P067: Adaptive Management Handbook and Tools for Vegetation Management and Estimation of Pollutant Loading from Forested Catchments

Project Report

Prepared by

Kevin Drake

Integrated Environmental Restoration Services

Submitted to

Peter Stine

U.S. Forest Service – Pacific Southwest Research Station

June 2015

INTEGRATED ENVIRONMENTAL
RESTORATION SERVICES, INC

P067: Adaptive Management Handbook and Tools for Vegetation Management and Estimation of Pollutant Loading from Forested Catchments

Project Report

Prepared by

Integrated Environmental Restoration Services

June 2015

This research was supported using funds provided by the Bureau of Land Management through the sale of public lands as authorized by the Southern Nevada Public Land Management Act (SNPLMA), and was funded in part through grant 12-CA-11272170-011 from the USDA Forest Service Pacific Southwest Research Station. The views in this report are those of the authors and do not necessary reflect those of the USDA Forest Service Pacific Southwest Research Station or the Bureau of Land Management.

Table of Contents

Project Overview

Background and Purpose

Efforts to reduce catastrophic fire potential in the Lake Tahoe Basin has resulted in a significant disparity between those efforts and efforts to minimize sediment loading to Lake Tahoe under the Lake Tahoe TMDL. Logging and vegetation management practices are generally believed to increase erosion potential and associated FSP loading to surface waters. Operations and regulatory implementation are constrained by a lack of local field-derived data and the ability to cost-effectively monitor treatments. Thus, management decisions are often made intuitively, through 'expert opinion', multiple interpretations of available research data, 'common sense', or model output. The purpose of this project was to develop an accessible decision support tool that focuses on achieving water quality protection *outcomes* in fuels reduction projects.

This project measured impacts of various vegetation management practices on soil function, hydrology and FSP transport, developed a set of cost-effective mitigation measures that can be used where impacts exist, and produced an adaptive management-based Guidebook for managers that translates this data and other relevant studies into Tahoe Basin-specific planning, implementation and assessment tools. The *Forest Management Guidebook* – the key product of this project – includes science-based tools for: 1) selecting and implementing appropriate vegetation management treatments, 2) measuring and mitigating operational impacts, 3) field assessment methods needed to support estimation and tracking of FSP loading from forested catchments, and 4) an adaptive management-based decision support framework for managing forest vegetation and protecting soil and water quality in the Tahoe Basin.

Goals and Objectives

<u>Goals</u>

1. To define and develop a practical, science-based adaptive management *process* for planning, implementing and assessing vegetation management treatments in order to achieve multiple objectives including fuel reduction and water quality protection.
2. To link existing and ongoing research and monitoring from various sources including relevant SNPLMA research, USFS monitoring programs and independent research being carried out by members of the Tahoe Fire and Fuels Team (TFFT) in a manner that is mutually inclusive so that all users within the Tahoe Basin can benefit from the range of currently disconnected efforts.
3. To develop a scientifically-supported set of *tools* for planning, implementation, assessment and mitigation of vegetation management activities that balance fuels reduction with water quality and soil protection.
4. To develop the data and field assessment methods necessary to increase confidence in modeled catchment-scale pollutant loading estimates associated with vegetation management actions in forested catchments.

<u>Objectives</u>

1. Measure impacts of Tahoe Basin-specific vegetation management practices on pollutant generation and transport in forested catchments.

2. Develop and test cost-effective mitigation measures to minimize the effects of vegetation management practices on pollutant generation and transport in forested catchments.
3. Empirically test the priority hypotheses associated with objectives #2 and #3 with resources available. Data collection efforts will focus on validating the hypotheses for forest land surface conditions and management actions assumed to have the greatest relative water quality risk with respect to FSP given the observed range of conditions.
4. Work closely with WEPP model developers to integrate field data and link field assessment protocols to hillslope- and catchment-scale pollutant loading estimates for top priority vegetation management treatments in the Tahoe Basin.

Research Sites

Field research was conducted at a range of sites around the Lake Tahoe Basin and in Truckee, CA. Many other potential research sites were identified early in the study, but were not included due to access or timing/scheduling constraints. Below is a list of the sites where field research was conducted for this project:

- **Burn Pile Sites**
  - Old Mill
  - Bear Creek (Alpine Meadows)
  - Ward Canyon
  - Granlibakken
  - Dollar Hill
- **Mechanical Treatment Sites**
  - Highlands
  - General Creek
  - Granlibakken
  - Skylandia State Park
  - Waddle Ranch
  - Homewood

Assessment Methods

A range of assessment methods were used to evaluate impacts of forest management activities on soil and hydrology and the effectiveness of various mitigation measures at rebuilding those impaired functions. Assessment methods used are summarized in Table 1. Additional information on each method can be found in the *Forest Management Guidebook*.

Table 1. Summary of field assessment methods and output data collected.

Assessment Method	Description	Output Data
Rainfall Simulation	Produces rain storm of a known precipitation rate to directly measure infiltration, sediment yield, and other pollutant concentrations in runoff.	Infiltration and runoff rate Particle size distribution Pollutant concentrations and mass measurements for sediment, organic matter, etc. + turbidity
Runoff Simulation	Used to simulate overland flow water at different flow rates to measure and visually assess infiltration, soil physical processes and erosion parameters.	Surface runoff rate Erosion behavior; paths, parameters, etc. Pollutant concentrations and mass measurements for sediment, organic matter, etc. + turbidity
Constant-Head Permeameter	Measures the saturated hydraulic conductivity of soils, or the permeability of soils.	Permeability; long-term constant infiltration rate when the soil is saturated.
Cone Penetrometer	Measures a soil's resistance to force, which can be used as a surrogate for compaction, soil density and infiltration potential.	Soil depth-to-refusal at specified pressure Depth of root-restricting soil layers Soil loosening depth
Soil Moisture	Measures soil water content by volume.	Percent soil water content by volume.
Cover (point-transect and ocular methods)	Two methods of measuring ground surface cover – one quantitative, one relative.	Plant cover Mulch cover Bare ground

Key Findings

Pile Burning

- Runoff velocities from burn scars roughly doubled following pile burning (without mitigation).
- Unmitigated burn scars generally had higher turbidity and higher surface runoff velocities than piles where duff was replaced post-burn.
- Different levels of mitigation treatment yielded different reductions in runoff velocities compared to unmitigated burn scars (Ward Canyon):
  - 16% reduction with duff removal and replacement only
  - 35% reduction with loosening only
  - 100% reduction (no runoff) with duff removal and replacement plus loosening
- Removing and replacing duff on burn scars has proven to be the most effective and important treatment for reducing sediment transport. At Ward Canyon, removal and replacement of duff with hand-loosening of burn scars led to at least a 95% reduction in turbidity in runoff (measured with runoff simulator), from more than 1000 NTU (burned, unmitigated) to generally less than 50 NTU (duff removed/replaced + hand loosening).
- Field trials at several sites suggest that hand-loosening burn scars alone (without adding surface cover) can slow runoff velocity but still tends to produce very high turbidity in runoff consistent with unmitigated burn scars(>1000 NTU).
- Vegetation re-establishment tends to be very slow in unmitigated piles; mostly conifer seedlings.
- Charcoal (and in some cases, ash) were still visible on soil surface up to 6 years post-burn on unmitigated piles.
- Highest post-burn vegetation cover and lowest amount of bare soil observed in piles where duff was salvaged and replaced.
- Applying perennial grass seed mix (in addition to duff salvage and replacement) yielded the highest vegetation cover of all mitigation treatments tested.
- Application of native grass seed mix reduced short-term establishment of conifer seedlings (i.e. ladder fuels) after burning, which may help to extend the amount of time before follow-up thinning is required.

Mechanical Treatment

- Soil compaction tends to increase as the number of vehicle passes increases. At three different North Tahoe sites, 6 passes with a rubber-tired harvester/forwarder led to 38-69% reductions in cone penetrometer depth-to-refusal (DTR); 4 passed led to a 79% reduction in DTR (Highlands only); and 2 passes led to a 3-32% reduction in DTR. This data suggests that 4-6 passes was the threshold for lasting compaction at these sites (Highlands, Skylandia).
- A soil's resistance to compaction can be very site-specific. At another site (Granlibakken), as few as 1-3 passes by a harvester/forwarder led to a 67% reduction in penetrometer DTR, which was the same change in compaction as that measured at an adjacent plot with 5-10 equipment passes (65% reduction). Another plot at the same site with 50-100 passes exhibited the greatest compaction—an 83% reduction in penetrometer DTR.

- Soil compaction from equipment operations can persist for long periods of time. Penetrometer DTR at a landing near Truckee averaged only 1.8 inches 15 years after the fuels reduction project was complete (Waddle Ranch).
- As the number of equipment passes increases, the width of the travelway (impacted area) tends to increase. Increasing the number of passes from 2 to 6 increased travelway width by 75% (Highlands) and 142% (Granlibakken).
- With other site and soil factors being equal, equipment tends to produce less compaction where a robust mulch/duff layer is present and more compaction where soil is bare.
- Operating equipment over a slash mat can minimize soil compaction when heavy slash layers are used, but thinner slash mats tend to get crushed and provide minimal soil protection, especially with increasing machine passes.
- Higher soil moisture levels tended to correspond to greater compaction with the same number of machine passes.
- The addition of 2-3 inches of wood chip mulch reduced runoff velocity by 60% and runoff distance by 54% compared to bare/unmitigated conditions.
- Incorporation of wood chips into the soil by hand tilling led to the same reduction in runoff velocity as mulching (60%) but a more substantial reduction in runoff distance of 85% due to much high infiltration rates.
- Incorporation of wood chips into the soil also led to a large (779%) increase in penetrometer depth and 230% increase in soil wetting depth during runoff simulation.
- Wood chip mulch has been observed to be displaced by concentrated runoff when not incorporated into the soil, particularly in dirt roads.
- Mulching alone can provide hydrologic and sediment reduction benefits in lower-angle conditions and that incorporating wood chips into soil via physical loosening provides the greatest and longest lasting improvements.

Roads and Travel Management

- Applying a layer of compacted asphalt grindings (1.5″ depth) to an unpaved haul road reduced turbidity in runoff by approximately 10 times with no measurable change in infiltration rate.
- Applying 1 inch of gravel to high-use unpaved road segments on the west shore of Lake Tahoe reduced sediment yield by 94 times (from 138,947 to 1,484 lbs/acre/in) on a graded road and by 10 times (from 4,227 to 408 lbs/acre/in) at an ungraded road.
- Applying a layer of wood chips (3″ depth) to an unpaved, recently used road reduced turbidity in runoff by approximately 10 times with no measurable change in infiltration rate.
- Wood chip mulch was applied to an inactive dirt road in the Homewood Creek watershed (west shore Lake Tahoe) at several depths (1″, 2″, 4″). Rainfall simulation showed wood chip mulch reduced sediment yield by an average of 17 times compared to bare soil conditions (from 868 lbs/acre/in to 51 lbs/acre/in). Deeper mulch depths (2-4″) resulted in the greatest sediment reductions of 21-22 times.
- Pine needle mulch was applied to an inactive dirt road in the Homewood Creek watershed (west shore Lake Tahoe) at several depths (1″, 3″, 5″). Rainfall simulation showed that pine needle mulch reduced sediment yield by an average of 5 times

compared to bare soil conditions (from 868 lbs/acre/in to 176 lbs/acre/in). The 5” mulch depth resulted in the greatest sediment reduction of nearly 7 times.

- Vegetative treatments that do not improve soil physical structure (e.g. hydroseeding) can temporarily reduce sediment yield; however, long-lasting sediment reductions tend to be associated with treatments that improve soil infiltration rates through loosening and soil amendment incorporation, which also tend to support robust native vegetation.
- Road decommissioning treatments – including soil loosening and wood chip incorporation, fertilizing, seeding, mulching – tested in the Homewood Creek watershed resulted in sediment reductions of more than 100 times (compared to untreated dirt roads) and foliar plant covers ranging from 3-18%. Three roads treated using these techniques resulted in NO RUNOFF and therefore no sediment yield, even at rainfall rates of 4.7 inches per hour.
- Runoff simulation conducted on a graded section of road directly adjacent to an ungraded section indicated that grading increased sediment yields by 33 times. Where road grading is necessary, application of gravel road base can substantially reduce sediment yield in runoff.

Management Recommendations

Pile Burning

- Avoid building piles in drainageways or other areas that are hydrologically connected to stream channels. When building piles in known flow areas, plan for post-burn mitigation treatment.
- Salvage duff from burn pile footprints and replace after burning whenever possible.
- Cover burn scars with at least 3 inches of duff after burning.
- Hand-loosen and seed burn scars with native grasses (in combination with duff addition) for greatest erosion protection and to expedite vegetation recovery.
- Piles comprised of large-diameter fuels should be considered higher priorities for post-burn mitigation treatment.
- Revisit burn piles at least once the season after burning to assess stability and recovery trajectory.
- Photo document burn scars immediately following burning and in subsequent years to track recovery trajectory and learn from different management strategies.

Mechanical Treatment

- Assess and document soil conditions prior to implementation (compaction, soil cover, duff depth, soil moisture).
- Assess and document soil conditions during and after project implementation to determine if and where mitigation treatments are needed.
- Use stratified entry approach: use main travel way to enter and exit project area; use spur access off main travel way and specify a maximum number of trips per spur where mitigation is not intended to be required post-project (4 trips is a good starting point).
- De-compact main travel way when demobilizing (use separate bucket or ripper attached to masticator head).

- Spread wood chips and/or masticator shreds over bare soil areas.
- Incorporate wood chips into soil in compacted areas for greatest hydrologic benefits and erosion resistance.
- Minimize or eliminate pivot turns (operators can make arced turns).
- Aim to conduct mechanized thinning treatment once soil moisture is less than 10%. If operating equipment during higher soil moisture conditions is necessary, concentrate trips to main travelway(s) and implement appropriate post-treatment mitigation measures (such as soil decompaction and mulching).
- Identify legacy sites (e.g. old landings, skid trails) that can be decommissioned as part of forest fuels reduction projects.

Roads and Travel Management

- Create a base map showing flow paths (not just streams) and legacy erosion source areas such as old roads and landings. Use this to create an access plan including protection/avoidance areas, temporary BMPs, and post-project mitigation areas. See 2.5 Flow Accumulation Analysis tool.
- Use stratified entry approach: use main travel way to enter and exit project area; use spur access off main travel way and specify a maximum number of trips per spur where mitigation is not intended to be required post-project (4 trips is a good starting point).
- Require contractors to submit GPS tracking data to document equipment travelways. Use this information to determine if and where mitigation may be required, and if other contract conditions were met (e.g. stream buffer restrictions).
- Spread wood chips and/or masticator shreds over bare soil areas.
- De-compact main travel way when demobilizing (use separate bucket or ripper attached to masticator head).
- Incorporate wood chips into soil in compacted areas for greatest hydrologic benefits and erosion resistance.
- Minimize or eliminate pivot turns and associated displacement of duff and topsoil (operators can make arced turns).
- Assess and document soil conditions during and after project implementation to determine if and where mitigation treatments are needed. See Step 4: Achieving for information on field assessment methods.
- Aim to conduct mechanized thinning treatment once soil moisture is less than 10%. If operating equipment during higher soil moisture conditions is necessary, concentrate trips to main travelway(s) and implement appropriate post-treatment mitigation measures.

Stakeholder Outreach and Engagement

Stakeholder input was critical to this project. Below is a brief overview of stakeholder outreach and engagement efforts associated with this project and development of the deliverables.

Project Directors (our "Steering Team") were selected both for their professional experience, their ability to consider diverse perspectives, and their personal commitments to finding common ground in the complex environmental management problems facing the Tahoe region. Directors participated in three in-person work sessions and provided review and feedback on treatment and mitigation tools, and were asked to reach out to their own professional networks in order to integrate a range of interests and perspectives into the project process and products. In short, Directors were invited to take ownership and actively steer this project.

Project Directors:

- Mike Vollmer - TRPA
- Doug Cushman – Lahontan Water Board
- Elwood Miller – Tahoe Fire and Fuels Team
- Martin Goldberg – Lake Valley Fire District
- Jack Landy – EPA
- Rich Adams – CA State Parks
- Mary Huggins – CalFire

Project Advisors are people beyond the "Steering Team" of Directors who were asked to provide targeted feedback in specific elements of the project and/or at different times in the project. Some advisors were asked to review Guidebook sections, and some were asked to attend occasional work sessions.

Project Advisors:

- Dave Mercer and Dave Theis (forestry contractor)
- John Freidrich – Tahoe Fund
- Sue Norman – USFS LTBMU
- John Pang – Tahoe Fire Chief's Association
- Brian Hirt – CTC
- Forest Schafer – NLTFPD
- Matt Busse and Ken Hubbert – USFS PSW researchers
- Bill Elliot – USFS Rocky Mountain Research Station

WEPP Integration: Data sharing and some collaborative rainfall simulation research was carried out at several points in the project with the team working to refine the WEPP model for forestry applications and develop the Tahoe web interface for the model.

Presentations: Some preliminary findings from research on this project were presented to more than 40 people at the Tahoe Roads Workshop in June 2013 in Kings Beach, CA.

Workshops: Two workshops were held as part of this project, covering both the outcome-based management process as well as key findings and treatment tools for water quality protection in fuels reduction projects. The first workshop was held on May 20th, 2015 at Lake Valley Fire's training room and the second workshop was held at Michael Hogan's residence in Tahoma, with field trips to two difference CTC project sites. In total, 37 people from 13 different organizations participated in the workshops.