


MOKELUMNE WATERSHED AVOIDED COST ANALYSIS:

Why Sierra Fuel Treatments Make Economic Sense

The Nature Conservancy
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SIERRA NEVADA CONSERVANCY

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

Chapter 2: Process of Analysis and Scenario Development

2.1 Cultural Resource Values

Lands within the Mokelumne watershed contain an extensive record of human activity, with the heaviest use occurring within the last 4,000 years. Materials from the surrounding forest indicate that people have been visiting the general vicinity for at least 7,000 years. This area is very important to the local Native American communities and to the study of California culture and history.

By 5,000 years ago, permanent villages were well established on the western Sierra slopes at elevations generally below 3,500 feet. Two different Native American ethnographic groups (Northern Sierra Miwok and Washoe) were using the resources and residing within these lands by late prehistoric times. Archaeological evidence confirms rather heavy use within the vicinity. The site density and composition within the area is unique within the Sierra Nevada. Recorded Native American archaeological sites include a massive salt-processing site, ethnographic village and mourning (cry) sites, rock shelters, midden sites with house pits, petroglyph sites, and small food-processing sites. These sites range from 5 square meters to well over 20 acres in size. The North Fork Mokelumne was an important trade route between the Northern Sierra Miwok on the Sierra's western slope and the Great Basin tribes on the Sierra's eastern slope.

As a result, 15,398 acres along the north side of the Mokelumne River canyon were designated as the Mokelumne River Canyon Archaeological District and were determined eligible for inclusion in the National Register of Historic Places in 1992.

While cultural and historic values are exceptionally high within the Mokelumne watershed, it is impossible to place a monetary value on them. These values are irreplaceable should they be lost.

2.2 Process of the Analysis

Multiple meetings were held throughout the watershed to gauge interest in an ecosystem services project with a primary focus on evaluating the upper watershed forests' relationship with and economic values for downstream beneficiaries. After positive feedback from those attending meetings within the watershed, similar meetings were held with the primary utilities that manage hydropower and water in the watershed. The utilities expressed interest in whether or not a business case could be made that upper watershed conditions and management affect the utilities' operations, maintenance, and overall costs. This would be achieved through a robust scientific analysis of the risk of fire in the watershed, the consequences of fires, and whether strategically placed fuel treatments are a cost-effective means of reducing fire risk and consequences.

2.2.1 February 2012 – Advisory Committee

On February 1, 2012, the Mokelumne Watershed Avoided Cost Analysis Kick-off Meeting was held in Sacramento, CA. The Advisory Committee included representatives from the Sierra Nevada Conservancy, The Nature Conservancy, the U.S. Forest Service (USFS) (Region and District offices), the Bureau of Land Management (BLM), Sustainable Conservation, Pacific Gas and Electric (PG&E), the East Bay Municipal Utility District (EBMUD), and the Environmental Defense Fund. At the kick-off meeting, each organization presented its challenges and priorities for the watershed, and the stark contrasts between the challenges of land management at different elevations within the watershed quickly became apparent. Between the elevations of 1,000 and 3,000 feet, BLM manages relatively small parcels that are interspersed with private lands, and are frequently near homes or structures. Above 4,000 feet, where most of the USFS land is located, the parcels are much larger in size and the density of homes and structures is much lower. These differences require distinct management strategies. The kick-off discussion also focused on expanding the committee to include representatives from local government, conservation groups, tribes, and local private industry.

This meeting established the two overarching phases for the process: 1) the data collection, risk/consequence modeling, environmental and economic analysis, and a technical report; and 2) an implementation phase that could involve developing memorandums of understanding and funding arrangements. This report is the primary outcome of the first phase.

2.2.2 March 2012 – Advisory Committee

A meeting held in March 2012 set the stage for much of our subsequent work. The expanded Advisory Committee (which by then included representatives from Foothill Conservancy, Sierra Forest Legacy, Calaveras County, Sierra Pacific Industries, and the Amador Calaveras Consensus Group) developed the following analytical foci for the project:

- Fire suppression costs
- Postfire rehabilitation costs
- Costs to communities
- Costs to timber production
- Costs to wildlife
- Water-related costs, including water quality and supply
- Power supply-related costs, including supply disruption and maintenance
- Fire risk
- Biomass
- Carbon stocks

We also identified new potential project values:

- Improved upstream-downstream relationships and new partnerships
- Local involvement and perspective
- Creative ways to pay for restoration
- Transfer of the approach to the upcoming Forest Plan revisions

- Informing long-term planning
- Expanding investment
- Integrating disparate knowledge to understand a more complete picture of consequences to resource disturbances
- Identification of the beneficiaries of fire protection
- Risk mitigation
- Building a collaborative framework, including beneficiaries
- Better understanding of the water quality aspects affected by fire

The Advisory Committee began working on the project's charter, and each organization identified personnel from their organizations to participate in the Technical Committee. The Technical Committee would be the group of individuals that would determine how best to achieve the scientific goals outlined by the Advisory Committee.

2.2.3 May 2012 – Technical Committee

The Technical Committee convened for the first time on May 29, 2012, with a focus on identifying data needs and modeling options. In addition to the initial consideration of fire and sediment modeling, the possibility of including bark beetle and tree disease forecasts in the modeling process was discussed. Because of the direct connection between bark beetle tree kills and fire hazard, we decided to incorporate a bark beetle analysis into the methodology, to be undertaken by the U.S. Forest Service Forest Health Group. The suite of models to be used for the analysis is designed to be iterative, whereby the bark beetle model outputs are inputs for the fire model, and the fire model outputs are then inputs for the sediment model (Figure 2.2). We were faced with the important question of how to model sediment and which model to use. The sediment model selected for this analysis would need to meet several criteria: it should be able to crosswalk to the fire model (i.e., outputs from one can easily be used as inputs to the other), have good standing within the scientific community, and have outputs that are meaningful to the analysis. Each of our partner organizations looked internally to determine if their colleagues could recommend a sediment model that they were familiar with or had used in the past.

We also discussed the importance of tracking and reporting information about assumptions and decisions, and The Nature Conservancy took the lead on composing an assumptions document (Appendix J). Other important questions that were raised included the geographic boundary for the analysis and what the baseline for vegetation would be. The primary basis for this question was whether or not to include fuels-related projects that are pending within the watershed. Put another way, if projects resulting from this analysis were not likely to be implemented until 2015, would it be worthwhile to account for any projects that may occur during that time that may affect fire behavior within the project area? [*In the end, we decided to not include upcoming projects primarily because these projects could change based on the outcomes of this modeling process. Additionally, the benefits of adjusting the vegetation layers to predict the projects' outcomes would not outweigh the benefits.*] We began to consider the factors that may drive the need for different modeling scenarios, including future management plans and climate change. The decision was made to first review the results of the baseline model run and use this information to develop the scenarios.

2.2.4 June 2012 – Advisory Committee

The June 2012 meeting focused largely on the modeling process. For most treatments, we decided that the methods described in the USFS General Technical Report (GTR) 220 would be the basis for our design. We also discussed the role of chronic sediment sources on the sediment budget, such as poorly constructed and managed roads. As opposed to sediment postfire, sediment from roads can be a constant sediment source within the watershed. Despite the magnitude and importance of chronic or annual sources, this type of sediment source falls outside the purview of this analysis and thus was not included in this phase. Instead, it is assumed that any erosive event that occurs due to a fire is additive to the sediment load produced by chronic sources.

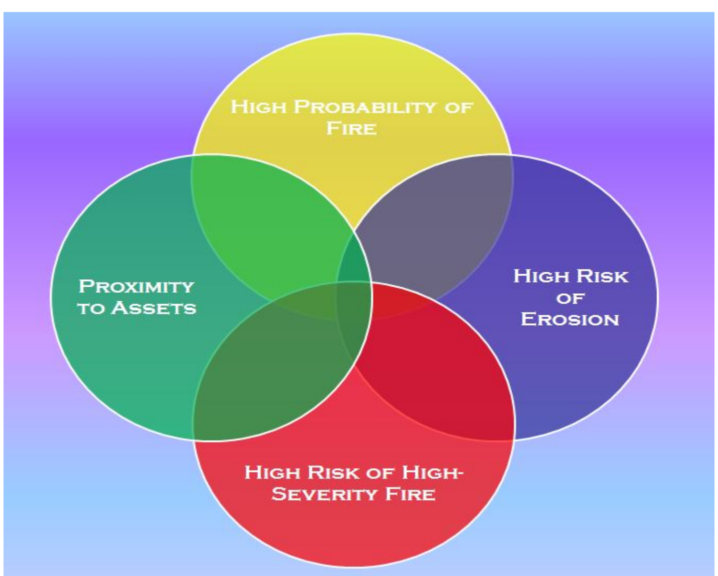
We then began developing a list of model scenarios to consider for the analysis:

a. *Baseline* – Current forest conditions and expected sediment when a fire occurs
b. *Cornerstone* – The changes that the Cornerstone Project (watershed Collaborative Forest Landscape Restoration Act project) will have on baseline conditions
c. *High-Priority Areas* – Use the baseline scenario results to define high priority areas in proximity to electric and water assets at risk and re-run the model with fuel treatments in these locations and compare results to the baseline scenario
d. *Climate Change* –A sub-scenario of each of the preceding scenarios to show how climate change influences each scenario

The locations where three or four criteria overlapped were identified as the high priority areas (Figure 2.1):

a. High probability of fire
b. High probability of high severity fire if a fire occurred
c. Proximity to assets/infrastructure (direct fire damage)
d. High risk of erosion impacts (indirect fire damage by way of sediment delivery)

Figure 2.1: Overlap of criteria to determine high priority areas



We also reaffirmed that the modeling effort would be a sequential and iterative process (Figure 2.2).

Figure 2.2: The sequential order of the modeling process

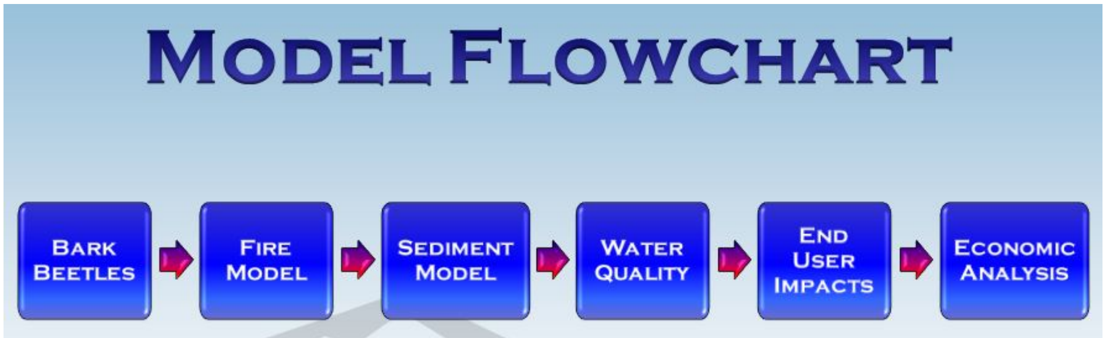
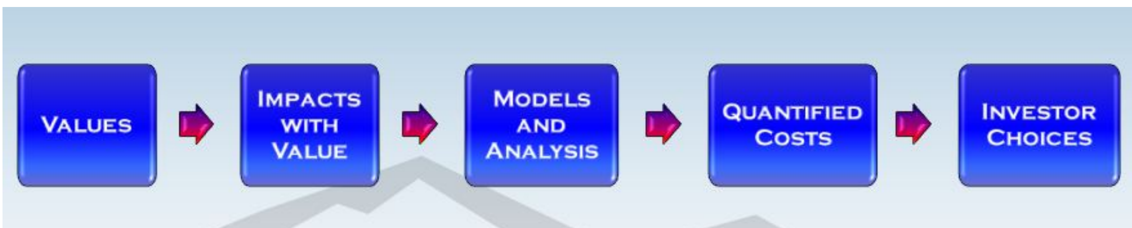


Figure 2.3: How economic analysis would lead to the identification of investors



For the remainder of the June 2012 meeting, we turned our attention to defining the term "investor," as well as which investors could potentially benefit from the findings of this analysis. A flowchart for the analysis was proposed, as shown in Figure 2.3. We would identify valuable services that are relied upon by businesses and then determine if we would be able to calculate impacts to those businesses through this analysis. Pending the results of the analysis, the investors in those businesses could then be approached with a business case relative to their concerns. Our brainstorming session led to the following potential list of investors to support forest treatments and fuels reduction:

- Utilities
- Local government (and communities)
- Tribal governments
- Private landowners
- Federal and State agencies, (e.g. public health agencies, Cal EPA [for the purpose of greenhouse gas emission reductions], and CA Corrections [seeking an outlet for its prison labor force])
- Environmental organizations
- Recreational organizations
- Private foundations (including corporate philanthropy)
- Green and/or local businesses (including future beneficiaries of a diversified forest economy, e.g., small woody biomass use)
- Insurers

  - Public Health (e.g. Sutter Health, California Healthcare West, Kaiser Permanente, CalPERS)
  - Property/Home
- Local water purveyors
- US Army Corps of Engineers

Based upon the list of potential investors and the assets in the watershed, we developed the following recommendations for potential costs to analyze:

- Fire-related costs
  - Fire suppression
  - Postfire restoration
  - Timber production on public lands
  - Timber production in areas where private and public lands meet
- Water quality treatment and supply costs
  - Sediment loading
- Power supply and infrastructure costs
  - Sediment loading
- Community and public safety costs
  - Homes and vegetation in the wildland-urban interface (WUI)
  - Rural community infrastructure (e.g., telephone lines, water and sewer lines, mobile communication facilities, roads)
  - Rural residents' values and perceptions (security, safety, aesthetic enjoyment)
- Costs of impacts to fish and wildlife
  - Salmon fishery
  - Sensitive species habitat (e.g. CA Wildlife Habitat Relationships)
  - Culturally significant plant species
- Costs of impacts to urban sector (e.g. recreationalists, camping, rafting, hiking, birding)

2.2.5 Modeling Observations – Summer and Fall, 2012

A key component to improving the reliability of the modeling process was to have the modeling teams tour the watershed with local experts and Committee members. These field trips occurred for the fire modeling team in June 2012, and for the sediment modeling team in November 2012. In both cases, the resulting model runs were considerably more robust as the modelers were able to adjust the "stock" parameters of the models to the site-specific conditions they observed (see the appendices for more information on the models).

The modeling teams' field visits helped them adjust the base layers (e.g. LANDFIRE vegetation layer), the inputs used in the model, and the model parameters to better reflect on-the-ground conditions. For example, the fire modeling team visited high-risk areas with a local fire chief (a member of the Technical Committee) and viewed regeneration of an area that burned at high intensity almost a decade ago. This visit helped them revise the model inputs and parameters so the model would more accurately model fire on that area. The fire modelers updated the baseline vegetation data at the lower elevations by adding more grassy areas and at higher elevations by adding more rock. They also significantly altered the ignition model parameter for the fire model and broke it into three elevation bands to ensure that ignition patterns would be appropriate based on many factors, including the duration of the snowpack into the spring and summer. The site visit helped the sediment modeling team adjust the soil profile for a variety of watershed locations and the soil coverage in postfuel treatment sites.

2.2.6 September 2012 – Technical Committee

The difficulty of developing a complete picture of sedimentation through models became apparent during the September 2012 meeting, but the decision was made to move forward with a fine sediment (2mm in size and less) hillslope erosion model using GeoWEPP (Appendix C). This model does not account for sediment sourced and transported by roadways, gully formations, landslides, and within water channels. [*This discussion continued for several months as options were considered in an attempt to reliably track as many sediment sources as possible. The result was the selection of three different sediment models as the best means to develop a general picture of non-chronic sediment transport and erosion pre- and postfire: GeoWEPP (fine sediment), FERGI (gully formation), and a landslide regression mode (debris flow). A channel sediment transport model was sought, but the appropriate model for our needs was not found. The WARMF model, which had been used and calibrated to the watershed previously by EBMUD, was intended to be used to model water quality parameters in the waterways as a result of fire, but the appropriate crosswalk between it and the fire model was not found.*]

This meeting provided time for the modeling teams to discuss the inputs, running procedures, outputs, and timeline. At this point, there were four distinct modeling teams participating: GeoWEPP, FERGI, tree insects and diseases, and fire. Through discussion, the modeling teams were able to find efficiencies and reliability through shared datasets. As each modeling team discussed their needs and potential hurdles, it allowed for clarifications of potential incompatibilities across the modeling efforts, such as the differing biophysical breaks (i.e., elevation bands the models break terrain into) that the fire and GeoWEPP models use. Each issue was tackled as a group, with consensus guiding the solution. For example, in the case of the elevation bands, we decided that the difference in elevation breaks between the two models was small enough that it would be more important to run the models within their optimum parameters than to align the breaks and potentially affect the accuracy of the results. The modelers were able to discuss their timelines and when their outputs would be available to others, allowing each team to better predict their own timelines. The skill set of the Technical Committee allowed the modeling teams the opportunity to vet their approach with other experts in their field as well as with local experts, once more improving the reliability of the results.

2.2.7 October 2012 – Advisory Committee

A primary goal of the October 2012 meeting was to expand the circle, from both the public-relations standpoint and the focus of the analysis. News of the analysis had been spreading throughout the region and the need was identified to share information with regional groups. Members of the Advisory Committee volunteered to reach out to these groups and to present materials from the analysis, receive feedback, and to determine how to coordinate efforts that overlap. Aiding this endeavor, the charter for the analysis was agreed upon during this meeting, defining the roles and responsibilities of the partners.

Committee members expressed interest in expanding the scope of the analysis and provided a list of areas to include. A ranking exercise was used to prioritize areas that could be added to the analysis, either quantitatively or qualitatively. The options were presented to the group by the Project Manager consulting team, which had identified ecosystem services that were likely to attract investment to the watershed and that were appropriate to the analysis based on their compatibility with the modeling effort and the available data. The top five priorities the committee identified were:

- Water quantity and timing
- Forest products (e.g., local biomass use)
- Tourism and recreation
- Carbon sequestration
- Clean air and water quality

The ecosystem services that would not be part of the analysis were:

- Wildlife and wildlife habitat
- Fisheries and fish habitat
- Cultural resources

A primary reason why these three were not considered for this analysis was that they were being addressed through other projects in the watershed. Also, in some cases, the group could not gain access to the data necessary to evaluate them appropriately.

The Committee also discussed how priority areas would be framed and how to define scenarios for the modeling effort beyond the baseline condition. Priority areas would be primarily determined by the results of the baseline model runs for fire and sediment, as well as the following:

- Project plans from other efforts within the watershed, especially the work being planned as part of the Cornerstone Project
- Threshold size
- Timeline
- Vegetation regrowth
- Cost effectiveness

For any given scenario, the following timescale considerations were highlighted:

- Would the treatments be modeled as if they occurred within a single year?
- What is the threshold for minimum effective size and timescale?
- Would the scenarios factor in regrowth and treatment maintenance?

The following sections of this chapter provide more information about how the priority areas were identified and the treatment conditions developed.

2.2.8 November 2012 – Technical Committee

A discussion of modeling efforts dominated the November 2012 meeting, given the fact that there was no reliable way to link the bark beetle model to the fire model. Because of this, the fire model results would not be influenced by the results of the insect and disease analysis. One can infer that the forest stands highlighted in the insect and disease analysis are susceptible to attack and are therefore at greater risk to fire than the fire model results indicate, but no quantitative values are associated with such an inference. For more information on the insect and diseases results, please see Appendix B.

The fire model was run at a scale considerably larger than the upper Mokelumne watershed to help identify areas outside of the watershed where fires could start and then move into the watershed. Prior to this meeting, the trial run had identified the areas outside the watershed where fuel treatments could be effective at reducing the probability of fire that could move into the watershed. As the group reviewed the model results from the trial runs, our discussion centered on the rate of spread and the fire size limitations in the trial runs. We determined that the model results had more than enough accuracy to achieve one of the goals of the analysis—to identify fire behavior differences under current forest conditions compared to treated areas.

2.2.9 December 2012 – Advisory Committee

With the work plan for the consulting team set during the October meeting, the goal for the December meeting was to determine ways to expand upon the final product to add more value. This was due in part to the fact that secondary targets—those which the consultants would not quantify, such as tourism and recreation—can increase the potential investor pool, adding value and potential support. Three ways to potentially include the secondary targets in the final analysis in at least a qualitative fashion were:

1. Taking into account previous work done in the watershed
2. Literature reviews
3. Partnerships

The Mokelumne watershed has been the focus of a significant number of groups and projects over the years, many of which may be potential sources of local data and/or knowledge that would be inexpensive to access and incorporate. Similarly, literature reviews could uncover trends that may apply to the watershed without the need to perform costly and time-consuming analyses within the watershed itself. Lastly, analysis partners, especially local organizations with their rich knowledge of the watershed, could independently evaluate issues and report back to the Advisory Committee. These three sources of information were vital to the development of the work plan, and applying them to secondary targets could be an efficient way to evaluate the targets' potential avoided costs.

The consultants provided context on upcoming decision points we would face, with a focus on the treatment conditions to select. Key questions were: what areas of the forest should be treated, what practices should be used to treat, and at what scale should the treatments occur? The next sections of this chapter have more details on the development of the treatment scenario. To help with the upcoming decisions, the consultants designed a method to break the watershed into 148 discrete units. These units were small enough and specifically designed to capture similarities in areas with respect to fire, sediment, slope aspect, and drainage so that averaging across the unit would not dilute important information. At the same time, the units were large enough to allow participants in this process to more easily visualize the trends of the model results from a full watershed perspective. The units were referred to as Analysis Units (AUs) and were an average size of 2,500 acres (maximum: 12,500 acres; minimum: 217 acres); they are similar to the Planning Units that the USFS relies upon but are much larger than the typical USFS Treatment Unit.

One difficulty the group faced at this point was that the data gathering for multiple elements in the process was occurring at once. The best way to develop a decision process would have been to optimize treatments based on dollar values (e.g. asset values and treatment costs), since this analysis is focused on avoided costs. Such an approach would have allowed a focus on treatments in areas where the highest asset values intersect with the greatest fire and sediment risks. The consulting team was actively developing a complete picture of the assets in the watershed, but it would not be complete in time to be a factor in the decision process of selecting areas to include in the treatment scenario [*In the end, we used building-density data, along with a variety of infrastructure data layers, as a proxy for asset values in our decision making process]*. However, we flagged the following criteria as those that would help optimize treatments, if the data could be available in time:

- Fire hazard (fire risk and assets at risk)
- Risk to infrastructure and timber
- Population density
- Land ownership
- Cost of treatments and maintenance
- Sediment yield
- Urban and wilderness land use designations

2.2.10 January 2013 – Technical Committee

With most of the modeling for current conditions (baseline) complete at the time of the January 2013 meeting, the process began to shift toward the development of one or more scenarios to compare to the baseline condition results. The purpose would be to determine what impact, if any, fuel treatments could have on reducing the risks posed by wildfire. The assumption made was that fuel treatments can reduce fire threat, but the degree to which fire threat is reduced can vary depending on the types of treatments that are used and their placement across the landscape.

The Technical Committee was broken into three groups and each group was provided with six maps, each with a range of model and watershed information to help members determine where to place treatments within the watershed. The groups were provided a loose framework to guide their discussions, but their priorities were determined within the group. Each group developed a recommendation on which AUs to treat and presented their recommendation and reasoning to the rest of the Committee. Group 1 focused their hypothetical treatments in clusters around areas that, if a fire were to start there, would be hard to control. This included steep, inner canyon areas, especially those near the wildland-urban interface (WUI) or recreation areas. Group 2 also used a cluster approach and based their treatment selections on where building density (a WUI proxy) and high fire intensity overlapped. Group 3 focused on areas that would have a high flame length and where fire could spread or could lead to heavy sedimentation runoff. They also selected areas that had assets at risk for fire damage. More on the group selections can be found later in this chapter.

Based on the feedback from this initial exercise, including which maps were useful during the selection process and what missing data elements would have been helpful, an online map environment was created to facilitate the input that both Advisory and Technical Committee members would provide to the process. The results from the models, along with a number of physical datasets, including building density, roads, and utility infrastructure, were uploaded to Arcgis.com. Each Committee member (Technical and Advisory) was given access to the site and was asked to select the AUs that they believed should be in a treatment scenario. Individual selections in a mapping environment made compiling, analyzing, and displaying the results much more simple. The feedback from the participants following this exercise was overwhelmingly positive.

2.2.11 February 2013 – Advisory Committee

Outreach to regional groups by members of the Advisory Committee had begun by February 2013 and the need for outreach materials to support these efforts was identified. Two different target audiences for the materials were identified: potential investors and the general public. The group discussed developing a brochure that could potentially be part of an EBMUD mailing, as well as creating a website for the project.

2.2.12 April 2013 – Advisory Committee

The Advisory Committee vetted the results of the Treatment Team selections (see below) in the April 2013 meeting. It was decided at this time that the canopy code for the riparian treatments needed to be changed from moderate to low, indicating that the canopy within riparian areas would be essentially undisturbed within the treatment scenario. A similar change for the treatment approach to steeply sloped areas was also recommended and accepted.

An in-depth discussion of how each land manager on the Advisory Committee approaches treatments on their lands followed, which highlighted the contrasting styles and restrictions the managers have in implementing treatments. In the lower elevations, the land is heavily fragmented, with public lands dispersed between multiple homesteads. Because of the fragmentation, management options are limited (e.g., prescribed fire is rarely used) and treatment costs are much higher because the high cost of staging for treatments is incurred for relatively small treatment areas. The land managers also shared that they often work with other public and private organizations in the area, including Fire Safe Councils, to achieve their goals. In the higher elevations of the watershed, the land managers have more management options and treatments in general are cheaper per acre because the lands are less broken up in ownership. However, competing priorities, such as degraded roads and meadows, often vie for the same pot of project money.

2.2.13 May 2013 – Advisory Committee

The fire model team reported the results of the treatment scenario during the May 2013 meeting. In general, the treatments were very effective at reducing both flame length and fire risk. But there were a couple of unanticipated issues, the greatest of which was the response of grassy areas to treatments. Because the model parameters were overlaid on a diverse set of vegetation types, it was likely that some of those would not respond well to treatments designed for forests. As a result, the treatment scenario allowed for much more grassland regrowth than would occur under normal circumstances; the model reflects this with increased flame length, rate of spread, and burn probability for those areas. The lesson we learned is to remove vegetation types from the treatment scenario that the intended treatment would never be prescribed to.

With the treatment scenario defined and results beginning to take shape, we used GIS data from partner organizations to compare upcoming planned and proposed projects with the treatment scenario. In some places, proposed projects overlapped with areas the model results suggested would be very effective. The land managers in the Advisory Committee were unanimous in their declaration that they will be looking to these data and the results to help refine their upcoming projects. Where the goals of those projects overlap with the results of this analysis, that information will be used to maximize the benefits. One result from having these representatives in the same room and reviewing the data together is the potential for the agencies to coordinate efforts across land ownership boundaries to achieve the greatest impacts in the most efficient way possible.

As the structure for the final report for the project began to take shape, we discussed at length the audiences it should speak to. We determined that the executive summary should speak to a broad range of audiences from diverse backgrounds, and the summary should distill the results of the study into concepts that are easily understood and relatable to the general public. Likewise, the report should, at least in sections, speak to ratepayers for utilities potentially impacted by the results, as well as to the actuarial scientists that manage the risk management divisions of organizations with assets in the watershed.

2.2.14 June 2013 – Technical Committee

With three different sediment models incorporated into the analysis, the Technical Committee discussed how to integrate the results of the three models into one reporting method. The challenge stemmed from the fact that each model used different weather events to obtain its results, and reported those results in different units. For example, the GeoWEPP model outputs are the result of averaging multiple years of weather patterns, whereas the Debris Flow model uses specific rainfall intensities to create its outputs.

This discussion overlapped with the issue of burn probabilities and how reliable it would be to use historical data in the fire models to predict future behavior, when recent trends indicate that fire seasons over the last decade are more destructive than ever before. At the same time, what reasonable assumptions can be made about fire probabilities over the next few decades if they are not based on the past? The group decided that we would frame the conversation similar to a discussion about 5.0 and 7.0 earthquakes: describe an average fire event within the watershed as well as a less probable but more destructive event. Using the fire model outputs, we teased out five discrete fire boundaries and identified fires that correspond to both average events and less probable but more destructive events. By using the fire perimeter and burn intensities, we plugged in specific postfire weather patterns and created predictions based on the other modeling work of the damage those fires could cause, both from direct fire damage and from postfire sediment runoff. This provided perspective on both likely and less likely events and provided tangible results that can be better understood by the general public than if we had used burn probabilities.

2.3 Stakeholder Selection of Forest Treatments to Reduce Fire and Postfire Sediment

The focus of this study is an assessment of the environmental and economic costs and impacts of the current watershed condition compared to a future modeled management scenario. This chapter describes the process we followed to develop the modeled management—or treatment—scenario.

Following the first round of fire and postfire sediment modeling based upon existing conditions, the Technical Committee, with input from the Advisory Committee, needed to determine the extent, location, and type of hypothetical forest treatments that could reduce fire and postfire sediment risk. (The rest of this chapter provides more details on how the team selected the treatment types.) The resulting treatment selection became the basis for the modified vegetation layer used in the second round of fire and sediment modeling. The committees made their treatment selection with incomplete information regarding the distribution of assets and cost of treatment.

Information on the locations of hydropower facilities and water intakes were available, but we had not acquired specific data on additional infrastructure throughout the watershed that was at risk to wildfire. This includes the location of many valuable resources, including cultural heritage sites, wildlife habitat (except Protected Activity Centers), or Wild and Scenic River designated areas, all of which would affect the potential implementation of the modeled treatments. A collaborative process with input from stakeholders living inside the watershed and land managers familiar with the watershed's assets helped bridge this gap. The diverse stakeholder input added a range of important qualitative values to a largely scientific modeling effort. With only one opportunity to run a modeled treatment scenario in the fire and sediment models, stakeholders took a fresh view of the entire watershed upstream of Pardee Reservoir and used the fire and postfire sediment model data to inform their treatment selection.

The purpose of the treatment selection process was to create a model scenario that would reduce wildfire and postfire sediment risks, with a focus on the water utility infrastructure. With the hypothesis that wildfire and postfire sediment would negatively affect utilities dependant on Mokelumne River water by direct fire damage, through filling of reservoirs with sediment, or decreased water quality from suspended sediment in postfire flows. Prior discussions with Pacific Gas and Electric (PG&E) informed the committees that sediment does not affect their hydropower operations in the Mokelumne watershed largely due to two reasons. They are able to flush sediment from the water intakes at key reservoirs (e.g., Tiger Creek Afterbay), and much of their water conveyance infrastructure consists of off-stream pipes or canals that allow PG&E to choose from multiple sources and easily clean out conveyance infrastructure. From the perspective of the East Bay Municipal Utility District (EBMUD) and their operations, upstream hydropower reservoirs act to trap sediment and prevent it from reaching Pardee Reservoir. River sections between Pardee Reservoir and the hydropower dams, as well as the Middle and South Fork Mokelumne, could affect Pardee Reservoir where EBMUD has their water intake.

Selecting forest treatment areas using a collaborative process versus model results—which would have led to the selection of treatment areas based on fire and sediment risk—captured a larger portion of the watershed for treatment, including the wildland urban interface (WUI) and areas with infrastructure at risk to direct fire damage. Comparing the final stakeholder-selected treatment area that falls within the United States Forest Service (USFS) boundary to existing USFS planned treatment areas illustrated the utility of the advanced fire modeling made available in this study. It is important to note, however, that local land managers have their own specific management goals that may take a higher priority over the issues captured in this analysis; their projects are designed to meet multiple objectives and account for many factors, including sedimentation.

In addition to providing an avoided cost analysis of proactive forest management, this study can help inform the Amador Calaveras Consensus Group (ACCG – a local stakeholder-driven collaborative process), Fire Safe Councils, USFS, and Bureau of Land Management (BLM)'s prioritization and location of treatments.

2.3.1 Methods

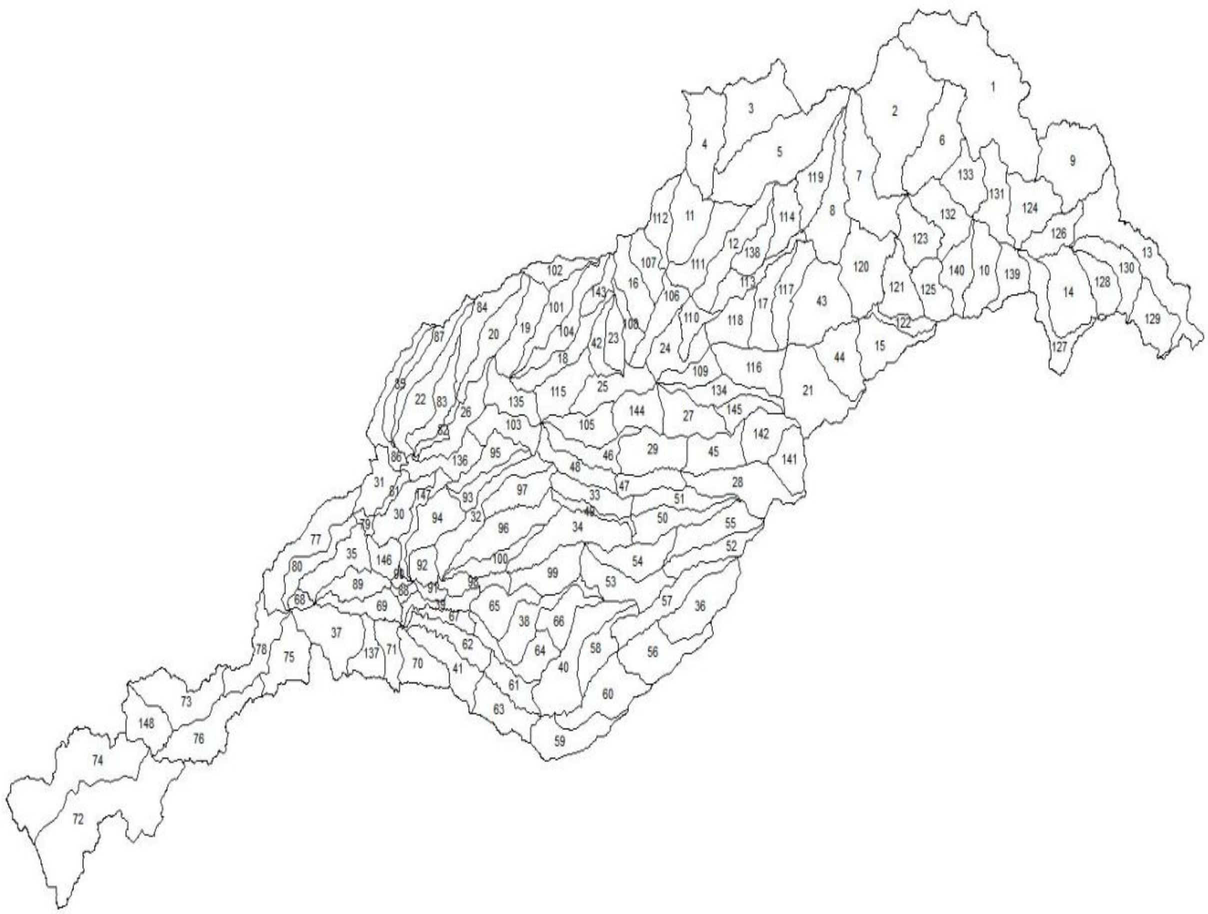
Stakeholders selected treatment areas across the entire watershed, including urban, BLM, USFS, and private land.[1] We excluded from treatment designated wilderness and roadless areas, despite the relatively high predicted insect mortality rates on some of those lands (Appendix B), per the USFS. These areas are located in the highest elevation portion of the watershed and have few management options or infrastructure. We summarized the pixel level data from the fire and sediment models into averages by subwatershed areas called Analysis Units (AUs). Each AU was approximately 2,500 acres in area and there were 148 total AUs within the watershed (Figure 2.4). Summarizing the pixel level data by AU made it easier to discuss the treatment selection and to identify the specific land areas that drained to specific reservoirs and water intakes. At the same time, the AUs were small enough and specifically designed to capture areas that had similar trends in the model results so that the upscaling from the pixel size (30 meters squared) modeling results to the larger AU size would not mask or dilute important results. In addition, we included areas outside of the watershed where fire could originate and spread into the watershed, which we refer to as Influence Units (IUs).

To determine the extent of treatment area necessary to reduce the fire risk, we first reviewed the literature. Overall, the literature suggested that fuel treatments on approximately 30% of the watershed reduce the overall fire risk (burn probability) for the whole watershed. The minimum area required to reduce fire risk from high severity fires moving across a landscape is 10-20% (Ager et al. 2007, Finney et al. 2007). As the area thinned increases beyond 20%, the rate of reduction in fire risk changes more gradually. Ager et al. (2013) modeled fire behavior and concluded that the strategic placement of treatments across 35% of the landscape were optimal to reduce wildfire

[1] Note that PG&E did not make a treatment selection.

mortality of old growth forests, compared to <20% or >80%. At the Sagehen Creek Experimental Forest, the ecological thinning planned for 2013 will treat 29% of the watershed (USDA 2011) to both reduce fire risk across the Experimental Forest and to improve its ecological function. Treatment rates of 1% to 30% per year had a maximum effectiveness of reducing fire risk for approximately two decades (Finney et al. 2007).

Figure 2.4: Analysis units (AUs) within the Mokelumne watershed—subwatershed areas that average 2,500 acres in size

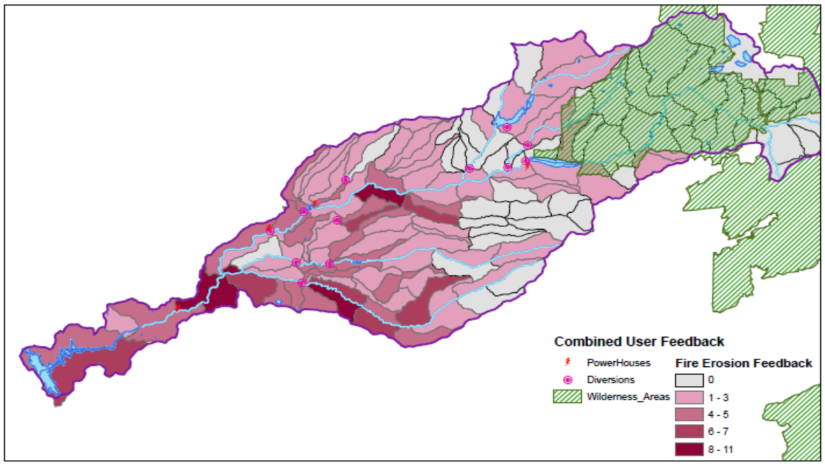


Selecting where to locate forest treatments was a collaborative process, with input provided in a group working session and then through an online ArcGIS platform. During the working session, three groups of 7-10 people discussed where to treat the forest based on the model results and their own expertise. We collected notes and their treatment selections and shared the information with the larger group before the online selection process began (see Group Working Session notes at the end of the chapter).

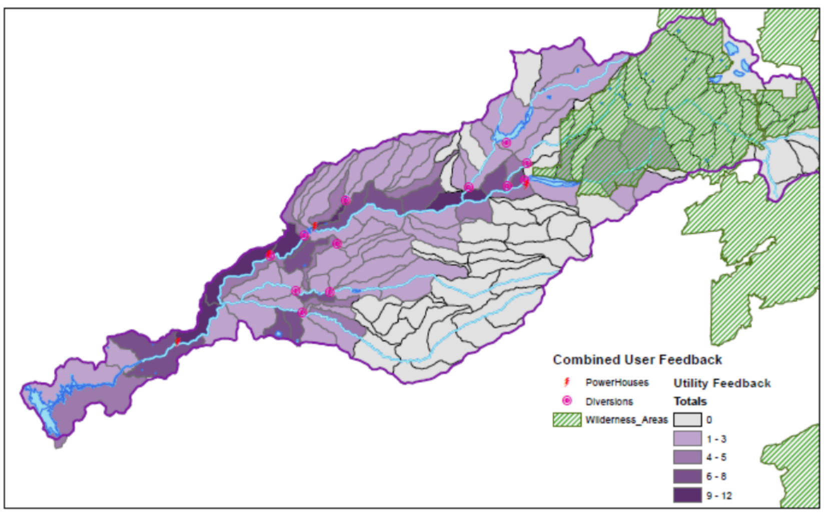
Stakeholders had two weeks to make online selections of treatment AUs using an ArcGIS platform (see Online GIS Participation Instructions at the end of the chapter). The online tool allowed each user to view all of the model results in a map viewer, in addition to many physical data sets such as building density, land ownership, and topography. This allowed the stakeholders to review and analyze all of the model data and many of the relevant decision factor data from different perspectives, including zooming and switching layers on and off. Individuals did not see each other's selections and each organization was able to have as many of their employees participate as they deemed reasonable. Users made selections to two maps: one with the mean fire and erosion results ranked into five quantile classes, and one with the utility burn probability ranked into five quantile classes. These maps contained additional layers that users could switch on or off, including water conveyances, wilderness and roadless areas, towns, hydropower powerhouses, electrical transmission lines, and municipal water intakes. During the selection process, users were asked to record the rationale for their selection of a particular AU.

After the stakeholders provided their input, we overlaid all of the stakeholder selections for both maps and determined the top selected AUs (Figure 2.5). A thorough discussion of these results with both committees further refined the priority areas. Coincidentally, by the time we included the additions that resulted from the meetings, the total area to be included in the modeled treatment scenario was approximately 30% of the watershed. To compare the stakeholder treatment selection to a selection based only on the fire and sediment model results, Phil Bowden, who performed the fire modeling for this analysis, calculated the top 40 AUs based on the highest risk (Figure 2.6).

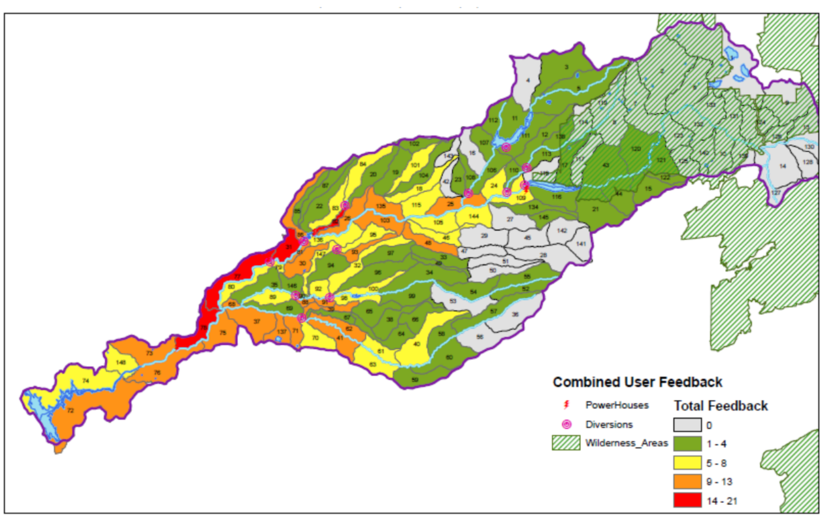
Figure 2.5: User selections for the mean fire and postfire erosion map (a), direct fire risk to water utility map (b), and combined user selections from maps a and b (c).



(a)

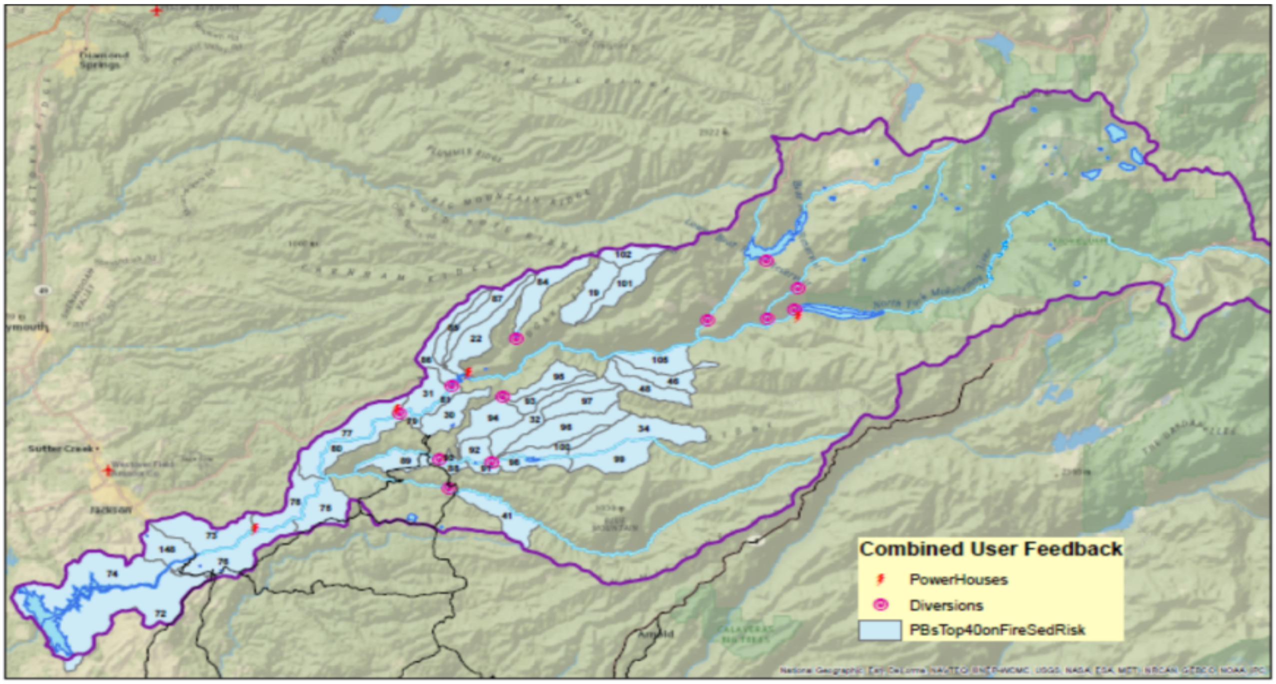


(b)



(c)

Figure 2.6: AU selection based only on fire and sediment risk model results - by Phil Bowden (USFS)



2.3.2 Results

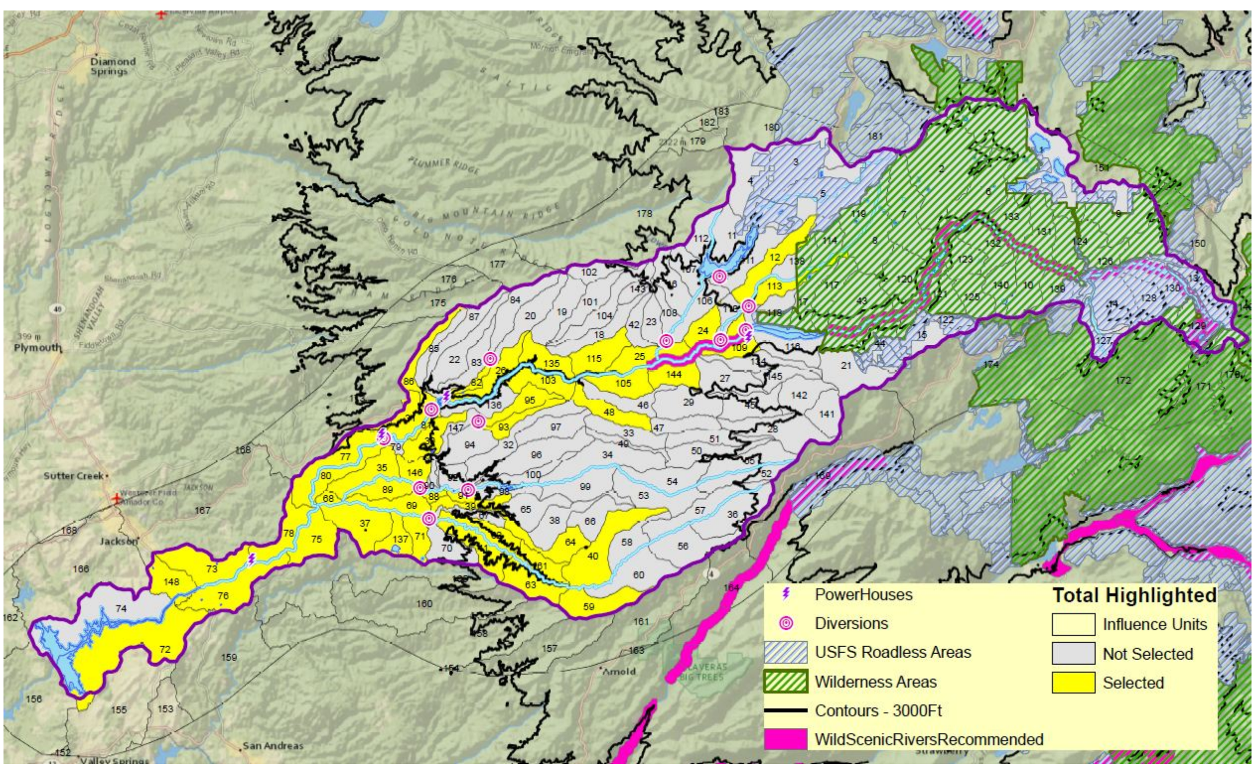
Through the iterative process of treatment selection, we decided to treat 46 AUs covering 99,894 acres, or roughly 29% of the watershed (Figure 2.7). All of the treatment areas were inside the watershed, even though the fire model showed a high probability that fires that start outside of the watershed could move into the watershed. Throughout the stakeholder selection process, the only bias we detected was between the inside- and outside-the-watershed stakeholders. Stakeholders outside the watershed selected AUs based more on the model results, whereas stakeholders inside the watershed relied more heavily on their local knowledge of assets and other factors. During the working group session, on the mean erosion and fire risk map, the groups identified clusters of AUs to treat based on a common objective as decided within each individual group. These objectives included recreational use, subdivision development, access routes for evacuations and firefighting, the potential need to focus on areas with difficult terrain (as they may be of most need of treatment), and a focus on erosion threats (see Group Working Session notes at the end of the chapter).

When we overlaid the selections from the two online maps, we identified 26 AUs that were common selections by 9-21 users (Figure 2.5). Using this initial set of 26 as a foundation, we built upon them by first looking at the two maps individually to ensure that the merging of the maps did not exclude critical feedback from either of the two maps (see Stakeholder AU Selection Rationale at the end of this chapter). As a result, we added two AUs from the utility burn probability map (AU 115, 24) identified as critical on one map but not the other. These were located at a high elevation in the watershed along the North Fork Mokelumne River, with south-facing slopes and high burn probabilities. As the result of comparing stakeholders' AU selections as they related to their relationship to the watershed (i.e., whether they lived and/or worked inside or outside the watershed) to the 28 that had so far been included, we added two that were high ranking (4-7 users selected, AU 40, 63). These two AUs are located near the South Fork Mokelumne River. We also added 4 AUs selected by EBMUD (AUs 148, 80, 69, 95), which are located downstream at the lower elevation of the study area, close to Pardee Reservoir.

In the next step of the process, we considered the results of the insect and disease mortality projects (see Appendix B) in the context of AUs. We initially added 14 AUs based on the insect and disease mortality projections, but through further discussion with the two committees and because many of these AUs were located within the wilderness and roadless areas, we reduced this number to two (AU 12, 133), a decision that was supported by one of the forest health experts that was engaged in the process. These two AUs were at very high risk for bark beetles damage and they are adjacent to Cole Creek.

The group also decided to add 3 AUs (35, 89, 146) in the WUI, the zone of transition between urban and forest land cover. Bill Haigh with the BLM designated these AUs as the “eye of the storm,” an area that should be prioritized for forest treatment to reduce community wildfire risk. In this same area, we removed AU 79 as there are no roads to facilitate treatment and it is steep (slope >35%). Sediment modeler Bill Elliott questioned the lack of north-facing slopes, which are at greatest risk for both high flame lengths and sediment but also have less infrastructure on them, and as a result we added AUs 105, 109, and 144 on the North Fork Mokelumne River. For similar reasons, we also added AUs 59, 61, and 64 on the South Fork of the Mokelumne River where some of the highest flame lengths, sediment loads, and burn probabilities were modeled and where we assumed there would be a potential threat to Pardee Reservoir.

Figure 2.7: Stakeholder selection of AU subwatershed areas to treat



2.3.3 Discussion

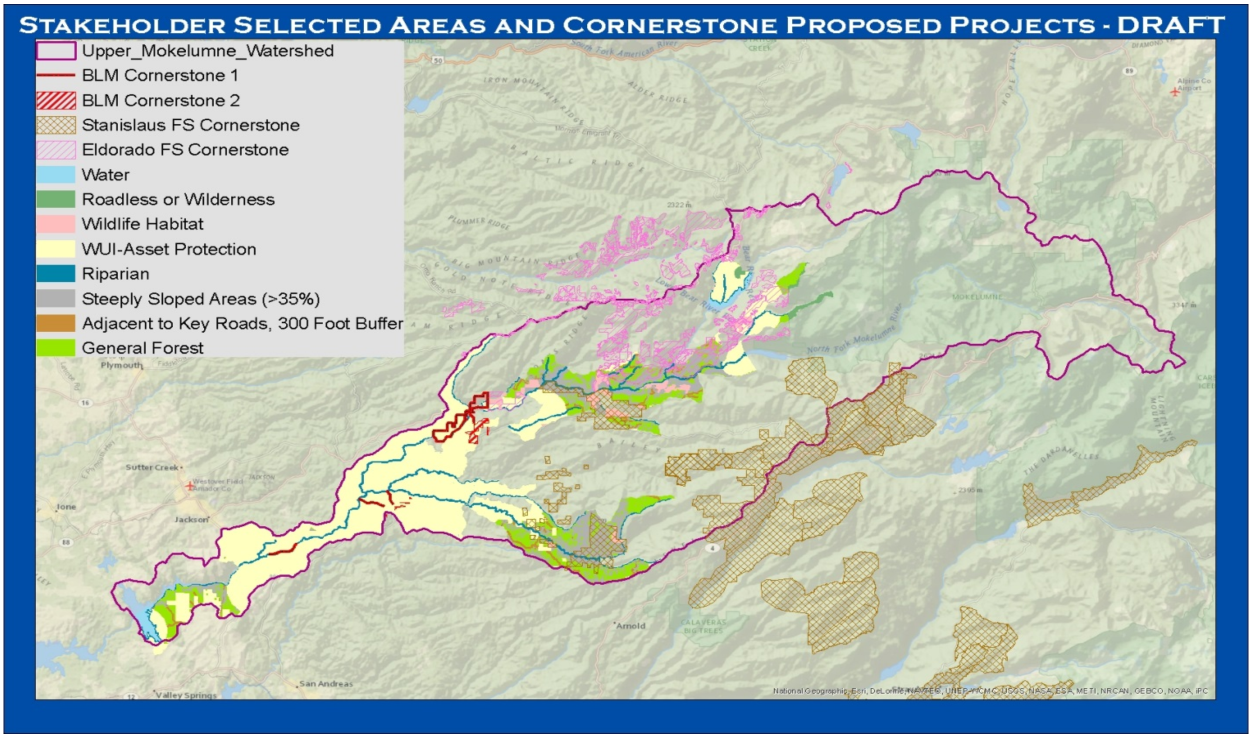
The collaborative selection of AUs for forest treatment allowed multiple opportunities for stakeholder input and led to a greater stakeholder understanding of the fire and sediment model results. As discussed in a later section, we had only one opportunity to run the fire and postfire sediment models for a hypothetical treatment scenario, so it was vital that the stakeholder values and opinions were captured, to the extent possible, the first time around. The stakeholder input identified assets and values within the watershed at risk from wildfire that were not included in the development of the two data layers the stakeholders used to select AUs. When compared to an AU selection process that only factors in the results from the models (Figure 2.6), the stakeholder selection included more forest around the South and North Forks of the Mokelumne River. In the model-based selection, the areas in the WUI with low erosion risk were not included. Likewise, a large area in the center of the watershed in the mid-elevation range was not included in the stakeholder selection. While this may result in a lower reduction in sediment from the posttreatment model run, the stakeholder process accounted for additional assets in the urban areas, and the potential cost of fire impacts to these assets was large. With more time and funding, it would have been an interesting exercise to run the model using a model-based selection, comparing the cost and benefit to the stakeholder selection. Another advance would be to create a cost surface of treatment compared to assets to optimize treatments to be cost effective, but we did not have the data for those costs in time to incorporate it at that point in the analysis.

Compared to the planned USFS- and BLM-proposed project areas within the Mokelumne watershed, the stakeholder AU selection encompasses a much larger area, including lands outside of their boundaries (Figure 2.8 and Table 2.1). There is overlap between the planned treatments and the stakeholder selection of AUs. The USFS has at least some land in 22 of the selected AUs and 16 of these (73%) have USFS-planned projects. BLM has land in 26 selected AUs and seven of these (27%) have planned projects. The USFS treatments are located across their respective districts, which fall within and outside the watershed, with a focus on the mid-elevation southern boundary of the watershed and along the north-facing slopes along the North Fork of the Mokelumne.

The BLM treatments are small in comparison, as their lands are dispersed among privately owned parcels, and include an area along the North Fork Mokelumne, and stretches along the main stem of the Mokelumne River upstream of Pardee Reservoir. The lack of overlap in some areas of the watershed highlights the fact that the USFS and BLM treatments focus on a range of objectives beyond those that are the focus of this analysis, and these projects were planned prior to the much higher resolution modeling that was performed as a part of this analysis. Further, their projects are limited to the area of land management they oversee. This study, in contrast, spans the entire watershed and uses advanced fire modeling, including burn probability and fire spread, across all ownership types.

The lessons learned from our modeling of fire and sediment in the watershed can help inform the prioritization and planning by the ACCG, Fire Safe Councils, USFS, and BLM. The data from the analysis will be available for the organizations to use in their own internal planning, as well as the broad range of topics covered in the analysis, including potential costs. As additional investments in treatments begin to be realized within the watershed, the data from this analysis will help the land managers and investors decide on the most effective and efficient investments.

Figure 2.8: Planned forest management on USFS and BLM land overlaid on the AU stakeholder treatment selection



Note: the AU stakeholder selection shows the land use classification, which later determined the treatment code.

Table 2.1: Breakdown of treatments by land type and ownership

Land type	USFS ownership	BLM ownership	Other ownership/private
Water	33%	2%	66%
Wilderness-roadless	83%	0%	17%
CSOPACs	97%	0%	3%
Riparian	27%	23%	50%
Transmission lines	32%	5%	63%
Key roads	11%	8%	81%
Steeply sloped	28%	20%	52%
Parcels with structures	0.04%	0.42%	99.54%
General forest	25%	10%	65%
All Land Types Combined	*24%*	*12%*	*64%*

Note: CSOPAC = California Spotted Owl Protected Activity Centers

2.4 Treatment Scenario Development

2.4.1 Selecting Land Types for Treatment

Following the completion of the current-condition, or baseline, model runs in all of the modeling processes, our efforts shifted to the development of a treatment condition scenario on which we could base the subsequent model runs. Given that we were limited to one treated-condition fire and sediment modeling run, our goal was to define a treatment scenario that would ensure that the modeled treatments encompassed enough of the landscape that their effectiveness could be assessed, while still allowing us to tease out key details at a smaller scale. As a first step, we reviewed how the fire model inputs would be adjusted to incorporate forest treatments. To this end, Phil Bowden, the Technical Committee member in charge of running the fire model, developed a matrix showing how he would integrate the treatments into the model (Figure 2.9).

The fire model bases its outputs on a single vegetation change (i.e., pre to post) rather than a series of changes over time. As such, it became clear that we needed to model the desired end result of the treatments on forest conditions, instead of breaking the treatment implementation stages into a multi-year process that may more-accurately represent the progression of treatment implementation. Additionally, the fire model can only process the desired end state of the forest with regards to vegetation, rather than inputting discrete treatment types directly into the model (e.g., mechanical thinning). That shifted our focus from the types of treatments to include to what the end goal of the treatment would be, highlighting the need to work with local land managers to learn how the treatments they implement impact vegetation. For example, hand thinning would be preferred in some situations over mechanical thinning, but the two treatment methods can result in similar end-states in terms of the forest structure. We worked with local land managers to determine the posttreatment forest conditions for the area so we could represent the desired final conditions in the fire model. After speaking with land managers that oversee forest management in either the lower or upper elevations of the watershed, we developed the following list of land types that would likely have differing approaches to treatments and therefore result in different forest stand conditions:

1. Wilderness and Roadless areas
2. Protected Activity Centers (PACs)
3. Riparian areas
4. Wildland-Urban Interface (WUI), Asset Protection areas, and Strategically Placed Landscape Area Treatments (SPLATs)
5. Steep slopes
6. Near key roads
7. General forest

The Advisory and Technical Committees worked together to refine the definitions of the included land types and codes that, based on the original matrix (Figure 2.9), would be most appropriate to apply in the modeled treatment scenario. The final matrix and codes that would be applied to the watershed can be found in Figure 2.10.

2.4.2 Geographic Application of Treatments

To determine where to place the treatments across the Mokelumne watershed, we convened a special Treatment Team composed of Technical Committee members as well as other regional experts who to date had not been involved in the analysis. In preparation for this meeting, we created a GIS data layer that broke the watershed into the seven categories listed above. For areas that could belong in two or more of the seven categories, we created a hierarchy of land types based on the category that would most restrict the level of treatment (e.g., we designated as Wilderness a steeply sloped parcel within the Wilderness area). We designated any parcel of land that did not fit into the six previous categories as general forest. We also specified the inclusion of the primary transmission line corridor that bisects the watershed and has a specific treatment strategy applied to it. The roughly 100,000 acres that the stakeholders selected for the treatment area break down into the following land types (see Table 2.1 for an ownership break down):

- General forest – 30.4%
- Steeply sloped – 29.8%
- Key roads – 15.8%
- Parcels with structures – 9.9%
- Riparian – 7.5%
- PACs – 3.0%
- Transmission line corridor – 1.5%
- Water – 1.2%
- Wilderness/roadless – 0.9%

In the end, the Treatment Team decided that the treatment conditions should be run at the full extent of the stakeholder-selected AUs (Figure 2.11). This was predominantly because we only had one opportunity to run a treatment scenario in the models, and running it at the larger scale of the stakeholder-selected AUs would capture more details than a smaller-scale run would. The full 100,000-acre treatment scenario would allow us to more easily tease out details from the results, such as a comparison between similar treatments in distinct locations in the watershed to see how treatment effectiveness may differ and why. These distinctions could help refine where further analysis should focus. Likewise, it was also important to not treat the entire watershed, as treatments can affect fire behavior in adjacent lands, and understanding the degree to which those lands are affected is important.

The incredible amount of stakeholder input we received during the development of the AU selections signified the importance of the selected areas; removing some of the selected areas from the treatment scenario would have been very difficult. Similarly, it would have been very time and resource intensive to address the multitude of management restrictions that would have been necessary to include in a more-focused treatment condition. By running the scenario at this scale, we were later able to review the economic value of certain areas, the cost of the treatments, and how the treatments affected flame length and sediment production. Interestingly, the distinct "fingers" of treatments across the watershed provided insights into where treatments had the greatest shadow effect on the burn probabilities of adjacent untreated areas (see Appendix A for more details).

Figure 2.9: Modeled treatment coding steps

MOKELUMNE AVOIDED COST ANALYSIS (MACA)
MODELED TREATMENT CODING STEPS

Step #1 Pick the unit to treat…………………

LANDFIRE Disturbance Code Information

The newest version of the LFTFC (LANDFIRE Total Fuel Change) Tool for ArcGIS 10 is being used to create and calibrate the needed FARSITE landscape files (LCP) so FlamMap5 and FSim can simulate fire behavior and spread.
LFTFC Info: http://www.frames.gov/partner-sites/niftt/tools/niftt-current-resources/
Fuel Disturbance Layer (FDIST) The FDIST is the input layer that simulates recent disturbances and is required when using the LFTFC. A FDIST is available from the LANDFIRE Data Distribution Site for disturbances prior to 2009. LANDFIRE Info: http://www.landfire.gov/
The use of the FDIST grid values will allow MACA to account for future disturbances such as prescribed fire or other vegetation treatments. This level of detail seems to be appropriate for this landscape scale analysis but would be of questionable value at the project scale.

The grid value of FDIST is denoted by a 3-digit integer which identifies the disturbance type, disturbance severity, and time since disturbance, respectively. That is, the first digit identifies the disturbance type (Table 2); the second digit identifies the disturbance severity (Table 3); and the third digit identifies the time since disturbance (Table 4).
LANDFIRE used Time Since Disturbance (TSD) to account for the transition of fuels through the first 10-years following disturbance. The classification system was stratified by geographic area as productivity in Hawaii and the Southeastern Unities States is substantially higher than the rest of the Unities States. *TSD for the 1st round of MACA modeled treatments the default code will be #2.*

Table 5 is for MACA use and deals with the modeled Treatment of Canopy Fuels.

Final Modeled Treatment Code Structure for MACA

MACA scenarios will simply create a geospatial file (shape, geodatabase) with polygons and at least these 3 attribute fields: **1) Unit_num**, IU or AU number; **2) FDIST**, the 3 digit FDIST code as described in the following three tables; and **3) CFTP**, Canopy Fuel Treatment Priority.

pb 1/4/2013

Step #2
Pick the treatment type

Table 2 Five disturbance types used by LANDFIRE For MACA choose Highlighted only

Disturbance Types and Effects	FDIST Grid Values	Examples
Fire– alters canopy fuel characteristics and surface fuel loads	100 series (e.g., 1XX)	Wildfire and Prescribed Fire
Mechanical – rearranges or adds fuel to the fuel bed	200 series (e.g., 2XX)	Mastication, lop & scatter, piling
Mechanical – removes fuel from the existing fuel bed	300 series (e.g., 3XX)	Timber harvest or other biomass removal treatments
Wind – alters canopy fuel characteristics and surface fuel loads	400 series (e.g., 4XX)	Any blow down event
Insects – modifies canopy fuel characteristics	500 series (e.g., 5XX)	Mountain pine beetle

Step #3
Pick the level of treatment

Table 3 Disturbance severity classes used by LANDFIRE If Green Highlight complete Step #5

Severity class and Effects	FDIST Grid Values	Examples
Low – less than 25% above-ground biomass removed	10 series (e.g., X1X)	Under burns, light thinning
Moderate – 25 to 75% above-ground biomass removed	20 series (e.g., X2X)	Mixed-severity burns, moderate thinning
High – more than 75% above-ground biomass removed	30 series (e.g., X3X)	Stand-replacement burns, clearcuts and seed tree

Step #4
Default 1st round of Modeled Treatments

Table 4 Time since Disturbance (TSD) classes used by LANDFIRE default for 1st FDIST is Highlighted

Time Since Disturbance (TSD) Classes		
Hawaii and Southeastern US	Remainder of US	FDIST Grid Values
Less than 1-year	Less than 5 (right after burn)	1 series (e.g., XX1)
1 to 3 years	1 to 5 years (2.5 year midpoint)	2 series (e.g., XX2)
3 to 10 years	5 to 10 years (7.5 midpoint)	3 series (e.g., XX3)

Step #5
Pick the level of Canopy treatment

Table 5 Canopy Fuel Treatment Priority for severity classes Low (10) and Moderate (20) only.

Canopy Fuel Treatment Priority	CFTP Value	Examples
Low – canopy treatment is not important or is restricted	1	light under burns, piling of existing surface fuels only
Moderate – Canopy treatment is somewhat important	2	GTR 220 type of treatments
High - Canopy treatment is very important; goal is to greatly reduce crown fire.	3	Shaded Fuelbreaks, WUI Treatments

1

Figure 2.10: Matrix for treatment coding

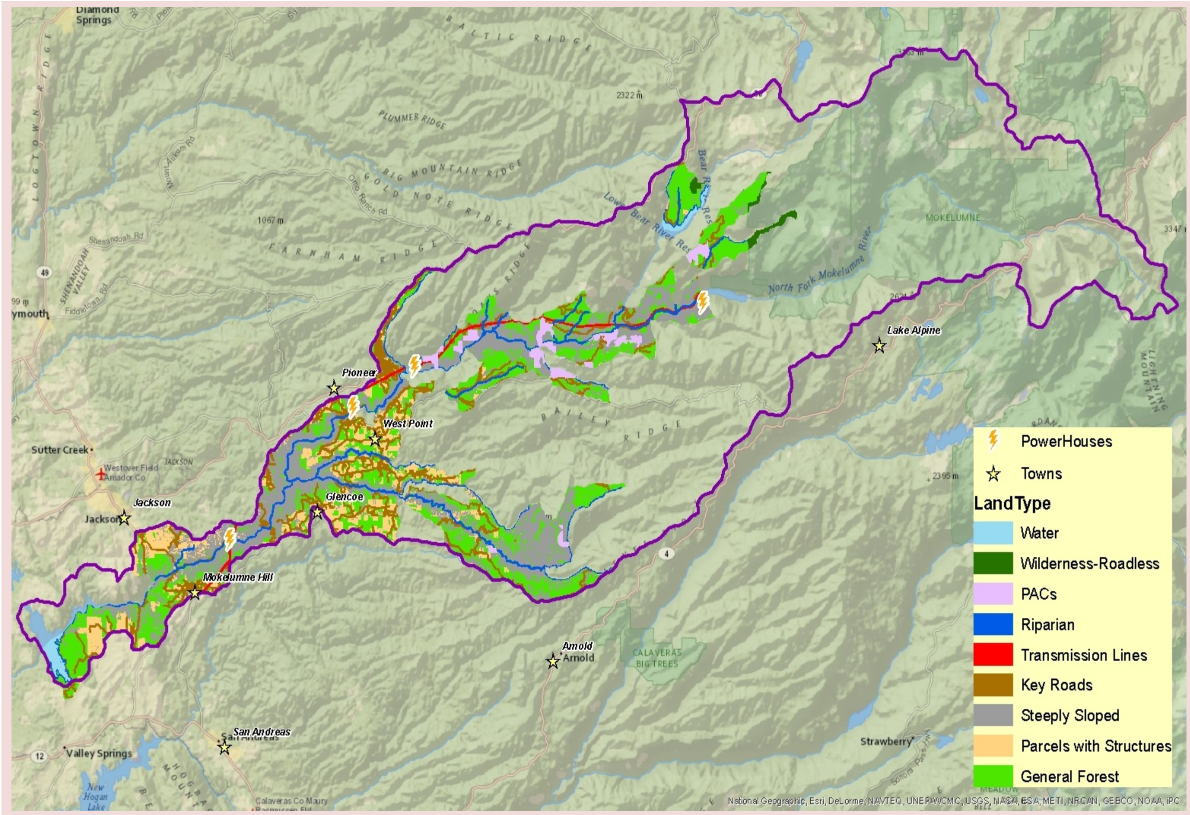
Select area ==>	Treatment type ==>	Level of treatment ==>	Level of canopy treatment
	100=wildfire and prescribed fire	10=low under burns, light thinning	1=low, light under burns, piling of existing surface fuels
	200=mechanical mastication, lop & scatter, piling	20=moderate, mixed severity burns, moderate thinning	2=GTR 220 type treatment
	300=mechanical timber harvest or biomass removal	30=stand replacing burns, clearcuts, seed tree	3=shaded fuelbreaks, WUI treatments
Example:	Mechanical timber harvest with moderate thinning in the GTR-220 style =		322

End Treatment Guide

Vegetation	Wilderness, Roadless, etc.	WUI, Asset Protection, SPLAT	PACs	Riparian Areas	General Forest	Steeply Sloped Areas (> 35%)*	Adjacent to key roads
Forested Lands	111	323	111	311	322	322	323

*** Areas within 0.5 miles of a road can be cable treated.**
Areas beyond that may be either helicopter treated or hand thinned and then prescribed burned.

Figure 2.11: Stakeholder-selected treatments in the Mokelumne watershed



References

Ager, A.A., Finney, M.A., Kerns, B.K., and Maffei, H. 2007. "Modeling wildfire risk to northern spotted owl habitat in Central Oregon, USA." *Forest Ecology and Management*. 246 (1): 45-56.

Andrews, P.L., and Butler, B.W. 2006. *Fuels Management-How to Measure Success: Conference Proceedings*. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-41.

Finney, M.A., Seli, R.C., McHugh, C.W., Ager, A.A., Bahro, B., Agee, J.K. 2007. "Simulation of Long-Term Landscape-Level Fuel Treatment Effects on Large Wildfires." *International Journal of Wildland Fire*. 16: 712-727

U.S. Department of Agriculture. 2011. "Purpose and need for action and proposed action-Sagehen project." Sagehen Project: Purpose of and Need for Action and Proposed Action. http://sagehen.ucnrs.org/blogs/SagehenForestProject/2011/7-12-11_new/Sagehen_Draft_PA_P&N_2011_07_07.pdf.

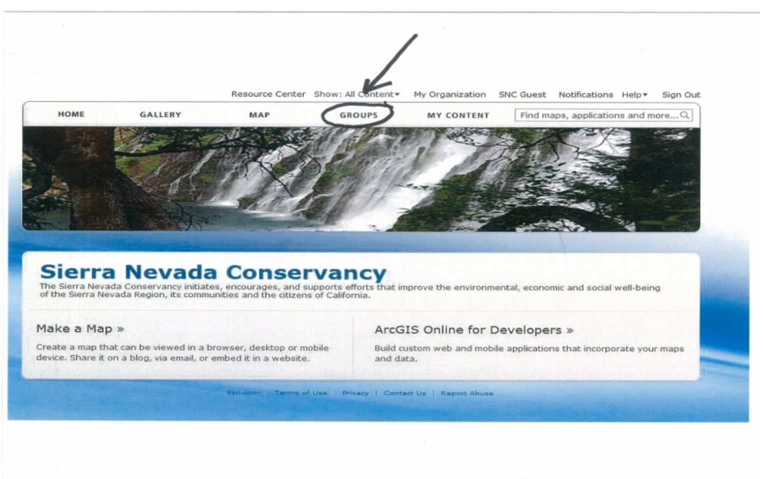
Materials from the Selection Process

Online GIS Participation Instructions

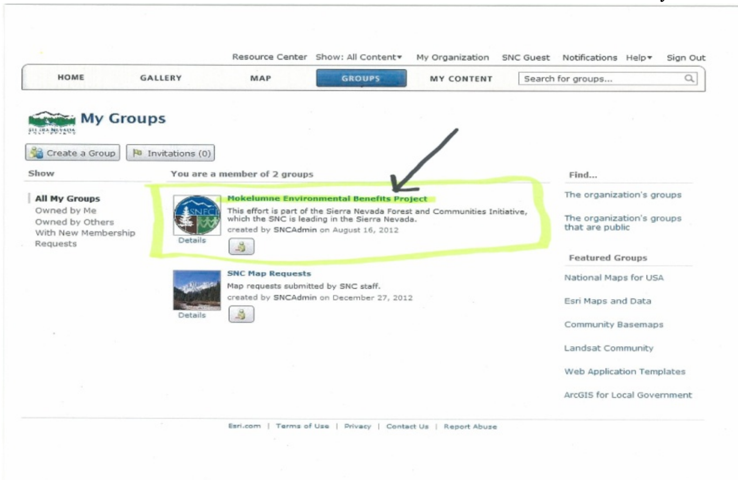
ArcGIS instructions for how users would select forest treatment areas based on model results and risks to water infrastructure (two maps: utility mean burn probability; mean fire and erosion risk).

1. Log on to the page

2: Click on Groups

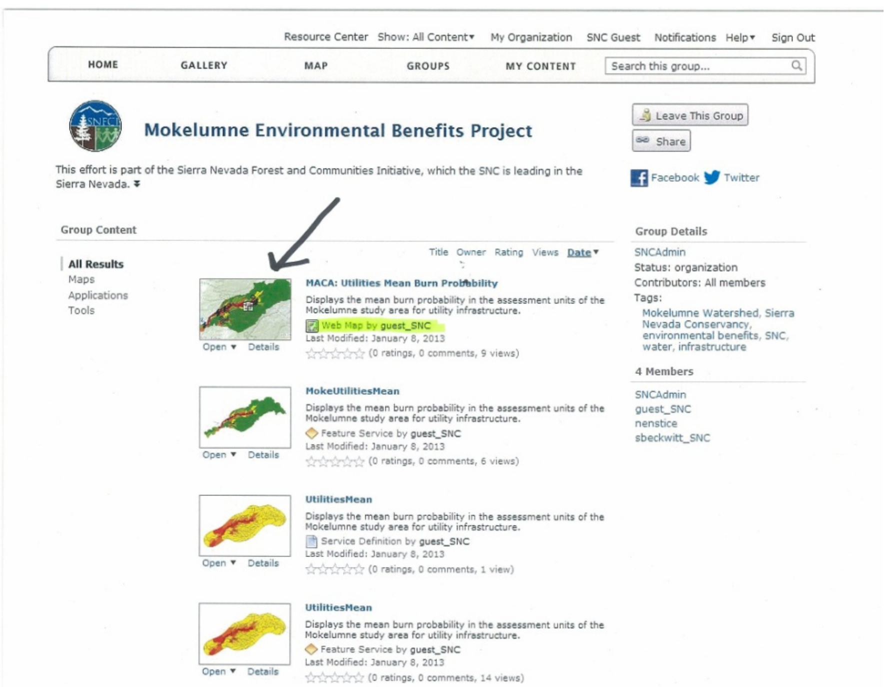


3. Click on Mokelumne Environmental Benefits Project

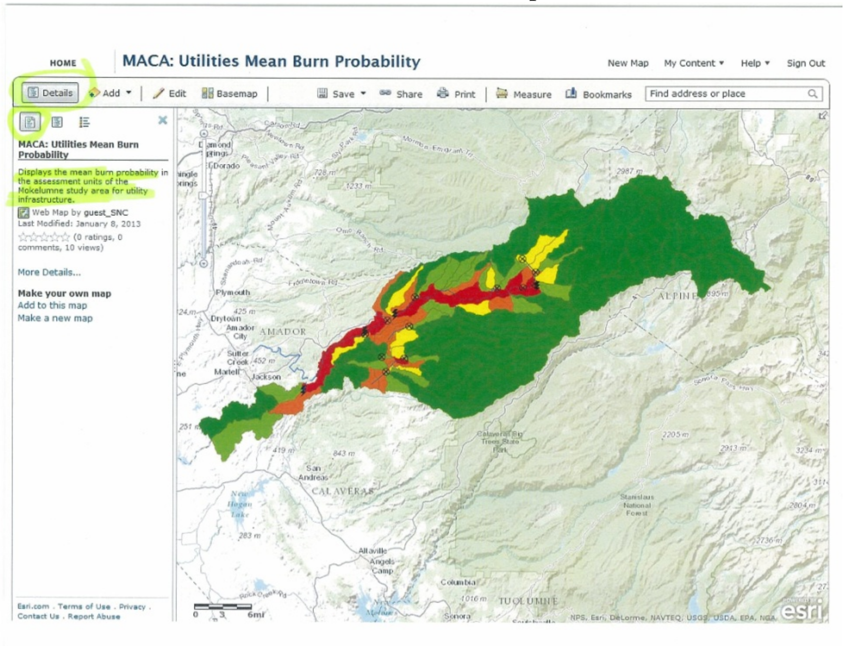


4. This is where all the individual maps will be located. For each of the four maps you will select AUs for, please select the one you are ready to work on by clicking the picture next to it. Make sure it says "Web Map" as highlighted below. The map names will be:

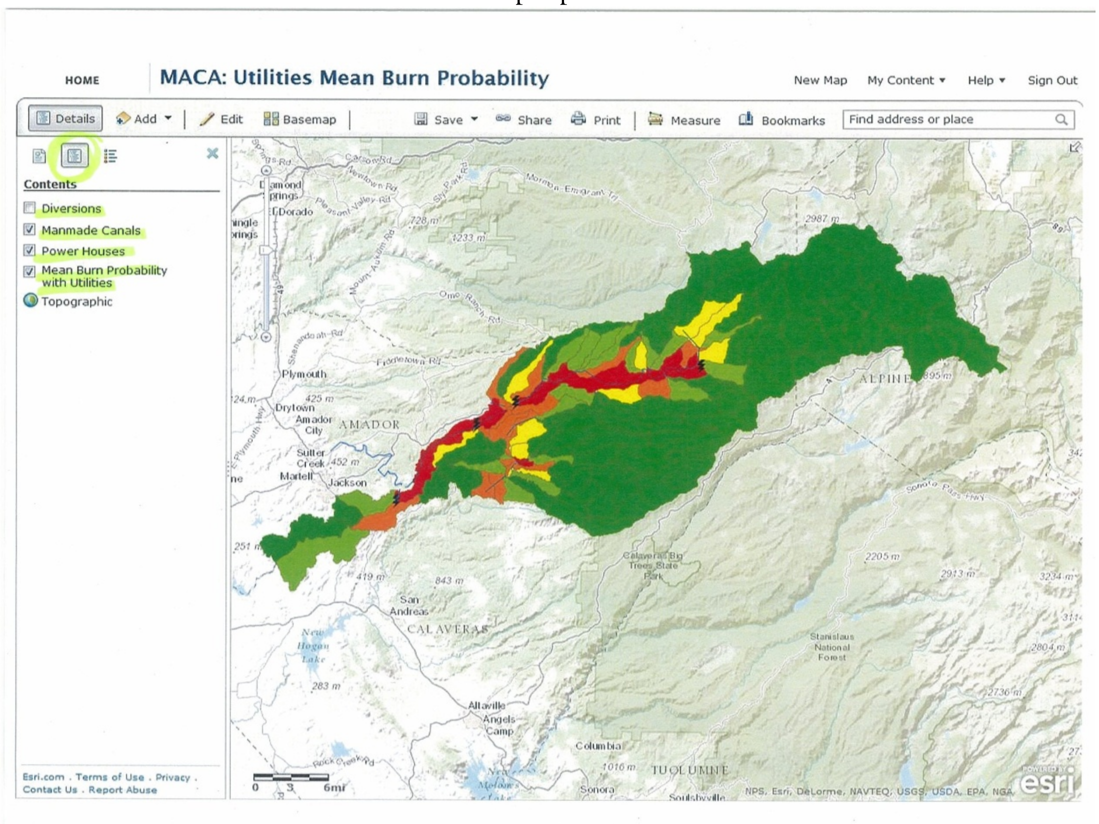
- MACA: Utilities Mean Burn Probability
- MACA: Mean Fire Erosion Risk
- MACA: Building Count
- MACA: Erosion and Intakes



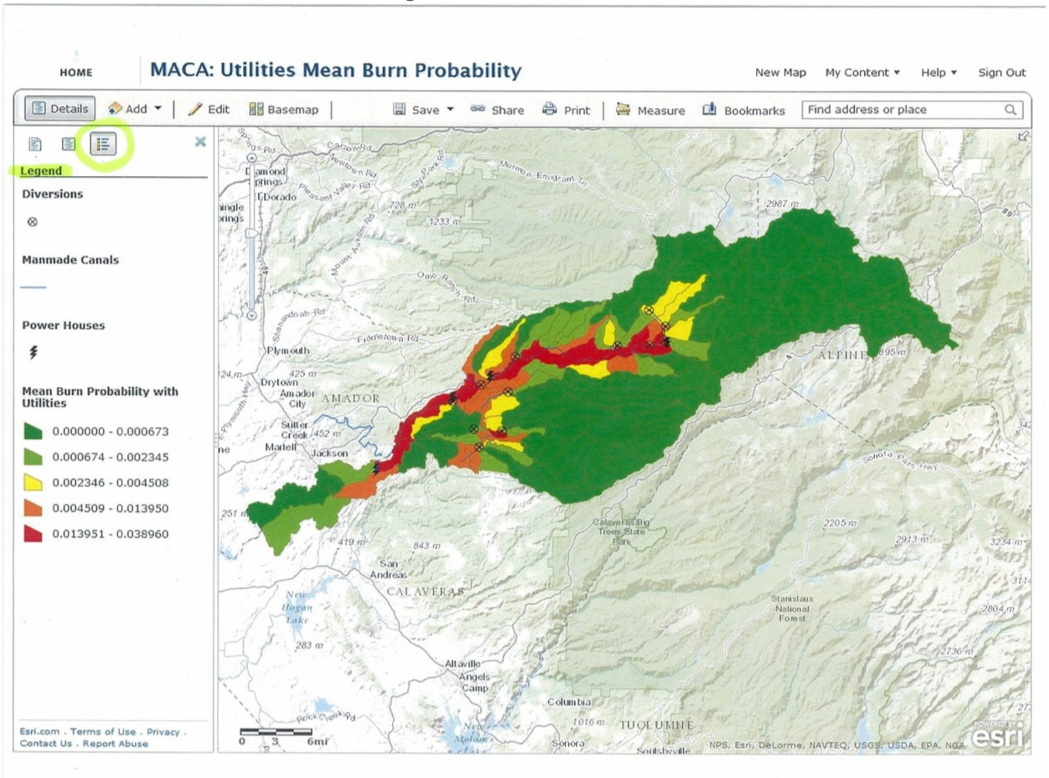
5. First tab under Details describes the map



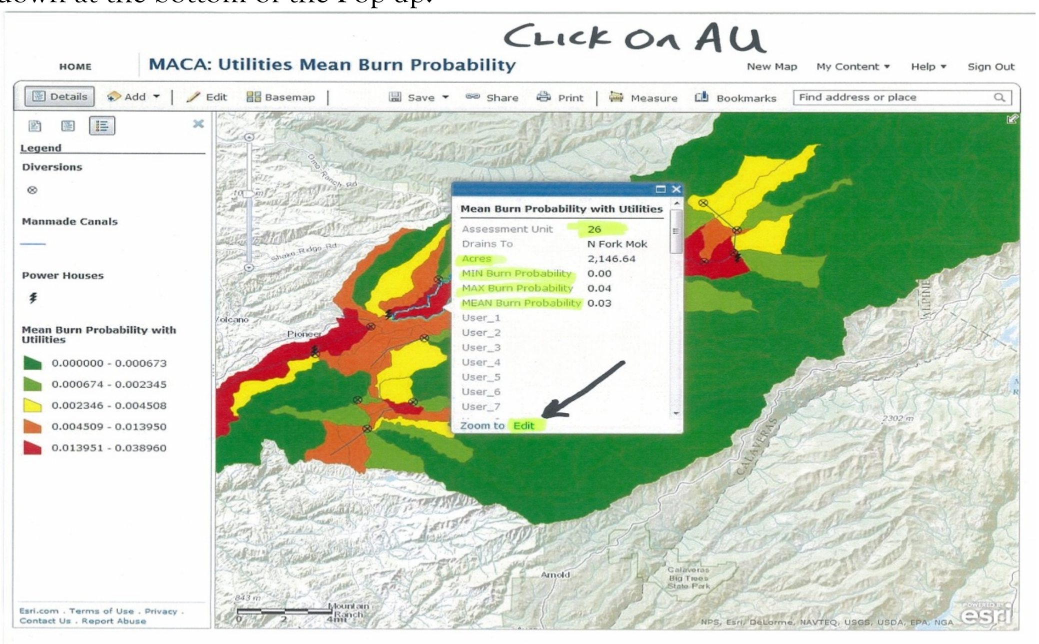
6. Second button under Details shows the layers available, which you can click on and off. Here I clicked Diversions off for demonstration purposes.



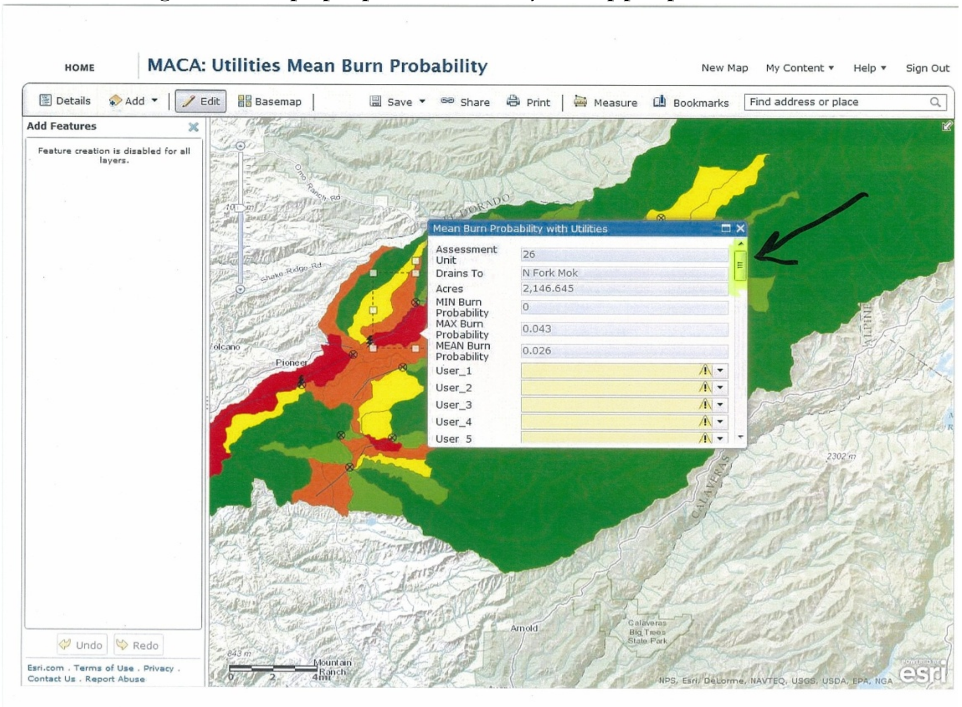
7. The third button shows the legend.



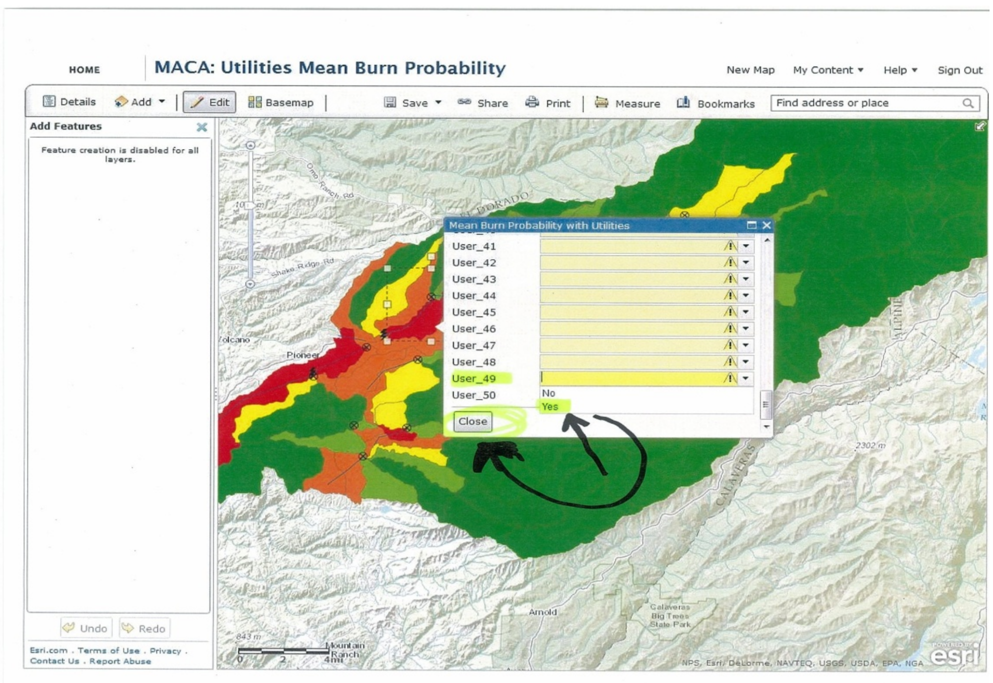
8. Once you click on an AU (zoom in or pan as necessary using the scroll bar on the left of the map), a Pop-up menu shows up. Here you can double check that you clicked on the correct AU you can see some of the attributes of the AU, including how many acres are in it and the min/max/mean burn probability of the AU. If you want to say “Yes” to this AU, click on EDIT down at the bottom of the Pop-up.



9. The Pop-up will change to what is below, where each user has a drop down menu. Use the scroll bar on the right of the pop-up to scroll to your appropriate user ID.

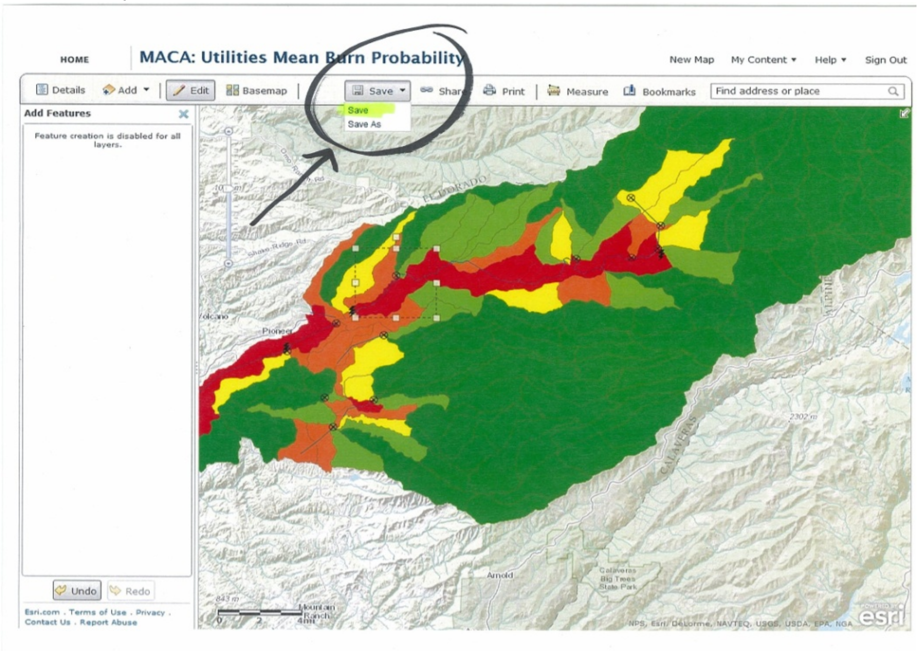


10. Once you find your User number (in this case user 49), click the drop down menu and select yes. It will set on yes, then you can hit close. Continue picking the AUs for selection on this map by repeating steps 8-10. I recommend saving after every 3-5 AU changes, which is shown under step 11.

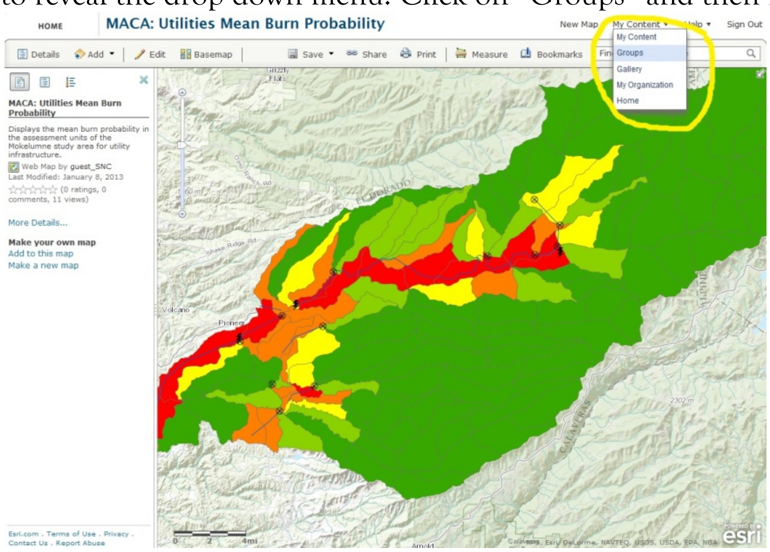


11. To save, click the Save button above the map, revealing a drop down menu. Please select "Save" only, not Save As.

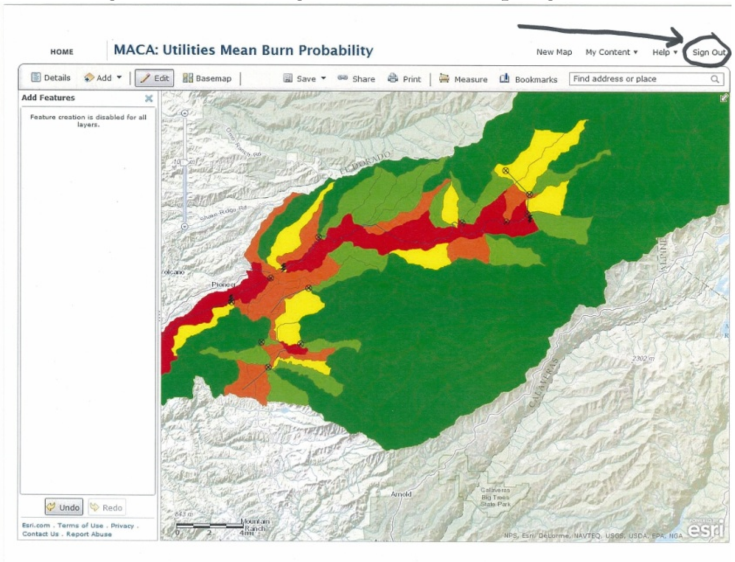
- If you are still selecting AUs, return to **step 8**.
- If you are done with this map but want to start working on another map, **go to step 12**.
- If you are done for this session, continue to **step 13**.



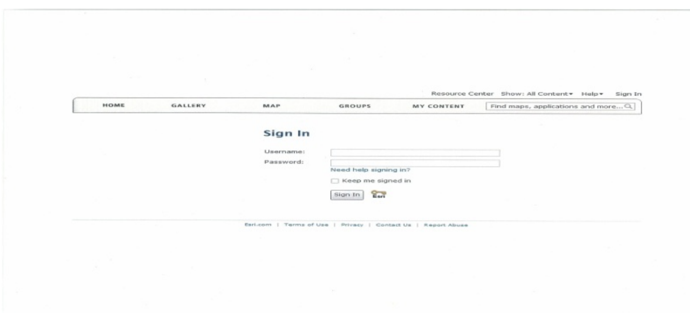
12. Once you have saved and you want to go to the next map, click on My Content in the top right to reveal the drop down menu. Click on "Groups" and then return to **step 3**.



13. To sign out, click Sign Out in the top right of the screen.



14. After you sign out, you will see the following screen and your session has ended. You can go ahead and close the window/tab/program.



Group Working Session on AU Selections for Treatment

January 10, 2013

Group 1
Identified clusters

1. 31,86,85 – High amount of recreational use, subdivision development at top (north side), PG&E infrastructure, existing community partnerships to treat, located in a steep inner canyon
2. 82,26,135 – High fire risk, high recreational use, difficult to contain fire spread in this canyon location, indirect effect to infrastructure
3. 136,95,103,81 – High sediment impacts
4. 105,144,109 – FDPA area i.e. CAL FIRE, sedimentation, Cornerstone, spread event from this location would be difficult to suppress
5. 78,75 – Steep canyon, canyon high risk for spread, containment is an issue

Group 2
Also identified clusters

1. Access routes for evacuation and firefighting: 112,107,101,102,104,115,84,20,10
2. Direct erosion threats to Pardee: 78,68,72,74,148,73,72
3. Upstream erosion threats to Pardee: 61, 40, 41, 63
4. Direct threats to Tiger Creek facility: 136,81,82,83,22,31,26

Group 3
Selection themes, no prioritization determined yet

Use red/orange cross-hatch on Erosion map (#3) to select AUs
Use red/orange Building Count map (#4) to select AUs
Use red/orange areas in Mean Utility Burn Probability map (#2)
Overlay all of the above with Burn Probability map (#6) to determine priorities.

Common AUs for Groups 1 and 2 = *26, 31, 78, 81, 82, 136*

PREPARED BY	Tim H.
DATE	1-9-2013

GROUP 1

MEAN FIRE EROSION RISK

#103 REASON - WUI w/ IT. LOTS OF EROSION & FUEL HAZARDS. LOW ROAD DENSITY. SUB-DIVISION AT TOP (NORTH SIDE) BUILDING COUNT. HIGH RISK

#31 TIGER CREEK - FS PROPOSED TREATMENTS BELOW PIONEER, POTENTIAL FOR FIRE STARTS DUE TO RECREATION, BUILDING COUNT LOW. AUs.

BUNDLE 31 + 85 & 86, HIGH RISK & POTENTIAL FOR WILDFIRE. STRUCTURES, COLLABORATION W/FS CA; COMMUNITIES PROTECTION OF STRUCTURES, PARTNERSHIPS W/ PVT & GOV'T LAND OWNERS. PG&E, POWER LINES

TAKE INTO ACCOUNT ADJACENT AUs OR SELECT AU FOR STRATEGIC REASONS. e.g. BUNDLE 70/41/63/61/ & 62.

#128 - FIRE RISK, LOW ROAD DENSITY, LOW INFRASTRUCTURE,

LOOK AT HIGH FIRE RISK, INFRASTRUCTURES, COMMUNITIES, MAP #3 CROSS HATCHED AREAS.

82, 26, 135, 103, 95, 136 & 81

SEDIMENTATION BE ISSUE CONTAINMENT SO IT DOES NOT CREATE ↑ SEDIMENTATION FROM OTHER AUs.

#109 - HIGH REC USE AREA. 144, 105 — CORNERSTONE PROJECT AREA;

DIFFICULT TO CONTAIN WILD FIRE THUS ↑ SEDIMENT; DIFFICULT TO IMPLEMENT.

1/9/2013

GROUP 1

SELECTION OF AUS FOR TREATMENT

CAL FIRE AREA

Priority	AU #	Reason (Explain with brief notes)
1	31, 85, 86	RECREATION / HIGH RISK, POWERLINES, INFRASTRUCTURE, COMMUNITIES, PARTNERSHIPS (FS CA)
2	26, 82, 135	HIGH RISK FIRE, HIGH RECREATION, DIFFICULT TO CONTAIN, PG&E etc. STEEP SLOPES
3	103, 95, 136, 81	HIGH RISK, PROXIMITY TO INFRASTRUCTURE.
4	109, 105, 144	
5	75, 78	COVERAGE / CAL FIRE INCLUDE; 136, 135, 82, 75, 103
6		

GROUP 2

FIRE-INDUCED SEDIMENTATION
EFFECTS ON INFRASTRUCTURE
" " STORAGE

WUI

(9) SAFETY OF TIGER CREEK FACILITY & ACCESS ROUTE
176
81-83
22
31
26

(1) ACCESS ROUTES
112, 107 BEAR R. RD
101, 102, 104, 115 - ELLIS RD.
84, 20, 19 - PANTHER

(2) EROSION RISK TO PARDEE N SLOPE HIGHER
↑78, 68 - ~~[illegible]~~ EXT. EROSION
74 - MOD HIGH EROSION, CLOSE TO PARDEE
148, 73, 72 S. SLOPE HIGHER

(3) HIGH FIRE EROSION W/US FILTERED BY BEEE, BUT EARTHEN EM. PARDEE
41, 63, 59, 40, 60 S. FACING SLOPES

INCLUDE PAW'S? ON UTILITY BURN MAP
NEED HIGH-TENSION LINE INFRASTRUCTURE
EVACUATION ROUTES/ACCESS ROUTES

GROUP 2

SELECTION OF AUs FOR TREATMENT

Priority	AU #	Reason (Explain with brief notes)
1	112	ACCESS ROUTES FOR EVACUATION & FIRE FIGHTING
2	107	↓
3	101	
4	102	
5	104	
6	115	
7	84	
8	20	
9	19	
10	78	DIRECT EROSION THREAT TO PARDEE - ~~HIGH~~ EXT. RISK
11	68	"
12	72	" - ~~HIGH~~ MOD. RISK, N. SLOPE
13	74	" - HIGH RISK, S SLOPE
14	148	"
15	73	"
16	72	"
17	61	UPSTREAM EROSION THREAT TO PARDEE - S. SLOPE EXT. RISK
18	40	" - "
19	41	" - N. SLOPE EXT. RISK
20	63	" - "

Priority	AU #	Reason (Explain with brief notes)
21	136	DIRECT THREAT TO TIGER CREEK FACILITY
22	81	"
23	82	"
24	83	"
25	22	"
26	31	"
27	26	"
28		
29		

Group 3

SELECTION OF AUs FOR TREATMENT

Priority	AU #	Reason (Explain with brief notes)
1		· Red/Orange in cross-hatch on Map 3
2		Red/Orange on map 4 : 51, 86, 77, 78, 73, 89, 30
3		Red/Orange Map 2 but only if ∃ fire probability. 76, 77, 78, 79
4		– all overlaid w/ Map 6 to determine priorities
5		

Stakeholder AU Selection Rationale

AUs with14-21 Selections

21 selections: AU 78

These are the AUs that have been marked as highest priority for treatment. Of these AUs, AU 78 was selected the most often for treatment (21 selections). 10 people chose AU 78 b/c of the location of utilities within the selection, and 11 people chose it because of fire erosion risk. There was a high degree of overlap (9) in the selection process, meaning that numerous individuals chose AU 78 for both utility and fire erosion risk. David E: prioritized AU 78 as second tier, "reduce direct risk of fire to utility infrastructure". Kim C selected it as top pick, coupled with AU 75: "Tiger Creek Afterbay is one of the primary vulnerable points in the watershed with high levels of sedimentation and no protection between PG&E and EBMUD's system." During the TC AU Selection meeting, Group 1 likewise chose 78, 75, however they marked it as the lowest priority cluster. Reasons given were that they are located in a steep canyon, with lots of infrastructure. John H placed AU 78 under Units Recommended for Fire Erosion Risk: "Highest probability. Near homes". Interestingly, those who did not participate in the TC Selection process set AU78 as lower priority. From BLM: selected it as 9th: "Understory thin" (AU 77 was selected in 8th position, for the same reasoning).

16 Selections: AU 77

The second highest chosen assessment unit was AU 77 (16 selections). In proximity, AU 77 is adjacent to AU 78. 12 people chose AU 77 because of the location of utilities within the selection, and 4 people chose it because of fire erosion risk. There was some overlap (4) in the selection process, meaning that some individuals chose AU 78 for both utility and fire erosion risk. It is noteworthy that although these AUs are adjacent, AU 78 was chosen at a significantly higher rate for fire erosion risk (11) than AU 77 was chosen for fire erosion risk (4). David E: prioritized it as second tier, "reduce direct risk of fire to utility infrastructure" John H. included AU 77 among AUs needing treatment because of Utilities located within the AU. His reasoning was "second highest priority to burn. Near homes. Water quality".

For Fire Erosion, AU 78 was selected 11 times whereas AU 77 was only chosen 4 times. That means that 7 more respondents chose AU 78 as needing treatment over AU 77 for fire erosion risk. For Utilities, the overall total was 12 for AU 78 and 10 for AU 77. That means 2 more respondents chose AU 77 as needing treatment over AU 78 for utilities. This suggests that AU 78 displays a similarity to AU 77 but that AU 78 poses a greater risk to fire erosion than AU 77. AU 77, however, poses a slightly greater risk to utilities, reflecting the fact that 2 members included it as needing treatment under the utilities map.

14 Selections: AUs 31, 82

AU 31 and AU 82 tied for overall total with 14 selections. AU 31 is adjacent to AU 77. For AU 31, of the total 14 selections, 10 people chose b/c of Utility, 4 people chose b/c of Fire Erosion. Group 1 identified AU 31 as a highest priority cluster, along with AUs 85 and 86. The reasoning was because of High amount of recreational use, subdivision development at the top (north side), PG&E infrastructure, existing community partnerships to treat, and because it was located in a steep inner canyon. Group 2 identified AU 31 in its fourth priority cluster to treat, along with AUs 136,81,82,83,22, and 26. David E. chose AU 31 along with AUs 72,73,76,77,78,86,89,146 and 30 to "protect communities/areas with dense buildings". John Hofmann chose this AU for both fire erosion and utilities risk. His reasoning for choosing AU 31 for fire erosion was because it is "opposite the side of the river from moderate probability (AU 81) which may burn also and add erosion if it (AU 81) burns." He also chose this AU for utilities risk because it was "highest probability to burn. Nearby homes. Influence electric water quality."

For AU82, of the total 14 selections, 5 people chose b/c of Utility, 9 people chose b/c of fire erosion. In the TC Analysis meeting, Group 1 included AU82 in their second cluster, along with AU 26 and AU 135. Their reasoning was that these clusters are in high fire risk areas, high recreation areas. Additionally, they reasoned that these AUs were in areas where if a fire were to occur it would be difficult to contain, and there's risk of an indirect impact on infrastructure. Group 2 included AU 82 in their fourth cluster, along with AUs 136,81,83,22,31 and 26. Their reasoning was that these AUs were close to the Tiger Creek Facility and because of the threat to PG& E structures (power lines, etc). David E included AU 82 in his second cluster of AUs that should be treated to reduce direct risk of fire to utility infrastructure. John H included AU 82 in his selection for units to be treated b/c of utilities: "highest probability to burn, close to powerhouse. Close to homes. Flume."

<u>9-13 Selections</u>

13 Selections: AU 91

These are the AUs that have received a number of selections, but aren't put into the top priority. With 13 selections, AU 91 received 8 selections for Utility and 5 for fire erosion. Interestingly, none of the groups within the TC AU Selection meeting chose AU 91 for treatment during the selection process, but participants chose this AU for treatment on the online GIS map. BLM included AU 91 as their 9th treatment priority, with the note: "understory thin". Jim C selected AU 91 as selection #5 for utilities. The following participants chose AU 91 for treatment: For Fire Erosion: CAL FIRE, Phil B, Reuben C, BLM, Jim C. For Utility: CAL FIRE, David E, Phil B, Bruce G, Reuben C, Stanislaus FS, BLM, Jim C.

12 Selections: AUs 73,75,76,88,103

AU 73 received 8 selections for Utility and 4 selections for fire erosion. In the TC AU Selection meeting, Group 2 included AU73 in their second cluster, along with AUs 78,68,72,74,148, and 72. Their reasoning was that these AUs were close to Pardee Reservoir and therefore had direction erosion threat to the reservoir. Within this cluster, the group prioritized the North –facing slopes (because they tend to have more fuels) over the South-facing slopes. David E chose AU 73 under this third cluster (along with AUs 72,76,77,78,31,86,89,146, and 30), because if treated it would protect community/areas with dense buildings.

AU 75 also received 12 selections, 3 were for Utility and 9 were for fire erosion. In the TC AU Selection meeting, Group 1 clustered AU 75 along with AU78 in its lowest priority cluster. Their reasoning was these AUs were in steep canyons where fire was at a high risk to spread, and fire containment is an issue. The following participants chose AU 75 for treatment: For Fire Erosion: CAL FIRE, Kim C, Barry H, Phil B, Kristen P, Frank M, Bruce B, Rick L, BLM. For Utility: Phil B, Reuben C, and BLM.

AU 76 likewise received 12 selections, 8 were Utility and 4 were fire erosion. David E included AU 76 (along with AUs 77,78,147,91,26,82,24,25,115,135,71, and 137) in his second prioritization group, with the reason that these AUs reduce the direct risk of fire to utility infrastructure. John H included AU 76 under AUs needing treatment for utility reasons: "medium probability to burn, near homes and communities. Recreational uses." BLM ranked it as 5th priority: "Fuel break, understory thin, multiple parcels".

AU 88 also received 12 selections, 7 were Utility and 5 were fire erosion. BLM included AU 88 as their 4th priority: "understory thin, multiple parcels". Jim C included AU 88 as his 4th priority for fire erosion risk.

AU 103 also received 12 selections, 3 were Utility and 9 were fire erosion. In the TC AU Selection meeting Group 1 selected AU103 in their third cluster, along with AUs 136, 95, and 81. These clusters were chosen because of the risk of high sedimentation loads (specifically AU 81). David H included AU 103 for fire erosion risk, with the following note: "highest probability, just below a home track".

11 Selections: AUs 30, 41, 72, 81

AU 30 was chosen 6 times for Utilities and 5 times for fire erosion. John H selected it for treatment because of utilities: "liability for homes from fires around powerhouses. Recreation" He also recommended it for treatment b/c of fire erosion risk: "uphill from a moderate probability (AU 81) but flatter and easier to treat. Although uphill will not prevent erosion downhill, it will help to reduce additional erosion from a wildfire that burns through AU81". BLM made it their 10th selection: "fuel break, understory thin". Jim C included it as his 4th selection for utilities, and 12th for erosion risk.

AU 41 also was selected 11 times, 3 times for utility and 8 for fire erosion risk. In the TC AU Selection meeting, Group 2 selected it (along with AUs 61, 40 and 63) in their third cluster because of these AUs' direct erosion threat to Pardee Reservoir: "These AUs are found on the south fork of the river, where PG&E infrastructure would not be trapping sediment so there's a pretty substantial threat to erosion affecting the reservoir. In this case, group 2 found the south facing slopes to be of high priority because they tend to heat up and burn and there's a pretty heavy fuel distribution on both sides of the canyon". Kim C included AU41 along with AUs 71, 70,62,61,63 and possibly 40- "these AUs show high fire severity and erosion adjacent to the South Fork. There is no protection (other than Tiger Creek Afterbay which is vulnerable) between this river channel and the EBMUD system. These AUs could be prioritized by slope, proximity to river, etc. but I just don't have the time to look that closely". David H included AU 41 as well under fire erosion risk: "highest probability and closest to communities"

AU 72 also was selected 11 times, 4 times for utility and 7 for fire erosion risk. In the TC AU Selection meeting, Group 2 included it in their second cluster (see AU 73 above for reasoning). David E included it in his third grouping, "protect communities/areas with dense buildings". John H said, "same as AU 77 but lower priority due to lower burn probability." AU 77 reads: "second highest probability to burn. Near homes. Water quality."

AU 81 likewise was selected 11 times, 7 times for utility and 4 for fire erosion. TC AU Selection meeting Group 1 noted it as being especially at risk for sedimentation loads. Group 2 also noted AU81 as being close to Tiger Creek facility and because of threat to PG&E structures (power lines, etc). See AU 31 above for reasoning. David E included it in one of his 1st groups along with 72, 74, 73, 148, 81, 82, 22, 26, 136, 84, 20, 19, 101, 104, 18, 115, 105, 46, 48, 11, 111, 3, 5, 116, 17, 43, 44, 15, 120, 121: reduce sediment risk within 10 miles upstream of facilities, combining postfire erosion risk with burn probability. Jim C included it as 4th choice for utilities.

With 10 selections: AUs 25, 48, 62, 71
With 9 selections: AUs 26, 37,39, 68, 86, 93
With 8 selections: AUs 98, 115
With 7 selections: AUs 24, 40, 95
With 6 selections: AUs 32, 46, 70, 74, 79, 80, 89, 100, 109
With 5 selections: AUs 18, 61, 83, 84, 92, 101, 105, 136, 148
With 4 selections: AUs 22, 38, 59, 67, 69, 110, 111

Mokelumne Watershed Avoided Cost Analysis: Why Sierra Fuel Treatments Make Economic Sense

Report Version 1.0

April 10, 2014

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Disclaimer

This report is rich in data and analyses and may help support planning processes in the watershed. The data and analyses were primarily funded with public resources and are therefore available for others to use with appropriate referencing of the sources. This analysis is not intended to be a planning document.

The report includes a section on cultural heritage to acknowledge the inherent value of these resources, while also recognizing the difficulty of placing a monetary value on them. This work honors the value of Native American cultural or sacred sites, or disassociated collected or archived artifacts. This work does not intend to cause direct or indirect disturbance to any cultural resources.

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