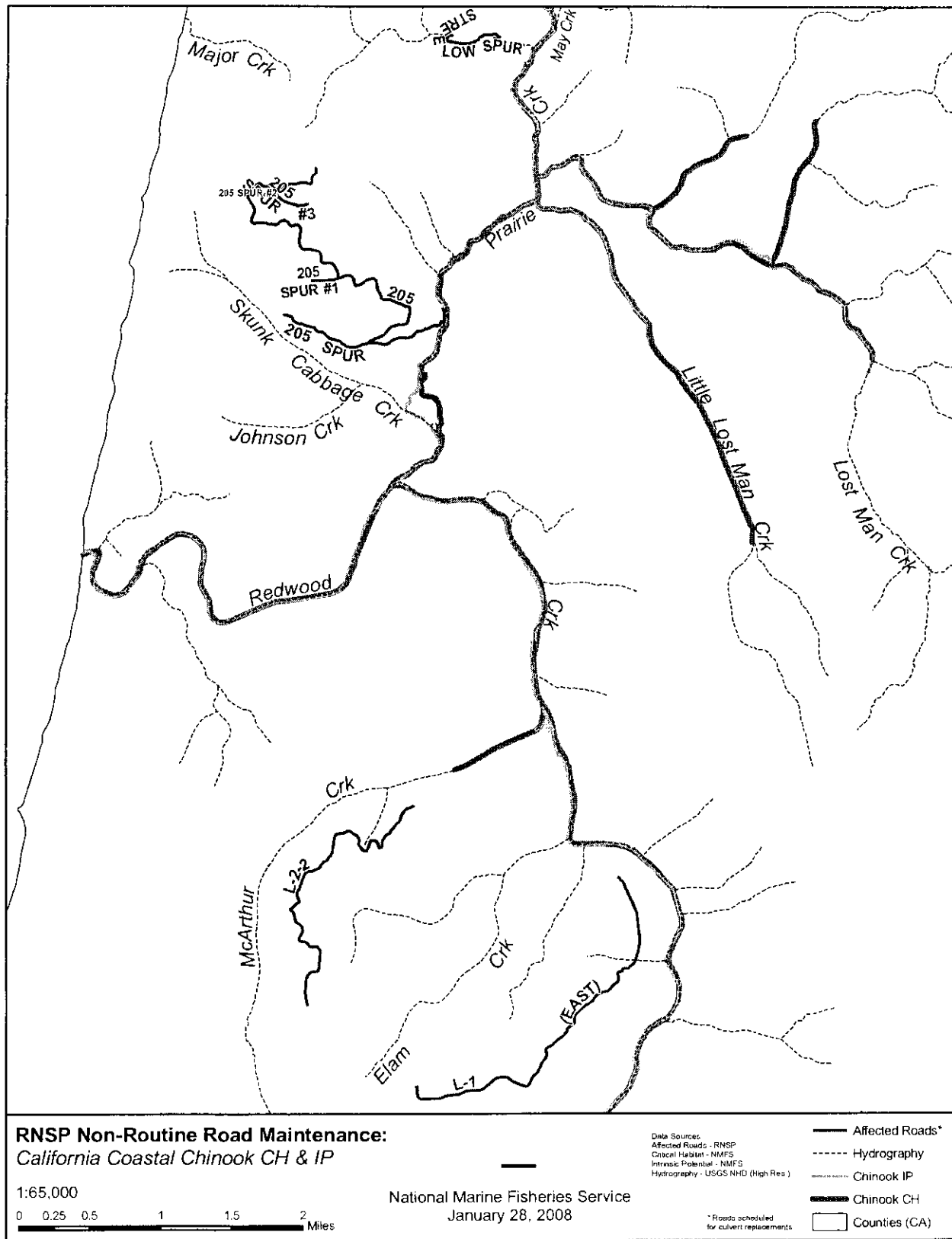


Figure 2. Roads slated for culvert replacement under the Roads Program, designated critical habitat for CC Chinook salmon, and habitat with intrinsic potential as favorable habitat for CC Chinook salmon (IP rating > 0).

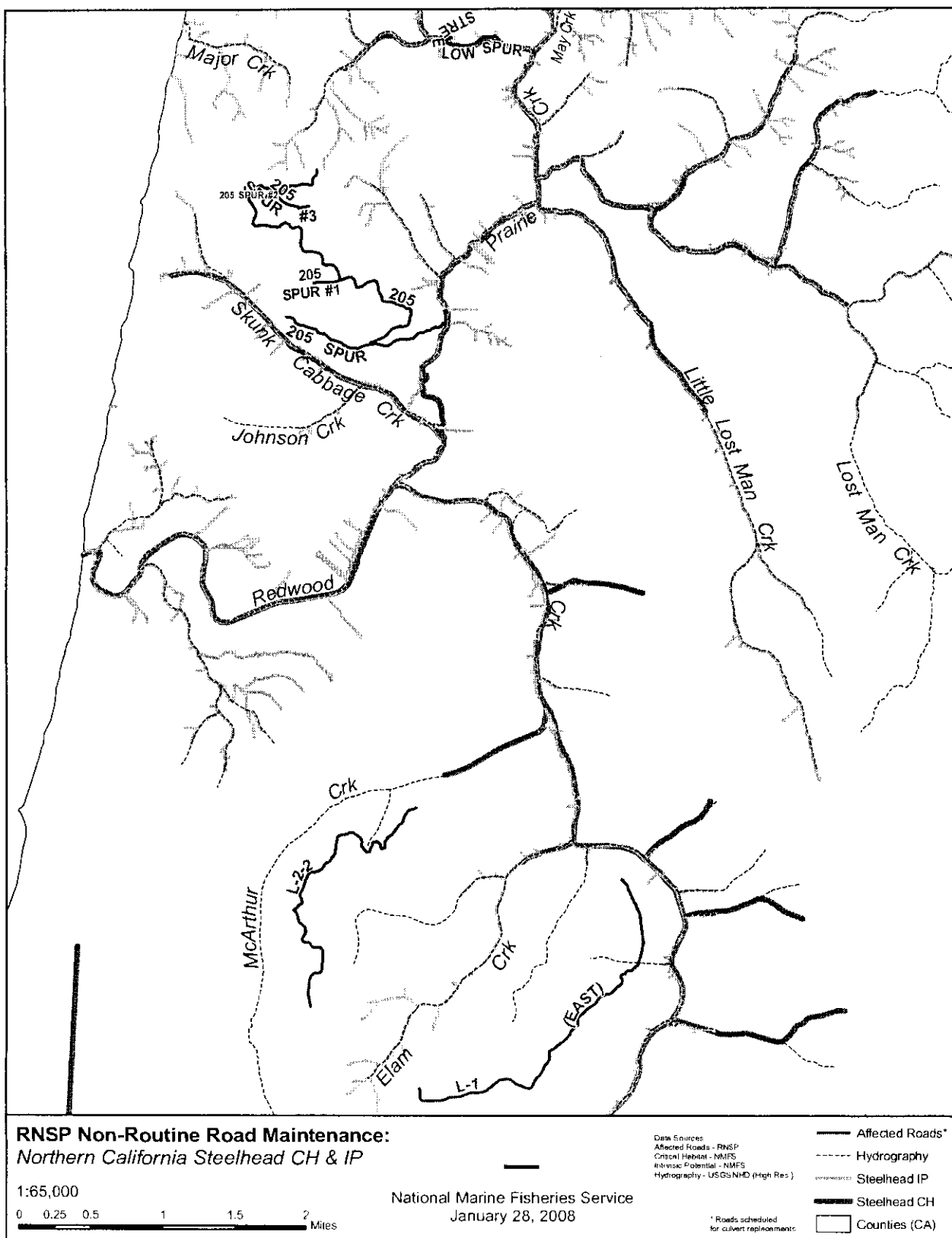


Figure 3. Roads slated for culvert replacement under the Roads Program, designated critical habitat for NC steelhead, and habitat with intrinsic potential as favorable habitat for NC steelhead (IP rating > 0).

III. STATUS OF THE SPECIES AND CRITICAL HABITAT

This Opinion analyzes the effects of the Roads Program on threatened SONCC coho salmon (May 6, 1997, 62 FR 24588), threatened CC Chinook salmon (June 28, 2005, 70 FR 37160), and threatened NC steelhead (January 5, 2006, 71 FR 834). The SONCC coho salmon and CC Chinook salmon ESUs include hatchery-born salmon. The NC steelhead Distinct Population Segment (DPS) includes both the Yager Creek and the North Fork Gualala River Hatcheries.

A. Species Life History, Distribution, and Abundance

The life history diversity of Pacific salmon (*Oncorhynchus spp.*) substantially contributes to their persistence, and conservation of such diversity is a critical element of recovery efforts (Beechie *et al.* 2006). Waples *et al.* (2001) and Beechie *et al.* (2006) found that life history and genetic diversity show a strong, positive correlation with the extent of ecological diversity experienced by a species.

1. NC steelhead

a. *Life History*

Steelhead probably have the most diverse life history strategies of any salmonid (Quinn 2005). There are two basic steelhead life history patterns, winter-run and summer-run (Moyle 2002, Quinn 2005). Winter-run steelhead enter rivers and streams from December to March in a sexually mature state and spawn in tributaries to mainstem rivers, often ascending long distances (Quinn 2005). Summer-run steelhead (also known as spring-run steelhead) enter rivers in a sexually immature state during receding flows of spring and migrate to headwater reaches of tributary streams where they hold in deep pools until spawning the following winter or spring (Moyle 2002). Both summer- and winter-runs generally spawn in the late winter or early spring. Eggs hatch in three to four weeks, and fry emerge from the gravel two to three weeks later (Moyle 2002). Juveniles spend one to four years in freshwater before migrating to estuaries and the ocean, where they spend one to three years before returning to freshwater to spawn. “Half pounder” steelhead are sexually immature steelhead that spend about three months in estuaries or the ocean before returning to lower river reaches on a feeding run (Moyle 2002). They then spend an additional one to three years in the ocean before returning to freshwater to spawn. Based on examination of scales from 11 sites in the Klamath River basin, Hopelain (1998) found 18 to 96 percent of adult steelhead had followed the “half-pounder” behavior. Some steelhead “residualize,” becoming resident trout and never adopting the anadromous life history. Steelhead are iteroparous (they can spawn more than once). Hopelain (1998) determined multiple spawning can be common in the NC steelhead ESU: based on his scale analysis, 18 to 48 percent of fall-run, 40 to 64 percent of spring-run, and 31 percent of winter-run steelhead from the Klamath River basin were repeat spawners.

b. *Current Condition and Abundance*

Quantitative information on NC steelhead is severely lacking, but there are a few survey index estimates of stock trends. Most data come from fish counts from the 1930s and 1940s at three

dams: Sweasey Dam on the Mad River (annual adult average 3,800 in the 1940s), Cape Horn Dam on the upper Eel River (annual adult average 4,400 in the 1930s), and Benbow Dam on the South Fork Eel River (annual adult average 18,784 in the 1940s; Murphy and Shapovalov 1951 *op. cit.*, Shapovalov and Taft 1954, Busby *et al.* 1996). These data can be compared to the annual average number of adults at Sweasey Dam in the 1960s (2,000), at Cape Horn Dam in the 1980s (1,000), and at Benbow Dam in the 1970s (3,355) (McEwan and Jackson 1996, Busby *et al.* 1996). In the mid-1960s, CDFG estimated about 198,000 steelhead spawned in the area occupied by the NC steelhead DPS (McEwan and Jackson 1996).

As of the most recent comprehensive comparison, the most abundant run is in the Middle Fork of the Eel River, with about 2,000 fish in 1996 (McEwan and Jackson 1996). Substantial declines from historic levels at major dams have indicated a probable decline from historic levels at the Distinct Population Segment (DPS) scale. Adams (2000) concluded that the status of the population had changed little since the 1996 status review. Based on this information and a lack of implementation of State conservation measures, NMFS concluded that the NC steelhead ESU warranted listing as a threatened species (June 7, 2000, 65 FR 36074).

Steelhead abundance estimates are summarized in the most recent NMFS west coast steelhead status reviews (Good *et al.* 2005). The Biological Review Team (BRT) made the following conclusions: (1) population abundances are low, compared to historical estimates; (2) recent trends are downward (except for a few small summer-run stocks), and (3) summer-run steelhead abundance was “very low” (Good *et al.* 2005). Lack of data on run sizes within the DPS was a major source of uncertainty in the BRT’s assessment.

2. CC Chinook salmon

a. *Life History*

Healey (1991) describes two basic life history strategies (races) for Chinook salmon, stream-type and ocean-type. There is further variation within each strategy. Like most salmonids, Chinook salmon have evolved variation in juvenile and adult behavior patterns which can help decrease the risk of catastrophically high mortality in a particular year or habitat (Healey 1991). Spring-run Chinook salmon are often stream-type (Healey 1991, Moyle 2002); adults return to lower-order, headwater, streams in the spring or early summer, before they have reached sexual maturity, and hold in deep pools and coldwater areas until spawning in early fall (Healey 1991, Moyle 2002). This strategy allows spring-run Chinook salmon to occupy mid-elevation habitats inaccessible during the summer and fall due to low flows and high temperatures (Moyle 2002). Juveniles emerge from the gravel in the early spring and typically spend one year in freshwater before migrating downstream to estuaries and then the ocean (Moyle 2002).

Fall-run Chinook salmon are ocean-type (Moyle 2002); adults move into rivers and streams from the ocean in the fall or early winter in a sexually mature state, and spawn within a few weeks or days upon arrival on the spawning grounds in lowland reaches of big rivers and their tributaries (Moyle 2002, Quinn 2005). Juveniles emerge from the gravel in late winter or early spring and migrate downstream to the estuary and the ocean within a few months (Moyle 2002, Quinn 2005). This life history strategy allows fall-run Chinook salmon to utilize quality

spawning and rearing areas in the valley reaches of rivers, which are often too warm to support juvenile salmonid rearing in the summer (Moyle 2002).

b. Current Condition and Abundance

Available historical Chinook salmon abundance information are summarized in Myers *et al.* (1998). The following are excerpts from this document. Although this is the most recent information of its type, it is ten years old and so may not describe current conditions.

"Estimated escapement of this ESU was estimated at 73,000 fish, predominantly in the Eel River (55,500) with smaller populations in Redwood Creek, Mad River, Mattole River (5,000 each), Russian River (500), and several small streams in Del Norte and Humboldt Counties.

Data available to assess trends in abundance are limited. Recent trends have been mixed, with predominantly strong negative trends in the Eel River Basin, and mostly upward trends elsewhere. Previous assessments of stocks within this ESU have identified several stocks as being at risk or of concern. Nehlsen *et al.* (1991) identified Redwood Creek, Mad River, and Eel River stocks as stocks of concern. The Russian River stock was found by U.S. Fish and Wildlife Service (USFWS) to be extinct."

Observed widespread declines in abundance and the present distribution of small populations with sometimes sporadic occurrences contribute to the risks faced in this ESU. This is particularly true for spring-run Chinook salmon. It is possible that Russian River and spring-run Chinook salmon in the ESU may have been extirpated. Low abundance, generally negative trends in abundance, reduced distribution, and profound uncertainty as to risk related to the relative lack of population monitoring in California contributed to NMFS' assessment that CC Chinook salmon are "threatened" under the ESA; that is, they are at risk of becoming endangered in the foreseeable future throughout all or a significant portion of their range (September 16, 1999, 64 FR 50394; Good *et al.* 2005).

Good *et al.* (2005) found, based on historical and current information, that CC Chinook salmon populations are depressed in basins where they are being monitored. Uncertainty about abundance, natural productivity, introduction of hatchery fish, and distribution continues to substantially contribute to risks facing this ESU. Concerns about current abundances relative to historical abundances, mixed trends in the few time series available, and potential extirpations in the southern part of the range contributed to the conclusion that CC Chinook salmon are "likely to become endangered" (Good *et al.* 2005). For a discussion of the extinction probability (current viability) of the CC Chinook salmon ESU, please see the *Status of the Species and Critical Habitat* section of this document.

3. SONCC coho salmon

a. Life History

Coho salmon adults spawn in small streams that flow directly into the ocean, or tributaries and headwater creeks of larger rivers (Sandercock 1991, Moyle 2002). Adults migrate upstream to spawning grounds from September through late December, peaking in October and November. Spawning occurs mainly in November and December, with fry emerging from the gravel in the spring, approximately three to four months after spawning. Juvenile rearing usually occurs in tributary streams with a gradient of up to three percent, although they may move up to streams of four or five percent gradient. Juveniles have been found in streams as small as one to two meters wide. They may spend one to two years rearing in freshwater (Bell and Duffy 2007), or may emigrate to an estuary shortly after emerging from spawning gravels (Tscharplinski 1987). Coho salmon juveniles are also known to “redistribute” into non-natal rearing streams, lakes, or ponds, often following rainstorms, where they continue to rear (Peterson 1982). At a length of 38 to 45 mm, fry may migrate upstream a considerable distance to reach lakes or other rearing areas (Godfrey 1965 *op. cit.* Sandercock 1991, Nickelson *et al.* 1992). Emigration from streams to the estuary and ocean generally takes place from March through May.

b. Current Distribution and Abundance

Reliable current time series of naturally produced adult migrants or spawners are not available for SONCC coho salmon ESU rivers (Good *et al.* 2005). For a summary of historical and current distributions of SONCC coho salmon in northern California, refer to CDFG’s (2002) coho salmon status review, historical population structure by Williams *et al.* (2006), as well as the presence and absence update for the northern California portion of the SONCC coho salmon ESU (Brownell *et al.* 1999). Good *et al.* (2005) concluded that SONCC coho salmon were likely to become endangered in the foreseeable future, this conclusion being consistent with an earlier assessment (Weitkamp *et al.* 1995). Although there are little data, available information shows the component populations are in decline and strongly suggests the ESU is at risk of extinction (Weitkamp *et al.* 1995, CDFG 2002, Good *et al.* 2005). NMFS (2001a) concluded that population trend data for SONCC coho salmon from 1989 to 2000 show a continued downward trend throughout most of the California portion of the SONCC coho salmon ESU.

The main stocks in the SONCC coho salmon ESU (Rogue, Klamath, and Trinity Rivers) remain heavily influenced by hatcheries and have little natural production in mainstem rivers (Weitkamp *et al.* 1995, Good *et al.* 2005). The listing of SONCC coho salmon includes all within-ESU hatchery programs (June 28, 2005, 70 FR 37160). Trinity River Hatchery maintains high production, with a significant number of hatchery SONCC coho salmon straying into the wild population (NMFS 2001a). The hatchery on the Mad River has ceased production, and production at Iron Gate Hatchery has declined in recent years (NMFS 2001a). The apparent decline in wild production in these rivers, in conjunction with significant hatchery production, suggests that natural populations of coho salmon are not self-sustaining (Weitkamp *et al.* 1995, Good *et al.* 2005). Coho salmon populations continue to be depressed relative to historical numbers, and there are strong indications that breeding groups have been lost from a significant percentage of streams within their historical range (Good *et al.* 2005).

Weitkamp *et al.* (1995) estimated that the rivers and tributaries in the California portion of the SONCC coho salmon ESU had “recently” produced 7,080 naturally spawning coho salmon and 17,156 hatchery returns, including 4,480 “native” fish occurring in tributaries having little

history of supplementation with nonnative fish. Combining the California run-size estimates with Rogue River estimates, Weitkamp *et al.* (1995) arrived at a rough minimum run-size estimate for the SONCC coho salmon ESU of about 10,000 natural fish and 20,000 hatchery fish. This estimate, although the most recent, is currently 13 years old and so may not describe current conditions.

Brown and Moyle (1991) suggested that naturally-spawned adult coho salmon runs in California streams were less than one percent of their abundance at mid-century, and estimated that wild coho salmon populations in California did not exceed 100 to 1,300 individuals. CDFG (1994) summarized most information for the northern California portion of this ESU, and concluded that "coho salmon in California, including hatchery stocks, could be less than 6 percent of their abundance during the 1940s, and have experienced at least a 70 percent decline in numbers since the 1960s." Further, CDFG (1994) reported that coho salmon populations have been virtually eliminated in many streams, and that adults are observed only every third year in some streams, suggesting that two of three brood cycles may have already been eliminated.

Scientists at the NMFS Southwest Fisheries Science Center compiled a presence-absence database for the SONCC coho salmon ESU similar to that developed by CDFG (Good *et al.* 2005). The data set includes information for coho salmon streams listed on the Brown and Moyle (1991) list, as well as other streams for which we have found historical or recent evidence of coho salmon presence. The database is a composite of information contained in the NMFS (2001a) status review update, additional information gathered by NMFS since publication of the 2001 status review, data used in the CDFG (2002) analysis, and additional data compiled by CDFG (Jong 2002 *op cit.* Good *et al.* 2005) for streams not on the Brown and Moyle (1991) list. Using the NMFS database, Good *et al.* (2005) compiled information on the presence of coho salmon in streams throughout the SONCC ESU, which closely matched the results of Brown and Moyle (1991); (Figure 4).

On an annual basis, the estimated percentage of streams in the SONCC for which coho salmon presence was detected generally fluctuated between 36 percent and 61 percent between brood years 1986 and 2000 (Figure 4). Data reported for the 2001 brood year suggest a strong year class, as indicated by an occupancy rate of more than 75 percent; however, the number of streams for which data were reported is small compared to previous years. The data suggest that, for the period of record, occupancy rates in the SONCC were highest (54 to 61 percent) between brood years 1991 and 1997, then declined between 1998 and 2000 (39 to 51 percent) before rebounding in 2001. However, the number of streams surveyed in 2001 was roughly 25 percent of the number surveyed in previous years (Good *et al.* 2005). For a discussion of the extinction probability (current viability) of the SONCC coho salmon ESU, please see the *Status of the Species and Critical Habitat* section of this document.

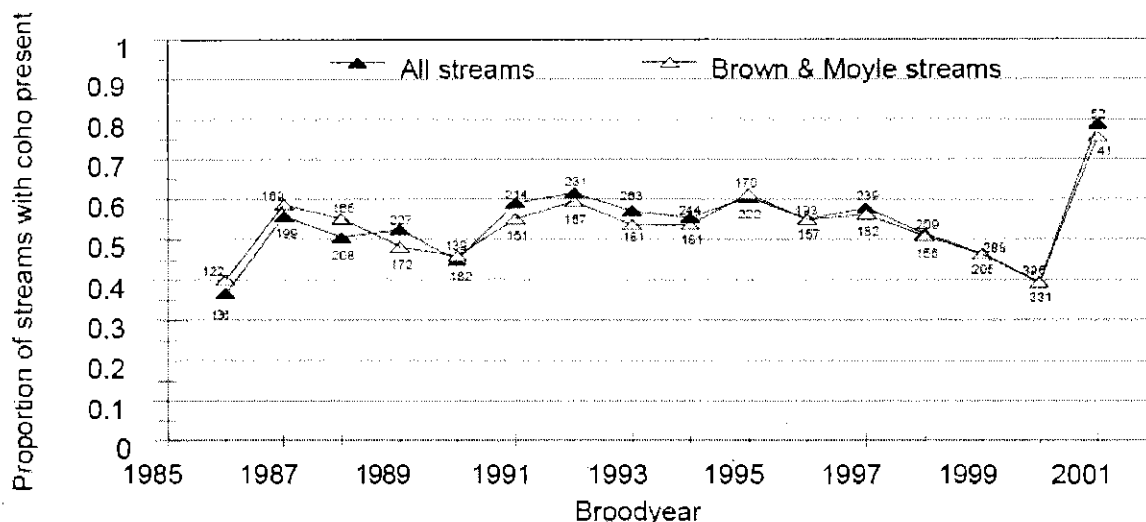


Figure 4. Proportion of surveyed streams where coho salmon were detected (Good *et al.* 2005).

Sample sizes (*i.e.*, number of streams surveyed) are shown next to data points. Figure from Good *et al.* (2005).

B. Factors in Salmonid Decline (ESU or DPS Scale)

Note: See the *Factors Affecting the Species and Critical Habitat in Redwood Creek* section in this Opinion for a discussion of additional factors which are currently important in Redwood Creek but which may not necessarily apply throughout the range of the SONCC coho salmon ESU, CC Chinook salmon ESU, and NC Steelhead DPS.

The factors that have caused declines in the SONCC coho salmon ESU, CC Chinook salmon ESU, and NC steelhead DPS are similar. These factors include habitat loss due to dam building, degradation of freshwater habitats due to a variety of agricultural and forestry practices, water diversions, urbanization, mining, and severe recent flood events, which are exacerbated by land use practices (Good *et al.* 2005). Sedimentation and loss of spawning gravels associated with poor forestry practices and road building are particularly acute problems that can reduce the productivity of salmonid populations. Nonnative Sacramento pikeminnow (*Ptychocheilus grandis*) have been observed in the Eel River basin, and could prey on juvenile steelhead where thermal conditions lead to niche overlap of the two species (Good *et al.* 2005). Late 1980s and early 1990s droughts and unfavorable ocean conditions are other likely causes of decreased abundance (Good *et al.* 2005).

MacFarlane *et al.* (2008) recently summarized information on low returns of coho salmon in California which showed there was a 72 percent decline in returning adults in 2007/08 compared to the same cohort in 2004/05. Because of the broad spatial extent of the decline (preliminary data from the Oregon coast showed a 70 percent decline), ocean conditions were suspected as a main causative agent. Recent ocean conditions in the spring and summer, when juvenile coho salmon and Chinook salmon enter the ocean, were unfavorable to growth and survival (MacFarlane *et al.* 2008). The quick response of salmonid populations to changes in ocean conditions (MacFarlane *et al.* 2008) strongly suggests that density dependent mortality of

salmonids is a mechanism at work in the ocean (Beamish *et al.* 1997, Levin *et al.* 2001, Greene and Beechie 2004).

Climate change is postulated to negatively affect salmonids throughout the Pacific Northwest due to large reductions in available freshwater habitat (Battin *et al.* 2007). Widespread declines in springtime snow water equivalent (SWE) have occurred in much of the North American West since the 1920s, especially since mid-century (Knowles and Cayan 2004, Hamlet *et al.* 2005, Mote *et al.* 2005, Regonda *et al.* 2005, Mote 2006). Trends in April 1 SWE appear to be driven primarily by temperature, which, along the Pacific Coast, is a function of elevation and latitude (Knowles and Cayan 2004, Mote 2006), and secondarily by precipitation (Hamlet *et al.* 2005, Mote *et al.* 2005, Stewart *et al.* 2005). These climactic changes have resulted in earlier onsets of springtime snowmelt and stream flow across western North America (Regonda *et al.* 2005, Stewart *et al.* 2005), as well as lower flows in the summer (Stewart *et al.* 2005). Although climate models diverge with respect to future trends in precipitation over the Pacific Northwest, there is widespread agreement that the trend toward lower SWE and earlier snowmelt will continue (Miller and Sadro 2003, Snyder *et al.* 2004, Barnett *et al.* 2005, Zhu *et al.* 2005, Vicuna *et al.* 2007). Thus, availability of water resources under future climate scenarios is expected to be most limited during the late summer (Gleick and Chalecki, 1999, Miles *et al.* 2000). In general, as the magnitude of climate fluctuations increases, the salmonid population extinction rate also increases (Good *et al.* 2005).

Several hatcheries operate throughout the area occupied by the SONCC coho salmon ESU, CC Chinook salmon ESU, and NC steelhead DPS (Good *et al.* 2005). There are three main classes of interactions between hatchery and wild salmonids: genetic, ecological, and harvest (Hatchery Science Review Group (HSRG) 2004). Genetic effects occur via gene flow when hatchery and natural salmonids spawn together. Ecological effects are those such as competition, predation and disease transfer. In mixed stock fisheries with fish of both wild and hatchery origin, high harvests targeting hatchery fish can result in harvest rates of wild fish that are too high.

Spawning by hatchery salmonids in rivers and streams is often not controlled (Independent Scientific Advisory Board 2002), with hatchery and natural stocks mixing freely and exchanging genetic material. Hatchery fish also stray into non-natal rivers and streams, transferring genes from hatchery populations into naturally spawning populations. This can be problematic because hatchery programs have the potential to significantly alter the genetic composition of reared fish (Crozier 1998, Reisenbichler and Rubin 1999, Lynch and O'Hely 2001, Ford 2002). When hatchery salmonids exchange genetic material with natural salmonids, the result can be progeny with lower survival (McGinnity *et al.* 2003, Kostow 2004) and ultimately, a reduction in the reproductive success of the natural stock (Reisenbichler and McIntyre 1977, Fleming *et al.* 2000, Chilcote 2003, Araki *et al.* 2007), potentially in a matter of a few generations (Araki *et al.* 2007). These changes in reproductive success resulting from hybridization of hatchery and natural stocks can increase the extinction risk of natural stocks via outbreeding depression (Reisenbichler and Rubin 1999, HSRG 2004).

Flagg *et al.* (2000) found that, except in situations of low wild fish density, increasing release numbers of hatchery fish can negatively impact naturally produced fish because naturally produced fish can be displaced from portions of their habitat. Competition between hatchery and

naturally produced salmonids can also lead to reduced growth of naturally produced fish (McMichael *et al.* 1997). Kostow *et al.* (2003) and Kostow and Zhou (2006) found that over the duration of the steelhead hatchery program on the Clackamas River, Oregon, the number of hatchery steelhead in the upper basin regularly caused the total number of steelhead to exceed carrying capacity, triggering density-dependent mechanisms that impacted the natural population. Competition between hatchery and wild salmonids in the ocean can also lead to density-dependent mechanisms affect wild salmonid populations (Unwin 1996, Beamish *et al.* 1997, Levin *et al.* 2001, Sweeting *et al.* 2003), especially during periods of poor ocean productivity (Beamish *et al.* 1997, Levin *et al.* 2001, Sweeting *et al.* 2003), such as the current ocean regime off the California and Oregon coasts (MacFarlane *et al.* 2008).

C. Critical habitat description

This Opinion analyzes the effects of the Roads Program on designated critical habitat for SONCC coho salmon (May 5, 1999, 64 FR 24049), CC Chinook salmon (September 2, 2005, 70 FR 52488), and NC steelhead (September 2, 2005, 70 FR 52488).

Critical habitat is defined as the specific areas within the geographical areas occupied by the species, at the time it is listed, on which are found those physical and biological features essential to the conservation of the species and which may require special management considerations or protection, or specific areas outside the geographical area occupied by the species at the time it is listed when the Secretary determines that such areas are essential for the conservation of listed species.

The ESA defines conservation as “to use all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to the ESA are no longer necessary.” As a result, NMFS approaches its “destruction and adverse modification” determinations by examining the effects of actions on the conservation value of the designated critical habitat, that is, the value of the critical habitat for the conservation of threatened or endangered species.

1. NC steelhead and CC Chinook salmon

Designated critical habitat for NC steelhead and CC Chinook salmon includes the stream channels within the stream reaches and a lateral extent as defined by the ordinary highwater line (50 CFR 226.211). In areas where the ordinary high-water line has not been defined pursuant to 50 CFR 226.211, the lateral extent is defined by the bankfull elevation. Critical habitat in estuaries is defined by the perimeter of the water body as displayed on standard 1:24,000 scale topographic maps or the elevation of extreme high water, whichever is greater.

Critical habitat for NC steelhead was designated as occupied watersheds from the Redwood Creek watershed, south to and including the Gualala River watershed. Critical habitat for CC Chinook salmon was designated as occupied watersheds from the Redwood Creek watershed, south to and including the Russian River watershed (70 FR 52488). Humboldt Bay and the Eel River estuary were designated as critical habitat for both the NC steelhead DPS and CC Chinook

salmon ESU. Some areas within the geographic range were excluded due to economic considerations or because they overlap with Indian lands (Table 2).

Table 2: Watersheds excluded, in whole or in part, from critical habitat designation for NC steelhead DPS and/or CC Chinook salmon (70 FR 52488).

NC Steelhead DPS		CC Chinook Salmon ESU	
Watershed Name	Area Excluded	Watershed Name	Area Excluded
Ruth	Entire watershed	Bridgeville	Entire watershed
Spy Rock	Tribal land	Spy Rock	Indian lands
North Fork Eel River	Entire watershed; Indian lands	North Fork Eel River	Indian lands
Lake Pillsbury	Entire watershed	Eden Valley	Tributaries only; Indian lands
Eden Valley	Indian lands	Round Valley	Indian lands
Round Valley	Indian lands	Black Butte River	Entire watershed
		Wilderness	Entire watershed
		Navarro River	Entire watershed
		Santa Rosa	Entire watershed
		Mark West	Entire watershed

Designated critical habitat for NC steelhead and CC Chinook salmon overlaps the Roads Program action area. In designating critical habitat for NC steelhead and CC Chinook salmon, NMFS focused on the known primary constituent elements (PCEs) essential for the conservation of each species. PCEs are those sites and habitat components that support one or more life stages, including: (1) freshwater spawning, (2) freshwater rearing, (3) freshwater migration, (4) estuarine areas, (5) nearshore marine areas, and (6) offshore marine areas. Within the PCEs, essential elements of CC Chinook salmon and NC steelhead critical habitats include adequate (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food, (8) riparian vegetation, (9) space, (10) safe passage conditions, and (11) salinity conditions (September 2, 2005, 70 FR 52488).

2. SONCC Coho salmon

Critical habitat for the SONCC coho salmon ESU encompasses accessible reaches of all rivers (including estuarine areas and tributaries) between Cape Blanco, Oregon and Punta Gorda, California (May 5, 1999; 64 FR 24049). Excluded are: (1) areas above specific dams identified in the FR notice; (2) areas above longstanding natural impassible barriers (*i.e.*, natural waterfalls in existence for at least several hundred years); and (3) Indian lands.

Designated critical habitat for SONCC coho salmon overlaps the Roads Program action area. In designating critical habitat for SONCC coho salmon, NMFS focused on the known physical and biological features within the designated area that are essential to the conservation of the species. These essential features may include, but are not limited to, spawning sites, food resources, water quality and quantity, and riparian vegetation. Within the essential habitat types (spawning, rearing, migration corridors), essential features of coho salmon critical habitat include adequate (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6)

cover/shelter, (7) food, (8) riparian vegetation, (9) space, and (10) safe passage conditions (May 5, 1999, 64 FR 24049).

3. Current condition of critical habitat

Timber harvest and associated activities, road construction, urbanization and increased impervious surfaces, migration barriers, water diversions (including a levee system on Redwood Creek), and large dams throughout a large portion of the freshwater range of the ESUs and DPS continue to result in habitat degradation, blockages to spawning and rearing habitat, and reduced stream flows. These ongoing poor land management practices have limited reproductive success, reduced rearing habitat quality and quantity, and created migration barriers to both juveniles and adults. These factors likely limit the conservation value of freshwater habitats at the ESU/DPS scale; that is, they limit the numbers of salmonids that can be supported by that habitat.

D. Status of the Species and Critical Habitat

1. Status of the Species

An ESU (*e.g.*, SONCC coho salmon ESU, CC Chinook salmon ESU) is an Evolutionarily Significant Unit of a particular species (*e.g.*, coho salmon or Chinook salmon). Similarly, a DPS (*e.g.*, NC Steelhead DPS) is a Distinct Population Segment of a particular species (*e.g.*, the anadromous form of steelhead). For an ESU or DPS to persist, populations within it must be able to successfully respond to changes in environmental conditions (Williams *et al.* 2007). When the location or distribution of an ESU's or DPS' habitat changes, a species can avoid extinction either by genetically adapting to the new environmental conditions, or by spatially tracking the environmental conditions to which it is adapted (Pease *et al.* 1989 *op. cit.* Williams *et al.* 2007). An ESU/DPS is expected to persist in places where it is able to respond to environmental changes, and to become extinct if it fails to keep up with the shifting distribution of suitable habitat (Thomas 1994 *op. cit.* Williams *et al.* 2007).

An ESU or DPS is made up of multiple populations. The extinction risk, or viability, of an ESU or DPS can be assessed by considering the extinction risk of its component populations, and the effects of a proposed action on an ESU or DPS can be assessed by first considering the effects of the proposed action on its component populations. To integrate population information into extinction risk criteria at the ESU/DPS scale, NMFS has identified "diversity strata", which are "groups of populations that span the diversity and distribution that currently exists or historically existed within an ESU" (Bjorkstedt *et al.* 2005). Diversity strata account for the important variability that exists in environments and in the physical characteristics and genetic makeup of salmonids. Bjorkstedt *et al.* (2005) and Williams *et al.* (2006) provide a set of rules describing certain configurations of populations within each diversity stratum that they believe would constitute a viable ESU. A population is part of a particular diversity stratum, which is part of a particular ESU or DPS. The ESU or DPS cannot be considered at low risk of extinction [less than a 5% extinction probability within 100 years (Williams *et al.* 2007, Spence *et al.* 2008)], unless all its diversity strata are at low extinction risk; similarly, each diversity stratum cannot be considered at low extinction risk unless its populations are as well. A diversity stratum could be

considered at low extinction risk even if one or more of its component populations were at a higher risk of extinction, if enough of the remaining populations had enough spawners (Bjorkstedt *et al.* 2005, Williams *et al.* 2006).

Consideration of the extinction risk of all diversity strata within a particular ESU or DPS is beyond the scope of this Opinion. Similarly, this Opinion will not determine the extinction risk of all the populations making up the diversity stratum of which Redwood Creek is a part. This Opinion will instead consider the extinction risk of the SONCC coho salmon ESU, CC Chinook salmon ESU, and the NC steelhead DPS. Then the extinction risk of the Redwood Creek populations of salmon and steelhead will be discussed. Finally, the impacts of the Roads Program on the extinction risk of the Redwood Creek populations of salmon and steelhead, and the implications for the extinction risk of the ESUs and DPS, will be considered.

In order to determine the current extinction risk or viability of each ESU or DPS, we use the concept of a Viable Salmonid Population (VSP) and the parameters for evaluating populations described by McElhany *et al.* (2000). The four parameters are population size, productivity, spatial structure, and diversity. Each parameter is described below, followed by an assessment of the viability of each parameter for each ESU or DPS which may be affected by the Roads Program. Where the extinction risk of an ESU is discussed below, the following definitions apply. High-risk populations are those with greater than a 20% probability of extinction within 20 years. Moderate risk populations are those with at least a 5% probability of extinction within 100 years but less than 20% probability of extinction within 20 years; and low risk populations are those with less than a 5% extinction probability within 100 years (Williams *et al.* 2007, Spence *et al.* 2008).

a. Population Size

Information about population size provides an indication of the sort of extinction risk that a population faces. For instance, smaller populations are at a greater risk of extinction than large populations because the processes that affect populations operate differently in small populations than in large ones (McElhany *et al.* 2000). One risk of low population sizes is depensation. Depensation occurs when populations are reduced to very low densities and *per capita* growth rates decrease as a result of a variety of mechanisms (*e.g.*, failure to find mates and therefore reduced probability of fertilization, or failure to saturate predator populations; Liermann and Hilborn 2001). Depensation results in a negative feedback that accelerates a decline toward extinction (Williams *et al.* 2007).

The final rule for the ESA listing of the CC Chinook ESU (June 28, 2005, 70 FR 37160) stated “an assessment of the effects of [multiple] small artificial propagation programs on the viability of the ESU in-total concluded that they collectively decrease risk to some degrees by contributing to local increases in abundance . . .” However, McElhany *et al.* (2000) cautioned, “note that the ESA’s primary focus is on natural populations in their native ecosystems, so when we evaluate abundance to help determine VSP status, it is essential to focus on naturally produced fish (*i.e.*, the progeny of naturally-spawning parents).” Based on these guidance documents, to the extent that hatchery-reared parents may boost production of naturally produced fish if and when they spawn in the wild, they may benefit the VSP parameter of

population size. However, a population cannot be considered viable (at low risk of extinction) unless it has the minimum number of *naturally produced* spawners identified in recent guidance documents (Spence *et al.* 2008, Williams *et al.* 2007). Although the operation of a hatchery tends to increase the abundance of returning adults (70 FR 37160), the reproductive success of hatchery-born salmonids spawning in the wild is far less than that of naturally produced ones (Araki *et al.* 2007). As a result, the higher the proportion of hatchery-born spawners, the lower the productivity of the population, as demonstrated by Chilcote (2003). Chilcote (2003) examined the actual number of spawners and subsequent recruits over 23 years in 12 populations of Oregon steelhead with varying proportions of hatchery-origin spawners and determined “. . . a spawning population comprised of equal numbers of hatchery and wild fish would produce 63 percent fewer recruits per spawner than one comprised entirely of wild fish.”

Status reviews for the SONCC coho salmon ESU, the CC Chinook salmon ESU, and the NC steelhead DPS concluded data were insufficient to set specific numeric population size targets associated with low extinction risk (Spence *et al.* 2008, Williams *et al.* 2007). In the absence of such targets, McElhany *et al.* (2000) suggested ESUs “. . . have been historically self-sustaining and the historical number and distribution of populations serves as a useful ‘default’ goal in maintaining viable ESUs.”

(1) NC steelhead. Steelhead abundance has been monitored at three dams in the NC steelhead ESU since the 1930s. Reviewers participating in the most recent status review determined these data showed population abundances were low relative to historical estimates, and that summer-run steelhead abundance was very low (Good *et al.* 2005). Regarding abundance, reviewers concluded “Although there are older data for several of the larger river systems that imply run sizes became much reduced since the early 20th century, there are no recent data suggesting much of an improvement” (Good *et al.* 2005). Experts consulted during the status review gave this DPS a risk score of 3.7 (out of 5, where 5 is the highest risk score) for the abundance category (Good *et al.* 2005), indicating its reduced abundance contributes significantly to long-term risk of extinction, and may contribute to short-term risk of extinction in the foreseeable future. NMFS concludes this DPS falls far short of McElhany’s ‘default’ goal of historic population numbers and distribution and is therefore at an elevated risk of extinction (not viable) in regards to the population size VSP parameter.

(2) CC Chinook salmon. The most recent status review found continued evidence of: (1) low population sizes relative to historical abundance, (2) mixed trends in the few time series of abundance indices available for analysis, and (3) low abundances and potential extirpations of populations in the southern part of the ESU (Good *et al.* 2005). Experts consulted during the status review gave this ESU a mean risk score of 3.9 (out of 5) for the abundance category (Good *et al.* 2005), indicating its reduced abundance contributes significantly to long-term risk of extinction, and is likely to contribute to short-term risk of extinction in the foreseeable future. NMFS concludes this ESU falls far short of McElhany’s ‘default’ goal of historic population numbers and distribution and is therefore at an elevated risk of extinction (not viable) in regards to the population size VSP parameter.

(3) SONCC coho salmon. The most recent status review (Good *et al.* 2005) concluded SONCC coho salmon populations “. . . continue to be depressed relative to historical numbers, and [there

are] strong indications that breeding groups have been lost from a significant percentage of streams within their historical range.” Experts consulted during the status review gave this ESU a mean risk score of 3.8 (out of 5) for the abundance category (Good *et al.* 2005), indicating its reduced abundance contributes significantly to long-term risk of extinction, and is likely to contribute to short-term risk of extinction in the foreseeable future. NMFS concludes this ESU falls far short of McElhany’s ‘default’ goal of historic population numbers and distribution and is therefore at an elevated risk of extinction (not viable) in regards to the population size VSP parameter.

b. Population Productivity

The productivity of a population (*i.e.*, the number of individuals generated over a specified time interval) can reflect conditions (*e.g.*, environmental conditions) that influence the dynamics of a population and determine abundance. In turn, the productivity of a population allows an understanding of the performance of a population across the landscape and habitats in which it exists and its response to those habitats (McElhany *et al.* 2000). Status reviews for the SONCC coho salmon ESU, the CC Chinook salmon ESU, and the NC steelhead DPS concluded data were insufficient to set specific numeric population productivity targets for viability (Williams *et al.* 2007, Spence *et al.* 2008). McElhany *et al.* (2000) suggested a population’s natural productivity should be sufficient to maintain its abundance above the viable level. This guideline seems a reasonable goal in the absence of numeric abundance targets.

(1) NC steelhead. As described in the *Species and Critical Habitat Description* and *Status* sections, populations of NC steelhead have declined substantially from historic levels. Experts consulted during the status review gave this DPS a risk score of 3.3 (out of 5) for the growth rate/productivity VSP category (Good *et al.* 2005), indicating its current impaired productivity level contributes significantly to long-term risk of extinction and may contribute to short-term risk of extinction in the foreseeable future. As productivity does not appear sufficient to maintain viable abundances in many NC steelhead populations, NMFS concludes this DPS is at elevated risk of extinction (not viable) in regards to the population productivity VSP parameter.

(2) CC Chinook salmon. As described in the *Species and Critical Habitat Description* and *Status* sections, populations of CC Chinook salmon have declined substantially from historic levels. Experts consulted during the status review gave this ESU a risk score of 3.3 (out of 5) for the growth rate/productivity VSP category (Good *et al.* 2005), indicating its current impaired productivity level contributes significantly to long-term risk of extinction and may contribute to short-term risk of extinction in the foreseeable future. As productivity does not appear sufficient to maintain viable abundances in many CC Chinook salmon populations, NMFS concludes this ESU is at elevated risk of extinction (not viable) in regards to the population productivity VSP parameter.

(3) SONCC Coho salmon. As described in the *Species and Critical Habitat Description* and *Status* sections, populations of SONCC coho salmon have declined substantially from historic levels. Experts consulted during the status review gave this ESU a risk score of 3.5 (out of 5) for the growth rate/productivity VSP category (Good *et al.* 2005), indicating its current impaired productivity level contributes significantly to long-term risk of extinction and may contribute to

short-term risk of extinction in the foreseeable future. As productivity does not appear sufficient to maintain viable abundances in many SONCC coho salmon populations, NMFS concludes this ESU is at elevated risk of extinction (not viable) in regards to the population productivity VSP parameter.

c. Spatial Structure

Understanding the spatial structure of a population is important because the population structure can affect evolutionary processes and, therefore, alter the ability of a population to adapt to spatial or temporal changes in the species' environment (McElhany *et al.* 2000). Status reviews for the SONCC coho salmon ESU, the CC Chinook salmon ESU, and the NC steelhead DPS concluded data were insufficient to set specific population spatial structure targets (Spence *et al.* 2008, Williams *et al.* 2007). In the absence of such targets, McElhany *et al.* (2000) suggested the following: "As a default, historic spatial processes should be preserved because we assume that the historical population structure was sustainable but we do not know whether a novel spatial structure will be."

(1) NC steelhead. Experts consulted during the most recent status review gave this DPS a mean risk score of 2.2 (out of 5) for the spatial structure and connectivity VSP category (Good *et al.* 2005), indicating it is unlikely this factor contributes significantly to risk of extinction by itself, but there is some concern that it may, in combination with other factors. Blockages to fish passage exist on two major rivers in the DPS and on numerous small tributaries (Good *et al.* 2005). These blockages degrade the spatial structure and connectivity of populations within the DPS. As the 'default' historic spatial processes described by McElhany *et al.* (2000) have likely not been preserved, NMFS concludes this DPS is at an elevated risk of extinction (not viable) in regards to the spatial structure VSP parameter.

(2) CC Chinook salmon. Experts consulted during the most recent status review gave this ESU a mean risk score of 3.2 (out of 5) for the spatial structure and connectivity VSP category (Good *et al.* 2005), indicating its current spatial structure contributes significantly to long-term risk of extinction but does not in itself constitute a danger of extinction in the near future. However, Good *et al.* (2005) found that "reduction in geographic distribution, particularly for spring-run Chinook [salmon], and for basins in the southern portion of the ESU, continues to present substantial risk." As the 'default' historic spatial processes described by McElhany *et al.* (2000) have likely not been preserved, due to the reduction in geographic distribution described above, NMFS concludes this ESU is at an elevated risk of extinction (not viable) in regards to the spatial structure VSP parameter.

(3) SONCC coho salmon. Relatively low levels of observed presence in historically occupied coho salmon streams (32 to 56 percent from 1986 to 2000) indicate continued low abundance in the California portion of the SONCC coho salmon ESU. The relatively high occupancy rate of historical streams observed in broodyear 2001 suggests that much habitat remains accessible to coho salmon (June 28, 2005, 70 FR 37160). Brown *et al.* (1994) found survey information on 115 streams within the SONCC coho salmon ESU, of which 73 (64 percent) still supported coho salmon runs while 42 (36 percent) did not. The streams Brown *et al.* (1994) identified as presently lacking coho salmon runs were all tributaries of the Klamath River and Eel River systems. The BRT was concerned by the loss of local populations in the Trinity, Klamath, and

Rogue River basins (June 28, 2005, 70 FR 37160). CDFG (2002) reported a decline in SONCC coho salmon occupancy, with the percent reduction dependent on the data sets used. Although there is considerable year-to-year variation in estimated occupancy rates, it appears that there has been no dramatic change in the percent of coho salmon streams occupied from the late 1980s and early 1990s to 2000 (Good *et al.* 2005). In summary, recent information for SONCC coho salmon indicates that their distribution within the ESU has been reduced and fragmented, as evidenced by an increasing number of previously occupied streams from which they are now absent (NMFS 2001a). However, extant populations can still be found in all major river basins within the ESU (June 28, 2005, 70 FR 37160).

Experts consulted during the status review gave this ESU a mean risk score of 3.1 (out of 5) for the spatial structure and connectivity VSP category (Good *et al.* 2005), indicating its current spatial structure contributes significantly to long-term risk of extinction but does not in itself constitute a danger of extinction in the near future. As the 'default' historic spatial processes described by McElhany *et al.* (2000) have not been preserved, due to the habitat fragmentation described above, NMFS concludes this ESU is at an elevated risk of extinction (not viable) in regards to the spatial structure VSP parameter.

d. Diversity

Diversity, both genetic and behavioral, is critical to success in a changing environment. Salmonids express variation in a suite of traits, such as anadromy, morphology, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, and physiology and molecular genetic characteristics. The more diverse these traits, the more diverse a population is, and the more likely it is those individuals, and therefore the species, would survive and reproduce in the face of environmental variation (McElhany *et al.* 2000). However, when this diversity is reduced due to loss of entire life history strategies (*e.g.*, loss of summer-run NC steelhead and spring-run CC Chinook salmon), or to loss of habitat used by fish exhibiting variation in life history traits, the species is in all probability less able to survive and reproduce given environmental variation.

Negative effects to genetic diversity can result from hatchery production and stocking of hatchery-bred fish into wild streams. Hatchery-reared fish may be less genetically diverse than wild fish due to artificial selection, and may have originated in areas with different environmental conditions. Once in the hatchery, artificial selection for fish which survive well in the hatchery rather than those that survive well in the wild is likely to occur (Allendorf and Ryman 1987). If the hatchery-bred fish later interbreed with wild fish, they can reduce the genetic diversity of the wild population. Even if the overall genetic diversity of the wild population is unchanged, the introduction of non-native or less diverse genetic material into a native salmonid population can "dilute" the native population's adaptation to its local environment and make it less able to survive and reproduce (McElhany *et al.* 2000).

Genetic variability of wild stocks is naturally altered by straying from natural populations in nearby streams, which results in gene flow and often sustains or even increases the genetic diversity of a population over time. Straying is a normal and important part of the life history

and evolution of Pacific salmon (Quinn 2005), but human activities can increase the rate of straying and cause more genetic interaction between populations than would naturally occur. Founding hatchery populations with broodstock from outside the watershed can make straying more common, as seen in the Columbia River (Pascual *et al.* 1995). Therefore, the genetic makeup of hatchery steelhead from the Mad River could detrimentally affect steelhead in many other rivers within and even outside the geographic range of the NC steelhead DPS. Excessive straying can also be detrimental to wild fish populations born in their natal streams. When habitat becomes degraded, or inaccessible due to dams or road crossings, salmonid spatial distribution can become fragmented. In this situation, straying into non-natal streams is likely to increase when salmonids are denied access to their natal areas and are forced to enter other streams that are accessible. Increased stray rates would be expected to reduce population viability, particularly if the strays are accessing unsuitable habitat or are mating with genetically unrelated individuals (outbreeding depression) (McElhany *et al.* 2000).

Status reviews for the SONCC coho salmon ESU, the CC Chinook salmon ESU, and the NC steelhead DPS concluded data were insufficient to set specific numeric diversity targets (Spence *et al.* 2008, Williams *et al.* 2007). McElhany *et al.* (2000) suggested the following in the absence of specific targets for diversity: “Historically, salmonid populations were generally self-sustaining, and the historical representation of phenotypic diversity serves as a useful ‘default’ goal in maintaining viable populations.”

(1) NC steelhead. Millions of steelhead from outside the Mad River or outside the DPS have been stocked into rivers in the NC steelhead DPS many times since the 1970s. Bjorkstedt *et al.* (2005) documented 39 separate releases of this kind, and many of these releases occurred over multiple years. Of particular concern is the practice of rearing Eel River-derived steelhead in a hatchery on the Mad River before restocking them into the Eel River (Bjorkstedt *et al.* 2005). Over ten years, more than one-half million yearlings were reared and released in this way. This practice may have reduced the effectiveness of adult homing to the Eel River (Bjorkstedt *et al.* 2005). In addition, the abundance of summer-run steelhead was considered “very low” in 1996 (Good *et al.* 2005), indicating an important part of the life history diversity in this DPS may be at risk.

Experts consulted during the most recent status review gave this DPS a mean risk score of 2.5 (out of 5) for the diversity VSP category (Good *et al.* 2005), indicating this factor may contribute significantly to the long-term risk of extinction, but does not itself constitute a danger of extinction in the near future. NMFS concludes the current behavioral diversity in this ESU is much reduced compared to historic levels, so by McElhany’s criteria, it is at elevated risk of extinction (not viable) in regards to the diversity VSP parameter. In addition, the genetic integrity of the DPS may have been compromised by hatchery introductions.

(2) CC Chinook salmon. Bjorkstedt *et al.* (2005) concluded “most recent and ongoing artificial propagation efforts in the CC Chinook ESU are small in scale and restricted to supplementing depressed populations with progeny of local broodstock.” The only current hatchery program for CC Chinook salmon is a supplementation program that uses local broodstock to boost populations in a tributary to the South Fork of the Eel River (Spence *et al.* 2008). The low hatchery production observed in the ESU is less likely to mask trends in ESU population

structure and pose risks to ESU diversity than if hatchery production were higher, making hatchery production less of a concern for this ESU than others. The BRT did have concerns with respect to diversity that were based largely on the loss of spring-run Chinook salmon in the Eel River basin and elsewhere in the ESU, and to a lesser degree on the potential loss of diversity concurrent with low abundance or extirpation of populations in the southern portion of the ESU (Good *et al.* 2005).

Experts consulted during the status review gave this ESU a mean risk score of 3.1 (out of 5) for the diversity VSP category (Good *et al.* 2005). This score indicates the ESU's current genetic variability and variation in life history factors contribute significantly to long-term risk of extinction but do not, in themselves, constitute a danger of extinction in the near future. Low genetic diversity is therefore not considered the most important factor to this ESU's viability. However, Spence *et al.* (2007) expressed concern over the loss of spring-run populations in this ESU. NMFS concludes the current behavioral diversity in this ESU is much reduced compared to historic levels, so by McElhany's criteria it is at elevated risk of extinction (not viable) in regards to the diversity VSP parameter.

(3) SONCC coho salmon. Genetic variability is important because differing genetic traits favor a population being able to survive and reproduce under changing environmental conditions. With regard to the SONCC coho salmon ESU, human activities (including construction of migration barriers, *e.g.*, Iron Gate Dam on the Klamath River and Lewiston Dam on the Trinity River) have eliminated portions of some coho salmon populations from the ESU. In addition, runs of coho salmon within the Klamath River basin are now composed largely of hatchery fish from Iron Gate and Trinity River Hatcheries.

The high hatchery production in some systems in the SONCC coho salmon ESU may mask trends in ESU population structure and pose risks to ESU diversity (June 28, 2005, 70 FR 37160). NMFS determined that the Cole Rivers Hatchery, Trinity River Hatchery, and Iron Gate Hatchery coho salmon hatchery programs are part of the ESU, and that these artificially propagated stocks are no more divergent relative to the local natural populations than what would be expected between closely related natural populations within the ESU (June 28, 2005, 70 FR 37160). Within the 10 historical populations that have dams, 26.4 percent of historical habitat is currently located upstream of the dams (Table 5 in Williams *et al.* 2007). Loss of or limiting spawning and rearing opportunities are expected to adversely affect the species' basic demographic and evolutionary processes, causing a reduced potential that the ESU can withstand environmental fluctuations. Activities that affect evolutionary processes (*e.g.*, natural selection) have the potential to alter the diversity of the species.

The primary factors affecting the diversity of SONCC coho salmon appear to be the influence of hatcheries and out-of-basin introductions. In addition, some brood years have abnormally low abundance levels or may even be absent in some areas (*e.g.*, Shasta River and Scott River), further restricting the diversity present in the ESU. Experts consulted during the most recent status review gave this ESU a mean risk score of 2.8 (out of 5) for the diversity VSP category (Good *et al.* 2005). This score indicates the ESU's current genetic variability and variation in life history factors contribute significantly to long-term risk of extinction but do not, in themselves, constitute a danger of extinction in the near future. NMFS concludes the current

phenotypic diversity in this ESU is much reduced compared to historic levels, so by McElhany's criteria it is at elevated risk of extinction (not viable) in regards to the diversity VSP parameter.

e. Summary

(1) NC steelhead. Based on the above descriptions of the population viability parameters, and qualitative viability criteria presented in Spence *et al.* (2007), NMFS believes that the NC steelhead DPS is currently not viable and is at an elevated risk of extinction.

(2) CC Chinook salmon. Based on the above descriptions of the population viability parameters, and qualitative viability criteria presented in Spence *et al.* (2007), NMFS believes that the CC Chinook salmon ESU is currently not viable and is at a moderate to high risk of extinction.

(3) SONCC coho salmon. Based on the above descriptions of the population viability parameters, and qualitative viability criteria presented in Williams *et al.* (2007), NMFS believes that the SONCC coho salmon ESU is currently not viable and is at moderate risk of extinction.

1. Critical Habitat

Watershed restoration activities have improved freshwater critical habitat conditions in some areas, especially on Federal lands. In addition, the five northern California counties affected by the Federal listing of coho salmon (which includes Humboldt County) have created a 5 County Conservation Plan that will establish continuity among the counties for managing anadromous fish stocks (Voight and Waldvogel 2002). The plan identifies priorities for monitoring, assessment, and habitat restoration projects. However, although watershed restoration activities have improved freshwater critical habitat conditions in isolated areas, reduced habitat complexity, poor water quality, and reduced habitat availability as a result of continuing land management practices continue to persist in many locations.

As part of the critical habitat designation process, NMFS convened Critical Habitat Analytical Review Teams (CHARTs) for steelhead and Chinook salmon. These CHARTs determined the conservation value of Hydrologic Subareas (HSAs) of watersheds under consideration. A CHART was not convened for SONCC coho salmon, because critical habitat had already been designated in 1999. NMFS determined the condition of SONCC coho salmon critical habitat based on other, readily available information.

NMFS will evaluate the effects of the project on critical habitat as follows. If the effects of the Project, when added to the environmental baseline and combined with cumulative effects, are not reasonably likely to destroy or adversely modify the value of constituent elements essential to the conservation of SONCC coho salmon, CC Chinook salmon, or NC steelhead in the action area, then the action is not likely to destroy or adversely modify designated critical habitat as a whole. Conversely, if the conservation value of the affected essential habitat features in the action area is likely to be destroyed or adversely modified, NMFS must then determine whether the impacts reduce the function of the overall critical habitat at the ESU/DPS scale for the conservation of the species or reduce the current ability of the critical habitat to establish essential habitat

features and functions. For the final steps, NMFS evaluates whether, with implementation of the proposed action, critical habitat would remain functional to serve the intended conservation role for the ESUs/DPS or retain its current ability to establish those features and functions essential to the conservation of these species.

a. CC Chinook salmon

NMFS' assessment of the current condition of critical habitat for the CC Chinook salmon ESU shows PCE's for spawning and rearing habitat in the two major rivers within this ESU, the Eel and Russian Rivers, to be severely degraded by the persistence of highly turbid flows during the winter and spring, even at low flows. These highly turbid flows result from releases at Scott Dam and Coyote Valley Dam (Brown and Ritter 1971). Migration and rearing habitat PCEs in the Eel River (both riverine and estuarine) are degraded by diminished flows resulting from water storage in Lake Pillsbury (Scott Dam) and by interbasin diversions to the Russian River through the Potter Valley Project tunnel. Rearing habitat PCEs of the Russian River, both riverine and estuarine, are considered to be degraded as a result of land use patterns changing the channel configuration limiting available habitat, and a program of keeping the Russian River estuary breached throughout the year. Within the smaller coastal streams of the ESU that support populations of Chinook salmon, the status of critical habitat PCEs for rearing, spawning, and migration are considered degraded to a lesser extent.

For CC Chinook salmon, the CHART identified 45 occupied HSAs within the freshwater and estuarine range of the ESU. Eight HSAs were rated low in conservation value, 14 were rated medium, and 27 were rated high in conservation value (NMFS 2005). Within the ESU, CHART ratings and economic benefits analysis resulted in the designation of critical habitat with essential features for spawning, rearing and migration in approximately 1634 miles of occupied habitat. NMFS believes the status of CC Chinook salmon critical habitat in the 45 HSAs has not changed substantially since the 2005 assessment, so nearly half of the HSAs are still of low or medium conservation value.

b. NC steelhead

For NC steelhead, the CHART identified 50 occupied HSAs within the freshwater and estuarine range of the DPS. Nine HSAs were rated low in conservation value, 14 were rated medium, and 27 were rated high in conservation value (NMFS 2005). Within the DPS, the CHART ratings and economic benefits analysis resulted in designation of critical habitat with essential features for spawning, rearing and migration in approximately 3,148 miles of occupied stream habitat. NMFS believes the status of NC steelhead critical habitat in the 50 HSAs has not changed substantially since the 2005 assessment, so nearly half of the HSAs are still of low or medium conservation value.

c. SONCC coho salmon

The condition of SONCC coho salmon critical habitat, specifically its ability to provide for their conservation, has been degraded from conditions known to support viable salmonid populations. NMFS has determined that present depressed population conditions are, in part, the result of the

following human-induced factors affecting critical habitat: logging, agricultural and mining activities, urbanization, stream channelization, dams, wetland loss, and water withdrawals for irrigation. All of these factors were identified when SONCC coho salmon were listed as threatened under the ESA, and they all continue to affect this ESU. However, efforts to improve SONCC coho salmon critical habitat have been widespread and are expected to benefit the ESU. Within the SONCC recovery domain, from 2000 to 2006, the following improvements were completed: 242 stream miles have been treated; 31 stream miles of instream habitat were stabilized; 41 cubic feet per second of water has been returned for instream flow; and thousands of acres of upland, riparian, and wetland habitat have been treated (NMFS 2007). Therefore, the condition of SONCC coho salmon critical habitat is likely improved compared to when it was designated in 1999.

d. Summary

Although watershed restoration activities have improved freshwater critical habitat conditions in isolated areas, reduced habitat complexity, poor water quality, and reduced habitat availability as a result of continuing land management practices continue to persist in many locations and are likely limiting the conservation value (*i.e.*, limiting the numbers of salmonids that can be supported) of designated critical habitat within these freshwater habitats at the ESU scale.

E. Distribution and Abundance in the Redwood Creek Watershed

1. Distribution

a. Redwood Creek Steelhead

Steelhead are the last of the anadromous salmonid species to return to Redwood Creek in the annual cycle, generally between January and April. They are able to leap above barriers that might impede coho salmon. Whether logjams are barriers to movement depends upon stream dynamics, such as the size of the logjam and the stream discharge, as well as the timing and duration of the steelhead migration. These events change from year to year. Steelhead are found in most small order, high gradient tributaries to Redwood Creek. Juvenile steelhead were found in all but one of the 19 small tributaries of Redwood Creek surveyed in 2005 (Holden 2005). The majority of juvenile steelhead in Redwood Creek spend their second year of life in the estuary and lower part of Redwood Creek (Sparkman 2005).

b. Redwood Creek Chinook Salmon

Most of the CC Chinook salmon within Redwood Creek watershed begin their upstream migration around November, if access through the Redwood Creek estuary is possible, and have spawned and died by January. RNSP has conducted summer-run steelhead surveys every year since 1981. Adult spring-run Chinook salmon were observed in only one year, and are not typically considered to use the Redwood Creek watershed. Only one juvenile Chinook salmon was found in a survey of 19 small tributaries of Redwood Creek (Holden 2005). Stream barriers may impede Chinook salmon spawning in RNSP tributaries, but they may be able to get over barriers that may block the smaller coho salmon.

Sparkman (2005) found that juvenile Chinook salmon rear in the upper, middle and lower sections of Redwood Creek for up to several months before migrating to the estuary. Sparkman (2005) also indicates that juvenile Chinook salmon may rear in river sections for a longer period of time compared to their residency in the estuary. RNSP (2002b) also showed that juvenile Chinook salmon will spend an extended period (to late summer) rearing in the estuary before entering the ocean. Thus, both Redwood Creek and its estuary are important rearing habitat for juvenile Chinook salmon, but small tributaries of Redwood Creek do not appear to currently support this species.

c. Redwood Creek Coho Salmon

Coho salmon distribution in the Redwood Creek watershed is limited to the mainstem and the larger low gradient tributaries primarily in Prairie Creek and its tributaries, possibly owing to the lower gradient and more pristine nature of that watershed (Anderson and Brown 1983). Juvenile coho salmon were found in 11 of 19 small tributaries of Redwood Creek surveyed in 2005 (Holden 2005). RNSP conducted general stream surveys of the basin in 1980 and 1981 to describe and characterize the salmonid rearing habitat and distribution of juvenile salmonids (Anderson 1988, Brown 1988). Migration barriers at tributary mouths were identified during these surveys. No coho salmon were found during these early electrofishing surveys above the barriers. However, subsequent surveys in the 1990s detected coho salmon in streams where coho salmon were not observed in 1980-81. Whether these barriers still exist, have changed to allow fish passage, or new barriers have been created is unknown.

Downstream migration of coho salmon juveniles to the ocean from rearing areas in upper Redwood Creek occurs from March to June (Sparkman 2006). Past survey data from RNSP indicate coho salmon move directly into the ocean, spending a minimal amount of time in the Redwood Creek estuary (Anderson 1994), although some remain an additional year. Adult coho salmon migration through the Redwood Creek estuary is dependent upon the mouth being open to the ocean. Whether or not the mouth is open depends on a combination of wave action on the sand berm, the volume of water in the estuary, and the flow of water in the stream. Adult coho salmon typically migrate upstream to spawn from late October to early March depending on access through the estuary (Anderson 1994), with the peak of the spawning run beginning in late November (Anderson 1997).

3. Abundance

The numbers of native salmonid species in Redwood Creek have declined substantially, by perhaps as much as 90 percent by the mid-1970s (EPA 1998), but few data are available to describe past and present salmonid populations in Redwood Creek (Spence *et al.* 2008). Furthermore, available data on listed salmonids specific to tributaries of Redwood Creek are also rare or not of the type that would facilitate accurate assessments of the population status and trends of listed salmonids found there. Therefore, most of the descriptions presented below are general in nature, addressing salmonids in Redwood Creek as a whole, but should be understood to include its tributaries.

a. Redwood Creek steelhead

In 1965, CDFG estimated that 10,000 winter-run steelhead spawned in Redwood Creek (EPA 1998). RNSP summer-run steelhead surveys in a Redwood Creek index reach (Lacks Creek to Tom McDonald Creek) indicate a continuous decline in abundance (Anderson 2005). The 44 adult summer-run steelhead observed in both 1984 and 1985 represent the highest counts within this reach from 1981 to 2005 (Anderson 2005). No adult summer-run steelhead were seen in 1989 or 2001, and only 3 were observed in 2002 (Anderson 2005).

Winter-run steelhead numbers are much higher than summer-run steelhead numbers. Factors which may limit the number of adult summer-run steelhead in Redwood Creek include: (1) access to Redwood Creek if the sand berm blocks the mouth in late June, July, and August; (2) high summer water temperatures; and (3) the lack of deep holding pools (Sparkman 2006). In 1994, Meyer found that fall-run and summer-run steelhead outnumbered coho salmon and Chinook salmon in Redwood Creek, potentially due to a higher tolerance to elevated sediment and disturbance regimes (Meyer 1994).

CDFG has used a rotary screw trap to capture outmigrant juvenile steelhead leaving upper Redwood Creek since March 2000 (Sparkman 2005). Based upon mark and recapture efficiency rates, CDFG estimated the number of 1+ steelhead trout population emigration to range from 28,501 to 68,030, with an average of 43,762. CDFG also estimated 2+ steelhead population emigration ranging from 2,846 to 12,668, with an average of 6,667. Each season, CDFG found that large numbers of 0+ steelhead trout emigrated from upper Redwood Creek: trap catches ranged from 55,126 to 128,885 individuals with an average of 102,760 (Sparkman 2005). The large proportion of young-of-year steelhead emigration compared to 1+ and 2+ steelhead population emigration suggests that rearing conditions, in combination with passive out-migration and an innate/genetic predisposition to out-migrate, may be limiting the abundance of older, juvenile steelhead age-class production from upper Redwood Creek. Sparkman (2006) found a statistically significant negative trend in juvenile smolt production (1+) from 2000 to 2006. Additional years of monitoring will be required to detect other trends, because of high variability in population abundance between years and low sample size.

RNSP conducted seine net surveys of juvenile steelhead populations in the Redwood Creek estuary every summer from 1997 to 2005 (Anderson 1997, 1998, 1999, 2000, 2001, 2007). Sampling dates vary, but population sampling efforts have been conducted for 3 days in at least three of the months of June, July, August, September, and October. Monthly population estimates of juvenile steelhead in the Redwood Creek estuary were never zero, and ranged from a low of 300 in August 2005 to a high of 39,380 in July 2004 (Anderson 2007). Unfortunately, the number of adult steelhead expected to return to spawn in Redwood Creek cannot be extrapolated from these data; thus, no reliable estimate of the current adult population size of steelhead in Redwood Creek is available. However, RNSP has conducted summer-run spawning adult and carcass counts of steelhead in Lost Man Creek since 1999, which range from a high of 8 live spawning adults and 0 carcasses in 2003-2004 to a low of 0 live spawning adults and 0 carcasses in 1999-2000. These numbers indicate very low numbers of returning adult steelhead (RNSP 2006). However, the interpretation of carcass counts for steelhead is problematic because they are capable of spawning more than once. Therefore, spawner counts can

underestimate the number of fish that spawned in a particular year, because some of the spawners may return to the ocean instead of dying and so their carcasses would not be counted.

b. Redwood Creek Chinook salmon

CDFG has trapped outmigrant juvenile Chinook salmon leaving upper Redwood Creek since March 2000, using a rotary screw trap located approximately 5.6 miles downstream of the Chezum summer dam site (Sparkman 2005). Based upon mark and recapture efficiency rates, CDFG estimated the number of 0+ Chinook salmon leaving upper Redwood Creek to range from 987 to 629,847 individuals per season, with an average of 390,926 emigrants (Sparkman 2005). The low number (987) of Chinook salmon emigrating in year 2003 likely indicated a year class failure. Eighty four percent of the variation in population emigration over the 5-year period was explained by high winter flows during the egg incubation period (Sparkman 2005). Sparkman (2006) found a negative trend in juvenile smolt production from 2000 to 2006, although it was not statistically significant. Additional years of monitoring will be required to detect other trends, because of high variability in population abundance between years and low sample size.

RNSP has conducted seine net surveys of juvenile Chinook salmon populations in the Redwood Creek estuary every summer from 1997 to 2005 (Anderson 1997, 1998, 1999, 2000, 2001). Sampling dates vary, but population sampling efforts have been conducted for 3 days in at least three of the months of June, July, August, September, and October. Monthly population estimates of juvenile steelhead in the Redwood Creek estuary were never zero, and ranged from a low of 50 in September 2005 to a high of 58,630 in June 2001 (Anderson 2007). Unfortunately, the number of adult Chinook salmon expected to return to spawn in Redwood Creek cannot be extrapolated from these data. Spence *et al.* (2008) described spawner surveys on Prairie Creek, a tributary to Redwood Creek, which have been conducted since 1998. Population estimates for the surveyed reaches averaged 342 (range 106-531) over six years. However, there is no information on adult Chinook abundance in the mainstem of Redwood Creek or its other tributaries, which have been substantially more influenced by land-use practices (Spence *et al.* 2008). RNSP has been conducting winter spawning adult and carcass counts of Chinook salmon in Lost Man Creek since 1999. A high of 38 live spawning adults and 8 carcasses were found in 2000-2001, and a low of 8 live spawning adults and 5 carcasses in 1999-2000. These numbers indicate low numbers of returning adult Chinook salmon (RNSP 2006).

c. Redwood Creek coho salmon

Current coho salmon runs are far below those that occurred 70-80 years ago. The Prairie Creek Hatchery propagated coho salmon in the basin from 1926 through 1992, planting non-indigenous coho salmon taken from outside the Redwood Creek Basin (Holden 2002). A total of 9,610 coho salmon juveniles were seined from Prairie Creek and its tributaries in 1951 (Hallock *et al.* 1952). The total population of SONCC coho salmon in Redwood Creek may have conservatively numbered more than 2,000 adults in 1992, but the current adult population of SONCC coho salmon in Prairie Creek is almost certainly well below that number (Anderson 2003). Documented escapement numbers of adult coho salmon in Prairie Creek for the years 1999-2002 were 69, 53, 252, and 363 individuals, respectively (Duffy 2003). RNSP has been conducting winter spawning adult and carcass counts of coho salmon in Lost Man Creek since 1999. Counts

have ranged from a high of 46 live spawning adults and 11 carcasses in 2001-2002, to a low of 1 live spawning adult and 3 carcasses in 1999-2000, indicating low numbers of returning adult coho salmon (RNSP 2006). From 2000 to 2006, no coho salmon were captured migrating downstream from the upper Redwood Creek basin, suggesting that for the past 7 years, coho salmon have not successfully spawned in the middle to upper basin of Redwood Creek (Sparkman 2006). Coho salmon were rarely found in seine surveys of the Redwood Creek estuary after June, and were never very abundant: The highest population estimate was 1,660 (in June 1999), and on many days none were found (Anderson 2007).

F. Status of the Species and Critical Habitat in Redwood Creek

1. Status of the Species

a. *Population Size*

As described in the *Distribution and Abundance in the Redwood Creek Watershed* section of this Opinion, the numbers of coho salmon, Chinook salmon, and steelhead in Redwood Creek and its tributaries are extremely low compared to historic conditions. McElhany *et al.* (2000) suggests that it is reasonable to assume historical population sizes were viable, and that the further population abundance strays from historic levels, the higher the probability the population is not viable. Based on this criterion, the abundance of all salmonids in the Redwood Creek watershed is so low it is highly likely these populations are not viable.

Spence *et al.* (2008) and Williams *et al.* (2007) estimated the amount of habitat which historically occurred in Redwood Creek and was suitable for each of the three species addressed in this Opinion. They then calculated the number of spawners needed to avoid depensation based on the amount of habitat. This number is not the number needed for low risk of extinction (viability), which is much higher.

(1) Steelhead. Spence *et al.* (2008) determined at least 301 summer-run steelhead, and at least 301 winter-run steelhead, must spawn in Redwood Creek each year to avoid depensatory risk for either the summer-run or winter-run population. The authors described summer dive surveys of the mainstem of Redwood Creek which have been conducted since 1981. These surveys showed mean adult abundance had averaged just six fish over the past four generations (Dave Anderson *op cit.* Spence *et al.* 2008), and Spence *et al.* (2008) concluded the population of summer-run steelhead in Redwood Creek is at a very high risk of extinction. Summer-run Redwood Creek steelhead are, therefore, likely affected by depensation. Similarly, a high of only eight winter-run adult carcasses were observed at Lost Man Creek (RNSP 2006), indicating the abundance of steelhead in this tributary is quite low and they are also likely experiencing depensatory effects.

(2) Chinook salmon. Spence *et al.* (2008) determined at least 116 fall-run Chinook salmon must spawn in Redwood Creek each year to avoid depensatory risk to this population. The spring-run population is believed extinct (Spence *et al.* 2008), meaning all chance of future viability for this population is gone. Returns of spawning adults to Prairie Creek have averaged 342 annually in recent years (Spence *et al.* 2008), indicating that the minimum number of adults needed to avoid depensatory risk likely occurs there.

(3) *Coho salmon*. Williams *et al.* (2007) determined at least 151 spawners are needed each year to avoid depensatory risk. Depending on the area surveyed and the year, there have at times been 116 or more winter-run adults in Redwood Creek (see *Distribution and Abundance in the Redwood Creek Watershed* section of this opinion), suggesting Chinook salmon abundance in Redwood Creek is likely not sufficiently high to avoid the dangers of extremely low population sizes.

b. Population Productivity

Salmonid population growth rates Redwood Creek have not been quantified. The closest researchers have come to this goal is when Spence *et al.* (2008) described diver surveys which demonstrated the number of adult summer-run steelhead in the mainstem of Redwood Creek had declined at an average rate of 10 percent per year over the past four generations (from 1994 to 2002). The apparent decrease in population sizes of Redwood Creek coho salmon, Chinook salmon, and steelhead indicates the populations are not replacing themselves.

McElhany *et al.* (2000) provides population growth rate guidelines that must be met in order for an ESU to be considered viable with regard to the population growth rate parameter. The populations of salmonids in Redwood Creek do not meet the four of these guidelines, and may not meet the fifth. First, natural productivity should be sufficient to maintain population abundance above the viable level, but as described above the population abundance is too low to be viable. Second, the productivity in Redwood Creek does not maintain population abundance at or above viability thresholds either in the absence or presence of hatchery subsidy. Third, productivity during freshwater life-history stages has not been sufficiently high to maintain abundance at or above viable thresholds during years of poor (or good) ocean conditions. Fourth, the abundance of salmonids in Redwood Creek has declined steadily over multiple generations and multiple brood-year cycles. Fifth, a viable salmonid population should not exhibit trends or shifts in traits that predict declines in population growth rate. As such traits (e.g., size at return of spawners) have not been consistently monitored, no trends or shifts in traits are detectable at this time.

In conclusion, the Redwood Creek populations of SONCC coho salmon, CC Chinook salmon, and NC steelhead are not replacing themselves, and their productivity does not meet the minimum standards of a viable salmonid population.

c. Spatial Structure and Diversity

McElhany *et al.* (2000) advised that, “as a default, historic spatial processes should be preserved because we assume that the historical population structure was sustainable but we do not know whether a novel spatial structure will be”, and that “historically, salmonid populations were generally self-sustaining, and the historical representation of phenotypic diversity serves as a useful ‘default’ goal in maintaining viable populations.” Studies of salmon in more pristine areas (e.g., Hilborn *et al.* 2003) suggest that historical levels of salmon abundance in our study area were probably not sustainable without the biocomplexity and resiliency inherent within an aggregate of populations adapted to local conditions.

Historically, both fall-run and spring-run Chinook salmon populations were found in Redwood Creek. The spring-run population appears to be extinct (Spence *et al.* 2008). Summer-run and winter-run steelhead occur in Redwood Creek, but the summer-run steelhead are nearly extinct (Spence *et al.* 2008). The variation in run timing in Redwood Creek would have once helped the species persist there under detrimental environmental conditions which may otherwise greatly diminish the success of one or more year-classes. Accordingly, the loss of life history diversity will make it more difficult for these species to persist given inevitable environmental perturbation (Beechie *et al.* 2006).

Table 3 shows the number of spawners needed for each population to be a low risk of loss of spatial structure and diversity. This number was based on the amount of historically available habitat in Redwood Creek, and the number of spawners needed to seed freshwater habitat with juveniles.

Table 3. Number of spawners in the Redwood Creek basin needed for each population to be at low risk of loss of spatial structure and diversity.

Population	Number spawners needed	Source of estimate
Steelhead - summer run	6,000	Spence <i>et al.</i> 2008
Steelhead – winter run	6,000	Spence <i>et al.</i> 2008
Chinook salmon	3,400	Spence <i>et al.</i> 2008
Coho salmon	4,900	Williams <i>et al.</i> 2008

As the number of spawners in each population is almost certainly a small fraction of the number shown in Table 3, it is likely the Redwood Creek populations of steelhead, Chinook salmon, and coho salmon are at high risk of loss of spatial structure and diversity.

d. Summary

Based on the above descriptions of the population viability parameters, and qualitative viability criteria presented in Spence *et al.* (2008) and Williams *et al.* (2007), NMFS believes that the Redwood Creek populations of coho salmon, Chinook salmon, and steelhead are currently not viable and are at elevated risk of extinction.

2. Critical Habitat

Data describing the particular designated critical habitat in the action area are not available. The following discussion will address the status of salmonid habitat in the Redwood Creek watershed as a whole.

Due to excessive sedimentation and a reduction in shade canopy, the basin's streams are listed as sediment and temperature impaired under section 303(d) of the Clean Water Act (U.S. Environmental Protection Agency [EPA] 2003). High water temperatures and excessive sediment loads have caused the habitat in Redwood Creek streams to be undesirable for salmonids, especially in mainstem Redwood Creek. Madej *et al.* (2006) estimated that thermal restriction may have reduced the historical distribution of juvenile coho salmon habitat by 75

percent in Redwood Creek. Madej *et al.* (2006) found that water temperatures in Redwood Creek reach their maximum in the middle basin and become cooler farther downstream, and suggest that perhaps “coastal fog, old-growth redwood trees in the riparian zone, and an abundance of cool-water tributaries and seeps” contribute to cooler temperatures in the lower basin.

Turbidity in the mainstem is believed to persist longer and at higher frequencies than in the past (Cannata *et al.* 2006). Sedimentation has caused persistent, long-lasting impacts such as impaired spawning habitat, a decrease in channel diversity and depth, increase in channel width, and stream bank erosion. Logging and associated accelerated bank erosion has caused a decrease in amounts and recruitment of LWD. The loss of large wood has exacerbated the effects of sedimentation, and contributed to temperature increases and loss of channel stability and complexity, including deep pools important to oversummering adult salmonids such as summer-run steelhead, which require cold water refugia. Many of the Redwood Creek tributaries have cool water temperatures, but lack the structural complexity and diversity required to support healthy salmonid populations. Contributions from tributaries are unable to cool temperatures in mainstem Redwood Creek, but do provide cool water refugia at their confluences with mainstem Redwood Creek. Other temperature refugia in the mainstem exist at the bottom of thermally stratified pools, and areas receiving inflow from springs and seeps (Cannata *et al.* 2006).

Impairment of habitat quality and ecological processes, as well as diminishment of area, in the Redwood Creek estuary caused by presence of the levees, built in 1968 as a response to the 1964 flood, is believed to have significantly contributed to anadromous fish population declines. The levees altered the physical and biological functions of the estuary and adjacent wetlands. In the spring, the estuary serves as an acclimation area as juveniles undergo the physiological transformation from freshwater to saltwater.

IV. ENVIRONMENTAL BASELINE

During section 7 consultation, NMFS analyzes the effects of past and ongoing human and natural factors which have led to the current status of the species, its habitat (including critical habitat), and ecosystems within the action area. “Effects of the action” refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, which will be added to the environmental baseline. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process (50 CFR §402.02).

The discussion below first describes the general environmental setting of the Redwood Creek watershed and the action area in particular. Second, the historic and current impacts that have shaped the current salmonid populations and their designated critical habitats within the Redwood Creek watershed and the action area are described. Third, the current watershed conditions that continue to shape current salmonid populations and their designated critical

habitats are described. Fourth, the distribution and abundance of the three listed anadromous salmonid species in Redwood Creek are discussed. Finally, this information is summarized to describe the current condition of each salmonid species found there in terms of its likelihood of survival and recovery, and the role that the action area plays in the overall conservation of each listed species and its designated critical habitat.

Most of this information is compiled and summarized from the *Redwood Creek Watershed Assessment Report* (Cannata *et al.* 2006), the *Total Maximum Daily Load for Sediment: Redwood Creek, California* (EPA 1998), and the Lost Main Creek Restoration Plan BA (Holden 2006). More detailed descriptions and analyses can be found in these documents. With the exception of the flood control levees on lower Redwood Creek, many of the current factors affecting the Redwood Creek baseline conditions occur partially, or entirely, outside of the action area.

A. General Watershed Description

The 282-square mile Redwood Creek watershed is located in the Northern Coast Range of California, and flows into the Pacific Ocean near Orick (Cannata *et al.* 2006). The total length of the basin is about 65 miles, and its width varies from 4 to 7 miles (Janda *et al.* 1975). Total basin relief is about 5,300 feet, with a mean annual basin-wide precipitation of approximately 80 inches (Janda *et al.* 1975). Summertime is characterized by cool temperatures and fog by the coastal belt, with warmer temperatures and sunnier weather more inland. Current land use activities in the watershed include cattle grazing, gravel pit mining, logging, road construction, and residential use.

B. Factors Affecting the Species and Habitat in Redwood Creek

1. Logging and Road Construction

Widespread logging occurred throughout the Prairie Creek sub-basin before Redwoods Nation and State Parks was established. No logging has occurred there since 1978. However, this large-scale logging exacerbated naturally unstable geological conditions in the Redwood Creek watershed within RNSP, and these effects persist. The associated, intensive road-building has contributed to increases in peak runoff and accelerated erosion, interruption of natural hillslope processes, and destabilization of hillslopes and channel banks. Increased erosion and depletion of riparian and instream LWD cause other adverse impacts to fish, such as increases in water temperature, decrease in channel stability, complexity, and depth, loss of instream cover elements and suitable spawning gravel, and loss of functional riparian areas that once supplied shade, food web resources, and LWD recruitment. High turbidity levels due to accelerated erosion occur more frequently and persist longer than in the past, which can cause problems with fish's gills and sight feeding. Although channel deepening and pool development has been observed in all but the lower few miles of the creek, the mainstem of Redwood Creek within RNSP generally lacks an adequate pool-riffle structure, and cover. Coarse sediment deposited in the mainstem allows a large proportion of summer base flows to infiltrate and flow subsurface, thereby limiting the surface water available to fish and increasing surface water temperatures. Tributary water temperatures are generally suitable for salmonids, but water temperatures are suboptimal, or lethal, for fish along much of the mainstem of Redwood Creek within RNSP. Large deltas block

some tributary mouths and impede migration of fish. The lack of suitable rearing habitat in the mainstem and some areas of the tributaries may be resulting in some juvenile fish rearing in the estuary earlier than if the tributary habitat was in better condition.

Canopy closure along the upper reaches of Redwood Creek within RNSP is increasing, but is still far less than it was in the early 1900s. The reduction in shade canopy from conifers along the stream eliminates air cooling microclimate effects to water temperature. Without large wood to influence the shape of the channel, the channel widens and the stream bed level rises as it becomes filled with sediment. These changes can increase erosion. Such conditions are likely to persist into the future as deciduous willows and alders take the place of evergreen conifers along much of the mainstem and tributaries. Large, dense stands of second-growth exist throughout the Redwood Creek watershed within RNSP; as they stagnate, these stands prevent large trees from growing and being recruited into the channel and riparian areas.

2. Mining

Mining within the Redwood Creek watershed has been limited to gravel mining within the channel of Redwood Creek, and in rock quarries and borrow pits used for road construction. Gravel has been mined between the flood-control levees, near the mouth of Prairie Creek, at the mouth of Tom McDonald Creek, and near Highway 299 (Janda *et al.* 1975). Gravel extraction by the Georgia-Pacific Lumber Company from 1951 to 1958 near the Tall Trees Grove totaled between 200,000 and 800,000 tons (Kelsey *et al.* 1979). This gravel removal at the Tall Trees Grove was not significant relative to total sediment discharge in Redwood Creek, but may decreased the threat of bank erosion by lowering the channel bed locally (Milestone, J.F., Redwood National Park, written comm., 1979).

3. Grazing

The Bald Hills prairies and nearby grasslands were heavily grazed by sheep and cattle between 1860 and 1980. Grazing was eliminated on Park lands in the early 1980s. Cattle grazing continues on grasslands in the middle and upper basins and in the Orick Valley, where several dairies are located. In other areas of the western United States, livestock grazing has been associated with increased runoff and erosion. Although similar effects may have occurred in Redwood Creek, RNSP considers them to be insignificant in comparison to high natural rates of runoff and erosion and the effects of logging and road building (Holden 2002). Cattle affect water quality in Redwood Creek and its estuary, primarily through the introduction of nutrient-rich waste and reduction of riparian shading. An accurate determination of the effects of past and present grazing would require additional research (Holden 2002).

4. Orick Setback Levees

Salmonid habitat in the lower portions of Redwood Creek and its estuary has been degraded by the flood control levees, which were built by the U.S. Army Corps of Engineers in 1968. The levees bisect the estuary at the mouth of Redwood Creek and drastically impair the physical and biological functions of the estuary and adjacent wetlands, confining the Redwood Creek channel to a width of 300 feet. Levee construction removed streamside riparian tree cover, reduced

adjacent wetlands, altered valley drainage patterns, decreased instream woody debris structures, and reduced pool depths along lower Redwood Creek. The levees also disconnected Redwood Creek from its last downstream meander, reduced circulation into the south and north sloughs, and resulted in an increase in ocean derived marine sediment. Overall, the levees reduced the area of the lower estuary by approximately 50 percent. Reduced circulation within sloughs and embayments has compromised water quality, further reducing the estuary's value as suitable rearing habitat for listed salmonids. The degraded condition of the Redwood Creek estuary serves as a bottleneck to fish production in the watershed by affecting subsequent salmonid ocean survival and their eventual return as spawning adults (Holden 2002). A recent, exhaustive assessment of the Redwood Creek basin concluded the large reduction in area and habitat quality of the estuary/lagoon is a significant factor affecting salmonid production (Cannata *et al.* 2006).

5. Floods

Floods are critical events for the resources of Redwood Creek because they erode hillslopes, reshape channels, and transport large proportions of fluvial sediment loads. Several major floods have occurred on Redwood Creek during the past 150 years. Recent floods occurred in 1953, 1955, 1964, 1972 (two floods), 1975 and 1997. The peak discharges of these floods were quite similar, ranging from 45,300 to 50,200 cubic feet per second (cfs). The small range of these flood peaks indicates that watershed physiography (Ricks 1995) limits the peak discharges, though not the volumes, of floods near the mouth of Redwood Creek.

The 1964 storm was a regionally significant event that caused major damage to towns, highways, and other structures, as well as significant hillslope erosion and channel changes. Floods in 1861-62 and 1867 were as large as or larger than the 1964 flood (Coghlan 1984). Little is known about the effects of these earlier floods on watershed conditions. A number of redwoods were toppled and carried downstream during the 1861-62 floods, according to one report (Barlow 1984), but few landslide scars date from this flood.

Massive amounts of coarse sediment were deposited in tributaries and the upper and middle reaches of the mainstem during the flood of 1964 (Janda *et al.* 1975; Iwatsubo *et al.* 1976; Nolan and Janda 1979; Kelsey *et al.* 1981a, 1981b; Madej 1984, 1995; Varnum 1984; Varnum and Ozaki 1986; Nolan and Marron 1995; Madej and Ozaki 1996). During subsequent floods, particularly in 1972 and 1975, coarse sediment was scoured from tributaries and the upper mainstem and re-deposited in lower reaches (Varnum 1984; Madej 1995; Varnum and Ozaki 1986).

6. Fishing

Recreational catch-and-release fishing on Redwood Creek results in salmonid mortality, particularly to summer-run steelhead (Taylor and Barnhart 1997 *op. cit.* RNSP 2003). Taylor and Barnhart (1997 *op. cit.* RNSP 2003) showed increasing summer-run steelhead angling mortality with increasing water temperature beginning at 61 ° F, 10 percent mortality at 68° F, and 35 percent mortality at 75° F. Any incidental angling mortality on adult fish is significant to the small adult summer-run steelhead population and damaging to the potential for overall recovery. RNSP superintendents have requested a seasonal fishing closure between June and September in

the 3.9-mile reach of Redwood Creek between the confluences of McArthur and Bond Creeks, which has not been granted by the California Fish and Game Commission.

Fishing (both recreational and commercial) could also impact Redwood Creek salmonids while they are growing to maturity in the ocean. Chinook salmon are targeted by West Coast fisheries. Although there is no directed fishery for coho salmon and steelhead in California waters, they are still encountered as bycatch in West Coast fisheries (including California's Chinook salmon fishery) and coho salmon are targeted elsewhere off the West Coast (Pacific Fishery Management Council [PFMC] 2008). There is a fishery for Chinook salmon off California, Oregon, Washington, and Alaska as well as in international waters (PFMC 2008).

7. RNSP Management

Redwood Creek continues to benefit from RNSP management actions. These include protection from unsustainable land use practices, an extensive watershed restoration program that includes large-scale road decommissioning and upgrades, a proactive road maintenance program, a fire management plan, second-growth timber management, an exotic plant eradication program, and a recreation program that includes a significant public education component.

a. Road Removal

The legislation expanding Redwood National Park in 1978 authorized a major watershed restoration effort. Congress directed that this work focus on minimizing erosion from past land uses, re-establishing native vegetation, and protecting aquatic and riparian resources along RNSP streams (Spreiter *et al.* 1995).

Since 1981, former log-haul roads have been the primary focus of the watershed restoration efforts within RNSP. About 175 miles of logging roads have been treated since 1978. The total volume of sediment excavated from roads is approximately 1,300,000 cubic yards. This sediment removal should provide a long-term benefit to the Redwood Creek watershed conditions, by decreasing the sediment that would be deposited in stream channels in large storm events and by decreasing chronic erosion sources. Expected long-term benefits from watershed restoration to listed salmonids include deeper pools for rearing and holding, and cleaner substrates for spawning. Expected short-term impacts from watershed restoration include increased turbidity the first 2 years after implementation (Klein *et al.* 2007).

Stream crossing excavations in the Lost Man Creek watershed during 2000-2002 encountered an unusually large amount of fine sediments deposited upstream of the crossings. It appears that stream crossings that did not immediately fail became sediment traps for fine sediment washing off of the skid roads. The damming effect of these crossings has undoubtedly delayed the full impacts of logging from reaching the lower portions of Lost Man Creek, where aquatic habitat is still relatively healthy. However, woody debris incorporated in the sidecast fills and stream crossings is decaying and becoming less stable as time passes. As the woody debris rots, fills are beginning to lose their integrity, and failure is imminent in many locations. As these failures occur, not only will much of the material making up the fills erode and enter the stream transport system, but the accumulated sediment trapped by the crossings will be mobilized.

RNSP conducted erosion and turbidity monitoring in the Lost Man Creek watershed from 2002 to 2007 to evaluate the possible effects of road removal on listed salmonids and their habitats (Klein *et al.* 2007). During this monitoring, estimates of sediment release due to road removal were obtained. Post excavation observations revealed that the comparatively higher level of sediment released from restoration sites came the first winter after excavation, with a lesser amount of erosion the second winter, and an imperceptible amount of erosion the third winter after excavation. Three years after the restoration, the volunteer reestablishment of vegetation had eliminated surface erosion and, in some cases, started to encroach on the line-of-sight for photographic documentation. Similarly, the turbidity data (Klein *et al.* 2007) indicate that erosion at new stream crossing excavations was generally most severe in the earliest large storms of the first season and diminished as the winter runoff season progressed.

8. Climate Change

Climate change is postulated to have a negative impact on salmonids throughout the Pacific Northwest due to large reductions in available freshwater habitat (Battin *et al.* 2007). Because snowpack is a function of elevation and latitude, salmonids of Redwood Creek are particularly susceptible to the effects of climate change due to the relatively low elevation of the drainage basin and the southerly position of the basin, relative to the range of anadromous salmonids in western North America. These climactic changes have resulted in earlier onsets of springtime snowmelt and stream flow across western North America (Hamlet and Lettenmaier 1999, Regonda *et al.* 2005, Stewart *et al.* 2005), as well as lower flows in the summer (Hamlet and Lettenmaier 1999, Stewart *et al.* 2005), and increased stream temperatures (Barthelow 2005). NMFS expects that freshwater habitat in Redwood Creek will be altered and reduced due to global warming, which will negatively impact salmonids, because aquatic species have evolved life history strategies in direct response to natural flow regimes (Bunn and Arthington 2002, Beechie *et al.* 2006) and freshwater habitat is often a limiting factor for salmonid populations.

9. Ocean Conditions

The specific effects of ocean conditions on listed salmonids in the Redwood Creek Basin is not known, but these populations probably respond to ocean conditions in a manner similar to other populations that utilize the eastern Pacific Ocean. Variability in ocean productivity has been shown to affect salmon production both positively and negatively. Beamish and Bouillion (1993) showed a strong correlation between North Pacific salmon production and marine environmental factors from 1925 to 1989. Beamish *et al.* (1997) noted decadal-scale changes in the production of Fraser River sockeye salmon that they attributed to changes in the productivity of the marine environment. They also reported the dramatic change in marine conditions occurring from 1976 to 1977 (an El Niño year), when an oceanic warming trend began. These El Niño conditions, which occur on average every 3 to 5 years, negatively affect ocean productivity. Johnson (1988) noted increased adult mortality and decreased average size for Chinook salmon and coho salmon in Oregon during the strong 1982-83 El Niño. Of greatest importance is not how salmonids perform during periods of high marine survival, but how prolonged periods of poor marine survival affect the extinction risk of populations. MacFarlane *et al.* (2008) recently summarized information on low returns of coho salmon in California which showed there was a

72 percent decline in returning adults in 2007/08 compared to the same cohort in 2004/05. Because of the broad spatial extent of the decline, preliminary data from the Oregon coast showing a 70 percent decline, ocean conditions were suspected as a main causative agent.

C. Status of the Species and Critical Habitat in the Action Area

Researchers determined the “intrinsic potential” (IP) of particular stream reaches for rearing juveniles of each of the three species considered in this opinion (Bjorkstedt *et al.* 2005, Williams *et al.* 2006). The models used to identify IP predicted the potential for particular stream reaches to exhibit habitat characteristics suitable for a particular species as a function of the underlying geomorphic and hydrologic characteristics of the landscape (Agrawal 2005). The coho salmon IP evaluation also incorporated temperature as a limiting factor (Williams *et al.* 2006). We assumed a site with an IP value of zero would contain less suitable habitat for rearing juveniles than one with an IP value greater than zero.

Figure 1, Figure 2 and Figure 3 show areas with “IP” values greater than zero for each of the three salmonid species considered in this Opinion. Figure 1 does not show such discrete areas, because all areas in the ESU accessible to coho salmon were designated as critical habitat for this species.

Streelaw Creek holds 1.3 miles of habitat accessible to salmonids, Skunk Cabbage Creek has 0.6 miles, McArthur Creek has 0.5 miles, and Elam Creek has 0.3 miles (Cannata *et al.* 2006). The steep streambed gradient precludes salmon presence in much of the remaining habitat in these creeks.

The creeks which are crossed by roads slated for culvert replacement by the Roads Program constitute the action area for culvert replacements. These roads, and the creeks they cross, are as follows (Figure 1): Streelaw Spur on Streelaw Creek, 205 Spur near Skunk Cabbage Creek, L-2-2 near McArthur Creek, and L-1 East near Elam Creek. There has been no survey focused on these sites for culvert replacement which inventoried the species present at each site. However, all of the creeks containing the culvert sites have been surveyed, as discussed below.

1. Coho Salmon

Streelaw spur is the only one of the four creeks where the habitat was rated as having intrinsic potential to support coho salmon (Figure 1), but coho salmon have been observed in all four creeks. During an electrofishing survey conducted in fall 2001 and 2005, juvenile coho salmon were captured in Elam Creek and McArthur Creek, indicating these creeks function as coho salmon spawning and rearing habitat (Table 4; Holden 2001 and 2005). Coho salmon were observed by Brown (1988) in Streelaw Creek and Skunk Cabbage Creek.

2. Chinook salmon

None of the four sites was rated as having intrinsic potential to support CC Chinook salmon, nor did any occur in designated critical habitat (Figure 2). Brown (1988) failed to find Chinook salmon during surveys of Streelaw Creek and Skunk Cabbage Creek, and Holden (2001 and

2005) did not find juvenile Chinook salmon during surveys of Elam Creek or McArthur Creek (Table 4).

Table 4. Number juvenile coho, Chinook, and steelhead captured in Elam and McArthur Creeks during fall 2001 and 2005 (source: Holden 2001 and Holden 2005).

Species	2001		2005	
	Number in Elam Creek	Number in McArthur Creek	Number in Elam Creek	Number in McArthur Creek
Coho Salmon	34	86	19	21
Chinook Salmon	0	0	0	0
Steelhead	75	79	11	9

3. Steelhead

None of the three sites was rated as having intrinsic potential to support steelhead, nor were any designated as critical habitat (Figure 3). Portions of Elam Creek, McArthur Creek, Skunk Cabbage Creek, and Streeflow Creek were designated as critical habitat, and Elam Creek holds intrinsic potential to support steelhead. During an electrofishing survey conducted in fall 2001 and 2005, juvenile steelhead were captured in Elam Creek and McArthur Creek, indicating these creeks function as coho salmon spawning and rearing habitat (Table 4; Holden 2001 and 2005). Coho salmon were observed by Brown (1988) in Streeflow Creek and Skunk Cabbage Creek.

In 2003 and 2005, adult summer-run steelhead were found in a reach of the mainstem of Redwood Creek adjacent to the L-1 and L-2-2 sites (Anderson 2003, 2005). Summer steelhead surveys have not occurred in the mainstem near the other sites.

V. CUMULATIVE EFFECTS

Cumulative effects as defined in 50 CFR 402.02 are those effects of future State or private activities not involving Federal activities that are reasonably certain to occur within the action area considered in this Opinion. The entire action area lies within RNSP ownership. There are no reasonably foreseeable future non-Federal actions that will affect Roads Program impacts.

VI. EFFECTS OF THE ACTION

This opinion addresses RNSP's implementation of the Routine and Non-Routine Road Maintenance Program in the Redwood Creek watershed. An overview of the Roads Program is provided in the *Description of the Proposed Action* section of this Opinion. The *Status of the Species* has been summarized at the ESU and DPS scales. The *Environmental Baseline* summarizes the effects of past and present Federal, State, local, and private activities on SONCC coho salmon, CC Chinook salmon, and NC steelhead, and designated critical habitats within the action area.

Section 7(a)(2) of the ESA (16 U.S.C. 1536) directs Federal agencies to insure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat. In this section of the Opinion, NMFS assesses the direct and indirect effects of the proposed action, and the effects of any interrelated and interdependent activities on SONCC coho salmon, CC Chinook salmon, and NC steelhead. Additionally, NMFS assesses the effects on designated critical habitats of SONCC coho salmon, CC Chinook salmon, and NC steelhead. As defined by 50 CFR 402.02, "indirect effects" are caused by or result from the proposed action, are later in time, and are reasonably certain to occur. The purposes of these assessments are to determine if: (1) effects of the entire proposed action are likely to have effects on SONCC coho salmon, CC Chinook salmon, or NC steelhead that reduce appreciably their likelihood of both survival and recovery in the wild by reducing their numbers, reproduction, or distribution (the jeopardy standard defined in 50 CFR 402.02); and (2) the entire proposed action is likely to appreciably diminish the value of designated critical habitat for the conservation of SONCC coho salmon, CC Chinook salmon, and NC steelhead in the wild. This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.

The effects of the action are considered in five parts. First, we determine the effects of the Roads Program on individual SONCC coho salmon, CC Chinook salmon, and NC steelhead. Second, we discuss aggregated effects. Third, we describe the effects of the Roads Program on Redwood Creek populations of SONCC coho salmon, CC Chinook salmon, and NC steelhead and on the SONCC coho salmon ESU, CC Chinook salmon ESU, and NC steelhead DPS. Fourth, we describe the effects of the Roads Program on critical habitat. Fifth, we describe the effects of interrelated and interdependent actions. Together, these five sections determine the expected response of the salmonid populations by assessing changes in the numbers, reproduction, and distribution of SONCC coho salmon, CC Chinook salmon, and NC steelhead in the action area. These sections also evaluate whether any reductions in numbers, reproduction, or distribution caused by the Roads Program will appreciably reduce the likelihood of both the survival and recovery of SONCC coho salmon, CC Chinook salmon, and NC steelhead.

As described below, routine road maintenance and non-routine road maintenance other than culvert replacement is not likely to adversely affect listed species or their designated critical habitat. No culvert replacement will occur in the Smith River watershed. Therefore, the effects of the Roads Program on the Smith River watershed will not be discussed further.

Culvert replacement is the only activity associated with the Roads Program which is expected to impact salmonids. Although culverts will be replaced on roads or trails near four creeks (Figure 1), the culvert replacements affecting McArthur Creek, Elam Creek, and Skunk Cabbage Creek are not expected to adversely affect salmonids. Most culvert replacements under these creeks will serve as ditch relief and are designed to direct runoff from the road, not to allow the road to cross an existing stream (Table 1). Therefore, ditch relief culvert replacements are not expected to occur where fish are present. Other culvert replacements will facilitate crossing of a non-salmonid bearing stream (Table 1), and so will not affect salmonids. Only the replacement of four stream-crossing culverts on fish-bearing streams in Streeclow Creek have the potential to

adversely affect salmonids. For these reasons, all other culvert replacements are not likely to adversely affect salmonids and will not be considered further, and the following analysis will apply only to the four culvert replacements in salmonid-bearing streams within Streeflow Creek.

A. Effects on Individuals

Some aspects of the culvert replacement process may harm salmonids. Instream diversion berms and conduit structures will reroute the stream away from or around the activity area and reconnect it to the channel downstream of all activity. Alevins and juvenile coho salmon, Chinook salmon, and steelhead may be present at FMWR instream activity sites prior to culvert replacements. NMFS expects that most juvenile and adult salmonids present during the time of excavation will likely avoid the site or flee before the activity begins. Remaining fish will be removed prior to excavation, and relocated to suitable habitat located immediately upstream of the work area. Qualified fishery biologists will use nets and/or electrofishers to capture listed salmonids. This collection and relocation will stress some fish and increase their risk of death or injury.

Some salmonids may remain undetected during instream electrofishing and dewatering activities. If unable to move or be moved, alevins, juvenile salmonids, and adult steelhead would likely be harassed, crushed, suffocated, or desiccated during dewatering/rerouting activities. Harassment would include negative impacts to normal rearing or spawning behavior from equipment noise/vibrations, movement, shadows, and removal or exclusion from habitat. When stream reaches are rewatered after RNSP activities, salmonids still in the rewatered area will be exposed to noise, movement, and shadows. Dewatering could result in the temporary loss of designated critical habitat important to alevins, juveniles, or adults. The habitat would be restored once the stream reach was rewatered.

a. Effects on Salmonid Eggs or Alevins

(1) Immediate Effects

Salmon and steelhead eggs and alevins may be present during the June 1 to October 15 period of operations. A RNSP biologist will survey work sites prior to dewatering and, if redds are present, RNSP will delay dewatering the area until after the eggs have hatched. If any redds are missed, eggs or alevins remaining in the streambed could dry up when the streambed is rerouted, or may die when the reach is electrofished for juveniles and adults prior to rerouting. Cho *et al.* (2002) showed up to 34 percent of eggs subjected to electrofishing died. Eggs laid after a female has been subjected to electrofishing are likely to die. Cho *et al.* (2002) showed that electrofishing killed up to 93 percent of eggs from electrofished Chinook salmon females. However, the only adult salmonids expected to occur in the Redwood Creek watershed during the period of operations are steelhead. Few adult female steelhead are likely to be found in the limited number of small dewatered areas, and half of electrofished adults are likely to die (see *Effects on Adult Salmonids* section of this Opinion, below). Therefore, few eggs are expected to be laid by electrofished females.

Alevins are particularly susceptible to negative effects from instream activity because they often

hide near stream banks under vegetation or rocky cover, and their small size makes them hard to detect and effectively remove prior to dewatering. Alevins may also run a greater risk of harm from dewatering/rerouting activities if they have not yet developed normal flight behavior.

(2) Effects in the Year Following Culvert Replacement

A small amount of salmonid eggs and alevins in redds within 100 meters downstream of the culvert removal sites will likely be smothered during rain events over the subsequent year following culvert removal activities. Given the limited number of sites where culverts are to be replaced, and the relatively short time frame of effects, NMFS does not anticipate the effects will be sufficient to cause adverse effects to the salmon and steelhead populations in Redwood Creek or to the ESUs and DPS of which they are a part.

b. Effects on Juvenile Salmonids

During two years of fish relocation activities in Humboldt County, mortality rates associated with juvenile fish relocation (using electrofishing gear and nets) ranged from one to three percent (Collins 2004). Consequently, NMFS expects approximately three percent of all fry and juvenile salmonids present in an area subjected to electrofishing would die.

c. Effects on Adult Salmonids

Adult Chinook and coho salmon are not expected to be present when RNSP instream activities occur (June 1 to October 15), because their peak migration and spawning periods are at other times. SONCC coho salmon spawn from November to January (Quigley 2005, Magnuson and Gough 2006), and CC Chinook salmon spawn from late October to January (Nicholas and Hankin 1989). Therefore, adult Chinook and coho salmon are not expected to be directly affected by instream activities occurring between June 1 and October 15.

Due to the variation in run timing and sexual maturity of steelhead in Redwood Creek, adult steelhead may be present during instream activities, as described in the *Distribution, abundance, and trends of anadromous salmonids in the Redwood Creek watershed* section of this Opinion. These adults will be collected using electrofishing and nets when the area is cleared prior to channel diversion. Electrofishing can have severe effects on adult salmonids, particularly spinal injuries from forced muscle contraction. Sharber and Carothers (1988) reported that electrofishing caused severe injuries in 50 percent of the adult rainbow trout (*O. mykiss*) in their study. All injured fish suffered internal bleeding, splintered bones, or both, and NMFS believes they were likely to die from these injuries. Consequently, NMFS expects approximately fifty percent of all adult salmonids present in an area subjected to electrofishing would die.

B. Aggregated Effects

The individual effects of increased sediment loading, turbidity, toxic chemicals, and riparian loss are expected to be insignificant or discountable. It is possible for many individually insignificant effects to result in a significant total effect if each incrementally reduces the health of a fish to a sufficient extent. However, the intermittent nature of most of these effects will allow fish to

recover from one before they experience the next. For example, any releases of toxic chemicals would be accidental events, limited in space and time. Any increased mobilization of sediment in the channel would result from discrete, short-term, occasional construction actions. These intermittent, short-term effects, when combined with the slight reduction in shaded habitat from removal of riparian vegetation, are not expected to accumulate to the extent that they result in the injury or death of individual fish.

C. Effects on Populations and ESUs

Although some eggs, alevins, and juvenile salmon and steelhead could be affected by the proposed action, NMFS expects the number of affected individuals to be low. These individuals would be years away from achieving spawner size, so the loss of one egg, alevin, or juvenile is not equivalent to the loss of one sexually mature salmonid. Depending on the species, only 25 to 40 percent of Chinook and coho salmon and steelhead eggs survive to become juveniles, and only 10 to 17 percent of juveniles become smolts (Quinn 2005). Much of the mortality a salmonid is exposed to occurs when they are in the ocean. The exact percentage survival for Redwood Creek salmon and steelhead in the ocean is unknown, but general statements can be made about the extent of mortality suffered as a stocked fish grows from a smolt to adult. Although there is no directed ocean fishery for steelhead, or for coho salmon in California, some are caught as bycatch in other fisheries off California and other states. Beamish *et al.* (2000) found an average of 3.2 percent of hatchery-released coho salmon released as smolts from the Oregon Production Index Area before 1989 were captured in ocean fisheries as three year olds (sexually mature). Survival after 1989 was far lower, possibly due to unfavorable ocean conditions (Beamish *et al.* 2000). The OPA extends from Leadbetter Point, Washington, to Monterey Bay, California (Logerwell *et al.* 2003), but most of the smolts released from the area since 1960 have been from the Columbia River (Pearcy 1992). The survival rates described by Beamish *et al.* (2000) do not account for mortality faced by an adult salmonid once it leaves the ocean and migrates up its natal stream from the ocean. The smolt-to-adult return rate of winter-run steelhead raised in the Mad River hatchery accounts for marine as well as adult freshwater mortality, and was estimated from 1998 to 2000. Of the thousands of yearling steelhead released from the Mad River hatchery each year, at most, 1.5 percent returned to the hatchery as adults. Overall, regardless of the evidence considered, a very small percentage of eggs, alevins, juveniles, and smolts survive to successfully spawn. Therefore, the small numbers of eggs, alevins, and juveniles which may be harmed by the Roads Program is not expected to affect the number of sexually mature salmon and steelhead in Redwood Creek in subsequent years.

1. Steelhead

As described above, NMFS does not expect the Roads Program to reduce the number of adult steelhead by harming or killing eggs, alevins, or juveniles before they can become adults. Adult steelhead already occurring in the action area could be harmed by the Roads Program, but NMFS expects very few, if any, adults will be present and so affected. Such a small reduction in spawner abundance is not expected to worsen the extent of depensation, to reduce the population's productivity, to decrease the population's spatial structure by removing a small remnant population, or to reduce the gene pool to the extent that genetic drift becomes worse than otherwise expected. The Roads Program is therefore not expected to increase the extinction

probability of the wild spawning steelhead population in Redwood Creek, or the NC steelhead DPS.

2. Chinook Salmon and Coho Salmon

As described above, NMFS does not expect the Roads Program to reduce the number of adult Chinook salmon or coho salmon by harming or killing eggs, alevins, or juveniles before they can become adults. No eventual adult spawners are expected to be affected by the Roads Program, and no adult spawners are expected to occur in the area coincident with Roads Program activities. Therefore, the program is not expected to increase the extinction probability of the wild spawning Chinook salmon and coho salmon populations in Redwood Creek, or the CC Chinook salmon ESU and SONCC coho salmon ESU.

D. Effects to Critical Habitat

1. Increased Mobilization of Sediment

Construction on roads and culverts may cause temporary increases in turbidity (reviewed in Furniss *et al.* 1991, Reeves *et al.* 1991, and Spence *et al.* 1996). NMFS anticipates that short-term increases in turbidity will occur during road blading; maintenance of unpaved road shoulders, ditches, drainage structures, roadway drainage, and drainage dips; removal and end hauling of materials; vegetation removal; windstorm clearance; culvert replacement; rolling dip construction; and hydraulic flushing of culverts. Mobilized sediment may affect salmonids by a variety of mechanisms. For more information, please see the *Environmental Baseline*. Much of the sediment research discussed in the *Environmental Baseline* focused on turbidity levels higher than those likely to result from the Roads Program. Monitoring of newly replaced culverts within Humboldt County indicated temporary increases in turbidity following winter storm events. The measured turbidity at those sites was generally less than the turbidity threshold commonly cited as beginning to cause minor behavioral changes (Henley *et al.* 2000), and always less than turbidity levels necessary to injure or kill salmonids. The NPS proposes to minimize the effects of construction activities using various methods detailed in their 2002 BA (Holden 2002). These methods include use of erosion control measures and materials, minimizing the loss of native riparian vegetation, and replanting any disturbed soils with native vegetation. NMFS expects small temporary increases in turbidity that are likely to result in some limited behavioral effects, such as temporarily vacating preferred habitat or temporarily reduced feeding efficiency. These temporary behavioral changes are not expected to result in injury or death of listed salmonids.

The implementation of the Roads Program would likely decrease the amount of in-channel sediment in the long-term, resulting in a net benefit to the species. Additionally, some of the culvert replacements within the Roads Program would likely increase access to suitable spawning and rearing habitat, therefore expanding the potential distribution of SONCC coho salmon, CC Chinook salmon, and NC steelhead.

2. Introduction of Toxic Chemicals

Equipment refueling, fluid leakage, and maintenance activities within and near the stream channel pose some risk of contamination of aquatic habitat and subsequent injury or death to listed salmonids. Based on the environmental impact minimization measures detailed in the Roads Program BA (Holden 2002), NMFS anticipates toxic chemicals would only rarely reach the stream course. NMFS expects any adverse effects that might occur to listed salmonids or their critical habitat will be minimal and short term in nature.

3. Riparian Vegetation Removal

Road maintenance and culvert installation and replacement could require removal of riparian vegetation. This work would be performed on perennial and intermittent streamcourses. Intermittent stream courses flow only in response to precipitation; therefore, culvert installation or replacements will only infrequently occur on these intermittent streams when they contain water. The majority of trees removed during excavation include young alder, redwood, and Douglas-fir. The streamside side slopes of the proposed culvert replacement sites range from 15 to 40 percent. Water velocities within these stream crossings and stream courses are relatively fast, and water is not expected to pool along areas of excavation. The duration of sunlight is limited to a few hours daily due to steep topography and surrounding overstory vegetation (Holden 2002). Additionally, the amount of increased sunlight exposure from vegetation removal, relative to the action area itself, will be imperceptible. For the above reasons, NMFS does not anticipate that the removal of roadside riparian vegetation will adversely affect listed species or their designated critical habitat.

4. Water Drafting

RNSP applies water to roads before grading occurs in the dry months. Water drafting could adversely affect listed salmonids if drafting occurs while juvenile fish are present in the immediate area. Adverse effects could occur: (1) from the entrainment of juvenile salmon and steelhead into the uptake of the pump; (2) through harassment from people or vehicles approaching or working next to occupied habitat; or (3) from the removal of water that is critical to salmonid survival. However, NPS will follow NMFS' water drafting specifications (NMFS 2001b), which are designed to prevent adverse affects to salmonids. Because these specifications will be followed, and the duration and scope of the water drafting will be limited, NMFS expects that water drafting is not likely to adversely affect listed species or their designated critical habitat.

5. Channel Diversion

The diversion of the channel will eliminate a small amount of juvenile salmonid rearing habitat between June 15 and September 15. This temporary loss of aquatic habitat is not expected to significantly impact salmonids seeking rearing habitat in Redwood Creek, for three reasons. First, displaced juveniles will be moved to similar habitat found nearby; each creek holds at least 0.3 miles of suitable habitat. Second, the area to be affected is small, so the number of displaced juveniles is expected to be low. Third, the habitat will be restricted for a relatively short time.

6. Summary

The amount and quality of adult holding and juvenile rearing habitat in the action area are expected to decrease slightly during Roads Program activities. However, the conservation value of the habitat available at the ESU/DPS level during this time will not be significantly affected by the minor, temporary disruptions. No permanent decrease in the quality or quantity of adult holding or juvenile rearing habitat is expected as a result of the Roads Program. Overall, the Roads Program is expected to benefit CC Chinook salmon, NC steelhead, SONCC coho salmon, and their designated critical habitat by reducing the amount of sediment entering Redwood Creek and its tributaries. In addition, as all new culverts will meet NOAA Fisheries standards for fish passage, the Roads Program could increase the amount of available habitat for salmonids if it results in replacement of culverts which currently block migration.

E. Effects of Interrelated and Interdependent Actions

Regulations implementing section 7(a)(2) of the ESA require NMFS to consider the effects of activities that are interrelated or interdependent with the proposed Federal action (50 CFR 402.02). Interrelated actions are those that are part of the larger action and depend upon the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consultation. Both interrelated and interdependent activities are assessed by applying the “but for” test which asks whether any action and its resulting impact would occur “but for” the proposed action.

Implementation of the Roads Program is not expected to increase use of roads within the RNSP, therefore it will not change the amount of greenhouse gases emitted or encourage the growth of nearby towns. Therefore, no activities are anticipated to occur strictly as a result of the Roads Program.

VII. CONCLUSION

After reviewing the best scientific and commercial information available, the current status of SONCC coho salmon, CC Chinook salmon, NC steelhead, and their designated critical habitat, the environmental baseline for the action area, the effects of the proposed Roads Program, and the cumulative effects, it is NMFS’ biological opinion that the Roads Program, as proposed, is not likely to jeopardize the continued existence of threatened SONCC coho salmon, CC Chinook salmon, or NC steelhead; and is not expected to result in the destruction or adverse modification of designated critical habitat for these species.

VIII. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS as an act which actually kills or

injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not the purpose of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are nondiscretionary, and must be undertaken by the NPS and their designees for the exemption in section 7(o)(2) to apply. The NPS has a continuing duty to regulate the activity covered by this incidental take statement. If the NPS: (1) fails to assume and implement the terms and conditions, or (2) fails to require any designee to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to any permit, grant document, or contract, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the NPS must report the progress of the action and its impact on the species to NMFS as specified in the incidental take statement (50 CFR §402.14(i)(3)).

A. Amount or Extent of Take

The Roads Program is expected to result in incidental take of juvenile NC steelhead, CC Chinook salmon, and SONCC coho salmon. As the number of fish currently occurring in the affected areas is unknown, it is impossible to determine the number of fish of each species which may be taken by the Roads Program. NMFS expects that no more than a few fish of each species will be captured and relocated; the areas to be dewatered are not likely to hold many fish because they are quite small (15 inch stream width) and located high in the watershed, and only four of the dewatered areas occur in fish-bearing streams. Further, NMFS anticipates that most fish will exit the construction area when the site is seined prior to diversion of the channel. Approximately three percent of the captured fish are expected to be harmed by electrofishing.

B. Effects of the Take

NMFS determined that this level of anticipated take is not likely to jeopardize the continued existence of SONCC coho salmon, CC Chinook salmon, or NC steelhead.

C. Reasonable and Prudent Measures

Pursuant to section 7(b)(4) of the ESA, the following reasonable and prudent measures are necessary and appropriate to minimize the impact of incidental take of SONCC coho salmon, CC Chinook salmon and NC steelhead resulting from implementation of the Roads Program.

RNSP shall:

1. Take measures to reduce injury and mortality to SONCC coho salmon, CC Chinook salmon, and NC steelhead associated with fish capture and relocation.
2. Monitor effects of the Roads Program on listed SONCC coho salmon, CC Chinook salmon, and NC steelhead and their habitat.

D. Terms and Conditions

In order to be exempt from any prohibitions of sections 4(d) and 9 of the ESA, RNSP must comply with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are non-discretionary.

The following terms and conditions implement the Reasonable and Prudent Measures.

RMP 1. Take measures to reduce injury and mortality to SONCC coho salmon, CC Chinook salmon, and NC steelhead associated with fish capture and relocation.

1. Refrain from using electrofishing gear to collect fish at the four culver replacement sites on Streelow Creek. Instead, capture fish using seines and dip nets.
2. Prior to capturing fish, determine the most appropriate release location. Suitable areas shall be identified based on quality of habitat, risk of predation, and water quality. Perform initial fish relocation efforts 3-5 days prior to the start of construction. This provides the qualified fisheries biologist an opportunity to return to the work area and perform additional electrofishing passes prior to construction. All captured fish shall be held in water with temperatures not greater than ambient in-stream temperatures. If cooling is used, water temperatures shall not be allowed to cool more than 41° Fahrenheit (5° Celsius) below ambient in-stream temperatures. All captured fish shall be held in well oxygenated water, with a dissolved oxygen level of 7 parts per million or greater. Measures shall be taken to monitor and report the incidental take of SONCC coho salmon, CC Chinook salmon, and NC steelhead during capture and relocation activities. The fishery biologist conducting the capture and relocation will note the number of individuals observed in the affected area, the number of individuals relocated, the number of individual mortality, and the date and time of the collection and relocation. The fishery biologist shall also be empowered to halt work activity while covered salmonid collection is ongoing. Reports of fish relocation activities shall be submitted to NMFS (see address below). Listed salmonids shall be subject to minimal handling and holding. All captured fish shall be allowed to recover from capture stress before they are returned to the stream.

RMP 2. Monitor effects of the Roads Program on listed SONCC coho salmon, CC Chinook salmon, and NC steelhead and their habitat.

1. Visit Roads Program sites within one year following implementation to ensure that the Roads Program did not result in unintended consequences to listed SONCC coho salmon, CC

Chinook salmon, or NC steelhead or their habitat. Results of these site visits shall be included in the annual report issued to NMFS (see below).

2. Provide NMFS with an annual report summarizing the results of work accomplished. These annual reports shall be submitted by the end of January for each year the Roads Program is implemented. The report shall include the following information:

- (1) The number of culverts installed and replaced,
- (2) the locations and descriptions of all fill disposal sites including erosion control measures implemented at each fill disposal site,
- (3) data from longitudinal profiles and cross sections for culvert replacements within fish bearing streams,
- (4) documentation of compliance with applicable BMPs and all effect-minimizing measures identified in the Roads Program BA (Holden 2002) or this Opinion,
- (5) short descriptions of post-implementation site visits as may be helpful in determining whether unintended consequences may have occurred, and
- (6) an assessment of the number of individuals which were incidentally injured or killed during capture and relocation activities.

The report shall be sent to:

NMFS-Arcata Area Office
Attn: Area Office Supervisor
1655 Heindon Road
Arcata, CA 95521-4573

IX. ESA CONSERVATION RECOMMENDATIONS

NMFS believes the following conservation recommendations are consistent with these obligations, and therefore should be implemented by the RNSP:

1. RNSP should implement a Roads Program that results in the prioritization of sites based upon an environmental risk assessment of road and/or stream crossing failure. Prioritization should be given to sites most likely to threaten listed salmonids.
2. RNSP should install ditch relief culverts at a 30 degree skew to the ditch to improve inlet efficiency and minimize plugging and erosion at the inlet. When practicable, ditch flows should be discharged into a buffer area or filter strip, rather than directly into a watercourse; thereby minimizing sediment delivery to a stream course.

In order for NMFS to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, NMFS requests notification of the implementation of any conservation recommendations. In addition, NMFS requests participation in the development of any studies that may be implemented.

X. REINITIATION NOTICE

This concludes formal consultation for the proposed Roads Program in Humboldt County, California. As provided in 50 CFR §402.16, reinitiation of formal consultation is required and shall be requested by the federal agency or by NMFS, where discretionary Federal involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

XI. LITERATURE CITED

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MAGNUSON-STEVENSON FISHERY CONSERVATION AND MANAGEMENT ACT

**ESSENTIAL FISH HABITAT CONSULTATION AND
CONSERVATION RECOMMENDATIONS**

**FOR THE
REDWOOD NATIONAL AND STATE PARKS ROAD MAINTENANCE PROGRAM**

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) set forth new mandates for NOAA's National Marine Fisheries Service (NMFS), regional fishery management councils, and Federal action agencies to identify and protect important marine and anadromous fish habitat. The Councils, with assistance from NMFS, are required to delineate "essential fish habitat" (EFH) in fishery management plans (FMPs) or FMP amendments for all managed species. Federal action agencies which fund, permit, or carry out activities that may adversely affect EFH are required to consult with NMFS regarding potential adverse effects of their actions on EFH, and respond in writing to NMFS' Conservation Recommendations. In addition, NMFS is required to comment on any state agency activities that would impact EFH.

Identification of Essential Fish Habitat

Essential fish habitat is defined in the MSFCMA as "...those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.." NMFS regulations further define "waters" to include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; "substrate" to include sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" to mean the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" to cover a species' full life cycle (50 CFR 600.10).

The Pacific Fishery Management Council (PFMC) has delineated EFH for Pacific Coast Salmon (PFMC 1999). The action area of the preceding biological opinion (*i.e.*, Redwood Creek, Humboldt County, California) provides EFH for Chinook salmon (*Oncorhynchus tshawytscha*) and coho salmon (*Oncorhynchus kisutch*), which are part of the Pacific Coast Salmon Fishery Management Unit as managed under the MSFCMA.

Proposed Action

The proposed action is described in the preceding biological opinion. In summary, the National Park Service is proposing to implement a routine and non-routine roads maintenance program for the Redwood National and State Parks, near the town of Orick, California (Roads Program). The Roads Program is planned to start in 2008 and last four years. Details of which roads will receive which type of maintenance can be found in the Opinion. Routine road maintenance consists of blading, spot surfacing, asphalt pavement patching, maintenance of unpaved

shoulders, ditch maintenance, removal and end hauling of materials, drainage structure maintenance, drainage dip maintenance, vegetation establishment, windstorm clearance, cutting roadway vegetation, maintenance of cattle guards, and sign placement. Non-routine road maintenance consists of paved surface cleaning, rolling dip installation, and culvert replacement. Descriptions of these activities can be found in the BA.

The conservation measures described in the Opinion will reduce or avoid adverse effects to EFH. The NMFS regards these conservation measures as integral components of the proposed action and expects that all proposed activities will be completed consistent with those measures. Any deviation from these conservation measures will be beyond the scope of this consultation and may require supplemental consultation to determine what effect the modified action is likely to have on EFH.

Action Area

The action area includes "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" (50 CFR § 402.02). The action area for the routine maintenance portion of the Roads Program includes approximately 105,516 acres, which consists of all of RNSP, located along the northern California coast. The action area for the non-routine maintenance portion of the Roads Program (other than culvert replacements) is those roads identified in Appendix A of the BA (HOLDEN 2002). The action area for culvert replacements is existing culverts under L-2-2 road, L-1 East Road, 205 Spur Road, and Streelow Creek Trail.

As described in the "Effects of the Action" section, routine road maintenance and non-routine road maintenance other than culvert replacement is not likely to adversely affect listed species or their designated critical habitat. Only routine road maintenance will occur in the Smith River watershed. Therefore, the effects of the Roads Program on the Smith River watershed will not be discussed further.

Effects of the Proposed Action

NMFS expects effects to Pacific Coast salmon EFH to be similar to effects to critical habitat for SONCC coho salmon and CC Chinook salmon. The adverse effects of the action to critical habitat are described in detail in the "Effects of the Action" section of the Opinion.

Conclusion

NMFS has determined the Roads Program would adversely affect EFH for Pacific Coast Salmon species.

EFH Conservation Recommendations

1. RNSP should install ditch relief culverts at a 30 degree skew to the ditch to improve inlet efficiency and minimize plugging and erosion at the inlet. When practicable, ditch flows

should be discharged into a buffer area or filter strip, rather than directly into a watercourse; thereby minimizing sediment delivery to a stream course.

Reference

Pacific Fishery Management Council (PFMC). 1999. Amendment 14 to the Pacific Coast Salmon Plan, Appendix A: Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon. Portland, Oregon. 146 p. August.