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Water Quality and Riparian Areas Specialist's Report

Four Forest Restoration Initiative

Coconino and Kaibab National Forest

Coconino County, Arizona

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Water Quality and Riparian Area Report

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INTRODUCTION

This report documents the affected environment and environmental consequences of implementation of the Four Forest Restoration Initiative on the Coconino National Forest (CNF) and Kaibab National Forest (KNF) riparian ecosystems and water quality.

The objective of the Four Forest Restoration Initiative is to re-establish forest structure, pattern, and composition within the ponderosa pine ecosystem, which will lead to increased forest resiliency and function, thus increasing the ability of the ponderosa pine forest to survive natural disturbances such as insect and disease, fire, and climate change (FSM 2020.5). Restoration activities proposed with this project are expected to improve vegetation biodiversity, wildlife habitat, soil productivity, and watershed function.

Purpose and Need

The purpose of the Four Forest Restoration Initiative Project is to improve the health and sustainability of forested conditions within the project area by reducing hazardous fuels and moving vegetative conditions toward the desired conditions.

There is a need for:

- Restoring the structure, pattern and composition of fire-adapted ecosystems on the Coconino and Kaibab National Forests, which will provide for fuels reduction, forest health, and wildlife and plant diversity
- Moving stand conditions toward forest structures considered to be more typical of forest structure under pre-settlement fire regimes;
- Reintroducing fire as a natural part of the ecosystem;
- Reducing the risk for stand-replacing wildfires;
- Improving tree vigor and stand resilience;
- Improving the diversity of age classes and structure of woody vegetation;
- Improving ground cover, including down woody debris, fine litter and herbaceous understory composition and productivity;
- moving toward desired conditions in riparian ecosystems by having springs function at, or near, potential
- moving towards desired conditions for degraded ephemeral channels by restoring channel function
- Improve the motorized transportation system to provide for a more sustainable transportation network whereby poorly located roads are relocated or obliterated.

Alternatives

Alternative A – No Action

Alternative A is the no action alternative as required by 40 CFR 1502.14(c). There would be no changes in current management and the forest plans would continue to be implemented. Those forest plan actions and allocations are incorporated by reference. Approximately 166,897 acres of current and ongoing vegetation treatments and 195,076 acres of prescribed fire projects would continue to be implemented within and adjacent to the project area. Approximately 43,041 acres of vegetation treatments and 58,714 acres of prescribed fire and maintenance burning would be implemented within and adjacent to the project area by the Forests in the foreseeable future (within 5 years). Alternative A is the point of reference for assessing action alternatives B through E.

Alternative B – Proposed Action

The Coconino and Kaibab NFs propose to conduct approximately 583,330 acres of restoration activities over approximately 10 years or until objectives are met. On average, 45,000 acres of vegetation would be mechanically treated annually. On average, 40,000 to 60,000 acres of prescribed fire would be implemented annually across the Forests (within the treatment area). Up to two prescribed fires would be conducted on all acres proposed for treatment over the 10-year period. Restoration actions would:

- Mechanically cut trees on approximately 384,966 acres. This includes mechanically treating up to 16-inch d.b.h. within 18 MSO PACs.
- Apply prescribed fire on approximately 384,966 acres where mechanical treatment occurs and use low severity prescribed fire within 70 MSO PACs (excluding core areas).
- Utilize prescribed fire only on approximately 198,364 acres.
- Construct approximately 520 miles of temporary roads for haul access and decommission when treatments are complete (no new permanent roads would be constructed).
- Reconstruct up to 40 miles of existing, open roads for resource and safety concerns (no new permanent roads would be constructed). Of these miles, approximately 30 miles would be improved to allow for haul (primarily widening corners to improve turn radiuses) and about 10 miles of road would be relocated out of stream bottoms. Relocated roads would include rehabilitation of the moved road segment.
- Decommission 726 miles of existing system and unauthorized roads on the Coconino NF.
- Decommission 134 miles of unauthorized roads on the Kaibab NF.
- Restore 74 springs and construct up to 4 miles of protective fencing.
- Restore 39 miles of ephemeral channels.
- Construct up to 82 miles of protective (aspen) fencing.

- Allocate/manage as old growth 40 percent of the ponderosa pine type and 77 percent of the pinyon-juniper woodland on the Coconino NF.
- Manage and develop uneven-aged stands with a representation of old growth components across most of the project area on the Kaibab NF

No forest plan amendments would be needed on the Kaibab NF. The proposed actions are consistent with forest plan objectives, desired conditions, and standards and guidelines (see forest plan consistency section). Three nonsignificant forest plan amendments (see appendix B) would be required on the Coconino NF to implement alternative B:

Amendment 1 would add language to allow mechanical treatments up to 16-inch d.b.h. to improve habitat structure (nesting and roosting habitat) in 18 MSO PACs The amendment would remove language that limits PAC treatments in the recovery unit to 10 percent increments and language that requires the selection of an equal number of untreated PACs as controls. The amendment would remove language referencing monitoring (pre and post treatment, population, and habitat monitoring). Replacement language would defer final project design and monitoring to the FWS biological opinion specific to MSO for the project. The amendment, which is specific to restricted habitat in pine-oak, would add definitions of target and threshold habitat.

Amendment 2 would add the desired percentage of interspace within uneven-aged stands to facilitate restoration in goshawk habitat (excluding nest areas), add the interspace distance between tree groups, add language clarifying where canopy cover is and is not measured, allow 28,952 acres to be managed for an open reference condition, and add a definition to the forest plan glossary for the terms interspaces, open reference condition, and stands.

Amendment 3 would remove the cultural resource standard that requires achieving a “no effect” determination and would add the words “or no adverse effect” to the remaining standard. In effect, management would strive to achieve a “no effect” or “no adverse effect” determination.

Alternative C (Preferred Alternative)

The Coconino and Kaibab NFs would conduct restoration activities on approximately 586,110 acres over a period of 10 years or until objectives are met. On average, 45,000 acres of vegetation would be mechanically treated annually. On average, 40,000 to 60,000 acres of prescribed fire would be implemented annually across the Forests (within the treatment area). Up to two prescribed fires[1] would be conducted on all acres proposed for treatment over the 10-year period. Restoration activities would:

- Mechanically cut trees on approximately 431,049 acres. This includes: (1) mechanically treating up to 17.9-inch d.b.h. within 18 Mexican spotted owl protected activity centers.

[1] A single prescribed fire may include burning piles and a follow-up broadcast burn. Prescribed fire would be implemented as indicated by monitoring data to augment wildfire acres, with the expectation that desired conditions would require a fire return interval of about 10 years.

- Apply prescribed fire on approximately 431,049 acres where mechanical treatment occurs; this includes using low-severity prescribed fire within 70 Mexican spotted owl protected activity areas (including 54 core areas).
- Utilize prescribed fire only on approximately 155,061 acres.
- Construct approximately 520 miles of temporary roads for haul access and decommission when treatments are complete (no new permanent roads would be constructed).
- Reconstruct up to 40 miles of existing, open roads for resource and safety concerns (no new permanent roads would be constructed). Of these miles, approximately 30 miles would be improved to allow for haul (primarily widening corners to improve turn radiuses) and about 10 miles of road would be relocated out of stream bottoms. Relocated roads would include rehabilitation of the moved road segment.
- Decommission 726 miles of existing system and unauthorized roads on the Coconino NF.
- Decommission 134 miles of unauthorized roads on the Kaibab NF.
- Restore 74 springs and construct up to 4 miles of protective fencing.
- Restore 39 miles of ephemeral channels.
- Construct up to 82 miles of protective (aspen) fencing.
- Construct up to 12 flumes and 12 weather stations and associated instrumentation (up to 3 total acres of soil disturbance) to support the paired watershed study.
- Allocate/manage as old growth 40 percent of the ponderosa pine type and 77 percent of the pinyon-juniper woodland on the Coconino NF.
- Manage and develop uneven-aged stands with a representation of old growth components across most of the project area on the Kaibab NF

No forest plan amendments would be needed on the Kaibab NF. The proposed actions are consistent with forest plan objectives, desired conditions, and standards and guidelines. Three nonsignificant forest plan amendments (see appendix B) would be required on the Coconino NF to implement alternative C:

Amendment 1 would allow mechanical treatments up to 17.9-inch d.b.h. to improve habitat structure (nesting and roosting habitat) in 18 MSO PACs. These PACs would be managed for a minimum basal area of 110. It would allow low-intensity prescribed fire within 54 MSO PAC core areas. The amendment would remove language that limits PAC treatments in the recovery unit to 10 percent increments and language that requires the selection of an equal number of untreated PACs as controls. The amendment

Alternative D

Alternative D responds to Issue 2 (prescribed fire emissions) by decreasing prescribed fire acres by 69 percent (when compared to alternative B, proposed action). This equates to removing fire on about 404, 889 acres. A select number of MSO PACs would be mechanically treated but would not be treated with prescribed fire. All other components of the alternative are the same as described in alternative B.

The Coconino and Kaibab NFs would conduct restoration activities on approximately 563,407 acres over a period of 10 years or until objectives are met. On average, 45,000 acres of vegetation would be mechanically treated annually. On average, 40,000 acres of prescribed fire would be implemented annually across the Forests (within the treatment area). Two prescribed fires would occur over the 10-year treatment period. Restoration activities would:

- Mechanically cut trees on approximately 384,966 acres. This includes: (1) mechanically treating up to 16-inch d.b.h. within 18 MSO PACs, and, (2) disposing of slash through various methods including chipping, shredding, mastication, and removal of biomass off-site
- Utilize prescribed fire only on approximately 178,441 acres.
- Construct 520 miles of temporary roads for haul access and decommission when treatments are complete (no new permanent roads would be constructed).
- Reconstruct up to 40 miles of existing, open roads for resource and safety concerns (no new permanent roads would be constructed). Of these miles, approximately 30 miles would be improved to allow for haul (primarily widening corners to improve turn radiuses) and about 10 miles of road would be relocated out of stream bottoms. Relocated roads would include rehabilitation of the moved road segment.
- Decommission 726 miles of existing system and unauthorized roads on the Coconino NF.
- Decommission 134 miles of unauthorized roads on the Kaibab NF.
- Restore 74 springs and construct up to 4 miles of protective fencing.
- Restore 39 miles of ephemeral channels.
- Construct up to 82 miles of protective (aspen) fencing.
- Allocate/manage as old growth 40 percent of the ponderosa pine type and 77 percent of the pinyon-juniper woodland on the Coconino NF.
- Manage and develop uneven-aged stands with a representation of old growth components across most of the project area on the Kaibab NF

No forest plan amendments would be needed on the Kaibab NF. The proposed actions are consistent with forest plan objectives, desired conditions, and standards and guidelines. Three nonsignificant forest plan amendments (see appendix B) would be required on the Coconino NF to implement alternative D:

Amendment 1 would add language to allow mechanical treatments up to 16-inch d.b.h. to improve habitat structure (nesting and roosting habitat) in 18 MSO PACs. These PACs would be managed for a minimum basal area of 110. The amendment would remove language that limits PAC treatments in the recovery unit to 10 percent increments and language that requires the selection of an equal number of untreated PACs as controls. The amendment would remove language referencing monitoring (pre- and post-treatment, population, and habitat). Replacement language would defer final project design and monitoring to the FWS biological opinion specific to MSO for the project.

The amendment, which is specific to restricted habitat in pine-oak, would add definitions of target and threshold habitat.

Amendment 2 would add the desired percentage of interspace within uneven-aged stands to facilitate restoration in goshawk habitat (excluding nest areas), add the interspace distance between tree groups, add language clarifying where canopy cover is and is not measured, allow 28,952 acres to be managed for an open reference condition, and add a definition to the forest plan glossary for the terms interspaces, open reference condition, and stands.

Amendment 3 would remove the cultural resource standard that requires achieving a "no effect" determination and would add the words "or no adverse effect" to the remaining standard. In effect, management would strive to achieve a "no effect" or "no adverse effect" determination.

Alternative E

In alternative E eighteen MSO PACs would be mechanically treated to 9-inch d.b.h. No prescribed fire would be utilized within MSO PAC core areas. No acres would be managed for an open reference condition[2]. No treatments would occur within the Garland Prairie management area. MSO population and habitat monitoring would follow current forest plan direction and the FWS biological opinion. The paired watershed study and small mammal research would occur. Key components of the stakeholder-created large tree retention strategy are incorporated into the alternative's implementation plan.

The Coconino and Kaibab NFs would conduct restoration activities on approximately 581,020 acres over a period of 10 years or until objectives are met. On average, 45,000 acres of vegetation would be mechanically treated annually. On average, 40,000 acres of prescribed fire would be implemented annually across the Forests (within the treatment area). Two prescribed fires would occur over the 10-year treatment period.

Restoration activities would:

- Mechanically cut trees on approximately 403,218 acres. This includes: (1) mechanically treating up to 9-inch d.b.h. within 18 MSO PACs, and, (2) disposing of slash through various methods including chipping, shredding, mastication, and removal of biomass off-site.
- Apply prescribed fire on approximately 403,218 acres where mechanical treatment occurs.
- Utilize prescribed fire only on approximately 177,801 acres.
- Construct 520 miles of temporary roads for haul access and decommission when treatments are complete (no new permanent roads would be constructed).
- Reconstruct up to 40 miles of existing, open roads for resource and safety concerns (no new permanent roads would be constructed). Of these miles, approximately 30 miles would be

[2] Open Reference Condition is defined as forested ponderosa pine areas with mollic integrade soils to be managed as a relatively open forest with trees typically aggregated in small groups within a grass/forb/shrub matrix.

improved to allow for haul (primarily widening corners to improve turn radiuses) and about 10 miles of road would be relocated out of stream bottoms. Relocated roads would include rehabilitation of the moved road segment.

- Decommission 726 miles of existing system and unauthorized roads on the Coconino NF.
- Decommission 134 miles of unauthorized roads on the Kaibab NF.
- Restore 74 springs and construct up to 4 miles of protective fencing.
- Restore 39 miles of ephemeral channels.
- Construct up to 82 miles of protective (aspen) fencing.
- Construct up to 12 flumes and 12 weather stations and associated instrumentation (up to 3 total acres of soil disturbance) to support the paired watershed study.
- Allocate/manage as old growth 40 percent of the ponderosa pine type and 77 percent of the pinyon-juniper woodland on the Coconino NF.
- Manage and develop uneven-aged stands with a representation of old growth components across most of the project area on the Kaibab NF.

Note: Measuring canopy cover at the stand level on about 39,860 acres of goshawk habitat where there is a preponderance of VSS 4, 5 and 6 represents no change to the current Coconino NF forest plan.

Methodology and Analysis Process

This section describes the methodology and analysis processes used to determine the environmental consequences to water quality and riparian areas from implementing the alternatives. Environmental consequences are site-specific at the project planning level and will be described with qualitative and quantitative descriptions supported by past studies and observations.

Analyses for environmental consequences to water quality and riparian areas that may result from implementation of each alternative were conducted using information contained in the Terrestrial Ecosystem Survey (TES) of the Coconino National Forest (Miller et al. 1991), the TES of the Kaibab National Forest (Brewer et al. 1991), the Watershed Condition Framework, the Coconino National Forest Plan, as amended (1987), the Kaibab National Forest Land Management Plan, as amended (1988), the Revised Kaibab National Forest Land Management Plan (2014) information obtained from other CNF and KNF resource specialists, the Arizona Department of Environmental Quality (ADEQ), other agency reports, available literature, and input from KNF collaborators and cooperators. Geospatial analysis was used to quantitatively and qualitatively assess watershed, water quality, and riparian area conditions using Geographic Information Systems (GIS) data obtained from a variety of sources.

The TES of the CNF is available at the Coconino National Forest Supervisor's Office or via the internet at: http://www.fs.usda.gov/detail/coconino/landmanagement/?cid=stelprdb5331137

The TES of the KNF is available at the Kaibab National Forest Supervisor's Office or via the internet at:

http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5138598.pdf.

The TES is the result of the systematic analysis, mapping, classification and interpretation of terrestrial ecosystems, also known as terrestrial ecological units that are delineated and numbered. A TES represents the combined influences of climate, soil and vegetation, and correlates these factors with soil temperature and moisture along an environmental gradient. It is an integrated survey and hierarchical with respect to classification levels and mapping intensities. It is the only seamless mapping of vegetation and soils available across the CNF and KNF that includes field visited, validated and correlated sites with a stringent Regional and National protocol stemming from decades of work.

Effects to water quality will be assessed qualitatively by alternative by comparing predicted direct, indirect, and cumulative effects by major land disturbing activities (e.g. forest thinning, prescribed burning, ephemeral channel restoration, and spring protection and restoration, road reconstruction, temporary road construction, etc.) within the project area.

The general classification used for surface water quality by ADEQ is attaining, attaining some uses, inconclusive/not assessed, not attaining, and impaired for the identified uses. The classification designates each waterbody in one of five categories:

Category 1 Surface waters assessed as "attaining all uses." All designated uses are assessed as "attaining."

Category 2 - Surface waters assessed as "attaining some uses." Each designated use is assessed as either "attaining," "inconclusive," or "threatened."

Category 3 - Surface waters assessed as "inconclusive." All designated uses are assessed as "inconclusive" due to insufficient data to assess any designated use (e.g., insufficient samples or core parameters). By default, this category would include waters that were "not assessed" for similar reasons

Category 4 - Surface waters assessed as "not attaining." At least one designated use was assessed as "not attaining" and no uses were assessed as "impaired." A Total Maximum Daily Load[3] (TMDL) analysis will not be required at this time for one of the following reasons:

4 A. - A TMDL has already been completed and approved by EPA but the water quality standards are not yet attained;

4 B. - Other pollution control requirements are reasonably expected to result in the attainment of water quality standards by the next regularly scheduled listing cycle; or

4 C. - The impairment is not related to a "pollutant" loading but rather due to "pollution" (e.g., hydrologic modification).

Category 5 - Surface waters assessed as "impaired." At least one designated use was assessed as "impaired" by a pollutant. These waters must be prioritized for TMDL development.

Water quality is assessed by comparing existing conditions (category 1 to 5) with desired conditions that are set by Arizona under authority of the Clean Water Act. The Arizona Department of Environmental Quality (ADEQ) is the regulating authority for water quality in Arizona as promulgated by EPA. Waters that are not impaired (those not on 303d[4] list or in category 4 or 5) are providing for beneficial uses identified for that stream or water body and can be considered in a desired condition until further sampling indicates impairment. Those in category 2 or higher require special attention during site-specific project analysis. The ADEQ also interprets its surface water quality standards to apply to "intermittent, non-navigable tributaries." The ADEQ interprets the definition of "surface water" to include tributaries ("the tributary rule") and assigns water quality standards to intermittent surface waters that are not specifically listed by name in Arizona's surface water quality standards rules. ADEQ has determined it is necessary to regulate and protect these types of waters as "waters of the United States" because it is estimated that approximately 95 percent of the surface waters in Arizona are either intermittent or ephemeral.

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[3]A TMDL is a written analysis that determines the maximum amount of a pollutant that a surface water can assimilate (the "load"), and still attain water quality standards during all conditions. The TMDL allocates the loading capacity of the surface water to point sources and nonpoint sources identified in the watershed, accounting for natural background levels and seasonal variation, with an allocation set aside as a margin of safety.

[4] Under section 303(d) of the 1972 Clean Water Act, states, territories, and authorized tribes are required to develop lists of impaired waters. These impaired waters do not meet water quality standards that states, territories, and authorized tribes have set for them, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop TMDLs for these waters. (http://www.epa.gov/region9/water/tmdl/303d.html)

Effects to water yield will be discussed qualitatively, based on comparison of current activities to projected effects of implementing alternatives. Generally, reducing canopy cover in vegetation types within higher precipitation zones has been shown to generate more runoff, with the results strongly dependent upon climate, species composition, and the percentage change in vegetation density (Bosch and Hewlett 1982, Stednick 1996).

A watershed condition assessment was completed in 2011 for all sixth-level subwatersheds in the proposed project area as part of a Forest-level assessment of watershed condition (Potyondy and Geier, 2010) for each Forest. Watershed condition was classified using a core set of national watershed condition indicators that were updated with local data and interpreted by Forest interdisciplinary (ID) teams. These indicators are grouped according to four major ecosystem process categories: (1) aquatic physical; (2) aquatic biological; (3) terrestrial physical; and (4) terrestrial biological. These categories represent terrestrial, riparian, and riverine ecosystem processes or mechanisms by which management actions can affect the condition of watersheds and associated resources. Each indicator was evaluated using a defined set of attributes whereby each attribute was scored by the Forest interdisciplinary team as GOOD (1), FAIR (2), or POOR (3) using written criteria, rule sets, the best available data, and professional judgment.

Twelve core watershed condition indicators were evaluated for all sixth-level HUCs. Aquatic physical indicators included: 1) water quality condition, 2) water quantity (flow regime) condition, and 3) stream and habitat condition. Aquatic biological indicators included: 4) aquatic biota condition and 5) riparian vegetation condition. Terrestrial physical indicators included: 6) road and trail condition, and 7) soil condition. Terrestrial biological indicators included: 8) fire effect and regime condition, 9) forest cover condition, 10) rangeland, grassland and open area condition, 11) terrestrial non-native invasive species condition, and 12) forest health condition.

Attribute scores for each indicator were summed and normalized to produce an overall indicator score. The indicator scores for each ecosystem process category were then averaged to arrive at an overall category score. The Watershed Condition scores were tracked to one decimal point and reported as Watershed Condition Classes 1, 2, or 3. Class 1 = scores of 1.0 to 1.7; Class 2 = scores >1.8 and <2.3, and Class 3 = scores from 2.4 to 3.0. Class 1 watersheds are functioning properly. Class 2 watersheds are functional – at risk, and Class 3 watersheds have impaired function. Refer to the Soils and Watershed Specialist’s Report (Steinke, 2014) for watershed acreages and condition ratings within the Four Forest Restoration Initiative project area.

Issues

Issues 1 to 4 were edited to reflect public comments on the DEIS related to canopy cover, post-treatment openness and the conservation of old and large trees. In summary, this final environmental impact statement responds to four issues and evaluates five alternatives: the no action alternative (alternative A) required by the regulations, the proposed action (alternative B), and three alternatives (alternative C-E) to provide sharp contrast and comparison to the proposed action.

Two procedural concerns related to the range of alternatives and plan amendments were added to chapter 1 to highlight concerns raised by the public. Public concerns that are routine disclosures (see chapter 3) were not considered to be issues. For example, consultation with the U.S. Fish and Wildlife Service on endangered species is a requirement. Therefore, comments that stated consultation needed to occur were not considered a key issue. Appendix I of the FEIS provides a summary of comments as well as individual responses to comments received on the DEIS. Many public comments submitted during the scoping period suggested alternatives that were either considered in detail or eliminated from detailed analysis (see chapter 2).

Issue 1: Prescribed Fire Emissions

This issue relates to the emissions from prescribed fire activities and the impact on air and water quality, public health, quality of life, and the economy of northern Arizona. In response to comments on the DEIS, emissions include, but are not limited to, radionuclide particles and mercury.

An alternative that would eliminate all prescribed fire was considered but eliminated from detailed study as it did not adequately meet the purpose and need for restoring the fire-adapted southwestern ponderosa pine ecosystem. Alternatives B, C, and E propose using prescribed fire across the entire project area and alternative C adds acres on which prescribed fire would be used to restore additional acres of grasslands. Alternative D was developed to respond to the emissions/smoke issue by decreasing the acres proposed for prescribed fire by 69 percent (when compared to alternative B). This equates to removing fire on about 404, 889 acres. All action alternatives include design criteria aimed at reducing impacts to air quality (as practicable) and increasing coordination efforts amongst neighboring forests.

Issue 2: Conservation of Large Trees

This issue focuses on the conservation of large trees and the inclusion of the large tree retention strategy (LTRS), which was developed by the 4FRI stakeholders, into the action alternatives. Large post-settlement trees, as defined by a socio-political process, are those greater than 16-inch d.b.h.

Commenters stated alternatives B (proposed action alternative) and D do not incorporate the LTRS. Alternative C and E respond to this issue by incorporating key components of the LTRS and focusing on ecological desired conditions. In response, an implementation plan that is integral to all action alternatives was developed. The plan identifies ecological conditions where large, post-settlement trees may be removed in order to move towards or meet desired conditions. The intent of the LTRS has been incorporated into the alternative’s design criteria, the monitoring and adaptive management plan, and the project implementation plan. All resource reports have analyzed and disclosed how the modified LTRS (the Large Tree Implementation Plan) has been addressed in the environmental consequences section of the FEIS.

Issue 3: Post-treatment Canopy Cover and Landscape Openness

This issue focuses on retaining closed canopy conditions for species including, but not limited to, goshawk and Mexican spotted owl. Commenters stated measuring canopy cover in goshawk habitat at the group level would not meet forest plan stand- scale canopy requirements. Commenters stated a reduction in canopy and large tree densities have never been analyzed under the National Environmental Policy Act and National Forest Management Act and could have deleterious effects to goshawk, its prey species, and those wildlife species that are dependent on that cover. Because natural openings would no longer be included within the vegetation structural stages (VSS) classification, it would result in significantly more lands being in an open condition or outside of the VSS 4 to 6 classifications. This could substantially increase the logging of mature and old trees and negatively affect wildlife, including goshawk and its prey species.

Action alternatives B through E are designed to provide closed canopy conditions and comply with the forest plans. The vegetation analysis addresses the inter-relationship between canopy cover and old and large trees. To address post-treatment openness and canopy cover, a nonsignificant forest plan amendment for the Coconino NF was developed for alternatives B, C, and D. Alternative E does not propose a forest plan amendment.

Issue 4: Increased Restoration and Research

This issue focuses on recommendations to increase the acres and type of restoration treatments. Commenters recommended including additional acres of grassland restoration. The FWS recommended increasing prescribed fire and mechanical treatments within Mexican spotted owl habitat (to improve the quality of the habitat and be in alignment with the revised Mexican Spotted Owl Recovery Plan (USDI FWS 2012)). Commenters recommended including a paired watershed study and small mammal research to evaluate the impact of landscape-scale restoration. Alternative C was developed to respond to this issue.

Issues specific to water quality and riparian areas include:

- Potential for sediment delivery and contamination of streams, wetlands, riparian areas, and lakes.
- Soil erosion above tolerance thresholds.
- Road maintenance and obliteration could increase surface runoff, erosion, and sediment delivery to ephemeral drainages.
- The amount of sediment that reaches ephemeral streams or intermittent streams could increase.
- Changes to channel morphology as a consequence of increased flows caused by removal of upland vegetation resulting in increased stormwater runoff.
- Changes to stream temperatures as a result of increased warm water runoff from upland sources and changes to channel morphology that alter diurnal fluctuations of water temperature.
- The amount of sediment, debris, and ash that is introduced to water bodies that serve as municipal water supplies could adversely affect the quality of water entering the public water supply system.
- Cumulative effects to water quality and riparian areas, when combined with past, present, and reasonably foreseeable future actions could be significant.
- Retention of adequate coarse woody debris, including large logs, necessary to protect soil surfaces from erosion and provide wildlife habitat components for soil micro and macro-fauna.

Water Quality and Riparian Resources Condition Indicators

Units of Measure

For water quality and riparian areas, the units of measure of effects to these resources will be the amount of acres of soil disturbance that exceeds tolerance thresholds, the amount of acres subjected to high severity fire (estimated by Steinke (2014) and Lata (2014) to be less than 10 percent, and usually less than 5 percent of prescribed fire treatment areas), changes to the extents of riparian areas and changes to riparian vegetative communities, acres of ephemeral streamcourses that are restored, the number of springs that are restored, miles of permanent roads reconstructed, and miles of permanent and temporary roads decommissioned. Most adverse effects to water quality and riparian areas would be minimized or mitigated through implementation of design features, Best Management Practices (BMPs), and mitigation measures as outlined in Soil and Watershed Conservation Practices Handbook (Forest Service Handbook 2509.22)(USDA 1990) and site-specific BMPs included in Table 1.

For water quality measures, no physical stream measurements would be taken to determine water quality. A narrative description will explain the effects to water quality by Alternatives.

Desired Conditions

Water Quality and Quantity

Water quality is sustained at a level that retains the biological, physical, and chemical integrity of the aquatic systems and benefits survival, growth, reproduction, and migration of native aquatic and riparian species.

Water quality meets or surpasses State of Arizona or Environmental Protection Agency water quality standards for designated uses. Water quality meets critical needs of aquatic species.

Adequate quantity and timing of water flows are maintained to retain or enhance ecological functions, including aquatic species and riparian vegetation consistent with existing water rights and claims.

Ephemeral, intermittent, and perennial waters flow in natural patterns and at natural rates, have favorable flood plains, transport bedload adequately, and maintain longer sustained base flows on the landscape, rather than extreme peak flows. This will reduce flood potential.

Instream water rights are maintained or procured so that a minimum sufficient amount of water is guaranteed over time to ensure that long-term wildlife habitat is provided and Forest’s needs are met.

Channel downcutting is minimized and elevated water tables are maintained.

Springs

Springs and associated wetlands have the necessary soil, water, and vegetation attributes to be healthy and functioning. Water levels, flow patterns, groundwater recharge rates, and geochemistry are similar to reference conditions. Springs, streams, and ponds have appropriate plant cover to protect banks and shorelines from excessive erosion.

Spring water quality and quantity maintain native aquatic and riparian habitats and water for wildlife and designated beneficial uses, consistent with water rights and site capability.

Water rights are maintained or procured to protect in situ (on site) water quality and quantity necessary for maintaining riparian vegetation, fish and wildlife, and domestic livestock grazing use.

Native vegetation around springs exhibit diverse age classes, diverse composition of native species, and include species that indicate maintenance of riparian soil moisture characteristics (e.g., sedges, rushes, willows and other riparian vegetation), consistent with the type of spring. Vegetation association with springs is variable depending on spring type and can include aquatic plants (e.g., diatoms and algae), submergent and floating vegetation, emergent vegetation, grasses, forbs, sedges, shrubs and deciduous trees.

Plant cover protects the banks, edges, and shorelines of springs. Plant distribution and occurrence are resilient to natural disturbances.

Soil condition is satisfactory on most acres with only minor components in unsatisfactory or impaired conditions. Soil function (i.e., the ability of soil to infiltrate water, recycle nutrients, and resist erosion) is sustained.

Spring riparian zones are capable of filtering sediment, capturing and/or transporting bedload, improving or maintaining water quality and providing ground water recharge within their natural potential. Forestwide Management, Coconino National Forest Draft Land Management Plan, February 2011.

Springs are resilient to natural disturbances and changing climate conditions and are functioning across the landscape within their type and capability. They are in proper functioning condition as determined by on-site assessment by Forest interdisciplinary teams.

Stream and spring ecosystems are not fragmented by infrastructure or development, consistent with existing water rights and claims. Springs are undeveloped and unaltered by man-made structures such as head boxes, cisterns, and pipelines, consistent with existing water rights and claims.

The physical and biological components provide habitat for a diverse community of plant and wildlife species including cover, forage, available water, microclimate, and nesting/breeding habitat. Riparian dependent plant and animal (including invertebrates) species are abundant and diverse consistent with site capability and water rights. Aquatic and riparian habitats and native species are free of or minimally impacted by invasive exotic plant and animal species.

Riparian Areas

Riparian areas and stream channels are functioning properly or show a trend towards an improving condition where sufficient native vegetation, landforms, soil condition, and woody debris are present to:

- Dissipate water energy, thereby reducing erosion and improving water quality;
- Filter sediment, capture bedload, and contribute to favorable floodplain development;
- Improve flood water retention and ground water recharge;
- Develop fine root biomass that stabilizes ephemeral stream banks against scour, slumping, and erosion;
- Develop diverse ponding characteristics to provide habitat and water depth, duration, and temperature necessary for aquatic/amphibian habitat, waterfowl breeding, and other uses

Where practicable, return springs to their *natural spheres of discharge* (Springer and Stevens 2008). Thinning of dense ponderosa pine stands has potential to increase groundwater recharge. Exclosure fencing and controlling human ingress and egress, where warranted, would prevent adverse impacts from vertebrate herbivores and human visitation. Ensuring flow from spring sources is desired, except where otherwise prescribed by adjudicated water rights.

Roads

Only those roads identified as necessary for the management of the Forests and that provide for recreation needs are retained. Maintenance Level 1 roads are stabilized using BMPs and SWCPs and do not contribute sediment to stream channels. User created and unneeded roads have been obliterated.

Vegetation Condition Class

Vegetation Condition Class is returned to Class 1 where possible, which is an indicator for returning ecological functions to approximate historic conditions in the ponderosa pine vegetation type. This condition is characterized by a more open overstory, improved herbaceous understory, and is maintained by more frequent low severity fires rather than through mechanical means.

Watershed and Soil Condition

Current Forest Plans for both the Kaibab and the Coconino National Forests outline the need to maintain or improve soil productivity and watershed condition. Both forests have guidelines to improve soil productivity and watershed condition to satisfactory conditions by 2020. Each Forest Plan includes a management emphasis to improve or enhance unsatisfactory soils and watershed conditions.

Resource Protection Measures

Resource protection measures listed below include references to standard SWCPs and BMP's found in the Soil and Watershed Conservation Practices Handbook (USDA, 1990) and the National Core BMP Technical Guide (FS-990a, 2012), and contract clauses found in Timber Sale Contracts (TSCs). Resource protection measures are implemented to minimize nonpoint source pollution as outlined in Memorandum of Understanding Between the State of Arizona Department of Environmental Quality and the USDA Forest Service Southwest Region (ADEQ, 2013). Note that no resource protection measures are required for the No Action Alternative since no ground disturbance would occur. Table 1 provides a summary of soil and watershed protection measures for the Four Forest Restoration Initiative project area.

Table 1. Resource Protection Measures Required for All Action Alternatives.

BMP #	Mitigation	Objective
BMP's Common To All Activities		
BMP #1	Implement Best Management Practices prior to project implementation.	To minimize impacts to soil and water resources from project implementation, to minimize non-point source pollution, to adhere to the Clean Water Act, and to adhere to the intergovernmental agreement between Region 3 of the Forest Service and the Arizona Department of Environmental Quality.
BMP #2	Minimize mechanical operations when ground conditions are such that soil compaction can occur. All activities should be limited/restricted to when soils are dry or frozen. If compaction occurs, mitigate through ripping, seeding and covering compacted areas with slash.	To minimize soil compaction, soil detachment and sediment transport. To maintain long-term soil productivity.
BMP #3	All fueling of vehicles will be done on a designated protected, upland site. If more than 1320 of gallons of petroleum products are to be stored on site above ground or if a single container exceeds 660 gallons, then a spill prevention control and countermeasures plan (SPCC) will be prepared as per 40 CFR 112).	To prevent contamination of waters from accidental spills.
BMP #4	The following applies to any personnel implementing ground-disturbing actions: Prior to moving off-road equipment onto a project area, contractor shall identify the location of the equipment's most recent operation. Contractor shall not move any off-road equipment that last operated in an area infested with one or more invasive species of concern onto sale area without having cleaned such equipment of seeds, soil, vegetative matter, and other debris that could contain or hold seeds, and having notified Forest Service, as	To minimize the spread of non-native species

BMP #	Mitigation	Objective
	provided in (iii). If the location of prior operation cannot be identified, then contractor shall assume that the location is infested with invasive species of concern. If the contractor has worked in areas where potential chytrid fungus could occur, contractor shall assume chytrid fungus is present and must disinfect equipment prior to work adjacent to water bodies. (i – intentionally omitted) (ii) Prior to moving Off-road equipment from a cutting unit or cutting area that is shown on contract area or sale area map to be infested with invasive species of concern to, or through any other area that is shown as being free of invasive species of concern, or infested with a different invasive species, contractor shall clean such equipment of seeds, soil, vegetative matter, and other debris that could contain or hold seeds and/or disinfect as necessary, and shall notify the Forest Service, as provided in (iii). (iii) Prior to moving any off-road equipment subject to the cleaning and disinfecting requirements set forth above, contractor, shall advise Forest Service of its cleaning measures and make the equipment available for inspection. Forest Service shall have 2 days, excluding weekends and Federal holidays, to inspect equipment after it has been made available. After satisfactory inspection or after such 2 day period, contractor may move the equipment as planned. Equipment shall be considered clean when a visual inspection does not disclose seeds, soil, vegetative matter, and other debris that could contain or hold seeds. Contractor shall not be required to disassemble equipment unless so directed by the Forest Service after inspection. (iv) If contractor desires to clean off-road equipment on National Forest land, such as at the end of a project or prior to moving to, or through an area that is free of invasive species of concern, contractor shall obtain prior approval from contracting officer as to the location for such cleaning and measures, if any, for controlling impacts.	
BMP #5	If construction crews are to live on-site, then an approved camp and suitable sanitation facilities must be provided.	To protect surface and subsurface water from unacceptable levels of bacteria, nutrients and chemical pollutants.
Prescribed burning		
BMP #6	On areas to be prescribed burned, fire prescriptions should be designed to minimize soil temperatures over the entire area. High severity fire should occur on 10 percent or less of the entire area. Fire prescriptions should be designed so that soil and fuel moisture temperatures are such that fire severity is minimized and soil health and productivity are maintained. If containment lines are put in place, rehabilitate lines after use by either rolling berm back over the entire fireline, spreading slash across the fireline or waterbar the fireline. If line is only to be waterbarred, disguise the first 400 feet of line to discourage use as a trail.	To maintain long-term soil productivity and minimize sediment delivery from containment lines.

BMP #	Mitigation	Objective
BMP #7	On areas to be prescribed burned, manage for 5-7 tons/acre of coarse woody debris in ponderosa pine be left on-site after the prescribed burns to maintain long-term soil productivity on areas to be burned except in areas of identified WUI treatments. Within the pinyon-juniper cover type, snags would be managed for 1 per acre over 75 percent of the area and coarse woody debris (CWD) would be managed for an after treatment average of 1 to 3 tons per acre. Where available, a portion of the CWD would include two logs ≥10 inches and ≥10 feet in length.	To maintain long-term soil productivity.
BMP #8	On areas to be prescribed burned, establish filter strips (also known as streamside management zones. These stream reaches will be designated as protected streamcourse The following are recommendations to protect streamcourses. **Riparian streamcourse:** Severe erosion hazard: 120 feet on each side of streamcourse. Moderate erosion hazard: 100 feet on each side of streamcourse. Slight erosion hazard: 70 feet on each side of streamcourse. **Non-riparian streamcourse:** Severe erosion hazard: 100 feet on each side of streamcourse. Moderate erosion hazard: 70 feet on each side of streamcourse. Slight erosion hazard: 35 feet on each side of streamcourse. Do not ignite fuels within this buffer area. Some creep may occur into the buffer.	To minimize sediment and/or ash delivery into drainages and maintain water quality.
BMP #9	Intentionally left blank.	
BMP #10	All burning will be coordinated daily with the Arizona Department of Environmental Quality (ADEQ). Burning will not take place on any portion of the project without prior approval from ADEQ. Coordination with ADEQ will take place through the Kaibab and Coconino National Forest Zone Dispatch Center and the Prescribed Burning Boss.	To ensure that smoke management objectives are met.
Road Reconstruction and Channel Restoration		
BMP #11	Complete all required permitting (404 permits) and Water Quality Certification (if necessary), prior to project implementation.	To comply with Clean Water Act provisions.
BMP #12	Site rehabilitation on upland sites for stream channel, road reconstruction, and temporary road construction projects where ground disturbance occurs: Seed at 5 pounds/acre with native, certified weed free seed mix. Potential vegetation for individual sites should utilize the Kaibab and Coconino National Forest Terrestrial Ecosystem Survey to identify species to be utilized. Where feasible, protect site with slash spread across the disturbed area to create microclimates and protect from grazing ungulates.	To minimize soil erosion and minimize noxious weed spread and mitigate severe erosion hazard.

BMP #	Mitigation	Objective
BMP #13	Site rehabilitation on riparian sites for stream channel and road reconstruction projects where ground disturbance occurs: Seed at 5 pounds/acre with certified weed free native seed mix to rehabilitate the site and minimize impacts of noxious weeds. Potential vegetation for individual sites should utilize the Kaibab and Coconino National Forest Terrestrial Ecosystem Survey to identify species to be utilized. Where feasible, protect site with a variety of methods (e.g., ungulate proof fence, spreading slash etc.).	To comply with State and Federal water quality standards by minimizing soil erosion through the stabilizing influence of vegetation ground cover. Minimize noxious weed spread.
BMP #14	Install silt fences and/or waddles downstream from ground-disturbing activities in stream channels to minimize the chance of sediment being lost downstream during construction and until revegetation is completed.	To comply with State and Federal water quality standards by minimizing sediment delivery to drainages.
BMP #15	Provide site protection on newly disturbed soils (e.g. hydromulch, erosion mat, spread slash etc.) in channel restoration, road reconstruction, and temporary road construction sites on all sites as needed and where feasible.	To comply with State and Federal water quality standards by minimizing sediment delivery to drainages, minimize impacts on severe erosion hazard soils, and to create microclimate for regeneration of grass/forb community and minimize noxious weed spread.
BMP #16	Bring rock material from a local upland site to any headcut drop structures that may be installed in channel restoration projects.	To minimize disturbance in drainage systems and minimize sediment production within channel.
BMP #17	Site rehabilitation on disturbed sites at and stream channel shaping on previously obliterated roads: Site rehabilitation consists of several revegetation methods, such as, but not limited to: 1) Store sod removed from the initial ground disturbance and replace the sod from the top of the bank on the disturbed site; 2) Seed with a native seed mix (see BMP's above) 3) Protect site with slash spread across the disturbed area to create microclimates and protect from grazing ungulates. Slash placement will be limited to the upper 2/3 of the bank to limit transport downstream of woody material; 4) Fence out ungulates for 1 to 2 years (or until the site has re-established); 5) consider mycorhizal inoculum on severely disturbed sites where no topsoil is left, and, 6) install erosion mat.	To comply with State and Federal water quality standards by minimizing soil erosion through the stabilizing influence of vegetation ground cover. Minimize noxious weed spread.
BMP #18	Do not borrow road fill or embankment materials from the stream channel or meadow surface on road maintenance projects. End-load all material hauled on-site and compact fill.	To minimize disturbance in drainage systems and minimize sediment production within channel.
BMP #19	Where feasible, relocate roads out of filter strips into an upland position. If this is not feasible, use riprap or velocity checks to stabilize or disperse outfall on road maintenance projects when roads are located within filter strips. New temporary roads will be located in upland positions out of filter strips. Do not construct new temporary roads in filter	To minimize sediment delivery into drainages, to minimize disturbance in drainage systems and minimize sediment

BMP #	Mitigation	Objective
	strips.	production within channel.
BMP #20	At riparian stream reach restoration sites, restore riparian dependent grasses through 1) seeding of native species, 2) planting plugs of rushes, sedges, and spike rushes to improve success of regeneration efforts. Fence with ungulate proof fencing for 1 to 2 years (or until plants are established) if grazing is inhibiting regeneration efforts.	To comply with State and Federal water quality standards by minimizing soil erosion through stabilization of ground cover. Minimize noxious weed spread.
BMP #21	On areas that have had roads previously obliterated and the remaining roadbed will be removed, add slash/or erosion mat and seed to the disturbed areas. Temporary roads will be decommissioned immediately after use.	To add surface roughness and to comply with State and Federal water quality standards by minimizing soil erosion through stabilization of ground cover and to diminish the impact of the first rain event and to speed recovery of the site.
BMP #22	As a condition of approval for use of a temporary road within a Timber Sale Contract or Stewardship Contract, temporary roads will be decommissioned by the purchaser/contractor immediately after use using the adaptive management actions listed in Appendix A of the Transportation Specialist Report and BMP's for rehabilitation of ground disturbed sites in the soils design feature section.	To restore to desired conditions and ensure that temporary roads do not become de facto new roads.
BMP #23	Do not allow or approve new temporary road construction in filter strips. If feasible, avoid new temporary road locations in severe erosion hazard soils. If necessary to have a temporary road on severe erosion hazard soils, utilize BMP's outlined in the Soil and Water section to avoid affects from severe erosion hazard soils.	To minimize adverse environmental effects within stream filter strips and on severe erosion hazard soils.
Springs and seeps		
BMP #24	At spring restoration sites, restore riparian dependent species through 1) seeding of native species, 2) planting plugs/cuttings of native plants to improve success of regeneration efforts. Fence with ungulate proof fencing for 1 to 2 years (or until plants are established) if grazing is inhibiting regeneration efforts.	To comply with State and Federal water quality standards by minimizing soil erosion through stabilization of ground cover. Minimize noxious weed spread.
Harvesting operations		
BMP #25	Do not blade roads when the road surface is too dry. If the road surface is too dry, a water truck can apply water, or the project can be scheduled for when adequate moisture occurs to complete the project.	To minimize sediment detachment and to minimize impacts on .severe erosion soils
BMP #26	In grassland restoration sites, limit skidding and designate skid trails if wood is to be removed. Where material is not to be removed, do not skid logs in meadows and lop and scatter is the preferred method of treating slash. Do not machine pile within meadows. If	To minimize impacts to streams and soils in meadows from tree harvesting operations.

BMP #	Mitigation	Objective
	skidding has to occur across a riparian or non-riparian streamcourse, designate any crossing prior to skidding.	
BMP #27	Skid trails and obliterated roads will have slash placed on the trail or cross-ditched (waterbarred) to break the energy flow of water. Placing slash on skid trails is the preferred method to dissipate the energy flow of water. Waterbars are only to be implemented with equipment with an articulating blade (no skidders) or by hand.	To minimize soil erosion and maintain soil productivity. and to minimize impacts on .severe erosion soils
BMP #28	Landing locations will be in upland positions and out of meadows, riparian and non-riparian filter strips.	To minimize sediment delivery into drainage. and to minimize impacts on .severe erosion soils
BMP #29	Mechanical harvest or mechanical fuel treatment are only allowed on Cinder Cones greater than 25 percent slope with designated skid trails and slash mats placed on the skid trails. On other sites, mechanized harvesting can occur up to 40 percent slopes.	To maintain long-term soil productivity on slopes with severe erosion hazard potential
BMP #30	Designated skid trails and log landings will be required within the Integrated Resource Service Contract (BMP 24.18 in FSH 2509.22) on all cutting units. Skid trail design should not have long, straight skid trails that would direct water flow. Skid trails should also be located out of filter strips (exceptions are at approved crossings).	To minimize the number of acres disturbed and to minimize impacts on .severe erosion soils.
BMP #31	Felling to the lead will be required within the Integrated Resource Service Contract (IRSC) to minimize ground disturbance from skidding operations (**BMP 24.18**).	Felling of timber should be done to minimize ground disturbance from skidding operations and to minimize impacts on .severe erosion soils.
BMP #32	The IRSC outlines the timing and application of erosion control methods to minimize soil loss and sedimentation of streamcourses. Seed mix can include any of the following certified weed free native species at a minimum of 5 lbs./acre pure live seed: Potential vegetation for individual sites should utilize the Kaibab and Coconino National Forest Terrestrial Ecosystem Survey to identify species to be utilized. Corresponding BMP's from FSH 2509.22 to minimize soil loss and sedimentation of include 24.13, 24.21, 24.22, 24.23, 24.24, and 24.25. The preferred erosion control method on the skid trails in the harvest areas will be by spreading slash. Other acceptable erosion control measures include, but are not limited to, waterbarring (waterbars should not be more than two feet deep and need at least a ten foot leadout. Waterbars are only to be implemented with equipment with an articulating blade (no skidders) or by hand.), removing berms, seeding, mulching and cross-ripping. Erosion control after skidding operations must be timely to minimize the effects of log skidding.	Minimize soil loss and sedimentation of streamcourses from skidding operations and to minimize noxious weed spread and re-establish native vegetation and to minimize impacts on .severe erosion soils
BMP #33	Road drainage is controlled by a variety of methods (BMP 41.14), including rolling the grade, insloping outsloping, crowning, water spreading ditches, and contour trenching. Sediment loads at drainage structures can be reduced by installing sediment filters, rock and vegetative energy dissipaters, and settling ponds. Design of roads is included in the	To minimize soil movement and maintain water quality and to minimize impacts on .severe erosion soils.

BMP #	Mitigation	Objective
	transportation plan of the IRSC and T-specs.	
BMP #34	Road maintenance (BMP 41.25) through the IRSC should require prehaul and post haul maintenance on all roads to be used for haul.	To minimize soil movement and maintain water quality. and to minimize impacts on severe erosion soils.
BMP #35	The designation of filter strips (also known as streamside management zones) minimizes on-site soil movement from timber harvest activities along streamcourses (BMP 24.16). These stream reaches will be designated as protected streamcourses. Locations of protected streamcourses are included in the individual Task Order Maps and will be designated with a protected streamcourse designation. The following are recommendations to protect streamcourses within the proposed tree harvest units in relation to riparian and non-riparian streamcourses. The guidelines for filter strip designation are as follows: **Riparian streamcourse:** Severe erosion hazard: 120 feet on each side of streamcourse. Moderate erosion hazard: 100 feet on each side of streamcourse. Slight erosion hazard: 70 feet on each side of streamcourse. **Non-riparian streamcourse:** Severe erosion hazard: 100 feet on each side of streamcourse. Moderate erosion hazard: 70 feet on each side of streamcourse. Slight erosion hazard: 35 feet on each side of streamcourse. Accepted harvest activities within riparian and non-riparian filter strips include mechanical and conventional tree felling and limited skidding on designated skid trails and not across streamcourses. Landings, decking areas, machine piles, and roads (except at designated crossings) are planned outside of riparian and non-riparian filter strips.	Filtering sediment and/or providing bank stability on all streamcourses and to minimize impacts on .severe erosion soils To implement the Oak Creek *E. Coli* TMDL and Lake Mary Region Mercury TMDL and to filter sediment and/or provide bank stability.
BMP #36	Intentionally left blank.	
BMP #37	Manage for 5 to 7 tons (forest plan consistency) per acre of coarse woody debris in ponderosa pine sites that will be left on-site on all cutting unit sites except in areas of identified WUI treatments. Within the pinyon-juniper cover type maintain the following where possible: 1 snag per acre and 1 to 3 tons of coarse woody debris (CWD) per acre (specialist recommendation). Where available, a portion of the CWD would include two logs ≥10 inches and ≥10 feet in length (specialist recommendation).	To promote long-term soil productivity.
BMP #38	Mechanical crushing of lopped slash can only occur on 0-25 percent slopes.	To incorporate slash into the soil to promote long-term soil productivity.

BMP #	Mitigation	Objective
BMP #39	Identify landings, staging area for heavy equipment and sites for any in woods processing sites outside of filter strips and meadows. Sites will be rehabilitated after use by methods such as, but not limited to: 1) ripping to remove compaction, 2) seeding with certified weed free native seed to 5 lbs per acre. Potential vegetation for individual sites should utilize the Kaibab and Coconino National Forest Terrestrial Ecosystem Survey to identify species to be utilized; and, 3) spreading of slash to disguise the site and provide for a mulch for seeds.	To minimize and mitigate impacts from activities that compact sites and to restore long-term soil productivity and to minimize impacts on .severe erosion soils.
BMP #40	Within the pinyon-juniper cover type, snags would be managed for 1 per acre over 75 percent of the area and coarse woody debris (CWD) would be managed for an after treatment average of 1 to 3 tons per acre. Where available, a portion of the CWD would include two logs ≥10 inches and ≥10 feet in length (Huffman per. Com from Brewer, 2008).	To promote long-term soil productivity.
BMP #41	Provide soil and site protection on newly disturbed soils located on temporary roads on soils with severe erosion hazard as needed. Avoid locating temporary roads on soils with severe erosion hazard. Where unavoidable, provide soil protection through implementation of any of the following methods to control sediment and protect water quality. Methods may include, but are not limited to: wattling, hydromulching, straw or woodshred mulching, spread slash, erosion mats, terraces, blankets, mats, silt fences, riprapping, tackifiers, soil seals, seeding and side drains, and appropriately spaced water bars or water spreading drainage features. Temporary roads will be decommissioned and footprint obliterated and protected with any of the above methods.	To protect long-term soil productivity and water quality
BMP #42	Defer mechanical thinning and prescribed fire activities in the Slide Fire until 5 years after the signed decision at the earliest.	To minimize impacts to Oak Creek (Arizona Unique Water) from sediment. This BMP will allow for adequate post-fire recovery of soil and vegetation resources and minimize the cumulative effects from the fire.
BMP #43	Defer mechanical thinning and prescribed fire activities within the Slide Fire perimeter until adequate vegetative ground cover (plant litter, duff and basal area) is present (minimum of about 60% in ponderosa pine vegetation types) to filter and reduce sediment delivery into streamcourse.	To minimize impacts to the water quality of West Fork of Oak Creek and Oak Creek (Arizona Unique Water) from sediment. The BMP will assure streamside management zone is capable of filtering into connected perennial waters downstream.

Coconino and Kaibab National Forests Land Management Plan Direction

The Coconino NF and Kaibab NF forest plans set forth in detail the direction for managing the land and resources of the forests. The desired conditions for the project are based on forest plan objectives, goals, standards, and guidelines. This analysis tiers to the Coconino NF Final EIS (USDA 1987) for the forest plan as encouraged by 40 CFR 1502.20. This analysis also tiers to the Final EIS for the Kaibab National Forest Land and Resource Management (USDA 2014) and the revised Land and Resource Management Plan for the Kaibab National Forest (2014).

Table 2 summarizes the Forest-wide acreages for each Management Area (MA) of the Coconino National Forest and associated acreages within the Four Forest Restoration Initiative project area.

Table 2. Management Areas (MA) of the Coconino National Forest and Ecosystem Management Areas (EMA) of the Kaibab National Forest and their associated forest and project area acreages and Forest Plan emphasis.

CNF Forest Plan Management Areas (MA) and KNF Ecosystem Management Areas (EMA) within the project area	Description	Forest Plan Emphasis	Forest-wide MA and EMA acres	MA and EMA acres within project area
		Coconino National Forest		
MA 3	Ponderosa pine and mixed conifer on less than 40% slope	Sustained yield of timber and firewood, wildlife habitat, grazing, high quality water, dispersed recreation	511,015	236,245
MA 35	Lake Mary Watershed	Maintenance and/or improvement of soil condition and watershed function, reduced fire risk in urban/rural influence zone	62,536	59,301
MA 38	West	Reduced fire risk in urban/rural influence zone, recreation, scenic quality	36,298	36,134
MA 33	Doney	Reduced fire risk in urban/rural influence zone, recreation, grasslands, scenic quality	40,530	25,779
MA 36	Schultz	Reduce wildfire risk, maintain watershed health and water quality	21,289	21,130
MA 37	Walnut Canyon	Reduce fire risk in urban/rural interface zone, progress towards desired forest structure including MSO and goshawk habitats	20,566	18,030

CNF Forest Plan Management Areas (MA) and KNF Ecosystem Management Areas (EMA) within the project area	Description	Forest Plan Emphasis	Forest-wide MA and EMA acres	MA and EMA acres within project area
MA 13	Cinder Hills	OHV recreation opportunities and amenities, scenic integrity, geologic features	13,711	13,732
MA 6	Unproductive timber lands	Wildlife habitat, watershed condition, grazing	67,146	12,115
MA 4	Ponderosa pine and MC above 40%	Wildlife habitat, watershed condition, and dispersed recreation	46,382	11,793
MA 32	Deadman Wash	Grasslands, un-roaded landscape, grazing, hunting	58,133	11,659
MA 31	Craters	Restore natural grasslands, re-establish or maintain fire in pinyon-juniper woodland	29,940	8,969
MA 10	Transition Grassland/Sparse PJ above Mogollon Rim	Range management, watershed condition, and wildlife habitat	160,494	8,544
MA 9	Mountain Grasslands	Livestock grazing, visual quality, wildlife habitat	9,049	7,102
MA 20	Highway 180 Corridor	Scenic attraction, access to year-round recreation and Grand Canyon NP	7,608	6,213
MA 7	PJ Woodlands < 40%	Firewood production, watershed condition, wildlife habitat, grazing	273,815	3,206
MA 5	Aspen	Wildlife habitat, visual quality, sustain yield of firewood production, watershed condition, dispersed recreation	3,450	2,761
MA 28	Schnebly Rim	Seasonal gateway, conserve winter range for deer, elk, turkey	5,090	2,455
MA 34	Flagstaff	Reduce risk of catastrophic wildfire, recreation, scenic quality	1,781	1,675
MA 18	Elden	Visual resource management, watershed	1,577	1,611

CNF Forest Plan Management Areas (MA) and KNF Ecosystem Management Areas (EMA) within the project area	Description	Forest Plan Emphasis	Forest-wide MA and EMA acres	MA and EMA acres within project area
	Environmental Study Area	condition, manage for low fire potential with fire re-established		
MA 12	Riparian and Open Water	Wildlife habitat, visual quality, fish habitat, watershed condition on the wetlands, riparian forest, and riparian scrub, dispersed recreation on the open water portions	20,490	653
MA 7	PJ Woodlands > 40 %	Firewood production, watershed condition, wildlife habitat, and livestock grazing	273,815	451
MA 15	Developed Recreation Sites	Developed recreation	874	805
MA 14	Oak Creek Canyon	Scenery, recreation, wildlife habitat, healthy streams, clean air and water, manage fire hazards and risk	5,388	7
Kaibab National Forest				
Kendrick Mountain Wilderness	Designated Wilderness	Manage for natural processes	6,660	6,660
Arizona Bugbane Botanical Area	Designated Area	AZ bugbane habitat protection	490	490
Wildland Urban Interface (WUI)	Areas surrounding human development	Wildland fires are low intensity surface fires	389,720	117,272
Grand Canyon Game Preserve	Game preserve	Range of habitats and desired nonnative wildlife species, including predators	612,736	2,395
Developed Recreation Sites	Recreation sites, trailheads,	Developed Recreation	1,556	1,556
Bill Williams Mountain	Multiple uses	High natural, cultural and economic value	17,745	17,745
Garland Prairie	Former proposed research natural area	serves as reference for study of ecological changes	340	340

CNF Forest Plan Management Areas (MA) and KNF Ecosystem Management Areas (EMA) within the project area	Description	Forest Plan Emphasis	Forest-wide MA and EMA acres	MA and EMA acres within project area
Arizona National Scenic Trail	Non-motorized scenic trail		90 Miles	19 miles
Kendrick Mountain Wilderness	Designated Wilderness	Manage for natural processes	6,660	6,660

Consistency with the Revised Kaibab National Forest Land and Resource Management Plan

The Revised Kaibab National Forest Land and Resource Management Plan (Revised KNF LRMP) became effective on April 6, 2014 and Implementation of the Plan began on that date. It is therefore necessary to ensure that the proposed project is consistent with and conforms to the requirements of the Revised Plan, which includes desired conditions and management approaches for wetlands/cienegas, cottonwood-willow riparian vegetation, soils and watersheds, and natural waters. This section therefore addresses consistency with the Revised Kaibab National Forest Land and Resource Management Plan.

Desired Conditions for Wetlands/Cienegas

- Wetland conditions are consistent with their flood regime and flood potential.
- Native plant and animal species that require wetland habitats have healthy populations within the natural constraints of the particular wetland community.
- Wetlands infiltrate water, recycle nutrients, resist erosion, and function properly.

Objectives for Wetlands/Cienegas

- Restore native vegetation and natural water flow patterns on at least 6 acres of wetlands within 5 years of plan approval.

All Action Alternatives include restoration of 74 springs and up to 39 miles of ephemeral channels within the project area, which is consistent with desired conditions for wetlands as outlined in the Revised LRMP. Springs restoration treatments have potential to improve springs discharges and seasonal wetland distribution and extent. At a minimum, removal of dysfunctional spring infrastructure would naturalize spring conditions. Thinning of dense forest vegetation and reintroduction of low- to moderate-intensity fire has the potential to increase snowpack retention, runoff, surface water storage, and groundwater recharge rates, assuming adequate precipitation and infiltration. Exclosure fences, where warranted, would prevent adverse effects of human activities and vertebrate herbivores (including domestic livestock); such adverse effects include soil disturbance and compaction, riparian vegetation trampling and removal, and defecation near spring sources, etc.). Implementation of BMPs and SWCPs as outlined in Table 1 would minimize and mitigate potential adverse effects to water quality and riparian area from proposed restoration activities.

Additionally, proposed watershed research included in Alternative C would inform future management toward achieving desired conditions for wetlands within the KNF portion of the project area.

Alternative A would not contribute to desired conditions for wetlands within the KNF portion of the project area as it does not include restoration of native vegetation and natural water flow patterns on at least 6 acres of wetlands within 5 years of plan approval as outlined in the objectives for wetlands/cienegas.

Desired Conditions for Soils

- Soils provide for diverse native plant species. Vegetative ground cover is well distributed across the soil surface to promote nutrient cycling and water infiltration.
- Accelerated soil loss is minimal, especially on sensitive or highly erodible sites.
- Soils can readily absorb, store, and transmit water vertically and horizontally; accept, hold, and release nutrients; and resist erosion.
- Infiltration rates are good in TES soil units that are described as well drained and moderately well drained.
- Logs and other woody materials are distributed across the surface to maintain soil productivity.
- Biological soil crusts (mosses, lichens, algae, liverworts) are stable or increasing in semi-desert grasslands, desert, pinyon-juniper, and sagebrush communities.
- Soils are free from anthropogenic contaminants that could alter ecosystem integrity or affect public health.

All Action Alternatives would be consistent with desired conditions for soils within the KNF portion of the project area. Reduced stand densities and fuel loads would decrease the risk of uncharacteristic fire which typically results in increased soil erosion and long-term loss of soil productivity. Uncharacteristic fire also typically increases soil hydrophobicity, which affects the ability of soils to infiltrate, transmit and store water. Spring and ephemeral channel restoration has the potential to restore hydric (wetland) soil conditions where the frequency or duration of surface inundation or saturation is increased. Improved vegetative ground cover in treated areas would also contribute to improved soil porosity, aggregate stability, organic matter content, nutrient cycling, and carbon sequestration. Decommissioning of roads within the project area would improve soils on these sites. Installation of protective aspen fences would exclude domestic livestock and wildlife ungulates from aspen stands, thereby improving soil conditions in protected areas. Implementation of BMP s and SWCPs as described in Table 1 would minimize or mitigate potential adverse effects of treatment activities on soil productivity.

While Alternative A would generally be consistent with desired conditions for soils as described above, as previously noted, risk of uncharacteristic high-severity wildfire would remain in many areas since forest restoration treatments would not be implemented at the same scale as proposed under the Action

Alternatives. In the absence of restoration treatments, vegetative ground cover in dense ponderosa stands would not improve, but remain static. Additionally, soils conditions would not be improved in areas where springs restoration, ephemeral channel restoration, road decommissioning, and aspen fencing are proposed. Soils conditions would likely remain static or could trend downward over time. Where soil erosion is not minimized (e.g., ephemeral channels that exhibit downcutting, incision, or aggradation), Alternative A would not be consistent with desired conditions for soils.

Desired Conditions for Watersheds

- Vegetation conditions within watersheds contribute to downstream water quality and quantity. Surface runoff, sheet, rill, and gully erosion, and subsequent sedimentation into connecting waters downstream is minimal.
- Flooding maintains normal stream characteristics (e.g., water transport, sediment, woody material) and dimensions (e.g., bankfull width, depth, slope, and sinuosity). Vertical down cutting and embeddedness are absent in drainages.
- Flood plains are functioning and lessen the impacts of floods on human safety, health, and welfare.
- The fuels composition within watersheds does not put the watersheds at risk for uncharacteristic disturbance.
- Water quality meets or surpasses State of Arizona or Environmental Protection Agency water quality standards for designated uses. Water quality meets critical needs of aquatic species.

All Action Alternatives would be consisted with desired conditions for watersheds as outlined in the revised KNF LRMP. Vegetation conditions would be improved throughout the project area as a result of forest restoration treatments, including fuels reduction. Decommissioning of road would improve hydrologic conditions and reduce soil erosion and sediment delivery. Relocating roads out of stream courses would improve stream channel characteristics and water quality. Springs and ephemeral channel restoration would improve watershed conditions.

Alternative A would not be consistent with desired conditions for watersheds as existing fuels compositions in the ponderosa pine vegetation type are conducive to uncharacteristic, high-severity wildfire at many locations within the project area.

Guidelines for Soils and Watershed Management

- Projects should incorporate the national best management practices for water quality management and include design features to protect and improve watershed condition.
- In disturbed areas, erosion control measures should be implemented to improve soil conditions.
- Seeds and plants used for revegetation should originate from the same PNVT and general ecoregion (i.e. southern Colorado Plateau) as the project area.

All Action alternatives are consistent with revised LRMP guidelines for soils and watershed management since they include implementation of site-specific BMPs and SWCPs as described above.

Alternative A would also be consistent with the above guidelines for soils and watershed management since future projects would incorporate site-specific BMPs and SWCPs in accordance with the national best management practices for water quality management.

Desired Conditions for Natural Waters

- Stream channel stability and aquatic habitats retain their inherent resilience to disturbances and climate fluctuations. Stream channel morphology reflects changes in the hydrological balance, runoff, and sediment supply appropriate to the landscape setting.
- Springs and ponds have the necessary soil, water, and vegetation attributes to be healthy and functioning. Water levels, flow patterns, groundwater recharge rates, and geochemistry are similar to reference conditions. Springs, streams, and ponds have appropriate plant cover to protect banks and shorelines from excessive erosion.
- Hydrophytes and emergent vegetation exist in patterns of natural abundance in wetlands and springs in levels that reflect climatic conditions. Overhanging vegetation and floating plants such as water lilies exist where they naturally occur.
- The necessary physical and biological components, including cover, forage, water, microclimate, and nesting/breeding habitat, provide habitat for a diverse community of plant and wildlife species.
- Riparian dependent plant and animal species are self-sustaining and occur in natural patterns of abundance and distribution. Within its capability, stream flow and water quality are adequate to maintain aquatic habitat and water sources for native and desired nonnative species. Native macroinvertebrates are appropriately abundant and diverse.
- Native amphibians are free from or minimally impacted by nonnative predation and diseases. Unwanted nonnative species do not exert a detectable impact on aquatic and wetland ecosystems
- Where springs or other natural waters have been modified for livestock and/or human consumption, developments are operational.
- The location and status of springs and water resources are known, organized, and available.

All Action Alternatives are consistent with desired conditions for natural waters. Springs and ephemeral channel restoration would improve soil, water and vegetation attributes in these areas. Relocation of roads that are currently in stream channels would improve the condition of streamcourses.

Alternative A would not be consistent with desired conditions for natural waters as ephemeral stream channels proposed for restoration would not be meeting the desired condition of stream channel stability. Springs proposed for restoration would not receive restoration treatments under this alternative. Desired conditions for springs would therefore not be achieved.

Objectives for Natural Waters

- Protect and/or restore at least 10 individual springs within 5 years of plan approval.

All action alternatives would be consistent with objectives for natural waters described above since all Action Alternatives include springs restoration.

Alternative A would not be consistent with objectives for natural waters as no springs restoration would occur under this alternative.

Guidelines for Activities In and Around Natural Waters

- Access to natural waters should be restricted to designated trails and points of entry to mediate erosion and prevent trampling and inadvertent introduction of nonnative and undesirable biota and disease.
- Activities in and around waters should use decontamination procedures to prevent the spread of chytrid fungus.
- Fences constructed around natural waters should allow bats and other desirable wildlife to pass through unharmed.

All Action Alternatives would be consistent with guidelines for activities in and around natural waters. Springs restoration includes protective fencing where appropriate to control human ingress and egress and to minimize adverse effects of vertebrate herbivores. Protective exclosures around spring sources would be installed in a manner that prevents large herbivores (domestic livestock and elk) from accessing spring sources, while allowing smaller mammals and other wildlife to access spring sources unharmed.

Alternative A would not be consistent with guidelines for activities in and around natural waters. Springs sources that are not currently protected from human impacts and vertebrate herbivores would continue to exhibit adverse effects such as indiscriminate trampling of vegetation, soil compaction, and browsing of riparian vegetation at spring sources.

Affected Environment and Environmental Consequences

This section details the affected environment and environmental consequences for surface water quality and riparian area resources within the analysis area. It establishes the baseline against which the decision maker and the public can evaluate the effects of the action alternatives.

This section also describes the direct, indirect, and cumulative effects of implementing each alternative on surface water quality and riparian area resources in the project area. It presents the scientific and analytical basis for the comparison of the alternatives presented in Alternatives section. 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 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).

Affected Environment ___________________________

The resource areas within this analysis to be affected by the proposed action or other action alternatives are surface water quality and riparian area conditions.

Climate

The project area occurs within the North central climatological division of Arizona. In this division, the climate is highly variable as a consequence of the uneven topography and the wide range in elevation. Precipitation on the average varies from 16 to 30 inches annually and is bimodal. The wettest season extends from July to October; a second wet season extends from December to March. In the northern and eastern portions of the project area, less than 50 percent of the average annual precipitation occurs during the low-sun half year period of October 1st to March 31st. In the southern portion of the project area more than 50 percent occurs during the same time period. Mean annual snowfall ranges from 0 to over 80 inches. Summer precipitation is irregular, but usually takes place in the form of high-intensity, short duration thunderstorms during the monsoon season (July through September).

Average annual temperatures range from 55° Fahrenheit at lower elevations to 34° Fahrenheit at higher elevations. For the month of January, mean minimum temperatures range from 10° to 20° Fahrenheit; mean maximum temperatures range from 32° to 50° Fahrenheit. For the month of July, mean minimum temperatures range from 45° to 52° Fahrenheit; mean maximum temperatures range from 70° to 105° Fahrenheit.

The NOAA U.S. Seasonal Drought Monitor dated March 18, 2014 indicates that the region is currently in a moderate drought. Drought conditions could persist or intensify in the project area (Figure 1,

Appendix A). In northern Arizona, precipitation over the past 90 days has averaged less than 25 percent of normal. Currently, the NOAA U.S. Drought Monitor (dated March 20, 2014) indicates that drought is likely to intensify the project (Figure 2, Appendix A).

Water Quality & Quantity

Watersheds

The Four Forest Restoration Initiative Project occurs within eighty-two sixth-level, or 12-digit hydrologic units (i.e., subwatersheds). As previously noted, a watershed condition assessment was completed in 2011 for all subwatersheds in the project area as part of a Forest-level assessment of watershed conditions for each Forest. Existing watershed conditions for all subwatersheds in the project area can be found at: http://apps.fs.usda.gov/WCFmapviewer/. Watershed condition information is also included in the Soil and Watershed Specialist's Report.

City of Flagstaff Municipal Watersheds and Municipal Water Supplies

Inner Basin (MA 16)

The Inner Basin is a collapsed caldera, which was subsequently glaciated. It is 838 acres in size and located on the eastern slopes of the San Francisco Peaks, it provides a variety of recreational, scenic,

and water resources. The Inner Basin is located in the Bear Jaw Canyon subwatershed and contributes to the water supply for Flagstaff through an extensive water collection and distribution system. Originally developed by the railroad around the turn of the century, the water system includes spring developments, infiltration galleries, and wells, along with associated access roads and buried pipelines. It is a major component of the Flagstaff Municipal Watershed, an area designated by the Chief of the Forest Service. The area is open to day-use foot traffic, but closed to domestic livestock and public travel by vehicle. Protecting water quality is the primary management direction.

Lake Mary Watershed (MA 35)

The Lake Mary Watershed is 62,492 acres in size and provides water to the City of Flagstaff water system as part of the municipal water supply. However, the Lake Mary Watershed has not been formally designated by the CNF as a municipal watershed. Surface water from the Upper Lake Mary reservoir is an important municipal water supply for the City of Flagstaff. The 30-year median inflow to the reservoirs from January to May was 5,000 acre-feet, but due to evaporation and seepage losses, the average availability is approximately 2,250 acre-feet (USBOR, 2006). Because surface water availability is affected by drought conditions, it can be unreliable. This has stimulated interest in additional well drilling and development of groundwater supplies in the Flagstaff area. In wet years, Upper Lake Mary has provided up to 70% of the City's water supply (Pinkham and Davis, 2002); however in 1990, 2000 and 2002, there was very little inflow into Upper Lake Mary. Recently, groundwater use has increased and supplies about 70% of the annual demand (Reed, 2005).

Woody Mountain Well Field

The Woody Mountain well field has 10 producing wells and is capable of producing approximately five million gallons per day (City of Flagstaff, 2012). Water production from the Woody Mountain well field in 2010 was 476 million gallons, or 1,461 acre-feet.

City of Williams Municipal Watershed

The City of Williams Municipal Watershed is approximately 26,061 acres in size. Table 3 lists the eight subwatersheds and their associated acreages that occur within the Williams Municipal Watershed. Two of these subwatersheds, Cataract Creek Headwaters and Dogtown Wash, encompass more than 96 percent of the total municipal watershed area.

The objective in managing the Williams Municipal Watershed is to recognize its water supply values and to provide management of its lands and resources to harmonize present and foreseeable resource uses with domestic water supply needs, protection of its water supply facilities, and protection of the citizens of Williams from catastrophic floods (Elson 1972).

Table 3. Subwatershed (HUC12) names, acreages, and associated percentages of each that comprise the City of Williams Municipal Watershed. (acres are approximate).

WATERSHED NAME	HYDROLOGIC UNIT NUMBER (HUC12)	TOTAL WATERSHED ACRES	PERCENT OF WILLIAMS MUNICIPAL WATERSHED	ACRES IN PROJECT AREA	PERCENT OF PROJECT AREA
Dogtown Wash	150100040501	10,627	40.8	816.22	8.7
Cataract Creek Headwaters	150100040502	14,616	56.1	5,148.29	33.8
Upper Red Lake Wash	150100040503	681	2.6	0	0
Upper Cataract Creek	150100040504	23	<0.3	0	0
Johnson Creek	150602010302	70	<0.3	2,719.12	17.9
Upper Hell Canyon	150602020204	25	<0.3	1,639.21	10.7
Pitman Valley-Scholz Lake	150602020305	3	<0.3	0	0
Big Spring Canyon	150602020307	9	<0.3	0	0

Runoff impounded in reservoirs serves as the main water supply for the City of Williams. Seven primary reservoirs surrounding the City are the source of surface water for municipal uses. These reservoirs have a combined water storage capacity of 2,755 acre-feet (897 million gallons) of water. Approximately 2,026 acre-feet or 73.6 percent of the available water storage occurs in the two largest impoundments, Dogtown Reservoir and Kaibab Lake. However, the majority of the City's water supply (i.e., approximately 90 percent) originates from Dogtown Reservoir and City Dam. Groundwater from wells located near Dogtown Reservoir supplements surface water in the City municipal water supply. Table 4 below provides a list of reservoirs in the Williams Municipal Watershed and their approximate water storage capacities and percentages of total available surface water supply. Water from these reservoirs originates from snowmelt and summer precipitation.

Table 4. Reservoirs, associated water storage capacities, and percentages of total municipal surface water in the City of Williams Municipal Watershed.

RESERVOIR NAME	WATER STORAGE CAPACITY (Million Gallons)	WATER STORAGE CAPACITY (Acre-Feet)	PERCENT OF TOTAL WATER STORAGE CAPACITY
Dogtown Reservoir	360	1,105	40.2
Kaibab Lake	300	921	33.4
Cataract Lake	109	335	12.2
Santa Fe Reservoir	70	215	7.8
City Dam	36	111	4.0
Upper and Lower Saginaw	22	68	2.4

Some regional water stakeholders, including the Havasupai Tribe, have expressed concern regarding impacts of the City of Williams well development program on springs and seeps in the Grand Canyon area. The City of Williams and the Havasupai Tribe have entered into an agreement regarding regional ground water management and water conservation efforts by the City of Williams. The agreement includes discussions of tribal sovereignty, the significance of the Coconino Plateau to the tribe, the importance of water on the Coconino Plateau, the importance of water conservation, and the effect of drought on the water resources of the City of Williams. Specific agreement clauses address conditions under which the tribe would not contest or may contest well permits from the U.S. Forest Service and the city's right to respond to opposition, monitoring of well levels and production, restrictions on provision of water by the city to residents outside the city, city opposition to Coconino County allowing home development in areas without water supply, mutual support for development of other water supplies, mutual opposition to large-scale development proposals that rely on groundwater development, continuation of water conservation efforts by the City of Williams, and the City's support in principle for the tribe's position that any decrease to the natural flow of Havasu Creek cannot be tolerated (Pinkham and Davis 2002).

Water Quality

Section 305(b) of the Clean Water Act requires states to assess and report on the water quality status of waters within the states. Section 303(d) requires states to list waters that are not attaining water quality standards. This is also known as the list of impaired waters. This information is reported to Congress on a nationwide basis. The Arizona Department of Environmental Quality (ADEQ) is responsible for conducting monitoring, assessment, reporting under CWA Sections 303(d) and 305(b), and total maximum daily load (TMDL) development for the State of Arizona. Arizona's most recent Integrated Report (305(b) Water Quality Assessment and 303(d) list) is available from the ADEQ. The Arizona Impaired Waters List can be found at: http://www.azdeq.gov/environ/water/assessment/download/2006_2008.pdf

The ADEQ 2006/2008 Impaired Waters List indicates there are no impaired streams within the project area. However, Oak Creek, which is located outside of the project boundary and downstream of proposed treatment areas has been listed as impaired in the ADEQ 2006/2008 305(b) Assessment Report for exceedances of *Escherichia coli* (i.e., *E. coli*) single sample maximum (SSM) water quality standard. This segment of Oak Creek extends from the Arizona State Fish Hatchery for approximately 7.4 miles to the confluence with West Fork Oak Creek. Since 1998, 110 *E. coli* samples have been collected from this segment. Four samples have exceeded the applicable water quality standard since 2003, resulting in the impairment determination. Two of the exceedances were clearly related to storm flows as they plot on the left hand portion of the Load Duration Curve (LDC) at 0.01 percent flow (ADEQ 2010). It should be noted in 2013 there were no exceedances of *E. coli* per data gathered from Friends of Forest and Slide Rock State Park.

It is very likely that Oak Creek and West Fork Oak Creek will exhibit impaired conditions for the foreseeable future (i.e., at least 3 years and likely longer) as a result of the Slide Fire of 2014. Within the Slide Fire perimeter, approximately 3,115 acres (14 percent) burned at high severity, 7,067 acres (32 percent) burned at moderate severity, 10,415 acres (48 percent) burned at low severity and 1,293 acres (6 percent) remain unburned or burned at very low severity. Burned areas are on steep slopes along the Mogollon Escarpment and canyons above Oak Creek and West Fork Oak Creek. It is likely that large amounts of sediment and ash will be deposited in these stream channels and their associated tributaries during and after monsoon storms and during snowmelt.

Since the initial draft of this report, ADEQ completed the Draft 2010 Status of Water Quality in Arizona 305(b) Assessment Report. The 2010 303(d) list for Arizona has also been approved by EPA and is now final. Table 5 lists the findings for Oak Creek as part of the assessment of the Verde Watershed. Oak Creek was again assessed as Not Attaining (Category 4). Category 4 waters have available data and/or information which indicate that at least one designated use is not being supported but a TMDL is not required because either a TMDL has already been completed (4a) or a plan is in place to attain water quality standards within the next assessment cycle (4b).

Table 5. Findings of Oak Creek water quality as recorded in the 2010 ADEQ 303(d) list.

Assessment Unit	Category (year TMDL completed)	Cause(s) of Impairment (year first listed)
Oak Creek 15060202-017 Dry Creek to Spring Creek	4a (2011)	*E. coli*
Oak Creek 15060202-018A West Fork Oak Creek to Tributary at 345709 / 1114513	4a (2011)	*E. coli*
Oak Creek 15060202-018B Tributary at 345709 / 1114513 to Slide Rock State Park	4a (2011)	*E. coli*
Oak Creek 15060202-018C Slide Rock State Park to Dry Creek	4a (2011)	*E. coli*
Oak Creek 15060202-019 Headwaters to West Fork Oak Creek	4a (2011)	*E. coli*
Oak Creek 15060202-017 Dry Creek to Spring Creek	4a (2011)	*E. coli*

Direct recreational pollution does not appear to be a consistent source of *E. coli* in the upper watershed (ADEQ 2010). Therefore, indirect anthropogenic pollution may be a contributing factor. Several residential areas and a campground are located within the upper reach in close proximity to the stream. Additionally, pollutants may be introduced via Pumphouse Wash which drains portions of the watershed

southeast of Flagstaff. Cattle grazing, domesticated animals and septic systems are present within the Pumphouse Wash portion of the watershed as is the Kachina Village Wastewater Treatment Plant, which does not discharge to surface water. Increased access to the stream and the potential for greater runoff from these improved sites may contribute pollutants under wet conditions (ADEQ 2010).

ADEQ completed a Pathogen Total Maximum Daily Load (TMDL) in 1999 for Slide Rock State Park which called for a 30 percent reduction in summer recreational season *E. coli* values in order to attain the water quality standard of 580 colony forming units per 100 milliliters (cfu/100ml). Subsequently the standard was revised to its current single sample maximum (SSM) value of 235 cfu/100ml and geometric mean of 126 cfu/100ml. Continuing exceedances caused ADEQ to undertake a revision to the TMDL beginning in 2003. Sampling occurred on high visitation weekends, during stormwater runoff and snow melt events, and under baseflow conditions.

In 2009 the Oak Creek Watershed Council, a local watershed improvement group, was awarded a Water Quality Improvement Grant by ADEQ. The primary purpose of the grant is to develop a Watershed Improvement Plan (WIP). Several improvement projects have been implemented over the years to improve the water quality in Oak Creek, however, the effectiveness and necessity of these projects has been questioned. Development of the WIP will include watershed and social surveys aimed at locating and prioritizing future water quality improvement projects. The document will serve as a blueprint for improving water quality in Oak Creek.

The ADEQ has identified Upper and Lower Lake Mary as impaired for the presence of mercury in fish tissue. As outlined in the Lake Mary Regional TMDL (ADEQ 2010) for Mercury in Fish Tissue, ADEQ and the Arizona Game and Fish Department (AGFD) issued fish advisories for Upper and Lower Lake Mary in 2002. In 2002, EPA added five lakes in the Lake Mary Region (LMR) to Arizona's 303(d) List as impaired for mercury in fish tissue. These lakes included Upper and Lower Lake Mary, Soldiers, Soldiers Annex and Lower Long Lakes. The resulting TMDL will use the target of 0.3 mg/kg (wet weight) mercury, the fish tissue standard adopted by ADEQ in January 2009. The LMR is located on the Coconino National Forest, within the Little Colorado River Watershed in north-central Arizona. Land in the LMR is primarily rugged and undeveloped, with 98% under the jurisdiction of the U.S. Forest Service (USFS) and the remaining 2% as private holdings (ADEQ 2010). The TMDL and background lakes that occur within the project area are listed in Table 6.

Table 6. Lakes located in the Lake Mary Region (LMR).

TMDL Lakes	Water Body ID	Background Lakes	Water Body ID
Upper Lake Mary	15020015-0900	Mormon Lake	15020015-0970
Lower Lake Mary	15020015-0890		

All lakes in the LMR, except Mormon Lake, are man-made and were created to provide additional water sources for either people or livestock in the Flagstaff area. Upper and Lower Lake Mary are located approximately 6 miles southeast of Flagstaff. The majority of Upper and Lower Lake Mary watersheds are located to the south of the lakes, with elevations ranging from 6,800 to 8,500 feet. Lower Lake Mary was created in 1904 after an eight-year drought, to support the Arizona Lumber and Timber Company, local community and livestock industry. At full capacity Lower Lake Mary is approximately 765 acres in size, but most years is more accurately characterized as a wetland with a pool above the dam. Upper Lake Mary was constructed in 1940, and at full capacity is 860 acres in size, making it the larger of the two lakes. It is 8 miles long and over one-half mile wide at its widest point. However, due to the shallow depth, the aerial extent of the lake varies widely with precipitation. Upper and Lower Lake Mary are hydraulically connected and support substantial recreational use in the forms of fishing (Upper – largemouth and yellow bass, crappie, sunfish, channel catfish, walleye, tilapia and yellow perch; Lower – rainbow trout, sunfish, channel catfish, and northern pike), camping, wildlife viewing, boating (canoeing, sailing, rafting and power boats) and swimming.

Both Lakes have been assigned the following designated uses according to the Arizona Administrative Code (A.A.C.) Title 18, Chapter 11:

- Domestic Water Source (DWS),
- Aquatic and Wildlife Cold Water (A&W cold),

- Full Body Contact (FBC),
- Fish Consumption (FC), and
- Agricultural Livestock Watering (AgL).

Although Upper and Lower Lake Mary are designated as domestic water sources, the levels of total mercury observed do not approach drinking water maximum contaminant levels.

Ashurst Lake, Mormon Lake, and Willow Springs Lake serve as background lakes because fish tissue mercury results were lower than those measured in the TMDL lakes. According to ADEQ (2010), the original intent of the background lakes was to determine why some lakes in the LMR contained fish with high levels of mercury while others did not. However, since the lakes do not all contain the same fish species, this type of analysis is inconclusive.

Water quality sampling conducted by ADEQ indicate that inputs of mercury from tributaries are comparable among all of the lakes studied, indicating that in-lake processes and the fish species contained within each lake, play an important role in the bioaccumulation of mercury. ADEQ intends to continue fish tissue collection and bioaccumulation studies in the LMR in hope of determining the specific factors leading to mercury methylation.

The ADEQ has concluded that watershed loading can potentially be reduced through management of sedimentation and vegetative stability. Recommendations included a review of upland and drainage conditions, so that areas requiring soil stabilization measures and channel improvements may be identified (ADEQ 2010).

Streamcourses

Streamcourses within the project area are generally low-gradient ephemeral and intermittent streams with dendritic drainage patterns, except in areas with very steep terrain such as mountains (i.e., extinct volcanoes) and cinder cones, which typically have radial drainage patterns with high-gradient ephemeral and intermittent drainages flowing in all directions from upper slopes. Approximately 2,197 miles of streamcourses occur within the analysis area, of which approximately 8.2 miles exhibit perennial flow. Appendix B lists stream reaches that occur within the Four Forest Restoration Initiative analysis area, their associated lengths and flow regimes. It should be noted that the National Hydrography Data (NHD) does not differentiate between ephemeral and intermittent stream flow. As a result, ephemeral streamcourses are classified as intermittent in the NHD.

Three perennial streams occur outside of the Four Forest Restoration Initiative analysis area, although they are in close proximity to proposed treatment areas. These include Oak Creek, West Fork Oak Creek, and Sycamore Creek. Perennial flow in Oak Creek initiates at the Arizona State Fish Hatchery near the confluence with Sterling Spring. Sycamore Creek flows along the bottom of Sycamore Canyon and includes riparian habitat featuring many cottonwoods, walnuts and sycamores.

Three perennial stream segments occur within the project area, including the Rio de Flag, Pumphouse Wash, and Sawmill Wash. The Rio de Flag exhibits perennial flow from the Flagstaff reclaimed water treatment discharge location for approximately 5 miles to the Wildcat Hill Wastewater Treatment Facility where effluent is then dicharged into the Rio de Flag, contributing to perennial flow for an additional 2 miles through perennial wetlands in the Picture Canyon area. Winter snowmelt from the San Francisco Peaks and rainfall during the summer monsoons of July and August also contribute to streamflow in the Rio de Flag. Pumphouse Wash exhibits perennial flow from O'Neil Spring southwestward for approximately 1.2 miles through the Kachina Village area before surface water infiltrates and contributes to wetland conditions that support riparian vegetation. Sawmill Wash exhibits perennial flow for approximately 0.79 miles from the source at Sawmill Springs, eastward to Forest Service Road 124H, after which surface water infiltrates and contributes to wetland conditions that support riparian vegetation.

Riparian stream segments occur along 92.6 miles of streams within the project area. Of these, approximately 85.1 riparian miles (91 percent) occur on the CNF and 7.5 riparian miles (9 percent) occur on the KNF. Appendix C provides a list of riparian areas by stream reach or name and their associated conditions within the Four Forest Restoration Initiative analysis area. Within the analysis area, approximately 47.5 miles of streams area are currently in proper functioning condition, 38.6 miles are functioning at-risk, and 6.6 miles are non-functional.

There are approximately 77.5 miles of protected streamcourses in the Four Forest Restoration Initiative analysis area. These are areas where specific SWCPs and BMPs have been developed to prevent adverse impacts to streamcourses. Table 1 on page 8 lists BMPs specific to the Four Forest Restoration Initiative project. Appendix G provides a list of the protected stream courses within the project area and their associated functional condition classes and lengths. A map of the locations of protected streamcourses is also included in Appendix G.

Wetlands, Riparian Areas, and Springs

There are 66, natural lakes, reservoirs, and natural wetland depressions within the project boundary that impound water for a sufficient duration to exhibit some wetland characteristics and are therefore listed in the U.S. Fish and Wildlife Service National Wetlands Inventory database. Table 1 in Appendix C lists riparian stream reaches in the Four Forest Restoration Initiative analysis area and their associated lengths, sizes and condition ratings. Tables 1 and 2 in Appendix D list wetland habitats and their associated condition ratings.

There are approximately 145 springs located within the Four Forest Restoration Initiative Project analysis area. Tables 1 and 2 in Appendix E list known springs and their locations within the project area by Forest. Tables 3 and 4 in Appendix E list springs that occur within treatment areas and the associated treatments proposed for the surrounding landscapes. Information regarding historic flow or water quality from these springs is minimal. Most springs within the project area are either rheocrene – they flow directly from the ground resulting in a small stream, helocrene – they emerge from low gradient wetlands, or hillslope – they emerge from confined or unconfined aquifers on a hillslope (typically 30–60º); often with indistinct or multiple sources. Some of these springs were assessed in 2008 as part of the riparian area assessment conducted by Jeff Hink in 2008. Information from these assessments is included in Table 3 of Appendix D. Additionally, many springs within the project area have been assessed using the Spring Ecosystem Assessment Protocol (SEAP) by Stevens et al. 2011 to inform the KNF Forest Plan revision process. These assessments are ongoing and will continue through 2013 on the Coconino and Kaibab National Forests. Information gathered from these and other spring assessments are included in Table 4 of Appendix D. In general, many springs within the project area have been adversely affected by human activities including flow regulation through installation of spring boxes and piping of discharge to off-site locations, recreational impacts, urbanization and other construction activities, and grazing by domestic livestock and wildlife herbivores. As a result, many springs exhibit downward trends or static-degraded conditions (MacDonald 2011). Spring restoration has therefore been identified as a need for change within the project area and in the revised KNF Forest Plan. Figures 1 through 4 below provide an example of spring conditions at a typical developed spring on the KNF within the Four Forest Restoration Initiative Project area.

Figure 1. Photograph of Isham Spring on the Williams Ranger District, Kaibab National Forest. Note concrete spring box. This spring was dry at time of assessment in 2011. Photo courtesy of Spring Stewardship Institute (SSI).

Figure 2. Photo of Lower McDermit Spring on the Williams Ranger District, Kaibab National Forest. Note dilapidated wooden infrastructure. Photo courtesy of Spring Stewardship Institute (SSI).

Figure 3. Clover Spring infrastructure and associated channel on the Williams Ranger District of the KNF.

Figure 4. Clover Spring flow as observed on October 12, 2011. Flow rate was estimated at approximately 4 gallons per hour.

Flood Zones

Approximately 687,608 acres within the Four Forest Restoration Initiative Project area have been surveyed for presence of flood zones. Flood zones are geographic areas defined by the Federal Emergency Management Agency (FEMA) according to varying levels of flood risk. These zones are depicted on a community's Flood Insurance Rate Map (FIRM) or Flood Hazard Boundary Map. Each zone reflects the severity or type of flooding in the area. Flood hazard areas identified on the FIRM are identified as a Special Flood Hazard Area (SFHA). SFHA are defined as the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year. The 1-percent annual chance flood is also referred to as the base flood or 100-year flood. SFHAs are labeled as Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, Zone AR/A, Zone V, Zone VE, and Zones V1-V30. Moderate flood hazard areas, labeled Zone B or Zone X (shaded) are also shown on the FIRM, and are the areas between the limits of the base flood and the 0.2-percent-annual-chance (or 500-year) flood. The areas of minimal flood hazard, which are the areas outside the SFHA and higher than the elevation of the 0.2-percent-annual-chance flood, are labeled Zone C or Zone X (unshaded).

Within the Four Forest Restoration Initiative Project area, there are approximately 974,920 acres of flood zone X (minimal flood hazard), 9,098 acres of flood zone A (high flood risk, depth and base flood elevation unknown), 2,414 acres of flood zone AE (high flood risk, depth and base flood elevation known), 22 acres of flood zone AH (areas subject to inundation by 1-percent-annual-chance of shallow flooding, usually areas of ponding, where average depths are 1 to 3 feet), and 55 acres of flood zone AO (areas subject to inundation by 1-percent-annual-chance of shallow flooding, usually sheet flow on sloping terrain, where average depths are between one and three feet). The largest areas of 100-year flood zones within the project analysis area are in the following areas:

- Rio de Flag extending from Fort Valley Experimental Forest, through the City of Flagstaff to the confluence with San Francisco Wash
- Upper and Lower Lake Mary and drainages that flow into the lakes (i.e., Newman Canyon, Walnut Creek, Priest Draw, Howard Draw, and other unnamed ephemeral drainages that flow into the lakes from the south)
- Elk Meadows, northeast of Hoxworth Springs
- Switzer Canyon, north of Flagstaff
- Unnamed drainages in East Flagstaff
- Cataract Creek in the City of Williams
- Other low-lying areas in the City of Williams
- Volunteer Wash in Bellemont and drainages inside Camp Navajo

Roads

Many roads in the project area are inadequately engineered, infrequently maintained, or poorly located on the landscape and are consequently in a state of disrepair. Some of these roads are located adjacent to drainage channels or on ridge tops and are subject to erosion and sediment transport. Roads near drainages are contributing to degradation of surface water quality during snowmelt and following short duration high intensity monsoon storms. Some roads have eroded to the point where roads surfaces are below the grade of the surrounding landscape, resulting in stormwater runon that then pools on road surfaces or flows down the travelway eroding the roadbed and entraining sediment in the storm flow. Fine roadbed materials (i.e., sand, silt and clay) have washed off of many road prisms, leaving large stones and cobbles as the dominant road surface, resulting in roads that are difficult to travel in a standard 2-wheel drive vehicle. Where water pools in road surfaces, rutting is a problem. Where stormwater flows down road surfaces, rills and gullies are compromising road surfaces and water quality.

Relevant Laws, Regulations, and Policies that Apply

The following list includes applicable laws, regulations, and policies affecting soils and watershed management on the KNF, the requirements of which are incorporated by reference herein.

The U.S. Forest Service Directives System (FSM/FSH): Forest Service Manuals and

Handbooks codify the agency's policy, practice, and procedure. The system serves as the primary basis for the internal management and control of all programs and the primary source of administrative direction to Forest Service employees. The Forest Service Manual (FSM) contains legal authorities, objectives, policies, responsibilities, instructions, and guidance needed on a continuing basis by Forest Service line officers and primary staff in more than one unit to plan and execute assigned programs and activities. Forest Service Handbooks (FSH) are the principal source of specialized guidance and instruction for carrying out the direction issued in the FSM. Specialists and technicians are the primary audience of Handbook direction. Handbooks may also incorporate external directives with related USDA and Forest Service directive supplements.

Forest Service Manual – Service Wide Issuance

Forest Service Manual 2500 – WATERSHED AND AIR MANAGEMENT

Region 3 (Southwestern Region): Regional Issuances

Forest Service Manual 2504.3 Exhibit 01

Forest Service Manual 2510 - WATERSHED PLANNING

Forest Service Manual 2520 - WATERSHED PROTECTION AND MANAGEMENT

Forest Service Manual 2530 - WATER RESOURCE MANAGEMENT

Forest Service Manual 2540 - WATER USES AND DEVELOPMENT

Forest Service Manual 2580 - AIR RESOURCE MANAGEMENT

Forest Service Handbook – Service Wide Issuance

Forest Service Handbook 2500 – Watershed and Air Management

Region 3 (Southwestern Region): Regional Issuances

2509.16 - Water Resource Inventory Handbook

2509.21 - National Forest System Water Rights Handbook

2509.22 - Soil and Water Conservation Handbook

2509.23 - Riparian Area Handbook

2509.24 - National Forest System Watershed Codes Handbook

2509.25 - Watershed Conservation Practices Handbook

The Organic Administration Act: (at 16 U.S.C. 475, 551). States the purpose of the national forests, and directs their control and administration to be in accord with such purpose, that is, "[n]o national forest shall be established, except to improve and protect the forest within the boundaries, or for the purpose of securing favorable conditions of water flows, and to furnish a continuous supply of timber for the use and necessities of citizens of the United States." Authorizes the Secretary of Agriculture to "make such rules and regulations…to preserve the forests [of such reservations] from destruction."

Weeks Law of 1911: as amended (at 16 U.S.C. 515, 552). Authorizes the Secretary of Agriculture to enter into agreements with States for the purpose of conserving forests and water supply, and, to acquire forested, cutover, or denuded lands within the watersheds of navigable streams to protect the flow of these streams or for the production of timber, with the consent of the State in which the land lies.

Knutson-Vandenberg Act of 1930 (16 U.S.C. at 576b). Specifies that the Secretary may require any purchaser of national forest timber to make deposits of money in addition to the payments for the timber, to cover the cost to the United States of planting, sowing with tree seeds, and cutting, destroying or otherwise removing undesirable trees or other growth, on the national forest land cut over by the purchaser, in order to improve the future stand of timber, or protecting and improving the future productivity of the renewable resources of the forest land on such sale area.

Anderson-Mansfield Reforestation and Revegetation Joint Resolution Act of 1949 (at 16 U.S.C. 581j and 581 j(note)). States the policy of the Congress to accelerate and provide a continuing basis for the needed reforestation and revegetation of national forest lands and other lands under Forest Service administration or control, for the purpose of obtaining stated benefits (timber, forage, watershed protection, and benefits to local communities) from the national forests.

Granger-Thye Act of 1950 (16 U.S.C. at 580g-h). Authorizes the Secretary to use a portion of grazing fees for range improvement projects on NFS lands. Specific types of projects mentioned are artificial revegetation, including the collection or purchase of necessary seed and eradication of poisonous plants and noxious weeds, in order to protect or improve the future productivity of the range. Section 11 of the act authorizes the use of funds for rangeland improvement projects outside of NFS lands under certain circumstances.

Surface Resources Act of 1955 (30 U.S.C. 611-614). Authorizes the Secretary of Agriculture to manage the surface resources of unpatented mining claims located under the authority of the 1872 Mining Law as amended, including, but not limited to, reclamation of disturbance caused by locatable mineral activities.

Surface Mining Control and Reclamation Act of August 3, 1977: Authorizes the Secretary of Agriculture to enter into agreements with landowners, providing for land stabilization, erosion, and sediment control, and reclamation through conservation treatment, including measures for the conservation and development of soil, water, woodland, wildlife, and recreation resources, and agricultural productivity of such lands.

U.S. Mining Laws (Public Domain Lands) Act of May 10, 1872 - Provides that all valuable mineral deposits in lands belonging to the United States, both surveyed and unsurveyed, are free and open to exploration and purchase, and the lands in which they are found to occupation and purchase by citizens of the United States and those who have declared their intention to become such, under regulations prescribed by law, and according to the local customs or rules of miners, so far as the same are applicable and not inconsistent with the laws of the United States. There are a number of Acts which modify the mining laws as applied to local areas by prohibiting entry altogether or by limiting or restricting the use which may be made of the surface and the right, title, or interest which may pass through patent.

Sikes Act (Fish and Wildlife Conservation) of September 15, 1960 (16 U.S.C. at 670g). Section 201 directs the Secretary of Agriculture, in cooperation with State agencies, to plan, develop, maintain, coordinate, and implement programs for the conservation and rehabilitation of wildlife, fish and game species, including specific habitat improvement projects, and shall implement such projects on public land under their jurisdiction.

Soil and Water Resources Conservation Act of November 18, 1977 - Provides for a continuing appraisal of the United States' soil, water and related resources, including fish and wildlife habitats, and a soil and water conservation program to assist landowners and land users in furthering soil and water conservation.

Multiple-Use Sustained-Yield Act of 1960 (16 U.S.C. 528-531). States that the National Forests are to be administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes, and that establishment and maintenance of wilderness areas are consistent with this Act. This Act directs the Secretary to manage these resources in the combination that will best meet the needs of the American people; providing for periodic adjustments in use to conform to changing needs and conditions; and harmonious and coordinated management of the resources without impairment of the productivity of the land. Sustained yield means achieving and maintaining in perpetuity a high-level annual or regular periodic output of renewable resources without impairment of the productivity of the land.

Water Resources Planning Act of July 22, 1965 - Encourages the conservation, development, and utilization of water and related land resources of the United States on a comprehensive and coordinated basis by the Federal government, states, localities, and private enterprises.

Watershed Protection and Flood Prevention Act of August 4, 1954 - Establishes policy that the Federal government should cooperate with states and their political subdivisions, soil or water conservation districts, flood prevention or control districts, and other local public agencies for the purposes of preventing erosion, floodwater, and sediment damages in the watersheds of the rivers and streams of the United States; furthering the conservation, development, utilization, and disposal of water, and the conservation and utilization of land; and thereby preserving, protecting, and improving the Nation's land and water resources and the quality of the environment.

Water Quality Improvement Act of April 3, 1970 - Amends the prohibitions of oil discharges, authorizes the President to determine quantities of oil which would be harmful to the public health or welfare of the United States; to publish a National Contingency Plan to provide for coordinated action to minimize damage from oil discharges. Requires performance standards for marine sanitation device and authorizes demonstration projects to control acid or other mine pollution, and to control water pollution within the watersheds of the Great Lakes. Requires that applicants for Federal permits for activities involving discharges into navigable waters provide state certification that they will not violate applicable water quality standards.

National Environmental Policy Act (NEPA) of 1969: (16 U.S.C. 4321 et seq.). Declares it is the policy of the Federal Government 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. The Act requires agencies proposing major federal actions significantly affecting the quality of the human environment, to prepare a detailed statement on the environmental impacts of the proposed action, unavoidable adverse environmental impacts, alternatives to the action proposed, the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity, and any irreversible and irretrievable commitments of resources which would be involved if the proposed action is implemented. The Act also provides that for any proposal which involves unresolved conflicts concerning alternative uses of available resources, an agency must study, develop, and describe appropriate alternatives to recommended courses of action.

Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974, as amended by National Forest Management Act (NFMA) of 1976 (16 U.S.C. 1600-1614, 472a). States that the development and administration of the renewable resources of the National Forest System are to be in full accord with the concepts for multiple use and sustained yield of products and services as set forth in the Multiple-Use Sustained-Yield Act of 1960. It sets forth the requirements for land and resource management plans for units of the National Forest System, including requiring guidelines to provide for the diversity of plant and animal communities based on the suitability and capability of the specific land area.

The Federal Water Pollution Control Act of 1972: Public Law 92-500, as amended in

1977 (Public Law 95-217) and 1987 (Public Law 100-4) (also known as the Federal

Clean Water Act (CWA)): This Act provides the structure for regulating pollutant discharges to waters of the United States. The Act's objective is "…to restore and maintain the chemical, physical, and biological integrity of the Nation's waters," and is aimed at controlling both point and non-point sources of pollution. The U.S. EPA administers the Act, but many permitting, administrative, and enforcement functions are delegated to state governments. In Arizona, the designated agency for enforcement of the Clean Water Act is the Arizona Department of Environmental Quality (ADEQ).

Relevant sections of the Clean Water Act:

CWA Sections 208 and 319: recognizes the need for control strategies for non-point source pollution.

CWA Section 303(d): requires waterbodies with water quality determined to be either

impaired (not fully meeting water quality standards for designated uses) or threatened (likely to violate standards in the near future) to be compiled by ADEQ in a separate list, which must be submitted to EPA every 2 years. These waters are targeted and scheduled for development of water quality improvement strategies on a priority basis.

Total Maximum Daily Loads (TMDLs): As of May 2006, there were no applicable TMDL requirements in effect for the KNF.

CWA Section 305(b): requires that states assess the condition of their waters and produce a biennial report summarizing the findings.

CWA Section 401: allows states and tribes to review and approve, set conditions on, or deny Federal permits (such as 404 permits) that may result in a discharge to state or tribal waters, including wetlands. Applications for Section 404 permits are often joint 404/401 permits to ensure compliance at both the Federal and state levels.

CWA Section 404: outlines the permitting process for dredging or discharging fill material into waters of the U.S., including wetlands. The U.S. Army Corps of Engineers administers the 404 Program.

Safe Drinking Water Amendments of November 18, 1977: Amended the Safe Drinking Water Act to authorize appropriations for research conducted by the Environmental Protection Agency relating to safe drinking water; Federal grants to states for public water system supervision programs and underground water source protection programs; and grants to assist special studies relating to the provision of a safe supply of drinking water.

Clean Air Act, as amended 1977 and 1990: (42 U.S.C. 7401, 7418, 7470. 7472, 7474, 7475, 7491, 7506, 7602). Establishes a national goal to prevent any future, and remedy existing, visibility impairment in certain wilderness areas the Forest Service manages. It also directs the Forest Service as a Federal land manager to protect air quality related values from man-made air pollution in these same areas. Lastly, it obligates the Forest Service to comply with the Act's many provisions regarding abatement of air pollution to the same extent as any private person.

North American Wetland Conservation Act of 1989 (16 U.S.C. 4401 (note), 4401-4413, 16 U.S.C. 669b (note)). Section 9 (U.S.C. 4408) directs Federal land managing agencies to cooperate with the Director of the U.S. Fish and Wildlife Service to restore, protect, and enhance the wetland ecosystems and other habitats for migratory birds, fish and wildlife within the lands and waters of each agency to the extent consistent with the mission of such agency and existing statutory authorities.

Stewardship End Result Contracting Projects (16 U.S.C. 2104 (note)). Grants the Bureau of Land Management (BLM) and the Forest Service ten-year authority to enter into stewardship contracts or agreements to achieve agency land management objectives and meet community needs.

Executive Order 11988 (Floodplain Management (42 CFR 26951, May 25, 1977)**:** The purpose of this Order is "…to avoid to the extent possible the long and short term impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative." Section 1 states: "Each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing, and disposing of Federal lands, and facilities; (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities."

Executive Orders relevant to ecological restoration include:

Executive Order 11514: issued March 5, 1970, as amended by E.O. 11991 issued May 24, 1977. Protection and enhancement of environmental quality (35 FR 4247, March 7, 1970). This order states that the Federal Government shall provide leadership in protecting and enhancing the quality of the nation's environment to sustain and enrich human life. This order provides for monitoring, evaluation, and control on a continuing basis of the activities of each Federal agency so as to protect and enhance the quality of the environment.

Executive Order 11644: issued February 8, 1972. Use of off-road vehicles on the public lands. (37 FR 2877, February 9, 1972). Amended by E.O. 11989 issued May 24, 1977 and E.O. 12608 issued September 9, 1987. This order requires federal agencies to develop and implement procedures that will ensure that the use of off-road vehicles on public lands will be controlled and directed so as to protect the resources of those lands, to promote the safety of all users of those lands, and to minimize conflicts among the various uses of those lands.

Executive Order 11990 (Protection of Wetlands): …"in order to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands… Section 1. (a) *Each agency shall provide leadership and shall take action to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's*

responsibilities for… (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities. Sec. 5: In carrying out the activities described in Section I of this Order, each agency shall consider factors relevant to a proposal's effect on the survival and quality of the wetlands. Among these factors are: (b) maintenance of natural systems, including conservation and long-term productivity of existing flora and fauna, species and habitat diversity and stability, hydrologic utility, fish, wildlife, timber, and food and fiber resources; and (c) other uses of wetlands in the public interest, including recreational, scientific, and cultural uses."

Executive Order 13112 issued February 3, 1999. Invasive Species. (64 CFR 6183, February 8, 1999). This order requires federal agencies whose actions may affect the status of invasive species to, among other things, respond to and control populations of invasive species and provide for restoration of native species and habitat conditions in ecosystems that have been invaded by non-native invasive species.

Travel Management Rule: On December 9, 2005, the Forest Service published the TMR. The agency rewrote direction for motor vehicle use on National Forest Service (NFS) lands under 36 CFR, Parts 212, 251, and 261, and eliminated 36 CFR 295. The rule was written to address at least in part the issue of unmanaged recreation. The rule provides guidance to the Forest Service on how to designate and manage motorized recreation on the Forests. The rule requires each National Forest and Grassland to designate those roads, motorized trails, and Areas that are open to motor vehicle use.

Road System: 36 CFR 212.5 (b): ...the responsible official must identify the minimum road system needed for safe and efficient travel and for administration, utilization, and protection of National Forest System lands. ... The minimum system is the road system determined to be needed to meet resource and other management objectives adopted in the relevant land and resource management plan (36 CFR 219), to meet applicable statutory and regulatory requirements, to reflect long-term funding expectations, to ensure that the identified system minimizes adverse environmental impacts associated with road construction, reconstruction, decommissioning, and maintenance.

Regional Forester's direction: Roads analysis process (RAP) for all other existing roads should be completed in conjunction with implementation of the off-highway vehicle (OHV) Record of Decision, watershed analyses, other project level activities or Forest Plan revisions.

Identification of unneeded roads. Responsible officials must review the road system on each National Forest and Grassland and identify the roads on lands under Forest Service jurisdiction that are no longer needed to meet forest resource management objectives and that, therefore, should be decommissioned or considered for other uses, such as for trails.

Regional Forester's direction: Roads analysis process (RAP) for all other existing roads should be completed in conjunction with implementation of the off-highway vehicle (OHV) Record of Decision, watershed analyses, other project level activities or Forest Plan revisions.

Memorandum of Agreement on Fostering Collaboration and Efficiencies to Address

Water Quality Impairments on National Forest System Lands: Agreement between U.S. Forest Service and the U.S. Environmental Protection Agency signed in 2007. Purpose: to coordinate between agencies and address issues of water quality impairment regarding 303d list, as well as TMDLs. The leading cause of water quality impairments on National Forest lands includes temperature, excess sediment, and habitat modification. These issues are to be addressed via BMPs to the greatest extent possible. In terms of this project analysis area, BMPs can be applied to soil and watershed condition and are applicable everywhere on the KNF.

33 CFR 323 Permits for Discharges of Dredged or Fill Material into Waters of the United States - This regulation prescribes those special policies, practices and procedures to be followed by the Corps of Engineers in connection with the review of applications for permits to authorize the discharge of dredged or fill material into waters of the United States.

36 CFR 219 Planning - Sets forth a process for developing, adopting, and revising land and resource management plans for the National Forest System.

40 CFR 121-135 Water Programs - Sets forth the provisions for the administration of water programs including: state certification of activities requiring a Federal license or permit; EPA administered permit programs; state program requirements; procedures for decision making; criteria and standards for the National Pollutant Discharge Elimination System; toxic pollutant effluent standards; water quality planning and management; water quality standards; water quality guidance for the Great Lakes System; secondary treatment regulation; and, prior notice of citizen suits. See Title 40 (Protection of Environment), Chapter 1 (Environmental Protection Agency), subchapter D (Water Programs).

40 CFR 1500 Council on Environmental Quality - Council on Environmental Quality regulations implementing the National Environmental Policy Act.

Environmental Consequences

Direct, Indirect, and Cumulative Effects

Direct effects of an action are caused by the action and occur on site and affect only the area where they occur. Indirect effects are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Examples of potential direct and indirect effects to water quality and riparian areas as a result of the Action Alternatives include:

- Reduction of the forest canopy would decrease interception (precipitation captured by leaves, branches, and boles) and increase net precipitation reaching the soil surface. Where disturbance is recent, surface runoff could reach waterbodies and affect water quality.
- Partial removal of the forest overstory reduces evapotranspiration (water lost from plants to the atmosphere), increasing soil moisture and runoff (Baker 1999, Ffolliott et al. 1989), which may improve riparian conditions.
- Increased soil moisture and loss of root biomass could reduce slope stability and increase soil erosion resulting in adverse effects to water quality.
- Increases in water yield after forest thinning are transitory and decrease over time as forests regrow unless subsequent treatments maintain initial post-treatment conditions.
- When young, dense forests with high interception rates (or higher annual transpiration losses) replace mature forests with lower interception rates (or lower transpiration losses), water yield is reduced until the young forest matures and thins naturally or is thinned in treatments.
- Impervious surfaces (roads and trails) and altered hillslope contours (cutslopes and fillslopes) modify water flowpaths, increase overland flow, and deliver overland flow directly to stream channels.
- Impervious native surfaces increase soil erosion.

Table 7 provides a comparative summary of direct and indirect effects to water quality and riparian areas by Alternative for the Four Forest Restoration Initiative Project.

Table 7. Comparison of direct and indirect effects of each Alternative considered for the Four Forest Restoration Initiative Project.

Resource and Unit of Measure	ALTERNATIVES				
	A No Action	B Proposed Action	C Preferred Alternative	D	E
--- WATER QUALITY AND WATER YIELD ---					
Water quality (unit of measure are acres of soil disturbance that exceed tolerance thresholds, acres subjected to high severity burn, acres of ephemeral streamcourses restored, and number of springs restored)	There would be no changes to surface water quality under the No Action Alternative. However, adverse effects to water quality and riparian condition are possible under the No Action Alternative. A high severity wildfire within the project area would have the potential to increase flood flows of sediment and debris-laden stormwater in streamcourses within and downstream of burned areas. These conditions would adversely affectwater quality and riparian areas along streamcourses through transport and deposition of large amounts of sediment and debris with the potential to damage or overwhelm riparian systems. Water yield in the form	Minor, short term changes (i.e., 1-2 years) in water quality are possible in water bodies adjacent to or downstream from mechanical vegetation treatments, areas subjected to prescribed burning, areas of temporary road construction and decommissioning, and where spring and ephemeral stream channel restoration activities are conducted. However, long term surface water quality is expected to improve through more resilient forest conditions that minimize uncharacteristic fire behavior and through improved vegetative ground cover that minimizes soil erosion and sediment transport to connected streamcourses and other waterbodies. Since soil disturbance at the 6th HUC (i.e., subwatershed) level would average 3.3 percent and range from 0.1 to 11.3 percent (Steinke, 2014), adverse effects to water quality are minimal. Protective fencing around springs would improve surface water quality at the individual spring scale. Additionally, BMPs and	There would be more acres of mechanical vegetation and grassland restoration treatments and fewer acres of prescribed burning under Alternative C as compared to Alternative B. As a result, minor, short term adverse effects to water quality are possible in water bodies within and adjacent to mechanical vegetation and grassland restoration treatment areas. Steinke (2014) estimates soil disturbance of 3.5% at the 6th HUC level and range of 0.1 to 11.5 percent. Overall effects to surface water quality from implementation of Alternative C would therefore be similar to the Proposed Action. Differences in changes to water	Substantially fewer acres would receive prescribed burning treatments as compared to the Proposed Action since slash/biomass would be treated through chipping, shredding, or mastication or removed rather than burned. Soil disturbance that could adversely affect surface water quality is estimated to be 2.9% at the 6th HUC level (Steinke, 2014) and range from 0.1 to 9.7 percent. While Alternative D would result in the lowest level of soil disturbance that could adversely affect surface water quality of all Action Alternatives, this alternative would not meet the purpose	There would be somewhat fewer acres receiving mechanical treatment than Alternative C and more than Alternatives B and D. There would be more acres receiving prescribed fire treatment than Alternative C, but fewer acres than under Alternatives B and D. Minor, short term adverse effects to water quality are possible in water bodies within and adjacent to mechanical vegetation and grassland restoration treatment areas as outlined for other alternatives. Steinke (2014) estimates soil disturbance of 3.2 percent at the 6th HUC level and a range between 0.1 to 10.8 percent. Overall effects to surface water

Resource and Unit of Measure	ALTERNATIVES				
	A **No Action**	**B** **Proposed Action**	**C** **Preferred Alternative**	**D**	**E**
	of sediment and debris-laden runoff typically increases in watershed subjected to high severity fire for the first 3 to 5 years following wildfire.	SWCPs as outlined in Table 1 would minimize or mitigate most adverse effects to water quality or riparian areas.	quality when compared to Alternative B would not likely be detectable at the landscape scale. Best Management Practices and SWCPs as outlined in Table 1 would minimize or mitigate most adverse effects to water quality or riparian areas at the site-specific, or localized scale.	and need of achieving resilient forest conditions that promote high surface water quality through protection of forested ecosystems from uncharacteristic fire behavior. Additionally, restoration of natural fire regimes to fire-dependent landscapes and vegetation types would not occur under this Alternative. Best Management Practices and SWCPs as outlined in Table 1 would minimize or mitigate most adverse effects to water quality or riparian area at the site-specific, or localized scale.	quality from implementation of Alternative E are expected to be approximately the same as the other Action Alternatives, although the distribution and types of disturbances will vary in space, and are expected to be less in MSO PACS. Differences in changes to water quality when compared to Alternatives B through C would not likely be detectable at the landscape scale. Best Management Practices and SWCPs as outlined in Table 1 would minimize or mitigate most adverse effects to water quality or riparian areas at the site-specific, or localized scale.
Water yield (units of measure are increases in stream flow as measured at downstream gaging stations, and increases in	Water yield originating from the ponderosa pine vegetation type would continue to decline as a result of forest ingrowth that increases stand density. Increased stand density results in a corresponding increase in interception of precipitation and	Water yield would be expected to increase only slightly in areas where vegetation treatments remove from 25 to 50 percent of the overall tree canopy cover within a given watershed (Troendle et al. 2001; Burton 1997; Swank 1989; Baker 1999, 2003; Ffolliott et al. 1989, Miller 2007). Snow interception by tree canopies would be reduced, leading to increased snowpack in forest	Under this alternative, more acres would receive mechanical vegetation treatments than Alternative B and more trees would be removed from within MSO PACs since trees up to 18 inches DBH would be removed. Water yield is therefore	Mechanical vegetation treatments would result in similar effects as Alternative B since the same number of acres are proposed for mechanical treatment under Alternatives B and D. Since there would be fewer acres	More acres would receive mechanical treatments to reduce stand density than under Alternatives B and D. However, approximately 27,000 fewer acres would receive mechanical treatments to reduce stand density than under Alternative

Resource and Unit of Measure	ALTERNATIVES				
	A No Action	B Proposed Action	C Preferred Alternative	D	E
snowpack retention as measured at SNOTEL sites and snow courses)	evapotranspiration by trees, both of which would reduce soil moisture.	openings.	expected to be slightly higher than under Alternative B since there would be more forest openings and less dense forest conditions. Snow interception by tree canopies would be reduced more under this Alternative than under the proposed action, therefore potentially increasing winter snowpack retention more than would occur under Alternative B.	subjected to prescribed burning under this Alternative, there would be reduced potential for runoff and sediment delivery to streamcourses under Alternative D.	C, leaving these areas susceptible to uncharacteristic fire behavior. Water yield would initially be slightly lower than Alternatives B and D and slightly higher than Alternative C.
--- SPRING, RIPARIAN AREA, AND WETLAND CONDITION ---					
Spring Functional Condition (units of measure are initiation of spring discharge from springs that currently do not flow and increases in spring discharge	There would be no changes to spring conditions under the No Action Alternative.	Spring conditions would improve for up to74 springs within the analysis area. Additionally, vegetation treatments at the watershed scale combined with prescribed burning could restore or improve hydrologic function of springs that currently have reduced discharge. Evapotranspirational losses of soil water by trees would be reduced through forest thinning. Low intensity prescribed fire would reduce herbaceous ground cover temporarily, thereby further reducing water uptake by vegetation for one to	Same as Alternative B	Same as Alternative B	Same as Alternative B

Resource and Unit of Measure	ALTERNATIVES				
	A No Action	B Proposed Action	C Preferred Alternative	D	E
from currently flowing springs following restoration treatments (i.e., changes in discharge per unit of time)		three years. This could improve soil moisture and groundwater conditions, particularly if restored conditions are maintained through either mechanical or prescribed fire treatments, or through combinations of these treatments.			
Riparian Area and Wetland Function (units of measure are soil erosion above tolerance and areas of high severity fire)	Reduced riparian area and wetland function are possible under the No Action Alternative. Ongoing reduction in water yield from increasing stand density in the ponderosa pine vegetation type would decrease the amount of water reaching riparian areas. Spring discharge rates could continue to decline, reducing water reaching streamcourses. Roads proposed for decommissioning that are adversely affecting streams with	Riparian and wetland function are expected to improve through increased groundwater recharge and improved surface flows as a result of stand density reduction and short-term reductions in vegetative ground cover following prescribed fire. Restoration of 74 springs has the potential to increase riparian vegetation and wetland function of these springs, depending on existing spring condition and type of restoration activities. Decommissioning of roads that have altered flow patterns through increased drainage density (i.e. road ditches that intercept water and lead-out ditches that discharge concentrated ditch flow onto the forest floor) or redirected stormwater runoff (i.e., roads and ditches that intersect	Riparian and wetland function are expected to improve under Alternative C. However, fewer acres would be subjected to prescribed fire, which would otherwise reduce vegetative cover and therefore rainfall interception and evapotranspirational losses. More acres would receive mechanical forest thinning under this Alternative than under other Action Alternatives. Reduced stand densities would result in short-term reduction in	Mechanical thinning would have the same effect as Alternative B since the same acres would be treated. Riparian and wetland function are expected to improve under Alternative D, but to a lesser degree than under Alternative B since fewer acres would be subjected to prescribed fire which would otherwise reduce vegetative cover and therefore rainfall interception and evapotranspirational losses.	More acres would receive mechanical thinning than Alternatives B and D. The reduces stand densities could result in short-term increases in water yield from treated areas and therefore improved riparian and wetland function in downstream areas. Fewer acres would receive mechanical thinning treatment than under Alternative C. Restoration of 74 springs would have the same effect as the other

Resource and Unit of Measure	ALTERNATIVES				
	A No Action	B Proposed Action	C Preferred Alternative	D	E
	riparian vegetation would continue to do so.	streamcourses and discharge stormwater runoff directly to streamcourses) would improve overall watershed hydrology, thus improving water flow to riparian ecosystems. Restoration of 74 springs would improve riparian vegetation communities where they exist in association with springs. Restoration of grassland ecosystems through removal of encroaching trees would improve hydrologic function in meadow ecosystems, potentially increasing riparian vegetation in these areas. More acres would be subjected to low severity prescribed fire than Alternatives C, D, and E. Low severity prescribed fire reduces rainfall interception and evapotranspirational losses due to short-term reduction in vegetative cover.	evapotranspirational water loss. Restoration of 74 springs would have the same effect as the other Action Alternatives. Decommissioning of roads that have altered flow patterns or redirected stormwater runoff would have the same effect as the other Action Alternatives.	Restoration of 74 springs would have the same effect as the other Action Alternatives. Decommissioning of roads that have altered flow patterns or redirected stormwater runoff would have the same effect as the other Action Alternatives.	Action Alternatives Decommissioning of roads that have altered flow patterns or redirected stormwater runoff would have the same effect as Alternative B.

Alternative A – No Action

Direct and Indirect Effects

Since no activities are proposed under Alternative A, there would be no direct effects to water quality or riparian area conditions as a result of this Alternative. However, indirect effects of the No Action Alternative are likely.

Much of the ponderosa pine forest is in Vegetation Condition Class 3 and trends indicate that fuel loading would continue to increase in both living biomass and woody detritus through natural forest ingrowth and tree encroachment into existing openings, resulting in increased risk of high severity wildfire. Ingrown understories can create ‘ladder fuels’ which allow ground fires to ascend and spread quickly as crown fires. Fine and coarse woody debris are expected to increase over time as small, medium, and large diameter material falls to soil surfaces and begins to decay. While the increased organic matter would improve soil quality in some regards (organic matter accumulation in subsurface horizons, microhabitat for soil organisms, increased short-term water holding capacity, improved nutrient status) it can also result in decreased herbaceous plant productivity and soil nutrient cycling and an increased risk of high severity wildfires where fuel loading becomes excessive. A dense forest litter layer (i.e., duff) displaces herbaceous vegetation (McConnell and Smith, 1970). Vegetative ground cover provides greater benefits to soil ecological function that forest litter alone through improved nutrient cycling due to fine root turnover, increased fine litter, improved soil porosity and aggregate stability, increased water holding capacity, increased infiltration, and decreased runoff. The location, size and intensity of future wildfires cannot be predicted with reasonable accuracy, although some generalizations can be made. High intensity wildfires tend to occur in areas where fuel loading and fuel distributions are sufficient to carry a fire. Typically, uncontrolled wildfires occur during the drier times of the year, yielding higher severity fires than would occur under prescribed fire conditions. The adverse effects of a high severity fire to water quality and riparian areas such as soil erosion above tolerance thresholds, sediment delivery to connected streamcourses, increased stream bedload, stream channel incision and bank failure, increased water turbidity, and downstream flooding would be more widespread in an uncontrolled wildfire situation than under prescribed fire conditions where the size and intensity of the fire can generally be controlled. Soil erosion models indicate that approximately 24% of all soils left untreated could be subject to soil erosion above tolerable levels from severe wildfires if all soils burned under condition of high burn severity.

Uncharacteristic fires on the Coconino National Forest historically have ranged from about 20-45% of the burn acreage resulting in high severity fire. While large stand-replacing fires on the Kaibab National Forest historically have 10-25% of the burn acreage exhibiting high severity fire conditions. Lata, (2014) suggests that, for fires managed primarily for suppression in extreme burning conditions, about 33% of ponderosa pine forests in Arizona burn with high burn severity. Therefore, if a 10,000 acre wildfire (being managed primarily for suppression in extreme burning conditions) were to occur within the analysis area, approximately 1,000 to 3,000 acres of high severity fire would be expected to adversely affect water quality and riparian conditions.

There have been many examples of recent stand replacing wildfires occurring in the southwestern

United States in areas that were originally open, fire-maintained forests (e.g., Rodeo-Chediski, Schultz, Horseshoe 2, Wallow, Las Conchas, Tres Lagunas, Jaroso, Thompson Ridge, Whitewater-Baldy, Slide, etc.). Such events can have profound negative effect to water quality and riparian conditions including: a) increased soil hydrophobic conditions (i.e. the inability of soils to absorb water following precipitation resulting in increased overland flow, b) increased sediment, ash, debris, and nutrient delivery to water bodies, and c) downstream flooding resulting in changes to stream geomorphology (i.e. increased bedloads, channel downcutting/incision, and channel aggradation), to name a few.

A high-severity fire is not certain to occur within the project area during any given timeframe. However, the occurrence of a high-severity wildfire would have an increased potential for profound adverse impacts to hydrologic systems in project area watersheds and downstream locations. As previously discussed in this report, such a fire event would likely result in increased runoff and potential for soil erosion and sediment delivery to streamcourses as a result of loss of forest interception of rainfall, reduced soil water infiltration rates, and the reduction of effective ground cover at the soil surface. The infrequent nature of ephemeral stream flow results in the potential for sediment and ash to be stored within these stream channels and then transported during surface runoff events. This, in turn, could pose detrimental effects to surface water quality and water storage capacity, including impoundments that are the sources of municipal water supplies for the Cities of Flagstaff and Williams.

Other potential detrimental effects to hydrologic conditions in the project area and downstream locations could include the destabilization of the geomorphic conditions of stream channels due to excessive sediment delivery and debris loading, increased peak flows, and overall increases in average annual water yield resulting from loss of upslope interception, infiltration, and evapotranspiration. Ephemeral stream channels within high burn severity areas would lose their ability to buffer runoff from large rainfall events, resulting in increased channel scour and incision caused by accelerated runoff and erosion from severely burned watershed areas. Increased bedloads in stream channels effectively raises the elevation of stream bottoms, causing flood flows to exceed channel capacities, resulting in overland flooding. These conditions could result in increased flooding risk within the 100-year floodplains previously identified in this report.

Another effect is sediment and ash deposition in downstream roads, stock tanks and meadows, even if such areas may not have burned. In addition, sediment and ash-laden overland flows may damage low lying roads by eroding road traveled ways and filling culverts and low water crossings with sediment and debris. These are examples of why post-wildfire watershed conditions are significantly different from pre-fire or low-severity prescribed fire conditions.

Soil hydrophobicity occurs naturally in soils (DeBano 1981, Doerr et al. 2000). It is the result of leaching of hydrophobic compounds, such as aliphatic hydrocarbons, from the litter and humus layers. Under unburned conditions, soil hydrophobicity below the soil surface is commonly associated with fungal mycelia (Savage et al. 1969). However, high fire intensity can volatize hydrophobic compounds in the litter, humus, and soil organic matter (DeBano et al. 1966). These compounds can then enter the soil atmosphere and condense on cooler soil particles at or below the soil surface (DeBano 1981). The condensation of these compounds forms a hydrophobic layer on the soil particles (DeBano and Krammes 1966, Savage 1974).

The formation of a strong hydrophobic layer after natural or prescribed fires can inhibit infiltration (Scott and van Wyk 1990). When ash and soil above a hydrophobic layer become saturated, any additional precipitation will become runoff. The rate of runoff from forested areas can therefore increase dramatically after burning if a hydrophobic layer is present; and this surface runoff, when combined with the loss of a protective litter layer, can cause even larger increases in surface erosion and sediment yields (e.g. Helvey 1980, Scott and van Wyk 1990).

Sediment yields in the first year after a wildfire can range from very low in relatively flat topography with minimal rainfall to extreme on steep landscapes affected by high-intensity thunderstorms (Robichaud et al. 2000). Hendricks and Johnson (1944) observed wildfire induced sediment yields ranging from 71Mg per ha per year on 42 percent slopes to 202 Mg per ha per year on 66 percent slopes, and 370 Mg per ha per year on 78 percent slopes in Upper Pocket Creek in central Arizona. Following the North 25 Fire in in 1998, Robichaud and others (2006) observed first year mean erosion rates of 16 Mg per ha, with most erosion occurring during short duration, moderate intensity summer storms.

The physical, chemical and biological characteristics of surface water can be adversely affected by post fire conditions. The discussion in this report is limited to the physical and chemical changes to surface water resulting from fire. Biological effects are therefore inferred from the changes in the physical and chemical properties of surface waters following fire.

Increased sediment loads are the primary physical impacts to surface waters following fire. The bulking effect of sediment and ash in runoff increases the risk to surface water impoundments, infiltration basins, and public water treatment systems. Sediment and debris flows can damage water supply infrastructure. Sedimentation of impoundments can decrease their effective life, resulting in a need for dredging and other mitigation measures. Biological pathogens are easily adsorbed to sediment and ash, which can overload public drinking water treatment facilities, increasing the cost of water treatment. Metals such as Mercury and Iron and other chemical constituents in surface runoff can adsorb to clay particles in sediments, further adversely affecting water quality. The large quantities of post-fire sediment can overwhelm the biological habitats of aquatic organisms such as fish, as well as organisms that depend on water for some life stage, such as amphibians and invertebrates.

Altered solute and debris content in surface waters following wildfire can also change nutrient dynamics, light, and temperature regimes (i.e., thermal pollution) (Betts and Jones 2009). When riparian vegetation is removed by fire or other means, the stream surface is exposed to direct solar radiation, and stream temperatures increase (Neary et al. 2005). Reduced concentrations of dissolved oxygen (O_2) that can occur as a result of increased surface water temperatures can result in fish mortality.

Elevated pH values of soils following wildfires have been shown to increase pH values in streamflow (DeBano et al. 1998, Landsberg and Tiedemann 2000). The combustion process releases bound nutrients, many in elemental form. Some cations (i.e., positive ions), are stable at typical combustion temperatures and remain onsite after burning. They subsequently infiltrate into the soil or are transported in runoff where they exchange with H^+ ions; the resulting decrease in H+ ions in solution increases the pH. Nutrient availability is related to soil acidity (c.f., Tisdale and Nelson, 1975). Bicarbonates (HCO_3^-) and carbonates (CO_3^{2-}) may also contribute to increased surface water alkalinity.

Nitrate (NO_3^-), nitrite (NO_2^-), ammonium (NH_4^+) and ammonia (NH_3) are the forms of nitrogen that can be altered after fire. Values for nitrate generally increase after fire. Stream nitrate responses to prescribed fire are generally lower than for wildfire. In an undisturbed ponderosa pine and Gambel oak watershed in Arizona, Gottfried and DeBano (1990) observed slight, but significant increases in nitrate in surface water following fire. The potential for increased NO_3^- in streamflow after fire is attributed mainly to increased mineralization and nitrification (Vitousek and Melillo 1979, Covington and Sackett 1986, DeBano and others 1998) and reduced plant demand (Vitousek and Melillo 1979). This increase is the result of the conversion of organic N to available forms, mineralization (Covington and Sackett 1992), or mobilization by microbial biomass through the fertilizing effect of ash nutrients and improved microclimate (Ojima et al. 1994). These postfire effects are usually short lived, lasting only a year or two (Kovacic et al. 1986, Monleon et al. 1997)

The mobility of phosphorus (P) increases after wildfires, and to a lesser extent after prescribed fires since phosphorus is easily adsorbed to sediment and ash and is therefore readily transported in runoff. Most of the increase in P concentrations in surface water is therefore due to higher post-fire erosion rates.

The introduction of weeds and unwanted flora following a wildfire could lead to increased competition between less desirable invasive and noxious weeds and desirable native vegetation. Weeds can increase erosion by reducing soil moisture and depleting nutrient levels (DiTomaso 2000), leading to a less vigorous native plant community, and therefore overall ground cover. The resulting erosion can degrade surface water quality and increase bedloads and channel scour in riparian areas.

Under the No Action alternative, there would be no obliteration and no relocation of roads that are currently contributing to loss of soil productivity and degradation of water quality. These roads would remain at risk of unauthorized use, further contributing to soil destabilization, loss of productivity, and adverse impacts to surface water quality. Ongoing road maintenance of ML-2 and ML-3 roads within the project area would continue as it has in the past.

Under the No Action Alternative, there would be no restoration of springs and no restoration of ephemeral channels. These areas would continue to exhibit downward trends in functional condition or remain in static condition for the foreseeable future.

This alternative would result in no additional acres of ground disturbance from mechanical vegetation treatments, piling of activity-related woody debris, construction and maintenance of temporary roads, road obliteration, fence construction, and the use of prescribed fire. Since these activities can have short-term adverse effects to water quality and riparian areas, Alternative A poses fewer short-term risks to water quality and riparian areas than the Action Alternatives. However, since uncharacteristic fire behavior would not be reduced or mitigated within the project area, long-term risk to water quality and riparian areas would be greatly increased under the No Action Alternative.

The No Action Alternative would not meet the purpose and need of forest restoration that would provide for more resilient forest conditions that would better protect forested ecosystems and watersheds from uncharacteristic fire behavior and improve ecosystem function in grassland vegetative communities, spring ecosystems, ephemeral streamcourses, and perennial waterbodies.

Alternative A proposes no forest restoration treatments as described under the Action Alternatives. However, on-going treatments such as forest thinning, prescribed burning, road decommissioning, spring restoration, etc. would likely continue in accordance with applicable Forest Plans and National Environmental Policy Act (NEPA) analyses. Mechanical vegetation treatments and acres subjected to prescribed fire would likely be much less than all action alternatives since they would not be landscape-scale projects, so there would be fewer anticipated affects to water quality and riparian area conditions

It should be noted that in the absence of forest restoration treatments at the scales analyzed under the action alternatives, there is an elevated risk of uncharacteristic, high-severity wildfire that would result in severe detrimental effects to water quality and riparian area conditions. In areas where acres continue to receive restoration treatments under Alternative A water quality and riparian area conditions are expected to improve. Since these acres would be substantially less than all action alternatives, Alternative A would be the least effective alternative in achieving forest restoration objectives and desired condition within the 4FRI analysis area.

Cumulative Effects

The cumulative effects analysis area includes the eighty-two 6th-level (HUC12) subwatersheds, which total 2,032,080 acres. The timeframe for past actions is 10 years, based on vegetative and course woody debris recovery of treated areas. Vegetative recovery following fuel reduction treatments is generally rapid, with erosion rates typically returning to pre-treatment levels within 1 to 2 years (Elliot 2000). Because no actions are proposed, no direct cumulative effects would occur.

The No Action Alternative would result in no vegetation or fuels reduction treatments being performed, no new temporary road construction, no road obliteration, no unscheduled maintenance of existing roads, no restoration of springs or ephemeral channels, and no prescribed burning within the project. Therefore, there would be no cumulative effects to water quality, ephemeral or intermittent stream channels, watershed condition, or changes to water yield resulting from the No Action alternative. However, land management activities and changing vegetative conditions throughout the last 100 years have produced an uncharacteristic accumulation of fuels and increased tree density throughout much of the project area. These conditions make wildfire a possibility and suppression difficult.

A high severity wildfire within the Lake Mary Region (LMR) would result in atmospheric deposition of mercury within and beyond the LMR. The resulting soil hydrophobicity would increase stormwater runoff and delivery of mercury-containing sediment to water bodies in the LMR. Through reduced threat of uncharacteristic fire behavior and implementation of design features, BMPs, and mitigation measures as described in Appendix C of the DEIS, mercury levels in water bodies of the LMR are not expected to increase.

Direct and Indirect Effects to Water Quality and Riparian Resources Common to All Action Alternatives

Mechanical forest vegetation treatments have the potential to adversely affect water quality and riparian areas through delivery of sediment and additional nutrients from decomposing woody debris, particularly from vegetation treatments adjacent to stream courses.

The effects of the proposed forest restoration activities on sediment yields and water quality depend on methods and equipment used, skills of the equipment operators and personnel conducting the treatments, site-specific conditions, storm event timing and intensity, prescribed fire locations and burn severities, adaptive management strategies, and implementation and effectiveness of BMPs.

The risk of sediment delivery to streamcourses is expected to increase in areas where forest thinning and use of prescribed fire results in soil disturbance or complete removal of vegetative ground cover in close proximity to drainages. Such areas would include designated stream crossing, skid trails, log landings, temporary access roads, obliterated roads, installed firelines, existing National Forest System roads, and areas burned at high severity near streamcourses. With appropriate and effective implementation of BMPs and SWCPs as outlined in Table 1, most adverse effects to water quality and riparian conditions caused by forest vegetation treatments would be minimized or mitigated.

The removal of forest cover can decrease raindrop interception and evapotranspiration, which can increase water yields from treated areas (Bosch and Hewlett 1982, Stednick 1996). In areas where the annual precipitation is less than 20 in (500 mm), removal of the forest canopy does not typically increase annual water yields (Bosch and Hewlett 1982). In these drier areas, the decrease in interception and transpiration caused by forest thinning is usually offset by the increase in soil evaporative losses, resulting in no net change in runoff as long as factors affecting runoff processes are not changed (for example, soil compaction which causes a shift from subsurface flow to overland flow) (MacDonald and Stednick 2003). Evapotranspiration rapidly recovers with vegetative regrowth in partially thinned forests. Increases in runoff due to thinning operations rarely persist for more than 5 to 10 years, unless post-treatment conditions are maintained. However, long-term studies conducted in the central Arizona highlands in a variety of ecotypes (i.e., chaparral, riparian, ponderosa pine, mixed conifer, and pinyon-juniper) indicate that increases in water yield can be achieved, although the duration and intensity of effects vary considerably. In general, the largest increases in water yield were associated with the highest reductions in tree basal area and canopy cover within treated watersheds (Baker 1999, Brown et al. 1971, 1974, Rich et al. 1976).

Thinning of forest cover on soils currently characterized as unsatisfactory would improve soil conditions over the long-term by improving soil moisture and allowing greater sunlight penetration to the forest floor (i.e., sunflecks) resulting in an increase in grasses, forbs and shrubs in the forest understory. The increased herbaceous vegetation would reduce long-term soil erosion and associated sediment delivery rates by providing vegetative and litter ground cover that would intercept rain before it can reach soil surfaces and detach and entrain soil particles in runoff water. Improved vegetative ground cover also improves soil porosity, aggregate stability, and surface roughness, which decreases runoff velocities and sediment delivery. The long-term result is improved surface water quality and improved stream and riparian function.

Prescribed fire has the potential to impact water quality by increasing sediment, ash, dissolved solids, and nutrients in streams. Dissolved nutrients in streamflow primarily originate from weathering of parent materials and soils, decomposition of plant material and other organic matter, and anthropogenic sources. Vegetative communities accumulate and cycle nutrients (Tiedemann et al. 1979, 1980). Fire can disrupt nutrient cycling and cause nutrient volatilization, leaching, and transformations. When vegetation is consumed by fire, some of the soil nutrients contained in the organic matter such as nitrogen, phosphorus, copper, iron, manganese, and zinc are volatilized and lost from the system, while other nutrients such as calcium, magnesium, and potassium are converted into oxides and accumulated in ash (DeBano et al. 1998). These materials either can contribute to increased soil productivity or be entrained in runoff resulting in increased nutrient loads in streams and a corresponding degradation of surface water quality.

The mobility and concentration of nutrients in soils determines whether nearby water sources are at risk of contamination through increased nutrient loads when prescribed fire is used. Nitrate is highly mobile and is therefore subject to risk of being leached from burned areas and transported to either surface or ground water. Phosphorus adsorbs readily to sediment and organic materials. Thus, phosphorus is usually transported to streams and water bodies through soil erosion. Rates of soil erosion and phosphorus contamination are generally dependent on soil characteristics and topographic relief of the site.

The Lake Mary TMDL indicates the major source of mercury to the lakes in the Lake Mary Region (LMR) is atmospheric deposition with some mercury originating from natural geologic materials (primarily from volcanic activity). Historically, disturbances such as livestock grazing and timber harvesting have contributed to increased soil erosion and delivery of mercury-containing sediment to lakes during episodic precipitation events.

The primary form of mercury in lake water in the LMR is Hg^{2+}, which is a highly stable, inorganic form. This inorganic form can be partially reduced to Hg^0, which can be evaporated back to the atmosphere, and partially methylated into methyl-mercury ($MeHg^+$). The methylation of Hg^{2+} is a natural, biological process that produces highly toxic and bioaccumulative methyl-mercury compounds that build up in living tissue and can increase in concentration up the food chain, from microorganisms, to small fish, then to fish-eating species, including humans. Biomethylation rates of Hg^{2+} are a function of several environmental variables that control mercuric ion (Hg^{2+}) availability. These include, but are not limited to: the population sizes of methylating microbes, pH (which affects adsorption of mercury to organic matter and soil particles), the amount of organic matter present in the system, availability of sulfide ions, and water temperature (which controls biological activity).

The key to limiting the delivery of mercury to water bodies in the Lake Mary Region is implementation of design features, BMPs, and mitigation measures as described in Appendix C of the DEIS. Specific BMPs that would minimize or mitigate potential for mercury to be mobilized in sediment and delivered to water bodies include: FE2, FE3, FE5, FE6, FE8, FE9, R6, SW1, SW2, SW6-SW37, T3, T7, and T8.

Prescribed fire has the potential to alter short- and long-term soil productivity and moisture content by changing the amount and type of vegetation, the amount of forest floor organic matter, and surface soil texture and wettability. Prescribed fires typically leave greater amounts of organic matter (duff, forest litter, and large and small woody debris) on soil surfaces than uncontrolled fires. These materials serve as nutrient sinks, prevent soil particle detachment caused by raindrop impact, and capture sediments that would otherwise be transported to stream channels and waterbodies. Following low-intensity prescribed fires, an increase in grasses and other herbaceous vegetation often occurs. This rapid regrowth of vegetative ground cover further immobilizes nutrients in plant material and prevents soil erosion and sediment delivery to streamcourses, thus protecting surface water quality.

Prescribed fires that remove large amounts vegetation from a site have potential to alter watershed hydrology. As vegetation is removed, evapotranspiration in the watershed decreases, thus providing greater stream flow and overall water yield within the watershed. Water uptake from trees is species-specific. Conifers, which are the dominant vegetation type within the Four Forest Restoration Initiative Project area, generally transpire greater quantities of water than hardwoods such as oaks and aspen. Dense foliage and longer growing seasons promote the higher overall water uptake in conifers. Additionally, conifers have relatively dense crowns that intercept rainfall and allow for greater evaporative losses.

Once a site has undergone loss of vegetation and removal of the litter layer, stormwater runoff and rapid snowmelt can cause erosion problems and result in higher stream discharges. Fires not only consume portions of the litter layer, but at high temperatures fires can also cause short term hydrophobic soil conditions, thus making soils more susceptible to erosion. DeBano and Krammes (1966) and Robichaud (2000) observed that water repellency was dependent on the heating temperatures of the soils. At typical wildfire soil profile temperatures (less than 500°F) when the soil was dry, soil hydrophobicity occurs at shallow depths (less than 1 inch). When soils are moist (i.e. conditions that commonly occur during prescribed fire in the spring and fall), soil hydrophobicity was less pronounced and only occurred after long heating times, which would typically only occur during smoldering fires. Therefore, soil hydrophobicity under a prescribed fire scenario would likely be minimal throughout the majority of the treatment area. Compared to soils with moderate or high soil hydrophobicity, lower soil hydrophobicity results in faster soil water infiltration rates, thus protecting surface water quality and riparian systems by minimizing surface runoff and erosion.

The effects of restoration of 74 springs within the project area would be the same under all Action Alternatives. These effects include: a) naturalization of some springs that are in a degraded condition through removal of dilapidated infrastructure, b) improved ecological function of springs as a result of reduced tree density in areas above or surrounding springs and reintroduction of low-intensity fire to fire-adapted ecosystems c) potential increase in spring discharge following forest and grassland restoration treatments, and d) protection of springs from adverse impacts caused by humans and herbivores.

Runoff from road surfaces can detach and transport the fine material from road prisms and ditches. Sediment delivery directly from road surfaces to water courses is difficult to estimate since it occurs as non-point source runoff. Sediments delivered to streams from roadside ditches may have originated from sheet or rill erosion prior to entering road surfaces or drainage ditches. In the absence of vehicle traffic, sediment concentrations in road runoff decreases over time. However, vehicle traffic, particularly trucks, can pulverize road surface aggregates, resulting in more fine particles that are easily transported in runoff. Additionally, the pressure of vehicular tires on saturated road surfaces can force fine particles from below the surface to move upward to the surface (Truebe and Evans 1994). Road proximity and connectivity to drainages can strongly influence sediment delivery to watercourses and peak flows in streams. Roads within the project area intersect numerous ephemeral drainages. These points of intersection occur as both culverted crossings and low-water crossings. Road-stream intersections are the primary location where sediments are delivered to stream courses.

A total of approximately 860 miles (1,251 acres, based on an average road width of approximately12 feet) of existing system roads and unauthorized roads would be decommissioned under all Action Alternatives. Road decommissioning could ential activities such as ripping and seeding or mulching, filling of inside ditches, outsloping of road prisms, removal of culverts and fill materials, recontouring at stream crossings, removal or stabilization of unstable sidecast or cutslopes, and blocking of entrances to prevent future access or use. These activities would return unproductive acreage to a more stable, productive status over the long term by improving water infiltration, naturalizing water flow, increasing vegetative ground cover and reducing erosion. Upon completion of road decommissioning and obliteration activities, long term erosion rates of decommissioned roads are expected to approach natural erosion rates for TEUs where these roads occur. With implementation of appropriate BMPs and SWCPs as outlined in Table 1, water quality and riparian ecosystem conditions would be improved.

Approximately 520 miles of temporary roads with widths of approximately 12 feet (i.e., 756 acres) would be necessary to conduct vegetation treatments under all Action Alternatives. These roads would be constructed using BMPs and SWCPs as outlined in Table 1, thus minimizing adverse effects to surface water quality. No riparian areas would be adversely affected by temporary road construction as no temporary roads are proposed within riparian areas.

Reconstruction of up to 40 miles of existing, open roads for resource and safety concerns is proposed unde all Action Alternatives. Of these miles, approximately 30 miles would be improved to allow for haul (primarily widening corners to improve turn radii) and about 10 miles of road would be relocated out of stream bottoms. Relocated roads would include rehabilitation of the moved road segment. These practices would improve water quality and riparian area conditions by removing roads from stream bottoms where they do not belong and where they represent a direct and recurring threat to water quality through increased sediment and nutrient delivery and turbidity.

Thirty-nine miles (508 acres, based on an average channel width of 107.5 feet) of ephemeral streamcourses would be returned to a more natural condition, thus reducing channel and bank scour, downcutting, aggradation, and uncharacteristic levels of sediment transport. Initially, ephemeral streamcourse restoration would likely exhibit slight increases in short-term sediment production and transport since stream banks and channels would be disturbed during the reshaping and restoration process. As restored areas stabilize, these ephemeral streamcourses would return to a more natural state with banks having more gentle angles of repose that would support vegetative cover, more favorable floodplains to increase soil water and depression storage, and reduced stream velocities; thus decreasing sediment transport, channel downcutting, and stream bank undercutting that results in bank failure.

There would likely be some minor, short-term, localized adverse effects to water quality from the Action Alternatives in the project area in the form of increased runoff from treated areas, increased sediment delivery to ephemeral drainages and downstream waterbodies, increased short-term surface water turbidity, and increased nutrient loads in surface waters. Implementation of action alternatives is expected to improve water quality and riparian area conditions in the long term due to improved vegetative ground cover of grasses, forbs, and shrubs which would improve soil stability and water holding capacity, increase sediment capture in surface runoff, and minimize runon to roads and roadside ditches. Since treatments would be temporally sequenced (i.e., not occurring simultaneously throughout the project area or within a single watershed, but instead implemented over time), the likelihood of large-scale soil erosion or large sediment pulses delivered to streams is minimal.

Water yields from the ponderosa pine vegetation type are likely reduced from historic conditions due to increased stand densities that result in higher evapotranspiration rates (Covington and Moore 1994). Four Forest Restoration Initiative treatments will decrease basal area of ponderosa pine, which has been shown in past studies to increase water yield at least temporarily. The Beaver Creek Experimental Watersheds (BCEW) study found that initial water yield increases of 15 to 40% are realistic on shallow, basalt-derived soils when the basal area of ponderosa pine forest is reduced by 30 to 100%, due largely to reduced evapotranspiration (Baker 2003). Areas with a northern exposure or deeper soil profiles generally provide increased water yield for longer periods of time than south-facing slopes or sites with shallow soil development (Gottfried and DeBano 1990). Given that ponderosa pine yielded an average of about 0.25 acre-feet per acre annually from the late 1950s to the early 1980s (this amount would be less in recent drought years), water yields increased by approximately 0.375 to 0.10 acre-feet per acre following strip cut, patch cut, shelterwood and clear cut treatments on the BCEW. Following treatments, water yield increases diminished due to vegetative regrowth and increasing ET, so that after 6 to 10 years there was no significant difference in water yield.

Under the Proposed Action and other Action Alternatives, mechanical restoration treatments would be conducted on 384,966 acres (Alternatives B and D) to as much as 431,049 acres (Alternative C), with Alternative E representing a midpoint for mechanical treatments at 403,500 acres. These treatments are expected to result in a short-term increase in water yield *if restoration treatments are not maintained*. If 30,000 acres are consistently treated per year and the treatment effect on water yield diminishes each year following treatment for a period of 6 years, (depending on weather conditions) water yields may increase through the first 6 years and then remain static for as long as 30,000 acres per year are treated, after which they will naturally decline. Prescribed burning treatments that mimic the natural fire return interval might extend the period of increased water yield, particularly if treatments are maintained through subsequent burning. One of the objectives of the paired watershed study in Alternative C is evaluate the effects of treatments on water yield.

Cumulative Effects Common to All Action Alternatives

Cumulative effects include the impacts on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other action (40 CFR § 1508.7). The geographic setting for the cumulative effects analysis for soils and watersheds includes all of the 6th-level (HUC12) hydrologic unit watersheds that intersect the Four Forest Restoration Initiative analysis area, which comprises approximate 2,032,080 acres. The timeframe for past actions is 10 years, based on soil productivity, vegetative response, and coarse woody debris recovery within treated areas. Surface disturbing activities that are older than 20 years are assumed to be contributing negligible or no measurable cumulative effects within the analysis area.

Following is a partial listing of actions considered in the cumulative effects analysis for this project:

- Activities such as vegetation/fuels management, livestock grazing, and noxious weeds treatments have occurred in the past, are occurring, and are reasonably foreseeable actions within the analysis area. These activities could occur on private lands as well.
- Firewood cutting has occurred in the past and would likely continue in the foreseeable future on both Forests
- Other landowners (state and private) may harvest timber on their lands for lumber, fuelwood, or to reduce fire hazards.
- Urban development and interface growth will continue on private lands.
- Road construction, maintenance and right-of-way clearing can be expected to continue on non-National Forest System land.
- Road maintenance, reconstruction, or decommissioning will occur with future vegetation management projects on National Forest System land.
- Recreation activities are expected to continue to increase on the Forests. Future recreation projects may be developed.
- Activities associated with livestock grazing such as fence construction and maintenance and sediment removal from livestock and wildlife waters (i.e., stock tanks) have occurred in the past, are occurring, and are reasonably foreseeable actions within the analysis area.
- Forest reestablishment (tree planting) in areas subjected to high severity wildfire
- Gravel extraction, including expansion of existing gravel pits for road surface material within and outside of the analysis area has occurred in the past, is occurring, and is a reasonably foreseeable action within the analysis area.

Vegetation Management/Fuels Management

Vegetation management projects such as commercial timber harvesting, precommercial forest thinning, and fuelwood gathering reduce overstory cover in the short-term but typically result in an increase in understory vegetation within three to five years following treatment. These projects typically cause an initial increase in soil organic matter in the form of residual woody debris from tree harvesting activities, which improves surface roughness and soil nutrient cycling. As grasses and forbs increase in numbers, fine root material contributes to soil organic matter accumulation, organic carbon sequestration, improves soil aggregate stability and soil porosity, and protects soil surfaces from erosion. Reduction of tree canopy and fuel loads would reduce the threat of high severity wildfire that could remove plant and litter cover, consume soil seed banks, sterilize soils, and create erosion and flooding hazards. Decreased interception of precipitation (rain and snow) would result in increased soil moisture and surface runoff following vegetation treatments. Improved understory vegetation that serves as a filter for stormwater runoff; increased soil organic matter content that improves soil stability and nutrient cycling; reduced fuel loads that prevent uncharacteristic fire behavior; and reduced interception of precipitation by trees, would all contribute to improved surface water quality and riparian function by minimizing sediment delivery to streamcourses, and decreasing channel degradation, downcutting, aggradation, sediment transport, channel embeddedness, bank scour, etc.

From 2000 to 2010, the CNF has focused forest vegetation treatments on areas with smaller diameter trees (i.e., 12 inches dbh or less). Such projects include: Rocky Park Fuels Reduction (5,561 acres thinned up to 12” dbh, 2001), Eastside Fuels Reduction (3,404 acres thinned up to 12” dbh, 2006), and East Clear Creek Watershed Health Project (1,645 acres thinned up to 9” dbh, 2006). The Kaibab NF has also focused vegetation treatments on smaller diameter trees (generally 9 inches dbh and lower) on approximately 6,514 acres. Projects on the KNF include the Williams High Risk Project (756 acres, 2001), Scott (421 acres, 2001), Pineaire Fuels Reduction Project (650 acres, 2004), Topeka Fuels Reduction (1,100 acres, 2004), Ten X Pre-Commercial Thinning Project (1,780 acres, 2004), City Project (2,366 acres, 2005), and Horse Pine stewardship contract (2,333 acres, 2013). Approximately 3 percent of the total project area has therefore received beneficial vegetation treatments. Although these projects have improved forest conditions on a localized scale, and therefore reduced risk of uncharacteristic fire behavior on these treated acres, treatments have not effectively reduced forest ingrowth at the landscape scale. As a result, elevated risk of uncharacteristic fire behavior that would adversely affect surface water quality and riparian function persists throughout much of the project area.

On both Forests, vegetation management/fuels reduction projects have typically included the construction and subsequent decommissioning of temporary roads as well as decommissioning of NFS roads. Since 2000, approximately 47 miles of temporary roads have been constructed and decommissioned to facilitate vegetation management/fuels reduction treatments and 251 miles of NFS roads have been decommissioned. Of these, approximately 117 miles were on the KNF and 44 miles were on the CNF).

Livestock Grazing

Currently, livestock grazing is authorized on approximately 790,985 acres, or 38 percent of the overall analysis area. While grazing results in discontinuous fuel patterns in grass, forb and shrub vegetal communities, it has not effectively reduced the densities of seedlings and saplings in ponderosa pine stands. As a result, excessive stand densities in the ponderosa pine vegetation type are causing a shift in understory vegetative communities toward more shade tolerant species such as bromes and mountain muhly.

Based on historic range monitoring data, Brewer (2011) concluded that cool season species increased in numbers through the 1990's in response to an increase in cool season moisture. However, over the last 10 years, reduced cool season moisture and increased warm season moisture has resulted in a corresponding shift toward dominance of warm season species. Since increased livestock grazing is not proposed under any alternative, the increased herbaceous understory would provide improved protection of soil surfaces from erosion, thus improving water quality.

Many riparian areas on the CNF and KNF have already been fenced to exclude domestic livestock grazing. Riparian conditions would continue to improve over time in these areas as soil compaction is naturally reduced through freeze-thaw and wetting-drying cycles.

Since livestock grazing would be excluded from fenced springs, these areas would improve over time. Riparian vegetation extent and condition associated with spring ecosystems are expected to improve under all Action Alternatives where spring discharges occurs.

Noxious Weeds Treatments

Existing conditions within the project area indicate that weeds have expanded to as much as 187,500 acres or 3 percent of the land area within the Coconino, Kaibab and Prescott National Forests (USDA 2005). Bull thistle, leafy spurge, knapweeds, and Dalmatian toadflax have increased dramatically over the past 20 years. Riparian corridors, especially the Verde River, exhibit increases in tamarisk, Russian olive and tree of Heaven, as well as some of the knapweeds. There are currently 25 known weed species found within the 3 national forests and 4 species adjacent to them. The desired condition is to prevent any new weeds from becoming established on NFS lands. Eleven species (98 percent of the infested acres) have been assigned a contain/control objective; an additional 10 species are targeted for complete eradication; and 1 species (representing about 1 percent of the infested acres) is assigned an eradicate/control objective. The control of these plants promotes ecosystem health and prevents loss of the productive capacity of the land. These actions also prevent decline in riparian values within the project area.

Firewood Cutting

Firewood cutting typically reduces stand densities, thereby improving understory vegetative production. Adverse effects such as soil compaction, puddling, displacement, and erosion are short term, minor, and localized. Within 3 to 5 years, ground cover typically improves in areas where firewood collection has occurred due to increased sunlight reaching the forest floor, increased organic matter from residual fine woody debris, and improved nutrient availability. Implementation of BMPs and SWCPs during and after fuelwood cutting minimizes and mitigates adverse impacts to water quality and riparian areas by reducing stormwater runoff and sediment delivery to waterbodies.

Forest Management Activities on Private Property, State, and Other Agency Lands

The Rural Communities Fuels Management Partnership has resulted in reduction of tree density on more than 200 acres of private property in the Parks, Sherwood Forest Estates, and Williams communities adjacent to the KNF from 2001 through 2004. These treatments have decreased the risk of high severity fires in these areas. By reducing the risk of uncharacteristic fire behavior, overall watershed condition is improved thereby protecting water quality and riparian area conditions.

The Camp Navajo Multi-Service Training Site in Bellemont borders both the Kaibab and Coconino National Forests and is within the project area. Camp Navajo implemented forest thinning treatments on 350 acres in 2011 to complete post-tornado recovery. Below is a list of recently completed and proposed projects identified in the Integrated Natural Resources Management Plan (2014).

PROJECT 1A2: Timber Stand Improvement, Stands 1 & 22 (257 acres) (2013). Remove pre-commercial size trees (ladder fuels) to reduce fire risk in these stands in 2013. These stands were scheduled for treatment in the Finding of No Significant Impact West Buffer Training Area Forest Thinning and Prescribed Fire Project.

PROJECT 1A3: Timber Stand Improvement/Tornado Fuels Reduction Area (327 acres) (2013). Identify and perform timber stand improvement work (thinning of ladder fuels and treatment of slash) on the Tornado Fuels Reduction Project Area in 2013.

PROJECT 1A4: Harvest preparation of Stand 70 (2013). Expand the boundary of Stand 70 to include area suitable for ground-based equipment and mark and cruise the area in 2013. This stand was scheduled for treatment in the Finding of No Significant Impact West Buffer Training Area Forest Thinning and Prescribed Fire Project.

PROJECT 1A5: MTC-Light EA (2014). Complete NEPA through decision for the Maneuver Training Center Light Environmental Assessment, which includes plans for forest and grassland treatments (thinning and prescribed burning on 17,049 acres), by 2013.

PROJECT 1A6: MTC-Light Transportation Plan (2014) - Develop transportation plan for proposed MTC-Light Mechanical Thinning (Phases I-III).

PROJECT 1A7: Thinning of Stands 32 & 70 (347 acres) (2014). Thin Stands 32 and 70 to develop nesting and roosting habitat for MSO in 2014. These stands were scheduled for treatment in the Finding of No Significant Impact West Buffer Training Area Forest Thinning and Prescribed Fire Project.

PROJECT 1A8: MTC-Light Phase I, Sale Preparation (Appraisal, Layout, Contract Prep and Award) (2015) - Complete a report of appraised value of forest products; lay out and mark cutting unit boundaries; develop, advertise and award the contract for Phase I of MTCLight Forest Treatments.

PROJECT 1A9: MTC-Light Mechanical Thinning (4,700 acres), Phase I (2015-2017). Implement thinning treatments as prescribed in the MTC-Light EA. Target accomplishment is a minimum of 4700 acres by 2017.

PROJECT 1A10: MTC-Light Contract Administration (Annually, 2015-2023). Administration of the contract for all three phases of MTC-Light Forest Treatments.

PROJECT 1A11: Prescribed burn plan development / preparation of burn sites (2015-2025). Develop prescribed burn plans for scheduled burns and prepare proposed sites for burning.

PROJECT 1A12: Pile Burning (701 acres): Stands 1 & 22; Squirrel Meso Reserve Area; West Buffer MSO PAC; Tornado Fuels Reduction Area (2015).

PROJECT 1A13: West-Side Training Area Maintenance Burn (2015). Perform maintenance burning of previously burned areas to restore the historic fire interval. Perform prescribed burning on 304 acres in 2015.

PROJECT 1A14: West-Side Training Area Prescribed Burn (2015). Prescribed burning of Stands 47 & 67 (968 acres) in the West Side Training Area. This is the initial burning of these areas (including slash piles) following mechanical thinning. Implementation is planned for 2015 which allows 2 years for slash to cure.

PROJECT 1A15: West-Side Training Area Maintenance Burn (2016). Perform maintenance burning of previously burned areas to restore the historic fire interval. Perform prescribed burning on 370 acres in 2016.

PROJECT 1A16: West-Side Training Area Maintenance Burn (2017). Perform maintenance burning of previously burned areas to restore the historic fire interval. Perform prescribed burning on 501 acres in 2017.

PROJECT 1A17: MTC-Light Prescribed Burning (4700 acres), Phase I. Prescribed burn the mechanically treated areas in Project 10A1 in 2019.

PROJECT 1A18: MTC-Light Phase II, Sale Preparation (Appraisal, Layout, Contract Prep and Award) (2017) - Complete a report of appraised value of forest products; lay out and mark cutting unit boundaries; develop, advertise and award the contract for Phase II of MTCLight Forest Treatments.

PROJECT 1A19: West-Side Training Area Maintenance Burn (2018). Perform maintenance burning of previously burned areas to restore the historic fire interval. Perform prescribed burning on Stands 47 & 67 (968) acres in 2018.

PROJECT 1A20: MTC-Light Mechanical Thinning (6,320 acres), Phase II (2017-2020). Implement thinning treatments as prescribed in the MTC-Light EA. Target accomplishment is 6,320 acres by 2020.

PROJECT 1A21: MTC-Light Prescribed Burning (6,320 acres), Phase II. Prescribed burn the mechanically treated areas in Project 23A1 in 2022.

PROJECT 1A22: MTC-Light Phase III, Sale Preparation (Appraisal, Layout, Contract Prep and Award) (2020) - Complete a report of appraised value of forest products; lay out and mark cutting unit boundaries; develop, advertise and award the contract for Phase I of MTCLight Forest Treatments.

PROJECT 1A23: MTC-Light Mechanical Thinning (3,860 acres), Phase III (2020-2023). Implement thinning treatments as prescribed in the MTC-Light EA. Target accomplishment is a minimum of 3,860 acres by 2023.

PROJECT 1A24: MTC-Light Prescribed Burning (3,860 acres), Phase III. Prescribed burn the mechanically treated areas in Project 28A1 in 2025.

PROJECT 1A25: Conduct pre- and post-treatment monitoring/inventories/evaluation to plan and assess project effectiveness and allow for adaptive management (2013-2025).

These projects will protect infrastructure at Camp Navajo, improve forest health and vigor, return fire to fire-adapted ecosystems, improve wildlife habitat, and improve overall watershed conditions within and adjacent to Camp Navajo.

The Greater Flagstaff Forest Partnership and Arizona State Forestry Division cost-share program has resulted in hazardous fuels reduction treatments on approximately 78,184 acres (GFFP Report 2010). The GFFP boundary comprises approximately 180,000 acres within the project boundary. Recent vegetation treatments include the City of Flagstaff Well-field Project (80 ac.), the Airport Project (134 ac.), NAU (1,893 ac.), Sunset Crater (316 ac.), Arizona Department of Game and Fish (54,988 ac.), and Flagstaff Fire Department (9,203 ac.). Treatments were designed to improve forest conditions and/or community protection within the wildland-urban interface. Current projects include vegetation thinning and prescribed fire on approximately 100 acres of private property made up of 20 parcels within the GFFP boundary in 2012.

Foreseeable fuels reduction treatments in the GFFP boundary include treating (thinning/prescribed burning) 245 acres on 5 private land parcels in 2013, 190 acres on 4 to 10 parcels in 2014, and 100 acres of prescribed burning through 2014 (Childs 2014).

These projects protect human infrastructure and improve water quality and riparian health by reducing the risk of uncharacteristic fire behavior that can lead to soil erosion and delivery of excessive amounts of sediment, debris, ash, and nutrients to water bodies and adjacent riparian areas. Reduced canopy densities would improve precipitation throughfall to the soil surface, thereby improving soil moisture content. Excess soil moisture (i.e., gravitational water) would improve either groundwater recharge or streamflow.

The Greater Flagstaff Area Community Wildfire Protection Plan Review and Revision Report dated May 2012 states the following: "Significant treatment activity has been ongoing under various programs for addressing public and private land throughout the CWPP area. GFFP has maintained and annually updated a "treatment map" for a large portion of the CWPP area that is posted on their web page: www.gffp.org/about_gffp/map. It provides the best overview of accomplishments to date.

Summary statistics over the past 15 years include approximately 116,500 acres of forest treatments implemented (including 48,500 within GFFP and 12,300 within the City of Flagstaff) by at least a dozen different programs. Future activity in the area includes continuation of fuel reduction and forest health treatments through the State Forestry Division, GFFP, City of Flagstaff, Fire Districts, Rural

Communities Fuels Management Program (RCFMP), and other local, non-federal projects, and treatments under projects with approved NEPA and “shelf stock” associated with the Four Forest Restoration Initiative (4FRI) first analysis area on federal land.”

Urban Development

Continued urbanization is likely, particularly in the wildland-urban interface where there is greater opportunity for expansion than existing urbanized areas. These activities generally have adverse effects to surface water quality and riparian conditions as a result of construction activities, contaminated urban stormwater runoff, and increased ruderal vegetation. Vegetation/fuels reduction treatments that reduce wildfire hazard in these areas protect structures from damage or destruction by wildfires, thus minimizing the potential for contaminants (i.e. burned materials, household chemicals, etc.) to be transported to surface waters.

Road Construction, Maintenance, and Rights-of-Way Clearing – Non-NFS Lands

Road construction, maintenance, and rights-of-way clearing are expected to continue on non-NFS lands. These activities generally result in adverse effects to water quality and riparian conditions, depending on road locations, road geometries, and frequency of maintenance. Roads that intersect streamcourses or are in close proximity to them pose the greatest risk to water quality. Stormwater runoff from road surfaces has the potential to deliver sediment and other contaminants directly to surface waters, including riparian areas. Road stream crossings often require infrastructure or modification that regulates in-channel flow (i.e., culverts, bridges, stream bank stabilization measures, channelization, channel realignment, etc.). These activities can have short- and long-term adverse effects to water quality as a result of initial destabilization of stream beds and banks, permanent changes to flow patterns, and artificial flow regulation. It should be noted that implementation of construction stormwater pollution prevention measures, or BMPs minimizes or mitigates most adverse effects of road construction and maintenance activities on surface water quality, but does not usually eliminate them entirely.

Road Construction and Maintenance on NFS land

Road construction and maintenance on NFS land would result in similar effects to surface water quality and riparian condition as outline above for non-NFS roads. Temporary road construction would disturb approximately 954 acres of NFS land. Soil denudation, displacement and compaction would occur as roads are bladed and surfaces prepared for traffic. All action alternatives would result in 954 acres of soil disturbance that has the potential to adversely affect water quality as a result of temporary road construction. Roads have been shown to increase drainage network density as a result of concentrated runoff from road surfaces (Croke and Mockler 2001; Montgomery 1994; Wemple and others 1996). If wheel ruts form on temporary road running surfaces or grading results in a small berm at the edge of road surfaces, runoff will be concentrated on the running surface (Robichaud 2010) However, implementation of BMPs and SWCPs as outlined in Table 1 would minimize or mitigate most adverse effects of road construction and maintenance of NFS roads on surface water quality.

Recreation

Developed recreation sites are found within the project area in close proximity to surface water bodies and a variety of recreational activities with potential to affect surface water quality occur within the project boundaries. The primary impacts to water quality related to recreation management are turbidity, sedimentation, and introduction of contaminants and pollutants such as petroleum hydrocarbons, fecal coliform, and solid waste. Construction projects, dispersed camping, driving on roads, etc. can result in decreased vegetative ground cover and increased soil erosion, thus contributing to sediment delivery and increased turbidity. Motorized boating has the potential to introduce petroleum hydrocarbons and other contaminants directly to surface waters. Full body water contact (i.e., swimming) has the potential to introduce fecal coliform bacteria. Cumulative impacts to water quality from the proposed activities would include minor, short-term, increases in sediment and turbidity in surface water following treatment activities. As previously noted, implementation of BMPs and SWCPs as outlined in Table 1 would minimize or mitigate adverse effects to water quality and riparian areas.

Moonset Cinder Pit Safety & Operational Expansion Project

The Williams Ranger District is proposing to expand Moonset Cinder Pit by 5 acres areal extent. The cinder pit is located in T22N, R4E, Sec. 21. The purpose of the project is to meet safety requirements by increasing the decking area for improved operability and safe extraction of cinder and to better delineate areas of operation between Coconino County, The City of Williams, and individuals extracting material for personal use. This will also help alleviate the occurrence of steep side-walls which have been a recurring problem at the pit for decades. Additionally an expansion will help increase the designated area allotted for the burn pit, providing enough room for two pits, whereby one can be actively burning while the other can be used for collection of slash and woody debris for future burning.

Cumulative Effects Resulting from the Slide Fire of 2014

The Slide Fire started on May 20th, 2014, was human caused and burned over 21,227 acres, of which 7,800 are within the 4FRI project analysis area. In general, protective vegetative ground cover was totally consumed in areas of high burn severity and mostly consumed in areas of moderate burn severity. The remaining areas of the fire exhibit a mosaic of low burn severity intermingled with unburned areas. Total ground disturbance associated with the Slide Fire was calculated based on low burn severity (2% of acres disturbance), moderate burn severity (62%), and high burn severity (90%) for a total of about 7,455 acres.

The Burned Areas Emergency Response team assessed burn severity and values at risk and recommended emergency stabilization treatments including seeding and mulching to improve the immediate ground cover and reduce sediment delivery to connected streamcrouses from over 2,175 acres of moderate and high burn severity.

The fire resulted in disturbances to 3 watersheds that cumulatively exceed the 15% ground disturbance threshold (Steinke 2014). These include Upper Oak Creek, with a total disturbance of 4,362 acres or 20.6% of the watershed, West Fork of Oak Creek with a total disturbance of 16,432 acres or 30.1% and Pumphouse Wash with a total ground disturbance of 11,423 acres or 18.2% of the watershed. The fire burned in portions of Fry Canyon and Dry Creek but cumulative ground disturbance totals less than 10%.

Approximately 7,884 acres of restoration treatments are proposed within the Slide Fire perimeter under all action alternatives. However, proposed restoration treatments vary by alternative. Table 8 below displays proposed restoration treatments by action alternative within the Slide Fire Perimeter.

Table 8. Proposed restoration treatments under the Four Forest Restoration Initiative for areas within the Slife Fire of 2014.

Proposed Restoration Treatment	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
GL - Restoration	0	13	13	13	0
Grassland Mechanical	0	0	108	108	108
IT10	0	29	29	29	29
IT40	0	820	820	820	820
MSO Restricted Treatment	0	3793	3793	3793	3793
MSO Target Treatment	0	320	320	320	320
MSO Threshold Treatment	0	32	32	32	32
No Proposed Treatments	0	7	0	1020	7
PFA - IT40	0	34	34	34	34
PFA - UEA40	0	11	11	11	11
Prescribed Fire Only	0	1186	1186	173	1212
Prescribed Fire Only - Operational	0	108	0	108	0
Prescribed Fire Only - Core Area	0	0	7	0	0
Savanna	0	131	131	131	0
SI40	0	1	1	1	1
UEA10	0	395	395	395	395
UEA25	0	5	5	5	5
UEA40	0	1000	1000	1000	1118
Grand Total	**0**	**7884**	**7884**	**7884**	**7884**

As can be seen in Table 8, many of the restoration treatments proposed within the Slide Fire perimeter consist of the same acreages. However, Alternative B would have fewer acres of mechanical grassland restoration and Alternative D would have more acres that receive no restoration treatment, as well as substantially fewer acres of prescribed fire restoration treatment. Alternative E would have slightly fewer acres of savanna restoration than the other action alternatives and slightly more acres that receive uneven-aged 40 sq. feet of basal area per acre forest restoration treatment. No detectable difference in sediment delivery to water bodies is anticipated among alternatives B, C and E. The reduced acreage of prescribed burning restoration treatment under Alternative D, when compared to Alternatives B, C and E and the additional acreage that would receive no restoration treatments indicate that Alternative D would likely result in less sediment delivery to waterbodies as a result of less overall disturbance to soils. Table 9 below displays proposed forest and grassland restoration treatment acreages per HUC12 subwatershed within the Slide Fire perimeter.

Table 9. Proposed 4FRI Restoration Treatments by HUC12 Subwatershed within the Slide Fire Perimeter.

	Alternative				
Fry Canyon (150602020501)	A	B	C	D	E
Total Watershed Acres	19,175	19,175	19,175	19,175	19,175
Total Acres Proposed For Restoration Treatment	0	644	644	644	644
Percent of Watershed Proposed for Restoration	0	3.4	3.4	3.4	3.4
Grassland Mechanical		0	72	0	72
IT40	0	69	69	69	69
MSO Restricted Trt	0	83	83	83	83
Prescribed Fire Only - Operational	0	72	0	72	7
Savanna	0	7	7	7	0
UEA40	0	413	413	413	413
Pumphouse Wash (150602020502)					
Total Watershed Acres	31,546	31,546	31,546	31,546	31,546
Total Acres Proposed For Restoration Treatment	0	452	452	452	452
Percent of Watershed Proposed for Restoration	0	1.4	1.4	1.4	1.4
IT40	0	0	0	0	0
MSO Restricted Trt	0	239	239	239	239
MSO Target Trt	0	50	50	50	50
Prescribed Fire Only	0	143	143	143	143
Savanna	0	13	13	13	0
SI40	0	1	1	1	1
UEA25	0	3	3	3	3
UEA40	0	2	2	2	16
West Fork Oak Creek (150602020503)					
Total Watershed Acres	27,339	27,339	27,339	27,339	27,339
Total Acres Proposed For Restoration Treatment	0	5,178	5,178	5,178	5,178
Percent of Watershed Proposed for Restoration	0	19	19	19	19
GL - Restoration	0	13	13	13	36
Grassland Mechanical		0	36	0	0
IT10	0	29	29	29	29
IT40	0	542	542	542	542
MSO Restricted Trt	0	2,505	2,505	2,505	2,505
MSO Target Trt	0	268	268	268	268
MSO Threshold Trt	0	32	32	32	32

Fry Canyon (150602020501)	Alternative				
No Proposed Treatments	0	7	0	747	7
PFA - IT40	0	34	34	34	34
PFA - UEA40	0	11	11	11	11
Prescribed Fire Only	0	770	770	30	790
Prescribed Fire Only - Operational	0	36	0	36	0
Prescribed Fire Only – Core Area		0	7	0	0
Savanna	0	102	102	102	2
UEA10	0	395	395	395	395
UEA25	0	2	2	2	2
UEA40	0	433	433	433	529
Upper Oak Creek (150602020505)					
Total Watershed Acres	17,900	17,900	17,900	17,900	17,900
Total Acres Proposed For Restoration Treatment	0	1,609	1,609	1,609	1,609
Percent of Watershed Proposed for Restoration	0	9	9	9	9
IT40	0	209	209	209	209
MSO Restricted Trt	0	965	965	965	965
MSO Target Trt	0	2	2	2	2
Prescribed Fire Only	0	273	273	273	273
Savanna	0	9	9	9	0
UEA40	0	151	151	151	160
Grand Total for All Watersheds in the Slide Fire	0	7,884	7,884	7,884	7,884

As shown in Table 9, the total acres of proposed restoration treatment within the Slide Fire perimeter by HUC12 subwatershed ranges from a maximum of 5,178 acres (West Fork Oak Creek) to a minimum of 452 acres (Pumphouse Wash). The cumulative effects of post-fire ground disturbance when combined with proposed 4FRI treatments are not expected to disturb greater than 15 percent of the soil. Based on a disturbance threshold of 15 percent, total soil disturbance within each HUC12 subwatershed is estimated to range from a minimum of 97 acres (Fry Canyon) to a maximum of 777 acres (West Fork Oak Creek).

As noted in the Slide Fire Soil Resource Assessment Report, recommended land treatments (seeding and mulching) reduce soil hydrophobic conditions and dissipate the energy of stormwater runoff, thereby reducing the potential for slope destabilization, soil erosion, and debris flows. Land treatments such as seeding and mulching of areas subjected to moderate and high severity fire have been shown to reduce the "bulking" of stormwater runoff by providing protective soil cover that reduces soil particle detachment and entrainment in flood flows. A cubic foot of water weighs approximately 62 lbs. while a cubic foot of soil can weigh as much as 95 lbs. When soil and other debris are mobilized in surface runoff, the power of stormwater runoff therefore increases, thereby increasing the potential for additional material to be scoured from hillslopes, natural surface roads, stream banks and stream beds and mobilized in surface runoff and streamflow. However, land treatments are not expected to reduce flooding hazard substantially during the first 2 to 3 years following treatment since rainfall interception by forest vegetation and associated litter has been substantially reduced.

Soil erosion hazard rating acreages were calculated for each watershed within the Slide Fire, with soil burn severity as a factor in the rating. Ratings therefore represent a summary of soil erodibility as affected by slope gradient, effective ground cover (or lack thereof), and reduced infiltration due to water repellency. Field observations, information from the Terrestrial Ecosystem Survey of the Coconino National Forest, and GIS analyses were used to determine erosion hazard acreages. A summary of erosion hazard ratings within watersheds is presented in Table 10 below.

Table 10. Soil Erosion Hazard Rating Acreages for Subwatersheds within the Slide Fire where restoration treatments are proposed.

Watershed	Slight	Moderate	Severe
Fry Canyon (150602020501)	621	49	0
Pumphouse Wash (150602020502)	486	317	92
Upper Oak Creek (150602020505)	1,241	308	2,108
West Fork Oak Creek (150602020503)	6,926	3,015	6,493

Accelerated runoff and erosion are to be expected within the Slide Fire burned perimeter, depending on burn severity, slope, soil properties, and duration and intensity of precipitation that occurs within a given watershed. Rockfall and debris flows are also possible.

Quantitative sediment delivery rates within the Slide Fire were modeled using the Erosion Risk Management Tool (ERMiT), a WEPP modeling application developed by the USFS Rocky Mountain Research Station (USFS, RMRS GTR 188, April 2007). This modeling tool was developed specifically for use with post-fire erosion modeling. The ERMiT model estimates only sheet and rill erosion, which occurs when rainfall exceeds infiltration rates, and stormwater runoff entrains surface soil particles. The model does not account for landslides, gully erosion, effects of roads, or hillslope ravel.

In order to validate soil erosion estimates from ERMiT, the Hillslope Erosion Model (HEM) was used. The HEM is based on a mathematical model developed by scientists at the USDA-ARS Southwest Watershed Research Center in Tucson, Arizona. The model describes hillslope erosion processes. Given hillslope segment lengths, slopes, percent canopy cover, percent surface ground cover, runoff volume, and a soil erodibility value, the model simulates soil erosion processes along a hillslope and will return a runoff volume, sediment yield, interrill detachment, rill detachment, rill deposition, and the mean concentration of sediment in the flow for each hillslope segment. Sediment yield equations in HEM were developed for a single plane, and were extended to irregular slopes by approximating the irregular slopes as a cascade of planes.

Increasing sediment concentration in the downslope direction may indicate erosion along the hillslope. Deposition may be indicated by a decrease in sediment concentration in the downslope direction. Constant sediment concentration indicates an equilibrium.

All watersheds having area within the Slide Fire perimeter were included in the analysis. Model estimates were generated for each soil map unit and burn severity, and apportioned to watersheds on a per-acre basis. Model output is in tons per acre on a storm event basis for both ERMiT and HEM.

Erosion outcomes will depend upon what summer monsoon patterns brings in terms of rainfall amount and intensity for the next 3 to 5 years. A summary of erosion estimates is presented in Table 10. Erosion rates are expected to decline each year as revegetation and natural recovery processes occur. Soil erosion will decrease soil productivity through nutrient losses which prolong vegetative recovery, depending upon the amount of soil loss.

Table 11. Hillslope sediment yield rates for the Slide Fire for modeled burned conditions based on HEM model.

Watershed Name	Burned Acres	Percentage of Watershed Burned	Sediment Yield Burned (tons)
Dry Creek (150602020507)	232	0.67	3,246.5
Fry Canyon (150602020501)	590	3.07	1,608.1
Pumphouse Wash (150602020502)	851	2.71	8,474.3
Upper Oak Creek (150602020505)	3,577	19.98	164,918.4
West Fork Oak Creek (150602020503)	15,349	56.14	471,553.0

Modeling included estimation of natural or 'background' erosion rates for unburned portions of the fire. Soil burn severity is accounted for throughout these modeled estimates; other erosional processes as previously discussed are not. It is important to note that many areas that were initially classified as moderate burn severity using remote sensing methods were actually high severity. Although some areas initially characterized as moderate burn severity have been reclassified as high burn severity, the erosion and sediment yield response is not expected to change as field evaluations indicated that soils subjected to both moderate and high burn severities were strongly hydropobic (i.e., water repellant).

As can be seen in Tables 9 through 11, the greatest risk of accelerated soil erosion and sediment delivery to waterbodies from the combined effects of the Slide Fire and proposed 4FRI restoration treatments is in the West Fork Oak Creek watershed. This is primarily because West Fork Oak Creek experienced the greatest number of acres of high burn severity as a result of the Slide Fire and it also has the greatest acreage of proposed restoration treatments of all watershed affected by the Slide Fire. However, this increased risk can be mitigated through effective implementation of BMPs and SWCPs designed to maintain soil productivity and protect surface water quality. The National Core BMP Technical Guide (FS-990a) provides general guidance for implementation of BMPs that are applicable to all activities proposed within the Slide Fire and have been proven effective at protecting water quality when effectively implemented.

There is also an increased risk of fecal coliform (FC) increasing to very high levels in Oak Creek sediments, particularly in low gradient areas like Pine Flats, Slide Rock, and Grasshopper Point as a result of the Slide Fire. Additionally, this risk is exacerbated due to swimmers stirring sediments, particularly in the Slide Rock State Park area. In the TMDL for Oak Creek, the ADEQ noted the assumption that if sediment levels can be sufficiently reduced, much less will be available for resuspension in the water column. As there is no sediment fecal coliform standard, and the ratio of sediment fecal coliform to water fecal coliform varies, setting numeric targets is difficult. However, the TMDL proposed a stepped/iterative approach that, along with conscientious management of recreational areas, is designed to protect public health. Objectives stated in the TMDL include:

- reduce sediment FC reservoir in stream sediments
- identify relative contributions from sources: septic, recreation, runoff, animals within the watershed
- accelerate implementation of BMPs for recreation/'traffic' management
- increase safety margin for protection of swimmers
- accelerate septic upgrades/repair schedule
- TMDL Implementation Plan to include identification and implementation of stakeholder responsibilities
- develop and implement long-term contingency plan to meet standards

Actions relevant to USFS in the TMDL include:

- Continued oversight and maintenance of campground and day-use facilities to ensure
- compliance with proper animal and human waste disposal
- Continued education and posting of signage
- Patrol of campgrounds and imposition of fines for violations
- Cooperation with ASPs, AGFD, ADEQ, and CCEHS for quarterly water quality and sediment monitoring for fecal coliform and *E. coli* above and below campgrounds and day-use area (weekly from Memorial Day to Labor Day); cooperate with ASPs, ADEQ, and CCEHS to collect 'split' samples on regular basis; provide data on web page
- Development of BMPs for restriction of animal access to Oak Creek and drainages in the upper watershed
- conduct census of numbers and ranges of ungulates and other major contributors
- participate in annual review of TMDL status with other stakeholders

To adequately protect water quality, soil productivity, and watershed function, additional soil and water BMPs have been identified (BMP Nos. 42 and 43, Table 1) that should improve vegetative recovery and reestablishment in uplands and streamside management zones. These BMPs will improve sediment capture in the vegetative ground cover and prevent entrainment and transport of sediment to streamcourses, including Oak Creek. Proposed restoration treatments therefore do not pose an increased risk to water quality when recommended Slide Fire BMPs are implemented. Water quality is expected to meet designated beneficial uses and state water quality standards within the 4FRI project area.

Additional information related to the cumulative effects of the Slide Fire can be found in the Soils Resources Specialist's Report (Steinke 2014).

Alternative B – Proposed Action

Direct and Indirect Effects

Grassland Restoration

Under the Proposed Action, grassland restoration treatments would be conducted using mechanized equipment or manual methods to treat vegetation on approximately 11,185 acres within forty-one 6th-level HUCs. Treatment acreages within each HUC12 subwatershed range from one acre (Pumphouse Wash) up to a maximum of 1,735 acres (Upper Red Lake Wash). Steinke (2014) estimates soil disturbances of approximately 336 acres, or approximately 3 percent of total grassland restoration treatments. A threshold of 15 percent areal extent for soil disturbance within treatment areas has been established as a guideline. Soil disturbance of 3 percent in areal extent would not exceed established disturbance thresholds. Additionally, soil erosion models indicate that grassland restoration treatments would not result in soil erosion that exceeds tolerance limits. Since soil disturbance from grassland restoration treatments would not exceed disturbance thresholds and consequential soil erosion rates would not exceed soil erosion tolerance limits that indicate long term loss of soil productivity, it is very unlikely that adverse impacts to water quality or riparian conditions would occur as a result of grassland restoration treatments.

The following BMP's from Table 1 are site-specific for grassland restoration treatments: 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 36, 28, and 39. These BMPs would be implemented to prevent adverse effects to soils and would therefore minimize or mitigate potential adverse effects to water quality or riparian conditions.

Ponderosa Pine Restoration – Low Intensity Thinning

Under the Proposed Action, approximately 175,000 acres would be treated using low intensity thinnings to restore the ponderosa pine vegetation type. Of these acres, approximately 30,200, or 17 percent, have severe erosion hazard ratings. Tree felling would be conducted using either chain saws or harvesting machinery with mechanized skidding of logs to landings. Soil disturbance resulting from forest thinning and subsequent treatment of residual woody debris would vary by type of harvesting method and woody debris treatment. Treatment acreages at the HUC12 subwatershed level range from 1 acre (Curley Wallace Tank) to 18,661 acres (Coconino Wash Headwaters). Estimated disturbance at the HUC12 subwatershed level ranges from less than one acres (Curley Wallace Tank) to 2,239 acres (Coconino Wash Headwaters). Soil disturbance is estimated to total approximately 21,000 acres for the low intensity thinning treatment. This represents approximately 3.6 percent of the entire 583,330 acre proposed treatment area. As previously noted, a threshold of 15 percent areal extent for soil disturbance is assigned as a guideline. Also, it is important to understand that low intensity thinning treatments would not occur simultaneously, but would instead be distributed both temporally and spatially within each treated watershed. Steinke (2012) determined that soil disturbance from low intensity thinning treatments would therefore not pose a risk to soil resources. Since soil resources would not be adversely affected by low intensity thinning treatments followed by woody debris management, adverse effects to water quality and riparian area conditions are not anticipated. Resource protection measures specific to ponderosa pine restoration treatments include the following BMPs from Table 1: 23-33, 35, 36, and 38. These BMPs and others outlined in Table 1 would minimize or mitigate potential adverse effects to water quality and riparian areas.

There would likely be short term adverse effects to water quality where transportation systems (i.e., permanent National Forest System roads, temporary access roads, and skid trails) intersect or cross stream channels. These areas pose the greatest risk of conveying adverse effects to surface water quality since stormwater runoff from road and skid trail surfaces can deliver sediment from disturbed areas directly to streamcourses. Adverse effects to water quality would be mitigated, but not eliminated entirely with implementation of BMPs and SWCPs as specified in Table 1.

Water quality and riparian areas would be expected to improve over the long term (i.e. greater that 2 years) as a result of increased understory vegetative production following low intensity thinning treatments. This is partly because vegetative and litter ground cover serve as a filter for stormwater runoff and snowmelt, increase water infiltration and percolation into and through soil profiles, and improve soil aggregate stability. Additionally, thinning would increase forest openings thereby improving snowpack retention in these areas and reducing net annual evapotranspiration since fewer trees would be evapotranspiring year-round. The expected outcome would be slight improvement in riparian vegetation and surface water quality in streamcourses adjacent to thinned area.

Ponderosa Pine Restoration on Slopes Greater than 40%

Approximately 99 acres of the proposed project area occur on slopes exceeding 40 percent. Steeper slopes can have greater erosion hazard when soils are disturbed. However, suitable restoration treatment practices and equipment can be employed to minimize soil disturbance, and therefore sediment delivery to streamcourses and riparian areas. These include low-impact ground-based machinery, helicopters, or cable yarding. With implementation of helicopter logging, disturbance (and therefore bare areas subject to erosion and sediment delivery to streamcourses) would be minimized since disturbance from helicopter logging is limited to the areas where trees are felled and yarded by the helicopter, a log landing of approximately 2 acres, and a service landing for helicopter fueling and maintenance of approximately 1 acre. Cable yarding corridors would result in slightly more disturbance since a cable yarding road would be required and corridors are estimated to be 12 feet wide with 80 feet between corridors. Potential erosion and sediment delivery would therefore be slightly greater under cable yarding. However, the overall acreage with slopes exceeding 40 percent is minimal and disturbance would be less that 10 percent using cable yarding. Additionally, with implementation of BMPs and SWCPs as specified in Table 1, potential adverse effects to water quality and riparian areas resulting from restoration treatments on slopes greater than 40 percent would be minimized.

Ponderosa Pine Restoration – High Intensity Thinning

This treatment type is proposed on approximately 154,700 acres in the ponderosa pine vegetation type. Of these acres, approximately 18,400 acres are on soils having severe erosion hazard ratings. Treatment acreages at the HUC12 subwatershed scale ranges from 7 acres (Little Red Horse Wash) to 9,567 acres (Upper Spring Valley Wash). Ground disturbance associated with this treatment type is expected to range from one acre (Little Red Horse Wash) to 1,435 acres (Upper Spring Valley Wash). Total soil disturbance is estimated to be approximately 23,017 acres or 15 percent of the overall high intensity thinning treatment acreage. This represents approximately 3.9 percent of the entire 583,330 acre proposed treatment area. Approximately 2,740 acres of soil disturbance from high intensity thinning treatments is expected on soils that have severe erosion hazard ratings. However, soil erosion models indicate that erosion would not exceed tolerance thresholds. As under low intensity thinning treatments, high intensity thinning treatments would not occur simultaneously, but would instead be distributed both temporally and spatially within each treated watershed.

Short-term, localized adverse effects to surface water quality are possible in ephemeral drainages within or adjacent to high intensity treatment areas, Subwatersheds with greater treatment acreages, such as Upper Spring Valley Wash (9,567 treatment acres), Walnut Creek-Upper Lake Mary (9,239 treatment acres) and Volunteer Wash (8,978 treatment acres) pose the highest risk of short term, localized adverse effects to water quality. Potential adverse effects include increases in turbidity, total dissolved solids, total suspended solids, and nutrients. As previously noted, BMP's and SWCPs specific for ponderosa pine restoration in Table 1 include the following: 23-33, 35, 36, and 38. Implementation of these BMPs and SWCPs would minimize adverse effects to surface water quality and riparian ecosystem function.

It is possible that thinning ponderosa pine stands to a lower residual basal area would increase groundwater recharge or streamflow discharge, particularly in riparian areas having perched aquifers or groundwater zones. Subwatersheds with the largest high intensity thinning treatment acreages have the greatest potential to respond hydrologically to treatments. The change in groundwater recharge would not likely exceed 1 cm of annual precipitation (Springer and Kolb 2000). However, this increased groundwater could be permanent if tree residual basal area is maintained with prescribed fire where ingrowth occurs. Prescribed burning following ponderosa pine thinning treatments and herbaceous vegetation recovery in upland areas adjacent to riparian ecosystems would likely play a larger role in increasing available soil moisture by reducing evapotranspiration by herbaceous plant communities (Springer et al. 2006).

Savanna Treatment

Approximately 45,470 acres are proposed for savanna restoration treatments in the ponderosa pine vegetation type. Of these acres, approximately 4,140 acres would be on soils with severe erosion hazard ratings. Soil disturbance as a result of savannah restoration treatments is estimated to be 10 to 20 percent of treatment areas in areal extent (Steinke 2012). At the HUC12 subwatershed scale, savanna treatment acreages are expected to range from 15 acres (Lower Sycamore Creek) to 4,444 acres (Walnut Creek-Upper Lake Mary). Soil disturbance is therefore expected to range from 2 acres (Lower Sycamore Creek) to 667 acres (Walnut Creek-Upper Lake Mary). Total disturbance from savanna restoration treatments is estimated to be 6,811 acres, or 1.2 percent of the entire 583,330 acre proposed treatment area.

Removal of trees that have encroached in savannas would decrease annual interception and evapotranspiration by trees. Loss of evapotranspiration by trees would result in an initial increase in soil moisture available to herbaceous plant communities in treated areas. Interception lost through removal of trees would likely be offset by herbaceous vegetation within 1 to 3 years. As herbaceous ground cover improves in treated areas, water infiltration and percolation would improve since herbaceous ground cover and associated litter would improve soil macropore space, aggregate stability, and porosity. Soil moisture that exceeds field capacity would become gravitational water and would either increase groundwater recharge or contribute to stream baseflow. Minor, localized areas of soil disturbance, including compaction, displacement, puddling, and erosion are likely in treatment areas. These conditions would be expected to occur primarily where roads, skid trails, and landing are located. Implementation of BMPs as specified in Table 1 would minimize or mitigate adverse effects to surface water quality, and riparian conditions from savanna restoration teatments.

Aspen Treatments

Aspen treatments are proposed on 1,227 acres. Of these acres, approximately 364 acres of treatment would occur on soils with severe erosion hazard ratings. Soil disturbance in aspen treatments is estimated to be 184 acres, or 15 percent areal extent (Steinke 2014). At the HUC12 subwatershed scale, aspen treatment acreages are expected to range from 1 acre (Volunteer Canyon; Cataract Creek Headwaters) to 383 acres (Upper Deadman Wash). Soil disturbance is therefore expected to range from 1 acre (Volunteer Canyon; Cataract Creek Headwaters; Sawmill Tank; Upper Woods Canyon; Pitman Valley-Scholz Lake; Garland Prairie;) to 57 acres (Upper Deadman Wash). Total disturbance from aspen treatments is estimated to be less than one percent of the entire 583,330 acre proposed treatment area. Thinning of encroached ponderosa pine and other conifers would be conducted to improve aspen vigor and natural regeneration potential. Prescribed burning would be implemented to improve aspen regeneration in treated stands. These treatments are not expected to result in adverse effects to surface water quality or riparian conditions since treatments would occur primarily in upland locations and ground disturbance would be minimal from removal of encroaching conifers and prescribed burning. Restoration treatment BMP's and SWCPs in Table 1 specific for aspen restoration that would be implemented include the following, 23-33, 35, and 36.

Pine Sage Treatments

Approximately 5,261 acres of ponderosa pine thinning and prescribed burning are proposed in the pine-sage vegetation type. Effects to soils from mechanical thinning are expected to be similar to low intensity ponderosa pine thinning. Streamcourses in the pine-sagebrush vegetation type are generally ephemeral and only flow during and immediately following monsoon storms or during extreme snowmelt runoff. There are no riparian areas in the pine-sagebrush vegetation type. There would therefore be no adverse effects to riparian areas as a result of this treatment type. Treatments that are conducted in accordance with BMPs and SWCPs as specified in Table 1 would not result in adverse impacts to surface water quality.

Pinyon-Juniper (P-J) Wildland-Urban Interface (WUI) Treatments

Approximately 535 acres are proposed for thinning and prescribed burning in the pinyon-juniper vegetation type. These treatments would occur south of the Village of Tusayan in Rain Tank Wash and Coconino Wash Headwaters 6-level (HUC12) subwatersheds. Treatments would improve protection of the Village of Tusayan from wildfire by reducing hazardous fuels in the wildland-urban interface. There are no riparian areas in close proximity to proposed treatments so there would be no adverse effects to riparian areas from proposed pinyon-juniper wildland-urban interface treatments. Soils in thse proposed treatment areas are currently in satisfactory condition. Steinke (2012) estimates that no more than 80 acres within the proposed treatment area would be subjected to soil disturbance. This level of soil disturbance is not expected to contribute to adverse impacts to surface water quality. Additionally, implementation of BMPs and SWCPs as specified in Table 1 would minimize or mitigate potential adverse effects to water quality. Best Management Practice No. 7 in Table 1 would require retention of 1 to 3 tons of coarse woody debris (CWD) per acre. Coarse woody debris would create surface roughness that prevents runoff from reaching velocities that cause soil particles to become entrained and delivered to adjacent streamcourses. There are therefore no anticipated adverse effects to surface water quality from P-J WUI treatments.

Prescribed Fire Treatment

Prescribed burning is proposed for the entire project area, or 586,110 acres. Prescribed burning only (no mechanical treatments) is proposed on approximately 198,364 acres, with the remaining approximately 384,966 acres having prescribed burning and mechanical restoration treatments proposed. Each of the approximately 586,110 acres would be subjected to maintenance prescribed fire as well over 10-20 year timeframe. Soil disturbance as a result of high severity burn conditions is estimated to vary between 1 and 3 percent areal extent of the proposed treatment acreage (Lata 2014, Steinke 2014). At the HUC12 subwatershed scale, soil disturbance acreage is expected to range from 2 acres (Curley Wallace Tank; Yeager Draw) to 629 acres (Munds Canyon). Total soil disturbance from prescribed burning is estimated to be 11,667 acres, or 2 percent of the entire 586,110 acre proposed treatment area. The primary factor that determines the effects of prescribed burning on stormwater runoff and erosion is the amount of surface and mineral soil organic matter that is consumed by fire that would otherwise protect mineral soil surfaces from raindrop impact, and improve soil structure and aggregate stability. The effects of burning can vary from partial removal of the litter (low burn severity) to total consumption of surface organic material and organic matter contained in the upper portion of the mineral soil layers (high burn severity). If the soil organic fraction is completely consumed by a fire, the mineral soil is exposed to rain splash, particle detachment, and entrainment in surface flow. Any loss of organic matter in the upper part of soil profiles will alter the soil structure, and the resultant disaggregation of the soil particles can greatly increase its susceptibility erosion (Brown et al. 1985, DeBano et al. 1998; Robichaud and Waldrop 1994). Robichaud and others (1994) observed total sediment yields from three 30-minute rainfall simulations that were an order of magnitude higher at high burn severity versus low burn severity. Similar differences in sediment yields were observed by Benavides-Solorio and MacDonald (2005).

Prescribed fire has potential to adversely affect water quality through increased soil hydrophobicity that results in a consequential increase in delivery of sediment and dissolved nutrients and ash to stream channels. The mobility and concentration of nutrients determines whether or not nearby water sources are at risk of contamination when prescribed fire is used. Nitrate is highly mobile and is therefore subject to risk of being leached from burned areas and transported to either surface or ground water. Phosphorus adsorbs readily to sediment and organic materials. Thus, phosphorus is usually transported to streams and water bodies through soil erosion.

Prescribed fires typically leave greater amounts of organic matter on soil surfaces than unplanned fires burning under hot, dry conditions. These materials serve as a nutrient sink, prevent soil particle detachment caused by raindrop impact, and capture sediments that would otherwise be entrained and transported to streamcourses and waterbodies. Following low severity prescribed fires, an increase in grasses and other herbaceous vegetation often occurs, particularly where forests have been thinned prior to prescribed burning. This rapid growth of ground cover further immobilizes nutrients in plant material.

As aboveground vegetation decreases immediately following prescribed fires, evapotranspiration in the watershed initially decreases, thus increasing surface runoff that can contribute to increased stream baseflow and overall water yield within the watershed. Water uptake from trees is species-specific. Conifers, which are the dominant vegetation type within the Four Forest Restoration Initiative analysis area, generally transpire more water than hardwoods such as oaks and aspen. Dense foliage and longer growing seasons promote the higher overall water uptake in conifers. Additionally, conifers have relatively dense crowns that intercept rainfall and allow for greater evaporative losses. Over time, herbaceous vegetation would increase in openings, causing a proportional increase in evapotranspirational loss.

Since prescribed burning treatments would be phased temporally and spatially, it is unlikely that large pulses of sediment would be mobilized and transported from treated areas to drainages or downslope locations. Also, since forest thinning would be conducted in many of the prescribed fire treatment areas prior to burning, resulting in increased size and extent of forest openings and increased ground cover of grasses and forbs that help to carry fire and provide a mosaic of fire effects, recovery of areas treated with low severity prescribed fire is expected to be rapid.

Low severity fire rarely consumes all of the forest floor litter, leaving some protective ground cover intact. Some of the nutrients contained in the organic matter would be converted to inorganic forms which are then available for plant uptake. The increase in plant available nutrients would improve short-term soil productivity, resulting in a rapid growth response of herbaceous vegetative cover. Low severity prescribed fire is therefore expected to result in minor, localized, short-term increases in soil erosion rates followed by long-term improvement in the stability, function, and productivity of forest soils in the project area. Since low severity fire has historically been a natural occurrence in these ecosystems, these impacts do not necessarily need to be construed as negative, as they could also occur after a naturally-caused wildfire. These vegetation types and associated soils are thus ecologically adapted to low severity fire, and to resulting fire impacts.

The potential for moderate severity prescribed fire increases in areas where excessive fuel loads currently exist, where forest thinning does not adequately reduce tree density, and where forest thinning results in large amounts of woody debris within a given treatment area. There would be an increased risk of accelerated soil erosion where moderate severity prescribed fire occurs. A likely scenario for prescribed burning would be the occurrence of small areas (0.10 – 3 acres) that exhibit moderate burn severity intermingled with areas dominated by low burn severity conditions. It cannot be predicted with accuracy where such conditions would occur within proposed treatment areas. With appropriate fuels management techniques such as lopping and scattering of activity-related woody debris and piling and burning debris where necessary, adverse impacts to soils caused by moderate severity fire would be minimized.

High severity prescribed fire would result in considerable risk of accelerated soil erosion where such conditions occur. While very unlikely, this would represent a worst case scenario with regard to the use of prescribed fire and would more accurately reflect watershed response to wildfire. It is possible that small, isolated occurrences of high severity burn conditions would occur where excessive fuel loads exist or where conditions result in atypical fire behavior for brief periods. Such areas would likely exhibit accelerated soil erosion for longer periods and at greater rates than low or moderate soil burn severity areas due to high levels of consumption of surface and mineral soil organic matter, vegetative cover, and soil seed banks, leaving such areas unprotected and potentially hydrophobic.

Steinke (2014) esimates that soil disturbance would amount to approximately 11,667 acres or approximately 2 percent of the entire treatment area. Furthermore, burned soils on slopes less than 40 percent are not expected to erode above tolerable or threshold levels. Long term soil productivity and stability would therefore be maintained. Given the minimal estimated acres that would be disturbed and soil erosion levels that would not exceed tolerance thresholds, it is unlikely that adverse impact to water quality would occur. With proper implementation of BMPs and SWCPs as outlined in Table 1, particularly those specific to prescribed burning which include numbers 6, 7, 8, and 10, adverse effects to water quality and riparian area conditions from prescribed burning would be minimized or mitigated.

It should be noted that riparian areas adjoining the ponderosa pine vegetation type are generally adapted to minor pulses of sediment and ash in stormwater runoff as a result of low severity fires. These minor pulses of sediment and ash deliver nutrients and new substrate which supports riparian vegetation. Riparian areas are therefore expected to respond in a positive manner to low severity prescribed fire as a result of increased available water and nutrients.

Mexican Spotted Owl Protected Activity Center (MSO PAC) Fuels Reduction

Treatments in MSO PACs would include fuel reduction thinning to decrease the risk of catastrophic wildfire by removing trees up to 9 inches dbh. Steinke (2012) estimates soil disturbance levels would be similar to those of low intensity treatments. There would therefore be no adverse effects to water quality or riparian areas as a result of fuels reductions in MSO PACs.

No Treatment Areas

Some MSO or goshawk sensitive treatment sites (Noble 2014) are not proposed for any mechanical treatments. Additionally, most steep slopes and mixed conifer stands are excluded from restoration treatments. These areas would remain at risk of uncharacteristic fire behavior, particularly where heavy fuel loads persist. There is therefore an increased risk of sediment and other pollutants to be delivered to streamcourses, causing water quality degradation. Riparian areas that are downstream and in close proximity to areas where restoration treatments are excluded would be at risk of sedimentation, downcutting, aggradation, streambank failure, and other hydrogeomorphic processes that can be accelerated following high severity fires. Since these areas comprise a small percentage of the total proposed project area, adverse effects to water quality and riparian areas would be relatively minor and proportional to acres of moderate and high burn severity in the event of an uncharacteristic wildfire.

Temporary Road Construction and Road Decommissioning

Approximately 517 miles of temporary roads (954 acres) would be required for access to treatment areas and for log hauling. Temporary roads would be decommission upon completion of treatments. Temporary roads commit soil resources to reduced productivity for shorter time periods than system, or permanent roads. Reduced soil productivity is typically realized during the time the temporary road is used for forest access and the time required for the road to fully recover following decommissioning and implementation of BMPs and SWCPs. With implementation of BMPs and SWCPs during temporary road construction and use, long-term loss of soil productivity and potential adverse effects to water quality are minimized or mitigated through improved road drainage features that prevent soil erosion and sediment delivery to stream courses.

Relocation of Existing System Roads

Approximately 40 miles (15 acres) of existing open roads would be reconstructed for natural resource protection, watershed health, and human safety reasons. Of these miles, approximately 30 miles would be improved to allow for log hauling (primarily widening corners to improve turn radiuses) and approximately 10 miles of roads would be relocated out of stream bottoms. Increasing road turning radiuses would commit additional soil resources to unproductive status for the long term. The increased road surface would increase the risk for road runoff to entrain and deliver sediment to nearby streamcourses. Implementation of BMPs and SWCPs to protect soil productivity and water quality during temporary road construction, use and decommissioning, including numbers 1, 12, 15 and 38, in Table 1 would minimize or mitigate adverse effects to water quality and riparian areas. Relocation of existing road segments to upland areas would include rehabilitation of segments located in stream bottoms, thereby eliminating adverse effects to water quality from these existing road segments.

Reopening, Use and Decommissioning of Closed Roads

Approximately 272 miles of existing closed roads would be reopened in order to conduct vegetaton treatments. These roads would then be decommissioned (closed and rehabilitated/naturalized) upon completion of vegetation treatments. Existing closed roads that are reopened would be at risk of increased sediment delivery to streamcourses when traffic is reintroduced. Many of these roads have not recovered since they were closed, indicating that reopening them would require blading and other road construction activities to reestablish a servicable road since vegetation has not established to prevent erosion.

Decommissioning of Existing System and Unauthorized Roads

Approximately 904 miles of existing system roads and unauthorized routes would be decommissioned on the Coconino and Kaibab National Forests. Total disturbance from system and unauthorized road decommissioning would therefore amount to 1,645 acres of disturbance. Approximately 38 miles, or 70 acres of road decommissioning would occur on soils having severe erosion hazard ratings, reducing the acreage of severe erosion hazard soils that are continuously exposed to raindrop impact and subject to accelerated erosion.

System roads convert productive soils to an essentially non-productive condition for the long-term (i.e., greater than fifty years). Most precipitation that falls on compacted road surfaces becomes surface runoff. Implementation of effective BMPs and SWCPs during road decommissioning would improve surface water quality since these road segments would no longer be redirecting surface flows via ditches and delivering sediment and other pollutants directly to streamcourses.

Decommissioning of 904 miles of existing NFS roads and unauthorized routes would improve surface water quality, particularly where roads intersect or cross stream channels. Road decommissioning also improves watershed condition by eliminating the amount of compacted surface area and sources of concentrated flow to connected stream channels. While road decommissioning is expected to produce an initial spike in sediment delivery to adjacent streamcourses, this increase would be of short duration. Brown (2002) measured the sediment delivery resulting from road obliteration at stream crossings in central Idaho. Peak suspended sediment concentrations ranged from 2.9 to 68,400 mg L^{-1}, depending on the number of straw bales placed in the stream and the flow diversion channel. Foltz and Yanosek (2005) observed sediment yields of 2 to 170 kg resulting from the removal of each of three corrugated metal pipe (CMP) culverts in central Idaho .

Many of these roads proposed for decommissioning are inadequately engineered, poorly located on the landscape and are consequently in a state of disrepair. Some of these roads are located near drainage channels or on ridge tops and are subject to erosion and sediment transport. Roads near drainages are contributing to adverse effects to surface water quality during snowmelt and following short duration, high intensity monsoon storms. Some roads have eroded to the point where roads surfaces are below the grade of the surrounding landscape, resulting in stormwater runon that then pools on road surfaces or flows down the travelway eroding the roadbed and entraining sediment in the storm flow. Where water pools in road surfaces, rutting is a problem. Where stormwater flows down road surfaces, rills and gullies are compromising the integrity of road surfaces and water quality.

Compacted road surfaces generate large amounts of surface runoff as a result of low infiltration rates (Luce and Cundy 1992, Reid and Dunne 1984, Robichaud et al. 2010). Road surfaces are subjected to rainsplash that results in soil particle detachment. When combined with large amounts of surface runoff, erosion rates are often several orders of magnitude greater than the adjacent undisturbed forest (MacDonald and others 2004; Megahan 1978). Research has consistently shown that roads have the greatest effect on erosion of all practices associated with forest management (Robichaud 2010). Soil erosion rates from road surfaces are the dominant source of sediment in most managed forests (Brown and MacDonald 2005).

Channel Restoration

Approximately 39 miles of degraded ephemeral channels would be restored under Alternative B. Steinke (2014) estimates that ground disturbance from mechanized equipment and bank shaping and stabilization activities would amount to approximately 561 acres, or less than 1 percent of the total 583,330-acre proposed treatment area. At the HUC12 subwatershed scale, disturbance acreages are expected to range from 2 acres (Johnson Creek) to 108 acres (Walnut Creek-Lower Lake Mary). Channel restoration activities would likely cause an initial, short term increase in sediment production from disturbed areas following restoration activities. With implementation of BMPs and SWCPs specific to channel restoration listed in Table 1 (i.e., BMP numbers 11 through 21, and 33), adverse impacts to surface water quality and riparian conditions would be minimized or mitigated.

Protective Fencing for Aspen and Springs

Approximately 86 miles of fencing is proposed around aspen stands (82 miles) and springs (4 miles) for protection of natural regeneration in aspen stands and protection of springs from adverse effects of browsing by vertebrate herbivores (including domestic livestock), and human activities. Approximately 184 acres of soil disturbance is anticipated.

Although there are no quantifiable data regarding the impacts that vertebrate herbivores and OHV traffic have on aspen stands and springs of the KNF and CNF, it is generally accepted that adverse effects to aspen stands and spring habitats from these activities are occurring.

Construction and maintenance of the proposed exclosures in aspen stands and spring habitats would result in short-term, minor soil compaction and trampling or removal of native vegetation in areas where fence construction occurs. Native vegetation would reestablish in these areas soon after construction is completed (i.e., 1 to 3 years). Soil stability and productivity within exclosures would improve over time through elimination of impacts to aspen regeneration and wetland vegetation by vertebrate herbivores (i.e., browsing and trampling). Additional benefits include reduced susceptibility of sites to invasion by noxious weeds by increasing native vegetation recruitment over time. Increased native plant cover would reduce the amount of open, ruderal sites susceptible to weed invasion. A slight improvement in water quality and riparian vegetation conditions would be expected as a result of protective fence installation in aspen and spring habitats.

Spring Restoration

Spring restoration is proposed on 74 springs within the project area. Springs have an important role at the landscape scale for hydrologic function of watersheds and they are very important for wildlife and plant diversity. Fifty-one developed springs on the Coconino NF are known to be not functioning at or near potential and 27 springs on the Kaibab NF have reduced function. The desired condition is to have the necessary soil, water, and vegetation attributes for springs to be healthy and functioning at or near potential.

Changes to spring discharge and ecological function following vegetation treatments and the locations of springs that exhibit such changes cannot be predicted with accuracy. Additionally, changes to the frequency and duration of spring discharge that may result from restoration treatments cannot be predicted with certainty. However, some generalizations can be made. The hydrologic response of springs in the project area to proposed treatments will depend on the summed effect of the changes in evaporation, transpiration, soil moisture storage, snowpack accumulation and melt processes, and presence or absence of drought conditions. Additionally, changes to spring ecosystem function could result from possible changes to the physicochemical characteristics of groundwater following vegetation treatments.

Precipitation accumulates in the winter over most of the analysis area as snowpack, with melting and sublimation occurring during warm phases throughout the winter. Much of the winter snow fall is currently intercepted by tree canopies. Some of this moisture evaporates or sublimates without contributing to soil moisture, while some is blown off of intercepting vegetation or simply falls off, thus reaching soil surfaces. When the remaining snowpack begins to melt in spring, melt water first recharges the soil by replacing the water that was depleted during the previous growing season. Once soil moisture storage capacity is at its maximum, remaining melt water either becomes surface runoff that may contribute to stream flow, or is available for groundwater recharge. On north facing slopes, some of the snowpack remains almost continuously from December to April. While the evaporation rate is lower than south facing slopes, the relatively large surface area of snow permits a substantial amount of evaporative loss to occur. In contrast, on south facing slopes, intercepted snow quickly leaves the less dense forest canopy, thus allowing less interception and evaporative loss. For the first 1 to 3 years following vegetation treatments, a slight increase in groundwater recharge and runoff is expected since snowpack interception would be reduced; there would be fewer trees to create evapotranspirational demand for soil moisture during the growing season; and understory vegetation of grasses, forbs and shrubs will not have reached maximum ground cover levels. These conditions have potential to increase spring discharge.

Higher intensity forest thinning treatments would likely have the greatest potential to improve spring discharge by reducing evapotranspiration rates in treated areas. Soil moisture would likely improve in these areas for the first 1-3 years following treatments. Soil moisture that is not utilized by remaining trees and developing understory vegetation would contribute to groundwater recharge. As grass, forb, and shrub communities increase, evapotranspiration would also increase. Groundwater recharge would therefore be slightly reduced as water demand by understory vegetation increases.

Prescribed fire has the potential to improve spring discharge and ecosystem function through introduction of low intensity fire that partially consumes vegetation and litter. The reduction in vegetative cover would reduce overall evapotranspiration rates in treated areas. This has the potential to increase both surface runoff and groundwater recharge rates.

An important consideration for restoration of springs is to restore discharge from the spring source except where prescribed by existing water rights adjudicated. This would allow discharge from springs to resume flow through their historic spheres of discharge as described by Springer and Stevens (2008).

Tables 1 and 2 in Appendix E list springs of the CNF and KNF that occur within the analysis area. Table 3 lists springs within each restoration unit for each Forest and the entire analysis area. Tables 4 and 5 list springs by Forest within each proposed treatment type.

Cumulative Effects

As previously noted, the cumulative effects analysis area includes the eighty-two 6th-level (HUC12) subwatersheds, which total 2,032,080 acres. The timeframe for past actions is 10 years, based on soil productivity, vegetative response, coarse woody debris recovery, and recovery of decommissioned roads within treated areas as these are the primary factors affecting water quality and riparian area conditions within and downstream of treatment areas.

Baseline

Livestock grazing, road construction and maintenance activities, management of utility corridors/rights-of-way, and activities undertaken on private lands are baseline, or background disturbances for the purpose of this cumulative effects analysis. These are common ground-disturbing activities within and adjacent to the proposed project area and are therefore considered ground disturbance constants.

Livestock grazing occurs on approximately 1,692,900 acres within the cumulative effects analysis area, which includes portions of the Coconino, Kaibab, and Prescott National Forests as well as intermingled state and private lands. Ground disturbance associated with livestock grazing includes minor, generally localized soil disturbance, displacement, compaction, puddling, and erosion from livestock trailing and in areas where animals congregate such as stock tanks, corrals, and areas where mineral supplements are placed. Individual wildlife and livestock trails occur throughout the analysis area, but these trails comprise a small percentage of the analysis area. Ground disturbance from livestock grazing is most typically concentrated around water sources (stock tanks, troughs, etc.) and livesock have been shown to degrade water quality in stock tanks when access is not controlled (Smith 2011, Pfost and Fulhage 2001). Soil disturbance is estimated at 1,100 acres, based on a 1/8 mile buffer around livestock and wildlife waters.

There are approximately 7,170 miles of roads within the analysis area, which includes both open and closed roads. For the purposes of this cumulative effects analysis, no distinction is made between closed or open roads as this would be the most conservative analytical approach. However, approximately 6,240 miles of roads, including Forest Service roads, State highways, Interstate highways, and County roads are currently used by travelers throughout the cumulative effects analysis area. Based on an average road width of 15 feet, soil disturbance associated with roads is estimated at 13,036 acres. Road maintenance activities such as blading, resurfacing (adding aggregate), compacting, crowning, paving, sediment removal from ditches, culvert replacement, cleaning sediment from cattle guards, and installing road BMPs are common, ongoing practices on National Forest System, State, and County roads. These activities have potential to introduce sediment and other pollutants to connected streamcourses, thereby contributing to a cumulative adverse effect to water quality within the analysis area. However, when combined with proposed road decommissioning and road relocation, the overall effect of roads to water quality would likely be improvement.

There are approximately 294 miles of utility corridors within the cumulative effects analysis area, including electric utility corridors, natural gas pipelines, and water pipelines. Some of these utility corridors are incorporated into existing road corridors. There is high variability in width and intensity of right-of-way management, depending upon the type of utility and associated infrastructure. Management of these areas typically includes vegetation control (i.e., tree felling and grinding, treatment of invasive and noxious weeds, revegetation of disturbed areas, installation of cathodic protection devices and maintenance and implementation of stormwater control structures (BMPs) on access roads. These activities have potential to adversely affect water quality and riparian areas, particularly where utility corridors intersect surface waters.

There are approximately 101,461 acres of private land within the cumulative effects analysis area. Conditions on private lands range from municipal/urban development in areas such as Flagstaff, Williams, Tusayan, and Sedona to completely undeveloped. For this analysis, each private land parcel was classified as having either high or low development by examining each parcel within the analysis area using remote sensing to determine the level and extent of development. For areas of high development, a disturbance factor of 70 percent was applied (this is the equivalent disturbed area factor used on the Apache-Sitgreaves Equivalent Disturbed Area process for high development). For areas of low development, a 10 percent disturbance factor was applied. The total estimated ground disturbance on private lands within the analysis area is approximately 30,900 acres.

Using the baseline acreages described above, estimated ground disturbance that has potential to adversely affect water quality within the cumulative effects analysis area would be approximately 45,040 acres. Substantial urban development occurs in six 6^{th}-code watersheds. These include: Cataract Creek Headwaters (11 percent baseline ground disturbance) associated with the City of Williams; Sinclair Wash (25 percent) and Lower and Upper Rio de Flag (18 percent), and Pumphouse Wash associated with the City of Flagstaff; and Middle Oak Creek (11 percent) associated with Sedona and private land developed adjacent to Oak Creek. No significant floodplain management has been taken by Coconino County to restrict development within floodplans. As a result, development in floodplains is common throughout the cumulative effects analysis area. Flooding in developed areas typically introduces pollutants to streamcourses and waterbodies in the form of solid waste, petroleum hydrocarbons, and other materials carried in urban runoff.

Past Actions

Vegetative recovery after fuels reduction treatments is generally rapid, with soil erosion and sediment delivery rates typically returning to pre-treatment levels within 1 to 2 years (Elliot et al. 2010). Vegetative ground cover that protects soil surfaces from erosive forces of wind and water is therefore expected to have recovered in areas that were disturbed more than 3-5 years ago. It is therefore unlikely that past treatments are contributing measurable amounts of sediment and other non-point source pollution to streamcourses, springs, other water bodies (i.e., stock tanks and impoundments) and riparian areas. Past treatments that are greater than 3-5 years old are therefore not expected to contribute to adverse cumulative effects to water quality or riparian area conditions within or downstream of the project area.

Recent activities (i.e., within the last 1-3 years), including fuels reduction treatments, commercial timber harvests, juniper clipping, prescribed burning, and road obliteration are continuing to revegetate and therefore pose a slightly elevated risk of contributing cumulatively to adverse effects to water quality if new treatments are implemented within, adjacent to above these areas. By delaying subsequent treatments in these areas until vegetative recovery is sufficient to protect soil surfaces from erosion and sediment delivery to streamcourses, springs, or riparian areas, cumulative impacts to water quality and riparian vegetation from proposed treatments would be minimized or mitigated. The magnitude of effects to water quality and riparian vegetation resulting from past actions is expected to be similar to the proposed action since BMPs and SWCPs would have been implemented in a similar manner as proposed under the Action Alternatives of this project.

This cumulative effects analysis does not attempt to quantify the effects of past human actions by summing the effects of all prior actions. Instead, existing forest conditions within the 82 HUC12 subwatersheds on the CNF and KNF that include the Four Forest Restoration Initiative analysis area are considered to be representative of the effects of past actions when combined with current actions and natural disturbances. Proposed treatments under Alternative B are expected to result in a total of 60,995 acres of disturbance, or 3 percent of the analysis area acreage of 2, 032,080.

Present Actions

Present actions that are occurring within the cumulative effects analysis area include additional fuels reduction projects, developed and dispersed recreation, road maintenance, fire suppression, permitted hunting, livestock grazing and special uses. Tables 1 through 4 in Appendix F and Attachment 4 in the soils specialist report list anticipated ground disturbance by HUC12 subwatershed and their associated acreages for each alternative. Current and ongoing activities have occurred from 2009 to the present. The use of the last three years for current and ongoing activities is based on the 1-2 year recovery time for vegetation as stated in Elliot et al., 2010. All listed activities use a 15% disturbance threshold factor, so the acreages for ground disturbance resulting from prescribed burning treatments are overestimated while acreages for ground disturbance from mechanical treatments reflect reasonable maximum ground disturbance rates.

For the purpose of this cumulative effects analysis, there are approximately 133,000 acres of current and ongoing projects within the cumulative effects boundary, or approximately 7 percent of the cumulative effects analysis area. Using a maximum disturbance of 15 percent areal extent for treatments, there are a total of approximately 19,900 acres of ground disturbance from projects within the cumulative effects boundary area, or about 1 percent of the cumulative effects boundary area.

Reasonably Foreseeable Future Actions

Recreational activities include: hiking, wildlife viewing, hunting, dispersed car-camping, backpack camping, orienteering, horseback riding, caving, rock climbing, photography, picnicking, taking scenic drives, ORV/ATV use, bicycling, shooting, and gathering in family or social groups. Snowmobile use and cross-country skiing are increasing as popular uses in the area. During normal winters, snowmobiles are the only vehicles that access the area.

Other uses of forest resources within the project area include firewood gathering, post and pole cutting, collecting boughs and cones, collecting and transplanting wildlings, gathering antlers, collecting food and medicinal resources such as berries, nuts, mushrooms, and ferns, and collecting biological specimens for research.

Implementation of Travel Management Rule throughout the Four Forest Restoration Initiative analysis area has effectively reduced the density of roads currently in use by visitors to both Forests. However, roads that remain in use can be expected to continue to deliver sediment as non-point source pollution to connected streamcourses within the project boundary where BMPs are not implemented or are ineffective at controlling sediment delivery to connected streamcourses. Implementation of BMPs and SWCPs as specified in Table 1 would reduce potential non-point source pollution from roads.

Stock tank use by domestic and wildlife ungulates would continue to contribute adverse effects to surface water quality. Domestic livestock grazing would continue to remove biomass that protects soil surfaces from erosion and resulting sediment delivery to streamcourses. Trampling and trailing by domestic livestock would result in minor, localized adverse effects to soil stability in ephemeral drainages.

Fuels reduction-related projects are expected to occur within the cumulative effects analysis area. Acres of disturbance for reasonably foreseeable and future actions are summarized in Tables 1 through 4 of Appendix F. Reasonably foreseeable and future actions include the Flagstaff Forest Partnership Project, the Kelly Trails Project, the Moonset Pit Expansion Project and the Bill Williams Mountain Restoration Project. There are approximately 157,000 acres of foreseeable and future treatment acres within the cumulative analysis area. Disturbance associated with these treatments amounts to approximately 7.7 percent of the cumulative effects analysis area. Assuming an average disturbance factor of 15 percent areal extent for restoration treatments, there are a total of approximately 23,550 acres of ground disturbance from projects within the cumulative effects boundary area, or about 1 percent of the cumulative effects boundary area. Ground disturbing activities would require implementation of BMPs to mitigate non-point source pollution to connected streamcourses.

Continued prescribed fire use and wildfires are likely to occur within and outside the Four Forest Restoration Initiative analysis area.

Wildfires continue to occur within and adjacent to the analysis area. Reviews of burned area reports indicates that between 1 and 5 percent of soils in the project area indicate adverse effects from wildfires. Until such soils have recovered from burned conditions, they are often a source of sediment and nutrient delivery to streamcourses.

Summary of Cumulative Effects

The geographic setting and boundary for the cumulative effects analysis will all 82 6th HUC watersheds for a total of about 2,032,00 acres. The total acres of current and reasonably foreseeable treatment acres within the cumulative effects project area are approximately 315,544 acres, or about 16% of the cumulative effects analysis area. Of these project acres, we are expecting that ground disturbance on about 64,252 acres, which is just under 3 percent of the cumulative effects analysis area. Under Alternative B with the expected 66,151 acres of expected ground disturbance from the proposed activities within Alternative B, the total acreage of ground disturbance across the cumulative effects analysis (including the approximately 45,000 acres of baseline ground disturbance) area would be approximately 162,241 acres, or about 8 percent of the cumulative effects analysis area. As previously noted, protection of water quality and riparian area resources is provided by the use of Best Management Practices that minimize the potential for adverse effects to soils, water quality and riparian areas. This Alternative will therefore not pose a detrimental cumulative effect to water quality or riparian resources within the cumulative effects analysis area.

Alternative C

Direct and Indirect Effects

Direct and indirect effects from implementation of Alternative C are only discussed for treatments with different acreages under each Action Alternative. Treatments having the same acreage under this Action Alternative are assumed to have similar direct and indirect effects as Alternative B.

Grassland Restoration

Under the Alternative C, grassland restoration treatments would be conducted using mechanized equipment or manual methods to treat vegetation on approximately 59,390 acres within sixty six 6th-level HUCs. Of these acres, approximately 279 acres are on soils with severe erosion hazard ratings. Treatment acreages within each HUC12 subwatershed range from 1 acre (Klostermeyer Lake) up to a maximum of 1,027 acres (Garland Prairie). Steinke (2014) estimates soil disturbances of approximately 1 percent (6,117 acres) as a result of restoration treatments in grasslands. However, since Alternative C includes thinning of encroached trees in the Garland Prairie Research Natural Area, disturbance associated with this treatment would increase overall ground disturbance from grassland restoration treatments since this area is more extremely encroached with ponderosa pine than other grasslands proposed for restoration treatment. Steinke (2014) estimates that total ground disturbance from grassland restoration treatments would be approximately 10 percent under Alternative C. A threshold of 15 percent areal extent for soil disturbance within treatment areas has been established as a guideline. Soil disturbance levels of 10 percent in areal extent would not exceed established disturbance thresholds. Estimated disturbance from grassland restoration under Alternative C is estimated to be slightly higher that the other action alternatives. However, soil erosion models indicate that grassland restoration treatments would not result in soil erosion that exceeds tolerance limits. Since soil disturbance from grassland restoration treatments would not exceed disturbance thresholds and consequential soil erosion rates would not exceed soil erosion tolerance limits that indicate long term loss of soil productivity, it is unlikely that adverse impacts to water quality or riparian areas would occur as a result of grassland restoration treatments. Additionally, implementation of BMPs and SWCP as outlined in Table 1 would minimize or mitigate potential adverse effects to soils resources, surface water quality, and riparian area conditions.

Ponderosa Pine Restoration – Low Intensity Thinning

Under the Alternative C, approximately 176,103 acres would be treated using low intensity thinnings to restore the ponderosa pine vegetation type. Treatments would be conducted as described under the Proposed Action with soil disturbance resulting from forest thinning and subsequent treatment of residual woody debris, varying by type of harvesting method and woody debris treatment. Treatment acreages at the HUC12 subwatershed level range from 1 acre (Curley Wallace Tank) to 18,661 acres (Coconino Wash Headwaters). Estimated disturbance at the HUC12 subwatershed level ranges from 4 acres (Smoot Lake) to 2,239 acres (Coconino Wash Headwaters). Soil disturbance is estimated to be approximately 21,132 acres or 12 percent of the total low intensity thinning treatment acreage. This represents approximately 3.6 percent of the entire 586,110 acre proposed treatment area. As previously noted, a threshold of 15 percent areal extent for soil disturbance is assigned as a guideline. Also, as under the Proposed Action, low intensity thinning treatments would not occur simultaneously, but would instead be distributed both temporally and spatially within each treated watershed. Steinke (2014) determined that soil disturbance from low intensity thinning treatments would therefore not pose a risk to soils resources. Since soil resources would not be adversely affected by low intensity thinning treatments followed by woody debris management, water quality and riparian area conditions are not expected to be adversely affected. Resource protection measures such as BMPs and SWCPs outlined in Table 1 would minimize or mitigate potential adverse effects to water quality and riparian areas.

Ponderosa Pine Restoration – High Intensity Thinning

This treatment type is proposed on approximately 149,351 acres in the ponderosa pine vegetation type. Treatment acreages at the HUC12 subwatershed scale ranges from 7 acres (Little Red Horse Wash) to 9,169 acres (Walnut Creek-Upper Lake Mary). The types of ground disturbance associated with this treatment type under Alternative C would be the same as the Proposed Action. Total soil disturbance is would be less than the proposed action at approximately 22,403 acres. When combined with current and foreseeable future projects, the overall ground disturbance would be would be approximately 15 percent of the proposed high intensity ponderosa pine thinning treatment under this alternative. This represents approximately 3.8 percent of the entire 586,110 acre proposed treatment area. However, soil erosion models indicate that erosion would not exceed tolerance thresholds. As under low intensity thinning treatments, it is anticipated that high intensity thinning treatments would not occur simultaneously within a given watershed, but would instead be distributed both temporally and spatially within each treated watershed.

Paired Watershed Study

Effects to water quality and riparian areas would be less than under the Proposed Action. However, there would be additional disturbance of approximately 3 acres for installation of up to 15 flumes, 20 weather station, and other instrumentation to support watershed research. Instruments to monitor precipitation include weighing rain gages, cameras to monitor snow depth, snow courses for monitoring snowpack and forecasting streamflow. Meteorological stations will be installed in the upper part of each watershed. These stations will record temperature, barometric pressure, humidity, wind speed, wind direction and precipitation. Sensors will be installed to to measure incoming and outgoing shortwave, longwave and photosynthetically active radiation. Cosmic-ray Soil Moisture Observing System (COSMOS) will be place near the center of each watershed in a location representative of the overall watershed treatment prescription. This will be done in collaboration with the University of Arizona for upscaling landscape-scale forest change to global climate processes (Zreda et al. 2008). Three sets of recording time domain reflectometry (TDR) soil moisture sensors will be placed at shallow (6 in., 15.2 cm") and deep (20 in., 50.8 cm") root zones within the footprint of each COSMOS, circle with a radius of 330 m (1,080 ft.). Water column heights will be measured by mounted time-lapsed cameras focused on a graduated T-post in the channel thalweg (deepest part of channel) and used with channel profile, and Manning's roughness coefficient to calculate flow. Stream gaging flumes with stilling wells and pressure transducers will be installed in selected stream channels to monitor stream discharge. Sediment traps will be installed in stream channels to monitor changes in stream bedloads.

Although some these instruments (i.e. flumes, bedload sediment traps and T-posts) would be installed directly in stream channels, adverse effects to water quality are not anticipated as a result of the research effort since these stream channels are either intermittent or ephemeral.

Reduced Mechanical Treatment Intensity Effects on Water Quality and Riparian Area Conditions - Alternatives C and E

Reducing treatment intensity on approximately 40,000 acres within the project area would not increase risk to water quality or riparian area conditions. With the implementation of identified BMPs ans

SWCPs, sediment delivery to streamcourses and other waterbodies would be minimized or mitigated. Steinke (2014) noted that soil disturbance direct effects associated with 4FRI treatments has already been shown not to exceed the 15 percent threshold for maintenance of soil productivity. Reducing treatment intensity on approximately 40,000 throughout the 4FRI analysis area is not expected to increase the risk of detrimental effects to water quality or riparian areas from uncharacteristic wildfire due to the limited number of acres proposed for reduced treatment intensity. This is because areas proposed for reduced treatment intensity are relatively small treatment areas that are non-contiguous and occur in multiple subwatersheds (HUC12). Treatment area sizes would range from about 4 to 344 acres, averaging 35 acres per stand. Approximately 1,880 acres (with the largest single polygon comprising approximately 90 acres) would be at an increased risk of uncharacteristic fire behavior (Lata 2014, Steinke 2014) that could result in increased sediment-laden stormwater runoff following post-fire precipitation and runoff events. These areas are small and discontinuous, allowing for maintenance of adequate vegetative ground cover in adjacent areas that would capture entrained sediment and reduce runoff velocities and volume, thereby reducing sediment delivery and potential adverse effects to waterbodies and riparian areas that could otherwise result from uncharacteristic fires associated with dense forest conditions on much larger acreages.

The maximum amount of acres in any 6th HUC watershed that could result in increased fire risk due to reduced fire intensity treatments is in RMU 6-3 is 646 acres (Lata, 2014). For Alternatives C and E, the total number of acres in the watershed is 51,193 with soil disturbance predicted at the watershed scale from originally proposed EIS treatments of 6.1% and 8.7% for cumulative effects (Steinke 2014). Reducing treatment intensity could therefore result in a very slight increase in soil disturbance from 6.1% to 7.4% while total disturbance from cumulative effects would increase from 8.7% to 9.9% for both alternatives at the watershed scale (Steinke 2014). It is very unlikely that this slight increase would result in a measurable change in sediment delivery to waterbodies and riparian areas. Effects to water quality are therefore not expected to be measurable at the watershed scale.

For all 6th-level HUC subwatersheds, reducing treatment intensity on approximately 40,000 acres would result in soil disturbance remaining less than the 15% established threshold (Steinke 2014). Since soil disturbance would remain below established thresholds, risks to water quality and riparian areas are not anticipated.

Savanna Treatment

Approximately 45,065 acres are proposed for savanna restoration treatments in the ponderosa pine vegetation type. Soil disturbance as a result of savannah restoration treatments is estimated to be 6,760 acres, or 15 percent areal extent. At the HUC12 subwatershed scale, savanna treatment acreages are expected to range from 3 acres (Long Lake-Chavel Pass Ditch and Middle Deadman Wash) to 622 acres (Walnut Creek-Upper Lake Mary). Soil disturbance, and therefore effects to water quality and riparian areas is the same as the Proposed Action.

Prescribed Fire Treatment

Prescribed burning is proposed for 586,199 acres, or approximately 2,870 acres more than the Proposed Action. Steinke and Lata (2014) estimate disturbance as a result of high severity burn conditions to vary between 1 and 3 percent areal extent of the proposed treatment acreage. At the HUC12 subwatershed scale, soil disturbance acreage is expected to range from 2 acres (Curley Wallace Tank, Yeager Draw) to 642 acres (Munds Canyon). Total soil disturbance from prescribed burning under Alternative C is estimated to be 11,724 acres, or 104 acres more than the Proposed Action. Direct and indirect effects to water quality and riparian areas would therefore be nearly the same as the Proposed Action. Effects to surface water quality and riparian areas are also expected to be similar to the Proposed Acion. It is unlikely that differences in disturbance levels between the Proposed Action and Alternative C with regard to water quality and riparian areas would be detectable at the watershed scale.

Summary of Cumulative Effects

The cumulative effects project area and the timeline are the same as Alternative B. The total acres of current and reasonably foreseeable treatment acres within the cumulative effects project area are approximately 312,492 acres, or about 15% of the cumulative effects analysis area. Of these project acres, we are expecting that ground disturbance on about 51,046 acres, which is just under 3 percent of the cumulative effects analysis area. Including the ground disturbance from Alternative C (about 71,371 acres), the total acreage of ground disturbance across the cumulative effects analysis (including the approximately 45,000 acres of baseline ground disturbance) area would be approximately 167,458 acres, or about 8.2 percent As such, the threshold of 15% aerial extent disturbance guideline (USDA, 1991) where soil impairment and productivity is measurable and may be appreciably reduced is not exceeded.

No threshold for ground disturbance occurs within the Kaibab or Coconino National Forest Land Management Plans. However, a general guideline of 15 percent reduction in inherent soil productivity potential serves as a basis for setting threshold values for measurable or observable changes in soil properties or conditions (Steinke 2014). Based on the estimated areal extent and low magnitude of soil disturbance, the 15% guideline for soil disturbance where soil productivity crosses a negative threshold would not be exceeded with this project within the cumulative effects boundary. Further protection of soils and water resources is provided by the use of BMPs and SWCPs. Alternative C will therefore not result in detrimental cumulative effects to water quality or riparian area conditions. The long-term effect of Alternative C would be an improvement in water quality and riparian area conditions through improved forest resiliency to uncharacteristic fire behavior and potential effects of climate change.

Alternative D

Direct and Indirect Effects

Ponderosa Pine Restoration – Low Intensity Thinning

Under the Alternative D, approximately 173,701 acres would be treated using low intensity thinnings to restore the ponderosa pine vegetation type. Treatments would be conducted as described under the Proposed Action with soil disturbance resulting from forest thinning and subsequent treatment of residual woody debris varying by type of harvesting method and woody debris treatment. Treatment acreages at the HUC12 subwatershed level range from 1 acre (Curley Wallace Tank) to 18,661 acres (Coconino Wash Headwaters). Estimated disturbance at the HUC12 subwatershed level ranges from 4 acres (Smoot Lake) to 2,239 acres (Coconino Wash Headwaters). Alternative D has1,003 fewer acres of low intensity thinning in comparison the the Proposed Action and 2,402 acres less than Alternative C. Direct and indirect effects to water quality and riparian areas would therefore be very similar among the three Action Alternatives. It is unlikely that differences in disturbance effects would be detectable at the watershed scale. Adverse effects to water quality or riparian areas are not anticipated under Alternative D. Timely implementation of BMPs and SWCPs as described in Table 1 would insure that adverse effects to water quality or riparian areas is minimized or mitigated.

Prescribed Fire Treatment

Alternative D responds to issue 2 (smoke) as described in chapter 1 by reducing the number of acres subjected to prescribed fire treatment by over 50 percent (in comparison to alternative B). Prescribed fire treatments are proposed on 178,442 acres, substantially fewer acres than the Alternative B, which proposes 586,110 acres of prescribed fire. At the HUC12 subwatershed scale, soil disturbance acreage is expected to range from 1 acre (Government Canyon and Sinclair Wash) to 259 acres (Doney Park). Total soil disturbance from prescribed burning under Alternative D is estimated to be 3,569 acres, or 2 percent. While Alternative D represents substantially fewer acres of disturbance from prescribed fire in comparison to all other Action Alternatives, it would not meet the purpose and need of returning fire to fire adapted ecosystems. Alternative D would also fail to provide forest resiliency to uncharacteristic fire behavior and mitigate the potential effects of climate change. Best Management Practices and SWCPs as outlined in Table 1 would minimize or mitigate potential adverse effects to water quality and riparian areas from proposed prescribed fire treatments under Alternative D.

Summary of Cumulative Effects

The total acres of current and reasonably foreseeable treatment acres within the cumulative effects project area are approximately 315,544 acres, or about 16% of the cumulative effects analysis area. Of these project acres, we are expecting that ground disturbance on about 64,252 acres, which is just under 3 percent of the cumulative effects analysis area. Under Alternative D with the expected 57,937 acres of expected ground disturbance from the proposed activities within Alternative D, the total acreage of ground disturbance across the cumulative effects analysis (including the approximately 45,000 acres of baseline ground disturbance) area would be approximately 154,025 acres, or about 7.6 percent of the cumulative effects analysis area. As such, the threshold of 15% areal extent disturbance guideline where soil impairment and productivity is measurable and may be appreciably reduced is not exceeded (Steinke 2014). Therefore, no adverse effects to surface water quality or riparian area conditions are anticipated. Additionally, implementation of BMPs and SWCPs as described in Table 1 would minimize or mitigate most adverse effects to water quality and riparian area conditions.

No threshold for ground disturbance occurs within the Coconino or Kaibab National Forest Land Management Plans. However, as previously noted, a general guideline of 15 percent reduction in inherent soil productivity potential serves as threshold value for measurable or observable changes in soil properties or conditions. Based on the estimated extent and magnitude of soil disturbance, the 15% threshold of detrimental soil disturbance where soil productivity crosses a negative threshold would not be exceeded under this alternative within the cumulative effects boundary. Further protection of soils, water quality, and riparian conditions is provided through implementation of BMPs and SWCPs as described in Table 1. Cumulative adverse effects to surface water quality or riparian area conditions.

Alternative E

Direct and Indirect Effects

Ponderosa Pine Restoration – Low Intensity Thinning

Under the Alternative E, approximately 176,104 acres would be treated using low intensity thinnings to restore the ponderosa pine vegetation type. This treatment acreage is the same as Alternative C, but approximately 1,400 acres more than Alternative B (174,704 acres). Treatments would be conducted as described under the Proposed Action with soil disturbance resulting from forest thinning and subsequent treatment of residual woody debris varying by type of harvesting method and woody debris treatment. Treatment acreages at the HUC12 subwatershed level range from 4 acres (Smoot Lke) to 18,661 acres (Coconino Wash Headwaters). Estimated disturbance at the HUC12 subwatershed level ranges from 4 acres (Smoot Lake) to 2,239 acres (Coconino Wash Headwaters). Direct and indirect effects to water quality and riparian area conditions would similar, but slightly greater than the Proposed Action and and approximately the same as Alternative C. It is unlikely that differences in disturbance effects would be detectable at the watershed scale. Adverse effects to water quality or riparian areas are not anticipated under Alternative E. Timely implementation of BMPs and SWCPs as described in Table 1 would insure that adverse effects to water quality or riparian areas are minimized or mitigated.

Prescribed Fire Treatment

Prescribed fire treatments are proposed on 581,020 acres, which is fewer acres than the Proposed Action (583,329 acres) and Alternative C (586,199 acres), but substantially more acres than proposed under Alternative D (178,442 acres). At the HUC12 subwatershed scale, soil disturbance acreage is expected to range from 2 acres (Yeager Draw) to 628 acres (Munds Canyon). Total soil disturbance from prescribed burning under Alternative E is estimated to be 11,620 acres, or 2 percent of the proposed treatment acres under this alternative. Two percent disturbance does not exceed the guideline of 15 percent disturbance threshold. It is therefore unlikely that adverse effects to water quality or riparian areas would occur as a result of this alternative. Additionally, prescribed fire treatments would not be implemented throughout an entire watershed at once, but would instead be implemented over time and in a spatial pattern that would minimize runoff and sediment delivery to streamcourses. Best Management Practices and SWCPs as outlined in Table 1 would further minimize or mitigate potential adverse effects to water quality and riparian areas from proposed prescribed fire treatments under Alternative D.

Savanna Treatment

There would be no savanna treatments under Alternative E. There would therefore be no adverse effects to water quality or riparian areas as a result of savanna treatments.

Summary of Cumulative Effects

The cumulative effects project area and the timeline are the same as Alternative B. The total acres of current and reasonably foreseeable treatment acres within the cumulative effects project area are approximately 312,492 acres, or about 15% of the cumulative effects analysis area. . Of these project acres, we are expecting that ground disturbance on about 51,046 acres, which is just under 3 percent of the cumulative effects analysis area. Under Alternative E, the total acreage of ground disturbance across the cumulative effects analysis (including the approximately 45,000 acres of baseline ground disturbance) area would be approximately 160,338 acres, or about 7.9 percent of the cumulative effects analysis area. As such, the threshold of 15% areal extent disturbance guideline where soil impairment and productivity is measurable and may be appreciably reduced is not exceeded (Steinke 2014). Therefore, no adverse effects to surface water quality or riparian area conditions are expected. Additionally, implementation of BMPs and SWCPs as described in Table 1 would minimize or mitigate most adverse effects to water quality and riparian area conditions.

No threshold for ground disturbance occurs within the Coconino or Kaibab National Forest Land Management Plans. However, as previously noted, a general guideline of 15 percent reduction in inherent soil productivity potential serves as threshold value for measurable or observable changes in soil properties or conditions. Based on the estimated extent and magnitude of soil disturbance, the 15% threshold of detrimental soil disturbance where soil productivity crosses a negative threshold would not be exceeded under this alternative within the cumulative effects boundary. Further protection of soils, water quality, and riparian conditions is provided through implementation of BMPs and SWCPs as described in Table 1. Cumulative adverse effects to surface water quality or riparian area conditions.

Conclusion

Effects of Action Alternatives

In summary, the Proposed Action and other Action Alternatives are expected to result in areal ground disturbance ranging from 2.9 percent (Alternative D) to 3.5 percent (Alternative C) of the cumulative effects analysis area of 2,032,080 acres. Cumulative soil disturbance from past, present and reasonably foreseeable actions estimated to range from 7.2 percent (Alternative D) to 7.9 percent (Alternative C). When combined with any of the Action Alternatives, total cumulative soil disturbance is estimated to range from 10.1 percent (Alternative D) to 11.4 percent (Alternative C).

Ephemeral and intermittent drainages in the project area typically respond to seasonal runoff events (i.e., spring snowmelt and short duration, high-intensity summer monsoon storms). Surface runoff has the potential to entrain and sediment and other pollutants, contributing to short-term surface water quality degradation. Turbidity (total suspended sediment) is the water quality standard that is most likely to be affected by proposed treatment activities. Turbidity is a measure of particulate matter in suspension. Typically, in wildland settings, turbidity is the existence of fine to very fine soil particles and organic matter in water. Sediment delivery ratios normally decline with increasing watershed area, resulting in dilution of sediment delivered to streams from a given activity within a watershed. It is unlikely that any of the Action Alternatives would contribute enough sediment or other pollutants to ephemeral or intermittent drainages within the project area to result in impairment of any downstream perennial waterbodies.

Climate Change

While it is currently not possible to discern climate change effects of the Proposed Action or other Action Alternatives, given the lack of effects that can be meaningfully evaluated under current science and modeling, one would expect an initial, short-term increase in atmospheric CO_2 and other greenhouse gases from the proposed treatments through burning of hydrocarbons to conduct mechanical vegetation treatments, rapid oxidation of vegetation and woody debris during prescribed burning, and increased decomposition of woody debris. However, long-term effects would be positive as the ground cover of grasses and forbs increases. Woody debris would provide long-term nutrient sources and contribute to surface roughness, decreasing potential erosion. Nutrients released in ash during prescribed burning and through decomposition of residual woody debris from forest thinning would also improve soil quality. As previously noted the increase in ground cover of grasses, forbs, and shrubs, which have higher root turnover ratios than large woody plants would result in greater soil organic matter content over time. Soils within the project area would therefore sequester more CO_2 over the long term.

The U.S. Environmental Protection Agency (EPA) has asserted that scientists know with virtual certainty that human activities are changing the composition of the Earth's atmosphere. It is also documented that "greenhouse" gases, including CO_2, methane (CH_4), nitrous oxide (N_2O), and hydrofluorocarbons have been increasing (EPA, 2010). The atmospheric increase of these gases is largely the result of human activities such as the burning of fossil fuels. Greenhouse gases absorb infrared energy that would otherwise be reflected from the earth. As this infrared energy is absorbed, the air surrounding the earth is heated (CARB 2007).

The Southwestern Region of the Forest Service recently released "Southwestern Region Climate Change – Trends and Forest Planning: A guide for addressing climate change in forest planning on southwestern National Forests and Grasslands. The following information is summarized from excerpts of this publication:

In the Southwest, climate modelers agree there is a drying trend that will continue well into the latter part of 21st century (IPCC 2007; Seager et al. 2008). Climate modelers predict increased precipitation, but believe that the overall balance between precipitation and evaporation would still likely result in an overall decrease in available moisture. Regional drying and warming trends have occurred twice during the 20th century (1930s Dust Bowl, and the 1950s Southwest Drought). Current drought conditions "may very well become the new climatology of the American Southwest within a time frame of years to decades". According to recent model results, the slight warming trend observed during the last 100 years in the Southwest may continue into the next century, with the greatest warming to occur during winter. Climate models predict temperatures to rise approximately 5 to 8 degrees Fahrenheit by the end of the century (IPCC 2007). This trend would likely increase demand on the region's already limited water supplies, as well as increase energy demand, alter fire regimes and ecosystems, create risks for human health, and affect agriculture (Sprigg et al. 2000).

Average ambient air temperatures are rising, and it is possible that continued warming will increase the temperature difference between the Southwest and the tropical Pacific Ocean, enhancing the strength of westerly winds that carry moist air from the tropics into the Southwest region during the monsoon season. This scenario may increase the monsoon's intensity, or its duration, or both, in which case floods would occur with greater frequency (Guido 2008). While the region is generally expected to dry, it is possible that extreme weather patterns leading to more frequent destructive flooding would occur. Along with monsoons of higher intensity, hurricanes and other tropical depressions are projected to become more intense overall. Arizona typically receives 10 percent or more of the annual precipitation from storms that begin as tropical depressions in the Pacific Ocean. In fact, some of the largest floods in the Southwest have occurred when remnant tropical storms intersect frontal storms from the north or northwest (Guido 2008). Most global climate models are not yet accurate enough to apply to land management at the ecoregional or National Forest scale. This limits regional and forest-specific analysis of the potential effects of climate change.

Due to the spatial and temporal limitations of climate models, as stated above, site-specific analysis of climate change at the Forest level with regard to implementing fuels reduction treatments remains impractical. Several unknown factors further limit discussion and analysis of climate change at the Forest level. These include: lack of data on emissions from prescribed fire and wildfires, lack of data on emissions from logging machinery and traffic increases due to transportation of logs to processing facilities, limited data on emissions from machinery used to construct, maintain, or obliterate roads, and limited knowledge of the contributions of surrounding areas to current and future climate impacts at the Forest level necessary to analyze cumulative effects. Impacts to climate change from implementation of the proposed project are therefore discussed in a qualitative manner.

Projected future climate change could affect Arizona in a variety of ways. Public health and safety could be compromised due to an increase in extreme temperatures and severe weather events. Agriculture would be vulnerable to altered temperature and rainfall patterns, increasing plant stress and susceptibility to insects and diseases. Forest ecosystems could face increased occurrences of high severity wildfires and may be more susceptible to insects and diseases. Snowpack could decrease and snowmelt may occur earlier.

While the future of climate change and its effects across the Southwest remains uncertain, it is certain that climate variability will continue to occur throughout the region. Forest management activities should strive to promote ecosystem resilience and resistance to impacts of climate change. Forest management activities should focus on maintenance and restoration of native ecosystems, thereby reducing the vulnerability of these ecosystems to variations in climate patterns. Ecological diversity remains an integral component in native ecosystems. Projects should promote connected landscapes and endeavor to restore significantly altered biological communities, thus restoring their resilience to changes in climate.

Recommendations

In order to ensure that desired conditions are achieved and remain consistent with the CNF and KNF Forest Plans, monitoring of soil disturbance caused by timber harvesting; use of prescribed fire;

precommercial thinning (both mechanized and non-mechanized); road construction, maintenance and obliteration; and commercial and personal fuelwood gathering is advised. Best Management Practices (BMP) implementation and effectiveness monitoring and soil disturbance monitoring should be conducted following treatment activities in order to ensure proper implementation of BMPs to prevent excessive soil disturbance that could result in delivery of sediment and other pollutants to waterbodies and to ensure activities are consistent with Forest Plans Standards and Guidelines where applicable. A recommended soil and watershed monitoring plan is summarized below.

Phase 1 – During Timber Harvest Activities

The timber sale administrator will monitor the implementation and effectiveness of BMP's during timber harvesting activities. These data will be entered into the National BMP database. Notes taken by the timber sale administrator will be used to track any issues or problems with BMP implementation. The Forest Soils and Watershed Specialists will provide assistance as needed by the timber sale administrator to provide clarification of BMP's specified in the Environmental Impact Statement (EIS).

Phase 2 – Timber Sale Closure

The timber sale administrator will verify that the timber purchaser has implemented all erosion control measures prior to the closure of the timber sale. Primary responsibility will be that of the timber sale administrator or monitoring personnel with assistance from the Forest Soils and Watershed Specialists as needed.

Phase 3 – Broadcast and Pile Burning

The District Fire Management Officers will verify that all erosion control measures associated with prescribed fire activities has been implemented. The Forest Soils and Watershed Specialists will provide assistance, as needed.

Phase 4 – Effectiveness Monitoring

Within the first 5 years following timber sale closure, BMP's are re-evaluated for effectiveness. Monitoring will concentrate on such items as erosion control measures for skid trails, log landing or decking areas, road maintenance, road obliteration, and burned areas. The Forest Soils and Watershed Specialists will conduct soil condition evaluations within treatment units. The focus of evaluations will be on such items as vegetative ground cover, coarse woody debris, soils erosion, soil compaction, and soil displacement. All monitoring results should be documented. Primary responsibility is with the District Ranger and the Forest Soils and Watershed Specialists.

Phase 5 – Follow Up

Documented information obtained from monitoring is used to adjust BMP's as necessary, to improve implementation and effectiveness of BMP's. Information regarding monitoring results and recommended changes to BMP's will be made available to the Arizona Department of Environmental Quality (ADEQ) for review as specified in the Intergovernmental Agreement between the State of

Arizona and U.S Department of Agriculture, Forest Service Southwestern Region. Primary responsibility is with the District Ranger and the Forest Soils and Watershed Specialists.

Certification

Kit MacDonald prepared the report considering the Best Available Science and locally gathered data. Much of the information related to the effects of fire on water quality and riparian attributes were attained through research of peer reviewed scientific publications and publications from the Rocky Mountain Research Station, including RMRS GTR-42, volume 4 *Wildland Fire in Ecosystems Effects of Fire on Soil and Water* (Neary et al, 2005) and RMRS-GTR-231 *Cumulative Watershed Effects of Fuel Management in the Western United States*. Local data include the *Terrestrial Ecosystem Survey of the Kaibab National Forest* (Brewer et al, 1991) and the *Terrestrial Ecosystem Survey of the Coconino National Forest* (Miller et al. 1995).

My experience includes a Master's Degree in Forestry with an emphasis in soil science and completion of coursework toward a Ph.D. in Forestry, with an emphasis in soil science from Stephen F. Austin State University. Prior to working for the U.S. Forest Service, I worked as an environmental consultant and soils and environmental scientist in the forest products industry throughout the southeastern U.S. in areas of forest soils classification and mapping, wetland delineation and functional assessment, wetland restoration, wetland mitigation banking, disturbed land remediation and reclamation, forest management practices certification, and forestry best management practices (BMP) implementation and effectiveness monitoring related to timber harvesting and silvicultural operations including site preparation, reforestation, prescribed fire, timber stand improvement, nutrient management, forest road construction and obliteration, and forestland acquisitions. Since my employment with the USFS in 2010, I have worked in areas of soils analysis and management, water quality management, rangeland assessment, watershed analysis, and burned area emergency response.

Prepared by: /s/ Kit MacDonald Date: October 13, 2014

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Appendix A: National Oceanic and Atmospheric Administration (NOAA) U.S. Drought Monitor and Seasonal Drought Outlook

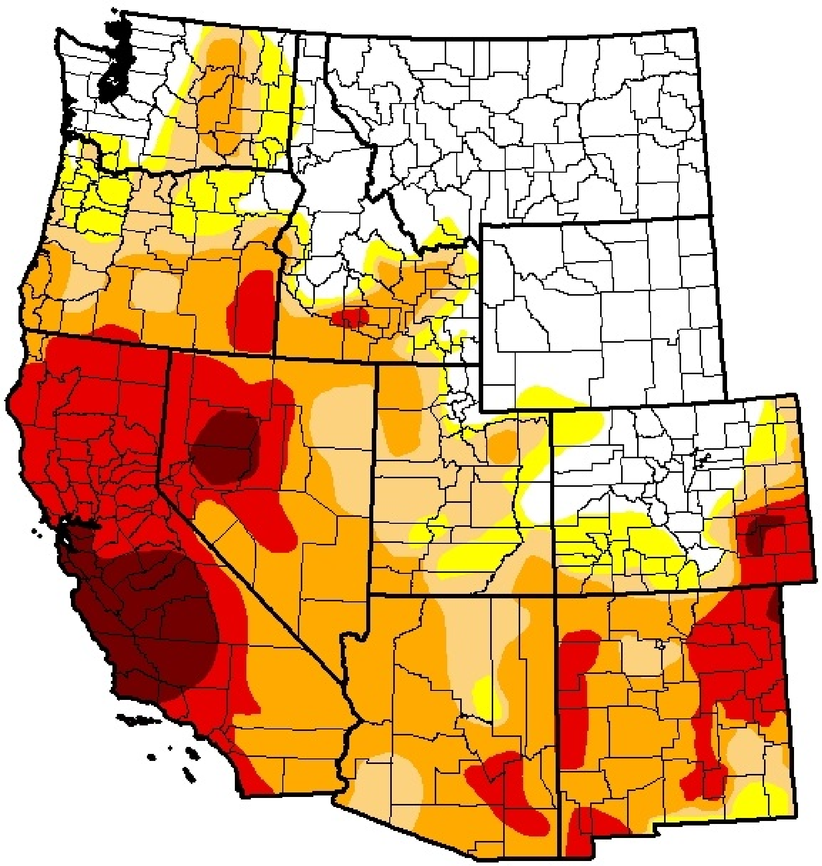
U.S. Drought Monitor

West

May 27, 2014

(Released Thursday, May. 29, 2014)

Valid 8 a.m. EDT



Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	31.18	68.82	60.38	47.20	20.21	4.31
Last Week 5/20/2014	31.18	68.82	60.82	47.50	20.37	4.81
3 Months Ago 2/25/2014	22.41	77.59	59.61	40.34	15.67	4.12
Start of Calendar Year 12/31/2013	22.20	77.80	51.44	31.11	7.75	0.63
Start of Water Year 10/1/2013	25.25	74.75	58.96	34.18	5.57	0.63
One Year Ago 5/28/2013	13.91	86.09	71.11	47.04	15.04	5.99

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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http://droughtmonitor.unl.edu/

Figure 5. US Drought Monitor for the Western United States.

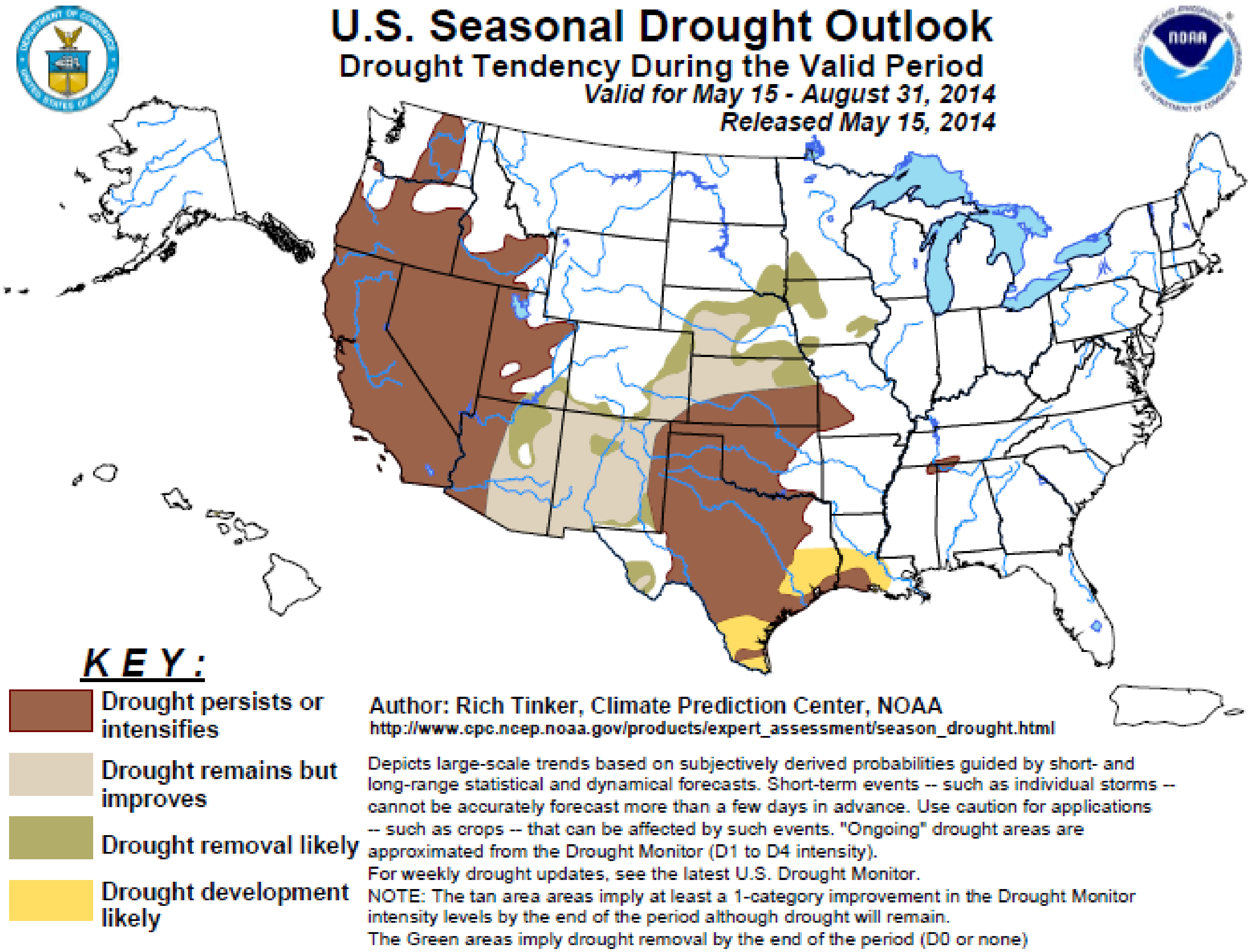

Figure 6. US Seasonal Drought Outloook, released April 17, 2014.

APPENDIX B: STREAM REACHES IN THE FOUR FOREST RESTORATION INITIATIVE ANALYSIS AREA AND THEIR ASSOCIATED LENGTHS AND FLOW REGIMES

Table 8. Stream reaches in the Four Forest Restoration Initiative Analysis Area from the National Hydrography Dataset of the U.S. Geological Survey.

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15010004000111	Cataract Creek	Stream/River	Intermittent	0.035
15010004000119		Stream/River	Intermittent	0.029
15010004000179		Stream/River	Intermittent	0.020
15010004000219	Dogtown Wash	Stream/River	Intermittent	0.046
15010004000221	Dogtown Wash	Stream/River	Intermittent	0.021
15010004000221	Dogtown Wash	Stream/River	Intermittent	0.017
15010004000224	Dogtown Wash	Stream/River	Intermittent	0.015
15010004000276		Stream/River	Intermittent	0.018
15010004000276		Stream/River	Intermittent	0.014
15010004000276		Stream/River	Intermittent	0.010
15010004000276		Stream/River	Intermittent	0.017
15010004000277		Stream/River	Intermittent	0.015
15010004000278		Stream/River	Intermittent	0.014
15010004000278		Stream/River	Intermittent	0.014
15010004000281		Stream/River	Intermittent	0.012
15010004000281		Stream/River	Intermittent	0.013
15010004000282		Stream/River	Intermittent	0.031
15010004000282		Stream/River	Intermittent	0.014
15010004000283		Stream/River	Intermittent	0.013
15010004000284		Stream/River	Intermittent	0.013
15010004000287		Stream/River	Intermittent	0.036

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15010004000292		Stream/River	Intermittent	0.012
15010004000292		Stream/River	Intermittent	0.021
15010004000294		Stream/River	Intermittent	0.031
15010004000392		Stream/River	Intermittent	0.021
15010004000395		Stream/River	Intermittent	0.029
15010004000395		Stream/River	Intermittent	0.034
15010004000396		Stream/River	Intermittent	0.015
15010004000398		Stream/River	Intermittent	0.015
15010004000399		Stream/River	Intermittent	0.028
15010004000400		Stream/River	Intermittent	0.061
15010004000400		Stream/River	Intermittent	0.024
15010004000401		Stream/River	Intermittent	0.077
15010004000403		Stream/River	Intermittent	0.012
15010004000403		Stream/River	Intermittent	0.010
15010004000404		Stream/River	Intermittent	0.040
15010004000404		Stream/River	Intermittent	0.015
15010004000405		Stream/River	Intermittent	0.056
15010004000406	Cataract Creek	Stream/River	Intermittent	0.020
15010004000414		Stream/River	Intermittent	0.012
15010004000419		Stream/River	Intermittent	0.014
15010004000419		Stream/River	Intermittent	0.015
15010004000467		Stream/River	Intermittent	0.022
15010004000890		Stream/River	Intermittent	0.021
15010004000897	West Cataract Creek	Stream/River	Intermittent	0.045
15010004000899		Stream/River	Intermittent	0.022

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15010004000906		Stream/River	Intermittent	0.027
15010004000908		Stream/River	Intermittent	0.016
15010004000908		Stream/River	Intermittent	0.052
15010004000909		Stream/River	Intermittent	0.047
15010004000920		Stream/River	Intermittent	0.017
15010004000922		Stream/River	Intermittent	0.020
15010004000922		Canal/Ditch	Canal/Ditch	0.011
15010004000989		Stream/River	Intermittent	0.032
15010004000990		Stream/River	Intermittent	0.011
15010004000990		Stream/River	Intermittent	0.029
15010004000993		Stream/River	Intermittent	0.017
15010004000994		Stream/River	Intermittent	0.020
15010004000995		Stream/River	Intermittent	0.012
15010004000995		Stream/River	Intermittent	0.017
15010004000996		Stream/River	Intermittent	0.032
15010004000996		Stream/River	Intermittent	0.022
15010004001539	Spring Valley Wash	Stream/River	Intermittent	0.030
15010004001540	Spring Valley Wash	Stream/River	Intermittent	0.020
15010004001541		Stream/River	Intermittent	0.011
15010004001542		Stream/River	Intermittent	0.045
15010004001543	Spring Valley Wash	Stream/River	Intermittent	0.021
15010004001544		Stream/River	Intermittent	0.014
15010004001544		Stream/River	Intermittent	0.011
15010004001544		Stream/River	Intermittent	0.011
15010004001545	Spring Valley Wash	Stream/River	Intermittent	0.042

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15010004001546	Spring Valley Wash	Stream/River	Intermittent	0.012
15010004001547	Spring Valley Wash	Stream/River	Intermittent	0.028
15010004001547	Spring Valley Wash	Stream/River	Intermittent	0.012
15010004001551		Stream/River	Intermittent	0.024
15010004001648	Coconino Wash	Stream/River	Intermittent	0.015
15010004001649	Coconino Wash	Stream/River	Intermittent	0.021
15010004001653	Coconino Wash	Stream/River	Intermittent	0.020
15010004001654		Stream/River	Intermittent	0.019
15010004001656		Stream/River	Intermittent	0.021
15010004001657		Stream/River	Intermittent	0.028
15010004001658		Stream/River	Intermittent	0.038
15010004001660		Stream/River	Intermittent	0.018
15010004001662		Stream/River	Intermittent	0.021
15010004001663		Stream/River	Intermittent	0.027
15010004001664		Stream/River	Intermittent	0.021
15010004001665		Stream/River	Intermittent	0.028
15010004001666		Stream/River	Intermittent	0.060
15010004001667		Stream/River	Intermittent	0.049
15010004001667		Stream/River	Intermittent	0.010
15010004001669		Stream/River	Intermittent	0.020
15010004001669		Stream/River	Intermittent	0.042
15010004001670		Stream/River	Intermittent	0.015
15010004002216	Dogtown Wash	Stream/River	Intermittent	0.021
15010004002511		Stream/River	Intermittent	0.016
15010004002512		Stream/River	Intermittent	0.012

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15010004002513		Stream/River	Intermittent	0.018
15010004002514		Stream/River	Intermittent	0.013
15010004002515		Stream/River	Intermittent	0.015
15010004002516		Stream/River	Intermittent	0.025
15010004002517		Stream/River	Intermittent	0.021
15010004002519		Stream/River	Intermittent	0.012
15010004002521		Stream/River	Intermittent	0.018
15010004002522		Stream/River	Intermittent	0.014
15010004002523		Stream/River	Intermittent	0.014
15010004002527		Stream/River	Intermittent	0.034
15010004002531		Stream/River	Intermittent	0.034
15010004002627		Stream/River	Intermittent	0.046
15010004003678		Stream/River	Intermittent	0.019
15010004003680		Stream/River	Intermittent	0.018
15010004003682		Stream/River	Intermittent	0.014
15010004003685		Stream/River	Intermittent	0.015
15010004003688		Stream/River	Intermittent	0.012
15010004003689		Stream/River	Intermittent	0.015
15010004003690		Stream/River	Intermittent	0.011
15010004003691		Stream/River	Intermittent	0.021
15010004003692		Stream/River	Intermittent	0.012
15010004003694		Stream/River	Intermittent	0.011
15010004003695		Stream/River	Intermittent	0.019
15010004003696		Stream/River	Intermittent	0.011
15010004003697		Stream/River	Intermittent	0.015

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15010004003760	Rain Tank Wash	Stream/River	Intermittent	0.018
15010004003761		Stream/River	Intermittent	0.038
15010004003762	Coconino Wash	Stream/River	Intermittent	0.014
15010004003767		Stream/River	Intermittent	0.014
15010004003770		Stream/River	Intermittent	0.016
15010004003771		Stream/River	Intermittent	0.012
15010004003772		Stream/River	Intermittent	0.011
15010004003774		Stream/River	Intermittent	0.015
15010004004325		Stream/River	Intermittent	0.019
15010004004365		Stream/River	Intermittent	0.017
15010004004379		Stream/River	Intermittent	0.016
15010004004818		Stream/River	Intermittent	0.015
15010004004819		Stream/River	Intermittent	0.014
15010004004822		Stream/River	Intermittent	0.014
15010004004823		Stream/River	Intermittent	0.011
15010004004824		Stream/River	Intermittent	0.011
15010004004826		Stream/River	Intermittent	0.019
15010004004827		Stream/River	Intermittent	0.025
15010004004828		Stream/River	Intermittent	0.043
15010004004829		Stream/River	Intermittent	0.011
15010004004830	Coconino Wash	Artificial Path	Artificial Path	0.013
15010004004832		Stream/River	Intermittent	0.027
15010004004833		Stream/River	Intermittent	0.011
15010004004834		Stream/River	Intermittent	0.015
15010004004836		Stream/River	Intermittent	0.021

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15010004004837		Stream/River	Intermittent	0.033
15010004004838	Coconino Wash	Artificial Path	Artificial Path	0.011
15010004004839		Stream/River	Intermittent	0.015
15010004004840		Stream/River	Intermittent	0.019
15010004004841		Stream/River	Intermittent	0.023
15010004004842		Stream/River	Intermittent	0.011
15010004004843		Stream/River	Intermittent	0.011
15010004004844		Stream/River	Intermittent	0.020
15010004004845		Stream/River	Intermittent	0.013
15010004004846		Stream/River	Intermittent	0.029
15010004004847		Stream/River	Intermittent	0.011
15010004004848		Stream/River	Intermittent	0.045
15010004004849		Stream/River	Intermittent	0.029
15010004004850		Stream/River	Intermittent	0.011
15010004004851		Stream/River	Intermittent	0.012
15010004004852		Stream/River	Intermittent	0.015
15010004004853		Stream/River	Intermittent	0.013
15010004004855		Stream/River	Intermittent	0.023
15010004004856		Stream/River	Intermittent	0.011
15010004004858		Stream/River	Intermittent	0.019
15010004004860		Stream/River	Intermittent	0.032
15010004004862		Stream/River	Intermittent	0.014
15010004004864		Stream/River	Intermittent	0.051
15010004004865		Stream/River	Intermittent	0.020
15010004004866		Stream/River	Intermittent	0.022

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15010004004867		Stream/River	Intermittent	0.023
15010004004869		Stream/River	Intermittent	0.029
15010004004870		Stream/River	Intermittent	0.017
15010004004875		Stream/River	Intermittent	0.017
15010004004922		Stream/River	Intermittent	0.013
15010004004930		Stream/River	Intermittent	0.013
15010004005074		Stream/River	Intermittent	0.012
15010004005077		Pipeline	Underground	0.019
15010004005105		Stream/River	Intermittent	0.022
15010004005109		Stream/River	Intermittent	0.010
15010004005117		Stream/River	Intermittent	0.012
15010004005118		Stream/River	Intermittent	0.016
15010004005119		Stream/River	Intermittent	0.013
15010004005120		Stream/River	Intermittent	0.018
15010004005121		Stream/River	Intermittent	0.017
15010004005125		Stream/River	Intermittent	0.013
15010004005127		Stream/River	Intermittent	0.022
15010004005128		Stream/River	Intermittent	0.011
15010004005129		Stream/River	Intermittent	0.014
15010004005131		Stream/River	Intermittent	0.012
15010004005132		Stream/River	Intermittent	0.014
15010004005133		Stream/River	Intermittent	0.018
15010004005134		Stream/River	Intermittent	0.014
15010004005135		Stream/River	Intermittent	0.020
15010004005136		Stream/River	Intermittent	0.011

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15010004005138	Dogtown Wash	Stream/River	Intermittent	0.015
15010004006202		Stream/River	Intermittent	0.014
15010004006223	Dogtown Wash	Artificial Path	Artificial Path	0.018
15020015000015	Rio de Flag	Stream/River	Intermittent	0.021
15020015000025	Rio de Flag	Stream/River	Intermittent	0.014
15020015000028		Stream/River	Intermittent	0.040
15020015000036	Walnut Creek	Stream/River	Intermittent	0.010
15020015000038		Stream/River	Intermittent	0.011
15020015000038		Stream/River	Intermittent	0.011
15020015000038		Stream/River	Intermittent	0.016
15020015000075		Stream/River	Intermittent	0.010
15020015000105		Stream/River	Intermittent	0.017
15020015000113	Sawmill Wash	Stream/River	Intermittent	0.012
15020015000113	Sawmill Wash	Stream/River	Intermittent	0.021
15020015000113	Sawmill Wash	Stream/River	Perennial	0.011
15020015000124	Sinclair Wash	Stream/River	Intermittent	0.011
15020015000126		Stream/River	Intermittent	0.053
15020015000126		Stream/River	Intermittent	0.012
15020015000127		Stream/River	Intermittent	0.065
15020015000128		Stream/River	Intermittent	0.036
15020015000128		Stream/River	Intermittent	0.027
15020015000129		Stream/River	Intermittent	0.013
15020015000129		Stream/River	Intermittent	0.056
15020015000130		Stream/River	Intermittent	0.046
15020015000131		Stream/River	Intermittent	0.034

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15020015000131		Stream/River	Intermittent	0.014
15020015000131		Stream/River	Intermittent	0.011
15020015000133		Stream/River	Intermittent	0.012
15020015000134		Stream/River	Intermittent	0.015
15020015000136		Stream/River	Intermittent	0.011
15020015000137		Stream/River	Intermittent	0.022
15020015000139		Stream/River	Intermittent	0.013
15020015000153		Stream/River	Intermittent	0.025
15020015000155		Stream/River	Intermittent	0.022
15020015000156		Stream/River	Intermittent	0.019
15020015000162		Stream/River	Intermittent	0.015
15020015000166		Stream/River	Intermittent	0.028
15020015000170		Stream/River	Intermittent	0.015
15020015000170		Stream/River	Intermittent	0.017
15020015000171		Stream/River	Intermittent	0.013
15020015000171		Stream/River	Intermittent	0.015
15020015000174		Stream/River	Intermittent	0.059
15020015000174		Stream/River	Intermittent	0.013
15020015000175		Stream/River	Intermittent	0.027
15020015000175		Stream/River	Intermittent	0.035
15020015000175		Stream/River	Intermittent	0.011
15020015000176		Stream/River	Intermittent	0.024
15020015000177		Stream/River	Intermittent	0.024
15020015000177		Stream/River	Intermittent	0.011
15020015000182	Ashurst Run	Stream/River	Intermittent	0.020

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15020015000184		Stream/River	Intermittent	0.019
15020015000185		Stream/River	Intermittent	0.021
15020015000186		Stream/River	Intermittent	0.017
15020015000188		Stream/River	Intermittent	0.024
15020015000195		Stream/River	Intermittent	0.011
15020015000195		Stream/River	Intermittent	0.013
15020015000195		Stream/River	Intermittent	0.015
15020015000196		Stream/River	Intermittent	0.075
15020015000197		Stream/River	Intermittent	0.034
15020015000197		Stream/River	Intermittent	0.048
15020015000198		Stream/River	Intermittent	0.026
15020015000199		Stream/River	Intermittent	0.017
15020015000206	San Francisco Wash	Stream/River	Intermittent	0.010
15020015000209		Stream/River	Intermittent	0.017
15020015000210		Stream/River	Intermittent	0.015
15020015000211		Stream/River	Intermittent	0.014
15020015000212		Stream/River	Intermittent	0.024
15020015000213		Stream/River	Intermittent	0.015
15020015000214		Stream/River	Intermittent	0.012
15020015000214		Stream/River	Intermittent	0.013
15020015000214		Stream/River	Intermittent	0.016
15020015000215	Walnut Creek	Stream/River	Intermittent	0.022
15020015000215	Walnut Creek	Stream/River	Intermittent	0.014
15020015000220	Walnut Creek	Stream/River	Intermittent	0.013
15020015000220	Walnut Creek	Stream/River	Intermittent	0.021

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15020015000221		Stream/River	Intermittent	0.028
15020015000223		Stream/River	Intermittent	0.014
15020015000224		Stream/River	Intermittent	0.020
15020015000225		Stream/River	Intermittent	0.013
15020015000226		Stream/River	Intermittent	0.021
15020015000227		Stream/River	Intermittent	0.034
15020015000227		Stream/River	Intermittent	0.028
15020015000227		Stream/River	Intermittent	0.013
15020015000228		Stream/River	Intermittent	0.027
15020015000229		Stream/River	Intermittent	0.023
15020015000229		Stream/River	Intermittent	0.019
15020015000231		Stream/River	Intermittent	0.021
15020015000231		Stream/River	Intermittent	0.017
15020015000233		Stream/River	Intermittent	0.021
15020015000233		Stream/River	Intermittent	0.023
15020015000234		Stream/River	Intermittent	0.018
15020015000234		Stream/River	Intermittent	0.033
15020015000235		Stream/River	Intermittent	0.016
15020015000235		Stream/River	Intermittent	0.021
15020015000236		Stream/River	Intermittent	0.013
15020015000236		Stream/River	Intermittent	0.016
15020015000238		Stream/River	Intermittent	0.025
15020015000239		Stream/River	Intermittent	0.010
15020015000239		Stream/River	Intermittent	0.012
15020015000239		Stream/River	Intermittent	0.020

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15020015000239		Stream/River	Intermittent	0.015
15020015000241		Stream/River	Intermittent	0.025
15020015000244		Stream/River	Intermittent	0.018
15020015000248		Stream/River	Intermittent	0.013
15020015000248		Stream/River	Intermittent	0.025
15020015000248		Stream/River	Intermittent	0.013
15020015000249		Stream/River	Intermittent	0.032
15020015000250		Stream/River	Intermittent	0.010
15020015000250		Stream/River	Intermittent	0.010
15020015000251		Stream/River	Intermittent	0.028
15020015000254		Stream/River	Intermittent	0.034
15020015000255		Stream/River	Intermittent	0.015
15020015000256		Stream/River	Intermittent	0.017
15020015000257		Stream/River	Intermittent	0.014
15020015000257		Stream/River	Intermittent	0.018
15020015000258		Stream/River	Intermittent	0.019
15020015000259		Stream/River	Intermittent	0.011
15020015000265		Stream/River	Intermittent	0.033
15020015000348		Stream/River	Intermittent	0.050
15020015000362		Stream/River	Intermittent	0.026
15020015000374		Stream/River	Intermittent	0.015
15020015000374		Stream/River	Intermittent	0.010
15020015000416		Stream/River	Intermittent	0.013
15020015000416		Stream/River	Intermittent	0.031
15020015000417		Stream/River	Intermittent	0.010

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15020015000426	Schultz Creek	Stream/River	Intermittent	0.028
15020015000426	Schultz Creek	Stream/River	Intermittent	0.015
15020015000427	Schultz Creek	Stream/River	Intermittent	0.010
15020015000432		Stream/River	Intermittent	0.029
15020015000433		Stream/River	Intermittent	0.015
15020015000435		Stream/River	Intermittent	0.036
15020015000436		Stream/River	Intermittent	0.037
15020015000440		Stream/River	Intermittent	0.020
15020015000448		Stream/River	Intermittent	0.014
15020015000450		Stream/River	Intermittent	0.018
15020015000451		Stream/River	Intermittent	0.020
15020015000451		Stream/River	Intermittent	0.017
15020015000451		Stream/River	Intermittent	0.017
15020015000452		Stream/River	Intermittent	0.036
15020015000456		Stream/River	Intermittent	0.019
15020015000458		Stream/River	Intermittent	0.011
15020015000458		Stream/River	Intermittent	0.017
15020015000459		Stream/River	Intermittent	0.022
15020015000569		Stream/River	Intermittent	0.023
15020015000577	Walnut Creek	Stream/River	Intermittent	0.011
15020015005559		Stream/River	Intermittent	0.020
15020015005560		Stream/River	Intermittent	0.014
15020015005562		Stream/River	Intermittent	0.025
15020015005566		Stream/River	Intermittent	0.062
15020015005570		Stream/River	Intermittent	0.011

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15020015005571		Stream/River	Intermittent	0.022
15020015005572		Stream/River	Intermittent	0.011
15020015005573		Stream/River	Intermittent	0.020
15020015005574		Stream/River	Intermittent	0.010
15020015005575		Stream/River	Intermittent	0.017
15020015005577		Stream/River	Intermittent	0.012
15020015005579		Stream/River	Intermittent	0.011
15020015005580		Stream/River	Intermittent	0.012
15020015005581		Stream/River	Intermittent	0.011
15020015005582		Stream/River	Intermittent	0.045
15020015005583		Stream/River	Intermittent	0.012
15020015005584		Stream/River	Intermittent	0.010
15020015005585		Stream/River	Intermittent	0.021
15020015005587		Stream/River	Intermittent	0.014
15020015005588		Stream/River	Intermittent	0.013
15020015005590		Stream/River	Intermittent	0.010
15020015005593		Stream/River	Intermittent	0.016
15020015005595		Stream/River	Intermittent	0.026
15020015005598		Stream/River	Intermittent	0.017
15020015005599		Stream/River	Intermittent	0.033
15020015005604		Stream/River	Intermittent	0.014
15020015005611	Schultz Creek	Stream/River	Intermittent	0.015
15020015005614		Stream/River	Intermittent	0.016
15020015005615		Stream/River	Intermittent	0.013
15020015005616		Stream/River	Intermittent	0.025

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15020015005618		Stream/River	Intermittent	0.028
15020015005619		Stream/River	Intermittent	0.015
15020015005620		Stream/River	Intermittent	0.019
15020015005621		Stream/River	Intermittent	0.012
15020015005623		Stream/River	Intermittent	0.016
15020015005625		Stream/River	Intermittent	0.022
15020015005626		Stream/River	Intermittent	0.014
15020015005630		Stream/River	Intermittent	0.014
15020015005635		Stream/River	Intermittent	0.020
15020015005635		Stream/River	Intermittent	0.013
15020015005639		Stream/River	Intermittent	0.012
15020015005642		Stream/River	Intermittent	0.020
15020015005644		Stream/River	Intermittent	0.011
15020015005648		Stream/River	Intermittent	0.017
15020015005649		Stream/River	Intermittent	0.013
15020015005651		Stream/River	Intermittent	0.013
15020015005653		Stream/River	Intermittent	0.025
15020015005658		Stream/River	Intermittent	0.010
15020015005659		Stream/River	Intermittent	0.012
15020015005667		Stream/River	Intermittent	0.021
15020015005669		Stream/River	Intermittent	0.020
15020015005671		Stream/River	Intermittent	0.016
15020015005686		Stream/River	Intermittent	0.014
15020015005689		Stream/River	Intermittent	0.022
15020015005693		Stream/River	Intermittent	0.017

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15020015005695		Stream/River	Intermittent	0.018
15020015005696		Stream/River	Intermittent	0.013
15020015005699		Stream/River	Intermittent	0.015
15020015005701		Stream/River	Intermittent	0.022
15020015005707		Stream/River	Intermittent	0.016
15020015005715		Stream/River	Intermittent	0.014
15020015005717		Stream/River	Intermittent	0.013
15020015005718		Stream/River	Intermittent	0.016
15020015005761		Stream/River	Intermittent	0.013
15020015005766		Stream/River	Intermittent	0.014
15020015005774		Stream/River	Intermittent	0.020
15020015005776		Stream/River	Intermittent	0.011
15020015005779		Stream/River	Intermittent	0.014
15020015005788		Stream/River	Intermittent	0.016
15020015005789		Stream/River	Intermittent	0.017
15020015005795		Stream/River	Intermittent	0.015
15020015005798		Stream/River	Intermittent	0.012
15020015005801		Stream/River	Intermittent	0.017
15020015005802		Stream/River	Intermittent	0.014
15020015005803		Stream/River	Intermittent	0.015
15020015005811		Stream/River	Intermittent	0.017
15020015005812		Stream/River	Intermittent	0.016
15020015005814		Stream/River	Intermittent	0.011
15020015005820		Stream/River	Intermittent	0.019
15020015005822		Stream/River	Intermittent	0.012

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15020015005823		Stream/River	Intermittent	0.017
15020015005826		Stream/River	Intermittent	0.012
15020015005827		Stream/River	Intermittent	0.012
15020015005828		Stream/River	Intermittent	0.011
15020015005832		Stream/River	Intermittent	0.020
15020015005836		Stream/River	Intermittent	0.018
15020015005838		Stream/River	Intermittent	0.024
15020015005846		Stream/River	Intermittent	0.011
15020015005849		Stream/River	Intermittent	0.015
15020015005851		Stream/River	Intermittent	0.022
15020015005853		Stream/River	Intermittent	0.012
15020015005857		Stream/River	Intermittent	0.011
15020015005858		Stream/River	Intermittent	0.010
15020015005861		Stream/River	Intermittent	0.031
15020015005872		Stream/River	Intermittent	0.012
15020015005882		Stream/River	Intermittent	0.011
15020015005884		Stream/River	Intermittent	0.016
15020015005887		Stream/River	Intermittent	0.013
15020015005896		Stream/River	Intermittent	0.011
15020015005898		Stream/River	Intermittent	0.014
15020015005899		Stream/River	Intermittent	0.030
15020015005903		Stream/River	Intermittent	0.023
15020015005904		Stream/River	Intermittent	0.013
15020015005905		Stream/River	Intermittent	0.019
15020015005906		Stream/River	Intermittent	0.025

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15020015005907		Stream/River	Intermittent	0.020
15020015005908		Stream/River	Intermittent	0.011
15020015005912	Walnut Creek	Stream/River	Intermittent	0.014
15020015005914		Stream/River	Intermittent	0.019
15020015005915		Stream/River	Intermittent	0.012
15020015005917		Stream/River	Intermittent	0.020
15020015005920		Stream/River	Intermittent	0.012
15020015005922		Stream/River	Intermittent	0.018
15020015005931		Stream/River	Intermittent	0.016
15020015005932		Stream/River	Intermittent	0.022
15020015005934		Stream/River	Intermittent	0.010
15020015005940		Stream/River	Intermittent	0.020
15020015005945		Stream/River	Intermittent	0.015
15020015005949		Stream/River	Intermittent	0.014
15020015005950		Stream/River	Intermittent	0.035
15020015005952		Stream/River	Intermittent	0.021
15020015005953	Walnut Creek	Stream/River	Intermittent	0.012
15020015005954		Stream/River	Intermittent	0.016
15020015005957		Stream/River	Intermittent	0.017
15020015005960		Stream/River	Intermittent	0.036
15020015005961		Stream/River	Intermittent	0.020
15020015005976		Stream/River	Intermittent	0.017
15020015005982		Stream/River	Intermittent	0.017
15020015005983		Stream/River	Intermittent	0.016
15020015005985		Stream/River	Intermittent	0.015

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15020015006003		Stream/River	Intermittent	0.015
15020015006004		Stream/River	Intermittent	0.018
15020015006005		Stream/River	Intermittent	0.015
15020015006006		Stream/River	Intermittent	0.018
15020015006007		Stream/River	Intermittent	0.010
15020015006011		Stream/River	Intermittent	0.016
15020015006012		Stream/River	Intermittent	0.011
15020015006016		Stream/River	Intermittent	0.016
15020015006019		Stream/River	Intermittent	0.021
15020015006023		Stream/River	Intermittent	0.012
15020015006024		Stream/River	Intermittent	0.016
15020015006032		Stream/River	Intermittent	0.019
15020015006034		Stream/River	Intermittent	0.017
15020015006035		Stream/River	Intermittent	0.015
15020015006046		Stream/River	Intermittent	0.048
15020015006047		Stream/River	Intermittent	0.014
15020015006060		Stream/River	Intermittent	0.018
15020015006061		Stream/River	Intermittent	0.012
15020015006068		Stream/River	Intermittent	0.017
15020015006092		Stream/River	Intermittent	0.022
15020015006122		Stream/River	Intermittent	0.012
15020015006125		Stream/River	Intermittent	0.015
15020015006135		Stream/River	Intermittent	0.019
15020015006137		Stream/River	Intermittent	0.017
15020015006177		Stream/River	Intermittent	0.014

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15020015006197		Stream/River	Intermittent	0.010
15020015006203		Stream/River	Intermittent	0.011
15020015006206		Stream/River	Intermittent	0.025
15020015006211		Stream/River	Intermittent	0.018
15020015006215		Stream/River	Intermittent	0.011
15020015006217		Stream/River	Intermittent	0.016
15020015006218		Stream/River	Intermittent	0.017
15020015006245		Stream/River	Intermittent	0.017
15020015006250		Stream/River	Intermittent	0.013
15020015006251		Stream/River	Intermittent	0.014
15020015006253		Stream/River	Intermittent	0.011
15020015006258		Stream/River	Intermittent	0.018
15020015006260		Stream/River	Intermittent	0.010
15020015006263		Stream/River	Intermittent	0.012
15020015006279		Stream/River	Intermittent	0.010
15020015006287		Stream/River	Intermittent	0.014
15020015006292		Stream/River	Intermittent	0.018
15020015006298		Stream/River	Intermittent	0.013
15020015006304		Stream/River	Intermittent	0.021
15020015006324		Stream/River	Intermittent	0.014
15020015006429	Sawmill Wash	Stream/River	Intermittent	0.012
15020015007155	Walnut Creek	Artificial Path	Artificial Path	0.013
15020015007156	Walnut Creek	Artificial Path	Artificial Path	0.027
15020015007160	Walnut Creek	Artificial Path	Artificial Path	0.021
15020015007164	Walnut Creek	Artificial Path	Artificial Path	0.013

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15020015007195		Stream/River	Intermittent	0.021
15020016000110		Stream/River	Intermittent	0.023
15020016000138	Deadman Wash	Stream/River	Intermittent	0.024
15020016000138	Deadman Wash	Stream/River	Intermittent	0.026
15020016000139	Deadman Wash	Stream/River	Intermittent	0.030
15020016000140		Stream/River	Intermittent	0.012
15020016000269		Stream/River	Intermittent	0.027
15020016000270		Stream/River	Intermittent	0.025
15020016000271		Stream/River	Intermittent	0.038
15020016000272		Stream/River	Intermittent	0.020
15020016000274		Stream/River	Intermittent	0.036
15020016000276		Stream/River	Intermittent	0.027
15020016000307		Stream/River	Intermittent	0.012
15020016000307		Stream/River	Intermittent	0.033
15020016000309		Stream/River	Intermittent	0.072
15020016000360		Stream/River	Intermittent	0.037
15020016000362		Stream/River	Intermittent	0.025
15020016000362		Stream/River	Intermittent	0.012
15020016000368		Stream/River	Intermittent	0.013
15020016000369		Stream/River	Intermittent	0.027
15020016000370		Stream/River	Intermittent	0.015
15020016000371		Stream/River	Intermittent	0.013
15020016000373		Stream/River	Intermittent	0.010
15020016000374		Stream/River	Intermittent	0.011
15020016000527	Cedar Wash	Stream/River	Intermittent	0.022

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15020016000801		Stream/River	Intermittent	0.024
15020016000802		Stream/River	Intermittent	0.012
15020016000802		Stream/River	Intermittent	0.013
15020016000802		Stream/River	Intermittent	0.016
15020016000803		Stream/River	Intermittent	0.046
15020016000803		Stream/River	Intermittent	0.050
15020016000805		Stream/River	Intermittent	0.024
15020016000810		Stream/River	Intermittent	0.022
15020016000810		Stream/River	Intermittent	0.031
15020016000811		Stream/River	Intermittent	0.073
15020016000812		Stream/River	Intermittent	0.034
15020016000812		Stream/River	Intermittent	0.010
15020016000814		Stream/River	Intermittent	0.011
15020016000814		Stream/River	Intermittent	0.014
15020016000819		Stream/River	Intermittent	0.013
15020016000820		Stream/River	Intermittent	0.011
15020016001137		Stream/River	Intermittent	0.030
15020016001137		Stream/River	Intermittent	0.022
15020016001142		Stream/River	Intermittent	0.025
15020016001167		Stream/River	Intermittent	0.024
15020016001168		Stream/River	Intermittent	0.010
15020016001168		Stream/River	Intermittent	0.026
15020016001172		Stream/River	Intermittent	0.021
15020016001200		Stream/River	Intermittent	0.012
15020016001200		Stream/River	Intermittent	0.015

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15020016001200		Stream/River	Intermittent	0.011
15020016001209		Stream/River	Intermittent	0.022
15020016005112		Stream/River	Intermittent	0.013
15020016005182		Stream/River	Intermittent	0.037
15020016005183		Stream/River	Intermittent	0.013
15020016005184		Stream/River	Intermittent	0.042
15020016005185		Stream/River	Intermittent	0.019
15020016005261		Stream/River	Intermittent	0.012
15020016005262		Stream/River	Intermittent	0.013
15020016005264		Stream/River	Intermittent	0.021
15020016005266		Stream/River	Intermittent	0.024
15020016005271		Stream/River	Intermittent	0.021
15020016005274		Stream/River	Intermittent	0.022
15020016005275		Stream/River	Intermittent	0.015
15020016005315		Stream/River	Intermittent	0.010
15020016005317		Stream/River	Intermittent	0.012
15020016005318		Stream/River	Intermittent	0.013
15020016005320		Stream/River	Intermittent	0.023
15020016005321		Stream/River	Intermittent	0.013
15020016005322		Stream/River	Intermittent	0.013
15020016005323		Stream/River	Intermittent	0.010
15020016005324		Stream/River	Intermittent	0.012
15020016005325		Stream/River	Intermittent	0.018
15020016005328		Stream/River	Intermittent	0.021
15020016005330		Stream/River	Intermittent	0.014

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15020016005335		Stream/River	Intermittent	0.014
15020016005338		Stream/River	Intermittent	0.026
15020016005339		Stream/River	Intermittent	0.015
15020016005340		Stream/River	Intermittent	0.015
15020016005341		Stream/River	Intermittent	0.017
15020016005342		Stream/River	Intermittent	0.010
15020016005649		Stream/River	Intermittent	0.011
15020016005650		Stream/River	Intermittent	0.014
15020016005651		Stream/River	Intermittent	0.018
15020016005654		Stream/River	Intermittent	0.014
15020016005655		Stream/River	Intermittent	0.016
15020016005656		Stream/River	Intermittent	0.016
15020016005657		Stream/River	Intermittent	0.013
15020016005659	Deadman Wash	Stream/River	Intermittent	0.026
15020016005662		Stream/River	Intermittent	0.023
15020016005664	Deadman Wash	Stream/River	Intermittent	0.017
15020016005665		Stream/River	Intermittent	0.022
15020016005666		Stream/River	Intermittent	0.020
15020016005902		Stream/River	Intermittent	0.017
15020016005903		Stream/River	Intermittent	0.017
15020016006390		Stream/River	Intermittent	0.027
15060201000423	Johnson Creek	Stream/River	Intermittent	0.014
15060201000431		Stream/River	Intermittent	0.020
15060201000431		Stream/River	Intermittent	0.011
15060201000432		Stream/River	Intermittent	0.027

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060201000433		Stream/River	Intermittent	0.036
15060201000453		Stream/River	Intermittent	0.010
15060201003860		Stream/River	Intermittent	0.011
15060201003864		Stream/River	Intermittent	0.019
15060201003926		Stream/River	Intermittent	0.011
15060201003954		Stream/River	Intermittent	0.014
15060201003966		Stream/River	Intermittent	0.026
15060201003969		Stream/River	Intermittent	0.010
15060201003972		Stream/River	Intermittent	0.023
15060202000079		Stream/River	Intermittent	0.048
15060202000140	Pumphouse Wash	Stream/River	Intermittent	0.011
15060202000140	Pumphouse Wash	Stream/River	Intermittent	0.016
15060202000141	Pumphouse Wash	Stream/River	Intermittent	0.018
15060202000143		Stream/River	Intermittent	0.013
15060202000143		Stream/River	Intermittent	0.015
15060202000143		Stream/River	Intermittent	0.011
15060202000143		Stream/River	Intermittent	0.020
15060202000148		Stream/River	Intermittent	0.010
15060202000157	West Fork Oak Creek	Stream/River	Intermittent	0.044
15060202000157	West Fork Oak Creek	Stream/River	Intermittent	0.015
15060202000253		Stream/River	Intermittent	0.010
15060202000255		Stream/River	Intermittent	0.010
15060202000255		Stream/River	Intermittent	0.012
15060202000256		Stream/River	Intermittent	0.026
15060202000260		Stream/River	Intermittent	0.020

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202000261		Stream/River	Intermittent	0.011
15060202000261		Stream/River	Intermittent	0.019
15060202000264		Stream/River	Intermittent	0.019
15060202000274	Tule Tank Wash	Stream/River	Intermittent	0.020
15060202000274	Tule Tank Wash	Stream/River	Intermittent	0.017
15060202000274	Tule Tank Wash	Stream/River	Intermittent	0.026
15060202000307		Stream/River	Intermittent	0.012
15060202000307		Stream/River	Intermittent	0.041
15060202000315		Stream/River	Intermittent	0.022
15060202000316		Stream/River	Intermittent	0.027
15060202000345		Stream/River	Intermittent	0.014
15060202000346		Stream/River	Intermittent	0.018
15060202000346		Stream/River	Perennial	0.013
15060202000347		Stream/River	Perennial	0.014
15060202000349		Stream/River	Perennial	0.024
15060202000350		Stream/River	Intermittent	0.013
15060202000354		Stream/River	Intermittent	0.032
15060202000354		Stream/River	Intermittent	0.011
15060202000354		Stream/River	Intermittent	0.014
15060202000474	JD Dam Wash	Stream/River	Intermittent	0.016
15060202000481	Volunteer Wash	Stream/River	Intermittent	0.029
15060202000481	Volunteer Wash	Stream/River	Intermittent	0.086
15060202000482	Volunteer Wash	Stream/River	Intermittent	0.034
15060202000482	Volunteer Wash	Stream/River	Intermittent	0.022
15060202000486	Volunteer Wash	Stream/River	Intermittent	0.026

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202000488	Volunteer Wash	Stream/River	Intermittent	0.025
15060202000490	Volunteer Wash	Stream/River	Intermittent	0.015
15060202000490	Volunteer Wash	Stream/River	Intermittent	0.012
15060202000500		Stream/River	Intermittent	0.012
15060202000501		Stream/River	Intermittent	0.030
15060202000503		Stream/River	Intermittent	0.033
15060202000504		Stream/River	Intermittent	0.018
15060202000505		Stream/River	Intermittent	0.018
15060202000507		Stream/River	Intermittent	0.011
15060202000508		Stream/River	Intermittent	0.010
15060202000508		Stream/River	Intermittent	0.017
15060202000509		Stream/River	Intermittent	0.041
15060202000512		Stream/River	Intermittent	0.011
15060202000513		Stream/River	Intermittent	0.034
15060202000517		Stream/River	Intermittent	0.028
15060202000575	Volunteer Wash	Stream/River	Intermittent	0.108
15060202000575	Volunteer Wash	Stream/River	Intermittent	0.033
15060202000575	Volunteer Wash	Stream/River	Intermittent	0.020
15060202000576		Stream/River	Intermittent	0.022
15060202000577		Stream/River	Intermittent	0.030
15060202000580		Stream/River	Intermittent	0.019
15060202000702		Stream/River	Intermittent	0.059
15060202000706		Stream/River	Intermittent	0.018
15060202000707		Stream/River	Intermittent	0.014
15060202000724		Stream/River	Intermittent	0.048

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202000725		Stream/River	Intermittent	0.011
15060202000725		Stream/River	Intermittent	0.014
15060202000727		Stream/River	Intermittent	0.021
15060202000728		Stream/River	Intermittent	0.015
15060202000728		Stream/River	Intermittent	0.011
15060202000730		Stream/River	Intermittent	0.020
15060202000730		Stream/River	Intermittent	0.013
15060202000731		Stream/River	Intermittent	0.020
15060202000732		Stream/River	Intermittent	0.038
15060202000733		Stream/River	Intermittent	0.020
15060202000733		Stream/River	Intermittent	0.032
15060202000733		Stream/River	Intermittent	0.037
15060202000734		Stream/River	Intermittent	0.017
15060202000735		Stream/River	Intermittent	0.042
15060202000739		Stream/River	Intermittent	0.016
15060202000740		Stream/River	Intermittent	0.049
15060202000741		Stream/River	Intermittent	0.021
15060202000745		Stream/River	Intermittent	0.033
15060202000747		Stream/River	Intermittent	0.021
15060202000747		Stream/River	Intermittent	0.024
15060202000748		Stream/River	Intermittent	0.026
15060202000750		Stream/River	Intermittent	0.043
15060202000751		Stream/River	Intermittent	0.016
15060202000751		Stream/River	Intermittent	0.017
15060202000752		Stream/River	Intermittent	0.011

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202000752		Stream/River	Intermittent	0.013
15060202000831		Stream/River	Intermittent	0.014
15060202000832		Stream/River	Intermittent	0.017
15060202000841		Stream/River	Intermittent	0.013
15060202000841		Stream/River	Intermittent	0.045
15060202000842		Stream/River	Intermittent	0.015
15060202000846		Stream/River	Intermittent	0.021
15060202000849		Stream/River	Intermittent	0.015
15060202000849		Stream/River	Intermittent	0.015
15060202000850		Stream/River	Intermittent	0.021
15060202000850		Stream/River	Intermittent	0.011
15060202000851		Stream/River	Intermittent	0.027
15060202000852		Stream/River	Intermittent	0.016
15060202000852		Stream/River	Intermittent	0.012
15060202000853		Stream/River	Intermittent	0.012
15060202000853		Stream/River	Intermittent	0.032
15060202000854		Stream/River	Intermittent	0.019
15060202000855		Stream/River	Intermittent	0.012
15060202000856		Stream/River	Intermittent	0.040
15060202000858		Stream/River	Intermittent	0.016
15060202000859		Stream/River	Intermittent	0.027
15060202000860		Stream/River	Intermittent	0.018
15060202000861		Stream/River	Intermittent	0.030
15060202000861		Stream/River	Intermittent	0.042
15060202000861		Stream/River	Intermittent	0.018

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202000865		Stream/River	Intermittent	0.041
15060202000866		Stream/River	Intermittent	0.013
15060202000867		Stream/River	Intermittent	0.010
15060202000868		Stream/River	Intermittent	0.026
15060202000869		Stream/River	Intermittent	0.014
15060202000870		Stream/River	Intermittent	0.012
15060202000870		Stream/River	Intermittent	0.010
15060202000870		Stream/River	Intermittent	0.017
15060202000871		Stream/River	Intermittent	0.024
15060202000872		Stream/River	Intermittent	0.014
15060202000872		Stream/River	Intermittent	0.014
15060202000873		Stream/River	Intermittent	0.010
15060202000874		Stream/River	Intermittent	0.016
15060202000874		Stream/River	Intermittent	0.010
15060202000875		Stream/River	Intermittent	0.016
15060202000877		Stream/River	Intermittent	0.029
15060202000878		Stream/River	Intermittent	0.022
15060202000879		Stream/River	Intermittent	0.031
15060202000880		Stream/River	Intermittent	0.036
15060202000881		Stream/River	Intermittent	0.017
15060202000882		Stream/River	Intermittent	0.019
15060202000883		Stream/River	Intermittent	0.019
15060202000886		Stream/River	Intermittent	0.016
15060202000888		Stream/River	Intermittent	0.022
15060202000888		Stream/River	Intermittent	0.020

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202000889		Stream/River	Intermittent	0.023
15060202000891		Stream/River	Intermittent	0.015
15060202000892		Stream/River	Intermittent	0.011
15060202000892		Stream/River	Intermittent	0.020
15060202000892		Stream/River	Intermittent	0.014
15060202000893		Stream/River	Intermittent	0.028
15060202000893		Stream/River	Intermittent	0.021
15060202000893		Stream/River	Intermittent	0.011
15060202000894		Stream/River	Intermittent	0.016
15060202000895		Stream/River	Intermittent	0.018
15060202000896		Stream/River	Intermittent	0.029
15060202000896		Stream/River	Intermittent	0.018
15060202000896		Stream/River	Intermittent	0.016
15060202000897		Stream/River	Intermittent	0.014
15060202000897		Stream/River	Intermittent	0.011
15060202000898	Pumphouse Wash	Stream/River	Intermittent	0.011
15060202000905	Pumphouse Wash	Stream/River	Intermittent	0.014
15060202000907		Stream/River	Intermittent	0.020
15060202000908		Stream/River	Intermittent	0.010
15060202000908		Stream/River	Intermittent	0.014
15060202000908		Stream/River	Intermittent	0.018
15060202000908		Stream/River	Intermittent	0.012
15060202000910		Stream/River	Intermittent	0.011
15060202000915		Stream/River	Intermittent	0.018
15060202000919		Stream/River	Intermittent	0.018

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202000921	Woody Wash	Stream/River	Intermittent	0.032
15060202000923		Stream/River	Intermittent	0.023
15060202000929		Stream/River	Intermittent	0.015
15060202000931		Stream/River	Intermittent	0.017
15060202000932		Stream/River	Intermittent	0.011
15060202000933		Stream/River	Intermittent	0.013
15060202000934		Stream/River	Intermittent	0.013
15060202000935		Stream/River	Intermittent	0.016
15060202000936		Stream/River	Intermittent	0.017
15060202000939		Stream/River	Intermittent	0.012
15060202000941		Stream/River	Intermittent	0.010
15060202000942		Stream/River	Intermittent	0.018
15060202000944		Stream/River	Intermittent	0.010
15060202000947		Stream/River	Intermittent	0.010
15060202000947		Stream/River	Intermittent	0.016
15060202000949		Stream/River	Intermittent	0.042
15060202000950		Stream/River	Intermittent	0.020
15060202000951		Stream/River	Intermittent	0.015
15060202000953		Stream/River	Intermittent	0.019
15060202000956		Stream/River	Intermittent	0.018
15060202000981		Stream/River	Intermittent	0.012
15060202000981		Stream/River	Intermittent	0.015
15060202000988		Stream/River	Intermittent	0.011
15060202000990		Stream/River	Intermittent	0.019
15060202001026		Stream/River	Intermittent	0.012

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202001083		Stream/River	Intermittent	0.014
15060202001087		Stream/River	Intermittent	0.029
15060202001093		Stream/River	Intermittent	0.016
15060202001093		Stream/River	Intermittent	0.017
15060202001093		Stream/River	Intermittent	0.012
15060202001094		Stream/River	Intermittent	0.019
15060202001095		Stream/River	Intermittent	0.010
15060202001097		Stream/River	Intermittent	0.014
15060202001098		Stream/River	Intermittent	0.018
15060202001098		Stream/River	Intermittent	0.018
15060202001099		Stream/River	Intermittent	0.014
15060202001100		Stream/River	Intermittent	0.013
15060202001100		Stream/River	Intermittent	0.029
15060202001101		Stream/River	Intermittent	0.015
15060202001101		Stream/River	Intermittent	0.017
15060202001102		Stream/River	Intermittent	0.030
15060202001102		Stream/River	Intermittent	0.016
15060202001104		Stream/River	Intermittent	0.013
15060202001105		Stream/River	Intermittent	0.023
15060202001110		Stream/River	Intermittent	0.020
15060202001115		Stream/River	Intermittent	0.034
15060202001116		Stream/River	Intermittent	0.023
15060202001117		Stream/River	Intermittent	0.012
15060202001117		Stream/River	Intermittent	0.023
15060202001118		Stream/River	Intermittent	0.021

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202001120		Stream/River	Intermittent	0.011
15060202001120		Stream/River	Intermittent	0.014
15060202001121		Stream/River	Intermittent	0.046
15060202001122		Stream/River	Intermittent	0.012
15060202001123		Stream/River	Intermittent	0.017
15060202001124		Stream/River	Intermittent	0.019
15060202001128		Stream/River	Intermittent	0.027
15060202001128		Stream/River	Intermittent	0.019
15060202001128		Stream/River	Intermittent	0.059
15060202001129		Stream/River	Intermittent	0.013
15060202001129		Stream/River	Intermittent	0.013
15060202001129		Stream/River	Intermittent	0.023
15060202001131		Stream/River	Intermittent	0.020
15060202001133		Stream/River	Intermittent	0.017
15060202001134		Stream/River	Intermittent	0.067
15060202001134		Stream/River	Intermittent	0.016
15060202001135		Stream/River	Intermittent	0.010
15060202001136		Stream/River	Intermittent	0.010
15060202001136		Stream/River	Intermittent	0.029
15060202001136		Stream/River	Intermittent	0.015
15060202001137		Stream/River	Intermittent	0.031
15060202001138		Stream/River	Intermittent	0.021
15060202001139		Stream/River	Intermittent	0.028
15060202001139		Stream/River	Intermittent	0.011
15060202001140		Stream/River	Perennial	0.016

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202001141		Stream/River	Intermittent	0.015
15060202001141		Stream/River	Intermittent	0.022
15060202001141		Stream/River	Intermittent	0.021
15060202001141		Stream/River	Perennial	0.038
15060202001142		Stream/River	Intermittent	0.012
15060202001142		Stream/River	Intermittent	0.015
15060202001143		Stream/River	Intermittent	0.015
15060202001144		Stream/River	Intermittent	0.023
15060202001144		Stream/River	Intermittent	0.046
15060202001145		Stream/River	Intermittent	0.012
15060202001145		Stream/River	Intermittent	0.011
15060202001146		Stream/River	Intermittent	0.011
15060202001146		Stream/River	Intermittent	0.026
15060202001148		Stream/River	Intermittent	0.048
15060202001149		Stream/River	Intermittent	0.019
15060202001149		Stream/River	Intermittent	0.029
15060202001150		Stream/River	Intermittent	0.015
15060202001152		Stream/River	Intermittent	0.014
15060202001152		Stream/River	Intermittent	0.030
15060202001152		Stream/River	Intermittent	0.012
15060202001152		Stream/River	Intermittent	0.042
15060202001153		Stream/River	Intermittent	0.016
15060202001153		Stream/River	Intermittent	0.021
15060202001154		Stream/River	Intermittent	0.043
15060202001155		Stream/River	Intermittent	0.013

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202001155		Stream/River	Intermittent	0.041
15060202001156		Stream/River	Intermittent	0.018
15060202001156		Stream/River	Intermittent	0.019
15060202001156		Stream/River	Intermittent	0.036
15060202001157		Stream/River	Intermittent	0.014
15060202001158		Stream/River	Intermittent	0.012
15060202001191		Stream/River	Intermittent	0.038
15060202001192		Stream/River	Intermittent	0.021
15060202001194		Stream/River	Intermittent	0.043
15060202001195		Stream/River	Intermittent	0.011
15060202001196		Stream/River	Intermittent	0.015
15060202001196		Stream/River	Intermittent	0.020
15060202001197		Stream/River	Intermittent	0.011
15060202001202		Stream/River	Intermittent	0.044
15060202001203		Stream/River	Intermittent	0.013
15060202001203		Stream/River	Intermittent	0.016
15060202001203		Stream/River	Intermittent	0.016
15060202001205		Stream/River	Intermittent	0.014
15060202001206		Stream/River	Intermittent	0.022
15060202001206		Stream/River	Intermittent	0.015
15060202001206		Stream/River	Intermittent	0.018
15060202001207		Stream/River	Intermittent	0.025
15060202001208		Stream/River	Intermittent	0.011
15060202001212		Stream/River	Intermittent	0.012
15060202001212		Stream/River	Intermittent	0.015

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202001228		Stream/River	Intermittent	0.011
15060202001229		Stream/River	Intermittent	0.011
15060202001230		Stream/River	Intermittent	0.013
15060202001231		Stream/River	Intermittent	0.016
15060202001232		Stream/River	Intermittent	0.014
15060202001232		Stream/River	Intermittent	0.011
15060202001233		Stream/River	Intermittent	0.016
15060202001234		Stream/River	Intermittent	0.041
15060202001235		Stream/River	Intermittent	0.012
15060202001235		Stream/River	Intermittent	0.018
15060202001236		Stream/River	Intermittent	0.045
15060202001237		Stream/River	Intermittent	0.048
15060202001252		Stream/River	Intermittent	0.010
15060202001252		Stream/River	Intermittent	0.019
15060202001564		Stream/River	Intermittent	0.011
15060202001564		Stream/River	Intermittent	0.013
15060202001567		Stream/River	Intermittent	0.023
15060202001567		Stream/River	Intermittent	0.011
15060202001568		Stream/River	Intermittent	0.012
15060202001568		Stream/River	Intermittent	0.011
15060202001570		Stream/River	Intermittent	0.020
15060202001571		Stream/River	Intermittent	0.011
15060202001571		Stream/River	Intermittent	0.015
15060202001588		Stream/River	Intermittent	0.034
15060202001595		Stream/River	Intermittent	0.017

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202001595		Stream/River	Intermittent	0.014
15060202001607		Stream/River	Intermittent	0.017
15060202001616		Stream/River	Intermittent	0.028
15060202001616		Stream/River	Intermittent	0.013
15060202001741		Artificial Path	Artificial Path	0.012
15060202001891		Stream/River	Intermittent	0.027
15060202001905		Stream/River	Intermittent	0.013
15060202001906		Stream/River	Intermittent	0.010
15060202001918		Stream/River	Intermittent	0.016
15060202001924		Stream/River	Intermittent	0.014
15060202001925		Stream/River	Intermittent	0.013
15060202001928		Stream/River	Intermittent	0.012
15060202001929		Stream/River	Intermittent	0.012
15060202001933		Stream/River	Intermittent	0.034
15060202001934		Stream/River	Intermittent	0.015
15060202001935		Stream/River	Intermittent	0.020
15060202001944		Stream/River	Intermittent	0.013
15060202001952		Stream/River	Intermittent	0.013
15060202001953		Stream/River	Intermittent	0.027
15060202001956		Stream/River	Intermittent	0.013
15060202001958		Stream/River	Intermittent	0.020
15060202001993		Stream/River	Intermittent	0.011
15060202001997		Stream/River	Intermittent	0.014
15060202002003		Stream/River	Intermittent	0.012
15060202002005		Stream/River	Intermittent	0.013

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202002015		Stream/River	Intermittent	0.027
15060202002024		Stream/River	Intermittent	0.016
15060202002030		Stream/River	Intermittent	0.014
15060202002044		Stream/River	Intermittent	0.026
15060202002058		Stream/River	Intermittent	0.013
15060202002059		Stream/River	Intermittent	0.011
15060202002065		Stream/River	Intermittent	0.017
15060202002072		Stream/River	Intermittent	0.012
15060202002077		Stream/River	Intermittent	0.021
15060202002082		Stream/River	Intermittent	0.018
15060202002107		Stream/River	Intermittent	0.013
15060202002117		Stream/River	Intermittent	0.015
15060202002142		Stream/River	Intermittent	0.022
15060202002151		Stream/River	Intermittent	0.012
15060202002157		Stream/River	Intermittent	0.018
15060202002165		Stream/River	Intermittent	0.017
15060202002169		Stream/River	Intermittent	0.020
15060202002199		Stream/River	Intermittent	0.011
15060202002211		Stream/River	Intermittent	0.010
15060202002211		Stream/River	Intermittent	0.012
15060202002257		Stream/River	Intermittent	0.012
15060202002266		Stream/River	Intermittent	0.015
15060202002274		Stream/River	Intermittent	0.017
15060202002284		Stream/River	Intermittent	0.017
15060202002300		Stream/River	Intermittent	0.012

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202002307		Stream/River	Intermittent	0.014
15060202002322		Stream/River	Intermittent	0.033
15060202002330		Stream/River	Intermittent	0.015
15060202002339		Stream/River	Intermittent	0.017
15060202002352		Stream/River	Intermittent	0.013
15060202002366		Stream/River	Intermittent	0.020
15060202002367		Stream/River	Intermittent	0.015
15060202002370		Stream/River	Intermittent	0.035
15060202002374		Stream/River	Intermittent	0.011
15060202002379		Stream/River	Intermittent	0.013
15060202002385		Stream/River	Intermittent	0.015
15060202002388		Stream/River	Intermittent	0.011
15060202002406		Stream/River	Intermittent	0.016
15060202002411		Stream/River	Intermittent	0.017
15060202002413		Stream/River	Intermittent	0.016
15060202002416		Stream/River	Intermittent	0.049
15060202002419		Stream/River	Intermittent	0.018
15060202002420		Stream/River	Intermittent	0.017
15060202002420		Stream/River	Intermittent	0.015
15060202002432		Stream/River	Intermittent	0.049
15060202002439		Stream/River	Intermittent	0.014
15060202002439		Stream/River	Intermittent	0.036
15060202002444		Stream/River	Intermittent	0.021
15060202002447		Stream/River	Intermittent	0.014
15060202002459		Stream/River	Intermittent	0.010

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202002459		Stream/River	Intermittent	0.010
15060202002467		Stream/River	Intermittent	0.013
15060202002469		Stream/River	Intermittent	0.019
15060202002472		Stream/River	Intermittent	0.010
15060202002474		Stream/River	Intermittent	0.011
15060202002479		Stream/River	Intermittent	0.012
15060202002487		Stream/River	Intermittent	0.013
15060202002489		Stream/River	Intermittent	0.012
15060202002492		Stream/River	Intermittent	0.031
15060202002493		Stream/River	Intermittent	0.023
15060202002505		Stream/River	Intermittent	0.013
15060202002506		Stream/River	Intermittent	0.017
15060202002514		Stream/River	Intermittent	0.013
15060202002516		Stream/River	Intermittent	0.022
15060202002527		Stream/River	Intermittent	0.032
15060202002536		Stream/River	Intermittent	0.011
15060202002537	JD Dam Wash	Stream/River	Intermittent	0.017
15060202002541		Stream/River	Intermittent	0.022
15060202002545		Stream/River	Intermittent	0.019
15060202002547		Stream/River	Intermittent	0.022
15060202002553		Stream/River	Intermittent	0.017
15060202002566		Stream/River	Intermittent	0.014
15060202002572		Stream/River	Intermittent	0.014
15060202002575		Stream/River	Intermittent	0.020
15060202002578		Stream/River	Intermittent	0.034

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202002579		Stream/River	Intermittent	0.033
15060202002588	JD Dam Wash	Stream/River	Intermittent	0.022
15060202002589		Stream/River	Intermittent	0.015
15060202002597		Stream/River	Intermittent	0.018
15060202002619		Stream/River	Intermittent	0.024
15060202002620		Stream/River	Intermittent	0.010
15060202002629		Stream/River	Intermittent	0.019
15060202002633		Stream/River	Intermittent	0.039
15060202002634		Stream/River	Intermittent	0.031
15060202002634		Stream/River	Intermittent	0.012
15060202002637		Stream/River	Intermittent	0.019
15060202002669		Stream/River	Intermittent	0.021
15060202002677		Stream/River	Intermittent	0.022
15060202002678		Stream/River	Intermittent	0.012
15060202002683		Stream/River	Intermittent	0.010
15060202002688	Sycamore Creek	Stream/River	Intermittent	0.016
15060202002688	Sycamore Creek	Stream/River	Perennial	0.033
15060202002692		Stream/River	Intermittent	0.014
15060202002738		Stream/River	Intermittent	0.012
15060202002758		Stream/River	Intermittent	0.012
15060202002813		Stream/River	Intermittent	0.013
15060202002813		Stream/River	Intermittent	0.014
15060202002813		Stream/River	Intermittent	0.013
15060202002820		Stream/River	Intermittent	0.017
15060202002832		Stream/River	Intermittent	0.013

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202002834		Stream/River	Intermittent	0.011
15060202002849		Stream/River	Intermittent	0.018
15060202002858		Stream/River	Intermittent	0.016
15060202002869		Stream/River	Intermittent	0.013
15060202002916		Stream/River	Intermittent	0.011
15060202002960		Stream/River	Intermittent	0.016
15060202002960		Stream/River	Intermittent	0.017
15060202002963		Stream/River	Intermittent	0.021
15060202002989		Stream/River	Intermittent	0.012
15060202002993		Stream/River	Intermittent	0.011
15060202003019		Stream/River	Intermittent	0.017
15060202003040		Stream/River	Intermittent	0.011
15060202003050		Stream/River	Intermittent	0.013
15060202003068		Stream/River	Intermittent	0.011
15060202003099		Stream/River	Intermittent	0.027
15060202003143		Stream/River	Intermittent	0.021
15060202003157		Stream/River	Intermittent	0.018
15060202003180		Stream/River	Intermittent	0.014
15060202003185		Stream/River	Intermittent	0.019
15060202003198		Stream/River	Intermittent	0.018
15060202003207		Stream/River	Intermittent	0.010
15060202003210		Stream/River	Intermittent	0.019
15060202003212		Stream/River	Intermittent	0.017
15060202003240		Stream/River	Intermittent	0.021
15060202003244		Stream/River	Intermittent	0.010

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202003248		Stream/River	Intermittent	0.017
15060202003249		Stream/River	Intermittent	0.011
15060202003253		Stream/River	Intermittent	0.013
15060202003254		Stream/River	Intermittent	0.012
15060202003266		Stream/River	Intermittent	0.014
15060202003272		Stream/River	Intermittent	0.015
15060202003280		Stream/River	Intermittent	0.014
15060202003292		Stream/River	Intermittent	0.022
15060202003298		Stream/River	Intermittent	0.017
15060202003325		Stream/River	Intermittent	0.014
15060202003354		Stream/River	Intermittent	0.019
15060202003359		Stream/River	Intermittent	0.016
15060202003365		Stream/River	Intermittent	0.010
15060202003380		Stream/River	Intermittent	0.014
15060202003381		Stream/River	Intermittent	0.015
15060202003411		Stream/River	Intermittent	0.014
15060202003417		Stream/River	Intermittent	0.026
15060202003418		Stream/River	Intermittent	0.011
15060202003426		Stream/River	Intermittent	0.012
15060202003430		Stream/River	Intermittent	0.011
15060202003431		Stream/River	Intermittent	0.016
15060202003437		Stream/River	Intermittent	0.021
15060202003440		Stream/River	Intermittent	0.013
15060202003473		Stream/River	Intermittent	0.017
15060202003493		Stream/River	Intermittent	0.011

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202003528		Stream/River	Intermittent	0.017
15060202003549		Stream/River	Intermittent	0.010
15060202003552		Stream/River	Intermittent	0.013
15060202003562		Stream/River	Intermittent	0.011
15060202003577		Stream/River	Intermittent	0.016
15060202003586		Stream/River	Intermittent	0.014
15060202003588		Stream/River	Intermittent	0.011
15060202003596		Stream/River	Intermittent	0.012
15060202003601		Stream/River	Intermittent	0.023
15060202003624		Stream/River	Intermittent	0.011
15060202003626		Stream/River	Intermittent	0.014
15060202003636		Stream/River	Intermittent	0.013
15060202003665		Stream/River	Intermittent	0.022
15060202003666		Stream/River	Intermittent	0.013
15060202003690		Stream/River	Intermittent	0.010
15060202003698		Stream/River	Intermittent	0.013
15060202003699		Stream/River	Intermittent	0.020
15060202003706		Stream/River	Intermittent	0.019
15060202003715		Stream/River	Intermittent	0.012
15060202003771		Stream/River	Intermittent	0.013
15060202003783		Stream/River	Intermittent	0.012
15060202003810		Stream/River	Intermittent	0.015
15060202003865		Stream/River	Intermittent	0.012
15060202003885		Stream/River	Intermittent	0.011
15060202003913		Stream/River	Intermittent	0.010

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202003919		Stream/River	Intermittent	0.012
15060202003926		Stream/River	Intermittent	0.011
15060202003937		Stream/River	Intermittent	0.026
15060202003938		Stream/River	Intermittent	0.013
15060202003940		Stream/River	Intermittent	0.016
15060202003959		Stream/River	Intermittent	0.015
15060202003961		Stream/River	Intermittent	0.017
15060202003970		Stream/River	Intermittent	0.018
15060202003974		Stream/River	Intermittent	0.013
15060202003987		Stream/River	Intermittent	0.012
15060202003998		Stream/River	Intermittent	0.012
15060202004006		Stream/River	Intermittent	0.014
15060202004016		Stream/River	Intermittent	0.014
15060202004022		Stream/River	Intermittent	0.011
15060202004023		Stream/River	Intermittent	0.016
15060202004032		Stream/River	Intermittent	0.016
15060202004050		Stream/River	Intermittent	0.014
15060202004052		Stream/River	Intermittent	0.019
15060202004071		Stream/River	Intermittent	0.019
15060202004077		Stream/River	Intermittent	0.017
15060202004108		Stream/River	Intermittent	0.012
15060202004110		Stream/River	Intermittent	0.011
15060202004134		Stream/River	Intermittent	0.012
15060202004135		Stream/River	Intermittent	0.014
15060202004144		Stream/River	Intermittent	0.027

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202004169		Stream/River	Intermittent	0.022
15060202004175		Stream/River	Intermittent	0.015
15060202004201		Stream/River	Intermittent	0.010
15060202004224		Stream/River	Intermittent	0.010
15060202004227		Stream/River	Intermittent	0.010
15060202004277		Stream/River	Intermittent	0.014
15060202004288		Stream/River	Intermittent	0.028
15060202004289		Stream/River	Intermittent	0.015
15060202004290		Stream/River	Intermittent	0.011
15060202004305		Stream/River	Intermittent	0.010
15060202004322		Stream/River	Intermittent	0.011
15060202004324		Stream/River	Intermittent	0.037
15060202004341		Stream/River	Intermittent	0.023
15060202004344		Stream/River	Intermittent	0.011
15060202004348		Stream/River	Intermittent	0.013
15060202004351		Stream/River	Intermittent	0.030
15060202004369		Stream/River	Intermittent	0.014
15060202004371		Stream/River	Intermittent	0.013
15060202004376		Stream/River	Intermittent	0.011
15060202004394		Stream/River	Intermittent	0.010
15060202004395		Stream/River	Intermittent	0.010
15060202004400		Stream/River	Intermittent	0.018
15060202004401		Stream/River	Intermittent	0.012
15060202004410		Stream/River	Intermittent	0.016
15060202004413		Stream/River	Intermittent	0.017

Reach Code	Name	Flow Type	Flow Code	Length (mi.)
15060202004415		Stream/River	Intermittent	0.012
15060202004419		Stream/River	Intermittent	0.014
15060202004426		Stream/River	Intermittent	0.039
15060202004433		Stream/River	Intermittent	0.010
15060202004438		Stream/River	Intermittent	0.010
15060202004455		Stream/River	Intermittent	0.013
15060202004479		Stream/River	Intermittent	0.019
15060202004533		Stream/River	Intermittent	0.018
15060202004546		Stream/River	Intermittent	0.017
15060202004589		Stream/River	Intermittent	0.014

APPENDIX C: RIPARIAN STREAM REACHES IN THE FOUR FOREST RESTORATION INITIATIVE ANALYSIS AREA AND THEIR ASSOCIATED LENGTHS, SIZES AND CONDITION RATINGS

RIPARIAN REACH	FUNCTIONAL CLASS	LENGTH (mi.)
1502001514D002	PROPER FUNCTIONING CONDITION	1.8
1502001514D001	AT RISK	2.3
1502001513A002	AT RISK	5.3
1502001513A002	AT RISK	2.2
1506020286D003	AT RISK	1.7
1506020286D002	AT RISK	0.7
1506020286C003	PROPER FUNCTIONING CONDITION	0.7
1502001513A003	AT RISK	1.3
1506020286C004	AT RISK	0.3
1506020286C005	AT RISK	2.0
1506020286D002	AT RISK	3.0
1502001513A004	AT RISK	2.2
1506020287H009	PFC	1.5
1506020287H010	PROPER FUNCTIONING CONDITION	1.7
1506020287H008	AT RISK	1.7
1506020287H008	AT RISK	0.9

RIPARIAN REACH	FUNCTIONAL CLASS	LENGTH (mi.)
1502001513C001	AT RISK	0.4
1502001513C001	AT RISK	0.4
1502001513C002	AT RISK	0.2
1502001513B001	NON-RIPARIAN	2.4
1502001513B002	AT RISK	0.2
1506020287H005	PROPER FUNCTIONING CONDITION	1.8
1506020287G001	PROPER FUNCTIONING CONDITION	1.8
1502001513B003	PROPER FUNCTIONING CONDITION	2.4
1502001513B002	AT RISK	0.1
1502001513B002	AT RISK	0.3
1506020287H006	PROPER FUNCTIONING CONDITION	1.3
1506020287H005	PROPER FUNCTIONING CONDITION	0.3
1506020287G002	PROPER FUNCTIONING CONDITION	1.2
1506020287F004	AT RISK	0.9
1506020287H007	PROPER FUNCTIONING CONDITION	3.8
1502001513C005	PROPER FUNCTIONING CONDITION	0.8
1502001513C003	NON-FUNCTIONAL	2.6
1506020287H002	PROPER FUNCTIONING CONDITION	1.9

RIPARIAN REACH	FUNCTIONAL CLASS	LENGTH (mi.)
1506020287H004	PROPER FUNCTIONING CONDITION	0.9
1506020287H002	PROPER FUNCTIONING CONDITION	0.3
1506020287H005	PROPER FUNCTIONING CONDITION	1.6
1506020287F005	AT RISK	0.2
1506020287F005	AT RISK	0.1
1506020287H003	PROPER FUNCTIONING CONDITION	0.5
1506020287F005	AT RISK	0.8
1506020287F002	PROPER FUNCTIONING CONDITION	1.8
1502001513C004	PROPER FUNCTIONING CONDITION	1.0
1506020287F003	PROPER FUNCTIONING CONDITION	0.2
1506020287H001	PROPER FUNCTIONING CONDITION	1.7
1502001513C006	AT RISK	4.8
1502001513C006	AT RISK	0.3
1506020287F002	PROPER FUNCTIONING CONDITION	0.3
1502001513C006	AT RISK	0.4
1506020287J003	PROPER FUNCTIONING CONDITION	0.4
1506020288E007	PROPER FUNCTIONING CONDITION	1.4
1506020288E006	PROPER FUNCTIONING CONDITION	1.7

RIPARIAN REACH	FUNCTIONAL CLASS	LENGTH (mi.)
1506020288E005	PROPER FUNCTIONING CONDITION	1.2
1506020288F002	PROPER FUNCTIONING CONDITION	2.5
1506020288E004	AT RISK	0.4
1506020288F002	PROPER FUNCTIONING CONDITION	5.8
1506020288F001	PROPER FUNCTIONING CONDITION	1.3
1506020288E003	PROPER FUNCTIONING CONDITION	1.0
1502001515B002	AT RISK	1.2
1502001515B001	AT RISK	0.6
1506020288G003	PROPER FUNCTIONING CONDITION	2.9

APPENDIX D: WETLAND HABITATS IN THE FOUR FOREST RESTORATION INITIATIVE ANALYSIS AREA AND THEIR ASSOCIATED EXTENTS AND USFWS WETLAND CLASSIFICATIONS

Table 12. Wetland areas on the Coconino NF within the Four Forest Restoration Initiative analysis area and associated condition assessment information from 2009 riparian area proper functioning condition assessment conducted by Jeff Hink.

NAME	CLASS	ACRES	PFC Assessment	Latitude	Longitude
Slate Lakes	Seasonal	0.38	PFC	35.48	-111.80
Slate Lakes	Seasonal	0.56	PFC	35.48	-111.81
Crater Lake	Seasonal	0.88	PFC	35.42	-111.81
Walker Lake	Semi-permanent	10.32	Functional At-risk	35.39	-111.73
Bismark Lake	Seasonal	1.50	PFC	35.36	-111.72
Crater Lake (pvt)	Seasonal	5.27	NA	35.32	-111.77
Dry Lake	Seasonal	13.83	Functional At-risk	35.17	-111.72
Rogers Lake	Seasonal	1201.23	Functional At-risk	35.15	-111.79
Marshall Lake	Semi-permanent	131.68	PFC	35.12	-111.53
Little Dry Lake	Semi-permanent	8.87	PFC	35.11	-111.53
Lower Lake Mary	Reservoir	148.69	PFC	35.11	-111.57

NAME	CLASS	ACRES	PFC Assessment	Latitude	Longitude
Upper Lake Mary	Reservoir	662.42	NA	35.06	-111.49
Antelope North	Seasonal	5.30	PFC	35.03	-111.44
Antelope Tank	Seasonal	8.31		35.02	-111.44
Indian Tank	Seasonal	13.30	Functional At-risk, PFC	35.01	-111.43
Perry Lake	Semi-permanent	27.48	PFC	34.99	-111.44
Mormon Lake	Semi-permanent	5228.99	PFC	34.97	-111.47
Tonys Tank	Seasonal	9.09	Functional At-risk	34.93	-111.41
Pine Lake	Seasonal	52.76	PFC	34.93	-111.37
Camillo Tank	Seasonal	45.85	PFC	34.92	-111.38
Wallace Lake	Seasonal	8.85	Functional At-risk	34.92	-111.43

Table 13. Riparian areas on the KNF within the Four Forest Restoration Initiative analysis area and associated condition assessment information from 2008 riparian area proper functioning condition assessment conducted by Jeff Hink.

Location	Type	East	North	SIZE	Category	Riparian Vegetation	PFC Assessment	Trend	Rationale	Comments
DISTRIBUTION TANK	Stock tanks with little or no riparian vegetation	399670	3877137	0.5	stock tank	Low and tall Spike rush are present	PFC - stock tank; functional at risk - riparian	Downward	Vegetation appears less than in 1990; time of year may influence, but elk use has probably increased over time.	Distribution tank is functional as a stock tank, and has moderate riparian quality
KENNEDY DAM	Stock tanks with little or no riparian vegetation	410148	3879749	1.0	stock tank	spikerush	PFC - stock tank; nonfunctional - riparian	Downward	No bulrush evident, but recent grazing and time of year may account for this.	
JD DAM WASH	Ephemeral streams with riparian vegetation	406570	3880726		Ephemeral drainage	carex	PFC	Static	Conditions appear similar between 1990 and 2008	
JD DAM	Reservoirs	406223	3880970	29.0	Semi-permanent wetland / reservoir	bulrush, cattail, cottonwood, spikerush and broadleaved pondweed	PFC	Static	Conditions appear similar between 1990 and 2008	
UPPER BEAR	Ephemeral streams with riparian	392211	3883094		Ephemeral	willow, spikerush,	PFC	Static	Conditions appear similar between	

Location	Type	East	North	SIZE	Category	Riparian Vegetation	PFC Assessment	Trend	Rationale	Comments
CANYON	vegetation				stream	juncus, carex			1990 and 2008	
BEAR SPRING	Perennial Springs with riparian vegetation	392230	3883130		Perennial Spring	juncus, tall spikerush, willow	Functional at risk	Downward	Vegetative conditions have deteriorated from 1990. Grazing impacts from ungulates are far more evident.	Spring is not fenced from livestock as reported in Kaibab Master.
COW TANK	Stock tanks with little or no riparian vegetation	383191	3883598	1.0	stock tank	Short and tall Spike rush and pondweed	PFC - stock tank; non functional - riparian	Static	Conditions appear similar between 1990 and 2008	The nature of the upland soils combined with moderate to high animal use results in moderately turbid water quality.
MC TANK	Stock tanks with riparian vegetation	389127	3883598	0.7	Stock tank	spikerush, pondweed, bulrush	PFC	Static	Conditions appear similar between 1990 and 2008	
FLAG TANK	Stock tanks with little or no riparian vegetation	400714	3883913	3.0	Stock tank	spikerush	PFC - stock tank; functional at risk - riparian	Static	Conditions appear similar between 1990 and 2008	

Location	Type	East	North	SIZE	Category	Riparian Vegetation	PFC Assessment	Trend	Rationale	Comments
MC CANYON	Ephemeral streams with riparian vegetation	388176	3884240		Ephemeral drainage	few willow	PFC	Static	Conditions appear similar between 1990 and 2008	
HOLLOWAY TANK	Stock tanks with little or no riparian vegetation	401305	3884952	0.3	Stock tank	spikerush	PFC - stock tank; functional at risk - riparian	Slightly downward	Conditions appear similar between 1990 and 2008. Spikerush may be less robust in 2008. Probably increased elk use.	
PERKINS TANK	Reservoirs	402506	3885957	3.7	Reservoir	Plants include bulrush, spikerush, carex and broadleaved pondweed.	PFC	Static to upward	Conditions appear similar between 1990 and 2008. Wetland appears to be a bit more mature in 2008.	
HITT SPRING	Perennial Springs with riparian vegetation	401788	3885976		Perennial spring	Riparian plants include medium and tall spike rush and juncus.	PFC	Static	Little basis from photo comparison to make call other than static.	

Location	Type	East	North	SIZE	Category	Riparian Vegetation	PFC Assessment	Trend	Rationale	Comments
WHITE HORSE LAKE	Reservoirs	407543	3886706	42.0	reservoir	bulrush	PFC	Upward	Based on photo comparison, riparian vegetation appears much improved from 1990 and 2008.	
SUNFLOWER FLAT	Semi-permanent wetland / stock tank	405485	3887362	33.0	Semi-permanent wetland / stock tank	bulrush, spikerush	PFC	Static	Conditions appear similar between 1990 and 2008	Appears to be an excellent bald eagle site.
MC TANK DRAINAGE	Intermittent streams	383775	3887432		Intermittent stream	willow, spikerush	PFC	Upward	Fencing has significantly improved the willow. Unstable stream banks are improving.	

Location	Type	East	North	SIZE	Category	Riparian Vegetation	PFC Assessment	Trend	Rationale	Comments
MCDOUGAL SPRING	Springs with little or no riparian vegetation	398255	3888195		Ephemeral Spring	spikerush	Nonfunctional.	Downward	McDougal Spring is an historic spring that currently has little riparian characteristics. Unlike the 1990 era photos, no water is present and only tall spike rush occupies the site.	
WILLOW SPRING	Perennial Springs with riparian vegetation	406375	3888215		perennial spring	A-1946	PFC	Static	Conditions appear similar between 1990 and 2008	
DUTCH KID TANK	Stock tanks with little or no riparian vegetation	383247	3888228	1.0	Stock tank	little riparian veg. spikerush	PFC - stock tank; functional at risk - riparian	Downward	Although not conclusive, spikerush is far less evident in 2008 photo compared to 1990.	
JD CANYON 1	Ephemeral streams with riparian vegetation	403805	3889178		Ephemeral drainage	spikerush, willow	Functional at risk	Static	Conditions appear similar between 1990 and 2008	

Location	Type	East	North	SIZE	Category	Riparian Vegetation	PFC Assessment	Trend	Rationale	Comments
COLEMAN LAKE	Seasonal wetlands	392701	3890197	79.0	Seasonal wetland	carex, low medium and tall spikerush, reedgrass, bulrush	PFC	Static	Veg. conditions appear to be similar over the 18-year period.	Complete livestock exclosure, duck nesting islands. Islands do not appear to be effective in providing protection to nesting ducks.
WHITING RANCH	Stock tanks with riparian vegetation	403715	3890485	7.0	stock tank	spikerush, reedgrass	PFC	Static	Although photos were taken at very different times of growing season, conditions are probably similar.	
HELL CANYON 1	Ephemeral streams with riparian vegetation	383734	3891400		Ephemeral stream	willow	PFC	Slightly downward	Probably increased elk impacts to willow.	

Location	Type	East	North	SIZE	Category	Riparian Vegetation	PFC Assessment	Trend	Rationale	Comments
COUGAR PARK DRAINAGE	Intermittent streams	397273	3892687	11.0	ephemeral drainage	spike rush, carex and reedgrass	PFC	Static	Conditions appear similar between 1990 and 2008	The stream course is fairly well evolved from gully formation in the past to a laterally and vertically stable C channel. Some stream bank erosion continues on steeper, poorly vegetated stream banks.
ROSILDA SPRING	Perennial Springs with riparian vegetation	403241	3892984	1.0	Perennial spring - intermittent stock tank	spikerush, reedgrass, pondweed	PFC	Static	Although water is present in the tank in 2008, conditions appear similar between 1990 and 2008	
SCHOLZ LAKE	Reservoirs	408210	3895033	34.0	Semi-permanent wetland / reservoir	reedgrass bulrush, spikerush, cattail, pondweed	PFC	Static	Conditions appear similar between 1990 and 2008	Excellent riparian developed below dam. Might be a good frog site.

Location	Type	East	North	SIZE	Category	Riparian Vegetation	PFC Assessment	Trend	Rationale	Comments
DOGTOWN LAKE	Reservoirs	397179	3896993	94.0	Reservoir	little riparian veg.	PFC	Static	Conditions appear similar between 1990 and 2008	Water level fluctuation appears to have a more pronounced effect on shoreline vegetation than other lakes (Whitehorse, Cataract, etc.
MINERAL LAKE	Seasonal wetlands	406642	3898790	22 tank=0.5	Seasonal wetland	low spike rush, pondweed	PFC	Downward	bulrush is absent in 2008, heavy grazing impacts in unfenced area. Semi-permanent wetland was probably a stretch in 1990 classification.	
LOWER McDERMIT SPRING	Springs with little or no riparian vegetation	416501	3902025		Historic Spring	No riparian vegetation	Non functional.	Downward	Condition of trough and vegetation has degraded since 1990. No evidence that 2008 was abnormally dry.	

Location	Type	East	North	SIZE	Category	Riparian Vegetation	PFC Assessment	Trend	Rationale	Comments
DAVENPORT LAKE	Temporary wetland / stock tank	402263	3903046	285.0	Temporary Wetland with stock tank	scattered low, tall spikerush	PFC	Static	Veg. conditions appear to be similar over the 18 year period.	
ROCK TANK (Keyhole)	Intermittent streams	407663	3903322	0.1	intermittent stream	spikerush, carex	PFC	Static	Conditions appear similar between 1990 and 2008	
DT WASH 2	Ephemeral streams with riparian vegetation	395974	3903394	1.0	Ephemeral stream	little riparian veg. spikerush	Functional at risk	Static	Conditions appear similar between 1990 and 2008	Water level fluctuation limits establishment of shoreline riparian vegetation.
DT WASH 1	Ephemeral streams with riparian vegetation	395924	3903502	1.0	Ephemeral stream	little riparian veg. spikerush	Functional at risk	Static	Conditions appear similar between 1990 and 2008	Water level fluctuation limits establishment of shoreline riparian vegetation.
UPPER McDERMIT SPRING	Springs with little or no riparian vegetation	416859	3903816	0.0	Perennial spring - piped trough	spikerush, juncus	Non functional.	Downward	No water in 2008, drought, tree encroachment. Non functional due to piping and to heavy grazing.	

Location	Type	East	North	SIZE	Category	Riparian Vegetation	PFC Assessment	Trend	Rationale	Comments
DRY LAKE	Temporary wetland / stock tank	401343	3904100	27.0	Temporary wetland / stock tank	Very little riparian vegetation	PFC - stock tank; functional at risk - riparian	Static	Riparian conditions appear to be consistently absent over the years.	
DUCK LAKE	Temporary wetland / stock tank	407079	3904285	51.0	Temporary wetland/ stock tank	Very little riparian vegetation	Functional at risk	Upward	Rated "upward" only because disturbance from trenching has somewhat healed.	Examples of this duck "habitat improvement" technique on both the Kaibab and Coconino suggest that the effort does not provide any positive improvement, and often causes irreparable damage to the natural system.
KAIBAB LAKE	Reservoirs	394985	3905256	45.0	Reservoir	little riparian veg.	PFC	Static	Conditions appear similar between 1990 and 2008	
EAST ELK SPRING	Perennial Springs with riparian vegetation	410305	3915252		Perennial Spring	Spikerush, Carex, and Juncus	PFC	Static	Source not flowing in 2008 survey	

Location	Type	East	North	SIZE	Category	Riparian Vegetation	PFC Assessment	Trend	Rationale	Comments
WEST ELK SPRING	Springs with little or no riparian vegetation	410177	3915589	1.0	intermittent spring - historic	none	Non functional.	Static	Conditions appear similar between 1990 and 2008	
W-TRIANGLE TANK	Stock tanks with little or no riparian vegetation	410424	3915807	1.0	Stock tank	spikerush	Functional at risk	Static	Conditions appear similar between 1990 and 2008	
RAYMOND LAKE	Temporary wetlands	412926	3918806	11.0	Temporary wetland	no riparian vegetation	PFC	Static	Conditions appear similar between 1990 and 2008	
LITTLE BOULIN TANK	Stock tanks with little or no riparian vegetation	405790	3919584	2.0	Stock tank	none	PFC - stock tank; non functional - riparian	Static	Limited riparian potential. Intended for stock water.	
MORITZ LAKE	Temporary wetlands	413557	3919905	52.0	Temporary wetland	no riparian vegetation	PFC	Static		
FAY LAKE	Temporary wetlands	411781	3920280	16.0	Temporary Wetland	No riparian vegetation	PFC	Static	Riparian conditions appear to be consistently absent over the years.	

Location	Type	East	North	SIZE	Category	Riparian Vegetation	PFC Assessment	Trend	Rationale	Comments
MARTEEN TANK	Stock tanks with little or no riparian vegetation	408730	3922078	1.0	Stock tank	spikerush	PFC - stock tank; functional at risk - riparian	Slightly downward	Based on reduced spikerush, although time of year may influence interpretation.	

APPENDIX E: SPRING HABITATS IN THE FOUR FOREST RESTORATION INITIATIVE PROJECT ANALYSIS AREA

Table 14. Springs of the Coconino National Forest and their associated locations that occur within the Four Forest Restoration Initiative Analysis Area.

NAME	Northing	Easting
Gooseberry Springs	3852636.76	463224.66
Seven Anchor Spring	3852795.78	462209.65
Fain Spring	3853020.87	452022.60
Roundup Park Spring	3853591.89	455427.61
NONE	3854578.23	459776.64
Tinny Spring	3854862.84	461203.65
Van Deren Spring	3854904.87	459219.64
Lee Spring	3854976.90	449262.59
Sawmill Springs	3855074.09	465510.67
Rock Top Spring	3856829.46	449903.69
Mint Spring	3857927.71	462494.56
NONE	3858058.40	462238.47
Bristow Spring	3858568.78	447387.89
Free Spring	3858676.09	454263.62
Tree Spring	3858676.09	454263.62
Dove Spring	3859157.85	465837.67

NAME	Northing	Easting
Railroad Spring	3859243.01	458781.64
Bristow Seep Spring	3860486.98	445564.56
Iowa Camp Spring	3861440.01	461125.34
Navajo Spring	3862011.03	456094.54
Sedge Spring	3862280.02	461508.65
T-Six Spring	3862883.04	445550.55
Bootlegger Spring	3863562.18	450908.60
Sheep Spring	3863872.19	450937.60
Munds Spring	3864390.00	447781.47
Wallace Spring	3864805.28	455107.64
Smith Spring	3866100.30	455616.65
Double Springs	3866624.34	454888.65
Mud Spring	3868678.32	450333.59
Mayflower Spring	3869361.42	455403.65
Weimer Spring	3870163.72	451701.43
Willard Spring	3870272.97	437835.38
Lockwood Spring	3870317.46	455006.66
Howard Spring	3871403.16	443173.46

NAME	Northing	Easting
Ritter Spring	3873426.93	435575.30
Buzzard Spring	3874121.88	424602.34
Scott Spring	3876176.88	434198.24
NONE	3876262.73	435125.94
Thomas Spring	3877338.21	444597.41
Mortgage Spring	3877399.92	435274.25
Hoxworth Springs	3877665.30	447563.45
Lockwood Spring	3878563.96	421245.38
NONE	3880011.48	437181.65
Babbit Spring	3880596.36	450899.45
Limbergh Spring	3885217.40	434267.95
Griffiths Spring	3886274.30	435372.74
Garden Spring	3887742.88	432815.10
Black Spring	3888076.97	437245.14
Poison Spring	3888328.18	411180.61
Railroad Spring	3888531.28	412529.48
Lion Spring	3889314.16	446746.22
Upper Hull Spring	3889483.17	412157.58

NAME	Northing	Easting
Paterson Spring	3890531.95	426359.20
Elsie Spring	3896054.93	429262.08
Elden Spring	3898405.05	445389.05
Paradies Spring	3898940.02	443136.03
Oak Spring	3900251.04	446356.02
Chimney Spring	3902516.10	438624.94
Little Elden Spring	3903905.05	447314.09
Pearson Spring	3904305.02	426626.22
Maxwell Spring	3904697.01	427538.20
Taylor Spring	3905026.96	432216.09
Little Leroux Spring	3905127.98	434990.10
Orion Spring	3905406.83	442059.62
Big Leroux Spring	3905810.98	434086.12
Leroux Spring	3905810.98	434086.12
Aspen Spring	3906992.02	441368.16
Doyle Spring	3910051.04	440024.25
Snowslide Spring	3910090.04	439070.25
NONE	3910754.66	434132.19

NAME	Northing	Easting
Flagstaff Spring	3910934.92	439285.78
NONE	3910967.66	434197.19
Raspberry Spring	3911090.42	441057.59
Bear Paw Spring	3911186.36	440054.69
Jack Smith Spring	3911519.17	441149.48
Beard Spring	3911619.67	439475.89
Philomena Spring	3912072.05	437975.31
Jack Smith Spring Number Two	3912855.06	445522.32
Lockett Meadow Spring	3913179.56	443603.42
Little Spring	3914806.07	434079.41
Alto Spring	3915087.69	443629.48
Pat Spring	3916777.09	437365.05
NONE	3922347.78	430704.99
Kendrick Spring	3922596.12	423770.77
NONE	3924190.31	432658.31

Table 15. Springs of the Kaibab National Forest that occur within the Four Forest Restoration Initiative Analysis Area and associated spring survey information (Stevens et al. 2011).

Name	Source	Inv	Quad Name	District	Easting	Northing	Elevat	Description
Andrews Spring	GEO	0	McLellan Reservoir	SKNF	385577	3891421	1997	This rheocrene spring is included in the Arizona State Land Office shapefile.
Bard Spring	GEO	0	McLellan Reservoir	SKNF	383546	3896440	2017	This spring is listed on the DRG, and included in the Arizona State Land Office shapefile.
Beale Spring	DLG	0	Parks	SKNF	417162	3913613	2255	This named spring is in a shallow drainage south of Beale Mountain, near a road. It is depicted on the DRG.
Bear Canyon upper unnamed spring	NHD	0	May Tank Pocket	SKNF	392611	3884714	2047	This unnamed spring is depicted on the DRG, and is included in the NHD database.
Bear Springs	NHD	1	May Tank Pocket	SKNF	392429	3883314	2013	According to the NPS, this is a perennial Spring with riparian vegetation. This named spring is depicted on the DRG.
Bennett Spring	NHD	0	Williams South	SKNF	389622	3899376	2178	This named site is depicted on the DRG.

Name	Source	Inv	Quad Name	District	Easting	Northing	Elevat	Description
Big Spring SKNF	NHD	0	Davenport Hill	SKNF	401566	3891102	2080	This named site is depicted on the DRG.
Bill Williams Loop unnamed spring	NHD	0	May Tank Pocket	SKNF	387545	3885837	1982	This site is located toward the head of a canyon, is marked on the DRG, and is included on the NHD Database.
Buck Spring	GEO	0	Davenport Hill	SKNF	404849	3894493	2087	This named site is depicted on the DRG.
Calcord Spring	NHD	1	Sycamore Point	SKNF	411067	3882166	1928	This is likely an excavated spring that forms a perennial pool. According to Glenn Rink, the pool supported frogs, bullfrogs, and fish; he also found several more pools within 200 m upstream from the site.
Camp Navajo pipe unnamed spring	NHD	2	Bellemont	SKNF	421661	3899093	2167	This spring is marked on the DRG and included in the NHD Database. It is in a heavily developed area within the military reservation boundary. This is a piped spring that emerges under a gravel road and flows into two troughs, then 50 m into a LGC.
Campbell Spring SKNF	NHD	0	Williams South	SKNF	387433	3890385	1999	This named spring is depicted on the DRG.

Name	Source	Inv	Quad Name	District	Easting	Northing	Elevat	Description
Clover Spring SKNF	GEO	0	Williams South	SKNF	390478	3899382	2198	This named site is depicted on the DRG.
Dow Spring	DLG	0	Garland Prairie	SKNF	410241	3890717	2050	This named site is located in the headwaters of Sycamore Canyon, and is depicted on the DRG.
East Elk Spring	GEO	1	Moritz Ridge	SKNF	410308	3915233	2219	This named spring, depicted on the DRG, was said to be a perennial spring with riparian vegetation, but the spring was dry during a USFS 2008 survey.
Fues Spring	NHD	0	Williams North	SKNF	396205	3906818	2075	This named site is depicted on the DRG.
Garland Spring	DLG	0	Garland Prairie	SKNF	409150	3894351	2052	This named site is depicted on the DRG.
Hat Tank lower unnamed spring	GEO	0	May Tank Pocket	SKNF	392754	3883968	2029	This unnamed site is depicted on the DRG, and is included in the NHD Database.
Hat Tank upper unnamed spring	NHD	0	May Tank Pocket	SKNF	393295	3884260	2059	This unnamed site is depicted on the DRG, and is included in the NHD Database.

Name	Source	Inv	Quad Name	District	Easting	Northing	Elevat	Description
Hausman Spring	GEO	0	Parks	SKNF	412463	3907881	2250	This site is not listed on the DRG, but was included in the AZ State Land Office layer.
Hitt Spring	NHD	1	White Horse Lake	SKNF	401784	3885959	2096	According to the NPS, this is a perennial Springs with riparian vegetation. This named spring is depicted on the DRG.
Holloway Spring	DLG	0	White Horse Lake	SKNF	400847	3886007	2100	This named site is depicted on the DRG.
Indian Seeps Tank	NHD	0	Sitgreaves Mountain	SKNF	400533	3914013	2045	This spring is depicted on the DRG as Indian Seeps Tank, and is included as an unnamed spring in the NHD Database.
Isham Spring	GEO	0	Davenport Hill	SKNF	405262	3895719	2079	This named site is included on the DRG, but labeled as dry.
Kaufman Spring	DLG	0	Parks	SKNF	410193	3907412	2229	This named spring is depicted on the DRG.
Klostermeyer Spring	GEO	0	Parks	SKNF	418621	3907146	2264	This named site is depicted on the DRG, on the northeast base of Klostermeyer Hill.
L O Spring	DLG	0	Garland Prairie	SKNF	410343	3890488	2041	This named site is located in the headwaters of Sycamore Canyon, and is depicted on the

Name	Source	Inv	Quad Name	District	Easting	Northing	Elevat	Description
								DRG.
Lee Canyon unnamed spring	NHD	-2	White Horse Lake	SKNF	401816	3883221	2072	Glenn Rink walked from the bottom of this draw to the top and back again and found no evidence of a spring. There is an old log cabin (401692, 3882903) and a 20' steel pipe that has been washed down the draw. There are abundant elk trails, but no H_2O or H_2O improvements.
Lee Canyon unnamed spring	NHD	-2	White Horse Lake	SKNF	399470	3885608	2153	This site is depicted as two springs on the DRG, located in a meadow. During fall survey 2010, Glenn Rink found no water.
Lee Canyon upper unnamed spring	NHD	-2	White Horse Lake	SKNF	398588	3884859	2139	There are two large elk exclosures in this meadow. Glenn Rink found no evidence of a spring. Two springs are depicted on the DRG, and they are included in the NHD database.
Little Spring SKNF	GEO	1	Parks	SKNF	412938	3907077	2234	This named spring is on the north base of Wright Hill. It is depicted on the DRG, and was included in the AZ State Land Office shapefile.

Name	Source	Inv	Quad Name	District	Easting	Northing	Elevat	Description
Lockett Spring	NHD	0	Williams South	SKNF	395020	3890149	2158	This named site is depicted on the DRG.
Lost Spring	GEO	0	Moritz Ridge	SKNF	419996	3925679	2198	This site is included in the AZ Land Office springs layer, and is depicted as a water tank on the DRG.
Lower McDermit Spring	DLG	1	Parks	SKNF	416545	3902041	2177	According to the USFS, this spring has little or no riparian vegetation. This named spring is depicted on the DRG.
McDermit Spring	DLG	0	Parks	SKNF	416944	3903258	2204	This named site is depicted on the DRG and included in the AZ State Land Office shapefile.
McDougal Spring	DLG	1	Williams South	SKNF	398255	3888184	2141	According to the USFS, this named spring, depicted on the DRG, has little or no riparian vegetation.
Mineral Spring	NHD	0	Garland Prairie	SKNF	409170	3900429	2096	Located near railroad tracks, this site is not depicted on the DRG, but is included in the NHD Database.
Mud Springs	NHD	0	May Tank Pocket	SKNF	391853	3886434	2115	This named site is depicted on the DRG.

Name	Source	Inv	Quad Name	District	Easting	Northing	Elevat	Description
NE Spring	GEO	0	Parks	SKNF	410232	3904753	2184	This named spring is located near a pipeline, and is depicted on the DRG.
Newman Spring	GEO	0	Kendrick Peak	SKNF	421519	3918267	2581	Located at the base of the west side of Kendrick Peak, this named site is depicted on the DRG.
Pitman Valley unnamed spring	NHD	0	Davenport Hill	SKNF	405442	3901245	2098	This site is not depicted on the DRG, although there are several tanks marked in the area. It is included in the NHD Database.
rocky Tule spring unnamed	NHD	1	White Horse Lake	SKNF	397604	3879880	2012	The spring has been heavily manipulated, with a vertical pipe about 20 inches in diameter. Glenn Rink surveyed the site in September 2010.
Ross Spring	GEO	0	Davenport Hill	SKNF	407215	3896187	2081	This named spring is depicted on the DRG, and labeled as dry.
Round Mountain unnamed spring	NHD	-2	White Horse Lake	SKNF	401764	3881492	2024	Glenn Rink explored upstream and downstream 200 m both ways from UTMs given and found no evidence of a spring.
Sawmill Spring	DLG	0	Parks	SKNF	412722	3905386	2211	This named spring is depicted on the DRG, and was included in the AZ State Land

Name	Source	Inv	Quad Name	District	Easting	Northing	Elevat	Description
								Office shapefile.
Spitz Spring lower	DLG	0	Parks	SKNF	411352	3902378	2128	This spring is the lower of two named springs depicted on the DRG, and included in the AZ State Land Office layer.
Spitz Spring upper	NHD	0	Parks	SKNF	411372	3902461	2130	This spring is the lower of two named springs depicted on the DRG, and included in the AZ State Land Office layer.
Stage Tank spring	GEO	0	Matterhorn	SKNF	384322	3884371	1969	This spring is included in the AZ State Land Office layer, and is depicted as Stage Tank on the DRG.
Stewart Spring	DLG	0	May Tank Pocket	SKNF	394475	3885558	2135	This named spring is depicted on the DRG, and was included in the AZ State Land Office shapefile.
Summitt Spring	NHD	0	May Tank Pocket	SKNF	395946	3887395	2214	This named site is depicted on the DRG, and may merge from more than one source.
Triangle Spring	NHD	0	Garland Prairie	SKNF	412723	3892376	2059	This site is not shown on the DRG.

Name	Source	Inv	Quad Name	District	Easting	Northing	Elevat	Description
Twin Springs	GEO	0	Williams South	SKNF	388450	3892396	2129	This named site is depicted on the DRG, and is included in the AZ State Land Office layer.
Twin Springs Rd unnamed spring	DLG	0	Williams South	SKNF	389263	3892429	2149	This unnamed spring is depicted on the DRG, and was included in the AZ State Land Office shapefile.
Upper McDermit Spring	DLG	1	Parks	SKNF	416891	3903774	2207	According to the USFS, this spring has little or no riparian vegetation.
Wade Spring	DLG	0	Sitgreaves Mountain	SKNF	405799	3906995	2148	This named spring is depicted on the DRG, and was included in the AZ State Land Office shapefile.
weed unnamed spring	NHD	-2	White Horse Lake	SKNF	398763	3884347	2146	There are two very large and recently built elk exclosures in this meadow. Glenn Rink found no evidence of a spring in September 2000.
West Elk Spring	GEO	0	Moritz Ridge	SKNF	410186	3915601	2195	This named spring is depicted on the DRG and was included in the AZ State Land Office shapefile.

Name	Source	Inv	Quad Name	District	Easting	Northing	Elevat	Description
Wild Horse Spring	DLG	0	May Tank Pocket	SKNF	393854	3883749	2048	This site is not depicted on the DRG, but was included in the AZ State Land Office shapefile.
Willow Spring SKNF	DLG	1	Davenport Hill	SKNF	406333	3888376	1980	This is a small pool-forming perennial spring, emerging from a basalt ledge orifice. Glenn Rink confirmed the site in September 2010.

Table 16. Springs by restoration unit and Forest for the Four Forest Restoration Initiative analysis area.

Analysis Area		Coconino NF		Kaibab NF	
Restoration Unit/Spring Name	**No. of springs**	**Restoration Unit/Spring Name**	**No. of springs**	**Restoration Unit/Spring Name**	**No. of springs**
1	**32**	**1**	**32**	**3**	**16**
Babbit Spring	1	Babbit Spring	1	Andrews Spring	1
Bootlegger Spring	1	Bootlegger Spring	1	Bear Springs	1
Bristow Spring	1	Bristow Spring	1	Big Spring	1

Analysis Area		**Coconino NF**		**Kaibab NF**	
Restoration Unit/Spring Name	**No. of springs**	**Restoration Unit/Spring Name**	**No. of springs**	**Restoration Unit/Spring Name**	**No. of springs**
Broken Spring	1	Broken Spring	1	Bill Williams Loop unnamed spring	1
Clarks Well	1	Clarks Well	1	Hat Tank lower unnamed spring	1
Dairy Spring	1	Dairy Spring	1	Hat Tank upper unnamed spring	1
Double Springs	2	Double Springs	2	Lee Canyon upper unnamed spring	1
Dove Springs	1	Dove Springs	1	McDougal Spring	1
Howard Spring	1	Howard Spring	1	Mineral Spring	1
Hoxworth Springs	3	Hoxworth Springs	3	rocky Tule spring unnamed	1
Lee Spring	1	Lee Spring	1	Rosilda Spring	1
Mint Spring	1	Mint Spring	1	Stewart Spring	1
Mud Spring	1	Mud Spring	1	Triangle Spring	1
Munds Spring	1	Munds Spring	1	weed unnamed spring	1

Analysis Area		Coconino NF		Kaibab NF	
Restoration Unit/Spring Name	**No. of springs**	**Restoration Unit/Spring Name**	**No. of springs**	**Restoration Unit/Spring Name**	**No. of springs**
Railroad Spring	1	Railroad Spring	1	Wild Horse Spring	1
Rock Top springs	1	Rock Top springs	1	Willow Spring	1
Sawmill Springs	1	Sawmill Springs	1	**4**	**11**
Sedge Spring	1	Sedge Spring	1	Beale Spring	1
Seven Anchor Spring	1	Seven Anchor Spring	1	Fues Spring	1
Sheep Spring	1	Sheep Spring	1	Kaufman Spring	1
Smith Spring	1	Smith Spring	1	Lost Spring	1
Thomas Spring	1	Thomas Spring	1	Lower McDermit Spring	1
Tinny Spring	1	Tinny Spring	1	NE Spring	1
Tree Spring	1	Tree Spring	1	Sawmill Spring	1
T-Six Spring	1	T-Six Spring	1	Spitz Spring lower	1

Analysis Area		**Coconino NF**		**Kaibab NF**	
Restoration Unit/Spring Name	**No. of springs**	**Restoration Unit/Spring Name**	**No. of springs**	**Restoration Unit/Spring Name**	**No. of springs**
unnamed	1	unnamed	1	Spitz Spring upper	1
Van Deren Spring	1	Van Deren Spring	1	Upper McDermit Spring	1
Weimer Spring	1	Weimer Spring	1	Wade Spring	1
Willard Spring	1	Willard Spring	1	**Grand Total**	**27**
3	**28**	**3**	**12**		
Andrews Spring	1	Barney Spring	1		
Barney Spring	1	Black Spring	1		
Bear Springs	1	Garden Spring	1		
Big Spring	1	Griffiths Spring	1		
Bill Williams Loop unnamed spring	1	Lockwood Spring	1		
Black Spring	1	Lower Hull Spring	1		

Analysis Area		Coconino NF		Kaibab NF	
Restoration Unit/Spring Name	**No. of springs**	**Restoration Unit/Spring Name**	**No. of springs**	**Restoration Unit/Spring Name**	**No. of springs**
Garden Spring	1	Poison Spring	1		
Griffiths Spring	1	Railroad Spring	1		
Hat Tank lower unnamed spring	1	Ritter Spring	1		
Hat Tank upper unnamed spring	1	Scott Spring	1		
Lee Canyon upper unnamed spring	1	unnamed	1		
Lockwood Spring	1	Upper Hull Spring	1		
Lower Hull Spring	1	**4**	**3**		
McDougal Spring	1	Curley Seep	1		
Mineral Spring	1	Howard Seep	1		
Poison Spring	1	Kendrick Spring	1		
Railroad Spring	1	**5**	**4**		

Analysis Area		**Coconino NF**		**Kaibab NF**	
Restoration Unit/Spring Name	**No. of springs**	**Restoration Unit/Spring Name**	**No. of springs**	**Restoration Unit/Spring Name**	**No. of springs**
Ritter Spring	1	Alto Spring	1		
rocky Tule spring unnamed	1	Chimney Springs	1		
Rosilda Spring	1	Little Elden Spring	1		
Scott Spring	1	Pat Spring	1		
Stewart Spring	1	**Grand Total**	**51**		
Triangle Spring	1				
unnamed	1				
Upper Hull Spring	1				
weed unnamed spring	1				
Wild Horse Spring	1				
Willow Spring	1				

Analysis Area		Coconino NF		Kaibab NF	
Restoration Unit/Spring Name	**No. of springs**	**Restoration Unit/Spring Name**	**No. of springs**	**Restoration Unit/Spring Name**	**No. of springs**
4	**14**				
Beale Spring	1				
Curley Seep	1				
Fues Spring	1				
Howard Seep	1				
Kaufman Spring	1				
Kendrick Spring	1				
Lost Spring	1				
Lower McDermit Spring	1				
NE Spring	1				
Sawmill Spring	1				

Analysis Area		Coconino NF		Kaibab NF	
Restoration Unit/Spring Name	**No. of springs**	**Restoration Unit/Spring Name**	**No. of springs**	**Restoration Unit/Spring Name**	**No. of springs**
Spitz Spring lower	1				
Spitz Spring upper	1				
Upper McDermit Spring	1				
Wade Spring	1				
5	**4**				
Alto Spring	1				
Chimney Springs	1				
Little Elden Spring	1				
Pat Spring	1				
Grand Total	**74**				

Table 17. Springs of the Coconino National Forest that occur within the Four Forest Restoration Initiative treatment areas.

Name	Forest	Meadow	Comment	Acres	Working	Possible Mech	Cover Type	ImpCovType
Seven Anchor Spring	yes	no		101.4	IT10	Yes	TPP	PP
Broken Spring	yes	no		62.6	UEA40	Yes	TPP	PP
	edge	edge		18.1	Operational Burn	No	GRA	
Tinny Spring	yes	no		22.9	UEA25	Yes	TPP	PP
Van Deren Spring	yes	yes		350.2	MSO Restricted Trt	Yes	TPP	PP
Lee Spring	edge	yes	tree succession in meadow	50.5	Pot PAC Trt	Yes	TPP	PP
Sawmill Springs	yes	edge	Bebb's willow , riparian reach	66.5	MSO Restricted Trt	Yes	TPP	PP
Rock Top springs	yes	no		61.0	Pot PAC Trt	Yes	TPP	PP
Mint Spring	yes	no		71.8	UEA40	Yes	TPP	PP
Tree Spring	no	yes		12.7	Operational Burn	No	GRA	

Name	Forest	Meadow	Comment	Acres	Working	Possible Mech	Cover Type	ImpCovType
Dove Springs	yes	no	345 kV powerline corridor	76.9	UEA40	Yes	TPP	PP
Railroad Spring	yes	edge		7.6	UEA40	Yes	TPP	PP
Bristow Spring	yes	no		52.8	SI40	Yes	TPP	PP
Sedge Spring	yes	no		35.8	MSO Restricted Trt	Yes	TPP	PP
T-Six Spring	edge	yes	next to private	36.6	UEA40	Yes	TPP	PP
Bootlegger Spring	yes	no		29.0	Aspen Treatment	No	TAA	AA
Sheep Spring	yes	no		19.0	Savanna	No	TPP	AA
Munds Spring	no	yes		364.0	Operational Burn	No	GRA	
Smith Spring	edge	yes	edge of Mormon Lake	61.8	MSO Restricted Trt	Yes	TPP	PP
Double Springs	yes	no	next to campground	57.5	MSO Restricted Trt	Yes	TPP	PP
Double Springs	edge	edge	next to	57.5	MSO Restricted Trt	Yes	TPP	PP

Name	Forest	Meadow	Comment	Acres	Working	Possible Mech	Cover Type	ImpCovType
			campground					
Dairy Spring	yes	edge	next to Mormon Lake	73.4	MSO Restricted Trt	Yes	TPP	PP
Mud Spring	yes	edge		7.6	Operational Burn	No	GRA	
Weimer Spring	edge	edge	heavy recreation use	4.0	Operational Burn	No	GRA	
Willard Spring	yes	no		18.8	UEA25	Yes	TPP	PP
Howard Spring	yes	no		13.8	MSO Restricted Trt	Yes	TPP	PP
Ritter Spring	yes	no	sparse canopy	24.1	MSO Restricted Trt	Yes	TPP	PP
Scott Spring	no	yes		81.5	MSO Restricted Trt	Yes	TPP	PP
Thomas Spring	edge	edge		2.4	Operational Burn	No	GRA	
Lockwood Spring	yes	no		3.6	MSO Restricted Trt	Yes	TPP	PP
Babbit Spring	yes	edge		34.7	SI40	Yes	TPP	PP

Name	Forest	Meadow	Comment	Acres	Working	Possible Mech	Cover Type	ImpCovType
Clarks Well	edge	yes	Elk Park project	32.2	Operational Burn	No	GRA	
Griffiths Spring	edge	edge		46.0	UEA25	Yes	TPP	OS
Poison Spring	yes	no	next to private	59.2	UEA40	Yes	TPP	PP
Railroad Spring	no	yes		29.6	Operational Burn	No	GRA	
Lower Hull Spring	edge	edge	next to private land	344.1	UEA40	Yes	TPP	PP
Upper Hull Spring	no	yes		30.3	Operational Burn	No	GRA	
Chimney Springs	yes	no		12.4	IT25	Yes	TPP	PP
Little Elden Spring	yes	no	Cultural site, large oak	2.6	Operational Burn	No	GRA	
Alto Spring				30.0	UEA10	Yes	TPP	PP
Pat Spring	yes	no		130.4	Operational Burn	No	GRA	
Curley Seep	yes	no	Hochderffer Fire	19.4	Savanna	Yes	TPP	PP

Name	Forest	Meadow	Comment	Acres	Working	Possible Mech	Cover Type	ImpCovType
Kendrick Spring	yes	no		35.1	UEA40	No	TPP	AA
Howard Seep	yes	no	Hochderffer Fire	171.6	Operational Burn	No	GRA	

Table 18. Springs of the Kaibab National Forest that occur within the Four Forest Restoration Initiative treatment areas.

NAME	forest	meadow	Acres	Working	Poss_Mech	Cov_Type	ImpCovTyp
rocky Tule spring unnamed			23.5	MSO Restricted Trt	Yes	TPP	PP
Bear Springs			6.6	UEA10	Yes	TPJ	PP
Wild Horse Spring			26.8	MSO Restricted Trt	Yes	TMH	OS
Hat Tank lower unnamed spring			41.2	MSO Restricted Trt	Yes	TPP	OS
Hat Tank upper unnamed spring			174.6	MSO Restricted Trt	Yes	TPP	PP
weed unnamed spring			53.0	MSO Restricted Trt	Yes	TPP	PP
Lee Canyon upper unnamed spring			9.6	Aspen Treatment	Yes	TAA	PP

NAME	forest	meadow	Acres	Working	Poss_Mech	Cov_Type	ImpCovTyp
Stewart Spring			11.5	MSO Restricted Trt	Yes	TPP	PP
Bill Williams Loop unnamed spring			24.3	UEA40	Yes	TPP	PP
McDougal Spring			10.3	Savanna	Yes	TPP	PP
Willow Spring			13.7	UEA40	Yes	TPP	PP
Big Spring			29.9	Savanna	Yes	TPP	PP
Andrews Spring	yes/canyon	no	85.5	IT10	No	TPP	PP
Triangle Spring			2087.6	Operational Burn	No	GRA	
Rosilda Spring			9.1	Operational Burn	No	GRA	
Mineral Spring			6.0	Operational Burn	No	GRA	
Lower McDermit Spring			92.6	MSO Restricted Trt	Yes	TPP	PP
Spitz Spring lower			19.5	Operational Burn	No	GRA	
Spitz Spring upper			52.0	UEA40	Yes	TPP	PP

NAME	forest	meadow	Acres	Working	Poss_Mech	Cov_Type	ImpCovTyp
Upper McDermit Spring			78.2	Savanna	Yes	TPP	PP
NE Spring			20.1	IT40	Yes	TPP	PP
Sawmill Spring			11.0	UEA40	Yes	TPP	PP
Fues Spring			730.8	Operational Burn	No	GRA	
Wade Spring			48.3	UEA25	Yes	TPP	PP
Kaufman Spring			55.7	UEA40	Yes	TPP	PP
Beale Spring			41.7	IT10	Yes	TPP	PP
Lost Spring			133.7	UEA25	No	TPP	PJ

APPENDIX F:

CURRENT AND FORESEEABLE FUTURE PROJECTS IN THE FOUR FOREST RESTORATION INITIATIVE ANALYSIS AREA AND ASSOCIATED DISTURBANCE

Table 19. Total ground disturbance under Alterantive B, including current and forseeable projects by HUC12 subwatershed withing the Four Forest Restoration Initiative Analysis Area.

	Expected net ground disturbance under current EIS														Baseline	Future Foreseeable Projects		Current and Ongoing Projects		**TOTAL PROJECTED DISTURBANCE**	
6th CODE HUC NAME	**6th code acres**	**grassland**	**high intensity**	**low intensity**	**savanna**	**aspen**	**rx burn**	**temp rd**	**decom rd**	**relocate rd**	**channel restore**	**TOTAL EIS ground distrurbacne**	**TOTAL EIS treatment % ground disturb**	**TOTAL EIS % Ground Disturb**	**TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--**	**TOTAL TREAT ACRES**	**TOTAL Future/Fore ground disturbance**	**TOTAL TREAT ACRES**	**TOTAL current ground disturbance**	**TOTAL CUM EFFECTS Ground Disturb**	**TOTAL CUM EFFECTS % Ground Disturb**
Anderson Canyon	31,284	34	167	30	0	0	68	4	2	0	0	305	9.0%	1.0%	93	229	34	2,608	391	824	2.6%
Babbitt Lake	28,413	77	950	270	0	18	308	54	73	0	0	1,750	11.4%	6.2%	250	141	21	436	65	2,087	7.3%
Bar M Canyon	17,551	23	859	686	0	0	310	10	10	0	0	1,898	12.2%	10.8 %	164	125	19	3,026	454	2,535	14.4%
Bear Canyon	21,982	3	249	663	0	12	165	23	8	0	0	1,122	13.6%	5.1%	165	488	73	85	13	1,373	6.2%
Bear Jaw Canyon	11,135	0	173	175	0	0	74	12	17	0	0	452	12.2%	4.1%	70	36	5	247	37	564	5.1%
Big Spring Canyon	31,697	22	1,156	452	0	9	286	65	37	1	0	2,028	14.2%	6.4%	395	8,757	1,314	2,746	412	4,148	13.1%
Cataract Creek Headwaters	16,699	9	159	5	0	0	57	6	11	0	0	247	8.6%	1.5%	1,787	1,500	225	1,461	219	2,478	14.8%
Cedar Creek	8,888	1	86	22	0	0	20	2	0	0	0	131	13.1%	1.5%	21	0	0	872	131	283	3.2%
Cherry Canyon-Walnut Creek	28,330	11	417	360	0	0	153	22	51	1	64	1,078	14.1%	3.8%	437	10,903	1,635	9,359	1,40 4	4,543	16.0%
Cinder Basin	39,864	13	0	0	0	0	164	0	13	0	0	189	2.3%	0.5%	124	256	38	0	0	352	0.9%

Coconino Wash Headwaters	51,193	2	301	2,239	0	0	545	24	14	3	6	3,135	11.5%	6.1%	552	36	5	4,971	746	4,437	8.7%
Curley Wallace Tank	13,431	0	11	0	0	0	2	0	0	0	0	13	16.9%	0.1%	78	0	0	5,541	831	922	6.9%
Dent and Sayer Tank	37,216	16	434	213	0	3	217	38	21	0	0	942	8.7%	2.5%	247	16	2	8,386	1,258	2,450	6.6%
Devil Dog Canyon	11,196	1	71	0	0	0	16	5	0	0	0	94	11.7%	0.8%	176	69	10	70	11	291	2.6%
Dogtown Wash	11,662	3	317	59	0	0	87	7	7	0	0	480	11.0%	4.1%	380	5,861	879	865	130	1,869	16.0%
Doney Park	42,133	37	2	92	0	0	277	0	134	0	22	564	4.1%	1.3%	3,584	1,377	207	948	142	4,497	10.7%
Double Cabin Park-Jacks Canyon	21,660	1	97	90	0	3	34	1	3	0	3	233	13.5%	1.1%	299	9,958	1,494	2,871	431	2,456	11.3%
Dry Creek	34,398	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	947	1,152	173	0	0	1,120	3.3%
Fry Canyon	19,175	19	526	167	0	0	121	5	11	0	26	877	14.4%	4.6%	163	1,222	183	1,620	243	1,466	7.6%
Garland Prairie	25,054	244	649	333	0	1	323	9	25	1	0	1,585	9.8%	6.3%	638	3,512	527	272	41	2,791	11.1%
Government Canyon	12,765	0	127	10	0	0	23	6	5	0	0	171	14.6%	1.3%	68	0	0	142	21	260	2.0%
Government Prairie	20,399	115	792	184	0	7	229	9	23	0	0	1,360	11.9%	6.7%	973	7,676	1,151	435	65	3,549	17.4%
Grapevine Canyon	19,186	2	234	21	0	0	56	3	1	0	0	317	11.3%	1.7%	83	43	6	0	0	407	2.1%
Grindstone Wash	17,796	0	92	31	0	0	32	8	0	0	0	163	10.1%	0.9%	169	0	0	1,235	185	517	2.9%
Johnson Creek	30,857	1	221	21	0	0	57	8	2	0	2	312	11.0%	1.0%	537	789	118	1,455	218	1,186	3.8%
Juan Tank Canyon	14,231	0	40	0	0	0	5	4	0	0	0	49	18.4%	0.3%	177	0	0	13	2	228	1.6%
Kinnikinick Canyon	24,895	11	771	134	0	0	160	9	9	0	0	1,095	13.7%	4.4%	134	206	31	2,667	400	1,660	6.7%
Klostermeyer Lake	28,109	0	30	30	0	0	25	3	5	0	0	93	7.4%	0.3%	127	0	0	0	0	220	0.8%

Little LO Spring Canyon	12,260	3	441	354	0	0	148	24	22	0	7	999	13.5%	8.1%	71	408	61	0	0	1,131	9.2%
Little Red Horse Wash	27,465	0	1	49	0	0	17	0	0	0	0	67	8.0%	0.2%	149	0	0	3,360	504	720	2.6%
Long Lake-Chavel Pass Ditch	14,590	0	31	29	0	0	19	0	0	0	0	78	8.5%	0.5%	108	2,597	390	0	0	576	3.9%
Lower Deadman Wash	31,266	0	0	0	0	0	20	0	5	0	0	25	2.5%	0.1%	148	200	30	0	0	204	0.7%
Lower Rio de Flag	35,308	10	170	103	0	0	124	4	56	0	0	467	7.5%	1.3%	6,189	3,274	491	2,649	397	7,545	21.4%
Lower Sycamore Creek	30,677	0	8	8	0	0	3	2	0	0	0	20	13.9%	0.1%	45	177	27	38	6	98	0.3%
Lower Woods Canyon	26,131	3	143	434	0	0	192	8	18	0	0	798	8.3%	3.1%	143	0	0	272	41	981	3.8%
MC Canyon	21,686	1	143	55	0	0	52	3	7	0	0	262	10.1%	1.2%	156	6,319	948	193	29	1,395	6.4%
Meath Wash	37,538	6	16	0	0	0	9	1	0	0	0	31	6.8%	0.1%	265	157	24	127	19	338	0.9%
Middle Deadman Wash	22,888	5	61	38	0	0	98	11	51	0	0	263	5.4%	1.1%	406	159	24	0	0	692	3.0%
Middle Oak Creek	39,896	0	7	16	0	0	22	0	2	0	0	47	4.3%	0.1%	4,276	0	0	4	1	4,323	10.8%
Middle Spring Valley Wash	32,672	3	302	47	0	0	94	10	0	0	67	521	11.1%	1.6%	119	7	1	0	0	642	2.0%
Middle Sycamore Creek	18,335	2	224	416	0	0	137	11	4	0	0	793	11.6%	4.3%	104	998	150	0	0	1,046	5.7%
Miller Wash Headwaters	31,220	19	75	253	0	5	156	21	0	0	0	529	6.8%	1.7%	252	23	3	5,936	890	1,675	5.4%
Mormon Canyon	19,252	4	55	0	0	0	21	0	5	0	0	85	8.0%	0.4%	134	193	29	488	73	321	1.7%
Mormon Lake	25,968	14	518	734	0	0	259	4	61	0	7	1,598	12.4%	6.2%	706	2,537	380	7,296	1,094	3,778	14.5%
Munds Canyon	41,179	25	1,198	2,182	0	19	628	58	73	0	35	4,219	13.4%	10.2%	1,481	435	65	2,267	340	6,095	14.8%

Pitman Valley-Scholz Lake	28,459	111	1,065	338	0	1	331	21	6	1	0	1,874	11.3%	6.6%	710	760	114	1,792	269	2,967	10.4%
Porcupine Canyon-Walnut Creek	16,622	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	667	530	80	33	5	751	4.5%
Pumphouse Wash	31,546	6	716	777	0	0	284	12	93	0	58	1,947	13.7%	6.2%	1,746	1,427	214	10,528	1,579	5,474	17.4%
Rabbit Canyon	41,339	0	9	0	0	0	6	3	0	0	0	18	6.4%	0.0%	74	0	0	251	38	130	0.3%
Rain Tank Wash	38,483	0	133	279	0	0	93	0	22	1	0	527	11.4%	1.4%	209	0	0	2,144	322	1,057	2.7%
Rattlesnake Canyon	17,023	0	63	100	0	0	60	0	0	0	0	223	7.5%	1.3%	143	1,173	176	1,584	238	780	4.6%
Rattlesnake Wash	16,259	0	46	0	0	0	14	2	0	0	0	62	8.8%	0.4%	87	0	0	313	47	196	1.2%
Red Horse Wash Headwaters	19,561	0	128	591	0	0	138	4	4	2	0	867	12.5%	4.4%	141	9	1	897	135	1,144	5.9%
Sawmill Tank	13,730	124	612	99	0	1	189	18	3	0	0	1,046	11.1%	7.6%	384	103	15	78	12	1,458	10.6%
Sawmill Wash	12,385	2	314	339	0	0	123	11	6	0	5	800	13.0%	6.5%	90	190	29	0	0	918	7.4%
Secret Canyon	11,138	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	53	3,684	553	0	0	605	5.4%
Sinclair Wash	6,766	2	14	0	0	0	3	0	5	0	0	25	15.4%	0.4%	1,699	0	0	103	15	1,739	25.7%
Smoot Lake	21,535	0	163	4	0	0	34	8	0	0	0	208	12.4%	1.0%	119	11	2	0	0	329	1.5%
Spring Creek	30,830	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	258	1,361	204	0	0	463	1.5%
Telephone Tank	14,934	10	250	313	0	2	97	4	32	0	0	708	14.5%	4.7%	497	6,074	911	1,813	272	2,388	16.0%
Tule Canyon	29,866	18	933	804	0	7	384	68	24	1	15	2,253	11.7%	7.5%	293	7	1	7,064	1,060	3,607	12.1%
Upper Cataract Creek	25,011	2	157	0	0	0	55	3	0	0	0	218	7.8%	0.9%	181	7	1	116	17	417	1.7%

Upper Cedar Wash (Local Drainage)	23,476	56	570	107	0	4	188	28	47	0	0	1,000	10.7%	4.3%	229	7	1	0	0	1,230	5.2%
Upper Deadman Wash	22,752	32	95	342	0	57	286	22	85	0	7	926	6.5%	4.1%	260	3,832	575	842	126	1,886	8.3%
Upper Hell Canyon	29,249	1	212	237	0	2	93	11	10	0	0	566	12.1%	1.9%	312	9,592	1,439	1,700	255	2,572	8.8%
Upper Kana-a Wash	38,801	16	0	0	0	0	210	0	11	0	0	238	2.3%	0.6%	155	318	48	991	149	589	1.5%
Upper Lee Canyon	29,537	0	12	34	0	0	77	0	3	0	0	127	3.3%	0.4%	159	1,156	173	1,765	265	724	2.5%
Upper Oak Creek	17,900	5	169	880	0	0	193	10	34	0	0	1,291	13.4%	7.2%	284	1	0	711	107	1,682	9.4%
Upper Padre Canyon	22,105	8	232	92	0	0	72	1	2	0	0	407	11.3%	1.8%	246	284	43	4,131	620	1,315	6.0%
Upper Red Lake Wash	26,930	37	627	493	0	0	313	28	15	1	9	1,523	9.7%	5.7%	420	14	2	1	0	1,945	7.2%
Upper Rio de Flag	44,551	10	403	586	0	3	204	6	90	0	6	1,308	12.8%	2.9%	3,990	12,354	1,853	4,152	623	7,774	17.4%
Upper San Francisco Wash	34,397	29	0	0	0	0	225	0	32	0	0	286	2.5%	0.8%	942	1,355	203	687	103	1,535	4.5%
Upper Spring Valley Wash	38,305	62	1,625	608	0	17	464	58	29	0	0	2,864	12.3%	7.5%	670	1,309	196	7,979	1,19 7	4,927	12.9%
Upper Sycamore Creek	14,916	12	704	161	0	0	137	17	7	0	5	1,043	15.3%	7.0%	362	777	117	0	0	1,521	10.2%
Upper Woods Canyon	12,671	6	509	480	0	1	220	3	13	0	0	1,231	11.2%	9.7%	151	382	57	1,575	236	1,676	13.2%
Volunteer Canyon	24,506	5	539	137	0	0	120	18	1	0	16	835	14.0%	3.4%	173	10,623	1,593	3,323	499	3,101	12.7%
Volunteer Wash	31,771	44	1,493	467	0	6	339	30	171	0	0	2,551	15.0%	8.0%	894	8,457	1,269	686	103	4,817	15.2%
Walnut Creek-Lower Lake Mary	18,920	37	480	281	0	0	158	13	41	2	108	1,120	14.1%	5.9%	224	6,172	926	2,200	330	2,594	13.7%
Walnut Creek-Upper Lake Mary	34,473	56	1,517	1,073	0	4	503	47	37	0	74	3,311	13.2%	9.6%	264	3,725	559	416	62	4,197	12.2%

West Fork Oak Creek	27,339	3	579	505	0	0	189	15	33	0	20	1,344	14.2%	4.9%	258	10,070	1,510	0	0	3,112	11.4%
Yeager Draw	24,465	0	9	5	0	0	2	0	0	0	0	16	15.9%	0.1%	102	173	26	0	0	143	0.6%
TOTAL	**2,032,080**	**1,436**	**26,702**	**21,132**	**0**	**184**	**11,620**	**954**	**1,645**	**17**	**561**	**64,252**	**11.1%**	**3.2%**	**45,041**	**157,772**	**23,666**	**132,837**	**19,926**	**152,844**	**7.5%**

Table 20. Total ground disturbance under Alternative C, including current and forseeable projects by HUC12 subwatershed within the Four Forest Restoration Initiatve Analysis Area.

	current EIS-expected ground disturbance														Baseline	Future Foreseeable		Current/Ongoing		**PROJECT TOTAL**	
6th CODE HUC NAME	**6th code acres**	**grassland**	**high intensity**	**low intensity**	**savanna**	**aspen**	**rx burn**	**temp rd**	**decom rd**	**relocate rd**	**channel restore**	**TOTAL EIS ground distrurbacne**	**TOTAL EIS treatment % ground disturb**	**TOTAL EIS % Ground Disturb**	**TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--**	**TOTAL TREAT ACRES**	**TOTAL Future/Fore ground disturbance**	**TOTAL TREAT ACRES**	**TOTAL current ground disturbance**	**TOTAL CUM EFFECTS Ground Disturb**	**TOTAL CUM EFFECTS % Ground Disturb**
Anderson Canyon	31,284	140	167	30	99	0	68	4	2	0	0	510	15.0%	1.6%	93	229	34	2,608	391	1,029	3.3%
Babbitt Lake	28,413	313	786	270	245	18	308	50	70	0	0	2,059	13.4%	7.2%	250	141	21	436	65	2,396	8.4%
Bar M Canyon	17,551	94	801	686	86	0	331	10	9	0	0	2,017	12.2%	11.5%	164	125	19	3,026	454	2,653	15.1%
Bear Canyon	21,982	13	238	663	48	12	165	23	8	0	0	1,170	14.2%	5.3%	165	488	73	85	13	1,421	6.5%
Bear Jaw Canyon	11,135	0	116	175	57	0	74	12	14	0	0	449	12.1%	4.0%	70	36	5	247	37	562	5.0%
Big Spring Canyon	31,697	90	1,069	452	256	9	286	65	38	1	0	2,265	15.8%	7.1%	395	8,757	1,314	2,746	412	4,386	13.8%
Cataract Creek Headwaters	16,699	50	139	5	35	0	57	6	10	0	0	302	10.5%	1.8%	1,787	1,500	225	1,461	219	2,533	15.2%
Cedar Creek	8,888	8	62	22	18	0	20	2	0	0	0	133	13.3%	1.5%	21	0	0	872	131	285	3.2%
Cherry Canyon-Walnut Creek	28,330	42	413	360	8	0	154	22	50	1	64	1,114	14.5%	3.9%	437	10,903	1,635	9,359	1,404	4,579	16.2%
Cinder Basin	39,864	51	0	0	0	0	164	0	12	0	0	227	2.8%	0.6%	124	256	38	0	0	390	1.0%
Coconino Wash Headwaters	51,193	10	301	2,239	0	0	545	24	14	3	6	3,142	11.5%	6.1%	552	36	5	4,971	746	4,445	8.7%

	current EIS-expected ground disturbance														Baseline	Future Foreseeable		Current/Ongoing		**PROJECT TOTAL**	
6th CODE HUC NAME	**6th code acres**	**grassland**	**high intensity**	**low intensity**	**savanna**	**aspen**	**rx burn**	**temp rd**	**decom rd**	**relocate rd**	**channel restore**	**TOTAL EIS ground distrurbacne**	**TOTAL EIS treatment % ground disturb**	**TOTAL EIS % Ground Disturb**	**TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--**	**TOTAL TREAT ACRES**	**TOTAL Future/Fore ground disturbance**	**TOTAL TREAT ACRES**	**TOTAL current ground disturbance**	**TOTAL CUM EFFECTS Ground Disturb**	**TOTAL CUM EFFECTS % Ground Disturb**
Curley Wallace Tank	13,431	0	11	0	0	0	2	0	0	0	0	13	17.0%	0.1%	78	0	0	5,541	831	923	6.9%
Dent and Sayer Tank	37,216	65	349	213	129	3	219	38	21	0	0	1,037	9.5%	2.8%	247	16	2	8,386	1,258	2,545	6.8%
Devil Dog Canyon	11,196	6	70	0	7	0	16	1	0	0	0	101	12.6%	0.9%	176	69	10	70	11	298	2.7%
Dogtown Wash	11,662	32	257	59	98	0	87	7	7	0	0	547	12.5%	4.7%	380	5,861	879	865	130	1,936	16.6%
Doney Park	42,133	146	2	92	0	0	278	0	127	0	22	667	4.8%	1.6%	3,584	1,377	207	948	142	4,600	10.9%
Double Cabin Park-Jacks Canyon	21,660	4	91	90	13	3	35	1	3	0	3	244	13.9%	1.1%	299	9,958	1,494	2,871	431	2,468	11.4%
Dry Creek	34,398	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	947	1,152	173	0	0	1,120	3.3%
Fry Canyon	19,175	79	442	167	122	0	121	5	11	0	26	974	16.0%	5.1%	163	1,222	183	1,620	243	1,563	8.2%
Garland Prairie	25,054	1,027	388	333	284	1	331	9	25	1	0	2,399	14.5%	9.6%	638	3,512	527	272	41	3,605	14.4%
Government Canyon	12,765	2	122	10	26	0	23	6	4	0	0	193	16.5%	1.5%	68	0	0	142	21	282	2.2%
Government Prairie	20,399	466	582	184	236	7	229	9	23	0	0	1,737	15.2%	8.5%	973	7,676	1,151	435	65	3,926	19.2%
Grapevine Canyon	19,186	10	201	21	60	0	56	3	1	0	0	352	12.6%	1.8%	83	43	6	0	0	441	2.3%

	current EIS-expected ground disturbance													Baseline	Future Foreseeable		Current/Ongoing		**PROJECT TOTAL**	
6th CODE HUC NAME	**6th code acres**	**grassland**	**high intensity**	**low intensity**	**savanna**	**aspen**	**rx burn**	**temp rd**	**decom rd**	**relocate rd**	**channel restore**	**TOTAL EIS ground distrurbacne**	**TOTAL EIS treatment % ground disturb**	**TOTAL EIS % Ground Disturb**	**TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--**	**TOTAL TREAT ACRES**	**TOTAL Future/Fore ground disturbance**	**TOTAL TREAT ACRES**	**TOTAL current ground disturbance**	**TOTAL CUM EFFECTS Ground Disturb**	**TOTAL CUM EFFECTS % Ground Disturb**
Grindstone Wash	17,796	0	92	31	5	0	32	7	0	0	0	167	10.3%	0.9%	169	0	0	1,235	185	521	2.9%
Johnson Creek	30,857	8	217	21	18	0	57	7	2	0	2	332	11.7%	1.1%	537	789	118	1,455	218	1,206	3.9%
Juan Tank Canyon	14,231	0	40	0	0	0	5	3	0	0	0	49	18.1%	0.3%	177	0	0	13	2	227	1.6%
Kinnikinick Canyon	24,895	46	647	134	227	0	162	9	9	0	0	1,235	15.3%	5.0%	134	206	31	2,667	400	1,800	7.2%
Klostermeyer Lake	28,109	1	30	30	24	0	25	3	5	0	0	118	9.4%	0.4%	127	0	0	0	0	245	0.9%
Little LO Spring Canyon	12,260	12	386	354	56	0	151	24	22	0	7	1,013	13.4%	8.3%	71	408	61	0	0	1,145	9.3%
Little Red Horse Wash	27,465	0	1	49	0	0	17	0	0	0	0	67	8.0%	0.2%	149	0	0	3,360	504	720	2.6%
Long Lake-Chavel Pass Ditch	14,590	0	31	29	3	0	20	0	0	0	0	82	8.3%	0.6%	108	2,597	390	0	0	580	4.0%
Lower Deadman Wash	31,266	0	0	0	0	0	20	0	5	0	0	25	2.5%	0.1%	148	200	30	0	0	204	0.7%
Lower Rio de Flag	35,308	39	143	103	26	0	124	4	48	0	0	488	7.9%	1.4%	6,189	3,274	491	2,649	397	7,566	21.4%
Lower Sycamore Creek	30,677	0	5	8	2	0	3	2	0	0	0	20	14.1%	0.1%	45	177	27	38	6	98	0.3%
Lower Woods Canyon	26,131	12	135	434	8	0	195	8	15	0	0	807	8.3%	3.1%	143	0	0	272	41	991	3.8%

	current EIS-expected ground disturbance														Baseline	Future Foreseeable		Current/Ongoing		**PROJECT TOTAL**	
6th CODE HUC NAME	**6th code acres**	**grassland**	**high intensity**	**low intensity**	**savanna**	**aspen**	**rx burn**	**temp rd**	**decom rd**	**relocate rd**	**channel restore**	**TOTAL EIS ground distrurbacne**	**TOTAL EIS treatment % ground disturb**	**TOTAL EIS % Ground Disturb**	**TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--**	**TOTAL TREAT ACRES**	**TOTAL Future/Fore ground disturbance**	**TOTAL TREAT ACRES**	**TOTAL current ground disturbance**	**TOTAL CUM EFFECTS Ground Disturb**	**TOTAL CUM EFFECTS % Ground Disturb**
MC Canyon	21,686	5	136	55	33	0	52	3	7	0	0	291	11.3%	1.3%	156	6,319	948	193	29	1,425	6.6%
Meath Wash	37,538	22	16	0	0	0	9	1	0	0	0	47	10.4%	0.1%	265	157	24	127	19	355	0.9%
Middle Deadman Wash	22,888	19	61	38	3	0	98	11	39	0	0	268	5.5%	1.2%	406	159	24	0	0	697	3.0%
Middle Oak Creek	39,896	0	7	16	0	0	22	0	2	0	0	47	4.3%	0.1%	4,276	0	0	4	1	4,323	10.8%
Middle Spring Valley Wash	32,672	23	254	47	34	0	94	10	0	0	64	526	11.2%	1.6%	119	7	1	0	0	646	2.0%
Middle Sycamore Creek	18,335	30	214	416	75	0	139	11	4	0	0	889	12.8%	4.8%	104	998	150	0	0	1,142	6.2%
Miller Wash Headwaters	31,220	77	62	253	20	5	156	21	0	0	0	593	7.6%	1.9%	252	23	3	5,936	890	1,739	5.6%
Mormon Canyon	19,252	18	22	0	64	0	21	0	4	0	0	130	12.2%	0.7%	134	193	29	488	73	365	1.9%
Mormon Lake	25,968	58	356	734	219	0	266	2	59	0	7	1,701	12.8%	6.6%	706	2,537	380	7,296	1,094	3,882	14.9%
Munds Canyon	41,179	102	1,020	2,182	186	19	642	58	65	0	35	4,309	13.4%	10.5%	1,481	435	65	2,267	340	6,185	15.0%
Pitman Valley-Scholz Lake	28,459	489	876	338	235	1	331	21	6	1	0	2,298	13.9%	8.1%	710	760	114	1,792	269	3,392	11.9%
Porcupine Canyon-Walnut Creek	16,622	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	667	530	80	33	5	751	4.5%

	current EIS-expected ground disturbance														Baseline	Future Foreseeable		Current/Ongoing		**PROJECT TOTAL**	
6th CODE HUC NAME	**6th code acres**	**grassland**	**high intensity**	**low intensity**	**savanna**	**aspen**	**rx burn**	**temp rd**	**decom rd**	**relocate rd**	**channel restore**	**TOTAL EIS ground distrurbacne**	**TOTAL EIS treatment % ground disturb**	**TOTAL EIS % Ground Disturb**	**TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--**	**TOTAL TREAT ACRES**	**TOTAL Future/Fore ground disturbance**	**TOTAL TREAT ACRES**	**TOTAL current ground disturbance**	**TOTAL CUM EFFECTS Ground Disturb**	**TOTAL CUM EFFECTS % Ground Disturb**
Pumphouse Wash	31,546	24	625	777	108	0	292	12	80	0	58	1,976	13.5%	6.3%	1,746	1,427	214	10,528	1,579	5,503	17.4%
Rabbit Canyon	41,339	6	9	0	0	0	6	1	0	0	0	22	7.7%	0.1%	74	0	0	251	38	134	0.3%
Rain Tank Wash	38,483	0	133	279	0	0	93	0	22	1	0	527	11.4%	1.4%	209	0	0	2,144	322	1,057	2.7%
Rattlesnake Canyon	17,023	2	48	100	15	0	61	0	0	0	0	227	7.4%	1.3%	143	1,173	176	1,584	238	783	4.6%
Rattlesnake Wash	16,259	0	34	0	15	0	14	2	0	0	0	66	9.4%	0.4%	87	0	0	313	47	200	1.2%
Red Horse Wash Headwaters	19,561	1	128	591	0	0	138	4	4	2	0	868	12.5%	4.4%	141	9	1	897	135	1,145	5.9%
Sawmill Tank	13,730	504	508	99	112	1	189	18	3	0	0	1,433	15.2%	10.4%	384	103	15	78	12	1,845	13.4%
Sawmill Wash	12,385	9	291	339	51	0	127	11	6	0	5	839	13.2%	6.8%	90	190	29	0	0	957	7.7%
Secret Canyon	11,138	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	53	3,684	553	0	0	605	5.4%
Sinclair Wash	6,766	8	14	0	0	0	3	0	5	0	0	31	19.2%	0.5%	1,699	0	0	103	15	1,745	25.8%
Smoot Lake	21,535	6	137	4	22	0	34	8	0	0	0	210	12.5%	1.0%	119	11	2	0	0	331	1.5%
Spring Creek	30,830	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	258	1,361	204	0	0	463	1.5%

	current EIS-expected ground disturbance														Baseline	Future Foreseeable		Current/Ongoing		PROJECT TOTAL	
6th CODE HUC NAME	6th code acres	grassland	high intensity	low intensity	savanna	aspen	rx burn	temp rd	decom rd	relocate rd	channel restore	TOTAL EIS ground distrurbacne	TOTAL EIS treatment % ground disturb	TOTAL EIS % Ground Disturb	TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--	TOTAL TREAT ACRES	TOTAL Future/Fore ground disturbance	TOTAL TREAT ACRES	TOTAL current ground disturbance	TOTAL CUM EFFECTS Ground Disturb	TOTAL CUM EFFECTS % Ground Disturb
Telephone Tank	14,934	38	186	313	70	2	97	4	31	0	0	741	15.2%	5.0%	497	6,074	911	1,813	272	2,421	16.2%
Tule Canyon	29,866	106	778	804	326	7	384	68	24	1	15	2,513	13.1%	8.4%	293	7	1	7,064	1,060	3,866	12.9%
Upper Cataract Creek	25,011	14	137	0	40	0	55	3	0	0	0	249	9.0%	1.0%	181	7	1	116	17	449	1.8%
Upper Cedar Wash (Local Drainage)	23,476	225	366	107	291	4	188	25	45	0	0	1,250	13.3%	5.3%	229	7	1	0	0	1,480	6.3%
Upper Deadman Wash	22,752	127	84	342	121	57	286	22	85	0	7	1,132	7.9%	5.0%	260	3,832	575	842	126	2,092	9.2%
Upper Hell Canyon	29,249	6	206	237	36	2	93	11	9	0	0	601	12.9%	2.1%	312	9,592	1,439	1,700	255	2,607	8.9%
Upper Kana-a Wash	38,801	64	0	0	0	0	210	0	11	0	0	285	2.7%	0.7%	155	318	48	991	149	637	1.6%
Upper Lee Canyon	29,537	1	12	34	0	0	77	0	2	0	0	127	3.3%	0.4%	159	1,156	173	1,765	265	724	2.5%
Upper Oak Creek	17,900	20	157	880	15	0	193	10	33	0	0	1,308	13.6%	7.3%	284	1	0	711	107	1,699	9.5%
Upper Padre Canyon	22,105	49	208	92	66	0	72	1	2	0	0	490	13.6%	2.2%	246	284	43	4,131	620	1,398	6.3%
Upper Red Lake Wash	26,930	201	512	493	182	0	313	28	15	1	9	1,753	11.2%	6.5%	420	14	2	1	0	2,175	8.1%
Upper Rio de Flag	44,551	40	334	586	69	3	204	3	64	0	6	1,309	12.8%	2.9%	3,990	12,354	1,853	4,152	623	7,775	17.5%

	current EIS-expected ground disturbance														Baseline	Future Foreseeable		Current/Ongoing		**PROJECT TOTAL**	
6th CODE HUC NAME	**6th code acres**	**grassland**	**high intensity**	**low intensity**	**savanna**	**aspen**	**rx burn**	**temp rd**	**decom rd**	**relocate rd**	**channel restore**	**TOTAL EIS ground distrurbacne**	**TOTAL EIS treatment % ground disturb**	**TOTAL EIS % Ground Disturb**	**TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--**	**TOTAL TREAT ACRES**	**TOTAL Future/Fore ground disturbance**	**TOTAL TREAT ACRES**	**TOTAL current ground disturbance**	**TOTAL CUM EFFECTS Ground Disturb**	**TOTAL CUM EFFECTS % Ground Disturb**
Upper San Francisco Wash	34,397	115	0	0	0	0	225	0	32	0	0	372	3.3%	1.1%	942	1,355	203	687	103	1,621	4.7%
Upper Spring Valley Wash	38,305	279	1,329	608	488	17	465	58	28	0	0	3,273	14.1%	8.5%	670	1,309	196	7,979	1,197	5,336	13.9%
Upper Sycamore Creek	14,916	49	515	161	221	0	137	17	7	0	5	1,111	16.3%	7.4%	362	777	117	0	0	1,589	10.7%
Upper Woods Canyon	12,671	22	403	480	120	1	233	3	13	0	0	1,275	10.9%	10.1%	151	382	57	1,575	236	1,720	13.6%
Volunteer Canyon	24,506	19	465	137	74	0	121	18	1	0	16	852	14.1%	3.5%	173	10,623	1,593	3,323	499	3,117	12.7%
Volunteer Wash	31,771	178	1,186	467	361	6	339	30	171	0	0	2,739	16.1%	8.6%	894	8,457	1,269	686	103	5,005	15.8%
Walnut Creek-Lower Lake Mary	18,920	149	390	281	149	0	162	13	39	2	108	1,291	16.0%	6.8%	224	6,172	926	2,200	330	2,766	14.6%
Walnut Creek-Upper Lake Mary	34,473	231	1,375	1,073	622	4	511	47	36	0	74	3,974	15.6%	11.5%	264	3,725	559	416	62	4,859	14.1%
West Fork Oak Creek	27,339	14	464	505	122	0	189	14	33	0	20	1,361	14.4%	5.0%	258	10,070	1,510	0	0	3,129	11.4%
Yeager Draw	24,465	0	9	5	0	0	2	0	0	0	0	16	15.9%	0.1%	102	173	26	0	0	144	0.6%
TOTAL	**2,032,080**	**6,117**	**22,403**	**21,132**	**6,760**	**184**	**11,724**	**931**	**1,545**	**17**	**558**	**71,371**	**12.2%**	**3.5%**	**45,041**	**157,772**	**23,666**	**132,837**	**19,926**	**159,963**	**7.9%**

Table 21. Total ground disturbance under Alternative D, including current and foreseeable projects by HUC12 subwatershed within the Four Forest Restoration Initiative Analysis Area.

	current EIS-expected ground disturbance														Baseline	Future Foreseeable		Current/Ongoing		**PROJECT TOTAL**	
6th CODE HUC NAME	**6th code acres**	**grassland**	**high intensity**	**low intensity**	**savanna**	**aspen**	**rx burn**	**temp rd**	**decom rd**	**relocate rd**	**channel restore**	**TOTAL EIS ground distrurbacne**	**TOTAL EIS treatment % ground disturb**	**TOTAL EIS % Ground Disturb**	**TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--**	**TOTAL TREAT ACRES**	**TOTAL Future/Fore ground disturbance**	**TOTAL TREAT ACRES**	**TOTAL current ground disturbance**	**TOTAL CUM EFFECTS Ground Disturb**	**TOTAL CUM EFFECTS % Ground Disturb**
Anderson Canyon	31,284	4	167	30	99	0	25	4	2	0	0	331	9.8%	1.1%	93	229	34	2,608	391	850	2.7%
Babbitt Lake	28,413	4	841	226	245	18	118	54	73	0	0	1,579	10.3%	5.6%	250	141	21	436	65	1,916	6.7%
Bar M Canyon	17,551	0	801	684	86	0	31	10	10	0	0	1,622	12.3%	9.2%	164	125	19	3,026	454	2,259	12.9%
Bear Canyon	21,982	0	238	663	48	12	15	23	8	0	0	1,007	12.2%	4.6%	165	488	73	85	13	1,258	5.7%
Bear Jaw Canyon	11,135	0	116	175	57	0	22	12	17	0	0	399	10.7%	3.6%	70	36	5	247	37	512	4.6%
Big Spring Canyon	31,697	3	1,105	528	262	9	32	65	37	1	0	2,042	13.4%	6.4%	395	8,757	1,314	2,746	412	4,163	13.1%
Cataract Creek Headwaters	16,699	15	139	5	35	0	23	6	11	0	0	234	8.2%	1.4%	1,787	1,500	225	1,461	219	2,465	14.8%
Cedar Creek	8,888	4	62	22	18	0	3	2	0	0	0	112	11.2%	1.3%	21	0	0	872	131	264	3.0%
Cherry Canyon-Walnut Creek	28,330	0	413	360	8	0	33	22	51	1	64	951	12.7%	3.4%	437	10,903	1,635	9,359	1,404	4,416	15.6%
Cinder Basin	39,864	0	0	0	0	0	164	0	13	0	0	177	2.2%	0.4%	124	256	38	0	0	339	0.9%
Coconino Wash Headwaters	51,193	0	301	2,239	0	0	131	24	14	3	6	2,719	10.0%	5.3%	552	36	5	4,971	746	4,021	7.9%
Curley Wallace Tank	13,431	0	11	0	0	0	0	0	0	0	0	12	15.0%	0.1%	78	0	0	5,541	831	921	6.9%

	current EIS-expected ground disturbance													Baseline	Future Foreseeable		Current/Ongoing		**PROJECT TOTAL**	
6th CODE HUC NAME	**6th code acres**	**grassland**	**high intensity**	**low intensity**	**savanna**	**aspen**	**rx burn**	**temp rd**	**decom rd**	**relocate rd**	**channel restore**	**TOTAL EIS ground distrurbacne**	**TOTAL EIS treatment % ground disturb**	**TOTAL EIS % Ground Disturb**	**TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--**	**TOTAL TREAT ACRES**	**TOTAL Future/Fore ground disturbance**	**TOTAL TREAT ACRES**	**TOTAL current ground disturbance**	**TOTAL CUM EFFECTS Ground Disturb**	**TOTAL CUM EFFECTS % Ground Disturb**
Dent and Sayer Tank	37,216	1	419	157	129	3	115	38	21	0	0	882	8.2%	2.4%	247	16	2	8,386	1,258	2,390	6.4%
Devil Dog Canyon	11,196	1	70	0	7	0	5	5	0	0	0	89	11.1%	0.8%	176	69	10	70	11	286	2.6%
Dogtown Wash	11,662	20	257	59	98	0	17	7	7	0	0	464	10.6%	4.0%	380	5,861	879	865	130	1,853	15.9%
Doney Park	42,133	0	2	92	0	0	259	0	134	0	22	509	3.7%	1.2%	3,584	1,377	207	948	142	4,442	10.5%
Double Cabin Park-Jacks Canyon	21,660	0	91	90	13	3	2	1	3	0	3	207	13.2%	1.0%	299	9,958	1,494	2,871	431	2,430	11.2%
Dry Creek	34,398	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	947	1,152	173	0	0	1,120	3.3%
Fry Canyon	19,175	2	568	66	122	0	15	5	11	0	26	816	13.7%	4.3%	163	1,222	183	1,620	243	1,405	7.3%
Garland Prairie	25,054	15	377	333	284	1	170	9	25	1	0	1,214	7.5%	4.8%	638	3,512	527	272	41	2,420	9.7%
Government Canyon	12,765	2	122	10	26	0	1	6	5	0	0	171	14.6%	1.3%	68	0	0	142	21	260	2.0%
Government Prairie	20,399	6	629	147	236	7	84	9	23	0	0	1,141	10.0%	5.6%	973	7,676	1,151	435	65	3,331	16.3%
Grapevine Canyon	19,186	1	201	21	60	0	17	3	1	0	0	304	10.8%	1.6%	83	43	6	0	0	393	2.0%
Grindstone Wash	17,796	0	92	31	5	0	14	8	0	0	0	149	9.2%	0.8%	169	0	0	1,235	185	504	2.8%

	current EIS-expected ground disturbance													Baseline	Future Foreseeable		Current/Ongoing		**PROJECT TOTAL**	
6th CODE HUC NAME	**6th code acres**	**grassland**	**high intensity**	**low intensity**	**savanna**	**aspen**	**rx burn**	**temp rd**	**decom rd**	**relocate rd**	**channel restore**	**TOTAL EIS ground distrurbacne**	**TOTAL EIS treatment % ground disturb**	**TOTAL EIS % Ground Disturb**	**TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--**	**TOTAL TREAT ACRES**	**TOTAL Future/Fore ground disturbance**	**TOTAL TREAT ACRES**	**TOTAL current ground disturbance**	**TOTAL CUM EFFECTS Ground Disturb**	**TOTAL CUM EFFECTS % Ground Disturb**
Johnson Creek	30,857	3	217	21	18	0	20	8	2	0	2	291	10.2%	0.9%	537	789	118	1,455	218	1,165	3.8%
Juan Tank Canyon	14,231	0	40	0	0	0	0	4	0	0	0	44	16.3%	0.3%	177	0	0	13	2	222	1.6%
Kinnikinick Canyon	24,895	0	648	134	227	0	8	9	9	0	0	1,035	14.1%	4.2%	134	206	31	2,667	400	1,600	6.4%
Klostermeyer Lake	28,109	0	30	30	24	0	13	3	5	0	0	105	8.3%	0.4%	127	0	0	0	0	231	0.8%
Little LO Spring Canyon	12,260	0	419	328	56	0	30	24	22	0	7	885	12.0%	7.2%	71	408	61	0	0	1,018	8.3%
Little Red Horse Wash	27,465	0	1	49	0	0	8	0	0	0	0	59	7.0%	0.2%	149	0	0	3,360	504	712	2.6%
Long Lake-Chavel Pass Ditch	14,590	0	31	29	3	0	0	0	0	0	0	63	13.2%	0.4%	108	2,597	390	0	0	560	3.8%
Lower Deadman Wash	31,266	0	0	0	0	0	15	0	5	0	0	21	2.7%	0.1%	148	200	30	0	0	199	0.6%
Lower Rio de Flag	35,308	0	143	103	26	0	84	4	56	0	0	418	6.7%	1.2%	6,189	3,274	491	2,649	397	7,495	21.2%
Lower Sycamore Creek	30,677	0	5	8	2	0	0	2	0	0	0	18	12.3%	0.1%	45	177	27	38	6	95	0.3%
Lower Woods Canyon	26,131	0	135	434	8	0	93	8	18	0	0	696	7.5%	2.7%	143	0	0	272	41	880	3.4%
MC Canyon	21,686	0	136	55	33	0	20	3	7	0	0	255	9.9%	1.2%	156	6,319	948	193	29	1,388	6.4%
Meath Wash	37,538	0	16	0	0	0	7	1	0	0	0	23	5.1%	0.1%	265	157	24	127	19	330	0.9%

	current EIS-expected ground disturbance														Baseline	Future Foreseeable		Current/Ongoing		PROJECT TOTAL	
6th CODE HUC NAME	6th code acres	grassland	high intensity	low intensity	savanna	aspen	rx burn	temp rd	decom rd	relocate rd	channel restore	TOTAL EIS ground distrurbacne	TOTAL EIS treatment % ground disturb	TOTAL EIS % Ground Disturb	TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--	TOTAL TREAT ACRES	TOTAL Future/Fore ground disturbance	TOTAL TREAT ACRES	TOTAL current ground disturbance	TOTAL CUM EFFECTS Ground Disturb	TOTAL CUM EFFECTS % Ground Disturb
Middle Deadman Wash	22,888	0	61	38	3	0	83	11	51	0	0	246	5.0%	1.1%	406	159	24	0	0	675	3.0%
Middle Oak Creek	39,896	0	7	16	0	0	18	0	2	0	0	43	4.0%	0.1%	4,276	0	0	4	1	4,319	10.8%
Middle Spring Valley Wash	32,672	13	254	47	34	0	39	10	0	0	67	464	9.9%	1.4%	119	7	1	0	0	584	1.8%
Middle Sycamore Creek	18,335	24	243	479	75	0	15	11	4	0	0	850	11.1%	4.6%	104	998	150	0	0	1,104	6.0%
Miller Wash Headwaters	31,220	0	62	253	20	5	102	21	0	0	0	463	5.9%	1.5%	252	23	3	5,936	890	1,609	5.2%
Mormon Canyon	19,252	2	22	0	64	0	8	0	5	0	0	102	9.6%	0.5%	134	193	29	488	73	338	1.8%
Mormon Lake	25,968	0	356	734	219	0	18	4	61	0	7	1,400	12.9%	5.4%	706	2,537	380	7,296	1,094	3,581	13.8%
Munds Canyon	41,179	1	1,020	2,180	186	19	43	58	73	0	35	3,614	12.7%	8.8%	1,481	435	65	2,267	340	5,491	13.3%
Pitman Valley-Scholz Lake	28,459	45	740	448	235	1	97	21	6	1	0	1,592	9.6%	5.6%	710	760	114	1,792	269	2,685	9.4%
Porcupine Canyon-Walnut Creek	16,622	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	667	530	80	33	5	751	4.5%
Pumphouse Wash	31,546	0	625	777	108	0	19	12	93	0	58	1,693	13.7%	5.4%	1,746	1,427	214	10,528	1,579	5,220	16.5%
Rabbit Canyon	41,339	6	9	0	0	0	0	3	0	0	0	18	6.6%	0.0%	74	0	0	251	38	130	0.3%

	current EIS-expected ground disturbance													Baseline	Future Foreseeable		Current/Ongoing		**PROJECT TOTAL**	
6th CODE HUC NAME	**6th code acres**	**grassland**	**high intensity**	**low intensity**	**savanna**	**aspen**	**rx burn**	**temp rd**	**decom rd**	**relocate rd**	**channel restore**	**TOTAL EIS ground distrurbacne**	**TOTAL EIS treatment % ground disturb**	**TOTAL EIS % Ground Disturb**	**TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--**	**TOTAL TREAT ACRES**	**TOTAL Future/Fore ground disturbance**	**TOTAL TREAT ACRES**	**TOTAL current ground disturbance**	**TOTAL CUM EFFECTS Ground Disturb**	**TOTAL CUM EFFECTS % Ground Disturb**
Rain Tank Wash	38,483	0	133	279	0	0	29	0	22	1	0	463	10.0%	1.2%	209	0	0	2,144	322	993	2.6%
Rattlesnake Canyon	17,023	0	48	100	15	0	13	0	0	0	0	176	9.3%	1.0%	143	1,173	176	1,584	238	733	4.3%
Rattlesnake Wash	16,259	0	34	0	15	0	8	2	0	0	0	60	8.4%	0.4%	87	0	0	313	47	193	1.2%
Red Horse Wash Headwaters	19,561	0	128	591	0	0	23	4	4	2	0	752	10.9%	3.8%	141	9	1	897	135	1,029	5.3%
Sawmill Tank	13,730	7	508	99	112	1	85	18	3	0	0	832	8.8%	6.1%	384	103	15	78	12	1,244	9.1%
Sawmill Wash	12,385	1	291	338	51	0	5	11	6	0	5	709	13.1%	5.7%	90	190	29	0	0	828	6.7%
Secret Canyon	11,138	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	53	3,684	553	0	0	605	5.4%
Sinclair Wash	6,766	0	14	0	0	0	1	0	5	0	0	21	13.0%	0.3%	1,699	0	0	103	15	1,735	25.6%
Smoot Lake	21,535	6	137	4	22	0	8	8	0	0	0	184	11.0%	0.9%	119	11	2	0	0	305	1.4%
Spring Creek	30,830	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	258	1,361	204	0	0	463	1.5%
Telephone Tank	14,934	0	186	313	70	2	11	4	32	0	0	618	12.7%	4.1%	497	6,074	911	1,813	272	2,298	15.4%
Tule Canyon	29,866	34	781	804	326	7	78	68	24	1	15	2,139	11.1%	7.2%	293	7	1	7,064	1,060	3,492	11.7%
Upper Cataract Creek	25,011	4	137	0	40	0	29	3	0	0	0	213	7.7%	0.9%	181	7	1	116	17	413	1.7%

	current EIS-expected ground disturbance														Baseline	Future Foreseeable		Current/Ongoing		PROJECT TOTAL	
6th CODE HUC NAME	6th code acres	grassland	high intensity	low intensity	savanna	aspen	rx burn	temp rd	decom rd	relocate rd	channel restore	TOTAL EIS ground distrurbacne	TOTAL EIS treatment % ground disturb	TOTAL EIS % Ground Disturb	TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--	TOTAL TREAT ACRES	TOTAL Future/Fore ground disturbance	TOTAL TREAT ACRES	TOTAL current ground disturbance	TOTAL CUM EFFECTS Ground Disturb	TOTAL CUM EFFECTS % Ground Disturb
Upper Cedar Wash (Local Drainage)	23,476	0	366	107	291	4	82	28	47	0	0	924	9.9%	3.9%	229	7	1	0	0	1,154	4.9%
Upper Deadman Wash	22,752	0	84	342	121	57	194	22	85	0	7	912	6.4%	4.0%	260	3,832	575	842	126	1,873	8.2%
Upper Hell Canyon	29,249	2	206	237	36	2	20	11	10	0	0	524	11.2%	1.8%	312	9,592	1,439	1,700	255	2,530	8.6%
Upper Kana-a Wash	38,801	0	0	0	0	0	206	0	11	0	0	217	2.1%	0.6%	155	318	48	991	149	569	1.5%
Upper Lee Canyon	29,537	0	12	34	0	0	70	0	3	0	0	120	3.1%	0.4%	159	1,156	173	1,765	265	717	2.4%
Upper Oak Creek	17,900	0	157	880	15	0	17	10	34	0	0	1,114	11.9%	6.2%	284	1	0	711	107	1,505	8.4%
Upper Padre Canyon	22,105	16	208	92	66	0	10	1	2	0	0	395	10.9%	1.8%	246	284	43	4,131	620	1,303	5.9%
Upper Red Lake Wash	26,930	52	512	493	182	0	103	28	15	1	9	1,395	8.9%	5.2%	420	14	2	1	0	1,817	6.7%
Upper Rio de Flag	44,551	0	334	586	69	3	47	6	90	0	6	1,141	11.5%	2.6%	3,990	12,354	1,853	4,152	623	7,607	17.1%
Upper San Francisco Wash	34,397	0	0	0	0	0	225	0	32	0	0	257	2.3%	0.7%	942	1,355	203	687	103	1,506	4.4%
Upper Spring Valley Wash	38,305	32	1,435	523	488	17	92	58	29	0	0	2,675	11.6%	7.0%	670	1,309	196	7,979	1,197	4,738	12.4%
Upper Sycamore Creek	14,916	0	571	116	221	0	12	17	7	0	5	949	13.9%	6.4%	362	777	117	0	0	1,427	9.6%

	current EIS-expected ground disturbance														Baseline	Future Foreseeable		Current/Ongoing		**PROJECT TOTAL**	
6th CODE HUC NAME	**6th code acres**	**grassland**	**high intensity**	**low intensity**	**savanna**	**aspen**	**rx burn**	**temp rd**	**decom rd**	**relocate rd**	**channel restore**	**TOTAL EIS ground distrurbacne**	**TOTAL EIS treatment % ground disturb**	**TOTAL EIS % Ground Disturb**	**TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--**	**TOTAL TREAT ACRES**	**TOTAL Future/Fore ground disturbance**	**TOTAL TREAT ACRES**	**TOTAL current ground disturbance**	**TOTAL CUM EFFECTS Ground Disturb**	**TOTAL CUM EFFECTS % Ground Disturb**
Upper Woods Canyon	12,671	0	403	480	120	1	15	3	13	0	0	1,035	12.5%	8.2%	151	382	57	1,575	236	1,480	11.7%
Volunteer Canyon	24,506	0	496	113	74	0	18	18	1	0	16	735	13.1%	3.0%	173	10,623	1,593	3,323	499	3,000	12.2%
Volunteer Wash	31,771	1	1,347	338	361	6	54	30	171	0	0	2,308	13.6%	7.3%	894	8,457	1,269	686	103	4,574	14.4%
Walnut Creek-Lower Lake Mary	18,920	0	390	281	149	0	25	13	41	2	108	1,008	14.0%	5.3%	224	6,172	926	2,200	330	2,482	13.1%
Walnut Creek-Upper Lake Mary	34,473	5	1,386	1,087	667	4	47	47	37	0	74	3,354	13.3%	9.7%	264	3,725	559	416	62	4,240	12.3%
West Fork Oak Creek	27,339	0	464	505	122	0	6	15	33	0	20	1,165	13.9%	4.3%	258	10,070	1,510	0	0	2,933	10.7%
Yeager Draw	24,465	0	9	5	0	0	0	0	0	0	0	14	13.9%	0.1%	102	173	26	0	0	142	0.6%
TOTAL	**2,032,080**	**336**	**23,017**	**20,844**	**6,811**	**184**	**3,569**	**954**	**1,645**	**17**	**561**	**57,937**	**10.3%**	**2.9%**	**45,041**	**157,772**	**23,666**	**132,837**	**19,926**	**146,529**	**7.2%**

Table 22. Total ground disturbance under Alternative E, including current and foreseeable projects by HUC12 subwatershed within the Four Forest Restoration Initiative Analysis Area.

	current EIS-expected ground disturbance														Baseline	Future Foreseeable		Current/Ongoing		PROJECT TOTAL	
6th CODE HUC NAME	6th code acres	grassland	high intensity	low intensity	savanna	aspen	rx burn	temp rd	decom rd	relocate rd	channel restore	TOTAL EIS ground distrurbacne	TOTAL EIS treatment % ground disturb	TOTAL EIS % Ground Disturb	TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--	TOTAL TREAT ACRES	TOTAL Future/Fore ground disturbance	TOTAL TREAT ACRES	TOTAL current ground disturbance	TOTAL CUM EFFECTS Ground Disturb	TOTAL CUM EFFECTS % Ground Disturb
Anderson Canyon	31,284	34	167	30	0	0	68	4	2	0	0	305	9.0%	1.0%	93	229	34	2,608	391	824	2.6%
Babbitt Lake	28,413	77	950	270	0	18	308	54	73	0	0	1,750	11.4%	6.2%	250	141	21	436	65	2,087	7.3%
Bar M Canyon	17,551	23	859	686	0	0	310	10	10	0	0	1,898	12.2%	10.8%	164	125	19	3,026	454	2,535	14.4%
Bear Canyon	21,982	3	249	663	0	12	165	23	8	0	0	1,122	13.6%	5.1%	165	488	73	85	13	1,373	6.2%
Bear Jaw Canyon	11,135	0	173	175	0	0	74	12	17	0	0	452	12.2%	4.1%	70	36	5	247	37	564	5.1%
Big Spring Canyon	31,697	22	1,156	452	0	9	286	65	37	1	0	2,028	14.2%	6.4%	395	8,757	1,314	2,746	412	4,148	13.1%
Cataract Creek Headwaters	16,699	9	159	5	0	0	57	6	11	0	0	247	8.6%	1.5%	1,787	1,500	225	1,461	219	2,478	14.8%
Cedar Creek	8,888	1	86	22	0	0	20	2	0	0	0	131	13.1%	1.5%	21	0	0	872	131	283	3.2%
Cherry Canyon-Walnut Creek	28,330	11	417	360	0	0	153	22	51	1	64	1,078	14.1%	3.8%	437	10,903	1,635	9,359	1,404	4,543	16.0%
Cinder Basin	39,864	13	0	0	0	0	164	0	13	0	0	189	2.3%	0.5%	124	256	38	0	0	352	0.9%
Coconino Wash Headwaters	51,193	2	301	2,239	0	0	545	24	14	3	6	3,135	11.5%	6.1%	552	36	5	4,971	746	4,437	8.7%

	current EIS-expected ground disturbance														Baseline	Future Foreseeable		Current/Ongoing		**PROJECT TOTAL**	
6th CODE HUC NAME	6th code acres	grassland	high intensity	low intensity	savanna	aspen	rx burn	temp rd	decom rd	relocate rd	channel restore	TOTAL EIS ground distrurbacne	TOTAL EIS treatment % ground disturb	TOTAL EIS % Ground Disturb	TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--	TOTAL TREAT ACRES	TOTAL Future/Fore ground disturbance	TOTAL TREAT ACRES	TOTAL current ground disturbance	TOTAL CUM EFFECTS Ground Disturb	TOTAL CUM EFFECTS % Ground Disturb
Curley Wallace Tank	13,431	0	11	0	0	0	2	0	0	0	0	13	16.9%	0.1%	78	0	0	5,541	831	922	6.9%
Dent and Sayer Tank	37,216	16	434	213	0	3	217	38	21	0	0	942	8.7%	2.5%	247	16	2	8,386	1,258	2,450	6.6%
Devil Dog Canyon	11,196	1	71	0	0	0	16	5	0	0	0	94	11.7%	0.8%	176	69	10	70	11	291	2.6%
Dogtown Wash	11,662	3	317	59	0	0	87	7	7	0	0	480	11.0%	4.1%	380	5,861	879	865	130	1,869	16.0%
Doney Park	42,133	37	2	92	0	0	277	0	134	0	22	564	4.1%	1.3%	3,584	1,377	207	948	142	4,497	10.7%
Double Cabin Park-Jacks Canyon	21,660	1	97	90	0	3	34	1	3	0	3	233	13.5%	1.1%	299	9,958	1,494	2,871	431	2,456	11.3%
Dry Creek	34,398	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	947	1,152	173	0	0	1,120	3.3%
Fry Canyon	19,175	19	526	167	0	0	121	5	11	0	26	877	14.4%	4.6%	163	1,222	183	1,620	243	1,466	7.6%
Garland Prairie	25,054	244	649	333	0	1	323	9	25	1	0	1,585	9.8%	6.3%	638	3,512	527	272	41	2,791	11.1%
Government Canyon	12,765	0	127	10	0	0	23	6	5	0	0	171	14.6%	1.3%	68	0	0	142	21	260	2.0%
Government Prairie	20,399	115	792	184	0	7	229	9	23	0	0	1,360	11.9%	6.7%	973	7,676	1,151	435	65	3,549	17.4%
Grapevine Canyon	19,186	2	234	21	0	0	56	3	1	0	0	317	11.3%	1.7%	83	43	6	0	0	407	2.1%
Grindstone Wash	17,796	0	92	31	0	0	32	8	0	0	0	163	10.1%	0.9%	169	0	0	1,235	185	517	2.9%

	current EIS-expected ground disturbance														Baseline	Future Foreseeable		Current/Ongoing		**PROJECT TOTAL**	
6th CODE HUC NAME	**6th code acres**	**grassland**	**high intensity**	**low intensity**	**savanna**	**aspen**	**rx burn**	**temp rd**	**decom rd**	**relocate rd**	**channel restore**	**TOTAL EIS ground distrurbacne**	**TOTAL EIS treatment % ground disturb**	**TOTAL EIS % Ground Disturb**	**TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--**	**TOTAL TREAT ACRES**	**TOTAL Future/Fore ground disturbance**	**TOTAL TREAT ACRES**	**TOTAL current ground disturbance**	**TOTAL CUM EFFECTS Ground Disturb**	**TOTAL CUM EFFECTS % Ground Disturb**
Johnson Creek	30,857	1	221	21	0	0	57	8	2	0	2	312	11.0%	1.0%	537	789	118	1,455	218	1,186	3.8%
Juan Tank Canyon	14,231	0	40	0	0	0	5	4	0	0	0	49	18.4%	0.3%	177	0	0	13	2	228	1.6%
Kinnikinick Canyon	24,895	11	771	134	0	0	160	9	9	0	0	1,095	13.7%	4.4%	134	206	31	2,667	400	1,660	6.7%
Klostermeyer Lake	28,109	0	30	30	0	0	25	3	5	0	0	93	7.4%	0.3%	127	0	0	0	0	220	0.8%
Little LO Spring Canyon	12,260	3	441	354	0	0	148	24	22	0	7	999	13.5%	8.1%	71	408	61	0	0	1,131	9.2%
Little Red Horse Wash	27,465	0	1	49	0	0	17	0	0	0	0	67	8.0%	0.2%	149	0	0	3,360	504	720	2.6%
Long Lake-Chavel Pass Ditch	14,590	0	31	29	0	0	19	0	0	0	0	78	8.5%	0.5%	108	2,597	390	0	0	576	3.9%
Lower Deadman Wash	31,266	0	0	0	0	0	20	0	5	0	0	25	2.5%	0.1%	148	200	30	0	0	204	0.7%
Lower Rio de Flag	35,308	10	170	103	0	0	124	4	56	0	0	467	7.5%	1.3%	6,189	3,274	491	2,649	397	7,545	21.4%
Lower Sycamore Creek	30,677	0	8	8	0	0	3	2	0	0	0	20	13.9%	0.1%	45	177	27	38	6	98	0.3%
Lower Woods Canyon	26,131	3	143	434	0	0	192	8	18	0	0	798	8.3%	3.1%	143	0	0	272	41	981	3.8%
MC Canyon	21,686	1	143	55	0	0	52	3	7	0	0	262	10.1%	1.2%	156	6,319	948	193	29	1,395	6.4%
Meath Wash	37,538	6	16	0	0	0	9	1	0	0	0	31	6.8%	0.1%	265	157	24	127	19	338	0.9%

	current EIS-expected ground disturbance													Baseline	Future Foreseeable		Current/Ongoing		**PROJECT TOTAL**	
6th CODE HUC NAME	**6th code acres**	**grassland**	**high intensity**	**low intensity**	**savanna**	**aspen**	**rx burn**	**temp rd**	**decom rd**	**relocate rd**	**channel restore**	**TOTAL EIS ground distrurbacne**	**TOTAL EIS treatment % ground disturb**	**TOTAL EIS % Ground Disturb**	**TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--**	**TOTAL TREAT ACRES**	**TOTAL Future/Fore ground disturbance**	**TOTAL TREAT ACRES**	**TOTAL current ground disturbance**	**TOTAL CUM EFFECTS Ground Disturb**	**TOTAL CUM EFFECTS % Ground Disturb**
Middle Deadman Wash	22,888	5	61	38	0	0	98	11	51	0	0	263	5.4%	1.1%	406	159	24	0	0	692	3.0%
Middle Oak Creek	39,896	0	7	16	0	0	22	0	2	0	0	47	4.3%	0.1%	4,276	0	0	4	1	4,323	10.8%
Middle Spring Valley Wash	32,672	3	302	47	0	0	94	10	0	0	67	521	11.1%	1.6%	119	7	1	0	0	642	2.0%
Middle Sycamore Creek	18,335	2	224	416	0	0	137	11	4	0	0	793	11.6%	4.3%	104	998	150	0	0	1,046	5.7%
Miller Wash Headwaters	31,220	19	75	253	0	5	156	21	0	0	0	529	6.8%	1.7%	252	23	3	5,936	890	1,675	5.4%
Mormon Canyon	19,252	4	55	0	0	0	21	0	5	0	0	85	8.0%	0.4%	134	193	29	488	73	321	1.7%
Mormon Lake	25,968	14	518	734	0	0	259	4	61	0	7	1,598	12.4%	6.2%	706	2,537	380	7,296	1,094	3,778	14.5%
Munds Canyon	41,179	25	1,198	2,182	0	19	628	58	73	0	35	4,219	13.4%	10.2%	1,481	435	65	2,267	340	6,095	14.8%
Pitman Valley-Scholz Lake	28,459	111	1,065	338	0	1	331	21	6	1	0	1,874	11.3%	6.6%	710	760	114	1,792	269	2,967	10.4%
Porcupine Canyon-Walnut Creek	16,622	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	667	530	80	33	5	751	4.5%
Pumphouse Wash	31,546	6	716	777	0	0	284	12	93	0	58	1,947	13.7%	6.2%	1,746	1,427	214	10,528	1,579	5,474	17.4%
Rabbit Canyon	41,339	0	9	0	0	0	6	3	0	0	0	18	6.4%	0.0%	74	0	0	251	38	130	0.3%
Rain Tank Wash	38,483	0	133	279	0	0	93	0	22	1	0	527	11.4%	1.4%	209	0	0	2,144	322	1,057	2.7%

	current EIS-expected ground disturbance														Baseline	Future Foreseeable		Current/Ongoing		**PROJECT TOTAL**	
6th CODE HUC NAME	6th code acres	grassland	high intensity	low intensity	savanna	aspen	rx burn	temp rd	decom rd	relocate rd	channel restore	TOTAL EIS ground distrurbacne	TOTAL EIS treatment % ground disturb	TOTAL EIS % Ground Disturb	TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--	TOTAL TREAT ACRES	TOTAL Future/Fore ground disturbance	TOTAL TREAT ACRES	TOTAL current ground disturbance	TOTAL CUM EFFECTS Ground Disturb	TOTAL CUM EFFECTS % Ground Disturb
Rattlesnake Canyon	17,023	0	63	100	0	0	60	0	0	0	0	223	7.5%	1.3%	143	1,173	176	1,584	238	780	4.6%
Rattlesnake Wash	16,259	0	46	0	0	0	14	2	0	0	0	62	8.8%	0.4%	87	0	0	313	47	196	1.2%
Red Horse Wash Headwaters	19,561	0	128	591	0	0	138	4	4	2	0	867	12.5%	4.4%	141	9	1	897	135	1,144	5.9%
Sawmill Tank	13,730	124	612	99	0	1	189	18	3	0	0	1,046	11.1%	7.6%	384	103	15	78	12	1,458	10.6%
Sawmill Wash	12,385	2	314	339	0	0	123	11	6	0	5	800	13.0%	6.5%	90	190	29	0	0	918	7.4%
Secret Canyon	11,138	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	53	3,684	553	0	0	605	5.4%
Sinclair Wash	6,766	2	14	0	0	0	3	0	5	0	0	25	15.4%	0.4%	1,699	0	0	103	15	1,739	25.7%
Smoot Lake	21,535	0	163	4	0	0	34	8	0	0	0	208	12.4%	1.0%	119	11	2	0	0	329	1.5%
Spring Creek	30,830	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	258	1,361	204	0	0	463	1.5%
Telephone Tank	14,934	10	250	313	0	2	97	4	32	0	0	708	14.5%	4.7%	497	6,074	911	1,813	272	2,388	16.0%
Tule Canyon	29,866	18	933	804	0	7	384	68	24	1	15	2,253	11.7%	7.5%	293	7	1	7,064	1,060	3,607	12.1%
Upper Cataract Creek	25,011	2	157	0	0	0	55	3	0	0	0	218	7.8%	0.9%	181	7	1	116	17	417	1.7%
Upper Cedar Wash (Local Drainage)	23,476	56	570	107	0	4	188	28	47	0	0	1,000	10.7%	4.3%	229	7	1	0	0	1,230	5.2%

	current EIS-expected ground disturbance														Baseline	Future Foreseeable		Current/Ongoing		**PROJECT TOTAL**	
6th CODE HUC NAME	**6th code acres**	**grassland**	**high intensity**	**low intensity**	**savanna**	**aspen**	**rx burn**	**temp rd**	**decom rd**	**relocate rd**	**channel restore**	**TOTAL EIS ground distrurbacne**	**TOTAL EIS treatment % ground disturb**	**TOTAL EIS % Ground Disturb**	**TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--**	**TOTAL TREAT ACRES**	**TOTAL Future/Fore ground disturbance**	**TOTAL TREAT ACRES**	**TOTAL current ground disturbance**	**TOTAL CUM EFFECTS Ground Disturb**	**TOTAL CUM EFFECTS % Ground Disturb**
Upper Deadman Wash	22,752	32	95	342	0	57	286	22	85	0	7	926	6.5%	4.1%	260	3,832	575	842	126	1,886	8.3%
Upper Hell Canyon	29,249	1	212	237	0	2	93	11	10	0	0	566	12.1%	1.9%	312	9,592	1,439	1,700	255	2,572	8.8%
Upper Kana-a Wash	38,801	16	0	0	0	0	210	0	11	0	0	238	2.3%	0.6%	155	318	48	991	149	589	1.5%
Upper Lee Canyon	29,537	0	12	34	0	0	77	0	3	0	0	127	3.3%	0.4%	159	1,156	173	1,765	265	724	2.5%
Upper Oak Creek	17,900	5	169	880	0	0	193	10	34	0	0	1,291	13.4%	7.2%	284	1	0	711	107	1,682	9.4%
Upper Padre Canyon	22,105	8	232	92	0	0	72	1	2	0	0	407	11.3%	1.8%	246	284	43	4,131	620	1,315	6.0%
Upper Red Lake Wash	26,930	37	627	493	0	0	313	28	15	1	9	1,523	9.7%	5.7%	420	14	2	1	0	1,945	7.2%
Upper Rio de Flag	44,551	10	403	586	0	3	204	6	90	0	6	1,308	12.8%	2.9%	3,990	12,354	1,853	4,152	623	7,774	17.4%
Upper San Francisco Wash	34,397	29	0	0	0	0	225	0	32	0	0	286	2.5%	0.8%	942	1,355	203	687	103	1,535	4.5%
Upper Spring Valley Wash	38,305	62	1,625	608	0	17	464	58	29	0	0	2,864	12.3%	7.5%	670	1,309	196	7,979	1,197	4,927	12.9%
Upper Sycamore Creek	14,916	12	704	161	0	0	137	17	7	0	5	1,043	15.3%	7.0%	362	777	117	0	0	1,521	10.2%
Upper Woods Canyon	12,671	6	509	480	0	1	220	3	13	0	0	1,231	11.2%	9.7%	151	382	57	1,575	236	1,676	13.2%
Volunteer Canyon	24,506	5	539	137	0	0	120	18	1	0	16	835	14.0%	3.4%	173	10,623	1,593	3,323	499	3,101	12.7%

	current EIS-expected ground disturbance														Baseline	Future Foreseeable		Current/Ongoing		PROJECT TOTAL	
6th CODE HUC NAME	6th code acres	grassland	high intensity	low intensity	savanna	aspen	rx burn	temp rd	decom rd	relocate rd	channel restore	TOTAL EIS ground distrurbacne	TOTAL EIS treatment % ground disturb	TOTAL EIS % Ground Disturb	TOTAL BASELINE (roads, private land, grazing) Ground Disturbance--	TOTAL TREAT ACRES	TOTAL Future/Fore ground disturbance	TOTAL TREAT ACRES	TOTAL current ground disturbance	TOTAL CUM EFFECTS Ground Disturb	TOTAL CUM EFFECTS % Ground Disturb
Volunteer Wash	31,771	44	1,493	467	0	6	339	30	171	0	0	2,551	15.0%	8.0%	894	8,457	1,269	686	103	4,817	15.2%
Walnut Creek-Lower Lake Mary	18,920	37	480	281	0	0	158	13	41	2	108	1,120	14.1%	5.9%	224	6,172	926	2,200	330	2,594	13.7%
Walnut Creek-Upper Lake Mary	34,473	56	1,517	1,073	0	4	503	47	37	0	74	3,311	13.2%	9.6%	264	3,725	559	416	62	4,197	12.2%
West Fork Oak Creek	27,339	3	579	505	0	0	189	15	33	0	20	1,344	14.2%	4.9%	258	10,070	1,510	0	0	3,112	11.4%
Yeager Draw	24,465	0	9	5	0	0	2	0	0	0	0	16	15.9%	0.1%	102	173	26	0	0	143	0.6%
TOTAL	**2,032,080**	**1,436**	**26,702**	**21,132**	**0**	**184**	**11,620**	**954**	**1,645**	**17**	**561**	**64,252**	**11.1%**	**3.2%**	**45,041**	**157,772**	**23,666**	**132,837**	**19,926**	**152,844**	**7.5%**

APPENDIX G: PROTECTED STREAMCOURSES IN THE FOUR FOREST RESTORATION INITIATIVE PROJECT AREA

Table 23. Protected streamcourses within the Four Forest Restoration Initiative Analysis Area.

Riparian Reach	Functional Class	Length (miles)
1502001514D002	PFC	1.8
1502001514D001	AT RISK	2.1
1502001513A002	AT RISK	2.0
1502001513A002	AT RISK	2.2
1506020286D003	AT RISK	1.7
1506020286D002	AT RISK	0.7
1506020286C003	PFC	0.7
1502001513A003	AT RISK	1.3
1506020286C004	AT RISK	0.3
1506020286C005	AT RISK	1.4
1506020286D002	AT RISK	3.0
1502001513A004	AT RISK	2.1
1506020287H009	PFC	1.3
1506020287H010	PFC	0.5
1506020287H008	AT RISK	0.5
1506020287H008	AT RISK	0.9
1502001513C001	AT RISK	0.4
1502001513C001	AT RISK	0.4
1502001513C002	AT RISK	0.2
1502001513B001	NON-RIPARIAN	1.5
1502001513B002	AT RISK	0.2
1506020287H005	PFC	1.8
1506020287G001	PFC	1.8
1502001513B003	PFC	2.4
1502001513B002	AT RISK	0.1
1502001513B002	AT RISK	0.3
1506020287H006	PFC	1.3
1506020287H005	PFC	0.3
1506020287G002	PFC	1.2
1506020287F004	AT RISK	0.2

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Riparian Reach	Functional Class	Length (miles)
1506020287H007	PFC	3.8
1502001513C005	PFC	0.8
1502001513C003	NON-FUNCTIONAL	1.5
1506020287H002	PFC	1.9
1506020287H004	PFC	0.9
1506020287H002	PFC	0.3
1506020287H005	PFC	1.6
1506020287F005	AT RISK	0.2
1506020287F005	AT RISK	0.1
1506020287H003	PFC	0.5
1506020287F005	AT RISK	0.8
1506020287F002	PFC	1.8
1502001513C004	PFC	1.0
1506020287F003	PFC	0.2
1506020287H001	PFC	1.7
1502001513C006	AT RISK	4.8
1502001513C006	AT RISK	0.3
1506020287F002	PFC	0.3
1502001513C006	AT RISK	0.4
1506020287J003	PFC	0.3
1506020288E007	PFC	1.4
1506020288E006	PFC	1.7
1506020288E005	PFC	0.9
1506020288F002	PFC	2.5
1506020288E004	AT RISK	0.3
1506020288F002	PFC	5.8
1506020288F001	PFC	1.3
1506020288E003	PFC	1.0
1502001515B002	AT RISK	1.2
1502001515B001	AT RISK	0.6
1506020288G003	PFC	2.9
		77.5

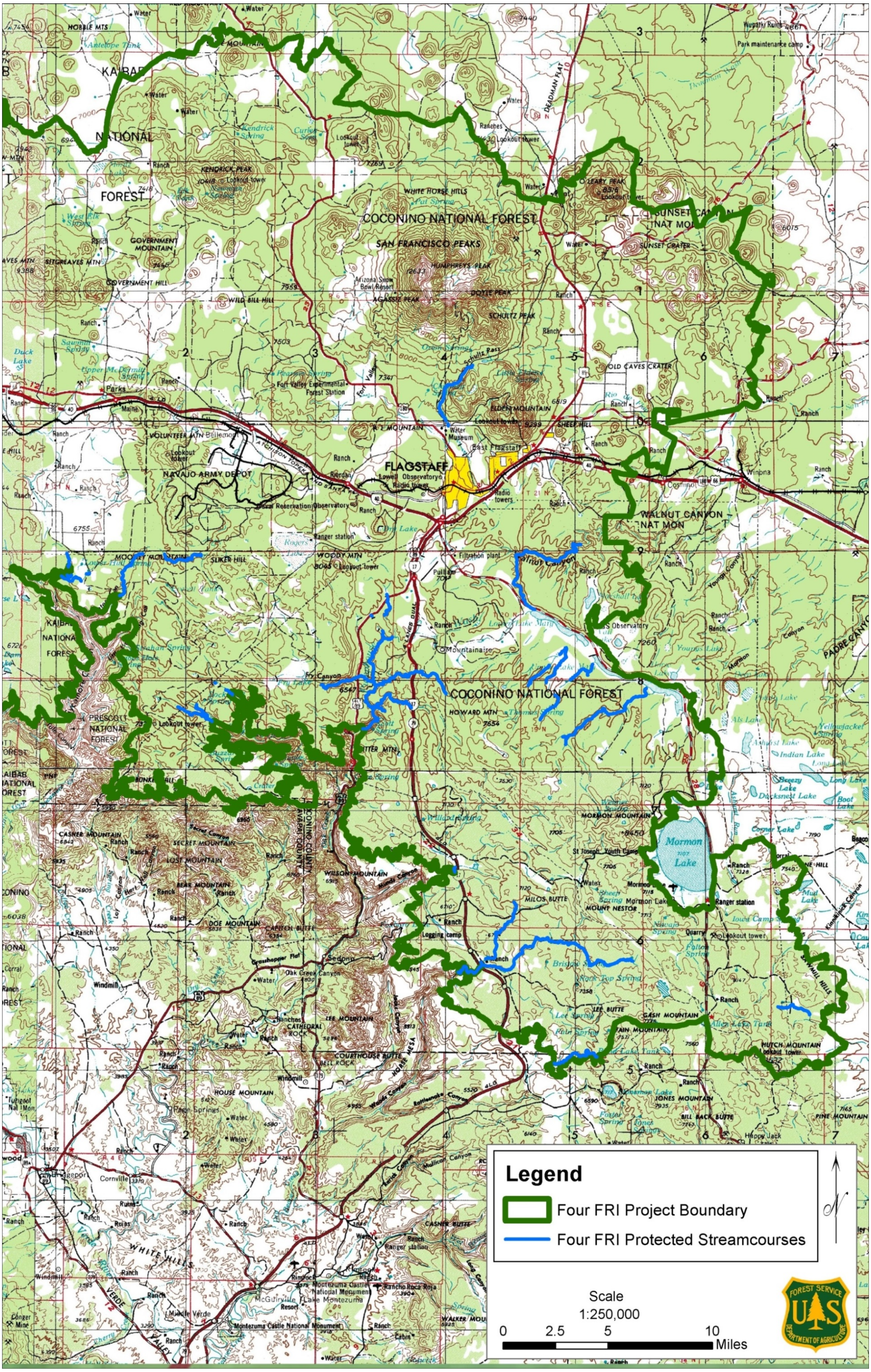

Figure 7. Locations of protected streamcourses in the Four Forest Restoration Initiative Project Area

Appendix H

Response to Public Comments (Soil, Water and Watershed Function)

Comment # and Location	Comment or Reference for Attachments	Comment Topic	General Response
Stakeholder Group/Waltz, Cara #98, May 28, 2013			
SH-1. Page 3, #4 (key issue #1)	The stakeholder group suggest openings promote snowpack accumulation and water retention and few openings are planned	Snowpack accumulation and water retention	Thank you for your comment. Treatments designed for snowpack accumulation and water retention are outside the scope of the project and do not meet the purpose and need (DEIS chapter 1, page 8) which is to reestablish and restore forest structure and pattern, forest health and vegetation composition and diversity. The need is to increase forest resiliency and sustainability and protect soil productivity and improve soil and watershed function. However, action alternative C includes a paired watershed study that would study the effects of forest treatments on water balance including snowpack water retention and water yield. Any increases in water yield are a secondary benefit of proposed forest restoration
SH-2. Page 6, 4b, 4d (recommendations)	The stakeholder group would like the proposed action and to provide a broader range of opening sizes and shapes capable of retaining a greater volume of snow water including guidelines.	Snowpack accumulation and water retention	Same response as comment SH-1.
SH-3. Page 13, subconcern 4, #1	Add guidance that will protect old trees during prescribed fire.	Soil Moisture and Old Tree Protection during Prescribed Burning and Soil Moisture Factor	Design features, and Soil and Water BMP's and mitigation measures (Appendix C, page 587 of DEIS) have been developed and will be implemented to maintain and protect soil productivity, minimize sediment delivery and protect water quality Specifically, design criteria #SW6 states, in areas to be prescribed burned fires prescriptions should be designed to minimize soil temperatures over the entire area. Fire prescriptions should be designed so that soil and fuel moisture temperatures are such that fire severity is minimized and soil health and productivity are maintained. Consequently old trees would be protected from prescribed fire.

Comment # and Location	Comment or Reference for Attachments	Comment Topic	General Response
SH-4. Page 16, Key Issue #5, pt 4.	Recommends adding FWPP to cumulative effects analysis.	Cumulative Effects	The FWPP has been added to the cumulative effects analysis and effects will be disclosed in the final EIS.
Gatewood, Wildwood Consulting LLC, Cara # 151. May 28, 2013			
SG-1. Page 2, Comment from page 23 of DEIS.	Rio de Flag should be mapped as a resource at risk.	Resource mapping	Thank you for your comment. The risks to the Rio de Flag have been analyzed and will be mitigated as part of the Flagstaff Watershed Protection Project (FWPP) project, which is also analyzed under cumulative effects on pg. 697 of the 4FRI DEIS. The Rio de Flag watershed will be added to the map as recommended.
SG-2. Page 2. Comment from page 24 of DEIS.	Is there a need to reduce fuel loadings in values at risk areas like streamside management zone?	Fuel loading effects to streamside management zones	Fuel reduction treatments are planned within streamside management zones. Best Management Practices and Design Criteria have been designed to mitigate potential adverse effects to soils, water quality, riparian and non-riparian vegetation and the aquatic environment of perennial streams. These include: SW8 (pg. 582), SW32(pg. 588)
SG-3. Page 3. Comment from page 26 of DEIS	A more detailed discussion of watershed features trying to be protected restored might be helpful. Watershed would exhibit high geomorphic, hydrologic, and biotic integrity is pretty vague.	Characterization of watershed function	Page 56 of the Soil Specialist report defines watershed condition and the process used to classify watershed condition and function. Page 26, 27 of DEIS (Watershed at the 6th Hydrologic Unit Code (HUC) Scale specifies which watershed features (or indicators) could improve watershed function and include reduction of tree density that would move the fire regime condition class towards historical range, decommissioning of unneeded roads to their natural condition, improvement of soil and riparian functional condition. Page 48 of the Soil Specialist report also details which watershed indictors need to improve to improve watershed function (Watershed dysfunction in the treatment area is a result in large part

Comment # and Location	Comment or Reference for Attachments	Comment Topic	General Response
			from dense forests with fire regime condition classes of 2 or 3, high density of road networks that can alter hydrology, riparian condition less than functional and other factors).
SG-4. Page 3. Comment from page 27, DEIS.	It is unclear here whether there are “32 miles of ephemeral streams……” on the project area or on the entire Coconino National Forest (CNF). It should be clear for each statement whether forest-wide or for the project portion of the forest, even if that approach is identified earlier in the document .	Characterization of ephemeral streams	The 32 miles of degraded ephemeral channel are within the project area on the Coconino National Forest. There are 7 miles of degraded non-riparian streamcourses on the Kaibab National Forest.
SG-4. Page 4. Comment from page 352 DEIS	There should be a definition of “Steep slopes” in the Glossary as it is used in this DEIS	Characterization of steep slopes	Steep slopes is used in chapter 1 (page 11) and chapter 3 (pages 109, 183), in reference to MSO habitat and soil. Steep slopes generally refer to those slopes greater than about 40%.
SG-5. Page 7. Comment from page 611 DEIS	Steep slopes are not defined – 40%, 50%, more? Add to Glossary?	Characterization of steep slopes	Same response as SG-4.
(NAU 4FRI DEIS Comments 5-29-13) (Springer/M. Lopez). Cara # 162			
NAU-1.	Concern 1: Conduct a word search in the document for the words “construct [or construction of] up to 15 weirs and 20 weather stations …” and change the wording to read something like this: “Install and maintain scientific instruments, weirs, flumes, sediment traps and survey courses in up	Request for improved discussion of the research instrumentation associated with the paired	Thank you for your comment.

Comment # and Location	Comment or Reference for Attachments	Comment Topic	General Response
	to 12 watersheds (up to 3 total acres of disturbance) to support watershed research and provide forest management tools to managers to protect watershed health.	watershed research	
NAU Concern 2, Recommendation, pg. 3	Concern 2: 1. Insert discussion of how the watershed study affects treatments, including the following: a. no treatment of the three control watersheds, b. continued road access (by researchers) for the duration of the study, c. follow-up burn treatments on experimental watersheds, and d. deferring treatment during the 7-year calibration period. 2. Change the prescriptions for the control watersheds from burn only and minimal mechanical treatment to "no treatment	Request for road access to research sites and changes to treatment regimes and timelines to facilitate watershed research	Control watershed will remain untreated as recommended. Roads that remain open for administrative use will be available for access to research sites for the duration of the study. Page vi, 2nd bullet of the EIS Summary states "On those acres proposed for prescribed fire, two fires would be conducted over the 10-year period." The paired watershed study is not expected to affect follow-up prescribed fire treatments. Prescribed burning treatments would require implementation protection measures (i.e., removal) for research instrumentation. Treatments in experimental watersheds will be deferred during the 7-year calibration period. Control watershed will not be treated.
NAU Concern 3, Recommendation, pg. 4	Concern 3: 1. Amend treatment prescriptions for watershed MS-3, LM-3L and LM-4 to evidence-based restoration from the current proposed treatment. Work with ERI to define the methods of evidence-based treatment for these watersheds.	Request to change treatment prescriptions in research watersheds to evidence-based restoration	Evidence-based restoration treatments are beyond the scope of this project.

Comment # and Location	Comment or Reference for Attachments	Comment Topic	General Response
	2. On page 47 – Alternative development process – please add that, besides eliminating mechanical thinning and burning in control watersheds, the watershed research will change the treatment prescription on approximately 2,700 acres to evidence-based restoration.		
NAU Concern 4, Recommendation, pg. 4	Concern 4: Please clarify what is meant by "A weather station located outside of the immediate foreground (300 feet)".	Request for clarification of the meaning of foreground	Sites, travelways, special places, and other areas are assigned a Concern Level value of 1, 2, or 3 to reflect the relative High, Medium, or Low importance of aesthetics. Seen Areas and Distance Zones are mapped from these 1, 2, or 3 areas to determine the relative sensitivity of scenes based on their distance from an observer; these zones are identified as Foreground (up to 1/2 mile from the viewer), Middleground (up to 4 miles from the foreground), and Background (4 miles from the viewer to the horizon). Reference: Landscape Aesthetics A Handbook for Scenery Management. Agriculture Handbook 701.
NAU Concern 5, Recommendation, pg. 5	Concern 5: The 4FRI Team should work collaboratively with NAU, ERI, and SRP to select and reanalyze a control watershed for the Lake Mary set of watersheds. NAU's preferences from highest to lowest are LM-1C, LM-1A, LM-1D and LM-1B.	Request for collaboration in identifying control watersheds for the Lake Mary paired watersheds	A new control watershed for the Lake Mary set of watersheds will be selected collaboratively with NAU, ERI, and SRP and analyzed in the FEIS.
NAU, page 5, Other comments	One minor edit could be made on page 262. The phrase "and wildlife and watershed research and restoration" should probably read, "and	Editorial recommendation	This editorial recommendation will be incorporated into the FEIS.

Comment # and Location	Comment or Reference for Attachments	Comment Topic	General Response
regarding the proposed paired watershed study	wildlife and watershed research on restoration" (emphasis added).		
NAU, Part 2, Other Watershed Related Topics, pg. 6	What is the difference between a significant and a non-significant forest plan amendment? Please, clarify.	Request for clarification on types of forest plan amendments	Regarding the definitions, see page X of Appendix C. it is defined for all alternatives 2. plan amendments are part of the record of decision 3. its unclear what additional information is needed -4. See previous response to stakeholders 5. plan amendments are based on the need to be consistent with the direct in the forest plan - see project's purpose and need and desired conditions, see previous response on evidence-based
NAU, Part 2, Other Watershed Related Topics, pg. 6	What is the timing of plan amendments relative to the EIS?	Request for clarification on the timing of plan amendments as they relate to the 4FRI project	Comment is not related to soils, watershed, water quality, or riparian areas.
NAU, Part 2, Other Watershed Related Topics, pg. 6	Besides table 2, where can we find more details about the proposed plan amendments (especially regarding interspace)?	Request for more detailed information on forest plan amendments	Comment is not related to soils, watershed, water quality, or riparian areas.
NAU, Part 2, Other Watershed Related Topics,	In appendix B it is stated "the interspaces between groups may range from 20 to 200 feet, but generally between 25 and 100 feet apart from drip line to adjacent drip line". Could you,	Request for more detailed explanation of how interspaces	Comment is not related to soils, watershed, water quality, or riparian areas.

Comment # and Location	Comment or Reference for Attachments	Comment Topic	General Response
pg. 6	please, provide a distribution of the different interspace distances (eg. 20% 25-40’, 40% 40-80’, etc.)? This would be very helpful in evaluating how planned interspaces may affect snowpack accumulation and retention that will have a large effect on water balance.	would be distributed	
NAU, Part 2, Other Watershed Related Topics, pg. 6	Would changing 3 experimental watersheds to evidence-based restoration require a plan amendment? One of the watersheds (LM-3L) is essentially already evidence-based, since >90% has a savanna prescription.	Request for explanation regarding whether changing treatment prescription in a research watershed requires a forest plan amendment	Comment is not related to soils, watershed, water quality, or riparian areas.
NAU, Part 2, Other Watershed Related Topics, pg. 6	We prefer the term “water *balance* research” to water “*yield”* research	Request for change in terminology in discussion of paired watershed research	Although the term “water *balance* research” better describes the objectives of the proposed research, “water *yield* research” is more easily understood by the general public and other stakeholders. The FEIS will therefore refer to the research as “water *yield* research” although we recognize the complexity and comprehensive nature of the study.
NAU, pg. 7	Please define the desired conditions for soil and watershed function or reference where in the document these can be found.	Request for definition of desired conditions for soils and watersheds	Desired conditions for soils can be found on pg. 25, paragraph 5 of the DEIS. Desired conditions for watersheds can be found on pg. 26, paragraph 2.

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NAU, pg. 7	The Rio de Flag watershed is not a source of water for the City of Flagstaff. Concern about the Rio de Flag centers on flood risk due to forest being highly susceptible to crown fire.	Recommend removal of Rio de Flag as a source of water for Flagstaff	Agreed. The Rio de Flag is not a source of water for the City of Flagstaff. This information will be corrected in the FEIS.
NAU, pg. 7	How have soil condition and function been determined? Please, provide a brief explanation.	soil condition	
NAU, pg. 7	How have soil condition and function been determined? Please, provide a brief explanation.	soil condition and function	Please see Methodology and Analysis Process on page 8 of the Soil Resources Specialist's Report.
NAU, pg. 7	Are there treatments planned in the 15% of area that does not have satisfactory soil condition? If so, what mitigating measures are planned?	treatments on unsatisfactory soils	Yes treatments are planned on unsatisfactory soils. The intent is to improve soil condition see SW BMPs in appendix C - SW 11, 14, 22, 24, 25, 26, 27, 28, 29, 30, 31,35, pages 584 to 589 in the hard copy and CD DEIS.
NAU, pg. 7	Please, include a Hydrologic Condition Framework map for the project area so we can visually see where the priorities areas are.	Request for map of watershed condition framework	I believe this comment is intended to reference the Watershed Condition Framework rather than Hydrologic Condition Framework. Watershed conditions for all National Forest System lands, including those within the 4FRI analysis area are available online at: WCATT 1.3.0 (Build 40)
NAU, pg. 7	We recommend an emphasis on engineering assessment of road drainage and simple measures to reduce long-term concentration of water along roadways, such as replacement of culverts with rolling water bars and mulching of abandoned roadbeds.	Roads	Page 28, paragraph 4 states "the desired condition is to restore decommissioned road prisms to their natural condition (USDA 1987, USDA 1988) ."

Four Forest Restoration Initiative

Water Quality and Riparian Area Report

Comment # and Location	Comment or Reference for Attachments	Comment Topic	General Response
NAU, pg. 7	This section is pretty vague about what would actually be done. If there is greater detail elsewhere in the document, such as Table 111, please reference it.	Requesting more detailed information	
NAU, pg.	Where are the references for the main body of the DEIS? I was looking for USDA 2009 and could not find it.	References	References can be found on pages 357-435 of the DEIS and are included in the project record.
NAU, pg. 7	By "major watersheds" do you mean 5th code watersheds? Please, clarify, since earlier there was discussion of the 6th code watersheds	5th code watersheds (HUC10)	Yes. This will be clarified in the FEIS.
NAU, pg. 8	Define ephemeral channel functionality	Ephemeral streams	Ephemeral channel functionality has been described on page iii, paragraph 5 of the DEIS. Desired conditions for ephemeral channels are described on page 27, paragraph 5 and page 28, paragraph 1 of the DEIS. Desired conditions for ephemeral channels are more specifically described on page 8, paragraph 2 of the Water Quality and Riparian Areas Specialist's Report.
NAU, pg. 8	Again, while the desired condition may be to restore decommissioned road prisms to their natural condition, this may be prohibitively expensive. It is not uncommon to find historic roads in the forest that have naturally revegetated and are stable. The focus should be on making sure that road prisms have frequent and adequate channels across them so that water can pass without being concentrated on or along the roadbed. Also, removal of culverts is advisable, since without ongoing	Road decommissioning	Page 28, paragraph 4 states "the desired condition is to restore decommissioned road prisms to their natural condition (USDA 1987, USDA 1988)." Appendix C – Design Features, BMPs, and Mitigation includes soil and water resources BMPs designed to prevent degradation water quality during and after forest treatments, including road decommissioning.

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	maintenance they are like to plug and cause erosion and sedimentation. Some of these culverts could likely be reused for temporary roads associated with restoration work or they could be recycled, both of which may help defray costs for the contractor. While road decommissioning is very important for soil and watershed condition, doing it in an economically practical fashion is necessary to ensure that practices will be adequately implemented. Also, if all roadbeds were to be ripped to restore the beds to natural condition, this would cause a tremendous amount of disturbance that would likely promote a flush of invasive plant growth.		
NAU, pg. 8	Again, please use the term “water balance” rather than “water yield”. Yield is only one part of what we will investigate and is not more important than the other parts of the water balance. Please, search and replace throughout the document so that instead of “water yield” it reads “water balance”, unless water yield is explicitly intended	Water balance vs. water yield	Although the term “water *balance* research” better describes the objectives of the proposed research, “water *yield* research” is more easily understood by the general public and other stakeholders. The FEIS will therefore refer to the research as “water *yield* research” although we recognize the complexity and comprehensive nature of the study.
NAU, pg. 8	Is there some sense of how much total area might be treated by an essentially evidence-based restoration approach according to, “Remove tree canopy to pre-settlement condition within 2–5 chains of the spring”? It seems like evidence-based restoration could be applied to 1.2 to 7.8 acres surrounding each	Springs restoration	The reference to “2-5 chains” is for demonstrational purposes only. It is anticipated that springs restoration would be implemented under consultation and coordination of local spring experts at NAU, the Museum of Northern Arizona, and Spring Stewardship Insituitute.

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	spring. Dr. Abe Springer and ERI would be very interested to know how the Forest Service will determine the desired acres of pre-settlement condition around springs. Ponderosa pine restoration treatments for the purpose of restoring springs is a novel approach, with little or no literature to support the supposition in table 16 that a 2-5 chain radius is appropriate. We encourage the Forest Service to treat this as a research opportunity and test varying treatment intensities and radii around springs to determine which treatments are most beneficial. Through research, monitoring and an adaptive management process, we may over time come to understand the best approaches for restoring ponderosa pine forest to benefit spring ecosystems.		
NAU, pg. 9	Oak Creek has had many more than 2 exceedences of the water quality standard for E. coli and at more than one location.	Water Quality	The Riparian and Water Quality Specialist's Report and DEIS will be revised to reflect this information.
NAU, pg. 9	"*Escherichia coliform* (E. coli)" should read "*Escherichia coli* (E. coli)". Note the use of "coli" rather than "coliform" and italics rather than no italics.	E. coli	The Riparian and Water Quality Specialist's Report and DEIS will be revised to correct the syntax of the *Escherichia coli* (E. coli).
NAU, pg. 10	Lower Lake Mary is not a designated domestic water source, so far as we know. Upper Lake Make is a designated municipal water source.	Domestic water sources	The Riparian and Water Quality Specialist's Report and DEIS will be revised to properly reflect Upper Lake Mary as the only municipal water source in the Lake Mary watershed.

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NAU, pg. 10	Covington and Moore (1994) would be a good citation for the statement "Water yields from the ponderosa pine vegetation type are likely reduced from historic conditions due to increased stand densities that result in higher evapotranspiration rates	Recommended citation	The citation will be added to the Riparian and Water Quality Specialist's Report and DEIS to support the statement related to reduced water yields from the ponderosa pine vegetation type.
NAU, pg. 11	Design Criteria number SW2 – This is a big concern. Because of the volume of fiber that needs to be removed each year, the contractor may be tempted to push the envelope and put equipment on the ground when soil moisture conditions are not favorable. Can some consequences (such as financial penalties) be imposed as part of this design criteria?	Recommendation related to mechanical treatments under wet ground conditions	This comment addresses a contract compliance issue and is not directly related to the NEPA analysis. Contract compliance issues would be addressed during project implementation.
NAU, pg. 11	Design Criteria number SWX – There should be design criteria that describe how planned hauling and burning practices may minimize soil burn severity. A member of the 4FRI team has previously given the impression that, as far as possible, "haul to the lead" would be used to bring unlimbed trees to a landing where they would be limbed, the limbs shredded and chips hauled for biomass production and the logs hauled for use in saw timber and/or composite wood products. Hence, there would probably remain at the landing some concentrated material that would likely burn at a high temperature, but little slash burned out in the unit. Please, discuss to what extent "haul to the	Mechanical treatments / logging operations	This comment is likely referencing a term known as "felling to the lead" whereby trees are felled in a predetermined direction to facilitate transport to the landing. This practice minimizes soil disturbance by reducing the number of turns necessary to position the machinery for skidding of harvested trees. Transporting (i.e., skidding) of trees with limbs intact is known as whole-tree skidding. This practice also reduces soil disturbance in comparison to skidding of limbed logs by reducing soil gouging. Concentrated material at landings could either be utilized or distributed across treatment areas to minimize burn severity.

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	lead" or other similar practices will be used.		
NAU, pg. 11	Design Criteria number SW8 (page 582) – This design criteria does not sound consistent with the LTRS □LTIP. Please, cross-check between this design criteria and the Large Tree Implementation Plan to see if the two are compatible with regards to ephemeral channels and riparian areas.	Best Management Practices	SW8 refers to a common Best Management Practice designed to protect water quality during forest mechanical operations. The purpose of establishing vegetative filter strips is to prevent sediment delivery to streamcourses. This BMP is also intended to reduce fire intensity (and therefore soil burn severity) on areas located in close proximity to water bodies and ephemeral channels.
AZ State Forestry (AZ4FRIDEISComments). Cara #166			
AZSF-1	In the DEIS pages 38-39 and 47, water yield is considered, but only as a potential research item. There is not any emphasis on actually designing treatments to capture snowfall and increase water flow. There is no recognition that within the present alternatives, implementation could be designed with the intent of increasing snowfall retention and water yield. The Forest Service should work with experts in this field to design and implement other aspects of treatments that will increase water yield.	Alternatives lack recognition of water yield	Thank you for your comment. Treatments designed to capture snowfall and increase water yield are outside the scope of the project and do not meet the purpose and need (DEIS chapter 1, page 8) which is to reestablish and restore forest structure and pattern, forest health and vegetation composition and diversity. The need is to increase forest resiliency and sustainability and protect soil productivity and improve soil and watershed function. However, action alternative C includes a paired watershed study that would study the effects of forest treatments on water balance including snowpack water retention and water yield. Any increases in water yield are a secondary benefit of proposed forest restoration.
Grand Canyon Trust (4FRIDEISComments). Cara#172			
GCT-1	In this case we urge the Forest Service to amend plans in a way that affords additional rather than less protection to springs and riparian areas from anthropogenic forces.	Request to amend Forest plans	This request is outside the scope of this project; however, as stated in the Draft Revised Kaibab National Forest Plan, protecting springs and wetlands came forward as an important need for change. Improved desired conditions for springs and wetlands have been

Comment # and Location	Comment or Reference for Attachments	Comment Topic	General Response
			incorporated into the Draft Kaibab National Forest Land and Resource Management Plan.
	What is the difference between a significant and a non-significant forest plan amendment? Please, clarify.		Comment is not related to soils, watershed, water quality, or riparian areas
	What is the timing of plan amendments relative to the EIS?		Comment is not related to soils, watershed, water quality, or riparian areas
	Besides table 2, where can we find more details about the proposed plan amendments (especially regarding interspace)?		Comment is not related to soils, watershed, water quality, or riparian areas
	In appendix B it is stated “the interspaces between groups may range from 20 to 200 feet, but generally between 25 and 100 feet apart from drip line to adjacent drip line”. Could you, please, provide a distribution of the different interspace distances (eg. 20% 25-40’, 40% 40-80’, etc.)? This would be very helpful in evaluating how planned interspaces may affect snowpack accumulation and retention that will have a large effect on water balance.		Comment is not related to soils, watershed, water quality, or riparian areas
	Would changing 3 experimental watersheds to evidence-based restoration require a plan amendment? One of the watersheds (LM-3L) is essentially already evidence-based, since >90% has a savanna prescription.		Comment is not related to soils, watershed, water quality, or riparian areas

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CBD Lininger (Cara 180 and 204 2013-0529LiningerCBD_1451MST)			
CBD-1. Page 25 and 26 of comment letter	The Forest Service must cease its practice of refusing to disclose the location and effects of new road construction and take a hard look at potential site-specific impacts to the environment. New roads may destroy large trees and coarse woody structure, permanently impair soil productivity and alter plant communities, and even if their use is temporary. New road construction may significantly impact soils and water quality, and this is a significant issue for environmental analysis. The Forest Service must cease its standard practice of refusing to disclose the location and effects of new road construction and take a hard look at potential site-specific impacts to the environment, as required by NEPA. New roads and ground-based logging activities may cause significant losses of soil productivity (Gucinski et al. 2001: 21) ("Losses of productivity associated with road-caused, accelerated erosion are site specific and variable in extent, but they are commonly reported for all steepslope landscapes."). New roads can permanently impair soil productivity even if their use is temporary (Trombulak and Frissell 2000	Disclosure of effects of roads on various resources including soil productivity.	Thank you for your comment. The DEIS proposes no new permanent road construction (DEIS page 40, p 63, p 81, p 88). The DEIS proposes a reduction of current roads through the proposed decommissioning of 904 miles of road (DEIS @ p41, p 63, Table 18 p 74, p 81, p 88), thus actually decreasing the effects of roads that are currently located within the analysis area. Chapter 3 of the draft EIS (DEIS) disclosed the affected environment for each resource (including roads) and the direct/indirect environmental consequences associated with the action alternatives in chapter 3, from page 63 to page 345. Effects analysis of roads (Transportation) can be found from page 329-333. Table 31, chapter 2, page 98 of the DEIS provides a comparison of the predicted effects of proposed treatments by alternative. The best (and relevant) available science, information, first-hand knowledge of the resources within the project area and experience with past and similar projects informed the effects analysis. Design features, mitigation measures and the following Soil and Water BMP's (SW2, SW14, SW16, SW20, SW24, SW30, SW32, T7, T8, RS3) located in Appendix C, page 567 of DEIS have been developed and will be implemented (for temporary road construction) to maintain and protect soil productivity, minimize sediment delivery and improve and protect water quality. The Chapter 3 soil and water analysis (DEIS, table 32, page 116 and pages 119-125) and (Soils Specialist report pages 62-92 and Attachment #1, page 165) shows less than 15% soil disturbance would occur (including temporary road construction) under all action alternatives which is less than 15% soil disturbance threshold identified that would maintain long term soil productivity.

Comment # and Location	Comment or Reference for Attachments	Comment Topic	General Response
			No new permanent roads would be constructed for this project. Temporary roads would be constructed to provide necessary access for forest treatments and decommissioned after use. The effects of roads are analyzed and disclosed at the following locations in the DEIS: pg. 26, para. 2; pg. 28, para. 3-5; pg. 29 para 1 and 2; pg. 40, para. 2; pg. 41, para. 1; pg. 47, para. 7; pg. 62, para. 6; pg. 63, para. 1; pg. 63, para. 2; pg. 65, table 16; pg. 74, table 18; pg. 81, para. 1; pg. 88, para. 2; pg. 109, para. 2; pg. 110, para. 3 and 6; pg. 111, para. 1; pg. 116, para. 2-4; pg. 142, para. 2 and table 52; 162, para. 2; pg. 185 (entire page); pg. 186, para. 1 and table 69; pg. 201, table 71; pg. 291, para. 6; pg. 221, para. 1. Additionally, Appendix C – provides design features, BMPs, and mitigation measures to protect soils and water quality as they relate to roads. These include SW10-12, 14, 16, 17, 20, 22, 24, 30, 31. The Riparian and Water Quality Specialist's Report provides a detailed description of the effects of forest roads on pg. 50 and 62-64.
CBD-3, comment letter page 25	New roads and ground-based logging activities may cause significant losses of soil productivity.	Disclosure of effects of roads on soil productivity.	The DEIS proposes no new permanent road construction (DEIS page 40, p 63, p 81, p 88). The DEIS proposes a reduction of current roads through the proposed decommissioning of 904 miles of road (DEIS @ p41, p 63, Table 18 p 74, p 81, p 88), thus actually decreasing the effects of roads that are currently located within the analysis area. Design features, mitigation measures and the following Soil and Water BMP's (SW2, SW14, SW16, SW20, SW24, SW30, SW32, T7, T8, RS3) located in Appendix C, page 567 of DEIS have been developed and will be implemented (for temporary road construction) to maintain and protect soil productivity, minimize sediment delivery and improve and protect water quality. The Chapter 3 soil and water analysis (DEIS, table 32, page 116 and pages 119-125) and (Soils Specialist report pages 62-92 and Attachment #1, page 165) shows

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			less than 15% soil disturbance would occur (including temporary road construction) under all action alternatives which is less than 15% soil disturbance threshold identified that would maintain long term soil productivity.
CBD-4, comment letter page 27	To comply with NEPA, the Forest Service must study, develop and describe (rather than mention and dismiss) an **action alternative** that foregoes road building on steep slopes and sensitive soils where it may increase erosion or impair soil productivity.	Disclosure of effects of roads on soil	The DEIS proposes no new permanent road construction (DEIS page 40, p 63, p 81, p 88). The DEIS proposes a reduction of current roads through the proposed decommissioning of 904 miles of road (DEIS @ p41, p 63, Table 18 p 74, p 81, p 88), thus actually decreasing the effects of roads that are currently located within the analysis area. Temporary road construction is proposed in action alternatives. Implementation of design features, mitigation measures and the following Soil and Water BMPs (Appendix C, page 567) (SW2, SW14, SW16, SW20, SW24, SW30, SW32, T7, T8, RS3) are expected to prevent increases in erosion and loss of soil productivity as well as protect water quality and therefore, no new action alternative is required. BMP SW 8 specifically requires a 100-120 foot vegetated, protected streamside management zone on adjoining soils with severe erosion hazard. Chapter 3 of the draft EIS (DEIS) discloses the affected environment for each resource (including roads) and the direct/indirect environmental consequences associated with the action alternatives in chapter 3, from page 63 to page 345. Effects analysis of roads (Transportation) can be found from page 329-333. The best (and relevant) available science, information, first-hand knowledge of the resources within the project area and experience with past and similar projects informed the effects analysis. The Chapter 3 soil and water analysis (DEIS, table 32, page 116 and pages 119-125) and (Soils Specialist report pages 62-92 and Attachment #1, page 165) shows less than 15% soil disturbance would occur (including temporary road construction) under all action alternatives which is less than 15% soil disturbance threshold

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			identified that would maintain long term soil productivity. Provide soil and site protection on newly disturbed soils located on temporary roads on soils with severe erosion hazard as needed. Avoid locating temporary roads on soils with severe erosion hazard. Where unavoidable, provide soil protection through implementation of any of the following methods to control sediment and protect water quality. Methods may include, but are not limited to: wattling, hydromulching, straw or woodshred mulching, spread slash, erosion mats, terraces, blankets, mats, silt fences, riprapping, tackifiers, soil seals, seeding and side drains, and appropriately spaced water bars or water spreading drainage features. Temporary roads will be decommissioned and footprint obliterated and protected with any of the above methods.
CBD, pg. 27, paragraph 1	Road-related soil erosion is a chronic source of sediment production that can limit water quality (Bowman 2001, Gucinski et al. 2001). The distance that sediment travels is an important factor in determining how much eroded soil is delivered to a water body. Soil loss and erosion occurring closer to a stream have greater potential to deliver sediment and lead to water quality impairment than erosion triggered farther away from streams. For this reason, road-stream crossings have high potential to adversely impact water quality (Endicott 2008). In addition, road construction	Roads	No new permanent roads would be constructed for this project. Temporary roads would be constructed to provide necessary access for forest treatments and decommissioned after use. The effects of roads are analyzed and disclosed at the following locations in the DEIS: pg. 26, para. 2; pg. 28, para. 3-5; pg. 29 para 1 and 2; pg. 40, para. 2; pg. 41, para. 1; pg. 47, para. 7; pg. 62, para. 6; pg. 63, para. 1; pg. 63, para. 2; pg. 65, table 16; pg. 74, table 18; pg. 81, para. 1; pg. 88, para. 2; pg. 109, para. 2; pg. 110, para. 3 and 6; pg. 111, para. 1; pg. 116, para. 2-4; pg. 142, para. 2 and table 52; 162, para. 2; pg. 185 (entire page); pg. 186, para. 1 and table 69; pg. 201, table 71; pg. 291, para. 6; pg. 221, para. 1. Additionally, Appendix C – provides design features, BMPs, and mitigation measures to protect soils and water quality as they relate to roads. These include SW10-12, 14, 16,

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	and fuel treatments may combine to increase overland water flow and runoff by removing vegetation and altering physical and chemical properties of soil, which can permanently alter watershed function (Elliot 2010, Robichaud et al. 2010). This has implications for the purpose and need to protect municipal water supplies from socially undesirable effects of flooding and erosion.		17, 20, 22, 24, 30, 31. The Riparian and Water Quality Specialist's Report provides a detailed description of the effects of forest roads on pg. 50 and 62-64.
CBD, pg. 27, paragraph 2	The extent and location road construction and its effects to soil erosion, runoff channelization and suspended sediment loads merit a hard look in the analysis. To comply with NEPA, the Forest Service must study, develop and describe (rather than mention and dismiss) an action alternative that foregoes road building on steep slopes and sensitive soils where it may increase erosion or impair productivity. 40 C.F.R. § 1502.14. Such an alternative would provide the decision-maker and the public with a meaningful basis on which to compare environmental impacts. See Steinke (2013: 90) (in all action alternatives, 22 miles of new road construction would occur "on severe erosion hazard soils").	Roads	No new permanent roads would be constructed for this project. Temporary roads would be constructed to provide necessary access for forest treatments and decommissioned after use. The effects of roads are analyzed and disclosed at the following locations in the DEIS: pg. 26, para. 2; pg. 28, para. 3-5; pg. 29 para 1 and 2; pg. 40, para. 2; pg. 41, para. 1; pg. 47, para. 7; pg. 62, para. 6; pg. 63, para. 1; pg. 63, para. 2; pg. 65, table 16; pg. 74, table 18; pg. 81, para. 1; pg. 88, para. 2; pg. 109, para. 2; pg. 110, para. 3 and 6; pg. 111, para. 1; pg. 116, para. 2-4; pg. 142, para. 2 and table 52; 162, para. 2; pg. 185 (entire page); pg. 186, para. 1 and table 69; pg. 201, table 71; pg. 291, para. 6; pg. 221, para. 1. Additionally, Appendix C – provides design features, BMPs, and mitigation measures to protect soils and water quality as they relate to roads. These include SW10-12, 14, 16, 17, 20, 22, 24, 30, 31. The Riparian and Water Quality Specialist's Report provides a detailed description of the effects of forest roads on pg. 50 and 62-64.
CBD, pg. 27, para. 3	Project design features may fail to mitigate significant cumulative effects (Endicott (2008: 93) ("… [A] lack of science to validate [Best Management Practices] effectiveness has been noted as a shortcoming of many BMPs related	Best Management Practices	Appendix C – provides design features, BMPs, and mitigation measures to protect soils and water quality as they relate to roads. These include SW10-12, 14, 16, 17, 20, 22, 24, 30, 31. These practices have generally been shown to effectively minimize and mitigate adverse effects to soil productivity and water quality when properly

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	to forest roads…”). New roads directly remove and cumulatively fragment wildlife habitat, and they indirectly contribute to biological invasions of noxious weeds (Gucinski et al. 2001). Significant cumulative effects of road construction are foreseeable because similar activity will occur in the FWPP, Hart Prairie, Mahan-Landmark, Marshall, Upper Beaver and Wing Mountain projects.		implemented. The FWPP, Hart Prairie, Mahan-Landmark, Marshall, Upper Beaver and Wing Mountain projects have been analyzed as potential Cumulative effects in Appendix F – Cumulative Effects.
CBD, pg. 27, para. 4	Pursuant to the Clean Water Act, each federal agency must comply with all Federal, state and local requirements concerning the control and abatement of water pollution. 33 U.S.C. § 1323(a). The project area includes several water bodies that have been designated as water quality impaired pursuant to Section 303(d) of the Clean Water Act, particularly for mercury in fish tissue: Upper and Lower Lake Mary, Soldiers, Soldiers Annex, and Lower Long Lakes. According to page 41 of the Water Quality and Riparian Areas Specialist Report, “The [Arizona Dept. Environmental Quality – “ADEQ”] has concluded that watershed loading can potentially be reduced through management of sedimentation and vegetative stability. Recommendations included a review of upland and drainage conditions, so that areas requiring soil stabilization measures and channel improvements may be identified.” The report further states on page 70: Short-term, localized adverse effects to surface water quality are	Water quality and TMDLs	In this comment, the following point is reiterated: “Implementation of BMPs and SWCPs as specified in Table 1 would minimize adverse effects to surface water quality and riparian ecosystem function.” Additionally, Appendix C provides design features, BMPs, and mitigation measures to protect soils and water quality as they relate to mechanical forest treatments, prescribed fire, and roads. These practices have generally been shown to effectively minimize and mitigate adverse effects to soil productivity and water quality when properly implemented. As described on pg. 70, para. 4 in the Riparian and Water Quality Specialist’s Report, It is unlikely that any of the Action Alternatives would contribute enough sediment or other pollutants to ephemeral or intermittent drainages within the project area to result in impairment of any downstream waterbodies.

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	possible in ephemeral drainages within or adjacent to high intensity treatment areas, Subwatersheds [sic] with greater treatment acreages, such as Walnut Creek-Upper Lake Mary (8,334 treatment acres), Upper Spring Valley Wash (7,369 treatment acres, and Volunteer Canyon (6,249 treatment acres) pose the highest risk of short term, localized adverse effects to water quality. Potential adverse effects include increases in turbidity, total dissolved solids, total suspended solids, and nutrients. Implementation of BMPs and SWCPs as specified in Table 1 would minimize adverse effects to surface water quality and riparian ecosystem function. The report is forthright on pages 44-45, 69 and 75 about the risks to riparian and aquatic systems from road construction and use in the project. Roads, skid trails and landings present a clear risk to riparian and aquatic habitats for increasing sedimentation, erosion, and turbidity, and they may cause the Forest Service to violate Total Maximum Daily Load ("TMDL") restrictions on water pollution. Therefore, the report admits on page 9, "Cumulative effects to water quality and riparian areas, when combined with past, present, and reasonably foreseeable future actions could be significant."		
pg. 28, para. 2	The 4FRI project will be implemented simultaneously with the construction of the Kelly Motorized Trails Project. The Kelly project	Cumulative effects of Kelly Motorized Trails	The Kelly Motorized Trails Project is included in Table 154. Reasonably foreseeable recreation projects within the project area.

Comment # and Location	Comment or Reference for Attachments	Comment Topic	General Response
	will bring increased usage to lands south of Lake Mary, and are likely to bring increased motorized traffic to the roads surrounding the Kelly trails. During and after 4FRI implementation, national forest lands will be opened to recreational motorized traffic with a significant but undisclosed mileage of newly constructed roads and reopened roads around Lake Mary. How will the Forest Service limit the cumulative effects of these two projects? How will it prevent trespass from the Kelly project onto roads used for the 4FRI project? How will it pay for increased enforcement and the need to completely obscure closed and re-closed roads after 4FRI project implementation? The Forest Service must describe cumulative impacts of the Kelly project and 4FRI project and offer a plan for controlling motorized vehicle traffic onto the roads to be constructed and used in the action alternatives. The plan should account for the costs of thoroughly obliterating and completely obscuring roads around the Kelly project area. The Forest Service should also offer a contingency plan should TMDL levels in Lake Mary increase as a result of the two projects.	Project	
Cara 207 CBD attachment #7 Responses - Watershed, pp 25-30, 71-92			
Pages 25-30 of comment	Effects of Forest Biomass Use on Watershed Processes in the Western United States. Elliot,	Reference from pages 25-30 of	The comment letter references this article stating road construction increases runoff and can permanently alter watershed function. 4FRI is not proposing any new road construction but is proposing

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letter. Referenced once on page 27 and once on page 32 of comment letter.	2010. Western Journal of Applied Forestry. The comment letter references this article stating road construction increases runoff and can permanently alter watershed function.	attachment #7. "	temporary road construction with We do not disagree that there is increased risk of runoff and erosion from forest treatments and (new or temporary road construction) if protective design features and best management practices are not made part of the action. The article goes on to say following well-established management practices can minimize these risks. No new permanent roads would be constructed for this project. Temporary roads would be constructed to provide necessary access for forest treatments and decommissioned after use. The effects of roads are analyzed and disclosed at the following locations in the DEIS: pg. 26, para. 2; pg. 28, para. 3-5; pg. 29 para 1 and 2; pg. 40, para. 2; pg. 41, para. 1; pg. 47, para. 7; pg. 62, para. 6; pg. 63, para. 1; pg. 63, para. 2; pg. 65, table 16; pg. 74, table 18; pg. 81, para. 1; pg. 88, para. 2; pg. 109, para. 2; pg. 110, para. 3 and 6; pg. 111, para. 1; pg. 116, para. 2-4; pg. 142, para. 2 and table 52; 162, para. 2; pg. 185 (entire page); pg. 186, para. 1 and table 69; pg. 201, table 71; pg. 291, para. 6; pg. 221, para. 1. Additionally, Appendix C – provides design features, BMPs, and mitigation measures to protect soils and water quality as they relate to roads. These include SW10-12, 14, 16, 17, 20, 22, 24, 30, 31. The Riparian and Water Quality Specialist's Report provides a detailed description of the effects of forest roads on pg. 50 and 62-64. The 4FRI project minimizes vegetation treatment impacts to soil and site productivity through establishment of management practices and implementation of design features, mitigation measures and the following Soil and Water BMP's listed and located in Appendix C, page 567 of DEIS. They have been developed and will be implemented (for timber harvest and fuels operations and retention of coarse woody debris) to maintain and protect soil productivity, minimize sediment delivery and improve and protect water quality.

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Referenced once on page 27 of comment letter. Pages 79-103 of comment letter	Cumulative Watershed Effects on Fuel Management in the Western United States. Robichaud et al. GTR-231. 2010. The comment letter references this article stating road construction increases runoff and can permanently alter watershed function.	Reference from pages 71-92 of attachment #7	This reference is used in the Soil report on pages 60, 86, 89, 96 and 413. The reference does not contain any statements stating road construction can permanently alter watershed function. 4FRI is not proposing any new road construction but is proposing temporary road construction. However, we do not disagree that there is increased risk of runoff and erosion from new (or temporary) road construction if protective design features and best management practices are not made part of the action. The article goes on to say following well-established management practices can minimize these risks. No new permanent roads would be constructed for this project. Temporary roads would be constructed to provide necessary access for forest treatments and decommissioned after use. The effects of roads are analyzed and disclosed at the following locations in the DEIS: pg. 26, para. 2; pg. 28, para. 3-5; pg. 29 para 1 and 2; pg. 40, para. 2; pg. 41, para. 1; pg. 47, para. 7; pg. 62, para. 6; pg. 63, para. 1; pg. 63, para. 2; pg. 65, table 16; pg. 74, table 18; pg. 81, para. 1; pg. 88, para. 2; pg. 109, para. 2; pg. 110, para. 3 and 6; pg. 111, para. 1; pg. 116, para. 2-4; pg. 142, para. 2 and table 52; 162, para. 2; pg. 185 (entire page); pg. 186, para. 1 and table 69; pg. 201, table 71; pg. 291, para. 6; pg. 221, para. 1. Additionally, Appendix C – provides design features, BMPs, and mitigation measures to protect soils and water quality as they relate to roads. These include SW10-12, 14, 16, 17, 20, 22, 24, 30, 31. The Riparian and Water Quality Specialist's Report provides a detailed description of the effects of forest roads on pg. 50 and 62-64. The 4FRI project minimizes vegetation treatment impacts to soil and site productivity through establishment of management practices

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			and implementation of design features, mitigation measures and the following Soil and Water BMP's listed and located in Appendix C, page 567 of DEIS. They have been developed and will be implemented (for timber harvest and fuels operations and retention of coarse woody debris) to maintain and protect soil productivity, minimize sediment delivery and improve and protect water quality.
Cara 210 CBD attachment #10 Responses – Soil and Water, pp 16-135			
Pages 26-27 of comment letter	Forest Roads, A Synthesis of Scientific Literature. Gucinski et al, 2001 GTR-509. The comment letter references this publication on page 26 stating, "New roads and ground-based logging activities may cause significant losses of soil productivity (Gucinski et al. 2001: 21) ("Losses of productivity associated with road-caused, accelerated erosion are site specific and variable in extent, but they are commonly reported for all steepslope" landscapes.") Page 27 comment letter. "Road-related soil erosion is a chronic source of sediment production that can limit water quality (Bowman 2001, Gucinski et al. 2001)". Page 27 comment letter. "New roads directly remove and cumulatively fragment wildlife habitat, and they indirectly contribute to biological invasions of noxious weeds (Gucinski et al. 2001)".	References from pages 16-135 of attachment #10.	Note of the citations in the comment letter occur in the Gucinski reference as quoted. GTR reference does not state "Undesirable consequences include adverse effects on hydrology and geomorphic features (such as debris slides and sedimentation), habitat fragmentation, predation, road kill, invasion by exotic species, dispersal of pathogens, degraded water quality and chemical contamination, degraded aquatic habitat, use conflicts, destructive human actions (for example, trash dumping, illegal hunting, fires), lost solitude, depressed local economies, loss of soil productivity, and decline in biodiversity." Reference does not state "New roads and ground-based logging activities may cause significant losses of soil productivity" Page 22 of GTR states, "Forest roads can significantly affect **site productivity** by removing and displacing topsoil, altering soil properties, changing microclimate, and accelerating erosion". Reference does not state "New roads directly remove and cumulatively fragment wildlife habitat, and they indirectly contribute to biological invasions of noxious weeds". However, the intent of the references is likely to show the presence of new or existing roads can cause losses in soil productivity, degrade water quality and fragment wildlife habitat and spread invasive

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			weeds. Soil report cites Gucinski pn pages 90 and 91 stating, Temporary roads may have fewer adverse effects than do permanent roads, depending on the extent to which they are decommissioned (Gucinski et al. 2000). Because of this, after use, all temporary roads would be restored and may be shallow ripped (≈6"), seeded, drained and/or covered with slash from landings. However, we do not disagree that there is increased risk of runoff and erosion or spread of invasive weeds from new (or temporary) road construction if protective design features and best management practices are not made part of the action. The article goes on to say following well-established management practices can minimize these risks. No new permanent roads would be constructed for this project. Temporary roads would be constructed to provide necessary access for forest treatments and decommissioned after use. The effects of roads are analyzed and disclosed at the following locations in the DEIS: pg. 26, para. 2; pg. 28, para. 3-5; pg. 29 para 1 and 2; pg. 40, para. 2; pg. 41, para. 1; pg. 47, para. 7; pg. 62, para. 6; pg. 63, para. 1; pg. 63, para. 2; pg. 65, table 16; pg. 74, table 18; pg. 81, para. 1; pg. 88, para. 2; pg. 109, para. 2; pg. 110, para. 3 and 6; pg. 111, para. 1; pg. 116, para. 2-4; pg. 142, para. 2 and table 52; 162, para. 2; pg. 185 (entire page); pg. 186, para. 1 and table 69; pg. 201, table 71; pg. 291, para. 6; pg. 221, para. 1. Additionally, Appendix C – provides design features, BMPs, and mitigation measures to protect soils and water quality as they relate to roads. These include SW10-12, 14, 16, 17, 20, 22, 24, 30, 31. The Riparian and Water Quality Specialist's Report provides a detailed description of the effects of forest roads on pg. 50 and 62-64. Page 28 (DEIS), paragraph 4 states "the desired condition is to

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			restore decommissioned road prisms to their natural condition (USDA 1987, USDA 1988) ". Appendix C – Design Features, BMPs, and Mitigation includes soil and water resources and invasive weed control BMPs are designed to prevent degradation water quality during and after forest treatments, and including road decommissioning. The 4FRI project minimizes vegetation treatment impacts to soil and site productivity and invasive weeds through establishment of management practices and implementation of design features, mitigation measures and the following Soil and Water BMP's listed and located in Appendix C, page 567 of DEIS. They have been developed and will be implemented to maintain and protect soil productivity.
5CGs et. Al (Cara196-200 2013-0529fiveconservation_Group_Comments_And_Lit)			
5CGs, pg. 7, para. 3	A more specific and highly significant example of differences between the collaborative Strategy and the DEIS implementation plan for large trees occurs in riparian areas. On page 11, the collaborative Strategy contains this selection criterion: "Where large trees are growing (rooted) within a riparian area and compromising available soil moisture or light that support that area's unique biophysical conditions." In contrast, the DEIS implementation plan for large trees lacks an equivalent limitation, but instead states, "If treatment occurs [in riparian areas], an equivalent number of large replacement trees remain where there is evidence that pre-settlement trees have grown in similar root and	Large tree retention in riparian areas and definition of riparian areas	Page 647, paragraph 2, last sentence states "However, it is likely to be a very rare circumstance that conifer trees of any size would need to be removed from forested riparian zones."

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	crown proximity to a particular seep or spring in the past." DEIS at 647. Vegetation patterns in and around riparian areas vary temporally and spatially, based on flooding history, water availability and soil composition (Hupp, 1988, Stromberg et al. 1993, Hupp and Osterkamp 1996, Poff 2002). Creating a one-for-one tree arrangement in riparian areas, representing the spatial arrangement of the previous century, is not necessarily the most appropriate way to protect soil stability and riparian forest health. The Forest Service should recognize the stakeholder agreement to conservatively treat riparian areas and leave large trees in place where possible. Also, please note that there is a typo in the DEIS statement cited above: a "seep" or "spring" is not necessarily a riparian zone. Riparian areas are characterized by moving water and/or floodplains, and not all seeps and springs have riparian zones. The wording should be changed to indicate that this part of the document is discussing riparian areas.		
5CDs-2, comment letter page 13	New roads can destroy large trees and coarse woody structure, permanently impair soil productivity and alter plant communities, and even if their use is temporary.	Kit to do	The DEIS proposes no new permanent road construction (DEIS page 40, p 63, p 81, p 88). The DEIS proposes a reduction of current roads through the proposed decommissioning of 904 miles of road (DEIS @ p41, p 63, Table 18 p 74, p 81, p 88), thus actually decreasing the effects of roads that are currently located within the analysis area. The Chapter 3 soil and water analysis (DEIS, table 32, page 116 and pages 119-125) and (Soils Specialist report pages 62-92 and Attachment #1, page 165) shows less than 15% soil disturbance

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			would occur (including temporary road construction) under all action alternatives which is less than 15% soil disturbance threshold identified that would maintain long term soil productivity. Temporary roads would be constructed to provide necessary access for forest treatments and decommissioned after use. The effects of roads are analyzed and disclosed at the following locations in the DEIS: pg. 26, para. 2; pg. 28, para. 3-5; pg. 29 para 1 and 2; pg. 40, para. 2; pg. 41, para. 1; pg. 47, para. 7; pg. 62, para. 6; pg. 63, para. 1; pg. 63, para. 2; pg. 65, table 16; pg. 74, table 18; pg. 81, para. 1; pg. 88, para. 2; pg. 109, para. 2; pg. 110, para. 3 and 6; pg. 111, para. 1; pg. 116, para. 2-4; pg. 142, para. 2 and table 52; 162, para. 2; pg. 185 (entire page); pg. 186, para. 1 and table 69; pg. 201, table 71; pg. 291, para. 6; pg. 221, para. 1. Additionally, Appendix C – provides design features, BMPs, and mitigation measures to protect soils and water quality as they relate to roads. These include SW10-12, 14, 16, 17, 20, 22, 24, 30, 31. The Riparian and Water Quality Specialist's Report provides a detailed description of the effects of forest roads on pg. 50 and 62-64. Page 60, paragraph 3 through page 61, paragraph 4 provides a more detailed description of the effects of roads on soil productivity and water quality, including construction and decommissioning. Finally, this section also notes that Implementation of effective Best Management Practices (BMPs) and Soil and Water Conservation Practices (SWCPs) during road decommissioning would improve surface water quality since these road segments would no longer be redirecting surface flows via ditches and delivering sediment and other pollutants directly to streamcourses. Decommissioning of 941 miles of roads would improve surface water quality, particularly where stream crossings would become naturalized over time.
5CGs, pg. 13,	The project area includes several water bodies	Water Quality and	In this comment, the following point is reiterated: "Implementation

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para. 3	that are on Arizona's "303(d)" list as impaired for water quality, particularly for mercury in fish tissue: Upper and Lower Lake Mary, Soldiers, Soldiers Annex, and Lower Long Lakes. According to page 41 of the Water Quality and Riparian Areas Specialist Report, "The [Arizona Dept. Environmental Quality –"ADEQ"] has concluded that watershed loading can potentially be reduced through management of sedimentation and vegetative stability. Recommendations included a review of upland and drainage conditions, so that areas requiring soil stabilization measures and channel improvements may be identified." The report further states on page 70: Short-term, localized adverse effects to surface water quality are possible in ephemeral drainages within or adjacent to high intensity treatment areas, Subwatersheds [sic] with greater treatment acreages, such as Walnut Creek-Upper Lake Mary (8,334 treatment acres), Upper Spring Valley Wash (7,369 treatment acres, and Volunteer Canyon (6,249 treatment acres) pose the highest risk of short term, localized adverse effects to water quality. Potential adverse effects include increases in turbidity, total dissolved solids, total suspended solids, and nutrients. Implementation of BMPs and SWCPs as specified in Table 1 would minimize adverse effects to surface water quality and riparian ecosystem function. The report is forthright on pages 44-45, 69 and 75 about the risks to	TMDLs	of BMPs and SWCPs as specified in Table 1 would minimize adverse effects to surface water quality and riparian ecosystem function." Additionally, Appendix C provides design features, BMPs, and mitigation measures to protect soils and water quality as they relate to mechanical forest treatments, prescribed fire, and roads. These practices have generally been shown to effectively minimize and mitigate adverse effects to soil productivity and water quality when properly implemented. As described on pg. 70, para. 4 in the Riparian and Water Quality Specialist's Report, It is unlikely that any of the Action Alternatives would contribute enough sediment or other pollutants to ephemeral or intermittent drainages within the project area to result in impairment of any downstream waterbodies.

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	riparian and aquatic systems from road construction and use in the project. Roads, skid trails and landings present a clear risk to riparian and aquatic habitats for increasing sedimentation, erosion, and turbidity, and they may cause the Forest Service to violate Total Maximum Daily Load ("TMDL") restrictions on water pollution. Therefore, the report admits on page 9, "Cumulative effects to water quality and riparian areas, when combined with past, present, and reasonably foreseeable future actions could be significant."		
5CGs, pg. 13, para. 6	The 4FRI project will be implemented simultaneously with the construction of the Kelly Motorized Trails Project. The Kelly project will bring increased usage to lands south of Lake Mary, and are likely to bring increased motorized traffic to the roads surrounding the Kelly trails.	Cumulative effects of Kelly Motorized Trails Project	The Kelly Motorized Trails Project is included in Table 154. Reasonably foreseeable recreation projects within the project area. Temporary roads would be decommissioned upon completion of activities.
5CGs, pg. 14, para. 1	The Forest Service should also offer a contingency plan should TMDL levels in Lake Mary increase as a result of the two projects.	Water quality and TMDLs	Appendix C – provides design features, BMPs, and mitigation measures to protect soils and water quality as they relate to roads. These include SW10-12, 14, 16, 17, 20, 22, 24, 30, 31. These practices have been proven effective at mitigating adverse effects to soil productivity and water quality when properly implemented.
5CDs-5. Comment letter page 14	It should explain why it will rely on fencing instead of taking proactive measures to limit motorized vehicle traffic, reintroduce natural predators, and limit livestock damage to aspen.	Motorized traffic, aspen stand conditions, and predator	Motorized vehicle traffic will be reduced through decommissioning of 904 miles of unnecessary roads (DEIS, pg. 28, para. 2). Reintroduction of natural predators is beyond the scope of this project.

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	According to pages 76-77 of the Water Quality and Riparian Areas Specialist Report supporting the DEIS, "Although there are no quantifiable data regarding the impacts that vertebrate herbivores and OHV traffic have on aspen stands and springs of the KNF and CNF, it is generally accepted that adverse effects to aspen stands and spring habitats from these activities are occurring." The Forest Service intends to rely on approximately 82 miles of aspen fencing to control for these risks to aspen forests. It should explain why it will rely on fencing instead of taking proactive measures to limit motorized vehicle traffic, reintroduce natural predators, and limit livestock damage to aspen. When large predators, particularly wolves, were reintroduced to Yellowstone National Park, USA, and Banff National Park, Canada, the wolves brought elk populations to manageable levels, and as a result of the decrease in grazing pressure, aspen populations near wolves rebounded (Hebblewhite et al. 2005, Ripple and Beschta 2007). How will the costs of fencing construction and maintenance for years into the future compare with the costs of removing artificial water supplies that occur within several miles of aspen stands, or with the costs of removing roads that pass through aspen stands and allow vehicle trespass?	reintroduction	Fencing of aspen stands is also intended to exclude all vertebrate herbivores, including domestic livestock from these areas. Artificial waters are intended for use by domestic livestock and wildlife.

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Dick Artley, A Few Comments on 4FRI draft EIS. 2013-0422			
DA, page 2, View 2	The DEIS indicates temporary road construction is a connected action to this timber sale. The DEIS at page 40 indicates that temporary roads will be "decommissioned" after use. If the Responsible Officials really wants to eliminate the sediment originating from temporary roads they will obliterate all temporary roads after use and say this will be done in the final EIS and ROD.	Roads	Page 350 of the DEIS provides a definition of road decommissioning These include: activities that result in the stabilization and restoration of unneeded roads to a more natural state (36 CFR 212.1, FSM 7705—Transportation System, USDA 2003). FSM 7712.11-Exhibit 01 identifies five levels of treatments for road decommissioning which can achieve the intent of the definition. These include blocking the entrance, revegetation, waterbarring, removing fills and culverts, establishing drainageways and removing unstable road shoulders, and full obliteration, recontouring, and restoring natural slopes.
DA-1, comment letter page 4	If the Responsible Officials really wants to eliminate the sediment originating from temporary roads they will obliterate all temporary roads after use and say this will be done in the final EIS and ROD. **Comment:** Decommissioning these temporary roads will not remove the running surface. Therefore, since temporary roads are outsloped with no ditch, sediment will be generated during precipitation events, find its way to streams and harm the aquatic resources for decades until the next timber sale. No amount of brush or grass placed on an outsloped running surface will stop sediment from being generated and deposited in streams.	Effects to aquatic resources	Thank you for your comment. Chapter 2, page 65 of the DEIS states construction (and decommissioning) temporary roads is an action common to the action alternatives. Page 65 further states reconstructing and improving roads, relocating a minimal number of road miles, and decommissioning existing roads and unauthorized routes is a common action to action alternatives. This would result in reduced sediment delivery to aquatic resources as well. Table 15 displays management actions and road adaptive management strategies designed to mitigate effects to soil and water resources and include complete road obliteration, blocking entrance reducing motorized impacts, re-establishing road drainage, removal of culverts, installation of waterbars, protecting against erosion with slash. In addition, Appendix C, page 567 includes design features, mitigation measures and the following Soil and Water BMP's (SW2, SW14, SW16, SW20, SW24, SW30, SW32, T7, T8, RS3) that will be implemented (for temporary road construction) to maintain and protect soil productivity, minimize sediment delivery and improve

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			and protect water quality and aquatic resources. The potential for soil disturbance and soil erosion is disclosed in the DEIS on page 109 to page 113 (affected environment), and on page 113 to page 118 (environmental consequences) and pages 118-126 (Water) and in the soil specialist report from page 60 to page 120. The Chapter 3 soil and water analysis (DEIS, table 32, page 116 and pages 119-125) and (Soils Specialist report pages 62-92 and Attachment #1, page 165) shows less than 15% soil disturbance would occur (including temporary road construction) under all action alternatives which is less than 15% soil disturbance threshold identified that would maintain long term soil productivity.
DA, page 12	Herbicides containing Glyphosate, Methyl Parathion, Triclopyr, Imazapyr, and Imidacloprid must Never be used on Public Land for Any Reason Under the Proposed Action Table 16 states the following phrase several times: “remove noxious weeds.” Beginning at page 256 the DEIS discusses Noxious and Invasive Weeds. If herbicides will be applied the public will want to know where and the type of herbicide that will be applied. Why? The research shows the herbicides listed above are lethal to some species. Comment: Please expand the description of the proposed action to describe the types of	Use of herbicides	Herbicides would be used to control invasive and noxious weeds as they are found within treatment area. All herbicides would be used in accordance with the Final Environmental Impact Statement for Integrated Treatment of Noxious or Invasive Weeds, Coconino, Kaibab, and Prescott National Forests within Coconino, Gila, Mojave, and Yavapai Counties, Arizona.

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	herbicide that will be applied and the exact location of this application with a map of sufficiently small scale that the public can easily locate and avoid these areas. Comment: The chemicals listed above kill aquatic life even if the concentrations of the chemical in water are very low. Fish deaths will occur in the streams in the project area and the herbicide toxicity will extend many miles downstream. Herbicides must never be allowed to contact water … even so-called aquatic-safe herbicides. These chemicals are also quite toxic to mammals (including humans), birds and insects. Under some conditions they are lethal. They cause: · birth defects · non-Hodgkin’s lymphoma · mitochondrial damage · cell asphyxia · miscarriages · attention deficit disorder · endocrine disruption DNA damage		
Dick Artley Opposing Views Logging Harm (Scientific Gray Literature/Popular Press/Popular Science)			

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DA 2/1, page 2, view #2	Timber Harvest Opposing View #2 - "Timber harvest operations have been shown to have many effects on adjacent watercourses and on the aquatic ecosystems they support. This may occur from introductions or loss of woody debris, loss of riparian vegetation, accelerated stream bank and bed erosion, the alteration of natural channel form and process, and the reduction of stream habitat diversity. However, the existing literature indicates one of the most insidious effects of logging is the elevation of sediment loads and increased sedimentation within the drainage basin. Sediment generation from various forestry practices has been studied extensively in the past. Forestry practices which generate suspended sediments include all operations that disturb soil surfaces such as site preparations, clear-cutting, log skidding, yarding, slash burns, heavy equipment operation and road construction and maintenance."	Primary Science	The referenced citation provides an excellent review of the literature of the effects of forest operations on aquatic ecosystems. Guidance provided by Waters (1995) includes Best Management Practices designed to minimize or mitigate adverse effects to water quality. Most of these BMPs are included in Appendix C of the DEIS (SW2, SW4, SW7, SW9, SW10, SW11, SW12, SW14, SW19, SW23 through SW36). These BMPs have been developed and will be implemented (for timber harvest operations) to maintain and protect soil productivity, minimize sediment delivery to streamcourses and other water bodies and improve and protect water quality.
DA-2/2, page 18, view #24	**Timber Harvest Opposing View #2 -** "Timber harvest operations have been shown to have many effects on adjacent watercourses and on the aquatic ecosystems they support. This may occur from introductions or loss of woody debris, loss of riparian vegetation, accelerated stream bank and bed erosion, the alteration of natural channel form and process, and the	Scientific Gray Literature	This comment that was included in "Opposing Views" discusses the potential for sedimentation from timber harvesting. The potential for soil disturbance and soil erosion is disclosed in the DEIS on page 109 to page 113 (affected environment), and on page 113 to page 118 (environmental consequences) and pages 118-126 (Water) and in the soil specialist report from page 60 to page 120. The Chapter 3 soil and water analysis (DEIS, table 32, page 116 and pages 119-125) and (Soils Specialist report pages 62-92 and Attachment #1, page 165)

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	reduction of stream habitat diversity. However, the existing literature indicates one of the most insidious effects of logging is the elevation of sediment loads and increased sedimentation within the drainage basin. Sediment generation from various forestry practices has been studied extensively in the past. Forestry practices which generate suspended sediments include all operations that disturb soil surfaces such as site preparations, clear-cutting, log skidding, yarding, slash burns, heavy equipment operation and road construction and maintenance." Anderson, P.G. 1996. "**Sediment generation from forestry operations and associated effects on aquatic ecosystems**" Proceedings of the Forest-Fish Conference: Land Management Practices Affecting Aquatic Ecosystems, May 1-4, 1996, Calgary, Alberta. http://www.alliance-pipeline.com/contentfiles/45____Sediment_generation.pdf		shows less than 15% soil disturbance would occur (including temporary road construction) under all action alternatives which is less than 15% soil disturbance threshold identified that would maintain long term soil productivity. Additionally, design features, mitigation measures and the following Soil and Water BMP's (SW2, SW4, SW7, SW9, SW10, SW11, SW12, SW14, SW19, SW23 through SW36) located in Appendix C, page 567 of DEIS have been developed and will be implemented (for timber harvest operations) to maintain and protect soil productivity, minimize sediment delivery and improve and protect water quality. Please note the hyperlink to the website did not result in an article on timber harvest and sedimentation. It led to a website for the alliance pipeline company.
DA, Logging Harm, pg. 18, para. 4 (View No. 24).	"Even 'kinder, gentler' commercial logging still inflicts environmental impacts such as eroded topsoil, degraded water quality, destroyed wildlife habitat, and extirpated species that are	Scientific Gray Literature related to logging impacts	Appendix C, pages 580 through 590 (SW1-SW37) provide design features, BMPs, and mitigation measures to protect soils and water quality during and after mechanized forest restoration treatments. The referenced article is a 1997 unpublished research paper for the

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	every bit as much symptoms of forest health problems as large-scale, severe wildfires." Ingalsbee, Timothy Ph.D. "Logging for Firefighting: A Critical Analysis of the Quincy Library Group Fire Protection Plan." Unpublished research paper. 1997. http://www.fire-ecology.org/research/logging-for-firefighting_2.htm		Western Ancient Forest Campaign and is a critical analysis of the Quincy Library Group Bill (H.R.858).
DA, Logging Harm, pg 24, View No. 32	Large-scale logging (by any name) has devalued our forests, degraded our waters, damaged soils, and endangered a wide variety of plants and animals. How will the current round of politically and environmentally propelled 'restorative' logging proposals differ, in practice, from past logging regimes?" Keene, Roy Restorative Logging? "More rarity than reality" Guest Viewpoint, the Eugene *Register Guard* March 10, 2011 http://eugeneweekly.com/2011/03/03/views3.html	Popular Press related to logging and forest restoration	The Four-Forest Restoration Initiative (4FRI) is a planning effort designed to restore ponderosa pine forest resiliency and function across four national forests in Arizona including the Coconino, Kaibab, Apache-Sitgreaves, and Tonto National Forests (DEIS, pg. 2) The referenced article is an opinion statement related to forest restoration and logging. No scientific literature or references are provided to support author's position.
DA, Logging Harm, pg 25, View No. 33	Timber Harvest Opposing View #33 - "Timber harvesting operations affect hydrologic processes by reducing canopy interception and evapotranspiration. Many studies have documented changes in soil properties following tractor yarding (Stone, 1977;	Primary Science related to hydroligic processes	It is well-documented that mechanical forest treatments have the potential to alter forest hydrologic processes. he commenter references a scientific publication on the effects of cable yarding in a second growth redwood stand in northern California. No cable yarding is proposed within the 4FRI project area.

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	Cafferata, l983), and low-ground-pressure skidding (Sidle and Drlica, 1981). More recently, researchers have evaluated cable yarding (Miller and Sirois, 1986; Purser and Cundy, 1992). In general, these studies report decreased hydraulic conductivity and increased bulk density in forest soils after harvest." Keppeler, Elizabeth T. Robert R. Ziemer Ph.D., and Peter H. Cafferata "Effects of Human-Induced Changes on Hydrologic Systems." An American Water Resources Association publication, June 1994 http://www.fs.fed.us/psw/publications/ziemer/Ziemer94a.PDF		
DA, Logging Harm, pg 25, View No. 34	Timber Harvest Opposing View #34 - "Among these four species of amphibians, the spotted salamander is most likely to be affected adversely by the logging as this species of salamander relies on dense forests with full canopies (Harding, 1997)." "Looking at the study on a larger scale, the potential for changes caused by logging is great. Absence of trees could influence water temperature by altering available sunlight, conductivity by changing the amount of organic matter that collects in the vernal ponds, or pH if the logging process deposits foreign residues to	Primary Science related to logging effects on spotted salamanders and other amphibians	This non-refereed research paper discusses the effects of logging on amphibian larvae populations, and specifically spotted salamanders on the Ottawa National Forest in Michigan. The report concludes that The Ottawa National Forest should be able to utilize the information to harvest timber in a manner that retains amphibian welfare. The environmental effects each action alternative to water quantity, water quality and riparian areas are disclosed in Table 31, pages 102 and 103 of the DEIS and in the Water Quality and Riparian Area Specialist's Report, Table 6, page 39.

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	the area. Also heavy equipment used to harvest the timber has the potential to alter the terrain." "Modifications to the landscape could change how water flows and collects at the surface and change the size, shape, and location of the vernal ponds. Loss or alteration to small temporary water sources less than four hectares can be extremely detrimental to amphibians water (Semlitsch, 2000). Without vernal ponds amphibians would have difficulty inhabiting forested areas because they rely on the ponds as breeding grounds. If logging disturbs the ponds, amphibian populations could diminish in the areas that surround these vernal pools." Klein, Al 2004. *Logging Effects on Amphibian Larvae* *Populations in Ottawa National Forest*. http://www.nd.edu/~underc/east/education/documents/AKlein2004Pre-loggingsurveyofamphibianlarvaeinvernalpools.pdf		
DA-2/5, page 27, view #36	"I will turn first to forest thinning aimed at reducing fire risks. There is surprisingly little scientific information about how thinning actually affects overall fire risk in national forests."	Popular Press	These statements are made by Senior Attorney Nathaniel Lawrence (Natural Resource Defense Council). The fourth statement says logging equipment compacts soils. In the 4FRI project, compaction of soil is mitigated through implementation of the Design Features, mitigation measures and the following Soil and Water BMP's (SW1, SW2) located in Appendix C, page 567 for timber harvest operations

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	"How can it be that thinning could increase fire risks? First, thinning lets in sunlight and wind, both of which dry out the forest interior and increase flammability. Second, the most flammable material - brush, limbs, twigs, needles, and saplings - is difficult to remove and often left behind. Third, opening up forests promotes brushy, flammable undergrowth. Fourth, logging equipment compacts soil so that water runs off instead of filtering in to keep soils moist and trees healthy. Fifth, thinning introduces diseases and pests, wounds the trees left behind, and generally disrupts natural processes, including some that regulate forest health, all the more so if road construction is involved." Lawrence, Nathaniel, NRDC senior attorney "**Gridlock on the National Forests**" Testimony before the U.S. House of Representatives Subcommittee on Forests and Forest Health (Committee on Resources) December 4, 2001. http://www.nrdc.org/land/forests/tnl1201.asp		to maintain and protect soil productivity, minimize sediment delivery and improve and protect water quality.
DA-2/6, Page 29, view #40	Timber Harvest Opposing View #6 - "Federal auditors have found that the Forest Service frequently fails to assess, prevent or correct environmental damage from logging on the national forests. After inspecting 12 timber projects in the field from 1995 to 1998, the Agriculture	Popular Press	The article references inspections conducted by the USDA inspector general. Twelve timber projects were inspected in the field from 1995 to 1998, and deficiencies were noted in all of them. The article is dated as these inspections were conducted a minimum of 16 years ago. These inspections were conducted prior to the development of the program titled: National Best Management Practices for Water Quality Management on National Forest System Lands (FS-990a, April

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	Department's inspector general found that all were deficient and that 'immediate corrective action is needed.' A new report on the audits found that the environmental studies required before logging was approved were poorly done, the rules to protect streams and wildlife habitat from undue damage during logging were not followed, and the steps planned to repair some of the harm after logging were not carried out. The inspector general, Roger C. Viadero, reported on Jan. 15 to Mike Dombeck, chief of the Forest Service, that the review had found ''numerous serious deficiencies.'' Agency officials generally agreed with the report's conclusions and recommendations."		2012). Best Management Practices, design features, and mitigation measures have been developed to minimize or mitigate adverse effects of mechanical forest treatments. These include SW1-SW37 in Appendix C of the DEIS (pages 580-590).
DA, Logging Harm, pg 30, View No. 42	Timber Harvest Opposing View #42 - "In addition to the direct effects of habitat loss and fragmentation, logging typically reduces ecosystem health by: a) damaging aquatic habitats through siltation, reduction in stream complexity and increased water temperatures." McIntosh, B.A., J.R. Sedell, J.E. Smith, R.C. Wissmar S.E. Clarke, G.H. Reeves, and L.A. Brown "Management history of eastside ecosystems: changes in fish habitat over 50 years, 1935-	Primary Science	The referenced article specifically addresses the effects of land use changes on anadromous fish populations in Washington and Oregon. There are no anadromous fish within the 4FRI analysis area. This comment is therefore irrelevant to the project.

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	1992." 1994 *GTR-321 93-181* http://www.fs.fed.us/pnw/publications/pnw_gtr321/		
DA, Logging Harm, pg 30, View No. 43	Timber Harvest Opposing View #43 - "Logging practices can indirectly result in changes in the biological components of a stream, and can have direct and indirect on the physical environment in streams. The primary environmental changes of concern are the effects of siltation, logging debris, gravel scouring, destruction of developing embryos and alevins, blockage of streamflow, decrease in surface and intragravel dissolved oxygen, increase in maximum and diel water temperatures, changes in pool/riffle ratios and cover, redistribution of fishes, reduction in fish numbers, and reduction in total biomass." Moring, John R. Ph.D. 1975. "The Alsea Watershed Study: Effects of Logging on the Aquatic Resources of Three Headwater Streams of the Alsea River, Oregon – Part III." *Fishery Report Number 9* Oregon Department of Fish and Wildlife. http://www.for.gov.bc.ca/hfd/library/ffip/Moring_JR1975b.pdf	Scientific Gray Literature	The referenced article is a non-refereed publication on the effects of logging on coastal headwater streams of western Oregon, which is not relevant to this project. However, several Best Management Practices similar to those outlined in Appendix C of the DEIS are recommended. These practices have been shown to be effective at minimizing and mitigating adverse effects to water quality and riparian habitats when properly implemented. The environmental effects each action alternative to water quantity, water quality and riparian areas are disclosed in Table 31, pages 102 and 103 of the DEIS and in the Water Quality and Riparian Area Specialist's Report, Table 6, page 39.
DA-2/9, page	Timber Harvest Opposing View #9 - "For much		The reference provided was an invalid (dead) link. However, based

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36, view #52,	of the past century the Forest Service, entrusted as the institutional steward of our National Forests, focused its management on an industrial-scale logging program. The result of the massive logging and road construction program was to damage watersheds, destroy wildlife habitat and imperil plant and animal species." "The continued logging of our National Forests also wastes American tax dollars and diminishes the possibilities of future economic benefits. The Forest Service lost $2 billion dollars on the commercial logging program between 1992-1997. Annually, timber produces roughly $4 billion while recreation, fish and wildlife, clean water, and unroaded areas provide a combined total of $224 billion to the American economy. Forests purify our drinking water - 60 million Americans get their drinking water from National Forests. When the dramatic values of ecological goods and services are taken into account, it is clear that protecting National Forests creates more economic benefits than continued logging."		on the quotes provided, this reference is appears to be a position statement against logging on NFS lands. It is important for the reviewer to understand that the purpose of the 4FRI project is not simply commercial logging, but forest restoration (i.e., to reestablish and restore forest structure and pattern, forest health, and vegetation composition and diversity). There is a need to increase forest resiliency and sustainability, protect soil productivity, and improve soil and watershed function.
DA-2/10, page 37, view #53	**Timber Harvest Opposing View #53 -** "The Act to Save America's Forests is based on the principles of conservation biology. It would make the protection native biodiversity the primary goal of federal forest management agencies. The bill would protect over 20 million	Popular Press (a letter)	This is a letter discussing a bill to protect 20 million acres of forest. In order for comments to result in improved analysis and decisions, they need to be within the scope of the project, relevant to the project and have a direct relationship to the proposed actions. We could not find meaningful recommendations or comments for the Responsible Official to consider.

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	acres of core forest areas throughout the nation, including ancient forests, roadless areas, key watershed, and other special areas. It is a comprehensive, sustainable, and ecologically-sound plan for protecting and restoring the entire federal forest system. If the current pace of logging planned by the Forest Service continues, nearly all of America's ancient and roadless wild forests will soon be lost forever. According to a recent report by the World Resources Institute, only one percent of the original forest cover remains in large blocks within the lower 48 states. The Act to Save America's Forests incorporates the solution recommended by the report, namely to protect core forest areas from any logging and to allow sustainable forest practices around these protected forests. Endorsed by over 600 leading scientists, this bill may be the last hope for America's forests." Raven, Peter, Ph.D., from his February 9, 2001 letter to Senator Jean Carnahan http://www.saveamericasforests.org/Raven.htm		
DA-2/11, page 42, view #59	Timber Harvest Opposing View #11 - "The proposition that forest values are protected with more, rather than less logging, and that forest reserves are not only unnecessary, but undesirable, has great appeal to many with a	Popular Press (supported by references, some of which are Primary Science)	The publication is, in general a position statement against commercial logging. However, Part III. Considerations for Ecosystem-Based Management Approaches, provides general guidance related to land management in the form of a checklist. The document is a good reference for analytical considerations for projects such as 4FRI.

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	vested interest in maximizing timber harvest. These ideas are particularly attractive to institutions and individuals whose incomes depend upon a forest land base. (page 2)" "On the other hand, approaches that involve reserving of a portion of the land base, or harvest practices that leave commercially valuable trees uncut to achieve ecological goals, are often considered much less desirable as they reduce traditional sources of timber income. (page 2)" Franklin, Jerry Ph.D., David Perry Ph.D., Reed Noss Ph.D., David Montgomery Ph.D. and Christopher Frissell Ph.D. 2000. "Simplified Forest Management to Achieve Watershed and Forest Health: A Critique." http://www.coastrange.org/documents/forestreport.pdf		However, most of these concerns are covered in the DEIS.
DA-2/12, page 43, view #60,	Timber Harvest Opposing View #12 - “Consequently, we specifically criticize the “simplified structure-based management” approaches derived from simple structural models and traditional silvicultural systems such as clearcutting. In our view, the assumptions underpinning simplified structure-based management (SSBM) are not supported by the published scientific literature on structural development of natural forests, disturbance ecology, landscape ecology and		

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	conservation biology, or by the relationships between ecosystem structures and processes. In this report, we review scientific findings associated with each of these areas with particular attention to the over-simplified structural models associated with SSBM and the importance and viability of forest reserves to achieve various ecological goals. (page 2) "We do not believe, however, that scientific literature or forestry experience supports the notions that intensively managed forests can duplicate the role of natural forests, or that sufficient knowledge and ability exist to create even an approximation of a natural old-growth forest stand." (page 3) Franklin, Jerry F. Ph.D. and James K. Agee Ph.D. 2007. "Forging a Science-Based National Forest Fire Policy." *Issues in Science and Technology*. A National Wildlife Federation publication sponsored by the Bullitt Foundation http://www.coastrange.org/documents/forestreport.pdf		
DA-2/13, page 48, view #70	**Timber Harvest Opposing View #70 -** "Logging equipment compacts soils. Logging removes biomass critical to future soil productivity of the forest. Logging disturbs sensitive wildlife. Logging typically requires roads and skid trails	Gray Literature	This is a community blog posted with an opinion on logging damage to wildlife fire regime, water balance and soils. Chapter 3 of the draft EIS (DEIS) discloses the affected environment for each resource (and the direct/indirect environmental consequences associated with the action alternatives. Table 31, chapter 2, page 98 of the DEIS provides

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	which create chronic sources of sedimentation that degrades water quality and aquatic organism habitat. Logging roads and skid trails are also a major vector for the spread of weeds. Logging disrupts nutrient cycling and flows. Logging can alter species composition and age structure (i.e. loss of old growth). Logging can alter fire regimes. Logging can change water cycling and water balance in a drainage. The litany of negative impacts is much longer, but suffice it to say that anyone who suggests that logging is a benefit or benign is not doing a full accounting of costs." Those who suggest that logging "benefits" the forest ecosystem are using very narrow definitions of "benefit." Much as some might claim that smoking helps people to lose weight and is a "benefit" of smoking." Wuerthner, George "**Who Will Speak For the Forests?**"*NewWest,* January 27, 2009 http://www.newwest.net/topic/article/who_will_speak_for_the_forests/C564/L564/		a comparison of the predicted effects of proposed treatments by alternative. The potential for soil disturbance and soil erosion is disclosed in the DEIS on page 109 to page 113 (affected environment), and on page 113 to page 118 (environmental consequences) and pages 118-126 (Water) and in the soil specialist report from page 60 to page 120. Additionally, design features, mitigation measures and the following Soil and Water BMP's (SW2, SW4, SW7, SW9, SW10, SW11, SW12, SW14, SW19, SW23 through SW36) located in Appendix C, page 567 of DEIS have been developed and will be implemented (for timber harvest operations) to mitigate soil compaction, maintain and protect soil productivity, minimize sediment delivery and improve and protect water quality. The Chapter 3 soil and water analysis (DEIS, table 32, page 116 and pages 119-125) and (Soils Specialist report pages 62-92 and Attachment #1, page 165) shows less than 15% soil disturbance would occur (including temporary road construction) under all action alternatives which is less than 15% soil disturbance threshold identified that would maintain long term soil productivity.
DA-2/14, page 49, view #71,,	**Timber Harvest Opposing View #71 -** "After logging, peak pipeflow was about 3.7 times greater than before logging." "The use of heavy logging equipment was expected to compact the soil, reduce infiltration rates, and increase surface runoff. In addition, heavy equipment might collapse some of the	Gray Literature	This is from proceedings from a symposium and discusses the effects of timber harvesting on northern California coastal environments. Northern California coastal environments have different environmental and climatic conditions (much more precipitation), different tree species, and different timber harvesting levels and protocols than the Ponderosa Pine dominated forests in the 4FRI project area and have higher risk of compaction of soil and increase surface runoff than within the 4FRI project area. The effects disclosed

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	subsurface pipes, increasing local pore water pressure and the chance of landslides (Sidle, 1986)." Ziemer, Robert R. Ph.D., **"Effect of logging on subsurface pipeflow and erosion: coastal northern California, USA."** Proceedings of the Chengdu Symposium, July 1992. *IAHS Publication*. *No. 209*, 1992 http://www.fs.fed.us/psw/publications/ziemer/Ziemer92.PDF		in chapter 3 of the DEIS are site-specific to this project. The potential for soil disturbance and soil erosion is disclosed in the DEIS on page 109 to page 113 (affected environment), and on page 113 to page 118 (environmental consequences) and pages 118-126 (Water) and in the soil specialist report from page 60 to page 120. Additionally, design features, mitigation measures and the following Soil and Water BMP's (SW2, SW4, SW7, SW9, SW10, SW11, SW12, SW14, SW19, SW23 through SW36) located in Appendix C, page 567 of DEIS have been developed and will be implemented (for timber harvest operations) to mitigate soil compaction, maintain and protect soil productivity, minimize sediment delivery and improve and protect water quality. The Chapter 3 soil and water analysis (DEIS, table 32, page 116 and pages 119-125) and (Soils Specialist report pages 62-92 and Attachment #1, page 165) shows less than 15% soil disturbance would occur (including temporary road construction) under all action alternatives which is less than 15% soil disturbance threshold identified that would maintain long term soil productivity.
DA, Logging Harm, pg 50, View No. 72	Timber Harvest Opposing View #72 - "As conservation-minded scientists with many years of experience in biological sciences and ecology, we are writing to bring your attention to the need to protect our National Forests. Logging our National Forests has not only degraded increasingly rare and valuable habitat, but also numerous other services such as recreation and clean water." "Unfortunately, the past emphasis of management has been on logging and the original vision for our National Forests has	Popular Press	Although the link was invalid, a reference to the letter was found. This letter, from known and respected scientists, requests the President of the United States to replace commercial logging with a scientifically- based program to restore habitat and native species throughout the 192 million acre national forest system. As described on page 2 of the DEIS, the Forest Service is proposing to conduct restoration activities on approximately 587,923 acres of the Coconino NF and Kaibab NF. This proposed project is therefore well aligned with what the scientists are recommending. The effects to water quality for each action alternative are disclosed in Table 31, pages 102 and 103 of the DEIS and in the Water Quality and Riparian Area Specialist's Report, Table 6, page 39.

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	failed to be fully realized. During the past several decades, our National Forests have suffered from intense commercial logging. Today almost all of our old growth forests are gone and the timber industry has turned our National Forests into a patchwork of clearcuts, logging roads, and devastated habitat." "It is now widely recognized that commercial logging has damaged ecosystem health, clean water, and recreational opportunities-- values that are highly appreciated by the American public. The continued logging of our National Forests also wastes American tax dollars and diminishes the possibilities of future economic benefits. The Forest Service and independent economists have estimated that timber accounts for only 2.7 percent of the total values of goods and services derived from the National Forests, while recreation and fish and wildlife produce 84.6 percent." From an April 16, 2002 letter to President Bush asking him to stop all logging in the national forests. http://www.forestwatch.org/content.php?id=108		
DA-2/16, page 60, view #73	**Timber Harvest Opposing View #73 -** "Recently, so called "salvage" logging has increased on national forests in response to a timber industry invented "forest health crisis" which points the finger at normal forest processes of fire, fungi, bacteria, insects and other diseases. In fact the	Popular Press	This is a statement made at a press conference with Senator Robert Torricelli about as study conducted in Idaho on salvage logging, forest health, and threats including clearcutting to soils, watersheds and biodiversity. The 4FRI project is not proposing salvage or clearcut logging. . In order for comments to result in improved analysis and decisions, they need to be within the scope of the project, relevant

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	crisis in the national forests is habitat destruction caused by too much clearcutting. My long-term studies of forest diseases in Idaho show the loss by disease and insect activity in all age classes of forests to be less than or slightly more than 1 percent per year over the past thirty-eight years. These findings are consistent with Forest Service national level data. Forests are structured systems of many life forms interacting in intricate ways and disturbances are essential to their functioning. It's not fire disease fungi bacteria and insects that are threatening the well being of forests. Disease, fire, windthrow, and other disturbances are a natural part of the forest ecosystem and assist in dynamic processes such as succession that are essential to long term ecosystem maintenance. The real threat facing forests are excessive logging, clearcutting and roadbuilding that homogenize and destroy soil, watersheds and biodiversity of native forests." Partridge, Arthur Ph.D., Statement at a Press Conference with Senator Robert Torricelli about S. 977 and HR 1376), the Act to Save America's Forests April 28, 1998, U.S. Capitol http://www.saveamericasforests.org/news/ScientistsStatement.htm		to the project and have a direct relationship to the proposed actions. We could not find meaningful recommendations or comments for the Responsible Official to consider.
Dick Artley's Opposing Views Attachment 4 Road Construction Harm			

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DA-3/2, page 2, view #2	Debris slides over a 20-year period were inventoried on 137,500 acres of forested land in the Klamath Mountains of southwest Oregon. Frequency during the study period was about one slide every 4.3 years on each 1,000 acres- an erosion rate of about 1/2 yd^3 per acre per year. Erosion rates on roads and landings were 100 times those on undisturbed areas, while erosion on harvested areas was seven times that of undisturbed areas. Three-quarters of the slides were found on slopes steeper than 70 percent and half were on the lower third of slopes." "Soil erosion rates due to debris slides were many times higher on forests with roads, landings, and logging activity than on undisturbed forests."	Popular Science	This is a report from logging operations on the Klamath National Forest in SW Oregon. SW Oregon environments have different environmental and climatic conditions (much more precipitation), than the dryer Ponderosa Pine dominated forests in the 4FRI project area and have higher risk of debris slides and higher erosion rates. In addition, the article states three-quarters of the slides were found on slopes steeper than 70%. 4FRI does not propose any ground disturbance treatments or roads construction on slopes greater than 40% and consequently, have very low risk of debris slides and associated erosion than on the Klamath. The effects disclosed in chapter 3 of the DEIS are site-specific to this project. The potential for soil disturbance and soil erosion is disclosed in the DEIS on page 109 to page 113 (affected environment), and on page 113 to page 118 (environmental consequences) and pages 118-126 (Water) and in the soil specialist report from page 60 to page 120. Additionally, design features, mitigation measures and the following Soil and Water BMP's located in Appendix C, page 567 of DEIS have been developed and will be implemented (for timber harvest operations) to maintain and protect soil productivity, minimize sediment delivery and improve and protect water quality.
DA Road_Const_Harm, pg. 2, View 3.	Road Construction Opposing View #3 - " 'Roads may have unavoidable effects on streams, no matter how well they are located, designed or maintained. The sediment contribution to streams from roads is often much greater than that from all other land management activities combined, including log skidding and yarding.' *(Gibbons and Salo 1973)*. Research by *Megahan and Kidd* in 1972 found that roads	Scientific Gray Literature	The link provided was invalid, but the citation was found. The article provides a general description of ecological consideration that should be incorporated into sound forest management practices. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of

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	built in areas with highly erosive soils can contribute up to 220 times as much sediment to streams as intact forests." "Applying Ecological Principles to Management of the U.S. National Forests" *Issues in Ecology* Number 6 Spring 2000 http://www.watertalk.org/wawa/ecosci.html		current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.
DA-3/4, page 3, view #4	Road Construction Opposing View #4 - "Plot-level studies have demonstrated the ability of forest roads to intercept and route both subsurface and surface overland flow more efficiently to the stream network. Significant amount of subsurface throughflow can be intercepted by the road, as a function of the road cut depth and the current saturation deficit, and then redirected, concentrating the flow in particular areas below the road. Road drainage concentration increases the effective length of the channel network and strongly influences the distribution of erosional processes. The concept of wetness index has been used in the study as a surrogate for subsurface throughflow, and the effect of forest roads on subsurface throghflow rerouting has been assessed by evaluating the changes in terms of draining upslope areas. A threshold model for shallow slope instability has been used to analyse erosional impacts of drainage modifications. In the model, the occurrence of	Primary Science	The referenced citation is merely an abstract. The abstract is only broadly relevant to roads within the project area as the publication is based on roads located in Italy. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.

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	shallow landsliding is evaluated in terms of drainage areas, ground slope and soil properties (i.e., hydraulic conductivity, bulk density, and friction angle). The model has been used to generate hypotheses about the broader geomorphic effect of roads. Modelling results have been compared with available field data collected in north-eastern Italy." Borga, M., F. Tonelli, G. Dalla Fontana and F. Cazorzi "**Evaluating the Effects of Forest Roads on Shallow Landsliding**" *Geophysical Research Abstracts*, Vol. 5, 13312, 2003 http://www.cosis.net/abstracts/EAE03/13312/EAE03-J-13312.pdf		
DA-3/5, page 4, view #5	Road Construction Opposing View #5 - "A large scale land use experiment has taken place over the last 40 years in the mountainous areas of the northwestern U.S. through timber harvesting. This land use change effects the hydrology of an area through two mechanisms: • Clear-cut logging which causes changes in the dynamics of Rain-On-Snow (ROS) events due to changes in the accumulation and ablation of snow caused by vegetation effects on snow interception and melt; and	Scientific Gray Literature?	The link provided was invalid (i.e., returned no results). The first comment is related to clearcutting, which is irrelevant to this project. The second comment is related to the effects of roads in the northwest U.S. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590

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	• Construction and maintenance of forest roads which channel intercepted subsurface flow and infiltration excess runoff to the stream network more quickly.” Bowling, L.C., D. P. Lettenmaier, M. S. Wigmosta and W. A. Perkins “Predicting the Effects of Forest Roads on Streamflow using a Distributed Hydrological Model” from a poster presented at the fall meeting of the American Geophysical Union, San Francisco, CA, December 1996. http://www.ce.washington.edu/~lxb/poster.html		(SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.
DA-3/7, page 5, view #7	Road Construction Opposing View #7 - "The present road system constitutes a legacy of current and potential sources of damage to aquatic and riparian habitats, mostly through sedimentation, and to terrestrial habitats through fragmentation and increased access" (Amaranthus et all 1985)." "The failure of the Report to properly address mitigation costs associated with the ecological effects is a serious problem that needs to be addressed in future drafts. Similarly, passive-use values need to be taken seriously and considered throughout the Roads Report. In order to rectify these problems, most of the Socio-Economic Effects subsections will have to	Popular Press	The article provides a review of the Forest Service roads policy titled: Forest Service Roads: a Synthesis of Scientific Information (1998). The article is a position statement that identifies proposed weaknesses in the analysis and policy. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist’s Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and

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	be reworked. Failing to do so, the Roads Report will paint an incomplete picture of the costs and benefits associated with the Forest Service's road program." Brister, Daniel. "A Review and Comment on: *Forest Service Roads:* *A Synthesis of Scientific Information*, 2nd Draft, USDA Forest Service." December 1998. http://www.wildlandscpr.org/forest-service-roads-synthesis-scientific-information-socio-economic-impacts		mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.
DA-3/8. Page 6, view #8	Road Construction Opposing View #8 - "Sediment input to freshwater is due to either the slower, large-scale process of soil erosion, or to rapid, localized "mass movements," such as landslides. Forest practices can increase the rate at which both processes occur. Most sediment from forestry arises from landslides from roads and clearcuts on steep slopes, stream bank collapse after riparian harvesting, and soil erosion from logging roads and harvested areas. Roads, particularly those that are active for long periods of time, are likely the largest contributor of forestry-induced sediment (Furniss et al. 1991)." "Sediment can increase even when roads comprise just 3% of a basin (Cederholm et al.		The reference cited is specific to salvage logging following mountain pine beetle infestations. The 4FRI project does not include salvage logging. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and

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	1981)." "More than half the species present in the study area will likely be negatively impacted by sedimentation from logging roads." "In areas made highly turbid (cloudy) from sedimentation, the foraging ability of adults and juveniles may be inhibited through decreased algal production and subsequent declines in insect abundance, or, for visual-feeding taxa dependent on good light, through their inability to find and capture food. Highly silted water may damage gill tissue and cause mortality or physiological stress of adults and juveniles." Bunnell, Fred L. Ph.D., Kelly A. Squires and Isabelle Houde. 2004 "Evaluating effects of large-scale salvage logging for mountain pine beetle on terrestrial and aquatic vertebrates." *Mountain Pine Beetle Initiative Working Paper 1*. Canadian Forest Service. http://warehouse.pfc.forestry.ca/pfc/25154.pdf		obliteration and permanent road maintenance activities.
DA-3/13, page 8, view #13	Road Construction Opposing View #13 - "Few marks on the land are more lasting than roads." "The negative effects on the landscape of constructing new roads, deferring maintenance, and decommissioning old roads are well documented. Unwanted or non-native plant species can be transported on vehicles and	Scientific Gray Literature	The publication discusses and discloses the adverse ecological effects of forest roads, which are not refuted. The citation concludes with a statement of support for a road management strategy on NFS lands that would improve service to users, protect environmental values, enhance public safety, mitigate environmental impacts, promote viable local communities, and boost credibility of our natural resource management.

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	clothing by users of roads, ultimately displacing native species. Roads may fragment and degrade habitat for wildlife species and eliminate travel corridors of other species. Poorly designed or maintained roads promote erosion and landslides, degrading riparian and wetland habitat through sedimentation and changes in streamflow and water temperature, with associated reductions in fish habitat and productivity. Also, roads allow people to travel into previously difficult or impossible to access areas, resulting in indirect impacts such as ground and habitat disturbance, increased pressure on wildlife species, increased litter, sanitation needs and vandalism, and increased frequency of human-caused fires." EPA entry into the Federal Register: March 3, 2000 (Volume 65, Number 43) Page 11675, "National Forest System Road Management." http://www.epa.gov/fedrgstr/EPA-GENERAL/2000/March/Day-03/g5002.htm		The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.
DA-3/14, page 9, view #14	Road Construction Opposing View #14 - "Fragmentation caused by roads is of special interest because the effects of roads extend tens to hundreds of yards from the roads themselves, altering habitats and water drainage patterns, disrupting wildlife movement, introducing exotic plant species, and increasing noise levels. The land development that follows roads out into rural	Scientific Gray Literature	The emphasis of this web page reference is forest fragmentation caused by roads. However other adverse effects of forest roads are discussed. These potential adverse effects are not refuted. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through

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	areas usually leads to more roads, an expansion process that only ends at natural or legislated barriers.” “Forest Fragmentation and Roads” Eastern Forest Environmental Threat Assessment Center U.S. Forest Service - Southern Research Station http://www.forestthreats.org/publications/su-srs-018/fragmentation		decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.
DA-3/15, page 9, view #15	Road Construction Opposing View #15 - “A huge road network with vehicles ramifies across the land, representing a surprising frontier of ecology. Species-rich roadsides are conduits for few species. Roadkills are a premier mortality source, yet except for local spots, rates rarely limit population size. Road avoidance, especially due to traffic noise, has a greater ecological impact. The still-more-important barrier effect subdivides populations, with demographic and probably genetic consequences. Road networks crossing landscapes cause local hydrologic and erosion effects, whereas stream networks and distant valleys receive major peak-flow and sediment impacts. Chemical effects mainly occur near roads. Road networks interrupt horizontal ecological flows, alter landscape spatial pattern, and therefore inhibit important interior species. Thus, road density and network structure are informative landscape ecology assays. Australia	Scientific Gray Literature	The publication provides a global-scale review of the ecological effects of road corridors. It does not address road construction. The article primarily concentrates on major, arterial roads and not unpaved forest roads. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist’s Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.

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	has huge road-reserve networks of native vegetation, whereas the Dutch have tunnels and overpasses perforating road barriers to enhance ecological flows. Based on road-effect zones, an estimated 15–20% of the United States is ecologically impacted by roads." Forman, Richard T. and Lauren E. Alexander "Roads and their Major Ecological Effects" *Annual Review of Ecology and Systematics*, Vol. 29: 207-231, November 1998 http://arjournals.annualreviews.org/doi/abs/10.1146/annurev.ecolsys.29.1.207?cookieSet=1&journalCode=ecolsys.1		
DA 3/18, page 11, view #18	Road Construction Opposing View #18 - "Rarely can roads be designed and built that have no negative impacts on streams. Roads modify natural drainage patterns and can increase hillslope erosion and downstream sedimentation. Sediments from road failures at stream crossings are deposited directly into stream habitats and can have both on-site and off-site effects. These include alterations of the channel pattern or morphology, increased bank erosion and changes in channel width, substrate composition, and stability of slopes adjacent to the channels." "All of these changes result in important biological consequences that can affect the entire stream ecosystem. One specific example involves anadromous salmonids, such as salmon	Primary Science	This publication provides a comprehensive review of the ecological effects of forest roads, and, more specifically, the effects of stream crossing. These adverse effects are not refuted. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and

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	and steelhead, that have complex life histories and require suitable stream habitat to support both juvenile and adult life stages." "A healthy fishery requires access to suitable habitat that provides food, shelter, spawning gravel, suitable water quality, and access for upstream and downstream migration. Road-stream crossing failures have direct impacts on all of these components." Furniss, Michael J., Michael Love Ph.D. and Sam A. Flanagan "Diversion Potential at Road-Stream Crossings." USDA Forest Service. *9777 1814—SDTDC.* December 1997. http://www.stream.fs.fed.us/water-road/w-r-pdf/diversionpntl.pdf		obliteration and permanent road maintenance activities.
DA-3/19, page 12, view #19	Road Construction Opposing View #19 - "Barry Noon, a professor of wildlife ecology at Colorado State University, noted that scientific research has consistently shown the adverse effects of roads on hydrologic processes and fish and wildlife populations. "One of the key things to recognize is the effects of the roads extend far beyond their immediate footprint," Noon said. For example, "in terms of hydrology, the roads are leading to faster runoff of water, often with great increases in sedimentation, particularly following storm events, and roads in watersheds often lead to increases in the	Popular Press	This web page citation includes a discussion of the adverse effects of road systems on hydrologic processes, which are not refuted. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and

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	intensity of floods." " These changes degrade fish habitat because of the increased sedimentation that leads to decreases in water quality, Noon said. And roads fragment wildlife habitat and create areas that animals avoid, often as result of increased hunting, he said." Gable, Eryn "Battling beetles may not reduce fore risks – report" *Land Letter*, March 4, 2010 http://www.xerces.org/2010/03/04/battling-beetles-may-not-reduce-fire-risks-report/		after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.
DA-3/20, page 12, view #20	Roads and skid trails have been identified as a major contributor to increased turbidity of water draining logging areas resulting in increases from 4 to 93 parts per million (Hoover, 1952). Forest roads have been found to have erosion rates from one to three orders of magnitude greater than similar undisturbed areas (Megahan, 1974) and perhaps account for as much as 90 percent of all forest erosion (Megahan, 1972). Forest roads can also cause soil erosion and stream sedimentation, which adversely impact on the nation's water quality (Authur et al., 1998)	Gray Literature	This article and comment were released in the proceedings from conference 34 international erosion control association; ISSN 1092-2806 place of publication unknown. They study was conducted on the Tuskegee National Forest in Alabama and studies the effectiveness of four alternative road sediment control treatments: vegetation, riprap, sediment fences, and settling basins (detention ponds), in reducing sediment export to the forest floor were evaluated. Studying the effectiveness of alternative roads sediment control treatments are outside the scope of the project and do not meet the purpose and need (DEIS chapter 1, page 8) which is to reestablish and restore forest structure and pattern, forest health and vegetation composition and diversity. In addition, the climatic conditions on the Tuskegee National Forest are not similar to climatic condition in the 4FRIproject area (they are hotter and wetter) and have higher potential for soil erosion than in the 4FRI project area. The DEIS proposes no new permanent road construction (DEIS page 40, p 63, p 81, p 88). The DEIS proposes a reduction of current roads

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			through the proposed decommissioning of 904 miles of road (DEIS @ p41, p 63, Table 18 p 74, p 81, p 88), thus actually decreasing the effects of roads that are currently located within the analysis area. Also see response DA #2 above relative to disclosure of site-specific effects and mitigation measures and soil and water BMPs designed to protect water quality.
DA-3/21, page 13, view #21	Road Construction Opposing View #21 - "Roads have well-documented, short- and long-term effects on the environment that have become highly controversial, because of the value society now places on unroaded wildlands and because of wilderness conflicts with resource extraction." "(Road) consequences include adverse effects on hydrology and geomorphic features (such as debris slides and sedimentation), habitat fragmentation, predation, road kill, invasion by exotic species, dispersal of pathogens, degraded water quality and chemical contamination, degraded aquatic habitat, use conflicts, destructive human actions (for example, trash dumping, illegal hunting, fires), lost solitude, depressed local economies, loss of soil productivity, and decline in biodiversity." Gucinski, Hermann Ph.D., Michael J. Furniss, Robert R. Ziemer Ph.D. and Martha H. Brookes, Editors. 2001. "Forest Roads: A Synthesis of Scientific Information." USDA Forest Service, General Technical Report	Primary Science	This publication provides a comprehensive description of the effects of forest roads, which include physical, ecological, geomorphic and hydrologic effects, indirect and landscape level effects (such as effects on aquatic habitat, terrestrial vertebrates, and biodiversity conservation), and socioeconomic effects (such as passive-use value, economic effects on development and range management). These effects are not refuted. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist’s Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.

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	PNW-GTR-509. http://www.fs.fed.us/pnw/pubs/gtr509.pdf		
DA-3/23, page 14, view #23	Many forested landscapes are fragmented by roads, but our understanding of the effects of these roads on the function and diversity of the surrounding forest is in its infancy. I investigated the effect of roads in otherwise continuous forests on the macroinvertebrate fauna of the soil. I took soil samples along transects leading away from the edges of unpaved roads in the Cherokee National Forest in the Southern Appalachian mountains of the United States. Roads significantly depressed both the abundance and the richness of the macroinvertebrate soil fauna. Roads also significantly reduced the depth of the leaf-litter layer. These effects persisted up to 100 m into the forest. Wider roads and roads with more open canopies tended to produce steeper declines in abundance, richness, and leaf-litter depth, but these effects were significant only for canopy cover and litter depth. The macroinvertebrate fauna of the leaf litter plays a pivotal role in the ability of the soil to process energy and nutrients. These macroinvertebrates also provide prey for vertebrate species such as salamanders and ground-foraging birds. The effect of roads on the surrounding forest is compounded by the sprawling nature of the road system in this and many other forests. My data suggest that even	Gray Literature	This is a paper submitted to the Conservation Biology Journal on the effects of roads on the macroinvertebrate fauna of the soil in the Cherokee National Forest in the southern Appalachian mountains. The study investigates the effects of roads on macroinvertebrates in the soil which is outside the scope of the 4FRI project. The 4FRI project is not proposing construction of any new roads and temporary roads will be obliterated, and adequately protected from erosional processes protecting both soil nutrient cycling function and loss of soil productivity (DEIS page 40, p 63, p 81, p 88). The DEIS proposes a reduction of current roads through the proposed decommissioning of 904 miles of road (DEIS @ p41, p 63, Table 18 p 74, p 81, p 88), thus actually decreasing the effects of roads that are currently located within the analysis area. Furthermore, the study site is located in dissimilar environmental, climatic and soil conditions than soils in the 4FRI project area. Chapter 3 of the draft EIS (DEIS) disclosed the affected environment for each resource (including roads) and the direct/indirect environmental consequences associated with the action alternatives in chapter 3, from page 63 to page 345. Pages 109 – 118 disclose affected environment and environmental effects to soil in and pages 119-136 disclose affected environment and environmental effects to water resources and pages 118-126 (Water) and in the soil specialist report from page 60 to page 120.

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	relatively narrow roads through forests can produce marked edge effects that may have negative consequences for the function and diversity of the forest ecosystem." Haskell, David G. Ph.D. 1999 "**Effects of Forest Roads on** **Macroinvertebrate Soil Fauna of the Southern Appalachian Mountains**" http://www.jstor.org/stable/2641904		
DA-3/24, page 15, view #24	Road Construction Opposing View #24 - "Roads remove habitat, alter adjacent areas, and interrupt and redirect ecological flows. They subdivide wildlife populations, foster invasive species spread, change the hydrologic network, and increase human use of adjacent areas. At broad scales, these impacts cumulate and define landscape patterns." Hawbaker, Todd J. Ph.D., Volker C. Radeloff Ph.D., Murray K. Clayton Ph.D., Roger B. Hammer Ph.D., and Charlotte E. Gonzalez-Abraham Ph.D. "Road Development, Housing Growth, and Landscape Fragmentation In Northern Wisconsin: 1937–1999" *Ecological Applications*: Vol. 16, No. 3, pp. 1222-1237. http://www.esajournals.org/doi/abs/10.1890/1051-	Primary Science	This article is largely related to road development in rural Wisconsin and associated subsequent habitation/development of roaded areas. The ecological effects of road networks are discussed. While the ecological effects of roads are not refuted, this article does not directly relate to temporary road construct as proposed under the action alternatives. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.

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	0761%282006%29016%5B1222%3ARDHGAL%5D2.0.CO%3B2?journalCode=ecap		
DA-3/26, page 16, view #26	Road Construction Opposing View #26 - "Although disturbance patches are created by peak flow and debris flow disturbances in mountain landscapes without roads, roads can alter the landscape distributions of the starting and stopping points of debris flows, and they can alter the balance between the intensity of flood peaks and the stream network's resistance to change." Jones, Julia A. Ph.D., Frederick J. Swanson Ph.D. Beverley C. Wemple Ph.D., and Kai U. Snyder. "Effects of roads on hydrology, geomorphology, and disturbance patches in stream networks." *Conservation Biology* 14, No. 1. 2000. http://www.jstor.org/stable/2641906	Primary Science	The article provides a synopsis of the biological and ecological effects of roads, particularly where roads intersect streams. The research was conducted in the H. J Andrews Experimental Forest in Oregon, so it is not directly relevant to this project. The effects disclosed are not refuted, but not all are relevant to the semi-arid Southwest. However, some general monitoring recommendations are provided that could prove useful for detecting adverse effects of roads intersecting perennial streams. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.
DA-3/27, page 16, view #27	In the Pacific Northwest, the two main processes that contribute to sediment production are mass failure and surface erosion from forest roads (Fredriksen 1970, Reid and Dunne 1984). In the Clearwater River basin in	Gray Literatture	This is a research note from the Pacific NW Research Station suggesting a method for measuring sediment production from roads. Measuring sediment production form roads is outside the scope of the 4FRI project and does not meet the purpose and need (DEIS chapter 1, page 8) which is to reestablish and restore forest structure

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	the State of Washington, as much as 40 percent of the sediment produced in the watershed was attributed to logging roads (Reid 1980)." Kahklen, Keith. **"A Method for Measuring Sediment Production from Forest Roads."** Pacific Northwest Research Station, USDA Forest Service. Research note *PNW-RN-529*, April 2001. http://www.fs.fed.us/pnw/pubs/rn529.pdf		and pattern, forest health and vegetation composition and diversity. The need is to increase forest resiliency and sustainability and protect soil productivity and improve soil and watershed function. The DEIS proposes no new permanent road construction (DEIS page 40, p 63, p 81, p 88). The DEIS proposes a reduction of current roads through the proposed decommissioning of 904 miles of road (DEIS @ p41, p 63, Table 18 p 74, p 81, p 88), thus actually decreasing the effects of roads that are currently located within the analysis area.
DA-3/30, page 18, view #30	The compaction of forest road soils is known to reduce aeration, porosity, infiltration rates, water movement, and biological activity in soils. Research indicates that soil bulk density, organic matter, moisture, and litter depths are much lower on roads than on nearby forest lands. Macropores, which provide soil drainage and infiltration, have been shown to significantly decrease in size as a result of road construction and use. Reduced infiltration and increased compaction promote soil erosion, especially during the seasonal southwestern monsoon rains (Elseroad 2001)." "Physical disturbances caused by road construction and vehicle use create ideal conditions for colonization by invasive exotic plant species. The use of roads by vehicles, machinery, or humans often aids the spread of exotic plant seeds. Once established, they can have long-term impacts on surrounding		This is a working paper describing the effects to soils from existing and new road construction. The DEIS proposes no new permanent road construction (DEIS page 40, p 63, p 81, p 88).The DEIS proposes a reduction of current roads through the proposed decommissioning of 904 miles of road (DEIS @ p41, p 63, Table 18 p 74, p 81, p 88), thus actually decreasing the effects of roads that are currently located within the analysis area. The 4FRI project propose about 500 miles of temporary road construction that will be obliterated with appropriate design features and BMPs. Appendix C, page 567 includes design features, mitigation measures and the following Soil and Water BMP's (SW2, SW14, SW16, SW20, SW24, SW30, SW32, T7, T8, RS3) that will be implemented (for temporary road construction) to maintain and protect soil productivity, minimize sediment delivery and improve and protect water quality and aquatic resources. Chapter 2, page 65 of the DEIS states construction (and decommissioning) temporary roads is an action common to the action alternatives. Page 65 further states reconstructing and improving roads, relocating a minimal number of road miles, and decommissioning existing roads and unauthorized routes is a

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	ecosystems and can be difficult to remove." "Roads are known to cause habitat fragmentation. Many create ecological 'edges' with different plant species, light levels, and hiding cover, all of which may alter animal survival, reproductive success, and movement patterns. The introduction of exotic plants can disrupt the availability of native vegetation used by wildlife for food and shelter (Trombulak and Frissell 1999)." "Forest roads often develop a water-repellent soil layer caused by lack of vegetative cover and changes in soil composition. This can substantially influence how runoff is processed. Erosion, the formation of water channels beside the road, and increased sediment loads in nearby streams are common results of this process (Baker 2003)." "Because they provide easier access to many forest tracts, forest roads often allow more human-caused fires to be ignited." Lowe, Kimberly Ph.D.,**"Restoring Forest Roads."**A Northern Arizona University Ecological Restoration Institute publication *Working Paper 12*. June, 2005. http://www.eri.nau.edu/en/information-for-practitioners/restoring-forest-roads		common action to action alternatives. Table 15 displays management actions and road adaptive management strategies designed to mitigate effects to soil and water resources and include complete road obliteration, blocking entrance reducing motorized impacts, re-establishing road drainage, removal of culverts, installation of waterbars, protecting against erosion with slash. In addition, (DEIS page 114) alternative B would decommission 496 miles of road in functioning at risk watersheds, and decommission 226 miles of roads located in impaired function watersheds resulting reduced the hydrologic connectivity between roads and steams and improved water quality. BMPs are designed to control and reduce the spread of invasive weeds and is located in DEIS Appendix C, page 586, SW BMP4 The effects of vegetation actions to resources including soils, water, noxious weeds, is located in the DEIS at page 109 to page 126 (soil and water and pages 268-271 (invasive weeds). The soils analysis indicates for all action alternatives, soil design features and best management practices are in place to reduce the potential for erosion (loss of soil productivity). The soils analysis (DEIS, table 32, page 116) shows less than 15% soil disturbance would occur under all action alternatives which is less than 15% soil disturbance threshold identified that would maintain long term soil productivity. Need statement on forest roads causing human fires.
DA-3/31, page	Road Construction Opposing View #31 - "Almost	Primary Science	The article provides a brief synopsis of roads-related effects to

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19, view #31	everywhere people live and work they build and use unimproved roads, and wherever the roads go, a range of environmental issues follows." "Among the environmental effects of unimproved roads, those on water quality and aquatic ecology are some of the most critical. Increased chronic sedimentation, in particular, can dramatically change the food web in affected streams and lakes." "The nearly impervious nature of road surfaces (or treads) makes them unique within forested environments and causes runoff generation even in mild rainfall events, leading to chronic fine sediment contributions." "If we look at the issue of what we need to learn or the research priorities for forest road hydrology, I would argue that the areas of cutslope hydrology and effectiveness of restoration efforts are perhaps most critical." "At a few sites in the mountains of Idaho and Oregon a substantial portion of the road runoff (80–95%) came from subsurface flow intercepted by the cutslope (Burroughs *et al.*, 1972; Megahan, 1972; Wemple, 1998)." Luce, Charles H. Ph.D., 2002. "Hydrological processes and pathways affected by forest roads: what do we still need to learn?" http://www.fs.fed.us/rm/boise/teams/soils/Publications/Luce%202002%20HP.pdf		surface and subsurface hydrology and research methods and opportunities that would improve our understanding of road effects on hydrologic processes. It is a useful reference for hydrologists and roads engineers. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.

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DA-3/32, page 20, view #32	Road Construction Opposing View #32 - "Roads in the watershed contribute to sediment production by concentrating runoff, thereby increasing sediment load to the stream network. Most unimproved (dirt) roads connect either directly or indirectly with streams and, therefore, act as extensions of stream networks by effectively increasing watershed drainage density and subsequently sediment loads to streams. In the South Fork subwatershed of Squaw Creek, road connectivity has resulted in an increase in effective drainage density of approximately 250%. Throughout the Squaw Creek watershed, it is estimated that dirt roads potentially contribute as much as 7,793 metric tons/year to the watershed sediment budget." Maholland, Becky and Thomas F. Bullard Ph.D., "Sediment-Related Road Effects on Stream Channel Networks in an Eastern Sierra Nevada Watershed." *Journal of the Nevada Water Resources Association*, Volume 2, Number 2, Fall 2005. http://www.nvwra.org/docs/journal/vol_2_no_2/NWRAjournal_fall2005_article4.pdf	Scientific Gray Literature	The publication provides a detailed description of a study located northwest of Lake Tahoe, California to improve understanding of the geomorphic processes influencing sediment movement through a subalpine tributary to a 303(d) listed stream (Squaw Creek) by conducting a sediment source assessment. The literature review provides a good synopsis of the adverse effects of roads on hydrology and sediment movement. However, the project was undertaken in a subalpine catchment. There are no treatments proposed in subalpine area as part of this proposed project. The article is therefore not directly relevant to this proposed project. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.
DA-3/33, page 20, view #33	Road Construction Opposing View #33 - "One of the greatest impacts of roads and (especially	Popular Press	This reference is a newsletter that describes, in general terms the effects of roads and what restoration entails. It's a good general

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	motorized) trails is their effect on the hydrology of natural landscapes, including the flow of surface and ground water and nutrients. These hydrologic effects are responsible for changes to geomorphic processes and sediment loads in roaded areas (Luce and Wemple 2001)." (pg. 12) Malecki, Ron W. "A New Way to Look at Forest Roads: the Road Hydrologic Impact Rating System (RHIR)" *The Road-RIPorter*, Autumn Equinox, 2006 http://www.wildlandscpr.org/files/uploads/RIPorter/rr_v11-3.pdf		information publication and provide some meaningful information on road decommissioning/obliteration and discusses funding mechanisms to facilitate ecological restoration. However, it is not directly relevant to the 4FRI project. The effects of roads discussed in this publication are not refuted. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.
DA-3/34, page 21, view #34	A study was made on 344 miles of logging roads in northwestern California to assess sources of erosion and the extent to which road-related erosion is avoidable. At most, about 24 percent of the erosion measured on the logging roads could have been prevented by conventional engineering methods. The remaining 76 percent was caused by site conditions and choice of alignment. On 30,300 acres of commercial timberland, an estimated 40 percent of the total erosion associated with	Gray Literature	This is a paper published in the Journal of Forestry studying the sources of erosion in northwest California. The findings indicate erosion could have been prevented with proper engineering methods and choice of road alignment. In the 4FRI project, design features, mitigation measures and the following Soil and Water BMP's (SW2, SW14, SW16, SW20, SW24, SW30, SW32, T7, T8, RS3) located in Appendix C, page 567 of DEIS have been developed and will be implemented (for temporary road construction) to maintain and protect soil productivity, minimize sediment delivery and improve and protect water quality In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p 63, p 81, p

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	management of the area was found to have been derived from the road system." McCashion, J. D. and R. M. Rice Ph.D. 1983. **"Erosion on logging roads in northwestern California: How much is avoidable?"** *Journal of Forestry* 8(1): 23-26. http://www.fs.fed.us/psw/rsl/projects/water/McCashion.pdf		88).The DEIS proposes a reduction of current roads through the proposed decommissioning of 904 miles of road (DEIS @ p41, p 63, Table 18 p 74, p 81, p 88), thus actually decreasing the effects of roads that are currently located within the analysis area. See response CBD-1 for same response.
DA-3/35, page 21, view #35	Road Construction Opposing View #35 - "Research has shown that roads can have adverse impacts on the water quality on the forest landscape (Authur et al. 1998; Binkley and Brown 1993; Megahan et al. 1991). The forest road system has been identified by previous research as the major source of soil erosion on forestlands (Anderson et. al 1976; Patric 1976; Swift 1984; Van Lear et al. 1997). Furthermore, roads are cited as the dominant source of sediment that reaches stream channels (Packer 1967; Trimble and Sartz 1957; Haupt 1959)." McFero III, Grace, J. "Sediment Plume Development from Forest Roads: How are they related to Filter Strip Recommendations?" An ASAE/CSAE Meeting Presentation, Paper Number: 045015, August 1-4, 2004. http://www.srs.fs.usda.gov/pubs/ja/ja_grace017.pdf	Scientific Gray Literature	This publication describes a study that was undertaken to assess sediment transport distances downslope of forest roads and characterize the factors influencing these distances. The study references sites in Georgia and Alabama, which have distinctly different soil types and precipitation patterns that this region. However, some general BMPs are recommended. BMPs outlined in the DEIS for this project exceed those recommended in the referenced publication. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist’s Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and

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			obliteration and permanent road maintenance activities.
DA-3/38, page 23, view #38	"Erosion from forest roads can be a large source of sediment in watersheds managed for timber production." Megahan, Walter F. Ph.D. "**Predicting Road Surface Erosion from Forest Roads in Washington State**"from a presentation presented at the 2003 Geological Society of America meeting. http://gsa.confex.com/gsa/2003AM/finalprogram/abstract_67686.htm	Popular Press	This is a presentation abstract given at the Geological Society of America meeting in 2003 on a road erosion model used in Washington State. It describes an erosion model tool used to predict erosion from roads. In order for comments to result in improved analysis and decisions, they need to be within the scope of the project, relevant to the project and have a direct relationship to the proposed actions. We could not find meaningful recommendations or comments for the Responsible Official to consider.
DA-3/39, page 23, view #39	Road Construction Opposing View #39 - "Today, addressing the adverse impacts of forest roads is consistently identified as one of the highest watershed restoration priorities in U.S. forests—in many forested watersheds in the western United States there is a greater road density than stream density. It is simply irrational to spend millions of dollars subsidizing further forest road construction when we are simultaneously spending millions of dollars to offset detrimental effects associated with similar actions in the past." Montgomery, David Ph.D., Statement at a Press Conference with Senator Robert Torricelli about S. 977 and HR 1376), the Act to Save America's Forests April 28, 1998, U.S. Capitol	Popular Press	The article provides economic justification for not constructing new forest roads, given the density of existing roads networks and the adverse ecological effects, particularly in the Western U.S. This article is relevant to the 4FRI project since the proposed projects includes decommissioning of 904 miles of existing roads, no new construction of permanent roads, and decommissioning of constructed temporary roads upon completion of activities. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590

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	http://www.saveamericasforests.org/news/ScientistsStatement.htm		(SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.
DA-3/43, page 26, view #43	Road Construction Opposing View #43 - “Erosion on roads is an important source of fine-grained sediment in streams draining logged basins of the Pacific Northwest. Runoff rates and sediment concentrations from 10 road segments subject to a variety of traffic levels were monitored to produce sediment rating curves and unit hydrographs for different use levels and types of surfaces. These relationships are combined with a continuous rainfall record to calculate mean annual sediment yields from road segments of each use level. A heavily used road segment in the field area contributes 130 times as much sediment as an abandoned road. A paved road segment, along which cut slopes and ditches are the only sources of sediment, yields less than 1% as much sediment as a heavily used road with a gravel surface.” Reid, L. M. Ph.D. and T. Dunne (1984), “Sediment Production from Forest Road Surfaces,” *Water Resour. Res.*, 20(11), 1753–1761. http://www.agu.org/pubs/crossref/1984/WR020i	Primary Science	This article presents a road sediment study conducted in NW Washington State on the Olympic Mountains. Soils in the project area are Inceptisols, which are very dissimilar to soils in the project area. Precipitation patterns are also vastly different than those of the Southwestern U.S. The publication is therefore not relevant to this proposed project. However, road sediment research methodologies are presented that would improve understand of the effects of roads on in-stream water quality. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist’s Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.

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DA-3/44, page 27, view #44	Road Construction Opposing View #44 - "Roads are associated with high sediment inputs and altered hydrology, both of which can strongly influence downstream channel habitats. Roads are also important as a source of indirect human impacts and as an agent of vegetation change and wildlife disturbance." "Any ground disturbance increases the potential for erosion and hydrologic change, and roads are a major source of ground disturbance in wildlands. Compacted road surfaces generate overland flow, and much of this flow often enters the channel system, locally increasing peak flows. Localized peak flows are also increased where roads divert flow from one swale into another, and where roadcuts intercept subsurface flows." "Overland flow from the road surface is a very effective transport medium for the abundant fine sediments that usually are generated on road surfaces. Road drainage also can excavate gullies and cause landslides downslope in swales. Cut and fill slopes are often susceptible to landsliding, and road-related landsliding is the most visible forestry-related erosional impact in many areas." Reid, Leslie M. Ph.D., Robert R. Ziemer Ph.D., and Michael J. Furniss 1994. "What do we know	Scientific Gray Literature	The publication provides a synopsis of the effects of forest roads on a variety of ecosystem functions, which are not unlike those within the project area. It further provides guidance on analytical methods for assessing and inventorying forest road network needs that would facilitate a more sustainable, and ecologically sound road network. This information is not refuted and is relevant to the 4FRI project. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.

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	about Roads?" USDA Forest Service. http://www.fs.fed.us/psw/publications/reid/4Roads.htm		
DA-3/45, page 28, view #45	Road Construction Opposing View #45 - "Disturbances from roadbuilding and logging changed the sediment/discharge relationship of the South Fork from one which was supply dependent to one which was stream power dependent, resulting in substantial increases in suspended sediment discharges." "Road construction and logging appear to have resulted in increases in average turbidity levels (as inferred from suspended sediment increases) above those permitted by Regional Water Quality Regulations." Rice, Raymond M. Ph.D., Forest B. Tilley and Patricia A. Datzman. 1979. "Watershed's Response to Logging and Roads: South Fork of Caspar Creek, California, 1967-1976." USDA Forest Service, *Research Paper PSW-146*. http://www.fs.fed.us/psw/publications/rice/Rice79.pdf	Primary Science	The publication describes a long-term study of the effects of logging and road building Ft. Bragg, CA. It is not directly relevant to this project, although it does identify increased surface water turbidity as a concern. This concern would also apply within the 4FRI analysis area and is discussed in the EIS. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.
DA-3/46, page 28, view #46	Road Construction Opposing View #46 - "Sediment eroded from gravel roads can be a major component of the sediment budget in streams in this region (Van Lear, et al, 1995)."	Primary Science	The publication presents a study undertaken in the southern Appalachian Mountains in northern Georgia and southern Tennessee. Soil types and precipitation patterns are vastly different than those in the Southwestern U.S. This publication is therefore not

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	Riedel, Mark S. Ph.D. and James M. Vose Ph.D., "Forest Road Erosion, Sediment Transport and Model Validation in the Southern Appalachians." Presented at the Second Federal Interagency Hydrologic Modeling Conference, July 28 – August 1, 2002. http://www.srs.fs.usda.gov/pubs/ja/ja_riedel002.pdf		relevant to this project. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.
DA-3/49, page 30, view #49	Road Construction Opposing View #49 - "The effects of forest roads on hydrology are related to the effects of forest clearing. Most logging requires road access, and the roads often remain after the logging, so there are both short and long-term effects.[94] Forest road surfaces are relatively impermeable. Water readily runs over the road surface and associated roadside ditches, often directly to a stream channel, with the net effect of extending channel networks and increasing drainage density.[95] In addition to providing conduits for overland flow, forest roads involve slope-cuts and ditching that may intersect the water table and interrupt natural subsurface		This publication is generally related to development in mountainous regions, although it does include information related to soil compaction and impervious surfaces and the effects of these areas on water quality and stream habitats. However, it is not directly relevant to the 4FRI project. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist's Report, pages 48 and 49, pages 53 and 54, and pages 62 and 63. The DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22,

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	water movement.[96] This diversion of subsurface water may be quantitatively more important than the overland flow of storm water in some watersheds.[97] The importance of roads in altering basin hydrology has been underscored in paired-watershed studies and recent modeling studies.[98] " (Pgs. 730 and 731) Shanley, James B. and BeverleyWemple Ph.D. "Water Quantity and Quality in the Mountain Environment" *Vermont Law Review*, Vol. 26:717, 2002		SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.
DA-3/50, page 31, view #50	Roads are often the major source of soil erosion from forested lands (Patric 1976)." "Generally, soil loss is greatest during and immediately after construction." Swift Jr., L. W. **"Soil losses from roadbeds and cut and fill slopes in the Southern Appalachian Mountains."** *Southern Journal of Applied Forestry* 8: 209-216. 1984. http://cwt33.ecology.uga.edu/publications/403.pdf	Gray Literature	This North Carolina study was published in the Southern Journal of Applied Forestry and shows that inclined surfaces of cut and fill slopes are potential sources of large soil loss but these losses can be mitigated by early establishment of grass cover and by design features to control storm water. In the 4FRI project, design features, mitigation measures and the following Soil and Water BMP's (SW2, SW14, SW16, SW20, SW24, SW30, SW32, T7, T8, RS3) located in Appendix C, page 567 of DEIS have been developed and will be implemented (for temporary road construction) to maintain and protect soil productivity, minimize sediment delivery and improve and protect water quality In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p 63, p 81, p 88). No new permanent roads are proposed for construction. The DEIS proposes a reduction of current roads through the proposed decommissioning of 904 miles of road (DEIS @ p41, p 63, Table 18 p 74, p 81, p 88), thus actually decreasing the effects of roads that are currently located within the analysis area. See response CBD-1 for same response.

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DA-3/55, page 35, view #55	Road Construction Opposing View #55 - “According to the DEIS, the Forest now manages a total of 5,914 miles of roads across the Forest. Scientific literature has established that roads have numerous widespread, pervasive and, if left untreated, long-lasting biological and physical impacts on aquatic ecosystems that continue long after completion of construction. (Angermeier et al. 2004). Roads increase surface water flow, alter runoff patterns, alter streamflow patterns and hydrology, and increase sedimentation and turbidity. Roads are the main source of sediment to water bodies from forestry operations in the United States. (US EPA 2002). Road construction can lead to slope failures, mass wasting and gully erosion. Road crossings can act as barriers to movement for fish and other aquatic organisms, disrupting migration and reducing population viability. (Schlosser and Angermeier 1995). Chemical pollutants that enter streams via runoff, such as salt and lead from road use and management, compound these impacts. Most of these adverse effects are persistent and will not recover or reverse without human intervention. The techniques for road remediation are well established, agreed upon and readily available. (Weaver et al. 2006).” (Pg. 2) Wright, Bronwen, Policy Analyst and Attorney Pacific Rivers Council	Popular Press	These are comments received by the Rogue River-Siskiyou National Forest on the proposed Motorized Vehicle Use Draft Environmental Impact Statement (DEIS). These comments are not relevant to the 4FRI project, although some similar roads-related concerns similar to those found within the 4FRI project area are identified. The effects of roads on water quality, including the potential for sediment delivery are disclosed in the Water Quality and Riparian Area Specialist’s Report, pages 48 and 49 and pages 53 and 54. In addition, the DEIS proposes no new permanent road construction (DEIS page 40, p. 63, p. 81, p. 88). The DEIS proposes a reduction of current road mileage within the project area through decommissioning of 904 miles of roads (DEIS page 41, p. 63, Table 18 p. 74, p. 81, p. 88), thus decreasing the adverse effects of roads at both local and landscape scales Appendix C, pages 580 through 590 (SW10, SW11, SW12, SW14, SW16, SW17, SW18, SW20, SW22, SW24, SW30, and SW31) provide specific design features, BMPs, and mitigation measures to protect soils and water quality during and after temporary road construction, decommissioning, and obliteration and permanent road maintenance activities.

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	Excerpt from a May 11, 2009 letter to the Rogue River-Siskiyou National Forest Travel Management Team http://www.pacificrivers.org/protection-defense/comment-letters/Rogue%20River%20Siskiyou%20TMP%20DEIS.pdf		