addition, past monitoring has shown that ground cover after mechanical treatment recovers after several years and that existing soil cover meets forest soil quality standard and guidelines (Roath, 1996).

The krew_prov_1 Management Unit has soils that are mostly deep to moderately deep including Holland family soils. Soil textures for most of the soils are coarse loamy to coarse sandy loams and have a low soil compaction hazard. The Holland family soils are present in this management unit and they have a moderate soil compaction hazard and there is a concern for reductions in soil porosity due to soil compaction in these soils. Dystric Lithic Xerocrepts are present in this management unit. These soils are mesic, shallow, and somewhat excessively drained soils formed from metasedimentary parent material. These soils have a slow infiltration rate, a high runoff potential and are highly sensitive to intensive management activities. These soils are susceptible to a potential loss of productivity from logging related disturbances. Approximately 135 acres of this management area has been treated with mechanical equipment in the last 5 years (Gallegos, 2005b). The area with Holland family soils has some soil compaction limited to the existing skid trails. Data has not been collected to determine the degree of soil compaction in these areas. Soil disturbance in this area is also unknown.

The n_soapro_2 management unit has soils that are mostly moderately deep to deep. These soils include Auberry family and Holland family which have coarse sandy loam surface soils and sandy clay loam sub soils. The surface soils have a moderate soil compaction hazard and there is a concern for reductions in soil porosity due to soil compaction in these soils. Tollhouse family soils are also present in this management unit. These soils are mesic, shallow, and somewhat excessively drained soils formed from granitic parent material. These soils have a slow infiltration rate, a high runoff potential and are highly sensitive to intensive management activities. These soils are susceptible to a potential loss of productivity from logging related disturbances. Some areas of lost soil productivity have been identified in the Soaproot Watershed Restoration Plan. Seven deteriorated watershed sites identified in the Soaproot Watershed Restoration Plan are outside of the proposed project area. Approximately 13 acres of the area has been treated with mechanical equipment in the last 10 years (Gallegos, 2005b). The area with Auberry and Holland family soils has some soil compaction limited to the existing skid trails. Data has not been collected to determine the degree of soil compaction in these areas. Soil disturbance in this area is also unknown.

Soil Transect and Grid Data

Soil conditions have been reviewed for all eight management units. Soil transects consisting of 20 points per transect were collected to characterize soil conditions using the 2005 Framework Soil Monitoring Methods Protocol. Data for soil cover, soil disturbance, soil compaction and large woody debris were collected along transects and summarized in the 2005 Kings River Project Soils Monitoring Report and 2006 Soil Conditions Report for the n_soapro_2, glen_mdw_1, krew_prov_1 and krew_bul_1 management units. This report will serve as baseline conditions from which to compare soil conditions in the future.

Soil transects data showed that soil cover ranges from 86% to 100%, which is well over the Forest Soil Standard and Guideline. Soil compaction ranges from less then 1% to 12.2%. Some areas in the Bear_fen_6 management unit have excessive levels of soil compaction that do not meet Forest Standard and Guidelines. Large woody debris (LWD) ranged from 23 to 1.1 pieces/acre. Management units that do not meet the Forest Standard and Guideline for large woody debris is the providen_4, n_soapro_2, and glen_mdw_1 management units, which have the approximately 1 piece/acre of LWD.

The following is a summary of soil conditions for the proposed management units.

Nine soil transects were collected in the el_o_win management unit. Soils in this management unit are mostly Shaver family, Sirretta family, and Umpa family. The average soil cover for all 9 transects is 86%. Transect 3 had an average soil cover of 38%, which is below the Forest Standard and Guideline of 50%. Transect 3 is located in the north end of a plantation in Treatment Unit 480. Less then 1% of the area has compacted soils and that occurred on transect 3, where 5% of the transect is compacted. Large woody debris (LWD) averages 23 pieces per acre, which is 4 times the Forest Standard and Guideline.

Eleven soil transects were collected in the providen_1 management unit. Soils in this management unit are mostly Holland family, Chawanakee family, Dystric Lithic Xerocrepts and rock outcrop. The average soil cover for all 11 transects is 99%. Compacted soils occur on 3 out of 11 soil transects for an average soil compaction of 5.36%. The 3 soil transects where soil compaction was found occurs in treatment units 205, 262, and 350. Large woody debris (LWD) averages 6.3 pieces per acre, which meets the Forest Standard and Guideline of 5 pieces per acre.

Three soil transects were collected in the providen_4 management unit. Soils in this management unit are mostly Holland family, Chaix family, Chawanakee family, and Shaver family. The average soil cover for the 3 transects is 100%. Compacted soils occur on 1 out of the 3 soil transects for an average soil compaction of 3.51%. The 1 soil transect where compaction was found occurs in treatment unit 956. Large woody debris (LWD) averages 1.1 pieces per acre, which does not meet the Forest Standard and Guideline of 5 pieces per acre.

Ten soil transects were collected in the bear_fen_6 management unit. Soils in this management unit are mostly Holland family and Shaver family. The average soil cover for all 10 transects is 97%. One transect had 5% moderately disturbed soils, which includes skid trails with several passes of equipment. One transect did not have a single large woody debris (LWD) piece, however 9 transects had between 98 and 5 LWD pieces/acres. The soil standard and guideline for LWD is 5 pieces/acre. One soil transect had 5% compacted soils. Based on this data, the bear_fen_6 Management Unit meets the Forest Soil Standard and Guidelines.

In 1996, soil monitoring was conducted in the Bear Meadow Project Area (Roath, 1996). A total of 144 soil transects were collected that included data to evaluate soil compaction. The average level of area compacted in the Bear Meadow Area is 12.2%, which is below the Forest Soil Standard and Guideline of 15%. Some individual stands have excessive levels of soil compaction that does not meet Forest Standard and Guidelines. Stands in the Bear Meadow Project Area that do not meet compaction standards include 7, 8, 20, 21, 23, 24, 25, 26, and 27 (see Bear Meadow Project Area Stand Map). Five of the nine stands that do not meet soil compaction standards occur in the Holland family soil type.

Nine soil transects were collected in the n_soapro_2 management unit. Soils in this management unit are mostly Auberry family, Holland family, Tollhouse family and rock outcrop. The average soil cover for the 9 transects is 97%, which meets forest standard and guidelines. Compacted soils occur on 4 out of the 9 soil transects for an average soil compaction of the management unit of 8%. This area is currently meeting forest standard and guidelines for soil compaction. The 4 soil transects where compaction was found occurs in treatment units 691, 698, and 591. Large woody debris averages 1 piece/ac, which does not meet the forest standard and guideline of 5 pieces/ac.

Six soil transects were collected in the glen_mdw_1 management unit. Soils in management unit are mostly Gerle family, Cagwin family, Umpa family, and Sirretta family soils. The average soil cover for the 6 transects is 87%, which meets forest standard and guideline. Compacted soils occur on 3 out of the six soil transects for an average soil compaction of the management unit of 4%. The 3 soil transects where compaction was found occurs in treatment units 245, 296, and 1037. Large woody debris averages 1 piece/ac, which does not meet the forest standard and guideline of 5 pieces/ac.

The n_soapro_2 management unit has soils that are mostly moderately deep to deep. These soils include Auberry family and Holland family which have coarse sandy loam surface soils and sandy clay loam sub soils. The surface soils have a moderate soil compaction hazard and there is a concern for reductions in soil porosity due to soil compaction in these soils. Tollhouse family soils are also present in this management unit. These soils are mesic, shallow, and somewhat excessively drained, formed from granitic parent material. These soils have a slow infiltration rate, a high runoff potential and are highly sensitive to intensive management activities. These soils are susceptible to a potential loss of productivity from logging related disturbances. Some areas of lost soil productivity have been identified in the Soaproot Watershed Restoration Plan. Seven deteriorated watershed sites identified in the Soaproot Watershed Restoration Plan are outside of the proposed project area. Approximately 13 acres of the area has been treated with mechanical equipment in the last 10 years (Gallegos, 2005b). The area with Auberry and Holland family soils has some soil compaction limited to the existing skid trails. Nine soil transects were collected in the n_soapro_2 management unit. The average soil cover for the 9 transects is 97%, which meets forest standard and guidelines. Compacted soils occur on 4 out of the 9 soil transects for an average soil compaction of the management unit of 8%. This area is currently meeting forest standard and guidelines for soil compaction. The 4 soil transects where compaction was found occurs in treatment units 691, 698, and 591. Large woody debris averages 1 piece/ac, which does not meet the forest standard and guideline of 5 pieces/ac.

Soils in glen_mdw_1 management unit are mostly Gerle family, Cagwin family, Umpa family, and Sirretta family soils. Six soil transects were collected in the Glen Meadow Management Unit. The average soil cover for the 6 transects is 87%, which meets forest standard and guideline. Compacted soils occur on 3 out of the six soil transects for an average soil compaction of the management unit of 4%. The 3 soil transects where compaction was found occurs in treatment units 245, 296, and 1037. Large woody debris averages 1 piece/ac, which does not meet the forest standard and guideline of 5 pieces/ac.

Soils data for the krew_bul_1 and krew_prv_1 management units have been collected by the PSW Fresno Lab, as part of their baseline data collection, for their watershed and soils study. Carolyn Hunsaker, coordinator for the KREW studies, provided their raw data in the form of Microsoft excel spreadsheets and ACCESS Database information. This information was evaluated and analyzed and determined that it meets the standards for determining if soil conditions meet Forest Soil Standard and Guidelines. Large woody debris (LWD) was collected using a different protocol then what is used in the Region 5 Method for soil monitoring. The Region 5 method calls for counting large woody debris over 10' long and at least 12" in diameter, within 37' radius, at every 5th point, along a 20 point transect. Whereas the KREW protocol measures all cover by large woody debris along a transect, in 1 square meter quadrats, at 2, 7 and 12 m along a 22 meter transect (Hunsaker, personal communication). Determining whether measurements of LWD along the KREW transects meets soil standard and guidelines is difficult because of the different protocols. However, 5 logs that are 10' long x 12" in diameter would cover a 50 ft^2 area, which is .1% of an acre. This would suggest that .1% cover in a 1 m^2 quadrant is equivalent to 5 pieces/ac.

Soil bulk density samples were collected at each soil horizon in 44 soil pits that were dug in the krew_bul_1 and krew_prv_1 management units. Soil cover and large woody debris data were collected along 114 transects in the krew_bul_1 and krew_prv_1 management units. The soil pits and vegetation transects were distributed throughout the eight sub-watersheds in their study area. The following is a summary of the soil conditions for the krew_bul_1 and krew_prv_1 management units.

The krew_prov_1 management unit has soils that are mostly deep to moderately deep including Holland family soils. Soil textures for most of the soils are coarse loamy to coarse sandy loams and have a low soil compaction hazard. The Holland family soils are present in this management unit and they have a moderate soil compaction hazard and there is a concern for reductions in soil porosity due to soil compaction in these soils. Dystric Lithic Xerocrepts are present in this management unit. These soils are mesic, shallow, and somewhat excessively drained soils formed from metasedimentary parent material. These soils have a slow infiltration rate, a high runoff potential and are highly sensitive to intensive management activities. These soils are susceptible to a potential loss of productivity from logging related disturbances. Approximately 135 acres of this management area has been treated with mechanical equipment in the last 5 years (Gallegos, 2005b). The area with Holland family soils has some soil compaction limited to the existing skid trails. Soil bulk density samples were collected in 19 soil pits in the krew_prv_1 management unit. Six soil pits were excavated in sub-watershed D102, 5 soil pits were excavated in sub-watershed P301, 4 soil pits were excavated in sub-watershed P303 and 4 soil pits were excavated in sub-watershed P304. Two out of the 19 soil pits, with one in sub-watershed D102 and one in sub-watershed P304 have A soil horizons with soil bulk density samples of 1.37 and 2.17, respectively. The 1.37 soil bulk density sample is on the outer range for soil bulk density for the soil type in this management unit and could indicate compacted soils or soil porosity outside the range of Forest Standard and Guidelines. The 2.17 soil bulk density sample clearly is indicative of compacted soils and does not meet Forest Standard and Guidelines. When all the soil bulk density data is considered, 10.53% of the soils in the krew_prv_1 management unit is compacted and does meet Forest Standard and Guidelines. Fourteen vegetation transects were collected in sub-watershed D102, 13 in sub-watershed P301, 15 in sub-watershed P303, and 10 in sub-watershed P304 for a total of 52 vegetation transects in the krew_prv_1 management unit. Soil cover ranged from 77% to 95% and large woody debris ranged from 16 to 20% for the four sub-watersheds in krew_prv_1. When all the soil cover and large woody debris data is averaged over the management unit, there is 89% soil cover and 18% large woody debris throughout the management unit. Therefore, soil standard and guidelines are being met in the krew_prv_1 management unit.

KREW_bul_1 Management Units have coarse textured, moderately deep to deep soils with less then 25 acres that have been treated in the last 5 years. Soil bulk density samples were collected in 25 soil pits in the krew_bul_1 management unit. Six soil pits were excavated in sub-watershed B201, 6 soil pits were excavated in sub-watershed B203, 6 soil pits were excavated in sub-watershed B204 and 7 soil pits were excavated in sub-watershed T003. Three out of the 25 soil pits, with 3 in sub-watershed B201 and one in sub-watershed B203 have A soil horizons with soil bulk density samples of 1.40, 1.42 and 1.39, respectively. These soil bulk density measurements are on the outer range for soil bulk density for the soil types in this management unit and could indicate compacted soils or soil porosity outside the range of Forest Standard and Guidelines. When all the soil bulk density data is considered, 12% of the soils in the krew_bul_1 management unit is compacted and does meet Forest Standard and Guidelines. Ten vegetation transects were collected in sub-watershed B201, 15 in sub-watershed B203, 15 in sub-watershed B204, and 20 in sub-watershed T003 for a total of 62 vegetation transects in the krew_bul_1 management unit. Soil cover ranged from 85% to 94% and large woody debris ranged from 23 to 32% for the four sub-watersheds in this management unit. When all the soil cover and large woody debris data is considered, there is an average of 91% soil cover and 27% large woody debris throughout this management unit. Therefore, soil standard and guidelines are being met in the krew_bul_1 management unit.

Environmental Consequences

Alternative 1 – Proposed Action

Soil resource management is achieved by maintaining soil productivity using Regional Soil Standard and Guidelines and management direction provided in the Forest Land Management Plan – Sierra National Forest, 1991. The project proposal could affect soil productivity by reducing soil porosity, soil cover and large woody debris.

<u>Direct Effects to Soils in General:</u> Mechanical harvest will cause soil disturbance and poses increased risk of soil compaction and erosion. Standard operating procedures such as cross ditching skid trails for erosion control will reduce the risk of erosion and promote surface soil stabilization and re-vegetation. The soils in this project area are highly productive so rapid natural re-vegetation is expected. Some of these soils are highly susceptible to soil porosity loss, due to compaction from heavy equipment operation when soils are moist or wet. To prevent soil compaction soil moisture needs to be dry enough to reduce the susceptibility to compaction. The ideal moisture content

varies between soils and should not be above 12% to prevent soil compaction. A soil scientist or other earth scientist should be consulted prior to mechanical equipment operating on soils that have a moderate soil compaction hazard, especially outside of the standard operating season (June 1 to October 15). Soil compaction will be reduced by subsoiling skid trails and landings to ensure that soil standard and guidelines are being met in the management units. See soil report in the project record for more details on soils that have a moderate soil compaction hazard.

Tractor logging is planned for areas with slopes under 35%, which will reduce excessive soil displacement. Areas of slopes in excess of 35% will be logged with a helicopter yarding system to prevent undue soil disturbance.

In areas where tractor piling of slash is planned, it is a normal Forest practice to leave at least 50 percent, well distributed soil cover for erosion protection on slopes under 35%. If slopes are greater then 35%, soil cover should be at least 70%. Past observations on the Sierra NF have found that this amount of soil cover generally prevents accelerated erosion. For tractor logging and piling, a design feature is to conduct tractor logging and piling when the soil is dry to avoid soil porosity loss (compaction). A buffer of 100' will be provided around rock outcrop to prevent accelerated erosion of the adjacent soils from rapid runoff from rock outcrops.

No significant impacts to soil productivity are expected given the design measures incorporated in the Proposed Action.

<u>Direct Effects from Mastication Treatment Areas:</u> Areas planned for mastication pose little risk of causing negative effects to soil because this treatment increases soil cover reducing the erosion hazard and generally causes little soil disturbance and compaction.

<u>Direct Effects from Treatment of Fuels with Prescribed Fire:</u> Areas planned for prescribed fire pose little risk of causing significant effects to soil productivity based on the past performance of the High Sierra District prescribed fire program. Past prescribed fires on the district has resulted in low burn severity where the fire has burned in a mosaic leaving patches of unburned vegetation and patches of burned area where duff and litter has burned. Most trees are left undamaged except for a few small patches that have burned at a moderate burn severity. Soil quality standards have been met from past prescribed fires and are expected to be met from the proposed action. Soil cover of 50% is expected to be met on slopes less the 35% and 70% on slopes greater the 35%. Monitoring of prescribed fire areas has shown that soil quality standard are being met in the last 5 years of prescribed fire on the High Sierra District (district files).

<u>Direct Effects from Treatment of Brush and Noxious Weeds by use of Glyphosate:</u> According to a review of studies by Ghassemi and others (1981) glyphosate rapidly attaches to organic matter on top of or in the soil and its mobility is very limited. The soils in the project area include: Holland family, Chaix family, Cannell family, Cagwin family. Glyphosate becomes strongly attached to soil particles or organic matter on the soil surface or the plant surface. It does not become mobile again with additional precipitation and does not leach through the soil. Because of its very low mobility in soil the only mechanism for off site movement of glyphosate would be if it were attached to soil particles that were eroded and transported to another location. Normal hydrolysis in a stream will not break the attachment of glyphosate to soil particles. So, even if the

combination reached the water, it would not be in a form that can be taken up by plants or released through digestion by animals. It would not affect either surface or ground water quality. The only potential impact to the soil resources is from direct disturbance and displacement of the soil by applicators walking on the ground.

Glyphosate provides a means of vegetation control that causes little, if any, direct soil disturbance. The dead foliage and leaf drop onto the soil surface continues to provide protection from erosion until seeds present sprout. It biodegrades within weeks of application into natural products including: carbon dioxide, nitrogen, phosphate and water. The primary metabolite of glyphosate is aminomethylphosphonate (AMPA). The position taken by U.S. EPA/OPP (2002) that AMPA is not of toxicological concern regardless of its levels in food appears to be reasonable and is well-supported (SERA 2003; p. 3-25). The half-life of glyphosate can range from 20 to 60 days (SERA 2003). Effects on soil microflora are minimal and not pronounced (Ghassemi, 1981). There is very little information suggesting that glyphosate will be harmful to soil microorganisms under field conditions and a substantial body of information indicating that glyphosate is likely to enhance or have no effect on soil microorganisms (SERA 2003; p. 4-7). R-11 is also broken down by soil microorganisms.

Indirect Effects

There are no potential indirect effects of the proposed action, to soil productivity, if soil compaction is kept to less then 15% of an activity area and erosion control measures are implemented in a timely manner. There could be an occasional summer storm event that could cause accelerated erosion of bare exposed soils. In the event that this should occur soil erosion sites may be restored to pre-storm conditions either through contracts or appropriated funds.

Cumulative Effects

Cumulative effects to soils are a component of analyzing cumulative watershed effects, so refer to the watershed effects section for the discussion.

Alternative 2 – No Action

If vegetation is left in its current state of high fuels and high wildfire risk, it is inevitable that a wildfire will occur. The area of potential high burn severity would not meet soil quality standards in terms of soil cover. Soil cover would be less the 10% and some soils would develop hydrophobic conditions which would result in accelerated erosion. Soil loss could range from 10–60 tons per acre in these areas. Past monitoring of wildfire areas on the nearby Stanislaus National Forest has found that bare ground averaged about 70% by spring of the first year and by spring of the second year bare ground averaged 27 percent (Janicki, 2003). Large woody debris would probably be consumed in a fire and long term soil productivity could be decreased without large woody debris. There would be no effect to soil porosity.

Modeling of the No Action alternative with a fire in the year 2015 predicted 52 tn/ha/yr (see Watershed Section). Modeling of the proposed action with a fire in the year 2015 predicted 13 tn/ha/yr. This analysis shows that the no action alternative with a fire in the year 2015 will result in 400% more erosion then the proposed action with a fire in the year 2015. This modeling exercise demonstrates that the no action alternative will have a significant effect on erosion and soil productivity if a wildfire occurs.

Alternative 3 – Reduction in Harvest Tree Size

The only difference between this alternative and Alternative 1, on the effects to the soils resource, is the design measures required in those sub-watersheds where cumulative watershed effects are a concern. These sub-watersheds include 519.0057, 519.3053, 519.4051, 520.1002, 520.1051, 520.1101, and 520.1151. These measures are designed to minimize ground disturbance and include light-on-the land mechanical logging and grapple piling of areas proposed for tractor piling. The effects of these treatments will result in no decrease of ground cover from pre-treatment conditions and soil compaction should be mitigated by the sub-soiling of the main skid roads and landings to at least pre-treatment conditions or less. Implementation of the watershed restoration component of the proposed project will result in increased soil productivity at those sites. Existing large woody debris is not expected to decrease because the prescribed burning is designed to be a low burn severity and the fire behavior rarely consumes large woody debris. In addition, trees larger then 30", are being retained and overtime will fall and become large woody debris. No impacts to soil productivity are expected given these management requirements and soil productivity should increase.

Watershed

Affected Environment

This section describes the existing condition and identifies the indicators and analysis methods used in the analysis of environmental consequences on watershed resources.

The Kings River Project lies in the Dinkey Creek and Big Creek watersheds (see Watershed Map 1, in Appendix F), comprised of three 6^{th} code Hydrologic Units (HUC6s); two within Dinkey Creek and one within Big Creek. Dinkey Creek is tributary to the North Fork Kings River and Big Creek flows directly into Pine Flat Reservoir.

Each of these basins is further divided into HUC7s and HUC8s (smaller areas nested within the HUC6s). The R5 Cumulative Watershed Effects (CWE) Analysis is conducted at the HUC8 scale, which ranges from approximately 400 to 2,200 acres in the Kings River Project area. In this analysis, the term 'sub-watershed' is used to refer to HUC8s.

The watershed analysis is based on the following factors: stream flow, water quality (including sediment), and CWE.

Table 3-45 summarizes the hydrography of the management units, based on District GIS data. This table provides a crosswalk between management units, streams, and sub-watersheds for future discussions. These sub-watersheds are shown on Watershed Maps 2a, 2b, and 2c, in Appendix F.

Table 3-45 - Stream systems, sub-watersheds, and miles of stream in each Management Unit.

Management Unit	Main Stream System(s)	Sub-watersheds	Stream miles			
			Perennial (order 3+)	Intermittent (order 2)	Ephemeral (order 1)	Total
Bear_fen_6	Bear Meadow Cr Oak Flat Cr	520.0053 520.0054 520.1001 520.1002 520.1051 520.1101 520.1151	6	6	22	34
El_o_win_1	Dinkey Cr Dinkey Meadow Cr	520.0014 520.0015 520.0016 520.0056 520.0057 520.4001 520.4051 520.4052	7	5	15	27
Glen_mdw_1	Glen Meadow Cr Rock Cr Dinkey Cr	520.0014 520.0016 520.0017 520.0056 520.0057 520.5051	8	6	18	32
Krew_bul_1	Bull Cr	520.3002 520.3051	2	4	8	14
Krew_prv_1	Duff Cr Providence Cr	519.0005 519.0007 519.0008 519.0011 520.0014 520.0016 520.0017	7	8	24	39
N_soapro_1	Rush Cr	519.0009 519.3001 519.3002 519.3003 519.3004 519.3052 519.3053	7	8	22	37
Providen_1	Providence Cr Summit Cr Big Cr	519.0007 519.0008 519.0011 519.0057 519.4001 519.4051	8	12	26	46
Providen_4	Duff Cr Big Cr	519.0007 519.0008 519.0055 519.0056	7	6	11	24

Stream Flow

Average annual precipitation ranges from 30 inches in the n-soapro_2 management unit to almost 60 inches in glen_mdw_1 and el_o_win_1. The stream flow parameters including peak flow, base flow, and annual yield will be used as indicators in the analysis of environmental consequences.

Peak flow is the highest flow for a given time period. There is a peak flow for each precipitation event, for each spring runoff season, and for each water year. Peak flow can be discussed in terms of an instantaneous peak (the highest flow reached, regardless of its duration) or an annual peak based on daily mean flows. There is less variability in daily mean flows, but often the instantaneous peak is important because of its effects on the stream channel and on infrastructure, particularly culverts and bridges.

Base flow is the portion of stream flow that comes from sub-surface rather than surface water sources. The level of base flow varies throughout the year – during wet periods with saturated soils, more sub-surface flow is delivered to streams than during dry periods when soil moisture is low. Base flow will be discussed as a contributor to high flows, but changes will only be estimated for the low flow period.

Annual yield is the average amount of water that flows out of an area over a one year period. It is often reported in acre-feet / year, which is the depth that the total volume of flow would cover a one acre flat surface.

Baseline stream flow data for the KREW Watershed Study has been collected in Providence, Duff, and Bull Creek watersheds since October 2003. The data collected at these stations is intended to answer specific questions about the response of flows in these small headwater drainages to the vegetation treatments, including before and after comparisons as well as comparisons between treated areas and ‘control’ areas that receive no treatment. It is also helpful in describing the current hydrology of the project area.

Automatic data loggers record the stream flow at least once every hour at each of 7 flumes in the project area, shown on Watershed Map 1 (Appendix F). Figure 3-58 shows an example hydrograph for selected stations in Water Year 2005 (WY 2005 = October 1, 2004 – September 30, 2005). Daily mean flows (the average of all flows recorded each day) are shown for two stations, Duff Creek (D102) and Bull Creek (B203). The project file contains this data and a complete set of hydrographs.

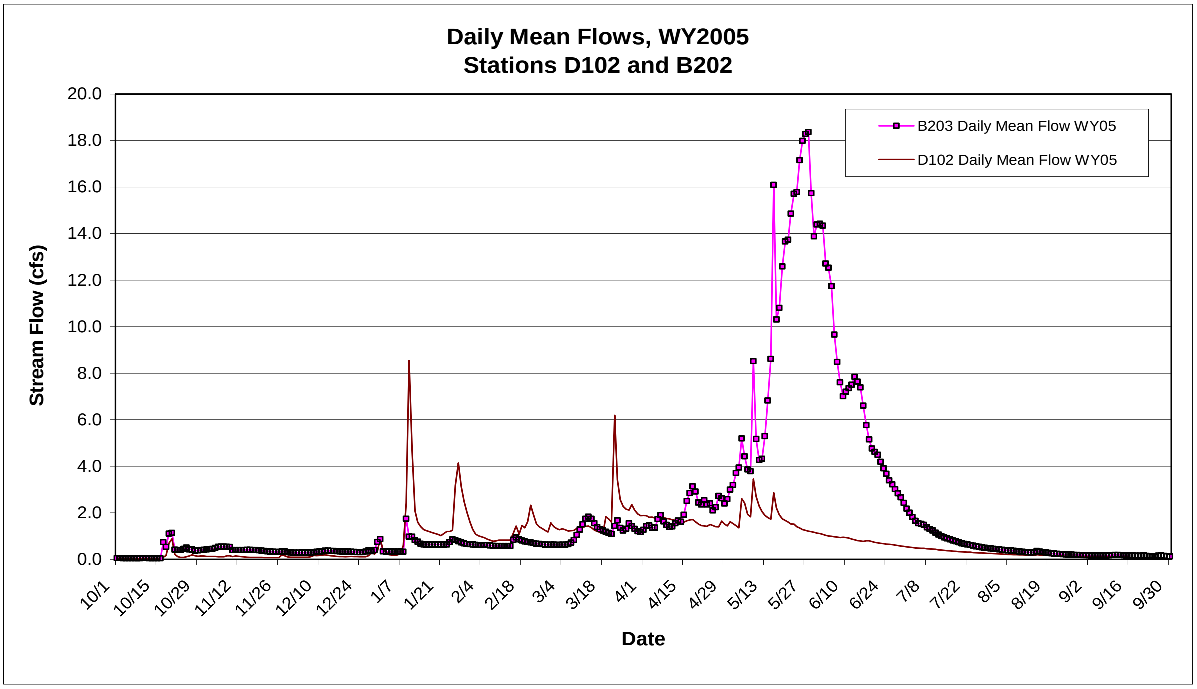


Figure 3-58 - Hydrograph of daily mean flows at stations D102 and B203, KREW Study.

In Figure 3-58, a clear difference can be seen between Duff 102 and Bull 203. Duff Creek (elev. 4920 ft) responds to winter season precipitation by producing immediate spikes, while in Bull Creek (elev. 7235) these spikes are much less dramatic. There is a sustained peak at B203 in May and June that is absent at the Duff Creek site. For example, the maximum daily mean flow in D102 was 8.6 cfs (cubic feet per second), which occurred on January 10. The matching peak at B203 was 1.7 cfs. Bull Creek's maximum daily mean flow occurred on May 28 and was 18.4 cfs. The largest spring flow at D102 was only 3.4 cfs on May 9. This illustrates that Duff Creek is rain-dominated and Bull Creek is snowmelt-dominated. The peaks in early May that occur at both stations are rain events that in Bull Creek were likely rain-on-snow. The data collected at the stations in Providence Creek resembles the Duff Creek data.

The daily maximum flows at these stations are an average of 10 – 15% higher than the daily mean flows. The instantaneous peaks from large storms are as much as 3.5 times higher than the daily mean at a given station.

The flow record is too short to support the calculation of flood frequencies, including bankfull flow. Cross section data has been collected at the stations, but bankfull flows have not yet been estimated (pers. comm., C. Hunsaker, July 25, 2006). Instead, the USGS Regressions for the Sierra Region (Waananen and Crippen 1977) and regional regressions for the Kern River (Kaplan-Henry and Schoener 2002) were used to estimate various return-interval flows[15].

The Kern River relationships were used because they include small watersheds and account for the effects of wildfire on small watersheds. The benefit of both of these methods is that they can be applied to any size watershed, including the sub-watersheds (HUC8s) used for the CWE analysis. However, Kaplan-Henry and Schoener (2002) found that the Sierra Region relationships under-estimated flows at sites with drainage areas less than 10 mi^2 in the Kern River Basin. Although the project area differs from the Kern River in several ways, and flows in the project

[15] Flows of various return intervals are denoted by Qx where Q = flow in cubic feet per second (cfs) and x = the return interval in years.

area may be more closely approximated by the Sierra Regional relationships than the Kern River stations are, both estimates are presented to represent the possible range of flows. The Kern River relationships are of particular interest for evaluating the possible effects of a wildfire such as the McNalley Fire.

The complete set of calculated flow estimates is available in the project file. In general, the flows calculated with the Kern River relationships are slightly lower than the USGS estimates for return intervals up to 5 years. At Q10, the results are fairly close, but the Kern River estimates are slightly higher in smaller watersheds. At Q50, the Kern River relationships produce flow estimates that are two orders of magnitude higher than the USGS regional relationships. Table 3-46 shows a few examples.

Table 3-46 - Subset of flow estimates at various return intervals, calculated with USGS Regional Regressions (Waananen and Crippen 1977) and with Kern River relationships (Kaplan-Henry and Schoener 2002). All flows in cfs (cubic feet per second).

Station or sub-watershed #	Q2		Q5		Q10		Q25		Q50	
	USGS	Kern	USGS	Kern	USGS	Kern	USGS	Kern	USGS	Kern
D102	10.3	6.8	33.0	13.6	52.3	59.9	90.2	414	178	5580
B203	10.0	7.4	32.8	15.1	52.5	65.0	91.4	442	183	5782
519.0005	37.3	16.5	107	37.5	165	133	278	783	527	7870
520.1001	19.4	10.4	58.4	22.1	91.1	87.9	155	563	299	6580

The USGS maintained a stream flow measurement station on Big Creek downstream of the project area from 1953 to 1973. There have been two stations on Dinkey Creek, one upstream of the project area and another at the mouth. Another station was operated on Rock Creek, a tributary to Dinkey Creek. The locations of these stations are shown on Watershed Map 1, in Appendix F. The data collected at these stations was used in developing the Regional Regressions for the Sierra. A summary of the data at these stations from Waananen and Crippen (1977) is shown in Table 3-47 and Table 3-48 shows a summarization of the data by unit area (flow per square mile of drainage area) for comparison between stations.

Table 3-47 – Stream flow at USGS gauging stations at various intervals (from Waananen and Crippen 1977). Flows in cfs.

Station	Drainage Area (mi^2)	Elevation (ft)	Average Annual Precip (in)	Q2	Q5	Q10	Q25	Q50
Big Cr	70	961	35	1810	4670	7700	13200	18800
Dinkey Cr	51	5440	38	1050	1780	2350	3170	3850
Dinkey @ mouth	136	1283	35	1940	3190	4140	5500	6620
Rock Cr	7.6	6148	36	404	928	1440	2320	3160

Table 3-48 - Selected stream flow information from USGS gaging stations operated in the project area watersheds, presented as absolute value and as normalized value (from Gallegos 2004).

Station	Mean Annual Flood cfs/mi²	Largest Rain-on-Snow Flood (cfs/mi²)	Largest Snowmelt Flood (cfs/mi²)	Period of Record
Big Cr	45	234	N/A	1953-73
Dinkey Cr*	48	219	50	1921-35; 1977-87
Dinkey @ mouth	2236		2900	1920-37
Rock Cr	110	375	62	1960-70

*The 1977-87 data from Dinkey Creek is not reflected in Table, which is based on data published in 1977

The monthly average flows for Big Creek are also displayed in the Big Creek Watershed Analysis, and presented in Figure 3-59. The shape of the hydrograph of the tributary Duff Creek at D102 (shown in Figure 3-58- 1st hydrograph) generally fits these monthly average flows in Big Creek.

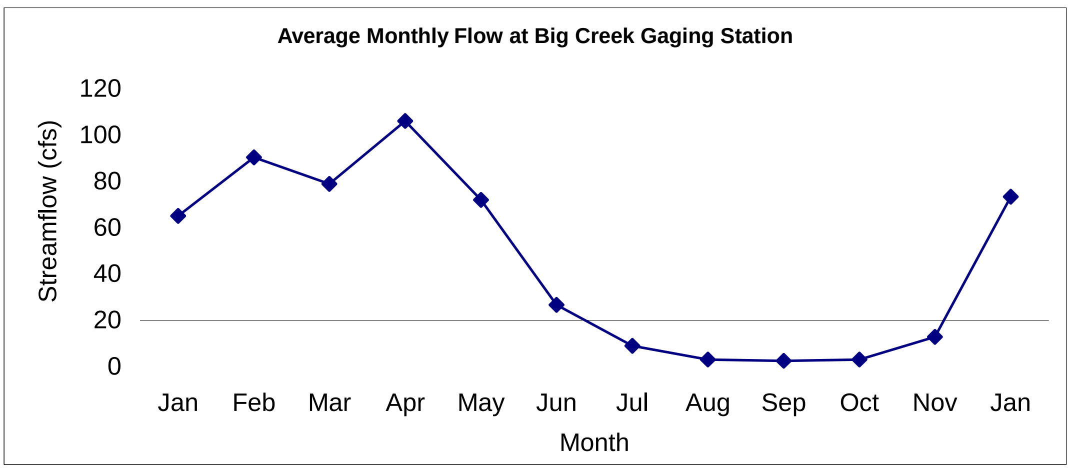


Figure 3-59 – Monthly average flows at the Big Creek gauging station, from Gallegos 2004.

Analysis Methods for Evaluating Changes in Stream Flow: Literature reviewed (and summarized in the General Discussion of Environmental Consequences) reports the effects of forest management actions on stream flow in terms of the amount of forest cover removed. For this analysis, the percent change in basal area and the percent change in forest canopy were calculated for each vegetation patch modeled in the vegetation and fuels analyses. These were then aggregated at the sub-watershed scale as a weighted average. These values are compared to reported studies in order to qualitatively predict the effects of the alternatives on stream flow.

Water Quality

Water quality in the project area is managed under the Water Quality Control Plan for the Tulare Lake Basin (Central Valley Regional Water Quality Control Board (CVRWQCB) 2004). This plan designates the beneficial uses to be protected, water quality objectives, and an implementation program for achieving objectives. The designated beneficial uses in the project area are shown in Table 3-49.

Table 3-49. California designated Beneficial Uses for Dinkey Creek and Big Creek, based on the Water Quality Control Plan for the Tulare Lake Basin.

Beneficial Use	Dinkey Creek	Big Creek
POW – Hydropower Generation	X	X
REC1 – Water Contact Recreation	X	X
REC2 – Non-Contact Water Recreation	X	X
WARM – Warm Freshwater Habitat (including reproduction and early development)	X	X
COLD – Cold Freshwater Habitat	X	X
WILD – Wildlife Habitat	X	X
RARE – Rare, Threatened, or Endangered Species	X	
SPWN – Spawning, Reproduction, and/or Early Development (cold water)	X	
FRSH – Freshwater Replenishment	X	X

Hydropower generation occurs at Pine Flat Dam, downstream of the project area. Water contact and non-contact recreation occurs in the streams in and downstream from the project and at Pine Flat Reservoir. Aquatic habitat is discussed more comprehensively in the Aquatics section, but some elements of habitat, such as sedimentation, are analyzed in this section.

Section 303(d) of the Clean Water Act requires states to identify waters that are not meeting water quality objectives and are at risk of not fully supporting their designated beneficial uses. These water bodies are called Water Quality Limited Segments (WQLS). The 2002 list is the most recent California list that has been approved by the EPA. No water bodies in the Kings River Project area are listed as water quality impaired. The nearest listed segment is the Lower Kings River approximately 50 miles downstream of Pine Flat Dam, which is identified for Electrical Conductivity, Molybdenum, and Toxaphene, all due to agricultural uses.

Water Quality Objectives are narrative or numeric limits designed to protect beneficial uses of water. The parameters with specified objectives in the Tulare Lakes Basin Control Plan include ammonia, bacteria, biostimulatory substances, chemical constituents, color, dissolved oxygen, floating material, oil and grease, pH, pesticides, radioactivity, salinity, sediment, settleable material, tastes and odors, temperature, toxicity, and turbidity. The parameters that this project has the potential to affect are chemical constituents (glyphosate), dissolved oxygen (DO), sediment, temperature, and turbidity.

Limited water quality sampling has been conducted in the analysis area. Between 1979 and 1983, the Forest collected water chemistry data at established stations on an irregular schedule. Data that was collected on dissolved oxygen, temperature, and turbidity at the mouth of Big Creek and the mouth of Dinkey Creek are presented in Table 3-48. Sampling locations are shown in Watershed Map 1 (Appendix F). These locations are well downstream of the project area, but serve as general indicators of the water quality in these watersheds. Since 1999, water quality data has been collected as part of Stream Condition Inventory (SCI) assessments, and aquatic species-specific surveys. This information includes macroinvertebrate samples (an indicator of water quality). This data is presented in the Aquatic Species Report (Sanders 2006b). More recent data has also been collected on sediment, which is considered to be the primary threat to water quality in these watersheds. Sediment data is discussed in a separate section below.

Table 3-50 - Water quality in Big Creek and Dinkey Creek, 1979-1983, including temperature, dissolved oxygen (DO), and turbidity.

Sample location	Date	Temp (air/water)	DO (mg/l)	Turbidity (NTU)
Big Creek	6/14/79	27 / 22° C	8.3	0.36
	12/22/81	13 / 5°C	9.0	0.34
	7/7/83	21 / 18°C	8.1	2.2
	10/21/82	21 / 11° C	8.4	10
	12/3/83	22 / 12° C	10.6	3.0
	11/1/84	Not recorded	9.1	10
Dinkey Creek	6/14/79	27 / 16° C	9.2	0.6
	12/16/81	22 / 10° C	9.0	3.0
	10/21/82	21 / 11° C	9.0	100
	7/7/83	15 / 4.5°C (water temp suspect)	10.5	0.75
	12/3/83	20 / 10° C	12.5	30
	11/1/84	Not recorded	9.2	20

The applicable CVRWQCB objective for temperature states:

> “Natural temperatures of waters shall not be altered unless it can be demonstrated to the Regional Water Board that such alteration in temperature does not affect beneficial uses”.

Temperatures are not thought to be a limiting factor for beneficial uses in these watersheds. The temperature recorded in Big Creek in June 1979 (22° C or 72° F) is the highest in this data set, and is similar to the maximum temperatures recorded with continuous data loggers in Big, Providence, and Summit Creeks in the summer of 2005 (Sanders 2006b; Strand 2006). The effects of this project on temperature are analyzed in the Aquatics section.

Dissolved oxygen (DO) is an important water quality parameter because aquatic organisms need oxygen. DO levels can range from 0 – 18 mg/l; levels of 5-6 mg/l are stressful for organisms, and lower can be fatal (Renn 1970). DO is related to water temperature; generally, cooler water has higher DO. Turbulence increases DO as oxygen from the air gets mixed into the water. Other factors that exert a control on DO include photosynthesis, respiration, and decomposition of plant material. Photosynthesis only occurs during the day, and it increases DO. Respiration and plant decomposition occur around the clock, and deplete DO.

The applicable CVRWQCB water quality objective for dissolved oxygen (DO) state:

> “The DO in surface waters shall always meet or exceed 7.0 mg/l in waters designated COLD or SPWN”.

Although the data record is short and sporadic, DO levels in these watersheds do not appear to be at risk of not meeting the objective. Dissolved Oxygen will not be used as an indicator of Environmental Consequences in this analysis.

Turbidity is a measure of the amount of fine material suspended in the water. Water with higher turbidity is cloudier than water with low turbidity. Turbidity varies naturally and is often higher during rainfall runoff, especially during large storms. It is often higher when stream flow is rising (‘on the rising limb of the hydrograph’) than when stream flow is falling. Chronically increased turbidity can result in increased temperature because solar warming has a greater effect on water carrying fine sediment particles. Fine sediment particles can also be associated with nutrients, and more nutrients can increase aquatic production, which in turn depletes DO. In the analysis area, erosion could carry fine sediment to streams and cause an increase in turbidity.

The applicable CVRWQCB water quality objective for turbidity states:

> "Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases in turbidity attributable to controllable water quality factors shall not exceed the following limits:
>
> - Where natural turbidity is between 0 and 5 NTU, increases shall not exceed 1 NTU.
> - Where natural turbidity is between 5 and 50 NTU, increases shall not exceed 20 percent.
> - Where natural turbidity is equal to or between 50 and 100 NTU, increases shall not exceed 10 NTU.
> - Where natural turbidity is greater than 100 NTU, increases shall not exceed 10 percent.
>
> In determining compliance with the above limits, the Regional Water Board may prescribe appropriate averaging periods provided that beneficial uses will be fully protected."

The highest measured turbidity in this data set occurred on 10/21/82 in both streams, and likely represents storm runoff although weather conditions were not noted at the time of data collection.

The data presented in Table 3-51 does not allow comparison with the water quality objectives. Because turbidity is highly variable seasonally and in response to runoff events, determining natural background levels is very difficult and requires continuous monitoring (National Council for Air and Stream Improvement (NCASI) 1999). Turbidity varies with flow levels – it tends to be lower in the drier, base flow period (June and July) and higher during winter, higher precipitation period (see Table 3-51). Literature shows that it also varies in different locations in the same stream, and in different positions both across a single channel cross section and at different positions in the flow profile (i.e., at different depths) (NCASI 1999). Conroy (2003) found that two identical turbidity meters gave different readings for the same sample, and Davies-Colley and Smith (2001) found even greater differences when different types of meters were used, making it difficult to compare data collected by more than a single meter.

Turbidity has not been thoroughly investigated in these watersheds because it is not thought to impair beneficial uses. It will not be used as an indicator of environmental consequences in this analysis.

Glyphosate is an herbicide that would be used in each of the action alternatives. The Tulare Lake Basin Control Plan does not specify objectives for glyphosate, but does note that waters designated MUN (municipal supply) shall comply with water quality objectives in Title 22 of the California Code of Regulations. The referenced table for Organic Chemicals displays numeric objectives for glyphosate in drinking water ranging from 700 – 1000 ppb (parts per billion). The project area waters are not designated for municipal use. However, glyphosate will be tracked through the analysis of effects due to public interest in the environmental effects of herbicides.

Routine water quality sampling does not include a test for glyphosate. However, in Bakke's (2001) review of studies of glyphosate use on several forests including the Sierra, surface water samples resulted in no detections (detection limits ranged from 6 to 25 ppb). Glyphosate is probably not currently present in surface water in the analysis area.

Sediment is the primary threat to water quality in the project area. The indicator used to measure sediment on the Sierra NF is V* ("V-star"), which is the fraction of scoured pool volume that is occupied by fine sediment (Lisle and Hilton 1992, Hilton and Lisle 1993). This is thought to be a good index of variations in fine sediment supply. Lisle and Hilton (1999) show that V* correlates with annual sediment yield in systems with abundant sandy sediment, and that changes in V* correspond to changes in the balance between sediment supply and sediment transport.

V* was collected in 1995, 1996, 1997, 2003, and 2004 in the Big Creek and Dinkey Creek watersheds to quantify existing fine sediment storage. Watershed Maps 2a, 2b, and 2c (Appendix F) show the locations of these V* reaches.

Data collected in the 1990s used a variation of the V* technique, and is not directly comparable to more recent data. The measurement areas were not explicitly identified and therefore cannot be revisited with confidence. The reaches were not selected using the criteria recommended by Hilton and Lisle (1993), and far fewer than the recommended 10 pools were sampled in almost every case. The data collected beginning in 2003 follows the established guidelines for V* measurement closely, and will be used as the baseline for project monitoring. However, the older data can be generalized for comparison with desired conditions.

The desired condition (DC) for sediment in pools in the Big Creek watershed, based on watershed potential considering the geology, soils, and channel types, is a maximum of 30%. V* was measured in twenty stream reaches in the Big Creek watershed in the 1990s. These reaches span from the headwaters of Summit Creek to the lower reaches of Big Creek (see Watershed Map 2a in Appendix F for approximate locations) and include some tributaries. Forty percent of the sampled areas had V* values that exceeded the DC. The 2003-2004 data in Big Creek (see Table 3-51) shows that both sampled reaches in Big Creek are above the DC. The reach in Summit Creek just above the confluence with Big Creek meets the DC.

The desired condition for sediment in pools in the Dinkey Creek watershed, based on the watershed potential considering the geology, soils, and channel types, is a maximum of 20%. This is lower than the DC in Big Creek due to differences in soils and channel types. Twenty-four stream reaches were measured in Dinkey Creek in the 1990s, from the headwaters of Dinkey Creek and including several tributaries (see Watershed Maps 2b and 2c for approximate locations). Eighty-three percent of these sampled areas met the DC. The reaches in upper (520.1002-1) and lower Bear Meadow Creek (520.1051-1 and 520.1051-2) are noteworthy because the measured V* values were approximately 80%, far higher than the DC. The reach in Oak Flat Creek (520.1151-1), tributary to Bear Meadow Creek, slightly exceeded the DC.

Table 3-51 - V* reach data 2003-2004 (after Morales 2004). (Reaches beginning with 519 are located in the Big Creek watershed. Reaches numbered 520 are in Dinkey Creek.)

Management Units	Creek	Reach #	# Pools	Mean V*
Not in initial eight management units	Big	519.0012-1	10	0.68
providen_1	Big	519.0057-1	10	0.40
providen_1	Summit	519.4051-1	10	0.18
Not in initial eight management units	Dinkey	520.0056-1	3	0.04
glen_mdw_1	Glen Meadow	520.0017-1	10	0.16
bear_fen_6	Oak Flat	520.1151-1	8	0.45
bear_fen_6	Oak Flat	520.1151-2	10	0.61

The 2003-2004 data in Dinkey Creek shows that surveyed reaches in Dinkey and Glen Meadow Creeks meet the DC. Both surveyed reaches in Oak Flat Creek clearly exceed the DC. Because of the limitations of the earlier data, the difference in V* values in Oak Flat Creek between the earlier measurement and the recent data cannot be interpreted as a trend.

The analysis method for evaluating changes in sediment relies on literature, WEPP modeling (described in the CWE analysis), current V* values, channel types (described below), the expected changes in flows, and the professional judgment of the hydrologist and geologist. Three sources are considered in the analysis of sediment; roads, treatment units, and in-channel erosion. The analysis of effects on sediment levels utilizes five types of information; the predicted effects on erosion and sedimentation from the soils analysis, the predicted increases in flows from this analysis, the effects of design measures whose purpose is to minimize or mitigate effects, channel type (sensitivity to disturbance) and channel condition (existing bank stability).

In addition to V*, stream condition data has been collected at various locations throughout the project area (see Watershed Maps 2a, 2b, and 2c) using the R5 Stream Condition Inventory (SCI) protocols (Frazier and others 2005). SCI was developed to inventory and monitor stream condition, and to enable comparison of conditions within or between reaches with statistical confidence. A suite of attributes are collected in order to characterize the channel. Baseline SCI reaches will be established and monitored as described in the Adaptive Management Plan, to detect possible changes in these streams. The baseline data has already been collected for some of the reaches.

For this analysis, bank stability measurements from SCI are used as an indicator of possible channel response to increases in flow that may result from project implementation. Rosgen channel type (Rosgen 1996) is also used as an indicator of sensitivity to disturbance. "Disturbance" includes changes in flow and sediment supply coming from upstream. It is important to note that this data represents the reach where it was collected, not the entire stream channel. Table 3-52 presents these attributes from the SCI data collected in the project area in 2005.

Table 3-52 - Selected SCI attributes for sample reaches in the project area. Bank stability ratings are based on 100 data points collected on each bank at 50 locations within the reach. Channel type is an average of 3 surveyed cross sections within each reach. The interpretation of sensitivity to disturbance comes from Table 8-1 in Rosgen (1996).

Reach	Sub-watershed	Bank Stability			Channel Type	Sensitivity to disturbance
		Stable	Vulnerable	Unstable		
Big Cr 7	519.0056	90%	9%	1%	B4c	moderate
Big Cr 4b	519.0012	37%	38%	25%	B4c	moderate
Big Cr 4a	519.0057	33%	40%	27%	F4	extreme
Big Cr trib	519.0011	71%	20%	9%	B3a*	low
Summit Cr	519.4051	75%	23%	2%	B3c	low
Oak Flat Cr	520.1002 520.1051	32%	39%	29%	B4c	moderate
Laurel Cr	520.4001	66%	23%	11%	B4c	moderate
Bull Cr	520.3002	65%	30%	5%	C3b	moderate

* indicates a transport reach, based on the reach gradient; all others are response reaches.

The SCI Technical Guide (Frazier and others 2005) presents a data summary from forests in the northern Sierras collected during pilot development of the program. This data is sorted into 'reference' and 'non-reference' sites, and 'transport' and 'response' stream reaches. In that data set, reference response reaches had a mean stability of 75%, and non-reference response reaches averaged 53% stable. The stability in transport reaches was slightly higher: 81% at reference sites and 56% at non-reference sites. Using these values as general indicators, the reaches Big Cr 4a, Big Cr 4b, and Oak Flat Cr have lower channel stability than would be expected, all in the 30-40% range. This is especially a concern for reach Big Cr 4a, where the channel type is extremely sensitive to disturbance.

Channel typing has also been done to various levels as part of other data collection efforts since 1989. High sensitivity reaches are listed in Table 3-53. The analysis method for evaluating effects on sensitive channel types is based on consideration of the estimated effects on stream flows and sediment, how those changes would be transmitted downstream and their potential to trigger effects in these locations. The indicator is change in stream bank stability.

Table 3-53 - Reaches with channel types characterized as having 'very high' or 'extreme' sensitivity to disturbance (per Rosgen 1996).

Management Unit	Sensitive Channel Reach Locations	Sub-watershed
bear_fen_6	B5 reach in headwaters of tributary to Bear Meadow Cr, outside of MU	520.1051
	B4 reach on Bear Meadow Cr, near downstream end of MU	520.1051
	F4/G4 reaches on Oak Flat Creek, at downstream end of MU	520.1151
el_o_win_1	B4 reach on tributary to Dinkey Creek	520.0017
glen_mdw_1	B4 reach on tributary to Glen Meadow Creek	520.0057
krew_bul_1	A4 and B6 reaches in headwater tributaries of Bull Creek	520.3002
krew_prv_1	None known	-
n_soapro_2	C4 reaches in Rush Creek and a tributary, upstream of the MU	519.3053
providen_1	None known	-
providen_4	B4 reach in Providence Creek, near mouth	519.0008
	F5 reach downstream of Providence Creek	519.0056
	B4/G4 reach in Big Creek, along edge of MU	519.0056 and 519.0057

The sub-watersheds containing the Management Units also contain a network of system roads that have the potential to contribute water and sediment to streams. The action alternatives include road maintenance, reconstruction, and construction, which may have the potential to change the effects of roads. Some of the characteristics of the road system are presented in Table 3-54.

Table 3-54 - Miles of road in Riparian Conservation Areas (RCAs) and the number of stream crossings.*

Management Unit	Road density (mi/mi^2)	Miles of road in RCAs	Total Number of Stream Crossings	Number of Perennial Stream Crossings
bear_fen_6	5.8	10.5	107	7
el_o_win_1	7.9	10.9	110	19
glen_mdw_1	9.8	16.0	148	28

Management Unit	Road density (mi/mi^2)	Miles of road in RCAs	Total Number of Stream Crossings	Number of Perennial Stream Crossings
krew_bul_1	5.4	4.9	48	2
krew_prv_1	4.0	8.8	84	11
n_soapro_2	1.8	3.4	13	4
providen_1	3.9	8.4	90	11
providen_4	5.4	7.1	81	18

*Based on GIS information. The Dinkey Creek map quadrangle has a noticeably denser channel network than surrounding maps. This is thought to be a mapping consistency problem rather than a reflection of actual conditions. It results in elevated values for that area compared to areas outside of that quad. This affects the miles of road in RCAs and the number of stream crossings in all of the management units except n_soapro_2 and krew_bul_1, although the degree of this effect has not been determined. Perennial stream crossings include crossings of roads and trails on order 3 and greater channels.

It is important to consider that not all roads are the same. Some generate very little erosion, while others have widespread problems. More commonly, roads have a few discrete trouble spots where drainage problems or erosion occur. We also do not assume that all roads within an RCA contribute water or sediment to streams. The miles of road within RCAs and the number of stream crossings are presented as indicators of the potential for roads to affect streams.

A measure such as the length of hydrologically connected roads (roads directly connected to streams via a surface flow path) would provide a better indication of the potential for roads to increase peak flows or sediment effects (Gucinski and others 2001). Other factors such as soil types, road grade, effectiveness of road drainage design, road condition, channel condition and channel sensitivity are also important factors to consider when determining this potential. Korte and MacDonald (2005) found that 13% of the road length in their study areas in krew_prv_1 and krew_bul_1 are hydrologically connected. The average length of connected segments is 553 ft on native surface and 385 ft on gravel surfaced roads (Gallegos 2006a).

The current sediment contribution from roads to streams was assessed using Korte and MacDonald's site-specific study (2005) and the WEPP:Road model (described in the CWE analysis later in this section). Stream crossings are by and large the most significant areas along roads that contribute sediment to the stream system. The effect of hydrologically connected portions of roads is that they concentrate surface flow from the road bed where sediment is produced and deposit it directly into channels, or near channels where it can eventually make its way to the channel.

Roads/channel crossings were evaluated to determine the average length of road that is hydrologically connected to a channel on native and gravel surfaced roads (Gallegos 2006a). The data set included 38 road/channel crossings, on nine Forest System Roads. Korte and MacDonald (2005) found that the annual sediment production rate was .44 kg/m^2 (1.98 tons/ac) for native surface roads and .06 kg/m^2 (0.27 tons/ac) for gravel surface roads in krew_prv_1 and krew_bul_1 management units. This sediment production rate is based on the sediment volume collected in silt fences in 2004 (a dry year) and 2005 (a wet year). A similar study conducted between 1999 and 2002 on the El Dorado National Forest determined that annual sediment production rates for native surface roads was .64 kg/m^2 and from gravel surfaced roads was .01 - .03 kg/m^2 (Coe and McDonald 2006). Coe and MacDonald's sediment production rates on the El Dorado National Forest corroborate Korte and MacDonald's findings in krew_prv_1 and krew_bul_1.

Korte and MacDonald's sediment production rates, the average length of hydrologically connected road, and the average road width of 14 feet, were used to calculate the average volume of sediment produced from each crossing as .35 tons/yr for a native surfaced road and .03 tons/yr for a gravel surfaced road. A parallel analysis of the same road/channel crossings over a 30 year simulation, using the WEPP:Road model, estimated that the average sediment delivery rate is 3.44 tons/yr for native surfaced roads and .67 tons/yr for gravel surfaced roads (USDA 2006). These estimates are compared in Table 3-55.

Table 3-55 - Comparison of estimated average annual sediment production at road/stream crossings

Road surface type	After Korte and MacDonald (2005)	WEPP:Road Model
Native surface	0.35 tons/yr	3.44 tons/yr
gravel	0.03 tons/yr	0.67 tons/yr

Comparison of these sediment production rates shows that the WEPP model predicts sediment production an order of magnitude greater than predictions based on local data. These estimates represent a potential range of sediment production, with Korte and MacDonald representing short term rates and the WEPP model representing potential long term rates.

Road/channel crossings were determined in GIS by intersecting roads and streams in the project area. There are approximately 658 crossings in the eight management units. There are approximately 116 crossings on gravel surfaced roads: 132 on native surface roads, 15 on paved roads, and 395 on roads whose surfaces have not been determined in the project area. Sediment production rates on the 395 crossings were determined using both native surface and gravel surface sediment production rates to provide a range. The total estimated sediment production from roads in the project area is 828 to 1890 tons/yr based on the WEPP model and 62 – 193 tons/yr using Korte and MacDonald's sediment production rates.

There are approximately 188 crossings in the eight sub-watersheds that are over their lower TOC: 13 on gravel surfaced roads, 105 on native surface roads, and 70 on roads whose surfaces have not been determined. The total amount of predicted sediment production from roads in the eight CWE sub-watersheds is 422 - 630 tons/yr based on the WEPP predictions and 39 – 59 tons/yr using Korte and MacDonald's sediment production rates.

The analysis method for evaluating the effects of roads includes literature review and the results of the WEPP sediment modeling to inform a qualitative assessment.

<u>Cumulative Watershed Effects (CWEs) Analysis</u>

The CWE analysis has two components consisting of the R5 Baseline and Detailed CWE Assessments following the direction in FSH 2509.22, and a qualitative discussion about how the direct and indirect effects are likely to be transmitted through the stream system.

The Baseline Assessment (Gallegos 2005a) was conducted using the Equivalent Roaded Acres (ERA) model to determine if the ERAs in any sub-watersheds are currently at or over their lower Threshold of Concern (TOC).

In the ERA model, the percent ERA in a sub-watershed is used as an index of watershed disturbance and the risk of impacts to watershed health. Each acre of activity is multiplied by a coefficient to express its level of disturbance to watershed function. The coefficients for vegetation management activities are determined by silvicultural prescription, logging system, and soil types. ERAs are prorated by their age, assuming a recovery period of 30 years (USDA 1990: Chapter 20).

Major assumptions that were used in the CWE analysis include:

1) The size of the sub-watershed is equivalent to a HUC 8 watershed, which for the Kings River Project ranges from 400 to 2200 acres.
2) Sub-watersheds vary in their sensitivity to management based on their watershed characteristics that include percent of unstable lands, percent of sensitive soils, and the bifurcation ratio of the channels in the sub-watershed.
3) An upper limit to tolerance to disturbance exists for each watershed. This limit, or upper TOC, has been estimated to be 14% for each watershed measured in terms of ERA. The risk of initiating adverse CWE greatly increases as this upper limit is approached and exceeded.
4) A lower limit to tolerance to disturbance exists for each watershed based on its watershed sensitivity. This limit, or lower Threshold of concern (TOC), has been estimated to be 4% for highly sensitive watersheds, 5% for moderately sensitive watersheds and 6% for watersheds with a low sensitivity. The purpose of the lower TOC is to identify those watersheds where the risk of CWE could occur to conduct a detailed, field based, cumulative watershed effects analysis. Sub-watersheds currently under the lower TOC have been determined to not have concerns for CWE and are not further analyzed in the detailed CWE analysis.
5) Management activities can be measured in terms of equivalent roaded acres (ERA). This is referred to as the ERA Model.
6) Key indictors of unacceptable degradation can be identified for watershed processes. An indicator of a cumulative watershed effect response could be one or more of the following: filling of channel pools with fine sediment; unstable channel banks; and/or poor aquatic habitat.
7) Activities causing land disturbance recover in 30 years.
8) The potential for initiating adverse CWE can be reduced by:
    a. Dispersing land disturbing activities in time and space.
    b. Controlling the physical size, shape, location and timing of land disturbing activities.
    c. Implement Best Management Practices to mitigate adverse on-site effects.
9) Watersheds will not reach or exceed the upper TOC of 14%.

The Baseline Assessment established that past impacts had raised some sub-watersheds to percent Equivalent Roaded Acres (%ERA) levels that exceeded their lower Threshold of Concern (TOC). As a result of the baseline assessment, nine sub-watersheds were identified to have a detailed CWE assessment. The detailed CWE assessment included field evaluation of channel conditions and aquatic habitat. Field data considered in the detailed analysis includes: channel condition in terms of channel bank stability and pool frequency and size, watershed improvement inventory data in terms of the number of sites found and the amount of erosion and sediment they may be contributing to the fluvial system, and aquatic species observed during aquatic surveys. These findings were documented in a report dated June 10, 2005 by Sanders and Hopson. Review of the data between the draft and final EIS determined that sub-watershed 519.0057 is also over the lower TOC. The detailed assessment for sub-watershed 519.0057 is summarized in a report dated August 8, 2006 by Gott and Sanders. In addition, the Detailed Cumulative Watershed Analysis Report for the 2000 Bear Meadow Project was also used to document available data and existing conditions. The ERA calculations from the Baseline Assessment are displayed in Table 3-56.

Table 3-56 – Summary of ERA by sub-watershed.

Sub-watershed Number	Size (ac)	Natural Sensitivity	TOC	Existing (2006) ERA	2007 ERA	2008 ERA	2009 ERA	2011 ERA	2036 ERA
519.0005	1140	High	4%	3.16%	*4.28%*			3.79%	2.11%
519.0006	630	Moderate	5%	2.71%		2.59%		2.41%	1.91%
519.0007	1719	High	4%	3.75%	*12.72%*			*13.79%*	2.53%
519.0008	1976	Low	6%	3.90%	*13.79%*			*11.57%*	2.31%
519.0009	**1335**	**High**	**4%**	**7.72%**			**7.11%**	**6.50%**	**3.51%**
519.0011	1246	Moderate	5%	3.91%	*11.82%*			*9.76%*	1.47%
519.0055	1574	Moderate	5%	3.55%	4.14%			3.59%	2.43%
519.0056	914	Moderate	5%	3.56%	*6.55%*			*5.78%*	3.46%
519.0057	**1078**	**Moderate**	**5%**	**7.16%**	**13.73%**			**11.44%**	**2.58%**
519.2001	2228	Moderate	5%	3.41%		3.38%		3.23%	2.89%
519.2002	2173	Moderate	5%	1.53%				1.43%	1.41%
519.3001	1484	Moderate	5%	2.69%			4.21%	4.05%	2.76%
519.3002	534	Moderate	5%	4.71%			*5.11%*	*5.07%*	4.74%
519.3003	716	Moderate	5%	2.08%			*7.46%*	*6.92%*	2.41%
519.3004	746	Low	6%	4.66%			*11.61%*	*10.91%*	5.12%
519.3052	727	Low	6%	1.97%			*10.00%*	*9.20%*	2.51%
519.3053	**2083**	**Moderate**	**5%**	**8.85%**			**9.16%**	**8.25%**	**2.31%**
519.4001	1828	Moderate	5%	1.13%	1.24%			1.10%	0.85%
519.4051	**1402**	**High**	**4%**	**4.69%**	**10.20%**			**8.06%**	**1.74%**
520.0013	439	Moderate	5%	3.26%	3.26%			2.58%	2.46%
520.0014	**1066**	**Moderate**	**5%**	**5.54%**	**10.22%**	**10.81%**		**9.30%**	**2.32%**
520.0015	2014	Low	6%	2.51%	*6.31%*			5.33%	1.38%
520.0016	591	Low	6%	2.71%	5.60%	*12.11%*		*10.81%*	3.03%
520.0017	1952	Moderate	5%	1.99%	3.84%	*7.67%*		*6.80%*	1.89%
520.0053	2189	Low	6%	2.34%		2.56%		2.17%	1.51%
520.0054	959	Low	6%	2.62%		2.87%		2.60%	1.67%
520.0055	1757	High	4%	2.26%		2.28%		2.12%	1.75%
520.0056	1209	Moderate	5%	2.98%	*13.99%*	*13.97%*		*12.39%*	3.33%
520.0057	1431	Moderate	5%	4.19%	4.72%	*9.75%*		*8.76%*	3.43%
520.1002	**1878**	**High**	**4%**	**6.22%**		**9.80%**		**8.18%**	**2.51%**
520.1051	**1411**	**High**	**4%**	**5.10%**		**11.72%**		**9.82%**	**2.52%**
520.1101	**1258**	**High**	**4%**	**7.02%**		**11.53%**		**10.08%**	**4.51%**
520.1151	**837**	**High**	**4%**	**4.33%**		**8.16%**		**7.40%**	**3.76%**
520.2001	2010	Moderate	5%	1.70%		1.73%		1.71%	1.67%
520.2051	2020	High	4%	2.34%		2.35%		2.30%	2.18%
520.3002	1661	Moderate	5%	4.87%		*10.26%*		*9.32%*	4.43%
520.3052	2206	Low	6%	2.45%		2.47%		2.46%	2.44%
520.3151	1317	Low	6%	2.57%		2.60%		2.49%	2.42%
520.4001	2023	Low	6%	1.81%	1.84%			1.61%	1.48%
520.4051	176	High	4%	1.34%	*5.07%*			*4.27%*	1.23%
520.4052	1309	Low	6%	3.10%	3.13%			2.62%	2.09%
520.5051	1582	High	4%	1.77%		2.13%		1.81%	1.34%

ERAs that exceed the lower TOC are shown in italics. Sub-watersheds that exceed the lower TOC prior to project implementation are shown in bold.

Nine of the 42 sub-watersheds, found to be over the lower TOC in the Baseline Assessment, were evaluated in the CWE Detailed Assessment (Gallegos 2006a). The information on the current condition of these areas that was gathered for the Detailed Assessment is presented in Table 3-57. The following is a summary of physical and biological conditions of the eight sub-watersheds where CWE are a concern.

Table 3-57 - Information gathered for the Detailed Cumulative Watershed Effects Analysis for the nine sub-watersheds identified as over their lower Threshold of Concern.

Sub-ws ID	Lower TOC	Existing ERA	Proposed ERA	Channel Condition	V*	Aquatic Species Observed	WIN Sites[16]
519.0009	4%	7.72%	7.11%	Mixed Stable & Unstable	25%	WPT/CN/PTF/ GS	8
519.0057	5%	7.16%	13.73%	Unstable	20-60%	TRT	10
519.3053	5%	8.85%	9.16%	Mostly Stable	70-90% [1]	WPT/CN/PTF/ GS/TRT Poor to moderate aquatic habitat	6
519.4051	4%	4.69%	10.20%	Stable	18%	WPT/RSS/GS/ TRT	8
520.0014	5%	5.54%	10.81%	Stable	10% [1]	No Data	7
520.1002	4%	6.22%	9.80%	No Data	58%	No Data	12
520.1051	4%	5.10%	11.72%	Unstable	51% & 49%	No species observed	25
520.1101	4%	7.02%	11.53%	Mixed		GS	
520.1151	4%	4.33%	8.16%	Unstable	45% & 61%	TRT	4

[1] = V* value visually estimated, not measured.

Aquatic Species Observed: WPT = Western Pond Turtle; CN = California Newt; PTF = Pacific Tree Frog; GS = Garter Snake; TRT = Trout; RSS= Relictual Slender Salamander

Sub-watershed 519.0009 - Approximately 3.3 acres of treatment stand 553 in the n_soapro_2 Management Unit is located on a ridge top in this sub-watershed. The Detailed Assessment found a mixture of stable and unstable channel banks in Ackers Creek. V* measured in 1996 met the DC. Surveys in 1999 noted that the sub-watershed's channels contain mostly small, shallow pools. A V* reach located at the confluence of this channel and Big Creek found residual pool filling of 25% in 1996 (Gallegos 2004). Watershed improvement needs inventories (WINI) collected between 1991 and 2004 indicate there are eight erosion problems documented in the sub-watershed. Seven of the problems were associated with system and non-system roads and one site is associated with grazing. The small acreage is insignificant and will not add to CWE. Therefore, this sub-watershed will not be discussed further in this analysis.

Sub-watershed 519.0057 is located in the providen_1 Management Unit and includes a reach of Big Creek between Summit Creek and Providence Creek and an unnamed tributary to Big Creek. Channel reaches in Big Creek are unstable, and some channel types are characterized as sensitive to disturbance. A survey performed in an ephemeral tributary suggests that large quantities of fine

[16] WIN = Watershed Improvement Needs, an established USFS program whose purpose is identifying, tracking, and repairing and monitoring watershed erosion problems.

sediment are being transported in that channel. The road system in this area (10S75) is badly gullied and crosses drainages in 45 locations. A large proportion of the sediment that has been removed from these roads is likely to have been delivered to tributary channels. V* measurements taken in Big Creek in 1995 indicated that pools were up to 60% filled with sediment in the upper portion of the sub-watershed, which exceeds the DC. Measurements near the downstream end of the sub-watershed were taken in a transport reach, where V* was just over the desired condition. Fourteen WIN sites have been documented in this sub-watershed, most of them describing erosion associated with roads or bank erosion in Big Creek. Of these sites, four were not found to be problems in 2005, which leaves 10 sites un-addressed. Based on the available data it appears that this sub-watershed is experiencing CWE.

Sub-watershed 519.3053 is located in the n_soapro_2 Management Unit in lower Rush Creek. The existing ERAs are 8.79%, which includes 367 acres of treatment in the South of Shaver Project. The CWE analysis for the South of Shaver Project concluded that it is unlikely to incur a CWE response. However, an additional review of two reaches of Rush Creek for this project indicated that a CWE response may already be occurring. It was estimated that channel pools are filled 70-90% of their volume with fines. This sub-watershed has mostly stable stream reaches with infrequent small pools. Inventories of watershed improvement needs (WINI) collected between 1991 and 2004 indicate six erosion problems. A 2004 air photo analysis identified thirteen skid trails/roads in the sub-watershed. Some of these trails are currently used by off highway vehicles; however no resource damage associated with these features has been reported (Morales and others 2004). Ongoing development of the Wildflower Subdivision, timber harvest on private land in the sub-watershed immediately upstream, and OHV use including the annual Mountain Toppers Blue Canyon OHV event, are likely some of the primary sediment sources. Based on the available data it appears that this sub-watershed is experiencing CWE.

Sub-Watershed 519.4051 is located in the providen_1 Management Unit. This sub-watershed has mostly stable stream reaches. V* collected near the mouth of Summit Creek in 1995 indicated that fine sediment in pools was approximately 12%, which meets DC (Gallegos 2004). V* in Big Creek was approximately 20% upstream and 60% downstream of the confluence. The only indication of excessive sediment in this sub-watershed is in the first perennial tributary on the east side of Summit Creek. Pool infilling (V*) was estimated in a 2004 survey to be 50% in this channel, and could be an effect from past management activities. Watershed improvement needs inventories (WINI) collected between 1995 and 2004 indicate eight erosion sites are present. Each site appears to be channel erosion initiated or influenced by culverts at road/stream crossings. Gully head cuts are located on an unnamed tributary to Summit Creek. Based on available data it does not appear that this sub-watershed is experiencing a CWE.

Sub-watershed 520.0014 is located in the el_o_win_1 Management Unit in Dinkey Meadow Creek. Approximately 75% of the 1066 acre watershed is privately owned. Southern California Edison has treated 320 acres of the private land as recently as 1995 and 2005. There is no evidence of a CWE response, or an increased risk of a CWE response, to these recent activities. Visual observations showed stable stream banks and little sediment in the channel. Large woody debris was common throughout the reach. Measurements of sediment depth in pools suggest that sediment accumulation is on the order of 10%, which meets DC. Embeddedness, a measure of fine sediment intrusion into the channel substrate (primarily gravels) was low throughout the reach. Aquatic species survey data is not available for this sub-watershed (Hopson 2005). Based on the available data it does not appear that this sub-watershed is experiencing a CWE.

Sub-watershed 520.1002 is located in the bear_fen_6 Management Unit in upper Bear Meadow Creek. This sub-watershed has no channel condition data or aquatic species survey data. A V* reach is located at the downstream end of the sub-watershed. Data collected in 1997 indicated that pools had residual pool filling of almost 60% (Gallegos 2004), clearly exceeding DC. Watershed improvement needs inventories (WINI) indicate several erosion problems. Twelve sites have been identified between 1989 and 1998. Most of the erosion problems are associated with roads or old skid trails. Based on the available data it appears that this sub-watershed is approaching a threshold for CWE and could be experiencing CWE.

Sub-watershed 520.1051 is located in the bear_fen_6 Management Unit in lower Bear Meadow Creek. Sub-watershed 520.1051 and sub-watershed 520.1001 have been combined into one sub-watershed because sub-watershed 520.1001 does not meet the criteria for watershed size for a cumulative watershed effects analysis. Bear Meadow Creek is the main channel in this watershed and it has a highly sinuous stream with unstable, down-cut banks and very fine particle size stream bottoms. Fence Meadow Creek is also located in sub-watershed. A channel analysis in 1999 indicated that this channel was fairly indistinct. In 1991, trample and chisel data collected for the Dinkey cattle allotment found 26% disturbance of the stream channel from cattle, which exceeded the DC of 20% maximum bank disturbance. In 1991 a channel analysis indicated that stream channel was poor, and the area was heavily cut-over from the 1989-1990 Fence Green timber sale. Two V* reaches established in 1995 and 1996 indicate that filling of pools was approximately 50%. Channel surveys of 1989 also showed the stream in poor condition. No aquatic species have been found in surveys to date in this sub-watershed. Watershed improvement needs inventories (WINI) indicate 25 WIN sites recorded between 1989 and 1998. Nearly all of the problems are associated with roads and skid trails. Only one site was non-road related, documenting heavy accumulation of fine sediment in Bear Meadow Creek.

A CWE analysis was conducted on March 16, 2000 for the Bear Meadow Project. The project proposed to mechanically treat vegetation in this watershed. The analysis concluded that the upper reaches of Bear Meadow Creek contain excessive sediment and have areas of channel down cutting. Extensive gullies and unstable channels are present in the upland watershed areas, upstream from reaches in Bear Meadow Creek containing high sediment loads. Soil compaction was found to occur over approximately 20% of past activity areas. Compacted soils located throughout the Bear Meadow project area have sufficiently decreased infiltration to increase runoff. This increases peak flows leading to channel adjustment including down cutting and greater sediment loading. These changes were concluded to constitute a cumulative watershed effect from past management activity (CWE Team, 2000).

Sub-watershed 520.1101 is located in the bear_fen_6 Management Unit and encompasses upper Oak Flat Creek. Channel surveys were conducted in 2004 along the 1,180 meter stream reach in section 5. The channel was characterized as a steep, deeply entrenched channel with mostly sands with flatter, unstable areas. Only a single garter snake was found during the survey. No Watershed Improvement Needs sites are recorded in District files.

Sub-watershed 520.1151 is located in the bear_fen_6 Management Unit and encompasses the lower half of Oak Flat Creek. Surveys between 1990 and 1999 indicate that fines in pools have been high since at least 1990, and may have increased from approximately 30% in 1995 to 45 – 60% measured in 2004. Surveys in 1999 described an unstable stream channel but some good fish habitat. Watershed improvement needs inventories (WINI) collected between 1989 and 2002 record four erosion sites in this sub-watershed. Three of the locations were related to road conditions. Two of the sites were repaired in 2003.

The conclusions of the Detailed Assessment are described in the Environmental Consequences section describing the Cumulative Effects of the Action Alternatives.

CWE – Erosion and Sediment Delivery Estimates

Sediment production was modeled for the Bear Meadow sub-watershed using GeoWEPP watershed modeling software (GeoWEPP, 2006). This sub-watershed was modeled as an example of the amount of sediment produced under several scenarios including the existing condition (No Action Alternative), the Proposed Action (Alternative 1), the No Action Alternative with a wildfire in the year 2015, and the Proposed Action with a wildfire in the year 2015.

The GeoWEPP software uses ArcView and digital elevation models (DEM) to create a channel network and catchments for a selected outlet point. In addition, the model uses climate data, soil data, slope data and management data to predict erosion and sediment under different scenarios. William Elliot provided assistance in customizing data input files including the soils and management files. Data from Yosemite National Park Climate was used as the climate data for the model. This climate file contains precipitation data similar to conditions in the proposed treatment area. Soils data from the Order 3 Soil Survey (Giger 1993) was used. Erosion and sediment prediction in the GeoWEPP model is sensitive to soil texture. Therefore, soil data from the soil survey was grouped into three classes based on soil texture. The Holland family taxonomic description was used to characterize fine textured soils. These soils represented other fine textured soils in the project area. The Shaver family taxonomic description was used to characterize coarse textured soils. The third class in the soils file is actually not a soil, but rock outcrop. Some outcrop exists in the project area and this rock outcrop sheds most of its precipitation, creating rapid runoff. Slope files were generated from 30m DEMs acquired from the Geospatial Spatial Data Center (GSDC). These files were processed and prepared in ArcMap. Management files were customized to model the proposed action. The most sensitive variable in the model that the proposed action would alter from the existing condition is soil cover.

The GeoWEPP estimate of the hillslope sediment production rate for the existing condition is approximately 2.8 tons/ha/yr (1.10 tons/ac/yr) with approximately 2,743 tons/yr of sediment produced in the bear_fen_6 management unit (see Table 3-59). Sediment production rates from the roads is estimated at 106 to 186 tons/yr (using WEPP:Road sediment production rates), or 10 to 20 tons/yr from roads using Korte and MacDonald's sediment production rates. Modeling for the existing condition used 99% cover for all slopes including the private land in the north part of the Bear Meadow Creek sub-watershed and the areas that are proposed for treatment. The model showed that most sediment is produced on the steeper slopes, especially the headwater slopes in the tributary channels of Bear Meadow Creek.

Environmental Consequences

The format of the discussion of Environmental Consequences includes a General Discussion of effects consisting of a literature review, followed by sections that describe the predicted effects of the various alternatives.

The effects of the No Action alternative will be described in terms of the potential effects of the modeled wildfire described at the beginning of Chapter 3 and in the Fuels section.

General Discussion

Effects of Timber Harvest on Flows and Water Quality: Most of the existing research on the effects of timber harvest on stream flows has examined the effects of clearcutting or other intensive treatments, and as a result, much of the understanding of the hydrologic effects of thinning is based on inference rather than direct study (Robichaud and others2006; Troendle and others 2006).

Researchers have concluded that if less than 10% of the basal area is removed, there is little impact on flows. This is supported by paired watershed studies and by modeling (Troendle and others 2006). With removal of between 10 and 20% of basal area, flow is affected but the change is not detectable due to the natural variability of flow. Many investigators have found that approximately 20% of the basal area must be removed before a statistical change in flow is detected (Troendle and others 2006). MacDonald and Stednick (2003) state that 15% basal area must be removed before a change in flow can be detected in small research watersheds, and detection becomes more difficult as watershed size increases. The percent change in basal area for each sub-watershed in each alternative is presented in Table 9. The maximum change is 12.1%. Most values are below 10%. This will be discussed further under the Environmental Consequences of each alternative.

There are several mechanisms by which timber harvest affects stream flows: changes in interception of precipitation, changes in snow accumulation and snowmelt (important in snow-dominated areas but less so in rain-dominated and 'warm snow' zones such as the project area), and changes in available soil moisture due to decreased evapotranspiration.

The change in interception is related to the change in canopy. Interception losses may account for 25-35% of the annual precipitation received in cold snow zone conifers, and 10-12% in deciduous forests (Troendle and others 2006). In the Rocky Mountains, any reduction in stand density will increase snowpack accumulation. This effect may occur in the project area, and would be most important in the glen_dw_1, el_o_win_1, bear_fen_6 and krew_bul_1 management units. The management units in the Big Creek watershed receive snow, but are not snowmelt dominated. Although this literature review found that interception changes were also reported as proportional to changes in basal area, the changes in canopy for the different alternatives are also displayed in Table 3-58. In general, canopy changes are slightly lower than basal area changes because the majority of trees removed are not the dominant canopy-forming trees. They are intermediate or suppressed trees that are growing under the dominant canopy.

Potential increases in peak flows are related to changes in snow accumulation and snow melt. This would apply mostly to the snow-dominated portions of the project area: el_o_win_1, glen_mdw_1, bear_fen_6 and krew_bul_1. Troendle and others (2006) note that there is debate over the effects of harvest on peak flows in maritime climates where mid-winter rain-on-snow events are responsible for the highest peak flows. They state that rain-on-snow events with warm wind increase snow melt the most, suggesting that changes in wind speed at the snow surface is a key element in determining the magnitude of the effect. Turbulence theory research has shown that widely-spaced objects can reduce turbulence at the bottom surface, so thinning may result in little increase from this process. In a study of the effect of the spatial arrangement of trees after thinning, Woods and others (2004) found that snow accumulation measured at the stand scale did not change in group selection cuts which left trees in patches, but increased by 35% when thinned trees were left evenly spaced. Both of their study units had 60% of the basal area removed.

In the group selection patches, the effects on snow accumulation would probably be similar to the effects of small clearcuts. Woods and others (2004) cite studies that found that small clearcuts (2 to 5 tree height diameters) accumulate more snow than the surrounding forest while large clearcuts (more than 20 tree heights in diameter) accumulate less snow because of wind scour and evaporation losses. The patch cuts proposed in this project are a maximum of 3 acres in size, which is similar to the small clearcut size. Therefore, these openings can be expected to accumulate more snow than prior to treatment.

Table 3-58 - Percent change in basal area and canopy cover for each of the three alternatives. The sub-watersheds that are currently over their lower Threshold of Concern for CWE are shown in bold.

Sub-watershed Number	Alt 1 Proposed Action		Alt 2 No Action		Alt 3 30-inch Alternative	
	BA	Canopy	BA	Canopy	BA	Canopy
519.0005	0.0	0.0	0.0	0.0	0.0	0.0
519.0007	3.6	2.7	0.0	0.0	3.5	2.6
519.0008	7.3	6.1	0.0	0.0	6.6	5.6
519.0009	**0.3**	**0.3**	**0.0**	**0.0**	**0.3**	**0.3**
519.0010	0.0	0.0	0.0	0.0	0.0	0.0
519.0011	8.0	7.4	0.0	0.0	7.5	7.0
519.0012	0.4	0.4	0.0	0.0	0.4	0.4
519.0055	4.1	3.6	0.0	0.0	3.7	3.1
519.0056	3.6	3.1	0.0	0.0	3.2	2.8
519.0057	**6.4**	**4.6**	**0.0**	**0.0**	**6.3**	**4.5**
519.2001	0.0	0.0	0.0	0.0	0.0	0.0
519.3001	5.6	3.0	0.0	0.0	5.5	3.0
519.3002	0.8	0.7	0.0	0.0	0.7	0.7
519.3003	4.0	3.4	0.0	0.0	3.8	3.4
519.3004	3.1	2.6	0.0	0.0	3.0	2.5
519.3005	5.8	5.1	0.0	0.0	5.3	4.7
519.3052	12.1	9.7	0.0	0.0	11.8	9.6
519.3053	**2.5**	**1.7**	**0.0**	**0.0**	**2.9**	**1.9**
519.4001	0.2	0.1	0.0	0.0	0.2	0.1
519.4051	**5.8**	**4.3**	**0.0**	**0.0**	**5.7**	**4.2**
520.0014	**3.8**	**3.3**	**0.0**	**0.0**	**3.4**	**3.0**
520.0015	1.8	1.4	0.0	0.0	1.6	1.3
520.0016	11.3	9.5	0.0	0.0	9.9	8.5
520.0017	4.8	4.4	0.0	0.0	4.2	3.8
520.0053	0.3	0.2	0.0	0.0	0.3	0.2
520.0054	0.8	0.8	0.0	0.0	0.8	0.7
520.0055	0.1	0.1	0.0	0.0	0.1	0.1
520.0056	10.0	9.2	0.0	0.0	8.8	8.2
520.0057	4.4	4.2	0.0	0.0	4.3	4.0
520.1001	2.0	1.5	0.0	0.0	1.9	1.5
520.1002	**1.8**	**1.6**	**0.0**	**0.0**	**1.7**	**1.5**
520.1051	**6.4**	**5.4**	**0.0**	**0.0**	**5.9**	**5.1**
520.1101	**6.2**	**5.1**	**0.0**	**0.0**	**6.0**	**5.0**
520.1151	**4.2**	**5.4**	**0.0**	**0.0**	**4.1**	**5.3**
520.2001	0.0	0.0	0.0	0.0	0.0	0.0
520.3002	4.5	5.1	0.0	0.0	4.0	4.7
520.3052	0.0	0.0	0.0	0.0	0.0	0.0
520.3151	0.0	0.0	0.0	0.0	0.0	0.0

Sub-watershed Number	Alt 1 Proposed Action		Alt 2 No Action		Alt 3 30-inch Alternative	
	BA	Canopy	BA	Canopy	BA	Canopy
520.4001	0.1	0.1	0.0	0.0	0.1	0.1
520.4051	9.9	8.7	0.0	0.0	8.9	8.1
520.4052	0.1	0.1	0.0	0.0	0.0	0.0
520.5051	0.3	0.5	0.0	0.0	0.3	0.5

Studies have found base flow increases after clearcutting. In Caspar Creek in northwestern California, after 67% of the timber volume in the watershed was removed, Keppeler and Ziemer (1990) found that the summer low flows were 14 to 55% higher than predicted based on the relationship between the watershed pre-harvest and an unlogged control. The number of days with flow lower than threshold value decreased by 40% after harvest. In Oregon, Hicks and others (1991) found that clearcutting increased low flow by 25% for 8 years, and then dropped below the unlogged control.

When a stand is thinned, the remaining vegetation captures at least a portion of the excess soil water, and the increase in water available for base stream flow is moderated. Troendle and others (2006) state that the potential for thinning to have an effect on streamflow due to reduced evapotranspiration depends on the amount of precipitation. In wet summers, there may be surplus water to contribute to increased stream flow, while in dry years; it is likely that the residual stand will use all of the available water. If the climate is dry in the summer and rainy in the winter, as in the management units in the Big Creek watershed, then the largest changes in runoff would occur during fall and early winter (Robichaud and others 2006). In snow-dominated areas such as the management units in the Dinkey Creek watershed, nearly all of the change in flows would occur during spring runoff, and spring runoff may occur slightly sooner if reductions in canopy allow faster melting of the snowpack. Any increase in flows that results from thinning is not likely to persist for more than 5 – 10 years (Robichaud and others 2006). Lewis (2001) found that under wet antecedent moisture conditions, flows in a partially clearcut watershed increased 3% compared to 23% in a clearcut watershed.

Effects of timber harvest on water quality could include increases in sedimentation caused either by the transport of eroded material out of harvested areas into stream channels, or by increased flows that result in channel erosion that in turn increases sedimentation. Best Management Practices (BMPs) are applied to minimize erosion and sediment delivery to streams. MacDonald and Stednick (2003) note that forest harvest and fuels treatments should have little effect on water quality if they are well-planned and BMPs are implemented.

Monitoring of BMP on Forest Service lands in California has shown that, when implemented, timber management BMP are 95-98% effective (USDA 2004). An exception is Streamside Management Zones, which were found to be 85% effective due to inadequate implementation (failure to properly identify SMZ on the ground). However, meadow protection was 98% effective. The Monitoring Report (USDA 2004) identifies a need to improve the implementation and effectiveness rates of timber management BMP, and presents a plan for accomplishing this goal that includes training and additional monitoring of these BMP. These measures are included in the Monitoring Plan for this project. The IDT has invested several days in refining treatments within SMZs (reflected in the SMZ prescription developed for Alternative 3), and in field checking the identification and application of SMZs.

Literature has shown that BMP are effective in minimizing the erosion in harvest units and at preventing sediment from reaching streams. In a study of sediment redistribution after harvesting, Wallbrink and Croke (2002) found that sediment eroded from skid trails was deposited in the harvest unit and the 23–30 m wide stream buffers. Water bars were found to be very effective at reducing coarse sediment loads, and finer sediment was deposited in the 5m below the water bar outlets. The stream buffers trapped more sediment per unit area than the harvested area. In a review of published studies of buffer strip effectiveness, Norris (1993) notes that studies he reviewed indicate that buffer zones are effective at reducing sediment concentrations in runoff.

Effects of Mechanical Fuels Treatments on Flows and Water Quality: Few studies have evaluated the effects of mechanical fuels treatments such as mastication, 'brush crushing', or tractor piling. Reid (2006) notes that the change in the density of live vegetation is not expected to be great enough to change stream flows.

A Hydro-Axe treatment reviewed by Robichaud and others (2006) increased wood groundcover slightly but also slightly increased bare ground. No runoff was generated from the site with 1.6 inches of rain within 30 minutes, at a maximum intensity of 2.4in/hour. Hatchett and others (2006) found that simulated rainfall on plots with post-mastication woodchip groundcover yielded no runoff during the normal rainfall rate of 2.9 inches per hour. Increasing the simulated rain intensity to 4.7 inches per hour (noted to be a high, rare intensity) did yield runoff and sediment from the plot, which they calculated to be 32% of the sediment yield from bare soil plots in their study.

According to Reid (2006), the impacts of mechanical fuel treatments on erosion and sediment yield are likely to result from direct soil disturbance where these activities affect swales and low-order stream channels. In this project, swales and Class V channels have no SMZs – mechanized access is not prohibited and could occur. Class IV channels have a 25-foot SMZ where equipment is excluded. BMP 1-19 prescribes practices to mitigate the potential effects, including requiring that stream crossings on Class IV and V streams be agreed to by the sale administrator. Unscoured swales that are dry during operations receive no special protection.

Activities that will be accomplished by hand, such as felling and leaving trees, hand piling, and planting, are assumed to have no effect on hydrology or water quality (Robichaud and others 2006). The Soils analysis concluded that these activities are not likely to increase erosion.

Effects of Roads on Flows and Water Quality: A synthesis of existing information on the effects of forest roads (Gucinski and others 2001) lists effects of roads on hydrologic processes: they intercept rainfall on the road surface and subsurface flow at cutbanks, and they concentrate flow on the road surface or in a ditch. Both of these effects divert water from the flow paths normally taken. When roads concentrate surface flow and deliver it to streams via surface flow paths, they operate as extensions of the drainage network and functionally increase drainage density (Wemple and others 1996). Areas with higher drainage density tend to have higher, faster peak flows as a result of precipitation. Wemple and others (1996) found 57% of the road length in their study was hydrologically connected to streams, which means that surface runoff was delivered directly into streams via stream crossings or gullies formed at culvert outlets. In a study of forest road segments on the Eldorado National Forest, Coe (2006) found that 25% of the road segments surveyed were hydrologically connected. Robichaud and others (2006) note that studies in the western US have found between 23 and 75% hydrologic connectivity of roads.

Robichaud and others (2006) describe three studies that were able to isolate the effects of forest roads alone (not in combination with other forest management actions) on stream flow. These studies in Colorado and Idaho were unable to detect a change in runoff from roads that occupied 2 – 4 percent of the watershed area. Jones and Grant (1996) suggested that roads could intercept increases in subsurface water resulting from clearcuts, convert it to surface water and deliver it to streams. The literature suggests that roads may affect peak flow timing and magnitude, but do not affect annual yield (Gucinski and others 2001).

Studies have consistently shown that roads produce more sediment than other forest management practices (Robichaud and others 2006). Schnackenberg and MacDonald (1998) found that fine sediment in their study stream channels in Colorado was more strongly correlated with the number of road crossings than with the Equivalent Clearcut Area (similar to the Equivalent Roaded Acres used in this analysis, but indexed to the effects of clearcuts rather than to roads) in the watershed.

Reid and Dunne (1984) found that road erosion rates tended to increase with increased traffic and with heavier vehicles. Timber harvest and other forest management projects can result in increases in the amount of heavy truck traffic.

Road design can mitigate these effects by controlling runoff and minimizing erosion. Maintenance is required on most roads to ensure that they function as designed, but Luce and Black (1999) found a short-term increase in erosion related to maintenance, especially cleaning inboard ditches. BMPs can also be used to mitigate the effects of roads. For example, Coe's study (2006) on the Eldorado NF found that native surface roads produced 10-25 times more sediment than rocked roads.

Rocking roads and reducing the length of roads hydrologically connected to the channel system will also reduce sediment. If half of the road crossings are redesigned to reduce hydrologic connectivity, sediment could be reduced by as much as 250 tons/yr based on WEPP:Road sediment production rates, or 25 tons/yr based on Korte and MacDonald's sediment production rates. This amounts to approximately 2 miles of road, and over ten years, sediment will be reduced by as much as 2500 tons (WEPP) to 250 tons (Korte and MacDonald).

<u>Effects of Herbicides (Glyphosate and R-11) on Water Quality:</u> A review of studies by Ghassemi and others (1981) states that glyphosate rapidly attaches to organic matter on top of or in the soil and its mobility is very limited. Because of its low mobility in soil, the only mechanism for off-site movement is soil erosion and transport. Normal hydrolysis in a stream will not break the attachment of glyphosate to soil particles. This means that even if glyphosate bound to soil particles reached surface water, it would not be in a form that could be taken up by plants or animals. It would not affect surface or ground- water quality.

From 1991 to 2000, surface water adjacent to seven projects using glyphosate on the Sierra, Stanislaus, and Eldorado National Forests was monitored. There were no detections (Bakke 2001) with detection limits ranging from 6–25 ppb, depending on the study.

<u>Effects of Wildfire and Prescribed Fire on Flows and Water Quality</u>: Many investigations of wildfire effects on hydrologic processes have found increases in stream flows and in sedimentation. MacDonald and Stednick (2003) state that wildfire poses the biggest threat to water quality in forested areas.

Changes in soil properties such as removal of organic ground cover and creation of water repellent (hydrophobic) conditions result in decreased infiltration capacity and increased runoff. This leads to larger and flashier peak flows and more erosion on hillslopes. Wondzell and King (2003) identify three mechanisms by which fire affects hydrology: 1) decreasing canopy interception increases the proportion of precipitation available for runoff; 2) decreasing evapotranspiration increases base flow; and 3) consuming ground cover increases runoff velocity and reduces infiltration and storage as soil moisture. Robichaud and others (2000) state that surface runoff can increase by 70% and erosion by three orders of magnitude when ground cover is reduced from 75% to 10%.

Fire severity has a large effect on erosion and sediment yields. Shakesby and Doerr (2006) report a study in Utah that estimated that in a burned area with 60-75% ground cover, 2% of rainfall contributed to overland flow while in an area where only 10% cover remained, over 70% of the rainfall ran off. In a study of post-fire erosion from simulated rainfall, Benavides-Solorio and MacDonald (2001) found that sediment yields from high burn severity plots was 10-26 times greater than from low severity and unburned plots. Ground cover accounted for 81% of the variability, including lower sediment yields found in older, recovering burned areas.

Sediment yield increases are usually the highest the first year following a fire (Robichaud and others 2000), then decease as groundcover increases, vegetation becomes established, and water repellency recovers (Neary and others 2005, Shakesby and Doerr 2006). Some studies have found that more of the observed sediment load increases were due to in-channel erosion than to hillslope erosion (Shakesby and Doerr 2006). Wondzell and King (2003) note that it is difficult to determine how large episodic sediment inputs factor into the sediment budget of a watershed, and that post-fire mass-wasting events such as landslides and debris flows exert lasting effects on stream channel morphology.

Post-fire peak flows increase more in smaller drainages than in larger ones. Bigio and Cannon (as cited in Neary and others 2005) found in their compilation of post-wildfire runoff data that the average unit area discharge from watersheds less than 1km^2 in size was 17,660 cfs/mi^2 (193 m^3/s/km^2), while the average for watersheds between 1 and 10 km^2 was 2,077 cfs/mi^2 (22.7 m^3/s/km^2). Intense rainfall produces the greatest increases in peak flows (Neary and others 2005). Wondzell and King (2003) note the steep gradients in intensity and total precipitation of convective thunderstorms, which seldom results in a watershed receiving equal rainfall intensity over its entire area. It is more likely that small watersheds would receive intense rainfall over their entire area than larger watersheds, which may help explain Bigio and Cannon's findings.

Robichaud and others (2000) found that summer peak flows in chaparral in Arizona increased 5 – 15 fold after a wildfire, but winter peak flows did not change. They attribute this to less intense precipitation and less water repellency during the winter season.

Empirical studies have often found it difficult to demonstrate increases in water yield due to fire (Clark 2001). However, a study in Arizona found that annual water yield increased eight-fold in a 20-acre drainage the first year after a wildfire; the increase dropped to 3.8-fold the following year (Campbell 1977, as cited by Shakesby and Doerr 2006). Reviews by Shakesby and Doerr (2006) and Neary and others (2005) note a study in Washington that found a 42% increase in water yield the year following a fire, and others that found 9 and 12% increases in water yield in Oregon and South Africa.

Because prescribed fire is planned and implemented in a manner to control burn severity and specifically to limit high burn severity, the effects of prescribed fire are much smaller in magnitude than those of wildfire. In a study comparing sediment production from different sources, MacDonald and others (2004) found that severely burned areas produced 1,000 times more sediment than prescribed burn areas. Little sediment yield was found in a study in the northern Sierra Nevada where ignition was allowed within the riparian area; Beche and others (2005) found that V* did not change significantly. Zwolinski (2000) reports that low-severity fires (such as most prescribed fires) generally have little or no hydrologic impacts, even though most contain a small proportion of high burn severity. Robichaud's investigation of post-timber harvest prescribed fires in Montana and Idaho found 5 and 15% of those areas burned at high severity (Robichaud and others 2006).

Erosion and Sediment Delivery Analysis: An erosion and sediment analysis was conducted for the proposed project area. The analysis consisted of two components: 1) erosion and sedimentation rates from roads in the project area; 2) and erosion and sedimentation rates from the watershed slopes under the existing conditions (no action), the proposed action, no action with a wildfire fire, and the proposed action with a wildfire. The analysis was accomplished by using GeoWEPP to estimate watershed erosion, the WEPP:Road interface for estimating erosion from roads, and a site-specific study designed to estimate erosion and sedimentation from roads by Korte and MacDonald (2005). Sediment production rates were approximated by modeling the Bear Meadow Creek sub-watershed to demonstrate the impacts of the proposed action and the effectiveness of the measures that were designed to mitigate the impacts of the proposed action. The CWE analysis concluded that mechanical treatment of the proposed project area would not alter soil cover, therefore would not increase erosion. We assumed that prescribed burning would reduce soil cover by as much as 40% (North, personal communication, 2006[17]). Estimated sediment production rates from underburned watershed slopes are higher than estimated sediment production rates from hydrologically connected portions of roads.

The results of the analysis suggest that sediment delivery rates would be double the background hillslope delivery rate. Approximately 5.6 tons/ha/yr will be produced from underburning, with approximately 2,743 tons/yr of sediment produced in the Bear Meadow Creek sub-watershed (see Table 3-59). Modeling for the proposed action used 60% cover for all the proposed underburn slopes and 99% cover for all the private land in the north part of the Bear Meadow Creek. In addition, SMZs in Class I, II and III channels were assumed to have 75% cover in the outer 50 feet and 90% cover in the remaining inner portion. Sediment production the second year after the underburn treatment was predicted to return to background rates. As in the existing condition, sediment is mostly produced on the steeper slopes, especially the headwater slopes in the tributary channels of Bear Meadow Creek. This is probably due to the high density of channels and an assumed 60% soil cover in the steep headwater slopes. This may actually be higher and soil cover monitoring will validate this assumption.

Table 3-59 - Watershed analysis – Bear Meadow erosion and sedimentation analysis.

Scenario	Erosion (ton/ha/yr)	Sediment Yield (ton/ha/yr)	SDI	Sediment Discharge from outlet (tons/yr)
Existing	12.2	2.8	.231	2743
Proposed	46.28	5.6	.121	5424
Proposed 2nd Yr	30.11	2.8	.093	2688
Proposed w/ Fire	12.86	7.4	.575	8946
No Action w/ Fire	52.31	10.2	.195	12322

GeoWEPP analysis of the effectiveness of SMZs as sediment filter strips shows that SMZs filter 32% of sediment produced on treated slopes above (see Table 3-60). This sediment filtering effect seems to be low and may actually be higher especially since most of the ground is covered with bear clover and small woody debris. Monitoring will validate this assumption. Areas that are proposed for light-on-the-land harvest systems, like cut-to-length or whole tree yarding systems with grapple piling will result in at least 95% ground cover and sediment will not be increased over background rates.

[17] North conducted a study in 2002 in the Teakettle Experimental Forest, where he measured several soil and vegetation characteristics before and after mechanically treating and under burning forested areas. The results of his study will be published in the Journal Forest Ecology and Management pending review.

Table 3-60 - GeoWEPP hillslope analysis for selected SMZ.

Hillslope #	Location	Slope Length	Slope Grade (%)	Soil	Land Cover	Precip. (in)	Runoff (mm)	Erosion (ton/ac)	Sed Yield (SY) (ton/ac)
143 w/out	E. side BrMdw	1476	.1-31	SCL	60%	36.3	1.7	2.5	.9
92 w/out	W. side BrMdw	164	3-7	SCL	60%	36.3	1.7	0	0
173 w/out SMZ Rx	E side BrMdw Ck @ dog leg left	480	29-33	SCL	60%	36.3	1.8	1.6	1.6
172 w/out	W side BrMdw	304	23-32	SCL	60%	36.3	1.7	.6	.6
982 w/out	E. side BrMdw	751	15-27	SCL	60%	36.3	1.8	1.3	1.3
Total								**6.0**	**4.4**
143 w/					99%	36.3	1.8	2.4	.3
173 w/					75-	36.3	1.8	1.4	1.3
172 w/					75-	36.3	1.7	.3	.3
982 w/					75-	36.3	1.8	1.2	1.1
Total								**5.3**	**3.0**
SMZ Sediment Filter Effectiveness = SY w/out SMZ -Total SY w/ SMZ Rx - Rx times 100									**32%**

Sediment produced in the sub-watersheds that are over their lower TOC will be mitigated by implementing the watershed restoration component of the proposed action. In-stream sediment will be reduced by implementing restoration of the WIN sites identified in the proposed action. The estimated amount of sediment reduced by implementing the watershed restoration projects is approximately 10 -15 tons/yr. Rocking roads (as prescribed in the design measures for Alternative 1 and Alternative 3) and reducing the length of roads hydrologically connected to the channel system (as prescribed in the design measures for Alternative 3) will also reduce sediment. Prescribed burning cannot be mitigated to the same degree as other treatments. Increases in sediment will be mostly in the steep headwater slopes in the proposed underburn areas. Not treating in Class I, II and III SMZ will also have an effect of less fuel on the ground and more ground cover after under burning.

Riparian Conservation Objectives Consistency Analysis: An analysis was conducted to determine the level of consistency of each alternative with the Riparian Conservation Objectives outlined in the Sierra Nevada Forest Plan Amendment (2004). The results are described in the following effects section for each alternative (refer to the project files for the full report).

Alternative 1 – Proposed Action

Direct Effects

Direct effects from mechanized equipment operation and skidding of logs during timber harvest and mechanical fuels reduction will occur under this alternative in swales without channels and in Class V channels, because these areas are not protected by SMZ (see BMP 1-8). These impacts are not expected to affect flows, but may increase sediment available for transport downstream for a few years following activity (Reid 2006). Literature supports that the volume of sediment available generally drops dramatically after the first year and is recovered within three years (Stednick 2000). Based on the method for assigning SMZ described in Appendix E, the number, length, and location of these areas are unknown – the first order streams on the stream layer in GIS are assumed to be Class IV and will receive 25-foot SMZ. This approach should minimize the number of drainage features with no SMZ, and thereby minimize this potential effect. In addition, the Forest has consistently demonstrated the ability to maintain at least 50% ground cover during mechanical treatments, made up of small wood debris and resilient groundcover vegetation such as bear clover. The impacts are also minimized by having the sale administrator approve equipment crossing locations on Class IV and V streams (BMP 1-19), operating when these areas are dry (BMP 1-5) and by performing rehabilitation and erosion control prior to leaving the unit (BMP 1-19). The effect of these impacts would be a possible short-term increase in V* near these disturbances.

Class I, II, and III channels have specified SMZs where mechanized equipment is prohibited. Stream crossings for equipment must be approved by a hydrologist, aquatic biologist or soil scientist (BMP 1-19).

Road construction and reconstruction will result in short-term increases in channel disturbance and sedimentation, and long-term decreases in sediment delivery due to improvements in road drainage design and reduction of hydrologic connectivity. BMPs (listed in Table 2-18) will minimize the short-term increases. However, the WEPP:Road model suggests that sediment contributions could be reduced by up to 3.44 tons/yr at each native surface crossing by reducing the hydrologic connectivity of the road. The effect of these impacts would be a short-term increase in V* downstream of the disturbances, followed by a reduction in V* in the long-term. The length of time between the increase and the decrease will be dependent on the length of time needed for the disturbed area to stabilize- estimated to occur within 3 years, with sharp reductions after the first year – and the occurrence of stream flows that are capable of transporting the sediment produced prior to stabilization downstream. Sand-sized material is transported annually in this system, so the time period for reductions in V* are expected to occur within 3 years in the immediate vicinity of the disturbance, and in approximately 10 years in the lower reaches of Big Creek and Dinkey Creek .

There could be direct effects from water drafting, which requires a vehicle to approach very near to the stream bank and usually requires repeated access. BMP 2-21 specifies protective measures including measures to reduce erosion and the impacts to stream flow from water drafting. Direct impacts to stream banks would be minimized by BMP 2-21, and any unexpected or unacceptable impacts to stream banks would be rehabilitated after use.

There is a slight risk of direct effects from an accidental glyphosate spill reaching surface water. This risk is minimized by implementation of BMP 5-7, which limits the transporting of herbicides to designated routes and specifies batching and mixing locations, and BMP 5-10, which requires a Spill Contingency Plan that is approved by the Forest Service prior to operations. No increase in glyphosate concentration is expected. Glyphosate is not expected to be detectable in surface waters after application.

Prescribed burning is not expected to change stream flows but may increase in-channel sediment in the short-term. The results of the GeoWEPP analysis suggest that sediment will be doubled from background sediment delivery rates, and approximately 5.6 tons/ha/yr will be produced from underburning. However, these burns are planned with a low burn intensity objective, and there will be no fire ignitions within the SMZ (except in KREW study watersheds). Burn patterns typically form a mosaic with unburned or lightly burned areas inter-fingered with a few moderate severity areas. Although some proportion of the area is likely to burn at high severity, the proportion is expected to be small, as found by Robichaud (Robichaud and others 2006). Any overland flow or eroded material that leaves a severely burned spot will be filtered in the unburned, low or moderate severity areas down slope. It is possible that high severity burn could occur at or near stream banks. However, soil and fuel moistures are likely to be higher near stream channels, and this limits the potential for high burn severity. The effect of unfiltered overland flow from burned areas entering streams would be a potential increase in V*. Any such increase would likely occur in an isolated stream reach and is not likely to be measurable in the next higher-order channel downstream. Sediment production the second year after the underburn treatment was predicted by the GeoWEPP model to be at the same level as the existing condition. As in the existing condition, sediment is mostly produced on the steeper slopes, especially the headwater slopes in the tributary channels of Bear Meadow Creek.

Broadcast burning of 146 acres in the n_soapro_2 management unit is the highest intensity burn planned. These acres are not located within sub-watershed 519.3053, which is over the lower TOC. The potential for generating increased sediment is greater in this unit than in the other prescribed burn areas, therefore, the risk of increasing V* in these tributaries to Rush Creek is higher than elsewhere in the project area. However, the target intensity is still moderate severity rather than high severity, and at least 50% ground cover will be maintained. This is expected to minimize effects.

Burning piles will create small isolated spots of high burn severity. These spots will be completely surrounded by unburned area which is expected to provide an adequate filter for any runoff or eroded material leaving the spot. There will be no piles burned in the SMZ (or in the RCA where habitat for Western pond turtle or Relictual slender salamander habitat occurs, as described in the Aquatics section), which will provide adequate filtering for any overland flow and sediment leaving these areas.

Watershed restoration will reduce sediment by 10-15 tons/year. Various localized hydrologic problems will be corrected, and conditions will be restored to closer to natural.

Indirect Effects

This project has the potential to indirectly affect stream flows through various processes as a result of thinning trees, other vegetation manipulation actions, and road construction, reconstruction, and maintenance.

Thinning trees is not expected to affect annual yield or increase peak flows. Many studies have shown that basal area must be reduced at least 10% in small research watersheds to detect any effect, and generally a 20% reduction is required before a detectable change in flow occurs (Troendle and others 2006). This alternative will reduce basal area by a maximum of 12.1% in sub-watershed 519.3052 (See Table 3-61), and total of 4 sub-watersheds will have between 9.9 and 12.1% reductions. Eight sub-watersheds will have 5 to 8%, and the remaining sub-watersheds will have less than a 5% reduction in basal area. There may be a slight increase in snow accumulation in the group selection patches in the Dinkey Creek watershed (the sub-watersheds that begin with 520) where snow is a more dominant process. This may increase peak flows slightly, but not measurably. The overall effect on stream flow in terms of annual yield and peak flows is not expected to be detectable.

Base flows may be augmented by the reduction in vegetation, but the effect is not likely to persist into the dry summer season where it would be detectable. The increase in soil moisture will be utilized by the remaining vegetation, so it will not be available for stream flow.

Road construction could indirectly affect stream flow and sediment, especially where new roads cross stream channels. BMP 2-1, 2-3, 2-5, 2-8 and 2-9 will help to minimize the impacts to stream channels and reduce the potential for sediment to be generated both during construction and once the roads are in place.

Road reconstruction could also affect stream flow and sediment. Road reconstruction will result in fewer resource impacts by establishing an effective drainage design for the road. Watershed design measures specify that in sub-watersheds that are currently over the lower TOC for cumulative watershed effects, hydrologic connectivity will be reduced during road reconstruction. The effect on stream flow is not expected to be measurable, but theoretically reducing connectivity will reduce the impact of the existing roads on the magnitude and timing of peak flows. Controlling road drainage will reduce the amount of sediment delivered from the road to the stream network. In addition, any culverts that are added or replaced will be sized to current standards to minimize the risk of culvert failure.

High severity burn could occur in the riparian area during prescribed burning, and result in riparian mortality. This could reduce the effectiveness of the streamside buffer and allow overland flow and eroded material to enter a stream channel. This effect has a low probability of occurring as a result of any given burn operation; the probability becomes lower the larger the spatial extent (i.e., it is more likely to occur on a small area than a large area). The effect would last for 1 – 3 years until groundcover is reestablished and water repellency recovers (Robichaud and others 2006).

More sediment in channels has the potential to result in increased channel erosion either due to aggradation or to the increased erosive power of sediment-laden high-flows, especially at the known locations with sensitive channel types identified in Table 3-53. These areas are the most likely to adjust to changes in flow and sediment that result from any cause, including natural disturbances such as fire or floods. Although this potential is slightly increased by this proposal in these locations (compared to the existing condition), it is not expected to occur widely across the project area nor to be severe enough to trigger adjustments of channel reach width/depth ratios or sinuosity.

Watershed restoration will increase the resilience of the restored areas to disturbances that could result from other events, such as large storm events or wildfire, and minimize the erosion that would occur as a result of such events.

Indirect Effects with wildfire in 2015:

The implementation of the fuels reduction activities will reduce the area that burns at high severity in the case of a wildfire (see the Vegetation and Fuels sections). Watershed damage including sedimentation rates would be less for the proposed action compared to the no action alternative in the event of a wildfire. Slopes would have at least 60% ground cover after treatment. Overland flows would remain normal and major channel modification would not likely occur. Modeling of the No Action alternative with a fire in the year 2015 predicted 10.2 ton/ha/yr or a total of 12,322 tons of sediment produced in the Bear Meadow Creek watershed. Modeling of the proposed action with a fire in the year 2015 predicted 7.4 tons/ha/yr, or a total of 8,946 tons of sediment. This comparison suggests that the proposed action would result in a smaller effect from wildfire. If a wildfire occurred in Bear Meadow Creek (bear_fen_6), sediment could be increased by 350%, whereas the proposed action followed by a fire would result in a predicted sediment increase of 250%. This suggests that treating the proposed area will result in a significant decrease in sediment production after a fire, compared to the No Action Alternative.

Cumulative Effects

For the purpose of this analysis, CWEs are all effects on beneficial uses of water that result from the synergistic or additive effects of multiple management activities within a watershed that are accumulated in the fluvial system. Effects can be adverse or beneficial. Adverse effects may result from multiple land use activities which combine to cause detrimental changes in watershed hydrology or sedimentation. Beneficial effects may result from management actions such as watershed improvement projects and special project mitigation. The CWE analysis is thoroughly documented in the Baseline and Detailed reports (Gallegos 2006a and 2006b). The results are summarized here.

Nine sub-watersheds in the analysis area (519.0009, 519.0057, 519.3053, 519.4051, 520.0014, 520.1002, 520.1051, 520.1101, and 520.1151) were identified as currently over their lower threshold of concern (TOC). Refer to Table 3-57 for a summary of the information considered in the Detailed Assessment of these nine sub-watersheds. Table 3-61 displays the conclusions of the Detailed Assessment for these same nine sub-watersheds. The potential for CWE to occur from increased sedimentation is a risk based assessment dependent on the occurrence of large storm events that occur in these sub-watersheds. If large storm events (10 or 20 year storm events) occur, the risk of CWE response increases. If a proposed treatment area has below normal precipitation the following winter, and storm events are less then 2-year events, the risk of CWE is reduced. The vulnerability of a sub-watershed for CWE is within the first year of the disturbance and significantly decreases after the 2nd and 3rd years. Risk is defined with 4 classes; "Unlikely" is expected to withstand a twenty-year storm event without incurring a CWE response, "Low" is expected to withstand a ten-year storm event, "Moderate" is expected to withstand a five-year storm event, and "High" is expected to incur a CWE response from a 2-year storm event.

Table 3-61 – Conclusions of the detailed CWE Assessment – Alternative 1

<table>
<tr><th>Sub-watershed Number</th><th>Management Unit</th><th>Main Stream Name</th><th>Risk of CWE Response</th></tr>
<tr><td>519.0009</td><td>n_soapro_2</td><td>Ackers Cr</td><td>Unlikely</td></tr>
<tr><td>519.0057</td><td>providen_1</td><td>Big Cr</td><td>Low</td></tr>
<tr><td>519.3053</td><td>n_soapro_2</td><td>Rush Cr</td><td>Low</td></tr>
<tr><td>519.4051</td><td>providen_1</td><td>Summit Cr</td><td>Low</td></tr>
<tr><td>520.0014</td><td>el_o_win_1
glen_mdw_1
krew_prv_1</td><td>Dinkey Meadow Cr</td><td>Unlikely</td></tr>
<tr><td>520.1101</td><td rowspan="4">bear_fen_6</td><td rowspan="2">Oak Flat Cr</td><td>Moderate</td></tr>
<tr><td>520.1151</td><td>Moderate</td></tr>
<tr><td>520.1002</td><td rowspan="2">Bear Meadow Cr</td><td>Low</td></tr>
<tr><td>520.1051</td><td>High</td></tr>
</table>

Design criteria and watershed restoration have been specified to reduce or offset the risk for CWE. In all sub-watersheds that are over the lower TOC, activities will be carried out using light on the land mechanical systems (i.e., cut-to-length harvest system, low ground pressure feller/buncher system, excavator debris piling).

The watershed improvement restoration described in the Proposed Action will be implemented, and monitoring of channel condition (SCI), sediment accumulation (V*), and other aquatic habitat indicators will occur according to the Monitoring and Adaptive Management Plan. These measures are summarized in Table 3-62. The discussion of the likelihood of cumulative effects responses in these sub-watersheds follows the table.

Table 3-62 - Mitigation measures for the sub-watersheds currently over their Threshold of Concern

<table>
<tr><th>Management Unit</th><th>Sub-watershed Number</th><th>Number of Watershed Restoration Sites</th><th>Other Mitigation</th></tr>
<tr><td>n_soapro_2</td><td>519.3053</td><td>4</td><td rowspan="9">Light-on-the-land harvest system
Subsoiling compacted skid trails or landings in excess of 15% of area</td></tr>
<tr><td rowspan="2">providen_1</td><td>519.0057</td><td>9</td></tr>
<tr><td>519.4051</td><td>0</td></tr>
<tr><td>el_o_win_1</td><td rowspan="2">520.0014</td><td>0</td></tr>
<tr><td>glen_mdw_1</td><td>0</td></tr>
<tr><td rowspan="4">Bear_fen_6</td><td>520.1002</td><td>0</td></tr>
<tr><td>520.1051</td><td>9</td></tr>
<tr><td>520.1101</td><td>0</td></tr>
<tr><td>520.1151</td><td>0</td></tr>
</table>

*In this Alternative, standard road design measures would be applied which would result in some drainage improvements even though the design criteria that specifies reducing hydrologic connectivity does not apply.

The following is a summary of effects for Alternative 1 and conclusions about the CWE concern sub-watersheds.

Sub-watershed 519.0057 – Approximately 498 acres of mechanical treatment units in the providen_1 management unit is proposed to be treated in this sub-watershed, with 7 acres of underburning in an un-named tributary of Big Creek and Big Creek between Summit and Providence Creeks. The proposed treatments for this sub-watershed would result in ERA of 13.73%. Sediment could be increased by as much as 8 tons from underburning 7 acres. Sediment would be reduced at 9 WIN sites. CWE would be mitigated by using light-on-the-land harvest methods identified in the design measures. These measures will control current sources of sediment and reduce the risk of initiating an additional CWE response. There is a moderate risk that CWE will occur in this sub-watershed.

Sub-watershed 519.3053 – Approximately 60 acres of mechanical treatment and 0 acres of underburn in the providen_1 management unit are proposed in this watershed in Rush Creek. The proposed ERA is 9.16%. By the year 2011, the ERA value will be 8.25%, which is lower then the existing ERA. By the year 2033, the ERA would be 2.31%. Sediment should not be increased because under burning is not proposed in this sub-watershed and mechanical treatment impacts will result in no change in soil cover. Cumulative watershed effects will be reduced by mechanically treating the area with a light on the land harvest system, sub-soiling all major skid roads and trails to reduce runoff, and implementing the watershed restoration described in the Proposed Action (from the Soaproot Watershed Restoration Plan). Implementation of these mitigations will result in watershed improvement, a reduced risk of initiating additional CWE response, and recovery over a shorter time period. There is a low risk of CWE is this sub-watershed.

Sub-Watershed 519.4051 – Approximately 359 acres of mechanical treatment and 0 acres of underburning are proposed in the providen_1 management unit located on the south side of Summit Creek. The proposed treatment will increase ERA to 10.20%. ERAs are expected to be 8.06% in 2011, and 1.74% in 2033. Sediment should not be increased because under burning is not proposed in this sub-watershed and mechanical treatment impacts will result in no change in soil cover. Cumulative watershed effects will be reduced by mechanically treating the area with light on the land harvest methods, sub-soiling all major skid roads and trails to reduce runoff, and implementing the watershed restoration projects identified in the Proposed Action (from the Providence 1 Watershed Restoration Plan). Implementation of these mitigations will result in watershed improvement, a reduced risk of initiating additional CWE response, and recovery over a shorter time period. There is a low risk that CWE will occur in this sub-watershed.

Sub-watershed 520.0014 – Approximately 228 acres of mechanical treatment units from the el_o_win_1 and krew_prv_1 management units is located in this sub-watershed with 84 acres of underburn in Dinkey Meadow Creek. The proposed treatments would result in ERA 10.81%. By the year 2011, the ERA value will be 9.30% and by the year 2033, ERA would be 2.32%. Sediment could be increased by as much as 95 tons from under burning 84 acres. Cumulative watershed effects will be reduced by mechanically treating the area with light on the land harvest methods and sub-soiling all major skid roads and trails to reduce runoff. There is low risk that CWE will occur in this sub-watershed.

Sub-watershed 520.1101 – Approximately 656 acres of mechanical treatment are proposed in 2007 with 413 acres of underburn in upper Oak Flat Creek. ERA's will be increased to 11.53%. ERA's are expected to be 10.08% in 2011, and 4.51% in 2033. Sediment could be increased by as much as 468 tons from the underburning. Cumulative watershed effects will be reduced by mechanically treating the area with light on the land harvest methods and by sub-soiling all major skid roads and trails to reduce precipitation runoff. There is a moderate risk that CWE will occur in this sub-watershed.

Sub-watershed 520.1151 – Approximately 321 acres are proposed for mechanical treatment in 2007 with 321 acres of underburn in lower Oak Flat Creek. The ERA will be increased to 8.16% and would recover to 7.40% in 2011, and 3.76% in 2033. Sediment could be increased by as much 363 tons from under burning. Cumulative watershed effects will be reduced by mechanically treating the area with light on the land harvest methods and by sub-soiling all major skid roads and trails to reduce precipitation runoff. There is a moderate risk that CWE will occur in this sub-watershed.

Sub-watersheds 520.1002 – Approximately 301 acres of mechanical treatment are proposed in 2008 with 297 acres of underburn in the upper Bear Meadow Creek sub-watershed. ERA will be increased to 9.8%. ERA's are expected to be 8.18% in 2011, and 2.51% in 2033. Sediment could be increased by as much 337 tons from the under burning 297 acres. Cumulative watershed effects will be reduced by mechanically treating the area with light on the land harvest methods and by sub-soiling all major skid roads and trails to reduce precipitation runoff. There is a low risk that CWE will occur in this sub-watershed.

Sub-watershed 520.1051 – Approximately 559 acres of mechanical treatment are proposed to be treated in 2008, with 485 acres of underburn in the lower Bear Meadow Creek sub-watershed. ERA will be increased to 11.72%. ERA's are expected to be 9.82% in 2011, and 2.52% in 2033. Sediment production in this sub-watershed could be increased by as much as 323 tons. In addition, the sediment produced in sub-watersheds 520.1002, 520.1101 and 520.1151 will be transmitted downstream and into this sub-watershed. Cumulative watershed effects will be reduced after implementing the proposed "Bear Meadow Watershed Restoration Plan" (as detailed in the Alternative 1 and 3 descriptions). CWEs will be reduced by mechanically treating the area with light on the land harvest methods and by sub-soiling all major skid roads and trails to reduce precipitation runoff. There is a moderate risk that CWE will occur in this sub-watershed.

Other Sub-watersheds Affected by the Proposed Action

Fifteen sub-watersheds that are currently below their lower TOC for Cumulative Watershed Effects (CWE) will exceed their threshold after project implementation (see Table 3-56). These sub-watersheds will be evaluated in a “Detailed Assessment” after each phase of treatments included in the selected alternative in order to determine whether the project has resulted in a CWE response. If at any time these sub-watersheds are found to be at increased risk for CWE response, the design measures that apply to sub-watersheds that are over their TOC prior to implementation of this project will be applied to the remaining phases of implementation.

The fifteen sub-watersheds whose management will be adapted according to an adaptive management strategy are: 519.0007; 519.0008; 519.0009; 519.0011; 519.0056; 519.3002; 519.3003; 519.3004; 519.3052; 520.0015; 520.0016; 520.0056; 520.0057; 520.3002; and 520.4051.

Additional sub-watersheds may be evaluated for CWE response based on factors other than from the ERA model. This will be developed through adaptive management techniques.

Other Projects and Uses Considered in the Cumulative Effects Analysis – The ERA model addressed the vegetation management projects listed in Table 3-3 (Past, Present, and Reasonably Foreseeable Actions), and the discussion of cumulative effects includes all known conditions and problems that are related to other activities. The project file contains more information about the rationale behind the consideration of cumulative effects that could result from each action listed in Table 3-3.

Beneficial Uses - Hydropower uses at Pine Flat Dam could be enhanced by the small increase in annual water yield. However, the slight increase in sediment delivered to streams could also slightly increase the rate of sedimentation in Pine Flat Reservoir. The increase is not predicted to be large enough to significantly affect the rate of filling of the reservoir.

There is a slight potential for contact and non-contact recreation to be affected if CWE responses increase. The reaches most likely to affect recreational experience are in the main Big Creek channel, such as the reach adjacent to Bretz Campground in sub-watershed 519.0057, and others downstream where dispersed campsites are situated on the banks. However, these reaches have been identified as likely exhibiting a CWE response currently. An additional CWE response would be reflected as more fine sediment accumulation in the channel. Since these areas already have accumulated sand (pools are completely filled), the potential difference is not likely to further affect recreational experience. The potential for effects on beneficial uses related to aquatic habitat are discussed in the Aquatics section.

Summary of Effects of Alternative 1:

Peak flows, annual water yield, and base flows would not be altered. The water quality objective for the chemical constituent glyphosate would be met. The water quality objective for sediment may be compromised. Increases in V* could occur. Erosion of channel banks in reaches with high sensitivity to disturbance could be increased. The increase would probably not be enough to significantly affect channel function, but could increase V*. Watershed restoration and road reconstruction would both reduce existing sediment inputs, but may not be enough to offset the increases from other activities. There is a moderate risk of a cumulative watershed effects response occurring in the bear_fen_6 management unit. The beneficial uses related to hydropower and recreation would probably not be affected. See the Aquatics section for a discussion of the effects on beneficial uses related to aquatic habitat.

Indirect and Cumulative Effects if Wildfire occurs in 2015:

Peak flows and annual water yield would increase in the watershed affected by the wildfire for several years following the event. Base flows would be reduced in the watershed experiencing the fire due to decreased infiltration and soil moisture storage. The water quality objective for glyphosate would not be affected by the wildfire, it would be met. The water quality objective for sediment would be more likely to be compromised in the watershed where the wildfire occurred than without a wildfire. Modeling using GeoWEPP suggests that the sediment produced by the activities under this alternative plus the effects of the wildfire would be approximately 70% less than the sediment generated by the wildfire under the No Action Alternative. The beneficial uses related to hydropower would probably not be affected. Recreation uses could be affected in the short-term by ash and additional sediment in streams. See the Aquatics section for a discussion of the effects on beneficial uses related to aquatic habitat.

Alternative 2 - No Action

Direct and Indirect Effects

No actions would be taken; therefore, none of the direct effects described under Alternative 1 would occur. There would, however, be indirect effects related to this alternative. The roads that are in need of maintenance or reconstruction would not be treated and would continue on their current trend. In most cases the trend is road deterioration including erosion and contributing sediment to streams. In some cases the trend is towards recovery of the road, and contributions to stream flows and sediment are negligible.

The watershed restoration sites would not be repaired and would continue on their current trend until they become the District-wide priority of the watershed restoration program, and funding to repair them is in place. This could take many years because there are hundreds of sites currently on the District WIN inventory with more added each year, and each year between 3 and 10 sites are repaired. In all cases, the sites identified in Alternatives 1 and 3 are actively eroding and degrading watershed conditions. The amount of sediment that would continue to be contributed from these sites is approximately 10 -15 tons/year.

Cumulative Effects

The ERA model would show continuing recovery from previous disturbances. Other planned actions that are not part of this decision would still occur, but the total ERA in the project sub-watersheds would be lower than if this project was implemented.

Roads would continue their current sediment contributions to cumulative watershed effects. Some segments may deteriorate, but the overall cumulative impact from the roads probably would not change relative to the current condition.

Stream channel conditions in reaches identified as having high sediment loads would probably not change in most reaches. In Rush Creek (particularly in sub-watershed 519.3053), sediment may continue to accumulate as a result of construction of the Wildflower subdivision. This activity began recently and an increase in fines has been detected. The OHV uses described in this sub-watershed would also contribute to the maintenance of the elevated sediment loads.

Overall, peak flows, annual yield and base flows would not change under this alternative. V* would probably also not change, except in Rush Creek where recreation, actions on private land, and actions taken under other decisions (particularly South of Shaver) would continue and have the potential to cause an increase in V*.

<u>Indirect and Cumulative Effects if Wildfire occurs in 2015</u>:

Under the No Action Alternative, the increased wildfire severity described in the Vegetation and Fuels sections increases the risk of water quality degradation. The Vegetation section identifies bear_fen_6 and el_o_win_1 as the management units with the most pronounced wildfire effects under this alternative. This suggests that Oak Flat and Bear Meadow Creeks (in bear_fen_6) and Dinkey Meadow Creek (in el_o_win_1) are at highest risk for severe impacts from wildfire. This does not mean that fire is more likely to occur in these areas than in other areas, only that if a wildfire were to occur here, the effects are more likely to be severe than if a wildfire were to occur in other areas. The effects described below are general, but can be considered to be more pronounced in these two management units than in the others.

Within and downstream of the burned area, sedimentation rates could increase by orders of magnitude and V* would increase significantly. Some areas that currently meet the desired condition would probably exceed it for several years following the fire.

Infiltration would be reduced in areas that burned at high severity, which based on previous fires on the Forest could be in the range of 20 – 30% of the burned area[18]. This would result in increased overland flow which would increase peak flows, and in decreased soil moisture, which would reduce summer low flows. Post-wildfire peak flows have been found to increase by up to three orders of magnitude (Neary and others 2005). Baseflows have been reported to increase due to the reduction in evapotransipiration that results from vegetation mortality (Neary and others 2005) and to decrease due to increased overland flow and decreased infiltration, which results in lower soil moisture and less subsurface flow to streams. The effect on baseflows is likely related to site-specific factors including the degree or vegetation mortality and the degree of soil water repellency and increases in runoff, and how these relate to the site's water balance.

Modeling of the No Action alternative with a wildfire in the year 2015 predicted 10.2 tons/ha/yr with a total of 12,322 tons of sediment produced in the Bear Meadow Creek watershed, which is greater than the 7.4 tons/ha/yr (total of 8,946 tons) of sediment modeled for the proposed action with a wildfire. If a wildfire occurred under this alternative, sediment could be increased by 350%, whereas in Alternatives 1 and 3 a wildfire could increase sediment by 250%. These model results suggest that the effects of a wildfire on erosion, sedimentation, and increases in V* will be higher under Alternative 2 (No Action) than for Alternative 1 or Alternative 3.

Alternative 3 – Reduce Harvest Tree Size

Direct and Indirect Effects

The effects of this alternative would be the same as those described under Alternative 1, with the following exceptions:

Direct effects from mechanized equipment operation and skidding of logs during timber harvest and mechanical fuels reduction would be similar to those described under Alternative 1. However, grapple piling will be used in sub-watersheds that are over their lower TOC and in sub-watersheds that are determined to be at increased risk for CWE response after implementation of the harvest treatments (Refer to the Adaptive Management section of Chapter 2). Grappling piling will not reduce ground cover and has less compaction than tractor piling which is proposed for these areas in Alternative 1. Application of the riparian silvicultural prescription described in the Watershed Design Measures for Alternative 3 (Chapter 2) would further reduce the potential for impacts and would provide additional protection to the SMZs of Class I and II streams in sub-watersheds that are over their TOC by prohibiting harvest in these areas.

As in Alternative 1, road reconstruction could affect stream flow and sediment. However, watershed design measures for Alternative 3 specify that in sub-watersheds that are currently over the lower TOC for cumulative watershed effects, hydrologic connectivity will be reduced during road reconstruction. The effect on stream flow is not expected to be measurable, but theoretically, reducing connectivity will reduce the impact of the existing roads on the magnitude and timing of peak flows. Controlling road drainage of peak flows will reduce the amount of sediment delivered

[18] Some of the fires that have occurred on the Sierra National Forest include Kirch Fire (high burn severity was 15%), Balch Fire (high burn severity was 30%), and North Fork Fire (high burn severity was 27%). Burn severity information is from "Burned Area Emergency Rehabilition"

from the road to the stream network. According to the WEPP model, sediment could be reduced by as much as 0.35tons/year from hydrologically connected crossings on native surface roads.

Cumulative Effects

Additional design measures are specified for this alternative which reduces the potential for CWE compared to Alternative 1. The differences between the cumulative effects under Alternative 1 and this alternative are described below.

The risk of a CWE response would be reduced under this alternative. This would be especially true in sub-watershed 520.1051, which is at high risk for Alternative 1 and at moderate risk for Alternative 3 for a CWE response. The additional design measures help to balance the possible effects of the harvest, fuels, and burning actions. The risk for CWE could be further reduced in the bear_fen_6 management unit by implementing underburning in multiple years rather than in one year. The risk of CWE for each sub-watershed under this alternative is displayed in Table 3-63 (refer to Table 3-61 for the definition of risk). Table 3-64 shows the mitigation measures that would apply to each sub-watershed under this alternative.

Table 3-63 - Conclusions of the Detailed CWE Assessment – Alternative 3

Sub-watershed Number	Management Unit	Main Stream Name	Risk of CWE Response
519.0009	n_soapro_2	Ackers Cr	Unlikely
519.0057	providen_1	Big Cr	Low
519.3053	n_soapro_2	Rush Cr	Low
519.4051	providen_1	Summit Cr	Low
520.0014	el_o_win_1 glen_mdw_1 krew_prv_1	Dinkey Meadow Cr	Unlikely
520.1101	bear_fen_6	Oak Flat Cr	Moderate
520.1151			Moderate
520.1002		Bear Meadow Cr	Low
520.1051			Moderate

Table 3-64 - Mitigation measures for the sub-watersheds currently over their Threshold of Concern, Alternative 3

Management Unit	Sub-watershed Number	Miles of Stream whose SMZ has No Harvest	# Stream Crossings Subject to Design Criteria	Number of Watershed Restoration Sites to be repaired	Other Mitigation
n_soapro_2	519.3053	1.7	8	4	Light-on-the-land harvest system Grapple piling Subsoiling compacted skid trails or landings in excess of 15% of area Suggest multi-year underburning in bear_fen_6
providen_1	519.0057	7.5	45	9	
	519.4051	4.0	16	0	
el_o_win_1	520.0014	1.2	19	0	
glen_mdw_1		0.2		0	
Bear_fen_6	520.1002	4.1	21	0	
	520.1051	2.5	29	9	
	520.1101	4.8	41	0	
	520.1151	1.1	8	0	

The differences in Cumulative Effects between Alternative 1 and this alternative for the sub-watersheds that are over their lower TOC of concern are due to implementation of grapple piling and road design criteria for reducing the road hydrologic connectivity. Each sub-watershed is listed with an estimated number of road/channel crossings, the number of WIN sites, and associated sediment reduction.

Sub-watershed 519.3053 – Sediment could be reduced on 8 road/channel crossings and four WIN sites by as much 3 to 28 tons per year.

Sub-watershed 519.0057 – Sediment could be reduced on 45 road/channel crossings and nine WIN sites by as much 7 to 75 tons per year.

Sub-Watershed 519.4051 – Sediment could be reduced on 16 road/channel crossings and by as much 5 to 55 tons per year.

Sub-watershed 520.0014 – Sediment could be reduced on 19 road/channel crossings and by as much 2 to 21 tons per year.

Sub-watershed 520.1101 – Sediment could be reduced on 41 road/channel crossings and by as much 7 to 77 tons per year.

Sub-watershed 520.1151 – Sediment could be reduced on 8 road/channel crossings and by as much 2 to 22 tons per year.

Sub-watersheds 520.1002 – Sediment could be reduced on 21 road/channel crossings and by as much 5 to 51 tons per year.

Sub-watershed 520.1051 – Sediment could be reduced on 21 road/channel crossings and nine WIN sites by as much 4 to 55 tons per year.

Summary of Effects of Alternative 3:

The effects would be the same as in Alternative 1 with the following exceptions: the potential for V* to increase is lower; and the risk of cumulative watershed effects, particularly in the bear_fen_6 management unit, is lower.

Indirect and Cumulative Effects if Wildfire occurs in 2015:

The measures designed to reduce watershed impacts that apply to this alternative could reduce post-wildfire erosion at some sites, but overall the benefits will be negligible in the case of a wildfire. Therefore, the effects under this Alternative would be similar to those described under Alternative 1.

Table 3-65 – Summary of the Effects of each Alternative on the Indicators Selected for the Watershed Analysis

Indicator	Alternative 1		Alternative 2		Alternative 3	
	No wildfire	Wildfire	No wildfire	Wildfire	No wildfire	Wildfire
Peak flows	No measurable change	Increase	No change	Greater increase than under Alt 1.	No measurable change	Increase similar to under Alt. 1
Annual water yield	No measurable change	Increase	No change	Increase	No measurable change	Increase similar to under Alt 1.
Base flows	No measurable change	Decrease	No change	Potentially greater decrease than under Alt 1	No measurable change	Decrease similar to under Alt 1.
WQ: glyphosate	Not detectable – meets WQ objectives	Not detectable – meets WQ objectives	Not detectable – meets WQ objectives	Not detectable – meets WQ objectives	Not detectable – meets WQ objectives	Not detectable – meets WQ objectives
WQ: V*	Slight risk of increase, especially in bear_fen-6 management unit	High risk of increase, especially in bear_fen-6 management unit	No change, except slight risk of increase in 519.3053 due to other land uses	Higher risk of increase than under Alt 1.	Slight risk of increase, similar to under Alt. 1	High risk of increase, similar to under Alt. 1
Risk of CWE Response	One high risk and two moderate risk sub-watersheds occur all in bear_fen_6 management unit; all other units are unlikely or low	Any burned sub-watershed from a wildfire will result in moderate and high risk	All sub-watersheds would continue to recover from past management activities	Any burned sub-watershed from a wildfire will result in moderate and high risk	Three moderate risk sub-watersheds occur all in bear_fen_6 management unit; all other units are unlikely or low	Any burned sub-watershed from a wildfire will result in moderate and high risk

AQUATIC SPECIES

Affected Environment

There are ten federally listed aquatic species that may be affected by activities occurring within the Kings River Project (KRP) area. For general information and the rationale for inclusion or exclusion of all the listed aquatic species that are on the Sierra National Forest species lists refer to the Aquatic Species Biological Assessment and Biological Evaluation report for the Final Environmental Impact Statement (EIS) for the Kings River Project (KRP) – Initial Eight Management Units (Sanders 2006b) and the Resident Trout Management Indicator Species report (Strand 2006). Provided in this section are brief descriptions of the ten federally listed aquatic species and their habitats within the Kings River Project area, initial eight management units. The ten listed aquatic species are:

- **California red-legged frog** (Threatened; CRLF), *Rana aurora draytonii*
- **Foothill yellow-legged frog** (Forest Service Sensitive; RABO), *Rana boylii*
- **Lahontan cutthroat trout** (Threatened and Management Indicator Species; LCUTT) *Oncorhynchus (=Salmo) clarki henshawi*
- **Mountain yellow-legged frog** (Candidate and Forest Service Sensitive; RAMU) *Rana muscosa*
- **Relictual slender salamander** (Forest Service Sensitive; RSS), *Batrachoseps relictus*
- **Resident trout species** (Management Indicator Species; RTS)
  - Brown Trout, *Salmo trutta*
  - Eastern Brook Trout, *Salvelinus fontinalis*
  - Rainbow Trout, *Oncorhynchus mykiss*
- **Western pond turtle** (Forest Service Sensitive; WPT), *Clemmys marmorata* (Subspecies *marmorata* and *pallida*)
- **Yosemite toad** (Candidate & Forest Service Sensitive; BUCA), *Bufo canorus*

Of these ten aquatic species and their habitats, eight are found within the initial eight management units and two within other management units of the Kings River Project. Each species either is known to occur, has habitat within or adjacent to the project area, or historically (prior to 1980) is known to have occurred within the project area (Table 3-66).

Table 3-66 - Aquatic species located within the Kings River Project (KRP).

Aquatic Species	Initial Eight Management Units								Adjacent to the Initial Eight MU & within the KRP Area
	Bear_fen_6	El-O-Win_1	Glen_mdw_1	Krew_bul_1	Krew_prv_1	N-Soapro_2	Providen_1	Providen_4	
CRLF	HA				HA	HA	HA	HA	HA
RABO					HA	HA	HA	HA	HA/HP
LCUTT									HA/SP
RAMU									HA/SP
RSS	HA/SP	HA	HA	HA	HA	HA	HA/SP	HA/SP	HA/SP
RTS	HA/SP	HA/SP	HA/SP	HA/SP	HA/SP	HA/SP	HA/SP	HA/SP	HA/SP
WPT	HA				HA	HA/SP	HA/SP	HA/SP	HA/SP
BUCA			HA	HA/SP					HA/SP

“HA” indicates habitat for the species is present, “SP” indicates the species is currently known to be present, and “HP” indicates the species was historically known to be present within the project area. Aquatic species names: California red-legged frog (CRLF); Foothill yellow-legged frog (RABO); Lahontan cutthroat trout (LCUTT); Mountain yellow-legged frog (RAMU); Relictual slender salamander (RSS); Resident trout species (RTS); Western pond turtle (WPT); Yosemite toad (BUCA).

The ten listed aquatic species occur in:

- Bear_fen_6 Management Unit – Habitat for the California-red-legged frog, relictual slender salamander, resident trout species, and western pond turtle occur within the management unit.

- El_o_win_1 Management Unit - Habitat for the relictual slender salamander and resident rout species occur within the management unit.

- Glen_mdw_1 Management Unit - Habitat for the relictual slender salamander, resident trout species, and the Yosemite toad occur within the management unit.

- Krew_bul_1 Management Unit - Habitat for the relictual slender salamander, resident trout species, and the Yosemite toad occur within the management unit.

- Krew_prv_1 Management Unit - Habitat for the California red-legged frog, foothill yellow-legged frog, relictual slender salamander, resident trout species, and the western pond turtle occur within the management unit.

- N_soapro_2 Management Unit – Habitat for the California red-legged frog, foothill yellow-legged frog, relictual slender salamander, resident trout species, and the western pond turtle occur within the management unit.

- Providen_1 Management Unit - Habitat for the California red-legged frog, foothill yellow-legged frog, relictual slender salamander, resident trout species, and the western pond turtle occur within the management unit.

- Providen_4 Management Unit - Habitat for the California red-legged frog, foothill yellow-legged frog, relictual slender salamander, resident trout species, and the western pond turtle occur within the management unit.

- Within other management units of the Kings River Project – Habitat for the California red-legged frog, foothill yellow-legged frog, Lahontan cutthroat trout and its Critical Aquatic Refuge, mountain yellow-legged frog and its Critical Aquatic Refuge, relictual slender salamander, resident trout species, western pond turtle, and the Yosemite toad occur within other management units of the Kings River Project.

A brief description of each of these species is described next, a complete species account can be found in the Aquatic Species Biological Assessment and Biological Evaluation report for the Final Environmental Impact Statement (EIS) for the Kings River Project (KRP) – Initial Eight Management Units (Sanders 2006b) and the Resident Trout Management Indicator Species Report (Strand 2006). A summary of the acres and miles of occurrences, suitable habitat, and dispersal habitat is presented in Tables 2 and 3.

California red legged frog

The California red-legged frog (*Rana aurora draytonii*) was federally listed as threatened on May 23, 1996 (61 **FR** 25813). Critical habitat was designated in 2001 (66 **FR** 14625), updated on April 13, 2004 (69 **FR** 19619), and a final recovery plan was published in 2002 (67 **FR** 57830; USFWS 2002). The California red-legged frog (CRLF) is the largest native frog in the western United States (Wright and Wright 1949), ranging from 4 to 13 centimeters (1.5 to 5.1 inches) in length (Stebbins 1985). CRLFs breed from November through March (Storer 1925). Populations of CRLFs are most likely to persist where multiple breeding areas are embedded within a matrix of habitats used for dispersal, a trait typical of many anuran species (Marsh and others 1999; Griffiths 1997; Sjogren-Gulve 1994; Mann and others 1991; Laan and Verboom 1990; Reh and Seitz 1990).

At any time of the year, adult CRLFs may move from breeding sites. They can be encountered living within streams at distances exceeding 2.8 kilometers (1.8 miles) from the breeding site and have been found greater than 100 meters (328 feet) from water in adjacent dense riparian vegetation for up to 77 days (USDI 2002), but are typically within 60 meters (200 feet) of water. During periods of wet weather, starting with the first rains of fall, some individuals may make overland excursions through upland habitats. Most of these overland movements occur at night. Newly metamorphosed juveniles tend to disperse locally July through September and then disperse away from the breeding habitat during warm rain events (USDI 2002).

The areas that might support CRLF breeding habitat within the project area (defined as stream slopes less than 4 percent with at least one pool deeper than 0.7 meters below 5,000 feet in elevation (USDI 2002)) was determined through habitat assessment surveys by Sierra National Forest in 1999 and 2000 (Eddinger 2000a and 2000b). The California Wildlife Habitat Relationships (CWHR) highly suitable habitats (CDFG 2002) for this species that occur within the KRP are riverine and fresh emergent wetlands with submerged organic, mud, and sand substrates and with short or tall herbaceous species and vegetation closures greater than 10%.

Foothill yellow-legged frog

The Pacific Southwest Region of the Forest Service designated the foothill yellow-legged frog (*Rana boylii*) as a sensitive species in 1998. The foothill yellow-legged frog (RABO) is moderate in size, measuring between 37-82 millimeters (1.5 – 3.2 inches). RABO are found in or near rocky streams and rivers in a variety of habitats including valley-foothill riparian, ponderosa pine, mixed conifer, coastal scrub, mixed chaparral, and wet meadow types (Stebbins 1985). The CWHR highly suitable habitats (CDFG 2002) for this species that occur within the KRP are riverine and valley foothill riparian with mostly submerged and flooded gravels, cobble, boulders, and bedrock with trees greater than six inches in diameter and canopy closures greater than 10%. This species generally occurs at elevations below 6,000 feet in perennial streams with breeding areas defined by some shading (> 20%), water temperatures not exceeding 20’C for egg-laying and larval development, shallow riffles (≤ 0.21 meters), and cobble or larger substrates (Hayes and Jennings 1986; CDFG 2002; Lind and others 2003).

Breeding occurs in shallow, slow flowing water with at least some pebble and cobble substrate between March and June after high flows have receded. During breeding season and in the summer, RABO are rarely encountered far from permanent water. During the winter, RABO have been observed in abandoned rodent burrows and under logs as far as 100 meters (328 feet) from a stream (Zweifel 1988). Suitable habitat for this species in the Kings River Project area is being considered as the perennial streams and tributaries of the Big Creek and Rush Creek drainage below 6,000 feet in elevation.

Lahontan cutthroat trout and the Cow Creek Critical Aquatic Refuge
The Lahontan cutthroat trout (LCUTT; *Oncorhynchus (=Salmo) clarki henshawi*) is both a federally threatened species and a Sierra National Forest management indicator species (MIS). On the Sierra National Forest this species was introduced into only two watersheds; West Fork Cow Creek and West Fork Portuguese Creek. These two populations are managed under the species recovery plan and terms and conditions of two U.S. Fish & Wildlife Service Biological Opinions (1-1-94F-44 and 1-1-95-F-42). The West Fork Cow Creek population occurs within the Kings River Project area but outside the initial eight management units. A Critical Aquatic Refuge (CAR) was established for this species in 2001 (USDA 2001a; USDA 2004b). The LCUTT is monitored annually for population abundance and every five years for habitat characteristics based on the recovery plan objectives, the terms and conditions of the Biological Opinion, and from the Sierra National Forest LMP monitoring requirements. Currently this species is maintaining its population size though fishing pressure appears to be increasing over the last few years (USDA 2005). There are no defined CWHR habitats for this species (CDFG 2002).

Mountain yellow-legged frog and the Snow Corral Critical Aquatic Refuge
The Mountain yellow-legged frog (RAMU; *Rana muscosa*) is a federal candidate species and a Forest Service sensitive species. The USFWS found that listing was warranted as threatened or endangered for this species however the listing was precluded at the time based on other higher priority issues (68 **FR** 2283). On the Sierra National Forest there are roughly 30 known locations of this species with one known population occurring within the Kings River Project but outside the initial eight management units in the Snow Corral meadow watershed and Critical Aquatic Refuge (CAR).

This species is a high elevation species that only occurs in the Sierra Nevada Mountains of California from elevations of 4,500 feet to 12,000 feet (CDFG 2002). The mountain yellow-legged frog is mostly diurnal and hibernates in the winter beneath ice-covered streams, lakes, and ponds (CDFG 2002). This species may move up to 165 feet from their habitat. Breeding and egg laying occur after snowmelt from June to August (CDFG 2002). Tadpoles over-winter in their habitat making them more susceptible to fish predation and diseases. The CWHR highly suitable habitats (CDFG 2002) for this species that occur within the Kings River Project are lacustrine, montane riparian, riverine, and wet meadows with mostly submerged and flooded gravels, cobbles, and boulders with trees greater than one inch in diameter, short or tall herbaceous cover, and vegetation and canopy closures greater than 10%.

Relictual Slender Salamander

The Relictual slender salamander (RSS; *Batrachoseps relictus*) is a Forest Service sensitive species. The Relictual slender salamander was listed on the Regional Forester's sensitive species list in 1998 prior to research (Jockush and others 1998; Jockush and Wake 2002; Hansen 2006) which delineated the Relictual slender salamander into four separate species in the Sierra Nevada. Three of the species would have distribution south of Fresno County with one species, Kings River Slender Salamander (*B. regius)* within the Sierra National Forest and adjacent to the Kings River Project but outside the initial eight management units. The Gregarious Slender Salamander (*B. gregarius*) also occurs on the Sierra National Forest within the Kings River Project and the initial eight management units and has been considered as part of the relictual slender salamander group based on the original distribution of the Relictual slender salamander as described in the 1998 Regional Forester's Sensitive Species List. Therefore the Relictual slender salamander is analyzed as if the original description and range of the species was still valid from Fresno County, south to the Greenhorn Mountains and Kern River Canyon in Kern County (CDFG 2002). Elevations for this species range from 560 feet to 7,600 feet (Jennings and Hayes 1994).

Direct threats to the species include changes in canopy structure, and activities that affect hydrology or the soil moisture regimes around seeps and meadows (Hansen 2005). Practices such as opening seeps and springs with explosives to enhance habitat for upland species or capping of springs are potentially devastating to localized populations (Hansen 2005). The CWHR highly suitable habitats (CDFG 2002) for this species that occur within the KRP are blue oak woodland, blue oak – foothill pine, montane hardwood, montane hardwood – conifer, montane riparian, sierra mixed conifer, valley foothill riparian, valley oak woodland, and white fir. In riparian areas any size tree and greater than 10% canopy closure is highly suitable. In oak woodland areas trees greater than 11 inches in diameter and canopy closures greater than 40% is highly suitable. In montane and white fir areas trees greater than 24 inches and canopy closures greater than 40% is highly suitable.

Use by the RSS is in relatively small, mesic areas (e.g., swales, drainages, etc.) with an overstory of trees or shrubs and abundant rocks, litter, or woody debris (CDFG 2002). They are normally active at night, and return to cover during daylight (CDFG 2002). During periods of extended rainfall, they may remain on the surface during the day to feed (Hendrickson 1954). Surface activity is limited by extremes of temperature and unfavorable moisture conditions (CDFG 2002). For the relictual slender salamander there is no data detailing the movements of the species however in similar species adults of *B. attenuatus* moved within a mean of 1.5 meters (5 feet) from their home cover over 2 years, and 59% of the individuals were found repeatedly under the same cover (Hendrickson 1954; CDFG 2002).

Species surveys for the relictual slender salamander conducted in 2003 located one population in a small seep area within potential suitable habitat of the South of Shaver Fuels Reduction project (sos_1 management unit) area. In addition, a monitoring study conducted by the Pacific Southwest Research Station of the Forest Service (Bagne 2003) near the Blue Canyon workstation area of providen_1 and providen_4 management units found the species occurring along Big Creek and Summit Creek. In 1999 a relictual slender salamander was found in moist bark approximately 33 feet west of Oak Flat Creek just downstream of the bear_fen_6 management unit (in the bear_fen_1 management unit).

Suitable habitat is being defined conservatively as within 300 feet of any known sight records of the species and within 300 feet of any known seeps, springs, bogs, meadows, or perennial streams within the initial eight management units. There is potentially suitable habitat within any riparian conservation areas (RCAs) for any of the management units occurring below 8,000 feet in elevation. Since defining suitable habitat for this species across the KRP area is problematic an estimate using the RCAs was generated for those management units outside of the initial eight.

Resident Trout Species – Brown Trout, Eastern Brook Trout, and Rainbow Trout
Brown trout (*Salmo trutta*) are considered as one of three resident trout management indictor species for the Sierra National Forest. Brown trout are native to Europe and are fished for sport around the world (Moyle 2002). Adult brown trout are usually found at the bottom of pools between 0.7 and 3.5 meters (2.3 – 11.5 feet) deep while younger, smaller brown trout tend to inhabit riffle areas less than 30 centimeters (11.5 inches) deep (Moyle 2002). The optimum habitat appears to be medium to large, slightly alkaline, clear streams with swift riffles and large, deep pools (Moyle 2002). However, they can be found throughout any stream and/or lake system (Moyle 2002). The preferred water temperature range is between 12 and 20 degrees (°) Celsius (C), avoiding streams that do not reach 13°C (Moyle 2002). Smaller brown trout typically feed on terrestrial insects and aquatic invertebrates while larger brown trout tend to feed on other fish species, crayfish, and dragonfly larvae (Moyle 2002). Spawning occurs in November or December in streams with pea to walnut sized gravel (approximately 10 to 40 millimeters (0.4 – 1.6 inches; Moyle 2002).

Eastern brook trout (*Salvelinus fontinalis*) are the second resident trout species to be listed as a management indicator species for the Sierra National Forest. Eastern brook trout were originally native to the northern half of the Eastern United States and Canada (Moyle 2002). Eastern brook trout have been introduced into streams throughout most of the world, becoming most abundant in Sierra mountain streams and lakes (Moyle 2002). Eastern brook trout prefer clear, cold lakes and streams and have become well established in the small, headwater, spring-fed streams and isolated lakes (Moyle 2002). Water temperatures for Eastern brook trout often range between 14 and 17° C though being able to feed in as cold as 1°C (Moyle 2002). When water temperatures begin to exceed 19°C it starts to slow growth and may become lethal for this species (Moyle 2002). Eastern brook trout mature within the first year for males and second year for females, spawning in the fall and living only for a total of 4 or 5 years (Moyle 2002). They tend to feed on terrestrial insects and aquatic insect larvae in both streams and lakes, with zooplankton added in at lakes (Moyle 2002). As they become larger in lakes they may begin to feed on other fish species (Moyle 2002).

Rainbow trout (*Oncorhynchus mykiss*) are the third resident trout species to be listed as a management indicator species for the Sierra National Forest. Resident rainbow trout is a general term used for hundreds of non-anadromous wild and hatchery planted rainbow trout populations existing throughout California (Moyle 2002). Rainbow trout were originally native to Pacific coast streams from Alaska to Baja, California (Moyle 2002). Rainbow trout have been introduced into coldwater streams and lakes throughout most of the world, including waters that were originally fishless (Moyle 2002). Rainbow trout prefer cool, clear fast-flowing permanent streams and rivers where riffles dominate over pools, invertebrate species for food is abundant, and there is ample riparian vegetation, and undercut banks (Moyle 2002). Water temperatures for rainbow trout often range between 4° and 23° C (Moyle 2002). When water temperatures exceed 24° C it is usually lethal for this species (Moyle 2002). They prefer alkaline waters (pH of 7 to 8). Smaller rainbow trout will chose shallow areas (less than 50 cm (1.6 feet)) while juveniles tend to use deeper (50 to 100 cm (1.6 – 3.3 feet)) and faster areas of the stream (Moyle 2002). Larger rainbow trout will select the deeper areas of runs, pools and behind rocks searching for drifting invertebrates (Moyle 2002). Threats to rainbow trout include birds that prey on the fish if in shallow water and other trout species such as Brown trout (Moyle 2002).

Species surveys within the project area have indicated all three resident trout species (and other unidentified fish species) occur in all the major perennial tributaries of the initial eight management units. Suitable habitat is defined as all perennial streams within the project area and is considered as marginal to good habitat. Most fish species have access to and from Pine Flat Reservoir to Big Creek and from the Kings River to Dinkey Creek (and thus their perennial tributaries) within the project area and are subject to heavy fishing pressure. Since defining suitable habitat for these species across the KRP area is problematic an estimate using perennial streams was generated for those management units outside of the initial eight.

Western pond turtle

The Pacific Southwest Region of the Forest Service designated the western pond turtle as a sensitive species in 1998. The central Sierra Nevada Mountains are an area of overlap between two pond turtle subspecies, *Clemmys marmorata marmorata* (Northwestern pond turtle) and *Clemmys marmorata pallida* (Southwestern pond turtle). These pond turtles, collectively known as western pond turtles (WPT), are found from sea level to 4,690 feet in elevation (Jennings and Hayes 1994).

Habitat for WPT occurs in a variety of both permanent and intermittent aquatic habitats. This turtle is often restricted to areas near the banks or in quiet backwaters where the current is relatively slow and basking sites and refugia are available (CDFG 2002). Movements of WPT of over 1 mile have been reported when local aquatic habitat conditions change (e.g. drought), however most stay within 325 feet of the stream channel mainly moving during breeding and egg-laying (CDFG 2002). Holland (1991) references information indicating that a significant portion of the turtles occurring in pond environments move out into adjacent wooded or grassland habitats to over-winter, with two turtles found dormant under logs and others in duff and litter under trees. Aerial basking on logs and rocks occurs when air temperature exceeds water temperature (Holland 1985).

Mating occurs in late April to early May (Holland 1991). Young WPT are believed to over-winter in the nest (Holland 1985). When hatchlings leave the nest they occupy shallow water habitats where they feed on nekton (Holland 1985, 1991). In California, maturity occurs at about 8 years (CDFG 2002).

The CWHR highly suitable habitats (CDFG 2002) for this species that occur within the KRP are blue oak woodland, blue oak – foothill pine, fresh emergent wetland, lacustrine, riverine, valley foothill riparian, and valley oak woodland. Highly suitable areas include those with short or tall herbaceous plants and vegetation closures greater than 40% with trees larger than six inches in diameter and canopy closure greater than 10% is highly suitable. In stream, lakes, and pond habitats are highly suitable areas are those that range from mostly exposed to flooded cobbles, boulders, and bedrock.

Surveys conducted during the late 1990's and into 2003 for the WPT, within and adjacent to the project area, have occurred including mark-recapture studies, population abundance and presence/absence surveys. Numerous WPT sightings occur along Billy Creek, Lower Rancheria Creek, Rush Creek, Big Creek and a few other perennial and intermittent tributary streams. Suitable habitat within the project area is considered marginal to moderately good.

Yosemite toad

The Yosemite toad (BUCA; *Bufo canorus*) is a federal candidate species and a Forest Service sensitive species. The USFWS found that listing was warranted as threatened or endangered for this species however the listing was precluded at the time based on other higher priority issues (67 **FR** 75834). This species occurs above 6,000 feet in elevation in meadows, lake edges, and some stream habitats only in the central Sierra Nevada Mountains of California and can disperse up to 0.6 miles (CDFG 2002) to reach breeding or over-winter habitats.

The Yosemite toad is mostly diurnal and seeks cover during non-breeding seasons (approximately August to March) in abandoned rodent burrows (Jennings and Hayes 1994) or by moving into adjacent forested areas (CDFG 2002). Breeding and egg laying occur after snowmelt in mid-April to mid-July in shallow, quite pools in wet meadows, or shallow tarns surrounded by forest (CDFG 2002). Desiccation of pools before metamorphosis is a major cause of mortality in tadpoles (CDFG 2002). The CWHR highly suitable habitats (CDFG 2002) for this species that occur within the KRP are wet meadows that have short (< 12 inches) herbaceous plants with vegetation closures greater than 10%.

This species was inventoried for occurrence between 2002 and 2004 across the Sierra National Forest. In 2006 a new set of occupied meadows was found within the Kings River Project area in the Bear drainage 4 miles east of the El-o-win_1 management unit. There are currently seven meadows (within and directly adjacent to the krew_bul_1 management unit) that are occupied with Yosemite toad. These occupied meadows could be considered a source population for the distribution of Yosemite toads in the Bull Creek and Teakettle watersheds since they appear to be isolated from other populations of Yosemite toads.

Table 3-67 - Miles and acres of habitat for the ten listed aquatic species within the entire KRP area.

Species	Type of Habitat	Amount
California red-legged frog	Acres of suitable breeding habitat	1,353
Foothill yellow-legged frog	Acres of suitable habitat	9,572
Lahontan cutthroat trout	Acres of Critical Aquatic Refuge for the Lahontan cutthroat trout	4,472
Mountain yellow-legged frog	Acres of Critical Aquatic Refuge for the mountain yellow-legged frog	1,516
Relictual slender salamander	Acres of potentially suitable habitat within Riparian Conservation Areas	45,643
Resident trout species	Miles of potentially suitable perennial stream habitat	406
Western pond turtle	Acres of potentially suitable habitat	19,197
Yosemite toad	Acres of meadow habitat occupied	268
Yosemite toad	Acres of meadow habitat	955
Yosemite toad	Acres of dispersal habitat	17,112

Table 3-68 - Miles and acres of habitat for the ten listed aquatic species within the initial eight management units of the KRP.

Species	Type of Habitat	Amount
California red-legged frog	Acres of suitable habitat	297
Foothill yellow-legged frog	Acres of suitable habitat	1,832
Lahontan cutthroat trout	Acres of Critical Aquatic Refuge for the Lahontan cutthroat trout	0
Mountain yellow-legged frog	Acres of Critical Aquatic Refuge for the mountain yellow-legged frog	0
Relictual slender salamander	Acres of potentially suitable habitat within Riparian Conservation Areas	6,510
Resident trout species	Miles of suitable perennial stream habitat	33
Western pond turtle	Acres of suitable habitat	623
Yosemite toad	Acres of meadow habitat	68
Yosemite toad	Acres of meadow habitat occupied	22
Yosemite toad	Acres of dispersal habitat	1,008

Environmental Consequences

This section analyzes the effects of the three alternatives on the ten listed aquatic species and their habitats. The effects of the alternatives are discussed in terms of direct, indirect, and cumulative impacts. Affects on aquatic species and their habitats are fully described for this project in the Aquatic Species Biological Assessment and Biological Evaluation report (Sanders 2006b) and the Resident Trout Management Indicator Species report (Strand 2006) found in the project file for the Kings River Project – Final Environmental Impact Statement for the Initial Eight Management Units. Only a brief discussion is presented in this section for each of the alternatives.

There were two significant issue detailed in Chapter 1 that relate to aquatic species:

3) the use of herbicide/surfactant will create an adverse risk of harmful effects to people

and wildlife (issue #2), and

4) the proposed action will threaten the viability and cause degradation of habitat of the spotted owl, marten, fisher, and goshawk and will lead to high short-term risks on aquatic management (issue #3).

The factors for aquatic species for these two issues (as listed in Chapter 1) involves the tracking of population viability (e.g. population dynamics and life stages present) and the quality of habitat they require to over winter in, disperse from, breed in, and forage from (e.g. sediment V* ratings in pools (Hilton and Lisle 1993) and channel conditions (Frazier and others 2005) including water temperature, shading, and instream woody debris).

The combined treatments proposed for Alternatives 1 and 3 of the initial eight management units involves timber harvesting, small tree thinning, plantation upkeep, prescribed fires and fire lines, road construction and reconstruction, temporary roads and skid trails, herbicide treatments for noxious weeds and in other areas, and selected watershed improvements sites. Overlapped with these activities are a few studies that will look at the effects on the environment (e.g. the watershed study) and some wildlife species (e.g. the spotted owl study). All these activities individually and together will have risks and both short-term and long-term effects on aquatic species, even with the design measures in place. The degree of these risks and effects can differ by species and the locations of their habitats within the project area. However, in general there are some commonalities of effects for aquatic species for both Alternative 1 and 3.

Aquatic species live in a wide variety of wetland habitats. In general, the riparian condition, especially vegetation, is important for all aquatic organisms to complete their life cycles. These organisms hide and seek shade in riparian vegetation. In addition most rely on both terrestrial and aquatic insects for food. The riparian vegetation is important for production of prey items. Within the project area, all Class I and II stream channels (perennial steams; order 3 and higher) provide potential habitat for the resident trout species. For reptiles and amphibians, meadow edges, seeps and damp headwater areas as well as the riparian conservation areas surrounding streams provide potential suitable habitat.

All management activities can affect aquatic habitat quality. Some changes may be beneficial and some may be detrimental. Fires (especially large stand replacing wildfires) decrease the amount of vegetation thus increasing runoff and sedimentation into the stream (Swanston 1991). However over time aquatic species have become adapted to large fires and can rebound if enough dispersal and good quality local habitat exists (Rieman and others 2005). Management activities like those proposed in Alternatives 1 and 3 (i.e. timber harvesting with tractors and road construction) can increase the amount of sedimentation into streams (Chamberlin and others 1991; Furniss and others 1991). Herbicide treatments can minimize unwanted, competitive plants. However, they may pose a threat to aquatic species if use is not carefully applied and monitored.

Increased sedimentation can affect stream water temperature, channel width, macroinvertebrate habitat, and dissolved oxygen levels. These effects are similar from all sources of sedimentation including natural events, roads, introduced fire, grazing, timber harvest, or mining (Meehan 1991). Other alterations to the stream such as increased water temperatures, decreased vegetative cover, and changes to channel morphology are similar in effect to the aquatic habitat quality though causes may be different (Meehan 1991).

Streambank vegetation is instrumental in maintaining the proper functioning of riparian areas and suitable habitat for fisheries and other aquatic life. Cover from streambank vegetation can help increase fish production (Boussu 1954; Hunt 1969; Hanson 1977; Binns and Eisermann 1979). Streambank vegetation provides for cover, streambank stability, stream temperature control and production of prey (Platts 1991). It also buffers the stream from incoming sediments and sediments from flood or high water events. It is essential for building and maintaining streambank structure. Natural erosion and rebuilding of streambanks occur as equilibrium over time. If this equilibrium is upset, streambank breakdown can occur faster than banks can be rebuilt (Platts 1991). If streambank vegetation exists, streambanks can remain more in equilibrium as it buffers high flow events and traps sediments to rebuild the banks. Streambank vegetation also shades the stream and contributes terrestrial insects and detritus to macroinvertebrates. This is critical to the basis of the aquatic food chain. Streambank vegetation provides directly organic material which can make up to 50% of the streams nutrient energy supply (Cummins 1974).

The effects of management activities from Alternatives 1 and 3 on aquatic resources are of concern within the Kings River Project. The quality of the aquatic ecosystem is dependent on many factors, such as low percentages of fine material or sediment, stable, well vegetated streambanks with instream woody debris and shading, and low water temperatures. These indicators of health for aquatic ecosystems directly and indirectly contribute to the viability of aquatic species.

Alternative 1 - Proposed Action

Direct Effects

Direct effects to aquatic species as a result of Alternative 1 include crushing (e.g. killing) or disturbing (e.g. noise disturbance and disruption of breeding cycle) amphibian and reptiles in their burrows and sheltering habitats, or as they disperse from upland habitat to aquatic habitat for breeding or feeding as a result of all the ground disturbing activities proposed. Amphibian and reptile species can move several hundred feet from streams and ponds to shelter in burrows or under logs that would not be protected during road building, road reconstruction, prescribed fires, or timber harvesting. In some cases, as in the relictual slender salamander, an unknown population may be so isolated (to within a few feet for dispersal for an entire population (CDFG 2002)), that a single activity such as tractor timber harvesting or construction of a new road, could kill a localized population. Watershed restoration projects may also produce direct effects on all aquatic species since egg masses can be dislodged or covered with fine sediment which will suffocate the eggs and larvae during instream restoration.

Of the activities being proposed by Alternative 1, commercial harvesting and underburning have the potential to directly affect canopy cover and / or stream shading. If forest harvesting occurred in streamside areas there could be an increase in solar radiation to the stream channel. Additionally, underburning could result in tree mortality and openings within the riparian canopy. Streamside shading affects the amount of solar radiation that filters to the surface of the water. Commercial harvesting would occur on over 6,200 acres under this alternative, which represents canopies over 45% of the project area potentially being altered. Underburning is proposed over approximately 4,700 acres (33% of the project area), with some of those acres overlapped with the commercial harvesting (treated % are not cumulative). Currently the levels of stream shading (based on 2005 data; Strand 2006) are currently within the desired condition of > 50%.

During late summer, when solar radiation potential is greatest, air temperatures are warmest, and stream flows are lowest, is the period when canopy cover is essential in moderating water temperatures. Typically only perennial channels flow during this period, thus concerns over water temperature focus on these stream channels. Base flows may be augmented by the reduction in vegetation, but the effect is not likely to persist into the dry summer season where it would be detectable (Gott 2006). The increase in soil moisture will be utilized by the remaining vegetation, so it will not be available for stream flow.

Perennial streams have a Class I streamside management zones (SMZs) of 100-feet prescribed for each side (1,240 acres) of the stream channel. Within portions of the California red-legged frog habitat, there would be no harvesting (50 acres). The Class I SMZs also have a 50-foot “No treatment” buffer on the inner 50-feet of the stream channel (590 acres), except for 70 acres that would be commercially harvested and yarded by helicopter. The remaining outer 50-feet exclude heavy mechanical equipment (600 acres) and would be treated under one of two harvest prescriptions. Under the “Old Forest Linkage” prescription (320 acres – including helicopter), basal area would be maintained at a minimum of 280 square feet and stand composition would focus on attributes for fisher (maintain large and decadent trees). The remaining Class I SMZs (350 acres) would be treated consistent with silvicultural prescription for the entire stand. These treatments would reduce the basal area between 0 - 70%, although most would retain more than 60% of current basal area. Basal area guidelines for these areas were developed based on the silvicultural objectives of the stand. For intermittent channels classified as Class II SMZs (they have flow during later summer) they are treated in a similar manner to perennial streams, although their SMZs are 75 feet (each side) and have a 25 feet “No Treatment” zone along the inner portions of the stream channel.

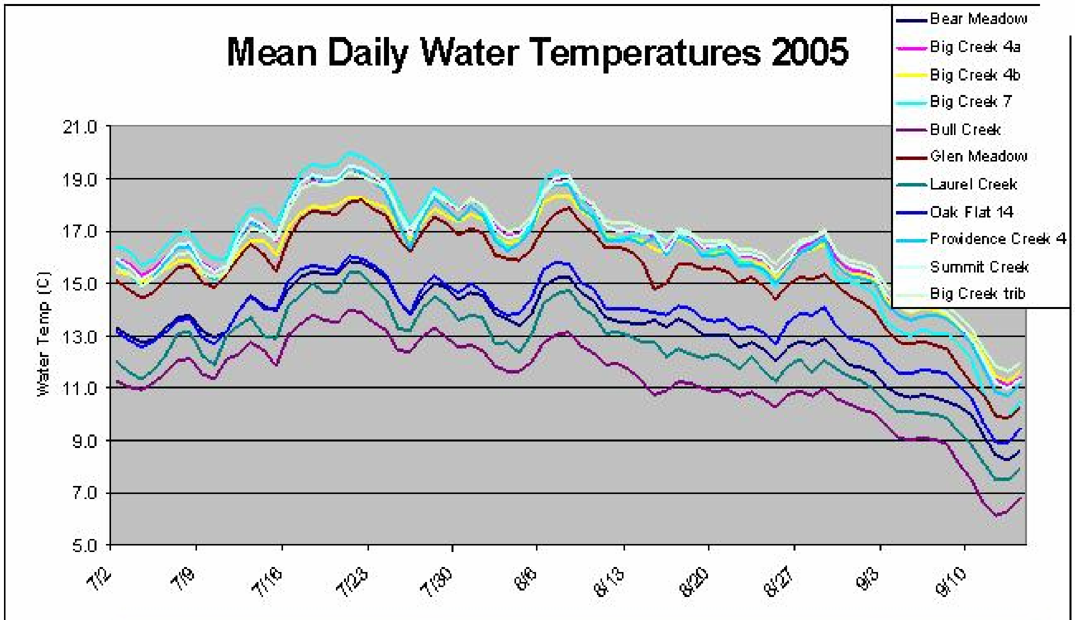
Beschta and others (1987) noted that buffers of 30 meters (98.4 feet) or more would generally provide the same level of shading as an old growth stand. Within buffers, mean air temperature rates decreased from a rate of -1.6º C/10 meters to -0.2º C/10 meters beyond 30 meters (98 ft), while relative humidity rates declined from +3.8%/10 meters to +0.6%/10 meters beyond that same distance as reported by Ledwith (1996). SNEP (Moyle and others 1996b) notes the benefits to riparian function and microclimate vary by the distance from the stream channel. Riparian shading appears to be maximized at one tree-height distance from the stream channel. Kattleman (1996) notes several studies have demonstrated that communities of aquatic invertebrates changed significantly in response to upstream logging, with some of these effects persisting for two decades.

Much of the food base for stream ecosystems is derived from adjacent terrestrial ecosystems with litter fall from deciduous stands exceeding that of coniferous stands. Deciduous input (leaves) generally breaks down in less than half the time necessary for the breakdown of coniferous input (needles; Gregory and others 1991). Buffer strips 30 meters (98.4 feet) wide are noted as protecting invertebrate communities from logging induced changes (Gregory and others 1987; EPA 1991).

Dwire and others (2006) suggest that prescribed fire may top-kill some riparian trees and shrubs. A study at Blodgett Forest in northern California introduced prescribed fire into the riparian zone and found that a 4.4% mortality rate resulted, occurring in trees 11 – 40 centimeters (4.5 - 15.7 inches) dbh (diameter at breast height; Bêche and others 2005). Prescribed fire is not proposed for introduction into the Class I/II SMZs for this project, it would be allowed to creep within the SMZ. Personal observations of past prescribed burning under these criteria on the High Sierra Ranger District are that it has not resulted in a noticeable decline in streamside canopy cover.

Some alteration of the existing stream shading (currently > 75%) is anticipated from Alternative 1. The inner "No Treatment" cores of the Class I and II SMZs (970 acres) would not be implementing commercial harvesting. Helicopter treatment areas would remove timber from within 140 acres adjacent to perennial streams. The helicopter acreage is part of the "Old Forest Linkage" Management Prescription with basal area retention of 280 square feet focusing on attributes desirable for fisher (large, decadent trees). It is not anticipated that large changes in overhead canopy would occur in this 10% of the streamside acreage. Stream shading would meet the desired condition of >50%.

There are no direct effects on water temperature anticipated from Alternative 1. Resident trout occupy approximately 33 miles of stream, out of 51 miles of perennial streams within the project area. Water temperature data collected from the project area in 2005 and lifestages of resident trout present during that period are displayed in Figure 3-60.



	Jul	Aug	Sep
YOY	X	X	X
Subadult	X	X	X
Adult	X	X	X

Figure 3-60 - Water temperature data from Stream Condition Inventories in 2005 and resident trout life stages (X) that would be present (YOY = young-of-year)

As measured during the summer of 2005, daily mean water temperatures were less than 21°C. This period of time represents that of highest air temperatures and lowest stream flow, thus it represents the most stressful time for coldwater resident trout. Climatological data from the Big Creek Powerhouse No.1 (NOAA COOP station 040755) indicates that the summer of 2005 was hotter than the mean (period 1999-2005) during most of the monitored period, except for August 10 through 25, 2005. The weather station is located at an elevation of 4,880 feet and is the nearest weather station with an elevation comparable to the midpoint elevation of the KRP analysis area, with a period of record more than 5 years. The data from 2005 is indicative of water temperatures during a period of above average heat, but not necessarily drought. Big Creek Powerhouse No.1 maximum air temperature data averaged 8° F (4.4° C) warmer than 2005 weather data collected by the Pacific Southwest Region Forest Service Research Station on Lower Bull Creek (5,800 ft elevation) in the month of August.

The hourly maximum water temperatures during the 2005 monitoring period showed some maximum water temperatures were above the upper bound preferences (generally < 20ºC) for resident trout, but no maximum was approaching the level of incipient mortality (26ºC) identified under the habitat descriptions.

Large woody debris (LWD) is of both physical and biological importance within stream channels and riparian zones (Bisson and others 1987; Sedell and others 1988). Modes of delivery are influenced by stand density; stand composition; bankfull channel width; management practices; tree proximity; lean and direction; wind patterns; valley form; degree and evenness of cover; and wood recruitment pathway (Bragg and Kershner 2004). Recruitment pathways can be chronic (ongoing mortality; channel adjustment) or episodic (avalanches, fires, floods, slides, disease). The project area is slightly lower than desired criteria for large woody debris. Summit Creek stands out as being low in both LWD and stable LWD. The element within the SMZs that represents the most immediate source of LWD is snags.

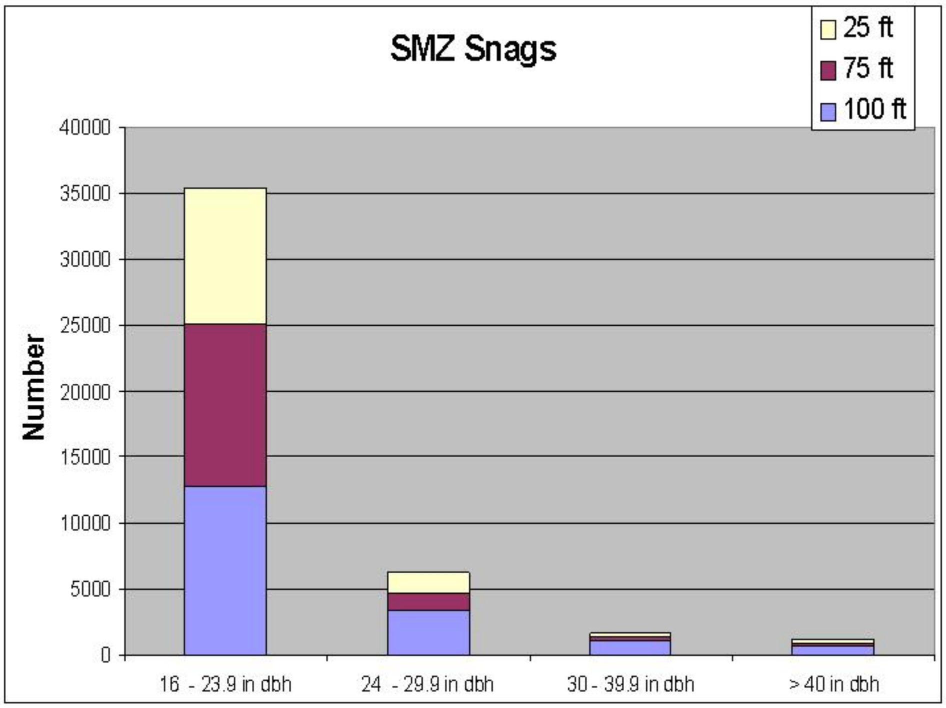


Figure 3-61 - Number of snags within project area streamside management zones (SMZs).

If Alternative 1 were to remove snags from SMZs there would be a direct affect. An approximate number of snags within SMZs (based on stand plot data) is displayed in Figure 3-61. These snags represent short-term potential LWD recruitment. Removal of snags is not being proposed, thus there is no direct effect on LWD recruitment from Alternative 1.

Herbicide use would occur on 1,183 acres under this alternative or approximately 8.5% of the project area. Two factors determine the degree of adverse impacts of herbicide application on aquatic species: the toxicity of the herbicide; and the likelihood that an organism would be exposed to toxic levels of the herbicide. The recovery plan for the California red-legged frog (USDI 2002) indicated the following for the use of glyphosate that would be applicable to the aquatic species covered here:

"Glyphosate does have the potential to contaminate surface waters due to its use patterns and through erosion, as it adsorbs to soil particles suspended in runoff. If glyphosate

reached surface water, it would not be broken down readily by water or sunlight. Toxicity tests performed under standard conditions at the Columbia National Fisheries Laboratory indicated that this compound is "moderately toxic" to rainbow trout (U.S. Environmental Protection Agency 1993). Some formulations may be more toxic to aquatic species due to the different surfactants used in formulation."

With ground application of the herbicide it is expected that drift would be negligible and streamside buffers would prevent herbicides from being applied too close to streams thus reducing the probability of direct effects of kill on resident trout.

It is highly unlikely that spraying with glyphosate formulated as Accord and R-11 would be harmful or toxic to aquatic species except in the case of an accidental spill or when project design measures are not followed. Precautions in handling of herbicides, explained in the Watershed Section, would help to prevent accidental spills. Monitoring results, referenced in the Watershed Section, from 1991 to 2000 of surface water adjacent to projects involving the use of glyphosate on seven projects on the Sierra, Stanislaus and Eldorado National Forests resulted in no detections.

Since glyphosate would not be applied to or near open water and it has very low mobility in soil as noted in the Soils Section, any direct effects to resident trout or other aquatic species in Big, Dinkey or other perennial creeks is highly unlikely. There appears to be no systematic differences in toxicity among species when doses of glyphosate are expressed in units of mg/kg body weight. (SERA 2003, p. 3-6). The results show glyphosate residues when applied aerially were 10,000 times less than would be necessary to produce acute mortality (Trumbo 2000).

R-11, the surfactant that would be used with glyphosate, is labeled for application to water and has a history of satisfactory use in aquatic situations by California agencies such as the Dept. of Water Resources and the Dept. of Boating and Waterways. Testing of R-11 has been limited because none is required by EPA and the Dept. of Pesticide Regulation only requires testing on fish and insects. The results of the Dept. of Fish and Game study referred to in the previous paragraph show R-11 residues when applied aerially were 100 times less than would be necessary to produce acute mortality (Trumbo 2000).

Indirect Effects

Alternative 1 has a risk of compacting soil and increasing both short term and long term sediment delivery to riparian and aquatic habitats. Since this alternative uses conventional tractor harvesting along with helicopter logging, there is a high likelihood of disturbing soil, thus contributing to higher increases in sediment delivery to the riparian and stream systems. This increased sediment may decrease available pool habitat for fish, amphibian species like the California red-legged frog, and for aquatic insects over time.

Though mechanical harvesting equipment within the streamside management zones are prohibited, cutting and pulling (i.e. grapping the top of a tree outside the SMZ with a grapple skidder) trees out of riparian zones and along streambanks will occur. Pulling trees out of riparian areas will greatly affect aquatic species both in and out of the water system. Bank trees provide key components for the aquatic ecosystem such as microclimate (shade, temperature, moisture) control, large organic material (i.e. large woody debris providing cover for fish species), and rooting strength. The act of pulling trees out of riparian areas and near meadows can also severely damage or eliminate burrow habitat for aquatic species, particularly for the Yosemite toad, which over time will reduce the viability of localized populations. A design measure protects these bank trees from removal thus reducing the chances of bank damage and protects riparian areas.

Watershed restoration projects should reduce sediment delivery to riparian and aquatic systems by improving watershed conditions. New and temporary roads and prescribed fire can reduce vegetative cover therefore there may be increased overland flow and sediment delivery to the aquatic ecosystem. Prescribed / understory burning, thinning, and fuelbreak construction / maintenance can furnish short-term (3 to 5 years) sediment supplies. This sediment can affect aquatic organisms by reducing the amount of suitable habitat by increasing stream width to depth ratios, increasing water temperature and reducing streambank stability. Where more ground is disturbed the potential for increased short term effects exist but the benefit from the fuel reduction is also reduced over time.

The indirect effect on the resident trout species and western pond turtle will be most seen in those sub-watersheds that are over their lower thresholds of concern both before and after project implementation. Filling of pools with fine sediment will reduce and perhaps eliminate over time the necessary pool habitat required by these aquatic species thus reducing the viability of the populations.

Elevation, aspect, stream width, channel roughness coefficient, riparian shading, solar radiation, air temperature, cloud cover, and stream discharge levels can affect water temperature. Of these elements, solar radiation has the most effect on water temperature (Beschta and others 1987; USGS 1997, 2000). Shading effects from forest canopies are important during the summer months due to high levels of radiation (high sun angles, long days, clear skies) accompanied by low stream discharges (Beschta and others 1987). Solar radiation through forest canopies depends on the heights of the crowns and density, along with the foliage (Moore and others 2005).

Underburning would take place through and within Class I SMZs. When this occurs there are design measures that allow for creeping into the SMZ, but not active introduction of fire. It is expected underburning would occur within the 100-foot zone and some understory trees could be killed as a result. It is not expected that trees contributing to stream shading and blocking solar radiation would be killed by the underburning.

If forest harvesting occurred in streamside areas there could be a direct increase solar radiation (reduction in canopy cover) to the stream channel. However, in evaluating possible project direct effects to canopy cover it was noted that large changes in overhead canopy from stands adjacent to perennial streams would not be anticipated. Stream shading would meet the desired condition of > 50%. However, in addition to direct solar radiation, Beschta and others (1987) addresses possible affects from angular solar radiation and describes how canopy cover can be evaluated as angular canopy density. Figure 3-62 provides a rough portrayal of solar radiation effects on a perennial stream. There would be no harvesting under any prescription within the inner 50-feet of the Class I SMZ, except for 70 acres of helicopter yarding. In the outer 50-feet of treated SMZs there is a possible increase of open space within the understory and intermediate components of the treated stand. This provides an opportunity for increased angular solar radiation. It is anticipated that the majority of the trees would be retained and the inner 50-foot "No Treatment" zone will intercept this angular solar radiation and there would be no change to water temperatures.

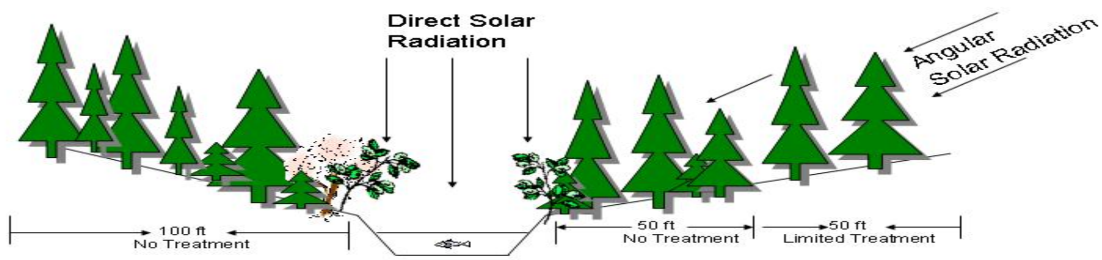


Figure 3-62 - Possible avenues of solar radiation for treated and untreated Class I SMZs (concepts from USGS 2000).

Helicopter yarding from Class I SMZs represents a possible change in angular radiation over 70 acres (inner 50 feet) adjacent to perennial streams. The helicopter yarding would occur over 5 stream segments: Bear Creek; an unnamed tributary to Big Creek (sub-watershed 519.0011); Providence Creek; Duff Creek; and Big Creek. To evaluate possible changes to stream temperature, these reaches were modeled using SSTEMP (USGS 1997, 2000) to characterize the extent of possible thermal heating resulting from treatments reducing vertical canopy by up to 20% in these areas. It is not anticipated that this level of reduction (20%) would actually occur as most trees providing overhead canopy would be maintained and basal area limits (280 square feet) for "Old Forest Linkage" would maintain overhead density. The projected results from SSTEMP for August 17 (the date with warmest mean temperatures during late summer period when flows are lowest) are provided in Table 3-69, which indicates an approximate increase of 0.2° F to Dinkey Creek and 1.18° F increase to Big Creek.

Table 3-69 - SSTEMP predicted affect on stream temperatures from helicopter treatments.

Stream Segment	Current Mean Temp (° F/C) 8/17	Post treatment SSTEMP modeled Mean Temp ° F (SD)/C 8/17	Estimated mixing affect at confluence (° F)
Bear Creek	54.5/12.5	55.4 (0.29)/13.0	0.20 (to Dinkey Creek)
Unnamed Big Creek trib	62.8/17.1	64.3 (0.34)17.9	0.15 (to Big Creek)
Providence Creek	62.2/16.8	64.5 (0.46)/18.1	0.3 (to Big Creek)
Duff Creek[1]	62.6/17.0	64.7 (0.42)18.2	0.33 (to Big Creek)
Big Creek	62.61/7.0	63.8 (0.30)17.7	1.18 Pine Flat Reservoir

[1] Used Providence Creek water temperature from adjacent watershed

Of the remaining elements that may affect water temperature, only stream discharge level could be affected by the proposal. Changes to stream discharge would be an indirect effect from the proposal due to decreases as basal area (and evapo-transpiration) decline due to changes in stand density (Chamberlin and others 1991; Kattleman 1996). If more water were available as baseflow during the late summer, there would be a possible reduction in stream temperature. Potential increases in peak flows are related to changes in snow accumulation and snow melt. This would apply mostly to the snow-dominated portions of the project area: el_o_win, glen_mdw, and krew_bull. The management units in the Big Creek watershed receive snow, but are not snowmelt dominated.

Class II stream channels (1,000 acres) are intermittent and are generally not expected to contribute flow during the late summer period when water temperatures are of greatest concern, although it is possible that some normally intermittent stream may flow into later summer for several years after implementation. Class II streams have 75 foot SMZ (on each side). Within the 1,000 acres of Class II SMZ, there are no treatment zones within the inner 25 feet (330 acres). These SMZ also provide protection from changes to direct solar radiation during the periods they flow water because of no activity within the inner zone that provides stream shading. The 25-foot “No Treatment” buffers may allow for an increase in angular solar radiation. Based on field observations, and SSTEMP modeling of helicopter SMZ it is not expected the amount would be sufficient to affect stream temperatures in the intermittent streams. Any changes would likely be ameliorated when mixing with the larger perennial streams occurs. It is anticipated that project design measures for Alternative 1 would maintain water temperatures within the current and desired condition (< 21° C), within the project area.

Of the treatments that would be implemented under Alternative 1, delivery of large woody debris could be affected by reduction in stand density through commercial harvest or underburning. There are approximately 3,130 acres of SMZ within the project area. However, this evaluation focuses on the perennial and intermittent stream channels (total 2,240 acres). Resident trout, western pond turtles, and amphibian species occupy the perennial channels (Class I SMZ), however intermittent channels (Class II SMZ) also contribute habitat to these species and water over half of the year. Additionally, intermittent channels may have sufficient flow to transport smaller pieces of LWD, thus influence LWD in the perennial channels. The ephemeral channels are more likely to retain LWD rather than transport it due to limited channel capacity.

There have been a number of models developed over the past decade attempting to project LWD recruitment. Modeling has been challenging considering that tree fall patterns may be chronic or episodic and influenced by geomorphology; tree or snag angle; bank steepness; prevailing wind direction; fragmentation; decomposition; mortality rates; and stem failure (Van Sickle and Gregory 1990; Bragg and others 2000; Bragg and Kershner 2002, 2004; Mellen and Ager 2002; Meleason and others 2002). The models attempt to address direction of tree fall and assign probability to angle of fall or assume angle is random. The random scenario could occur if tree failure is not influenced by disturbance or geomorphology. The variability from one channel reach to another has been difficult to model. It appears the more mature and intact the adjacent riparian forest is, the greater the likelihood of sustained LWD recruitment (Bragg and others 2000).

If forest harvesting occurred in streamside areas there would be a decrease in stand density, which is one of the elements that affect LWD recruitment. McDade and others (1990) indicated that 70% of LWD originated within ½ stand height (20 meters in that study) of the stream channel and approximately 85% of LWD would have been provided within a 30 meters (98.4 feet) buffer. Meleason and others (2002) noted that 90% of woody inputs were found to originate within 26 meters (85 feet) for mature conifer stands. To maintain LWD recruitment, the SMZs should be between 0.75-1.0 tree heights.

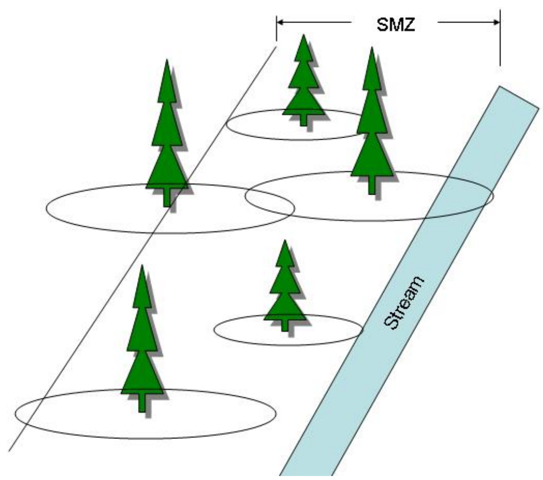


Figure 3-63 - Potential (independent of angle of fall probability) for large woody debris recruitment into stream channels.

The generalized drawing portrayed in Figure 3-64 illustrates the basic premise presented by Robison and Beschta (1990) that the probability of LWD entering a stream by direct fall is 0 when the distance exceeds the tree height. Stand data indicates that mean height for dominant trees along perennial streams in the project area is approximately 100-110 feet (32 meters) in height along Class I streams and 90-100 feet for Class II streams (29 meters).

Table 3-70 illustrates the percent (%) of trees within different height criteria (based on project data plots within SMZs). Approximately 46% of Class I SMZs acres will not have commercial harvesting implemented. When commercial harvesting is to occur within Class I and II SMZs it is primarily removal of suppressed and intermediate trees classes. These trees are expected to generally be 40-80 feet tall. For Class I stream channels this represents potential removal of up to 20% of the trees. However, ½ of the SMZ would not have timber harvesting and the % actually to be removed has basal area minimums and would be less than 20%. Robison and Beschta (1990) discuss the concept of effective height of the tree, which is the height to the minimum diameter and length necessary to qualify as LWD. It is has previously been noted that there are not common definitions for LWD, in particular with relation to length. If the most common criteria for diameter of 10 centimeters (4 inches) is applied, the top 10 feet of the tree would not meet the LWD criteria. Thus, it is more probable that 60 feet is the minimum that might have a probability of contributing LWD to a stream channel from the edge of a 50-foot "No Treatment" zone. The 60 to 80 foot height classes represent approximately 14% of the trees within the Class I SMZ; again ½ of this area would not be treated. The potential for these trees ever contributing LWD to the stream channel is further reduced by the probability that they occur within a band from 50-70 feet (effective heights) from the streambank. All 30" dbh trees in the outer 50 have height potential to reach the stream channel. If the project rate of removal for 30 inch trees were applied across the treated acres of Class I SMZ, there could be approximately 350 30 inch dbh trees removed from this zone.

Table 3-70 - Percent of trees in SMZ of based on various height criteria.

Tree Height	**40+ ft**	**50+ ft**	**60+ ft**	**70+ ft**	**80+ ft**	**90+ ft**	**100+ ft**
100 ft SMZ	85%	83%	79%	74%	65%	46%	33%
75 ft SMZ	77%	72%	61%	57%	48%	38%	25%

Trees within the Class II SMZs are generally shorter and the "No Treatment" zone is 25 feet. Approximately 33 % of the Class II SMZ acreage would not include commercial timber harvest. The trees within the Class II SMZs are shorter, thus a higher percentage of them is represented by the 40-80 height classes when compared to Class I streams. The 40-60 foot band represents 16% of the trees within the Class II SMZ, and represents those most likely for removal. These trees have potential to reach the stream channel if they occur in the band between 25 and 50 feet from the stream channel and it is probable that some would have contributed to LWD. It is unlikely that all these trees would be removed due to basal area retention objectives. All 30 inch dbh trees in the outer 50 have height potential to reach the stream channel. If the project rate of removal for 30 inch trees were applied across the treated acres of Class II SMZ, there could be approximately 280 30 inch dbh trees removed from this zone.

Underburning would take place through and within Class I and II SMZ. When this occurs there are design measures that allow for creeping into the SMZ, but not active introduction of fire. Dwire and others (2006) speculate that fuel reduction could potentially directly and indirectly affect aquatic habitat by altering the recruitment of large woody debris. They further note that prescribed fire would not necessarily remove LWD from riparian areas, and that mortality resulting from prescribed fire would likely contribute LWD to aquatic systems. In a limited (60 acres) study of active burning within the riparian zone, Bêche and others (2005) noted a loss of 4.4% of trees, with mortally occurring between 11-40 cm (4.5-15.7 inches) dbh. In that study several snags fell after being burned, but no overall increase in the amount or movement of LWD relative to unburned control sites. These effects were similar to those theorized by Dwire and Kauffman (2003) that moister, cooler microclimates within riparian areas likely contribute higher moisture content in fuels and soils, which could lower the intensity and severity of burns. Skinner (2002) also noted that fire often consumes material in the advanced stages of decay, but also creates snags and downed logs. It is expected underburning would creep within the SMZ and some understory trees could be killed as a result and possibly contribute to LWD.

Approximately 46% of the perennial stream SMZ and 33% of the intermittent SMZ would have "No Treatments". There would be treatments within Summit Creek sub-watershed (520.4051) Class I and II SMZ, where LWD was noted as currently deficient in both number and stable pieces. Underburning may creep into SMZ and it likely to result in some mortality, but mortality would remain on site to potentially contribute to LWD. There is a band between 50-70 feet along Class I (240 acres) SMZ and 25-50 feet along Class II SMZ (330 acres) where intermediate and some suppressed trees have the potential to reach the stream channel.

Additionally, approximately 70 acres of SMZ would be yarded with helicopters from areas that have trees with potential to reach the stream channel. These bands represent approximately 28% of the Class I and II SMZ acreage (640 acres) where trees could be removed that might potentially reach the stream channel independent of the direction they may ultimately fall if not harvested. Based on average values for removal of 30 inch dbh trees it was projected that 630 30 inch dbh trees within the Class I and II SMZ could be removed. Also based on stand plots collected from SMZ, there are an estimated 14,480 30 inch dbh trees in Class I and II SMZ. Up to 4.4% of the 30 inch dbh trees would be removed from Class I and II SMZ under Alternative 1. These trees have potential to contribute to LWD due to their heights and age. The potential to remove 4.4% of 30 inch dbh trees from the SMZ does not represent a direct 4.4% decline in recruitment to stream channels (not all these trees would have fallen toward channel). However, this would reduce recruitment to some extent of a size (large, stable pieces) that is currently lower than the desired condition. LWD would be negatively affected although it would remain within the range of variability displayed in Table 3-71.

Table 3-71 - Large woody debris (LWD) data from central Sierra Nevada. Standard deviation shown in parenthesis

	Mean density per 100 meters	Range	Mean stable pieces per 100 meters	LWD per 100 meter Size (0.3 x 3 m)
Stanislaus Unmanaged Stands[1]	17.8 (11.2)	1-50	4.5 (4.1)	
Stanislaus Second Growth[1]	9.5 (6.7)	1-24	3.1 (2.3)	
Sierra (Whiskey Ridge)				4.9 (4.2)

[1] Ruediger and Ward 1996

There is little risk to resident trout if glyphosate is applied at the recommended rate. Recent studies have shown that some herbicides, but not glyphosate, have an estrogen mimicking effect on reptiles (Raloff 1994). Estrogen and other endocrines are mainly six carbon ring molecules (cyclohexane or benzene) while glyphosate has a distinctly different structure. It is a carbon chain based on a single phosphorous atom so does not have a ring structure. The likelihood of these distinctly different molecules mimicking one another or working in the same lock-and-key relationship is remote.

There has been concern expressed about the potential for surfactants containing nonylphenol polyethoxylate (NPE)[19], such as R-11, to cause endocrine disruption and other deleterious effects. However, in comparison to natural estrogen NPE is approximately 10,000 to 1,000,000 times weaker in eliciting an estrogenic response (USDA 2003, p. 9). NPE is classified as slightly or practically non-toxic to mammals and is not mutagenic (USDA 2003).

Cumulative Effects

In addition to the direct and indirect effects of Alternative 1, a cumulative effect is expected on the aquatic species due to the nature of the Kings River Project, the ongoing private landownership activities (e.g. timber harvests and housing developments), and other ongoing Sierra National Forest management activities that are contributing to negative effects on aquatic species viability (e.g. active cattle allotments (Sanders 2005), off-highway vehicle use and events (Eddinger 2003), and prescribed fires (Wells 2003)) that occur within the same time frame and location for the aquatic species and their habitats. These past, present and reasonably foreseeable activities are described near the beginning of Chapter 3.

With the other activities planned for the Kings River Project area (both those associated with the KRP and those not associated with it) combined with Alternative 1 all provide incremental effects onto aquatic species. Continued habitat fragmentation, sedimentation into stream systems, compaction of soil, changes in vegetation composition, decreases in streambank vegetation and bank trees, and loss of streambank stability as well as the potential to be harmed by herbicide applications, could be expected.

Cumulative affects on canopy cover would be similar to the indirect effects, but would be expressed across the watershed. Commercial timber harvest and underburning were the two activities from the Past, Present, and Reasonable Foreseeable actions (Chapter 3) that could have potential to cumulatively affect canopy cover. Approximately 19,000 acres has undergone or is proposed for prescribed fire through 2012. Additionally, Southern California Edison conducts 1,500 acres annually of harvesting. Harvest levels are indicated to average approximately 3,300 board feet/acre. Harvest of timber on private property is under the California Forest Practices Act. Kings River Project design criteria to protect aquatic and riparian resources are not applied on private property. Harvesting on private lands requires a Timber Harvest Plan (THP) that evaluates compliance with state and federal rules and laws (CDF 2005). The Cumulative Watershed Effects portion of the THP evaluates water temperature effect and includes consideration of streamside canopy. The importance of near water vegetation is also evaluated under the biological assessment component of the THP.

Kings River Project design measures for prescribed fire have been successful in the past at maintaining canopy cover and it is unlikely stream shading would continue to be maintained. Design measures exclude removal of trees that provide stream shading during the critical summer period and are expected to protect federal lands. Considering

19 The primary active ingredient in many of the commercially available non-ionic surfactants is a compound known as NPE. It is found at rates varying from 20 to 80 percent. NPE is formed through the combination of ethylene oxide and nonylphenol (NP). NP is a material recognized as hazardous and is included on EPA List 1. (USDA 2003, p. v) NPE is widely used in industrial applications, detergents, cosmetics, shampoos, surfactants and spermicides.

the relatively low volume/acre of timber being removed from SCE lands and the consideration of near water vegetation in the THP, it is not expected the addition of SCE harvesting to federal harvesting in the analysis area would cumulatively affect canopy cover along perennial streams.

If canopy cover were affected on a cumulative basis it would be expected that water temperature would also be affected. FEMAT (1993) discussed the "edge" effect resulting from the harvesting of timber adjacent to riparian zones, and possible additive effects on microclimate. This influence would vary by season, time of day, aspect, channel orientation, and extent of tree removal. Changes to microclimate could affect air temperature, which is one of the components affecting water temperature. When timber removal occurs in SMZ, it would be primarily from suppressed and intermediate trees that are creating fuel ladder conditions. It is not expected that overhead canopy reductions would result in large changes in solar radiation or air temperature. The treatments within helicopter units have the potential to increase water temperatures in Big Creek by approximately 1.18º F (0.66º C). It is not anticipated that this difference in water temperature would be detrimental to any life stage of resident trout. Water temperatures within the project area would be maintained within the desired condition (< 21º C). However, some portion of Big Creek downstream of the project area that currently provides coldwater habitat would be transitioned to warm water fishery. This could represent a loss of 1 mile of coldwater habitat and it is not anticipated that a cumulative effect on water temperature would occur by implementing Alternative 1.

Considering the scale of Alternative 1 and the other past, present and reasonable foreseeable actions, a cumulative affects would be expressed similar to the indirect effect on LWD. The difference would be an increase in LWD in the event that a CWE were to occur. This would be a result of channel instability and tree recruitment as bank trees are undermined by the adjusting stream channels.

Commercial timber harvest and underburning are the two activities from the Past, Present, and Reasonable Foreseeable actions (Chapter 3) that have potential to cumulatively affect LWD. If mortality occurs as a result of underburning it is expected the tree would contribute to LWD. Commercial harvest prescriptions would retain predominant, dominant, co-dominant, and trees with broken tops, which are the trees most likely to provide LWD (both by size and age). SMZs should retain much of the potential LWD on federal lands. Harvesting on private lands requires a Timber Harvest Plan (THP) that evaluates compliance with state and federal rules and laws (CDF 2005). The Cumulative Watershed Effects portion of the THP evaluates organic debris. The importance of large woody material is also evaluated under the biological assessment component of the THP. The state does not have diameter limits on harvest trees, although protection of old growth is part of the THP analysis. It is probable that some trees that might contribute to LWD would be removed from SCE harvesting. Considering the relatively low volume/acre of timber being removed from SCE, it is not expected the number of these potential trees would be large. The combination of the federal and SCE timber removal is not expected to cumulatively effect LWD recruitment, which would remain lower than desired and within the range of variability displayed in Table 6.

In-stream sediment will be reduced by implementing restoration of the WIN sites identified in the Proposed Action. If a large precipitation event in the form of rain or rain on snow occurs immediately after project ground disturbing activities, erosion will probably occur even with proper implementation of BMP. After a few months and the loose soil has stabilized, the BMP will protect water quality.

Prescribed burning is not expected to change stream flows or increase in-channel sediment. These burns are planned with a low intensity objective. Burn patterns typically form a mosaic with unburned or lightly burned areas inter-fingered with a few moderate severity areas. Although some proportion of the area is likely to burn at high severity, the proportion is expected to be small, as found by Robichaud and others (2006). Any overland flow or eroded material that leaves a severely burned spot will be filtered in the unburned, low or moderate severity areas down slope. It is possible that high severity burn could occur at or near stream banks. However, soil and fuel moistures are likely to be higher near stream channels, and this limits the potential for high burn severity.

Broadcast burning in the n_soapro_2 management unit is the highest intensity burn planned. The potential for generating increased sediment is greater in this unit than in the other prescribed burn areas. However, the target intensity is still moderate severity rather than high severity, and 50% ground cover will be maintained. High severity burn could occur in the riparian area during prescribed burning, and result in riparian mortality. This could reduce the effectiveness of the streamside buffer and allow overland flow and eroded material to enter a stream channel. This effect has a low probability of occurring as a result of any given burn operation; the probability becomes lower the larger the spatial extent (i.e., it is more likely to occur on a small area than a large area). The effect would last for 1 – 3 years until groundcover is reestablished and water repellency recovers (Robichaud and others 2006).

Road construction and reconstruction could affect stream flow and sediment, especially where it crosses stream channels. BMPs 2-1, 2-3, 2-5, 2-8 and 2-9 will help to minimize the impacts to stream channels and reduce the potential for sediment to be generated both during construction and once the roads are in place. Road reconstruction will result in fewer resource impacts by establishing an effective drainage design for the road. Watershed design measures specify that in sub-watersheds that are currently over their TOC for cumulative watershed effects, hydrologic connectivity will be reduced during road reconstruction. The effect on stream flow is not expected to be measurable, but theoretically reducing connectivity will reduce the impact of the existing roads on the magnitude and timing of peak flows.

More sediment in channels has the potential to result in increased channel erosion either due to aggradations or to the increased erosive power of sediment-laden high-flows, especially at the known locations with sensitive channel types. Nine sub-watersheds in the analysis area (519.0009, 519.0057, 519.3053, 519.4051, 520.0014, 520.1002, 520.1051, 520.1101, and 520.1151) were identified as currently over their lower threshold of concern (TOC). Indicators of cumulative watershed effects in this assessment include increased sedimentation that fills channel pools with fine sediment, unstable channel banks, and/or degradation of aquatic habitat. Design criteria and watershed restoration have been specified to reduce or offset the risk for CWE. In sub-watersheds where a CWE response is potential or probable, activities will be carried out using light on the land mechanical systems (i.e., cut-to-length harvest system, low ground pressure feller/buncher system, excavator debris piling). Cumulative watershed effects will be reduced by mechanically treating these sub-watersheds with light-on-the land logging equipment, reducing the hydrologic connectivity of the roads, redesigning roads to be outsloped; rocking of roads; and by sub-soiling all major skid roads and trails to reduce precipitation runoff. Implementation of these mitigations will result in watershed improvement, a reduced risk of initiating additional CWE response, and a recovery over a shorter time period.

Overall, Alternative 1 has a higher potential to adversely affect the aquatic species and habitat than Alternative 2 or 3 in the short term (3 to 6 years). Over the long term Alternative 1 may result in decreasing the risk of large stand replacing fires which is the same for Alternative 3. However Alternative 1 may also continue to provide stresses on the aquatic species and their habitats. If a large wildfire does occur within the Kings River Project area; initial eight management units as described at the beginning of Chapter 3, a cumulative effect on aquatic species and their habitats would be the reduction of streamside vegetation, increases in sedimentation to the stream channel, and an overall loss of habitat in the short-term for those aquatic species occurring in the wildfire area. However aquatic species populations can be resilient if other good quality dispersal and breeding areas are available and can be found by the species.

For the California red-legged frog and the Foothill yellow-legged frog, both of which are unlikely to occur in the area, it is expected that the instream habitat will be negatively impacted due to increases in sediment in stream habitats.

For the Relictual slender salamander the cumulative effect of all the activities may lead to the isolated unknown populations being harmed. It is extremely difficult to determine the locations of this species and thus areas that have been identified as potential suitable habitat may not provide adequate protection.

For the western pond turtle and resident trout species the greatest concern is with sediment filling pool habitats. Western pond turtles can also be greatly affected by management activities in the uplands and the area surrounding Big Creek, Rush Creek, Providence Creek, and Duff Creek which all provide upland habitats. The instream habitat for these species may be lost as well due to sediment from the proposed, ongoing, and future activities.

In the meadows that are occupied with Yosemite toad the cumulative effect of this project coupled with the future management activities within the Kings River project area surrounding the occupied meadows may be detrimental to the local population in the Bull Creek / Teakettle watersheds. It appears that a core population for the Yosemite toad occurs in the meadows of the krew_bul_1 management unit (Bull Creek and Teakettle watersheds) and dispersal into other nearby over-wintering and breeding habitats occurs but is limited to within their potential dispersal distance. Currently, these meadows of krew_bul_1 provide good breeding areas however with continued management activities contributing sediment, noise disturbance, compaction of burrow habitat, and direct kills expected, the Yosemite toad in this population may be lost and the habitat significant impacted, thus the core population may be reduced to a point where the species can no longer exist in that watershed (an irreversible effect). Other populations of Yosemite toad may not be able to repopulate the Bull Creek / Teakettle watersheds since they occur over 0.6 miles away (the distance estimated that the Yosemite toad can disperse).

The determinations for the ten listed aquatic species are shown in Table 3-72. The rationale for the determinations and further information on the project affects on aquatic species are in the aquatic specialist reports (Sanders 2006b; Strand 2006).

Table 3-72 - The summary of determinations for Alternative 1 - Proposed Action for the ten listed aquatic species.

Species	Status	Determinations for Alternative 1 – Proposed Action
California red-legged frog	Federal Threatened	***may affect, but is not likely to adversely affect***
Foothill yellow-legged frog	Forest Service Sensitive	***may affect individuals, but is not likely to lead to federal listing or loss of viability***
Lahontan cutthroat trout	Federal Threatened and Sierra National Forest Management Indicator Species	***no effect***
Mountain yellow-legged frog	Federal Candidate and Forest Service Sensitive	***no effect***
Relictual slender salamander	Forest Service Sensitive	***may affect individuals , but is not likely to lead to federal listing or loss of***
Resident trout species (Brown Trout, Eastern Brook Trout, Rainbow Trout)	Sierra National Forest Management Indicator Species	*no official determination is required for Management Indicator Species however a finding of effect concerning the impact of the project on MIS population trend is needed therefore* ***neither an upward nor a downward trend*** *is expected*
Western pond turtle	Forest Service Sensitive	***may affect individuals, but is not likely to lead to federal listing or loss of viability***
Yosemite toad	Federal Candidate and Forest Service Sensitive	***may affect individuals, and is likely to result in a trend toward federal listing or loss of viability*** *primarily in the Bull Creek & Teakettle watershed population*

Alternative 2 - No Action

There is discussion on the effects of wildfire under Alternative 2. There is no debate among Aquatic Ecologists that high intensity fires can severely disrupt aquatic ecosystems, and that these affects can be prolonged (up to 300 years for LWD). Specific influences may include decreased channel stability; greater and more variable stream discharge; altered woody debris delivery and storage; increased nutrient availability; higher sediment delivery and transport; and increased solar radiation and altered water temperature regime (Bisson and others 2003; Dunham and others 2003). There is debate among Aquatic Ecologists regarding the need to treat riparian areas, and the types of treatments. Part of the controversy is related to the diverse and complex effects that fire can have on aquatic systems (Dunham and others 2003). Researchers agree that aquatic systems have developed under a disturbance regime. The ecological diversity of riparian corridors is maintained by natural disturbance regimes including fire and fire-related flooding, debris flows, and landslides (Dwire and Kauffman 2003). Many species have adapted life histories that are shaped by, and may depend on disturbance events (Dunham and others 2003; Bisson and others 2003; Rieman and others 2005). Some aquatic biologists believe that wildfire poses additional risk to endangered species, while others feel affects from treatments are more likely to damage aquatic systems than fire (Erman 1996; Bisson and others 2003).

Little is known about fire history of most riparian areas in the west and it is expected these areas have a different fire regime than upland areas (Dwire and Kauffman 2003; Bisson and others 2003). Riparian areas differ in topography microclimate, geomorphology, and vegetation. They are further characterized as having cooler air temperatures, lower daily maximum air temperatures, and higher relative humidity. These characteristics contribute to higher moisture content of live and dead fuels, and riparian soils, which presumably lowers the intensity, severity and frequency of fire (Dwire and Kauffman 2003). There is agreement among researchers that the differences between upland and riparian systems need to be recognized.

Direct Effects

There would be no new direct effects on aquatic species as a result of the implementation of Alternative 2. It is expected that other, smaller projects would be proposed if Alternative 1 was not selected and these projects would be focused on reducing the risk of wildfires in the area because of directives that require the reduction of fuels in the urban intermix zones.

No commercial timber removal or underburning would occur under this alternative. No direct, indirect, or cumulative affects to riparian canopy cover (current stream shading > 75%) are anticipated from Alternative 2. Stream shading will meet the desired condition of > 50%.

In the event of a wildfire, there could be an effect on canopy cover. It would be difficult to model such an effect because of the numerous factors affecting fire in riparian zones. Riparian areas differ from surrounding upland areas by topography, microclimate, geomorphology, and vegetation. Riparian microclimates are characterized by cooler air temperatures, lower daily maximum air temperatures, and higher relative humidity (Dwire and Kauffman 2003). Based on personal observations, fire may creep through riparian zones having little effect on riparian canopy cover (Big Creek Fire 1994) or remove nearly all riparian cover over vast segments of stream channel (Hopkins and Strand 2002). There would be no direct effect on water temperature or from herbicides or watershed improvement projects as a result of the Alternative 2.

If a small low to moderate intensity fire were to occur, there would be no expected direct affects on water temperature. Hitt (2003) reported a probable 7.7° C (14° F) increase in water temperature during the Moose Creek Fire (2001) in Montana. Probability of direct fish mortality would increase for low order (small) streams having high fire severity through streamside vegetation. Rinne and Jacoby (2005) identified records of direct fish kills from fire in Idaho and from a controlled burn in Oregon. Rieman and Clayton (1997) noted dead fish immediately after high severity fire burned though streams in the Boise River system. Water temperature monitoring on the McNally Fire indicated direct thermal affects as the fire burned through Tobias Creek (although not at high severity), but not to the extent it was probable that direct mortality of trout occurred. Personal observations on the other streams within the McNally Fire (Hopkins and Strand 2002) suggest possible direct mortality on several segments, although no dead fish were observed and displacement was probable.

There are no direct effects on LWD recruitment. A fire (either large of small) could increase LWD recruitment. Bêche and others (2005) noted that underburning within a riparian area burned several snags, which fell. A small, low severity fire in a riparian zone could produce a similar effect. A large, high severity fire would likely produce tree mortality.

Indirect Effects

There would be no new indirect effects to aquatic species as a result of the implementation of Alternative 2. It is expected that other, smaller projects would be proposed if Alternative 1 was not selected and these projects would be focused on reducing the risk of wildfires in the area because of directives that require the reduction of fuels in the urban intermix zones.

No indirect effects on canopy cover for stand density alteration or fuel treatment previously considered would occur under Alternative 2. In the event of a wildfire occurrence there could be varied response depending on size and severity. A large, high severity fire could disrupt flow regime and alter stream channel dynamics. Soil water storage; baseflow; streamflow regime; peak flow; water quality (sediment, temperature, pH, ash slurry); and chemical characteristics can be affected by wildfire (Neary and others 2005). Riparian trees not subject to direct mortality could be undermined and toppled, leading to loss of their stream shading. Amaranthus and others (1989) reported a reduction of 60% stream shading following the Silver Fire (1987) in Oregon. The effects would last until trees became re-established to the extent they were able to provide shading, which could last 25-50 years. A small, low/moderate severity fire would not likely have an indirect affect on stream shading.

Macroinvertebrate populations have been noted to increase when more sunlight has been available. Impact of fire on the macroinvertebrate community varies by burn intensity and extent; steam size and gradient; precipitation and amount of runoff; vegetative cover; geology; and topography. Some indicators of community health may return to pre-fire conditions within 1-2 years, but the overall community will probably vary for 5-10 years after the fire (Minshall 2003; Reardon and others 2005a). Recovery is related to the relative quick recovery of riparian vegetation (25-50 years for full canopies).

Water temperature data collected from the project area in 2005 indicate they are within both the desired condition and within the tolerance limits identified for resident trout species. It is anticipated that Alternative 2 would maintain water temperatures within the desired condition (< 21° C) and there are no indirect, affects.

If a wildfire were to occur and burn at greater than moderate severity, there is potential to influence water temperature due to reductions in canopy cover over SMZ (loss of stream shading). The extent of this affect would vary depending on severity of the burn and the extent it burned through SMZ. A large fire could indirectly affect water temperature through increased direct solar radiation, increased air temperatures, and reduced stream depths (due to increased fines and widening of stream channel). Amaranthus and others (1989) reported increases of up to 10° C (18° F) after the Silver Fire (1987) in Oregon, with increases related to remaining components of shade, aspect, topography, and amount of flow. Sestrich (2005) found that streams temperatures increased with burn severity and that daily mean increased by approximately 3.5° C along high severity sites.

Temperatures could be reduced through mixing with cooler, unaffected tributaries. These effects could last several decades until trees were of sufficient size and density to screen direct solar radiation.

The extent of the effects on fish populations would be related to recover of suitable water temperatures, suitable water quality, and connectivity to population refugia. Trout are noted as being resilient and adapted to disturbance (Reiman and Clayton 1997; Dunham and others 2003; Rinne and Jacoby 2005), but recovery could take a decade or more. Sestrich (2005) reported that native trout populations recovered rapidly, with some sites exceeding pre-fire population levels within three years following fires in the Bitterroot River Basin (2000). Greswell (1999) considered the disturbance regime resulting from wildfire could facilitate invasion by nonnative fish species.

There are no anticipated indirect effects on LWD from Alternative 2. A large fire would provide indirect LWD through direct mortality of trees. Fire represents one of the recruitment pathways for LWD. The pulse of LWD resulting from tree mortality would be accompanied by possible stream channel adjustments due to channel adjustments undermining streambank snags left from the fire. This increase would likely last for several decades until all material was one the ground. Berg and others (2002) estimated that more than 50% of pre-fire LWD volume on Badenaugh Creek (Tahoe NF) was incinerated by the Cottonwood Fire (1994); that average length of LWD had decreased by half, but that LWD total pieces and volume increased following the first winter. After reviewing aquatic systems 20 years post-burn, Robinson and others (2005) noted that much of the standing dead timber had fallen, but that 80% was still bridging the channel (not in the stream). They expected fire-related LWD inputs to continue for another decade. Through decay, breakage, and transport the fire-generated LWD would be removed from the system, leaving 50-300 years until the ecosystem stabilizes and trees were large enough to contribute to LWD (Bisson and others 2003; Reardon and others 2005).

Cumulative Effects

There would be no new cumulative effects to aquatic species as a result of the implementation of Alternative 2. If a large wildfire does occur within the Kings River Project area – initial eight management units as described at the beginning of Chapter 3, a cumulative effect on aquatic species and their habitats would be the reduction of streamside vegetation, increases in sedimentation to the stream channel, and an overall loss of habitat in the short-term for those aquatic species occurring in the wildfire area. However aquatic species populations can be resilient if other good quality dispersal and breeding areas are available and can be found by the species.

It is not anticipated there would be cumulative effects on canopy cover or large woody debris under Alternative 2. If a large, high severity wildfire across multiple sub-watersheds were to occur there would likely be a cumulative effect to riparian canopy cover. This would be the widespread loss of stream shading due to direct mortality. Rinne and Jacoby (2005) described changes in water temperature due to plant understory and overstory loss, ash-laden slurry flows, increases in flood peakflows, and sedimentation due to increased erosion as the greatest long-term impacts to fish habitat after wildfire.

On a localized level for small fire, loss of riparian canopy cover would likely affect stream water temperatures. The effect would be diminished when unaffected tributaries provide cooler flow. The effects would last until trees became re-established to the extent they were able to provide shading, which could last 25-50 years. Effects on macroinvertebrate community would be similar that discussed under Indirect Effects.

There would not be a cumulative affect to water temperature through implementation of Alternative 2. A large fire could indirectly affect water temperature through increased direct solar radiation, increased air temperatures, and reduced stream depths (due to increased fines and widening of stream channel). Lack of cooling tributary flows would extend the effect downstream from the basin. The Indirect Effects on water temperature noted temperature increases ranging from 3.5° C (Sestrich 2005) to 10° C (Amaranthus and others 1989). Additionally, Neary and others (2005) cited increases up to 16.7° C reported following fire. Thermal increases are accompanied by decreases in dissolved oxygen, which in combination decreases the quality of resident trout habitat. These effects could last several decades until water quality had recovered, and trees were of sufficient size and density to screen direct solar radiation.

Project design criteria to reduce current levels of sedimentation from roads and implement watershed restoration projects would not occur under this Alternative. Sedimentation rates and levels in streams would be maintained at current levels. A high severity fire could result in water quality degradation. Sedimentation rates would increase many times over the existing rate. With slopes denuded of ground cover overland flows would be increased and channel modification would occur to carry the additional flows. Loss of cover would reduce infiltration and base flows would be decreased.

If a large storm or rain on snow event occurred accelerated erosion and increased sedimentation would result, but with no ground disturbance the affect will be less than if the ground is disturbed. If a wildfire followed by a large precipitation event occurred, accelerated erosion and increased sedimentation will occur and sediment will be transported to the stream system via overland flow from burnt slopes and roads.

Overall, Alternative 2 has the least potential to cause adverse affects to aquatic species and habitats than Alternative 1 or 3. The determinations for the ten listed aquatic species are shown in Table 3-73. The rationale for the determinations and further information on the project affects on aquatic species are in the aquatic specialist reports (Sanders 2006b; Strand 2006).

Table 3-73.

Species	Status	Determination for Alternative 2 - No Action Alternative
California red-legged frog	Federal Threatened	***No effect***
Foothill yellow-legged frog	Forest Service Sensitive	***No effect***
Lahontan cutthroat trout	Federal Threatened and Sierra National Forest Management Indicator Species	***No effect***
Mountain yellow-legged frog	Federal Candidate and Forest Service Sensitive	***No effect***
Relictual slender salamander	Forest Service Sensitive	***No effect***
Resident trout species (Brown Trout, Eastern Brook Trout, Rainbow Trout)	Sierra National Forest Management Indicator Species	*no official determination is required for Management Indicator Species however a finding of effect concerning the impact of the project on MIS population trend is needed therefore* ***neither an upward nor a downward trend*** *is expected*
Western pond turtle	Forest Service Sensitive	No effect
Yosemite toad	Federal Candidate and Forest Service Sensitive	No effect

Alternative 3 – Reduced Harvest Tree Size

The significant changes to Alternative 3 over Alternative 1 are the additions of design measures specifically to protect streamside management zones and to protect the Yosemite toad. The base information on effects is the same as in Alternative 1.

Alternative 3 proposes to reduce fire severity through reducing timber stand density (reforestation of existing openings, uneven-aged management and thinning); pile slash for burning; burn slash piles; reduce brush competition using herbicides; plant trees; reduce fuel loading through controlled burning; construct and reconstruct roads; and implement watershed restoration projects (matrix of possible affects at end of Appendix A in Strand 2006). The actions are similar to Alternative 1, with the exception that trees greater than 30” dbh would be retained, new openings for regeneration would not be created, the canopy cover retention objective in fisher habitat would be changed, protections measures provided by USFWS (Appendix D) would be implemented; no commercial harvesting would occur within Class I & II SMZ in the nine sub-watersheds currently exceed their lower Threshold of Concern; and Riparian Management Areas would be prescribed along perennial streams to be yarded with helicopters. Other design measures to reduce affects on resident trout habitat would be similar to Alternative 1

Direct Effects

With the exclusion of commercial harvesting within Class I & II stream channel within the nine sub-watersheds exceeding the lower Threshold of Concern and use of Riparian Management Areas within helicopter units, Alternative 3 has 340 fewer SMZ acres being treated. The 1000 acres of SMZ that could have commercial treatments are within the outer 50 feet of the SMZ. There would be 130 fewer SMZ acres treated under the "Old Forest Linkage" prescription (250 acres), but basal area would be maintained at a minimum of 280 square feet and stand composition would focus on attributes for fisher (maintain large and decadent trees). The remaining Class I SMZs (200 acres) would be treated consistent with the SMZ prescription that would maintain a minimum of 70% of the current basal area, focusing on retaining pre-dominant; dominant; co-dominant; trees leaning toward the stream channel; and those within broken tops. It is not anticipated that changes in overhead canopy would occur in SMZ acreage. Stream shading would meet the desired condition of > 50%. There are no direct effects on water temperature anticipated from Alternative 3. The element within the SMZ that represents the most immediate source of LWD is snags. There would be no removal of snags from SMZ under Alternative 3, thus no direct affect on LWD.

Indirect Effects

Indirect affects on canopy cover (stream shading) could occur if Alternative 3 results in an alteration to the hydrologic regime. Such alteration could be expressed in bank and channel instabilities, widening of the stream channel, and undermining of bank trees. The widening of the stream channel would increase the level of reduce canopy cover over the stream (less stream shading). The Watershed Analysis indicates this effect is not anticipated (Gott 2006). Herbicide treatments would be implemented under Alternative 3. Design criteria should keep herbicide application away from trees providing stream shading and aerial application is not being proposed. Herbicide treatment is unlikely to indirectly affect canopy cover in the project area streams.

Indirect effects on water temperature evaluated under Alternative 1 indicated that areas yarded utilizing helicopters had the potential to influence water temperature through reduction on angular canopy density. Alternative 3 provides a 50 foot "No Treatment" buffer along perennial streams within the helicopter areas. These no treatment zones should reduce the probability of changes to existing angular canopy density. There are no anticipated effects on water temperature from Alternative 3. It is anticipated that project design measures would maintain water temperatures within the current and desired condition (< 21° C), within the project area.

Of the treatments that would be implemented under Alternative 3, delivery of large woody debris could be affected by reduction in stand density through commercial harvest or underburning. As in Alternative 1, there are 2,240 acres of Class I and II SMZ. Approximately 64% (790 acres) of the perennial stream SMZ and 45% (450 acres) of the intermittent SMZ would have "No Treatments". There would be "No Treatments" within Summit Creek sub-watershed (520.4051) Class I and II SMZ, where LWD was noted as currently deficient in both number and stable pieces. Underburning may creep into SMZ and it likely to result in some mortality, but mortality would remain on site to potentially contribute to LWD. Similar to Alternative 1 there is a band between 50-70 feet along Class I SMZ and 25-50 feet along Class II SMZ where intermediate and some suppressed trees have the potential to reach the stream channel. These bands represent approximately 20% of the Class I and II SMZ acreage (200 acres less than Alternative 1) where trees could be removed that might potentially reach the stream channel independent of the direction they may ultimately fall if not harvested. The predominant,

dominant, co-dominant and broken top trees would be retained where timber harvest treatments occur in SMZ. Harvesting of 30 inch dbh trees is not included under Alternative 3. Maintaining trees >= 30 inch dbh would retain up to 630 trees (compared to Alternative 1) within SMZ that could potentially provide LWD. This does not necessarily mean these trees are actually expected to fall toward the stream channels, only that they have potential to reach the channel. However, this would not reduce recruitment of a size (large, stable pieces) currently lower than the desired condition.

Cumulative Effects

Effects from Alternative 3 would be similar to those discussed under Alternative 1 for canopy cover. The reduction in coldwater habitat in Big Creek downstream of the project area due to helicopter treatments discussed under Alternative 1 would not be anticipated under Alternative 3. No cumulative effect to water temperature is anticipated. Considering the scale of Alternative 3 and the other past, present and reasonable foreseeable actions, a cumulative affects would be expressed similar to the indirect effect on LWD. The difference would be an increase in LWD in the event that a cumulative watershed effect was to occur. This would be a result from channel instability and tree recruitment as bank trees are undermined by the adjusting stream channels. Cumulative effects from Alternative 3 on LWD would be similar to Alternative 1.

Overall, Alternative 3 has a lower potential to adversely affecting the aquatic species and habitats than Alternative 1 but higher than Alternative 2. The determinations for the ten listed aquatic species are shown in Table 3-74. The rationale for the determinations and further information on the project affects on aquatic species are in the aquatic specialist reports (Sanders 2006b; Strand 2006).

Table 3-74 - The summary of determinations for Alternative 3

Species	Status	Determinations for Alternative 1 – Proposed Action
California red-legged frog	Federal Threatened	***may affect, but is not likely to adversely affect***
Foothill yellow-legged frog	Forest Service Sensitive	***may affect individuals, but is not likely to lead to federal listing or loss of viability***
Lahontan cutthroat trout	Federal Threatened and Sierra National Forest Management Indicator Species	***no effect***
Mountain yellow-legged frog	Federal Candidate and Forest Service Sensitive	***no effect***
Relictual slender salamander	Forest Service Sensitive	***may affect individuals , but is not likely to lead to federal listing or loss of viability***
Resident trout species (Brown Trout, Eastern Brook Trout, Rainbow Trout)	Sierra National Forest Management Indicator Species	*no official determination is required for Management Indicator Species however a finding of effect concerning the impact of the project on MIS population trend is needed therefore* ***neither an upward nor a downward trend*** *is expected*
Western pond turtle	Forest Service Sensitive	***may affect individuals, but is not likely to lead to federal listing or loss of viability***
Yosemite toad	Federal Candidate and Forest Service Sensitive	***may affect individuals, and is not likely to result in a trend toward federal listing or loss of viability***

The differences in the determinations between Alternative 1 and Alternative 3 for the Yosemite toad is the addition of protection measures, outlined below for Alternative 3, that would help protect the life stages of the Yosemite toad and their habitat by creating both a buffer around occupied meadows and limiting the time activities can occur in and near their habitat.

- No mechanical treatments within 100 feet of meadows.
- Trees may be felled within 100 feet of meadows and removed by dragging them out without entering the buffer; around meadows used as breeding habitat by Yosemite toads, only trees 50 or more feet away from the meadow would be felled.
- Within 0.6 miles of occupied meadows, operations would start after breeding is over and end by October 1, and operations would cease for 24 hours after rainfall 0.1 inch or greater.
    - meadow occupancy and timing of breeding would be determined annually by an aquatic biologist
- Heavy machinery would be kept at least 50 feet from moist upland habitats where toads are likely to be present during the summer, such as willow and lupine patches, but trees may be felled within this area and removed by dragging them out without entering the buffer.
- No chemical treatments within 500 feet of occupied meadows. (in Alternative 1 also)
- No water drafting within 0.6 miles of occupied meadows. (in Alternative 1 also)

HERITAGE RESOURCES and TRIBAL RELATIONS

Affected Environment

Cultural resources of the KRP represent a record of human land use. This record is contained in properties with archaeological research value, locations of cultural importance to local Native American groups, and the intangible beliefs and values connected with Forest land use by various ethnic and occupational groups (LRMP FEIS 3.5.18.1 in USDA 1992). SNF LRMP direction (as amended by the 2004 Sierra Nevada Forest Plan Amendment and Record of Decision) for cultural resource management has two emphases: 1) meeting the legally mandated requirements of identification and evaluation to avoid or mitigate impacts from project activities; and 2) coordination of site and resource management with Native Americans to protect significant sites, and allowing access to and use of traditional resources (LRMP 4.3.18 and 4.5.2.15 in USDA 1992, USDA 2004a). The LRMP standards prescribe integration of significant cultural resource information into project planning processes.

The Kings River Project is managed for cultural resources in accordance with the direction of the *First Amended Regional Programmatic Agreement Among the USDA*

Forest Service, Pacific Southwest Region, California State Historic Preservation Officer, and Advisory Council on Historic Preservation Regarding the Process for Compliance with Section 106 of the National Historic Preservation Act for Undertakings on the National Forests of the Pacific Southwest Region (Regional PA). The stipulations of the Regional PA satisfy the Forest's responsibilities for individual projects under the National Historic Preservation Act (NHPA) of 1966, as amended, and take into account the potential effects of undertakings on historic properties in lieu of the procedures of 36 CFR 800.

In accordance with the Regional PA, a cultural resource identification effort was conducted of the project area. The goal was to identify: archaeological research values, and other cultural values, especially contemporary Native American interests.

Archaeological Research Values: Archaeological research values are derived from data that reside in classes of archaeological constituents, typically found in archaeological sites, and that contribute to important research topics. Data are scientifically meaningful when they can be related to a theoretical framework that supports a coherent interpretation of the cultural past. An overarching research interest for the Sierran forests is the nature of human land use through time with regard to seasonally available resources, and how environments were modified, purposefully or inadvertently. Sierran research objectives should strive to define the role humans have played in structuring Forest ecosystems, and in turn, how those ecosystems may have prompted or affected human adaptation.

In the KRP area, the results of almost fifty years of cultural resource surveys and investigations have identified numerous archaeological properties that are associated with common themes of SNF history: prehistoric lifeways; Forest Service administration; exploration and settlement; grazing/range management; mining; water/hydropower manipulation; transportation, travel, tourism and recreation; and the forest products industry.

Results of these investigations are reported in *Archaeological Reconnaissance Report R2005051554005, Kings River Project* (Marsh 2005). This report, which describes the location and components of the archaeological sites, is kept administratively confidential under the provisions of the Archaeological Resource Protection Act (ARPA), 43 CFR 7. This report documents archaeological survey for the entire project area. There are 117 archaeological sites in the first eight units being analyzed. Within the KRP boundary, there are 422 archaeological sites, including 35 with historic-era components (8%), 354 with prehistoric components (84%), and 32 with multiple components (8%). One site is unknown.

The SNF has determined the significance of representative properties of these themes by evaluating their eligibility to the National Register of Historic Places (NRHP). The SNF manages those historic properties which are eligible to the NRHP. The Forest does not manage or protect ineligible properties in project activities, unless there is local interest in preservation. NRHP eligibility has been determined for five historic-era properties, including the Dinkey Creek Bridge, which is listed on the NRHP.

NRHP eligibility has been determined for ten sites representing prehistoric lifeways. Indian people managed the landscape to create and maintain preferred habitats (McCarthy 1993). The processes of subsistence, the hunter-gatherer lifestyle, and the resulting indigenous land use can be seen in the KRP archaeological record. These properties include features common to the material culture of the native people of the Sierra Nevada in habitation and subsistence sites (e.g. bedrock mortars, stone tool artifacts).

NRHP eligibility has not been determined for every archaeological property in the project area. Unevaluated sites are considered potentially eligible, and managed as if eligible. The Regional PA allows for deferred NRHP evaluation if the property would not be affected by the project, usually through application of the Regional PA Standard Protection Measures (Attachment B).

<u>Other Cultural Values:</u> Consultation with tribes, the local Native American communities, and other interested parties to identify other cultural values, including contemporary Native American interests, was initiated in 2004 in accordance with the Regional PA, NHPA, ARPA, and other laws and regulations. Consultation has consisted of meetings, letters, phone calls, field trips, and presentations, and is documented in the project record.

Relevant topics with respect to tribes associated with the SNF are 1) social and economic; 2) Federal responsibility to federally recognized and non-recognized tribes; 3) traditional knowledge; 4) reverence and links to the land for cultural survival; and 5) consultation and collaboration.

<u>Social and economic:</u> There are two Federally recognized tribes primarily associated with the study area (Cold Springs and Big Sandy Rancherias) and one tribe (the Dunlap Band of Mono Indians) having completed the federal recognition application process and awaiting determination of eligibility. The Federally recognized tribes operate from a politically sovereign position and may have different political, social, and economic needs from those tribes and individuals not federally recognized.

<u>Federal Responsibility to Federally recognized and non-recognized tribes:</u> Federally recognized tribal governments associated with the SNF, as elsewhere in the United States, have a special political and legal relationship with the Government of the United States. Tribes possess inherent powers of limited sovereignty.

Recognized tribes are also beneficiaries of a trust relationship with the Federal government. Federal agencies, such as the Forest Service, consult with tribes as with other governments and are responsible for protecting tribal interests. The Forest Service also consults with non-recognized tribes (USDA 1997).

<u>Traditional Knowledge:</u> Local Tribal communities have long-standing knowledge of and reliance on lands now managed by public agencies, including the SNF. This traditional knowledge is living and dynamic. When Euro-Americans first came to the Sierra Nevada, thousands of years of indigenous knowledge had already shaped the cultural landscapes of the area. In some areas, the effects of aboriginal resource management are fairly well understood; in others much research remains to be done (Anderson and Moratto 1996). Current research in several fields demonstrates that the Sierra Nevada was not an uninhabited, virgin wilderness. The use of fire played a key role (Lewis 1973) in establishing and maintaining the open, park-like forests and woodlands encountered at historic contact. The application of fire and its careful control were particularly important to the manipulation of the acorn and oak resources. Cultural factors, predominantly the aggressive burning by Indians, maintained the stability of mature black

oak areas. The abundance of acorn-bearing trees in places like Oak Flat (T.11S, R.26E, Sections 16-17) may be remnant indicators of an Indian managed landscape.

Also significant were the techniques used by the Indians to manage plant communities, such as tillage, sowing, weeding, pruning, irrigation, and burning. Research with Indian elders in the Sierra Nevada documents that California Indians purposefully and selectively managed the Sierran landscapes for specific cultural purposes (e.g., to increase the quality and quantity of food, basketry materials, habitat for game species, fuel wood) (Anderson and Moratto 1991, Blackburn and Anderson 1993, Fowler 1994, Lawton and others 1976, Reynolds 1996).

A complex tenure system governed harvesting and management practices to regulate and distribute resources. This system ensured enduring access to culturally important plants and animals. Populations of certain plant species maintained their vigor and distribution within the landscape under traditional Indian management (Blackburn and Anderson 1993). Modern ecosystem management practices do not always take into account culturally significant species (e.g., Anderson 1997, Harris and Cox 1997, Wolfley 1998). Traditional knowledge tells that each species was put in place for a reason, a rationale that dovetails nicely with the ecologist's recognition that ecosystems be considered as interactive wholes.

Analysis of the contents of archaeological sites, pollen cores, and other paleoenvironmental data can provide information about environmental conditions and ecosystems that existed before contact (Woolfenden 1996), but the information derived is patchy. Tribal traditional knowledge regarding landscapes can improve societal understanding and management of ecosystems. Oral histories about ethnobotanical management from Indian people about past ecosystems and ecosystem components (e.g., the presence/absence of culturally important plants and the visual characteristics of landscapes) can provide important baseline data to describe and explain change and continuity of cultural landscapes. Information about landscapes cultured under traditional management and regulatory mechanisms can be critical for restoring and maintaining ecosystems today.

<u>Reverence and Links to the Land for Cultural Survival:</u> Wherever Indians from Sierra Nevada tribes might reside, many retain a deep, abiding concern about what occurs within their aboriginal territory, including the SNF. These lands are considered the center of their universe, their homeland; spiritual reverence for the land is often expressed by tribal members. Thus, land management affects not only cultural survival, but spiritual survival as well; among many Indian people the concepts are inseparable—inherently united. It has been expressed at several Forest Service/tribal meetings that Indian people also feel that they also have a responsibility to manage the land properly; that the Creator put them there to do just that.

The SNF honors the traditional ties that many tribal communities have to this portion of the Sierra Nevada. Access to and use of the SNF and other public lands is critical. For many Indian people, community identity and cultural survival are dependent on continued access to ceremonial and sacred places, and access to resources at a variety of locations on forest land. Certain plants (e.g., sedges), animals (e.g., deer), and locations (e.g., fishing spots) provide for many needs, including food, medicine, utilitarian type materials, and ceremonial items. Specific resources insure that significant cultural traditions, such as basket weaving, survive and continue.

How resources are managed by the SNF continues to be of concern to tribes and Indian communities. Urban development has decreased resources available on private lands; commitments for needed wildlife habitat protection may alter resource availability on public lands; competition with non-Indians for resources such as pinyon and mushroom; timber harvesting activities; road construction; fuels treatment; fire management; and herbicide use are all concerns voiced by the Indian population. The mix of the various activities and the level of disturbance have the potential, as has been demonstrated in the past, to affect the integrity of archaeological sites, plant communities (particularly black oaks), ceremonial locations/cultural landscapes and other areas significant to Indian people.

<u>Consultation and Collaboration:</u> An ongoing process of tribal consultation and collaboration for ecosystem management and specific projects is beginning to establish firmer institutional roots in the Sierra Nevada. For many tribal communities whose reservations lie next to National Forests, Forest Service management affects their quality of life. Since forested ecosystems extend beyond land ownership boundaries, it is essential that the Forest Service and tribes collaborate to protect everyone's interests in such issues as fire protection, water quality, air quality, and other resources in National Forests

The spiritual and cultural survival of Indian people is to a large extent dependent upon National Forest lands because areas of cultural importance to tribal people are located there; namely, ceremonial locations, cemeteries, traditional gathering areas, and archaeological sites. These areas contribute to the tribal communities' way of life, their identity, their traditional practices and cohesiveness. Because ecosystem management within the forest may affect tribes in various ways, there are some important aspects that need to be considered. The following are some tribal concerns that have been expressed, which are applicable to the KRP:

1. **Culturally important uses of natural resources**. Traditional gathering for food, medicine, dance regalia for ceremonial use, basket weaving material, materials used for ceremonies such as sweat lodges, and other activities continue today. Present needs and gathering practices are not fully known. The SNF is aware that resource gathering locations are often scattered in small areas throughout the project area. Indian people have expressed concern that plants of significance to the Indian people are neglected in forest management processes, such as plants used in basket weaving. A key effect of the inception of federal administration of most of the land in the project area around the beginning of the twentieth century was a change in fire management. Wildfires were suppressed. The loss of controlled fire or natural fire to maintain prehistoric vegetative conditions contributed to heavy fuel buildup and conifer dominance. A cursory examination of those areas where resources are needed by basket weavers suggests that the existing condition on forest lands is poor, often overgrown by vegetation or weeds. Areas that were historically used to provide the everyday resources for large villages of several hundred people can barely provide resources for a few weavers today. The plants have not been tended, pruned and managed systematically to be productive and useful, i.e., sourberry *(Rhus trilobata*) and bunch grass or deer grass (*Muhlenbergia rigens*). Insufficient cultural plants include sourberry and "white root" (specific species of *Carex spp*., commonly known as sedge).

   Another concern is the protection and management of black oak groves. Various tribal representatives have pointed out past gathering areas. In the past several years, the SNF

Heritage and Tribal Programs and Fuel Programs have under-burned a number of locations in an effort to enhance the oak trees. The removal or reduction of understory and groundcover in black oak areas has improved conditions for gathering collect acorn.

2. **Special lands and associated activities on NF lands**. Presently, ceremonial activities, such as traditional healing ceremonies and bear dance gatherings or visits to special places, happen on Forest Service lands, including within the KRP. Sometimes they are held with little notice; sometimes they consist of large numbers of families participating. Some of these activities need to be performed in an environment conducive to the activity. Possible conflicting activity needs to be considered in project planning. The activities require items used during the ceremonies, such as poles (cedar, willow), certain rocks, and plants.

3. **Archaeological sites including historic Indian locations and non-Indian historic sites.** Many of the archaeological sites located within the project area are familiar to local tribes, particularly the Holkoma Mono, mainly associated with the Cold Springs Rancheria; members of the Dunlap Band of Mono Indians and other Wobonuch Mono people.

   The project area illustrates cultural diversity, with evidence of multiple lifestyles and economies depicted in the archaeological record. Throughout history, human activities have created the present cultural landscape within the Big Creek and Dinkey Creek watersheds. The project area offers unique opportunities for research, enhancement, interpretation, management and contemporary use of significant cultural values.

Heritage Resource Management: As described in the project design measures (Chapter II), proposed activities within the Project area would be managed according to the provisions of the Regional PA for no effect to cultural resources, including both archaeological values and contemporary Native American values. The Standard Protection Measures of the Regional PA require that historic properties be avoided when undertaking activity within their boundaries, unless specifically identified in the Regional PA (i.e. controlled burning through sites). The nature and scope of this project are such that the potential effects of project activities to archaeological research values and contemporary cultural values can be reasonably predicted, and appropriate measures can be taken to ensure the significant values of these heritage resources are not adversely affected. Not every part of the proposed action would avoid heritage resources.

Contemporary Native American interests can include traditional cultural properties (sites associated with cultural practices or beliefs that are rooted in history and important in maintaining cultural identity), and plant gathering sites for basket materials, medicines, and food resources. The SNF manages such known sites as cultural resources under the provisions of the Regional PA but where the interests of native people are considered to achieve a mutually beneficial outcome during project implementation. For example, some plant materials used in basketry respond positively to fire; sites containing these plants might be included in prescribed fire activities to promote their quality and abundance. The location of these sites is also kept administratively confidential. The SNF will maintain appropriate access to sacred and ceremonial sites, and to tribal traditional use areas, and has consulted with affected tribes and tribal communities to address access to culturally important resources and areas in this project analysis.

Environmental Consequences

Direct and Indirect Effects of Alternative 1 and 3

Cultural resources have been considered in all aspects of the proposed project, and in regards to the proposed actions. Since vegetation management and fuels reduction treatments involve ground disturbance, the proposed actions have the potential to damage or destroy cultural resources.

No direct effects to sites with archaeological value are anticipated from implementation of these alternatives. For archaeological sites, specific protection and management measures derived from the Regional PA would be applied as project design measures (Chapter 2, page 36). All National Register eligible and potentially eligible properties would be managed for No Effect (per the Regional PA) from project activities. No consultation on project effects with the California State Historic Preservation Officer is required.

Because of the entry into the project area with implementation activities, inadvertent effects to known and undiscovered heritage resources could occur. The management requirements derived from the Regional PA would be in place to ensure that this potential is minimized and to ensure appropriate consultation in the unlikely circumstance should inadvertent effects occur. The experience of SNF heritage resource managers and project implementation staff has proven that with careful application of the protection measures of the Regional PA, inadvertent effects to historic properties are the rare exception. According to the Regional PA, the Forest shall conduct monitoring to ensure the effectiveness of the protection measures or prevent the loss of unidentified heritage resources. Heritage Resource Managers will determine the schedule and requirement for any monitoring based on the timing of project implementation, the type of project activity, and the locations of known cultural resources. Monitoring results will be documented in the SNF annual Regional PA report.

There is a high degree of likelihood of discovery of previously unknown archaeological resources during project implementation. There is a small risk of damage to any sites not yet discovered, including those sites that are located entirely sub-surface. The implementation contracts would contain provisions to protect such sites, in the event that they are discovered because of treatment activities, by the cessation of activities until a heritage resource specialist evaluates the discovery and provides for an appropriate level of protection, in accordance with the provisions of the Regional PA.

An anticipated indirect effect is an increased awareness by the public, implementation personnel, and implementation contractors of the nature and location of heritage resources of the KRP. This may result from the public project analysis, any short-term increase in ground surface visibility due to the loss of vegetative cover by proposed fuels reduction activities (especially prescribed fire), the projected increase in human activities in the project area during implementation, and visible site protection measures necessary for implementation. Increased awareness can increase the risk of site vandalism through disturbance and illegal collection. Such illegal artifact collection and damage has been continually occurring in the project area since many of the archaeological sites were first documented in the 1970s. The loss of artifacts can adversely affect the archaeological information potential and National Register eligibility. This risk is anticipated to be only slightly higher than the no action alternative, due to the short-term nature of any exposure the sites would have to personnel conducting the treatments.

For non-archaeological cultural resources, the appropriate Native American Tribes, tribal councils and individuals were consulted about the presence of traditional cultural properties and plant gathering areas within the project area. Identified gathering sites would not be directly or indirectly affected by project activities, as they would be afforded protection through management measures derived from the Regional PA, as project design measures (Chapter 2).

If there are gathering sites within the project area that Native Americans have chosen not to disclose, then there could be adverse direct effects from project treatments, particularly shredding and herbicide application, on some plant populations important to California Indian basket weavers or gatherers.

These project alternatives would have direct effects on populations of plant species important to California Indian basket weavers and other Native American gatherers, outside of identified gathering sites. Plant species targeted for removal or reduction in fuels and vegetation management prescriptions include brush and plant species (e.g. bear clover, manzanita, buck brush, deer brush) that are identified by Native American organizations, tribes, and individuals as species of traditional use and interest. This effect is limited by the scope of the project treatments, and by the abundance and region-wide distribution of these species.

Alternatively, the abundance of traditional food, basketry, or medicinal plants may ultimately be enhanced by the proposed treatments in terms of conversion to uneven-age vegetation management strategy, reduction of decadent fuels, and limiting the spread of noxious weeds. A discussion of botanical diversity and native plants is found above in the Botanical Resources section of this Chapter.

Cumulative Effects of Alternative 1 and 3

The geographical area considered in this cumulative effects analysis is the KRP area. The overall cumulative effects of the action alternatives to heritage resources are expected to be beneficial, as the prescriptions that were developed through the interdisciplinary process in consideration of the presence of cultural resources may ultimately enhance the cultural resources in the following ways:

A cumulative effect of the action alternatives would be to reduce the effects of future wildfires, fueled by brush and vegetation buildup, that damage or destroy heritage resources directly, or because of fire suppression. Impacts to sites burned in wildfire include destruction of artifacts, increased erosion, enhanced visibility to vandals, contamination by fire retardant, introduction of modern carbon and charcoal, and mechanical impacts from fire suppression equipment (U.S. Army Corps of Engineers 1992). Implementation of an action alternative would serve to reduce the threat of wildfire damage to archaeological sites in the long-term by creating conditions that reduce the spread and intensity of wildfires.

Careful application of controlled fire can be beneficial to heritage resources. Controlled burns can be effectively used to control vegetation on archaeological sites without damage to the cultural resources (U.S. Army Corps of Engineers 1992). The procedures of the *Interim Protocol* of the Regional PA are based on the assumption that low- to moderate-intensity prescribed fires generally have few direct impacts to non-flammable heritage resources that have previously burned over.

Implementation of the proposed action would serve to move the KRP toward the desired future condition (Chapter 1), more representative of the prehistoric natural setting.

Past actions, both natural and human caused, have had varying degrees of cumulative effects on the cultural values in the project area. These effects, which include damage or destruction to archaeological sites, are the result of historic activities (i.e. logging, road construction), illegal artifact collection, and in particular, from wildfires. Implementation of the action alternatives is not anticipated to negatively affect the archaeological or cultural stability of the project area.

Alternative 2 - No Action

Direct and Indirect Effects

Cultural resources have been considered in all aspects of the proposed project. No direct or indirect effects to identified sites with cultural values (archaeological research values or contemporary Native American interests) are anticipated under this alternative because no project activities would occur.

Cumulative Effects

Past actions, both natural and human caused, have had varying degrees of cumulative effects on the cultural values in the project area. These effects, which include damage or destruction to archaeological sites, are the result of historic activities (i.e. logging, road construction), illegal artifact collection, and in particular, wildfires. These trends would continue under this alternative.

In this alternative, there is the potential for adverse effects to cultural resources without management intervention to address or mitigate the potential threat of future wildfires with high burn temperatures if current fuel conditions persist. Future stand-replacing fire events would have a negative cumulative effect by causing damage to sensitive archaeological site features, as well as exposure to potential vandalism.

This alternative may have a beneficial effect to the archaeological values in that the current vegetation conditions would persist, providing a level of protection from human disturbance. Many of the archaeological sites are very difficult to locate, and surface artifacts are hidden by the ground cover, discouraging the potential for detection, illegal collection, and vandalism.

On the other hand, this alternative may have a negative effect to non-archaeological cultural resources, especially plants of contemporary Native American interest. Noxious weeds and other invasive species would continue to spread, crowding out native species. Fuels and brush would continue to accumulate, making access to and use of resources by Native Americans more difficult or impossible.

ECONOMICS

Affected Environment

The economic benefit of an alternative is dependent on the value of the standing tree volume at a point in time, the costs and benefits of active management proposed in the alternative and the cost of standing tree volume lost to a severe fire.

As explained at the beginning of Chapter 3, each alternative incorporates the concept of wildfire entering the landscape ten years after the record of decision for the purpose of modeling and analysis of effects. The ten year period was chosen not as a prediction but because it would test the effectiveness of the proposed action and reduction of harvest tree size alternatives after all treatments have been accomplished vs. the no action alternative and display a comparison to the decision maker of the indirect and cumulative effects of the alternatives.

A simple approach to weighing the economic benefits of alternatives is to compare the present net value of the reasonably foreseeable activities that can be quantified by referring to recent market transactions (selling timber, contracting for piling debris, etc.) at a common point in time. For the purpose of modeling and analysis, the point in time is after a wildfire has entered the landscape ten years after the record of decision.

Environmental Consequences

Alternative 1 – Proposed Action

For the Proposed Action, the reasonably foreseeable activities are as follows: the current harvest of standing tree volume – a benefit; the post harvest vegetation, fuels and resource improvement projects – costs; the road reconstruction and construction work associated with the projects – a benefit because the improved or new roads are an asset which has value for many years; the road maintenance work associated with the projects – a cost because routine maintenance has value for only the life of a project to a few years; the value of the standing tree volume after wildfire enters the landscape in ten years – a benefit

Table 3-75 - Present Net Value, Proposed Action

	bear_fen	el-o-win	glen_mdw	krew_bul	krew-prv	n_soapro	prov_1	prov_4
Timber Harvest Value	$247,058	$1,078,261	$590,887	$311,148	$980,300	$50,249	$266,546	$17,770
Roads	$252,418	$116,452	$226,349	$149,168	$415,685	$256,356	$179,896	$167,924
Post Harvest Costs	$558,560	$355,436	$339,789	$341,670	$470,172	$363,500	$475,494	$144,853
Post Fire Timber Inventory Value	$535,748	$907,795	$866,869	$803,621	$740,373	$141,378	$375,767	$52,087
PNV	$148,520	$1,595,684	$1,050,063	$728,350	$1,125,796	-$248,780	$112,851	-$125,374

The present net value from carrying out the Proposed Action and a wildfire entering the landscape after ten years for the initial eight management units is $4,390,000.

Alternative 2 – No Action

For the No Action, the only reasonably foreseeable activity is the loss of standing tree volume after wildfire enters the landscape in ten years.

Table 3- 76 - Present Net Value, No Action

	bear_fen	el-o-win	glen_mdw	krew_bul	krew-prv	n_soapro	prov_1	prov_4
Post Fire Timber Inventory Value	$327,401	$453,897	$591,555	$889,192	$587,834	$178,583	$502,263	$63,248

The present net value remaining after wildfire enters the landscape in ten years for the initial eight management units is $3,595,000.

Alternative 3 – Reduction of Harvest Tree Size

For the Reduction of Harvest Tree Size Alternative, the reasonably foreseeable activities are the same as for the Proposed Action.

Table 3-77 - Present Net Value, Reduction of Harvest Tree Size

	bear_fen	el-o-win	glen_mdw	krew_bul	krew-prv	n_soapro	prov_1	prov_4
Timber Harvest Value	$209,371	$82,609	$357,983	$219,634	$565,558	$41,874	$222,122	-$8,885
Roads	$252,418	$116,452	$226,349	$149,168	$415,685	$256,356	$179,896	$167,924
Post Harvest Costs	$558,560	$355,436	$339,789	$341,670	$470,172	$363,500	$475,494	$144,853
Post Fire Timber Inventory Value	$535,748	$907,795	$866,869	$803,621	$740,373	$141,378	$375,767	$52,087
PNV	$110,833	$1,380,032	$817,159	$636,835	$711,053	-$257,155	$68,426	-$152,029

The present net value from carrying out the Reduction of Harvest Tree Size Alternative and a wildfire entering the landscape after ten years for the initial eight management units is $3,315,000.

HUMAN HEALTH AND SAFETY

Affected Environment

Currently there are noxious weeds, invasive plants and undesirable vegetation in the form of brush competing with tree seedlings for moisture and nutrients in the project area that will present an opportunity for correction with the herbicides. See section on botanical resources and vegetation for more information on current vegetative condition.

A Region-wide environmental analysis entitled: Vegetation Management for Reforestation Final Environmental Impact Statement (VMFEIS) (USDA 1988) is incorporated by reference.

The use of prescribed fire as a fuels reduction technique increases the potential for the degradation of air quality. The potential impacts of fire-induced air quality degradation on public heath and welfare range from occupational short term exposure of smoke on firefighters and local residences to long term health effects from ambient pollutants and particulate matter and fugitive dust in smoke sensitive areas. See section on air quality for more information on prescribed fire and air pollutants including an effects analysis.

An Air Quality Determination has been prepared for the Kings River Project to determine conformity to The Clean Air Act, the California State Implementation Plan and Title 17 of the California Code of Regulations and is incorporated by reference.

A risk assessment to determine the site-specific risks to human health and safety of using glyphosate in the commercial formulation, Accord, was prepared for the project and is incorporated by reference. The risk assessment is on file at the High Sierra District Office[20].

Direct and Indirect Effects of Alternative 1 and 3

The hazard information, the application method (backpack spraying), and the number and characteristics of people that could come in contact with glyphosate is similar to many other projects undertaken by the District in recent years.

Hazard analysis was accomplished by reviewing toxicity data in the literature and the Vegetation Management for Reforestation Final Environmental Impact Statement (USDA 1988) and identifying established acute toxicity values (LD50s), no observable effect levels (NOELs) for systemic and reproductive health effects. These data are summarized in the Toxicity Summary Table on page 2 of the risk assessment. Glyphosate is considered to be slightly toxic to humans. It is non-irritating to the skin and only slightly irritating to the eyes. There is no evidence that glyphosate causes birth defects, cancer, neurotoxicity, immunotoxicity or endocrine disruption (SERA 2002 & 2003).

The application rate per acre is based on the estimate that glyphosate would be mixed with water at 5 percent by volume and applied to all the target vegetation involved with reforestation or noxious weed control activities, which is about 25 to 75 percent of the vegetation in the areas to be treated. On this project, glyphosate mixed at 5 percent and applied spray-to-wet to the target vegetation would result in 9 to 24 gallons of mix per acre or 1.8 to 4.8 pounds of active ingredient per acre. Following the same methodology used in the VMFEIS and this application rate, doses were calculated for potentially exposed workers and members of the public. The results are in the Summary of Exposure Scenarios Table on page 3 of the risk assessment.

A margin of safety (MOS) was calculated for each dose estimate for workers and the public by dividing the systemic and reproductive NOEL for the herbicides by the estimated dose. A benchmark MOS of 100 is commonly accepted by the scientific community, regulatory agencies, and the Forest Service for setting acceptable exposure

20 The Forest Service primarily relied on the Vegetation Management for Reforestation Final Environmental Impact Statement (VMFEIS 1988) for the methodology and some of the data used in the human health risk assessment. As stated in the risk assessment for the project, it uses "the standard methodology, widely accepted by the scientific community that is described in detail in Appendix F of the VMFEIS." The risk assessment for the project is current and utilized information from recent risk assessments such as Selected Commercial formulations of Glyphosate - Accord, Rodeo, and Roundup risk assessment final report (SERA 1996) and Glyphosate (SERA 2003). Otherwise, the VMFEIS was not used to assess the impacts of herbicide use. The Forest Service did use the experience gained by carrying out reforestation activities that flowed from the VMFEIS to craft the alternatives and estimate the effects in this EIS.

rates. Values of 100 or greater are considered to pose an acceptable or low risk to human health and safety. All MOS values calculated for doses resulting from this application rate are greater than 100. Therefore, the risks to workers and to members of the public are low.

The only inert ingredient contained in Accord is water. However, the herbicide would be mixed with R-11 surfactant and dye, usually Colorfast Purple. The EPA has categorized approximately 1200 inert ingredients into four lists. List 1 and 2 contain inert ingredients of toxicological concern (Fed. Reg. 54:48314-16). List 3 includes substances such as soaps and List 4 substances such as corn oil, honey and water. Neither R-11 or Colorfast Purple nor inerts included in formulating them are on List 1 or 2.

There has been concern expressed about the potential for surfactants containing nonylphenol polyethoxylate (NPE)[21], such as R-11, to cause endocrine disruption and other deleterious effects. However, in comparison to natural estrogen NPE is approximately 10,000 to 1,000,000 times weaker in eliciting an estrogenic response (USDA 2003, p. 9). Based on a planned application rate of one percent R-11, there is no evidence that typical applications of NPE in R-11 will lead to accidental or chronic exposures that exceed the level of concern (i.e. MOS exceeding 100) in workers or the general public. A possible exception would be eye and skin irritation from direct and prolonged exposure through an accidental or mishandling incident where personal protective equipment (eye protection) was not used and first aid was not administered (USDA 2003, p. v). NPE is classified as slightly to practically non-toxic to mammals and is not mutagenic (USDA 2003). So, there would be almost no risk to the health and safety of the workers or public from these additives.

Cumulative Effects of Alternative 1 and 3

Use of glyphosate could result in cumulative doses of herbicides to workers or the general public. Cumulative doses result from (1) additive doses from various routes of exposure from this project and (2) additive doses if an individual is exposed to other herbicide treatments.

Reforestation and noxious weed control activities in the project would have one to three glyphosate applications over the years, so a worker or a member of the general public could be exposed to a second dose during application plus any residual herbicide remaining on the site. Since the half-life of glyphosate is less than three months (SERA 2003), no additive herbicide doses from a second application are anticipated.

Southern California Edison applies less than 100 gallons of glyphosate mix annually to its lands in the project area and PG&E applies herbicides to about 200 acres annually on the Helms/Gregg 230kV Transmission line right-of-way. There are a few other adjacent landowners with small acreages in the project area that may apply similar amounts of glyphosate in the foreseeable future. However, an additive dose would be almost impossible because the applications would be geographically separated and glyphosate does not persist in the environment.

21 The primary active ingredient in many of the commercially available non-ionic surfactants is a compound known as NPE. It is found at rates varying from 20 to 80 percent. NPE is formed through the combination of ethylene oxide and nonylphenol (NP). NP is a material recognized as hazardous and is included on EPA List 1. (USDA 2003, p. v) NPE is widely used in industrial applications, detergents, cosmetics, shampoos, surfactants and spermicides.

There is no indication that glyphosate causes sensitization or allergic responses, which does not eliminate the possibility that some individuals might be sensitive to glyphosate as well as many other chemicals (SERA 2003; 3-51).

Synergistic effects of glyphosate with other chemicals are not anticipated in the project area because they have not occurred when it has been used extensively in other forestry and agricultural applications.

For all instances, cumulative effects would be negligible with the exception of where individuals use herbicides at home on the same day of an exposure resulting from the project which would double the human health risk.

Direct, Indirect and Cumulative Effects of Alternative 2

None

RESEARCH

Affected Environment

Why is research important? The quality of aquatic, riparian and meadow ecosystems is directly related to the integrity of nearby uplands and their watershed. Research scientists believe that these ecosystems are the most altered and impaired habitats of the Sierra Nevada primarily because of dams and diversions, overgrazing, roads, logging and physical alteration. Forest managers, private companies and public interest groups have all expressed interest in whether uneven-aged forest management can maintain the long-term viability of California spotted owl and other wildlife populations, improve forest health and develop a sustainable level of productivity. Substantial interest has always existed around reintroduction of fire into the Sierra Nevada ecosystem.

Current research plans intended to determine how California spotted owls and fisher respond to changes in vegetation structure from the application of the KRP uneven-aged management strategy and prescribed fire; better understand the spatial distribution of ozone and other pollutant deposition on forest health and water quality; quantify the characteristics of stream ecosystems and their associated watersheds; determine the effect of fire and fuel reduction treatments on riparian and stream physical, chemical and biological conditions; determine how effective current stream buffers are at protecting aquatic ecosystems; determine if prescribed fire changes the rate of soil erosion and if it affects soil health and productivity.

The KRP area is representative of forest conditions found throughout the southern Sierra Nevada and is the only adaptive management project established in the south half of the Sierra Nevada to address a diverse set of questions about uneven-aged silvicultural systems and prescribed fire.

Environmental Consequences

Direct and Indirect Effects of Alternative 1 and 3

The need identified in Chapter 1, "*for knowledge about the response of forests to a management strategy consisting of a specific uneven-aged silvicultural system and prescribed fire program designed to restore forests to historical pre-1850 conditions across a large landscape*", would be chiefly satisfied. This project could become a management model for other national forests that are looking at methods to recreate the historical pre-1850 forest conditions because of the knowledge that is produced.

The research is described in Chapter 2 on pages 18 thru 24.

Cumulative Effects of Alternative 1 and 3

None

Alternative 2 - No Action

Under the No Action alternative, the research planned would not occur and the research underway (KREW) could not be completed. Invested time in research projects, especially the Kings River Experimental Watershed, would be lost. Questions would remain as to the effects of management activities to riparian and stream conditions, the effectiveness of stream buffers, and the use of prescribed fire on rates of soil erosion. No information would be gained on CA spotted owl or Pacific fisher with regard to forest restoration.

Short-term Uses and Long-term Productivity

NEPA requires consideration of "the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity" (40 CFR 1502.16). As declared by the Congress, this includes using all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans (NEPA Section 101).

Maintenance and enhancement of long-term productivity is at the heart of beginning to restore the historical pre-1850 forest condition, the KRP purpose. Obviously, the pre-1850 forest was sustainable and resilient. This is demonstrated by its survival for thousands of years shaped by natural forces and management of certain plant communities by Native Americans for cultural purposes. All plant and animal species present today occurred in varying numbers during those years. By comparison, the present forest is not sustainable or resilient as described in the SNFPA 2004 Record of Decision (USDA 2004a, p.6). So, the short-term uses of man's environment described in the Proposed Action or the Reduction in Harvest Tree Size Alternative in Chapter 2 are intended to be the activities that lead to enhancement of long-term productivity by beginning to restore the pre-1850 forest condition.

All the needs for action described in Chapter 1 lead to enhancement of long-term productivity, especially:

- the need to increase the number of large trees for the benefits described to various species in the wildlife section,
- the need to reduce tree density to gain the benefits and avoid the consequences described in the fuels and vegetation sections,
- the need to control noxious and non-native weeds to avoid the consequences described in the botanical resources section, and
- the need to improve watershed conditions to gain the benefits described in the soils and watershed sections of Chapter 3 on Environmental Consequences

Unavoidable Adverse Effects

There are no unavoidable adverse effects described in Chapter 3.

Irreversible and Irretrievable Commitments of Resources

Irreversible commitments of resources are those that cannot be regained, such as the extinction of a species or the removal of mined ore. Irretrievable commitments are those that are lost for a period of time such as the temporary loss of timber productivity in forested areas that are kept clear for use as a power line rights-of-way or road.

Within the KRP area there may be an irreversible effect to Yosemite toad if Alternative 1 – Proposed Action is selected but not if Alternative 3 – Reduction in Harvest Tree Size is selected. The possibility is described in Chapter 3, Aquatic Resources.

Cumulative Effects

Cumulative effects are addressed by each resource area in the environmental consequences discussions in Chapter 3.

Legal and Regulatory Compliance

NEPA at 40 CFR 1502.25(a) directs "to the fullest extent possible, agencies shall prepare draft environmental impact statements concurrently with and integrated with …other environmental review laws and executive orders." The proposed action and alternatives must comply with following:

Principle Environmental Laws

The following laws contain requirements for protection of the environment that apply to the proposed action and alternatives:

<u>Endangered Species Act –</u> This act applies to the proposal and the proposal will comply with the law through the conduct of Biological Assessments and Evaluations that analyzed effects of the proposed action and reduction in harvest tree size Alternative and made determinations on federally listed endangered, threatened candidate, and proposed species and their habitat. The analysis was conducted, in part, to determine whether formal consultation or conference is required with the United States Department of Interior (USDI) Fish and Wildlife Service, pursuant to the Endangered Species Act.

<u>Clean Water Act –</u> This act applies to the proposal and the proposal will comply with the law by adoption of Best Management Practices and other design measures as detailed in Chapter 2.

<u>Clean Air Act -</u> This act applies to the proposal and the proposal will comply with the law by implementation of the Best Available Control Measures (BACMs) for prescribed fire as required under section 190 of the Clean Air Act as amended in 1990.

<u>National Historic Preservation Act -</u> Project implementation will comply with the stipulations of the *First Amended Regional Programmatic Agreement Among the USDA Forest Service, Pacific Southwest Region, California State Historic Preservation Officer, and Advisory Council on Historic Preservation Regarding the Process for Compliance with Section 106 of the National Historic Preservation Act for Undertakings on the National Forests of the Pacific Southwest Region* (Regional PA), dated 2001 (USDA 2001b). This project complies with Stipulations III.C. (2) and III.D.(3)., Undertakings Where Management Measures Are Necessary for the Protection of Historic Properties.

<u>Coastal Zone Management Act –</u> This act does not apply to this proposal due to its geographic proximity to the coast.

<u>National Forest Management Act –</u> This act does apply to the proposal and the reader can refer to Chapter 3 under several topics, especially Vegetation including Fire, Historical Forests, and Reforestation section.

Executive Orders

The following executive orders provide direction to federal agencies that apply to the proposed action and alternatives:

Indian Sacred Sites, Executive Order 13007 of May 24, 1996 – This order applies to the proposed action and reduction in harvest tree size alternative because of the historic and prehistoric uses known in the area. This is specifically addressed in Chapter 3 under the topic Heritage Resources and Tribal Relations. All three alternatives comply with this order.

Invasive Species, Executive Order 13112 of February 3, 1999 – This order applies to the proposed action and reduction in harvest tree size alternative. There is a risk of introducing invasive species as well as a risk of spreading an existing population without measures in place for prevention. The action alternatives comply by providing measures to prevent introduction and spread of invasive species.

Recreational Fisheries, Executive Order 12962 of June 6, 1995 - This order applies to the proposed action and reduction in harvest tree size alternative. By implementing Best Management Practices and other design measures as detailed in Chapter 2 and correcting existing resource problems, the action alternatives comply with this order.

Migratory Birds, Executive Order 13186 of January 10, 2001 - This order applies to the proposed action and reduction in harvest tree size alternative. It states that each agency, to the extent permitted by law and subject to the availability of appropriations and within Administration budgetary limits, shall "… ensure that environmental analysis of Federal actions required by the NEPA or other established environmental review processes evaluate the effects of actions and agency plans on migratory birds, with emphasis on species of concern". To comply with this order, an analysis was conducted and the "Effects on Migratory Birds Specialist Report – Kings River Project" (Robinson 2006) was prepared. The effects are summarized as follows:

Immediately after implementation of the proposed activities (Alternatives 1 or 3), acres of coniferous forest (e.g., Ponderosa pine, red fir, Sierra mixed conifer) will remain unchanged with composition trending slightly to more trees in size classes 4 and 5 (i.e., larger trees), and a modest reduction in canopy cover. Acres of oak woodland habitat (e.g., montane hardwood and montane hardwood/conifer) remains unchanged with a slight increase in trees in size classes 2 and 3 (Tables 3mbta and 4mbta). These changes are small compared to the existing condition within the project area and the total number of acres of these habitats within the approximate 72,000 acres comprising all 80 management units of the KRP: 4235 acres of oak woodland and over 56,000 acres of coniferous forest (Tables 5mbta and 6mbta). Over the following ten years, considering all of the reasonably foreseeable and ongoing activities identified at the beginning of Chapter 3 of the FEIS, additional changes are expected; however, as shown above, the magnitude of these shifts is likely to be small compared to the total acres available.

Implementation of the proposed activities (Alternatives 1 or 3) may result in an unintentional take of individual birds. However, future management options for migratory birds would not be foreclosed because the overall change in available habitat is small, riparian areas and individual oak trees are well protected by project design measures and Best Management Practices, a long-term increase in the number of larger, older trees is projected, and fire would be reintroduced into the ecosystem thereby restoring a critical piece to the functioning of ecosystem processes that would result in a reduction of fuels and the threat of stand-replacement fires. In the absence of a natural fire regime, timber harvest along with prescribed fire can help mimic the natural disturbance regime that has created the diversity of habitat types and conditions that support the full compliment of avian species that breed in the Sierra Nevada ecosystem.

Floodplain Management, Executive Order 11988 of May 24, 1977 – This order does not apply because of the exclusions and buffers in place.

Protection of Wetlands, Executive Order 11990 of May 24, 1977 - This order does not apply because of the exclusions and buffers in place.

Environmental Justice, Executive Order 12898 of February 11, 1994 – This order applies to the proposed action and reduction in harvest tree size alternative. We have attempted comply with the order by making this document understandable and accessible.

Use of Off-Road Vehicles, Executive Order 11644, February 8, 1972 – This order does not apply to this proposal because no off road use is being proposed nor existing use changed.

Special Area Designations

The selected alternative will need to comply with laws, regulations and policies that pertain to the following special areas:

Research Natural Areas - There are no research natural areas in the project area. The Teakettle Experimental Forest lies adjacent to the KRP area but would remain unaffected and therefore this project would comply with the applicable laws, regulations and policies on this type of area.

Inventoried Roadless Areas – Adjacent to the project area in the north and again on the southern side are two separate designated roadless areas. Each occurs outside of any planned management associated with the initial eight management units. This project would comply with the applicable laws, regulations and policies on this type of area.

Wilderness Areas - The KRP area includes a small portion of the Dinkey Lakes Wilderness. This wilderness area is outside of any planned management associated with the initial eight management units. This project would comply with the applicable laws, regulations and policies on this type of area.

Wild and Scenic Rivers – No rivers designated as Wild and Scenic occur in the KRP planning area.

Municipal Watersheds (FSM 2540) - No municipal watersheds occur in the KRP planning area area.

Other Required Disclosures

NEPA at 40 CFR 1502.25(a) directs “to the fullest extent possible, agencies shall prepare draft environmental impact statements concurrently with and integrated with …other environmental review laws and executive orders.”

No water is planned for impounding or diversion within this proposal and therefore the Wildlife Coordination Act does not apply.

Species surveys, review of recent literature and professional judgment have been incorporated into determinations of possible effects on species. Surveys provide information on species presence and habitat on a local scale, but there is an element of uncertainty for effects on species with distributions beyond the project or Forest boundaries. The Pacific fisher and Yosemite toad are Forest Service "sensitive species" that have also been designated by the U.S. Fish and Wildlife Service (F&WS) as "candidate species" for listing under the Endangered Species Act. A candidate species is determined by the F&WS through a 12 month finding as warranted for listing, but the listing process is precluded by other priorities. To address the uncertainty related to these candidate species, the Forest requested and received technical advice from the F&WS. The advice is integrated extensively throughout the Wildlife and Aquatic Species sections of Chapter 3.