

Effectiveness Monitoring Committee
Full Project Proposal Form

Deadline for Submission: November 16th, 2019

Project #:

Date:

Project Title:

**Principal
Investigator(s):**

Collaborators:

Contact Information:

Project Duration (Years/Months):

Written Proposal Requirements:

Please address each of the following for consideration by the EMC. For further information please see the Request for Proposals or consult section 5.0 of the EMC's Strategic Plan.

1. Background and Justification

2. Objectives and Scope

3. Critical Questions and Forest Practice Regulations Addressed

Please identify the Critical Questions by number and letter (as identified in the EMC's strategic plan), and the associated regulations by number. Please also describe how your project will address these questions and the efficacy of each regulation.

4. Research Methods

5. Scientific Uncertainty and Geographic Application

Please consult section 4.4 of the EMC's strategic plan for further information.

6. Collaborations and Project Feasibility

7. Project Deliverables

8. Detailed Project Timeline

9. Requested Funding

Please provide the total requested amount of funding along with a line item budget for each fiscal year of the project (see page 2).

Include figures, tables, or photos as needed.

Please ensure that all "Categories" below are addressed in your budget. This will ensure that all information required by the state contracting process is present. You may break each "Category" into as many sub-categories as needed to fully describe your budget.

Category	Description	Year 1	Year 2	Year 3	Total
Personnel <i>Identify all personnel costs including field technicians, graduate students, Principal Investigators, etc. Show these values as individual rates per unit of time.</i>	PI				
	Graduate Student				
Fringe Benefits <i>Cite as actual benefits or a percentage of personnel costs.</i>	Fringe Benefit				
	Tuition, Fees, Health Ins (grad student)				
Other		37,350	37,438		74,788
Operating Expenses <i>Include rent, supplies, and equipment costs as separate line items</i>					
Indirect Cost <i>Not to exceed 15%</i>	IDC				
Travel <i>Express as per diem rates specified by CalHR, or verification that such rates are not available to you.</i>		3000	3000		6000
Total Cost					
Matching or In-Kind Contributions					
EMC Funding Requested					

Fuel Treatments and Hydrologic Implications in the Sierra Nevada

1. Background and Justification

The forested Sierra Nevada range acts as a natural reservoir collecting vast quantities of snow, which provides the majority of hydrologic needs for municipal, industrial, and agricultural sectors of California, and Reno Nevada (Margulis et al., 2016, Sterle & Singletary, 2017). These forested landscapes are changing in response to intensifying climate, fire patterns, and biological invasion (Slingsby et al., 2017). Decadal decreases in snowpack has altered the Sierras' capacity to provide water to a multitude of competing demands (Belmecheri et al., 2016). Thus, land managers are experimenting with more preventative forest management strategies to reduce forest fire risk and increase water quantity (North et al., 2015).

Changes in forest structure (thinning, mastication, logging, wildfire, etc.) have implications for local and regional water quantity and quality. Changes in basin yield are noted to be a function of regrowth rate, canopy cover and soil properties (Saksa et al., 2017). Given the dependency of the western U.S. on snowpack and mountain runoff for water supply (Painter et al., n.d.; Pierce et al., 2008); a minimal change of the current forest structure can have critical implications for regional and state water resources. Thus, ecohydrologic projects that monitor fuel management and forest stand treatments are needed, especially longer-term high-resolution studies (monthly and seasonal vs. traditional annual scale).

Studies evaluating the hydrologic response to forest fires have noted that there can be increases in water yield following reductions in forest structure (Evaristo & McDonnell, 2019; Hallema, 2018; Kinoshita & Hogue, 2015). Similarly, studies have noted that forest treatments can impact water yield (Hibbert, 1965; Rothacher, 1970; Saksa et al., 2017). We anticipate that there will be changes in water yield however, given current climate projections, modern forest conditions, and management techniques, we are unsure how treatments will impact water yield. While these studies provide insight into the complex interactions between changes in land cover and water quantity and quality, new forest treatments such as strategically placed area treatments (SPLAT), which could greatly improve forest resiliency, diversity and water yield (USDA, 2011) have not been studied with relation to water yield.

The Sagehen Experimental Forest is representative of the modern forest conditions found throughout the Sierra Nevada and Western U.S. (USDA, 2011). Sagehen is undergoing extensive and variable experimental treatments guided through SPLATs. The goal is to fragment the landscape, reducing fuels (forest stands) and ultimately, extent and severity of regional fires (Bahro et al., 2007). The Forest Service is managing the Sagehen basin in order to: 1) reduce hazardous fuel loads and modify wildfire behavior, 2) maintain and enhance habitat for wildlife (i.e. American marten, California spotted owl, and northern goshawk), 3) encourage a healthy forest fire regime, 4) create heterogeneous forest conditions natural to an active fire regime, and 5) restore

declining aspen stands. The implementation of the SPLATs are expected to serve as a prototype for forest management for the Sierra Nevada, as outlined in the USFS General Technical Report, “An Ecosystem Management Strategy for Sierran Mixed-Conifer Forests” (North et al., 2009).

By monitoring and evaluating these goals, this study will assess the effectiveness of natural resource protection of forest structure and health through wildfire hazard reduction and the hydrologic and habitat impacts these practices have. Specifically this study will deliver an improved physical process-based understanding of the following California Forest Practice Rules (FPRs) (Crowfoot & Porter, 2019). From Article three of the FPRs, we will be evaluating a multitude of forest stand treatments outlined in the SPLAT methods. This includes uneven-aged management, intermediate treatments, commercial thinning, and Aspen restoration. From Article six we will be evaluating the changes in hydrologic behavior, which will have important implications for determining if the quantity and beneficial uses of water has been unreasonably degraded, with the aim that it will improve. We will also evaluate the impact of these treatments on aquatic habitat, including relevant water quality and biota. Additionally, hydrologic impacts of hazard reduction including broadcast burning of slash from article seven will be evaluated.

To date, no studies take advantage of this unique opportunity to monitor and evaluate the potential range of hydrologic and aquatic habitat changes that will occur in the basin given the variety of treatments being applied. We have developed an extensive in situ observational network in Sagehen, supplemented with ground-based surveys and remote sensing information (pre and post-treatment data at sub-basin scales for each treatment type since 2012). With the largest amount of forest treatments occurring in 2018 it is imperative that monitoring Sagehen continues as this unique dataset allows us to evaluate the impact of forest treatments on critical ecohydrologic processes at a range of space and time scales not previously undertaken.

2. Objectives and Scope

The overarching goal of this research is to monitor, analyze, and develop a statistical framework to quantify the response of streamflow to forest treatments in Sierra Nevada watersheds. Results will significantly advance and transform our understanding of the impacts of deforestation on short- and long-term water yield in sub-alpine mountain systems and provide critical information for regional forest and water resource managers and planners. The proposed work also presents an opportunity to build upon and bridge interdisciplinary resource managers (water, forest, power, etc.) to jointly manage multiple and critical resources. In addition to our extensive monitoring, we propose the development of a predictive framework that is transferable to regional watersheds for quantifying stream and hydrologic response to relevant mitigation efforts. The proposed work also builds upon our extensive research on understanding and predicting hydrologic behavior in altered watersheds, which includes collaborations with the U.S. Forest Service, the Bella Vista Foundation, and The Nature Conservancy, as

well as our ongoing research activities in the Sagehen basin. Our research questions include:

- *How will variability in forest treatments affect sub-basin and basin scale discharge?*
- *What key variables determine hydrologic response to differing mitigation strategies?*
- *How will downstream aquatic habitat be impacted by upstream forest treatments?*
- *To what degree does sediment flux vary due to upstream forest mitigations?*
- *To what degree can remote sensing information quantify treatment impacts on forest structure?*
- *What key metrics best quantify system change and can be easily integrated into a predictive framework for evaluating habitat and hydrologic response in California watersheds?*

3. Critical Questions and Forest Practice Regulations Addressed

In addition to our main objectives and scope described above, monitoring an extensive forest treatment mitigation program is in line with the California State Board Forestry and Fire Protection formed Effectiveness Monitoring Committee (EMC) to develop and implement a monitoring program to address both watershed and wildlife concerns and to provide a better active feedback loop to policymakers, managers, agencies, and the public. While our proposed work will address several of the EMC themes and critical questions, our data and findings will also be broadly applicable to stakeholders and managers addressing these and other relevant themes across California. Of the 11 themes and critical questions identified in the EMC's strategic plan, we will address questions in Themes 1, 2, 5 and 6 as described below.

Theme 1: Watercourse and Lake Protection Zone (WLPZ) riparian function

The central theme of the work proposed in the Sagehen basin will be evaluating the impact of timber operations on the beneficial uses of water and functions of riparian zones (14 CCR § 916 [936, 956]). We will be able to elucidate these impacts relative to a range of treatment types and correlate this to function and form of the downstream aquatic system. Specifically, the following critical questions focused on the WLPZs will be addressed:

- (a) Are the FPRs and associated regulations effective in maintaining and restoring canopy closure?
- (b) Are the FPRs and associated regulations effective in maintaining and restoring stream water temperature?
- (e) Are the FPRs and associated regulations effective in maintaining and restoring input of organic matter to maintain or restore primary productivity as measured by macroinvertebrate assemblages?
- (h) Are the FPRs and associated regulations effective in managing WLPZs to reduce or minimize potential fire behavior and rate of spread?

- (i) Are the FPRs and associated regulations effective in filtering sediment that reaches WLPZs?

Theme 2: Watercourse channel sediment

A primary goal of the FPR regulations has also been to limit the delivery of management-related sediment to watercourse channels in California. Erosion and sediment delivery following timber operations have significant impact on downstream stream systems. We will monitor sediment flux approximated by geochemistry such as pH, dissolved oxygen, conductivity, and turbidity. Specifically, the following critical questions will be addressed:

- (a) Are the FPRs and associated regulations effective in minimizing management-related sediment delivery from forest management activities to watercourse channels at the watershed and sub-watershed level in managed watersheds?
- (b) Are the FPRs and associated regulations effective in minimizing management-related sediment delivery from forest management activities to watercourse channels for individual Plans at the project level to evaluate channel response to forest management prescriptions and additional mitigation measures?

Theme 5: Fish Habitat

This proposal will also relate to the protection of fish habitat features in forested watersheds [14 CCR § 916 (936, 956)], which require that timber operations shall be planned and conducted to provide protection for water temperature control, streambed and flow modifications by large woody debris, filtration of organic and inorganic material, upslope stability, bank and channel stabilization, and spawning and rearing habitat for salmonids [14 CCR § 916.4 (936.4, 956.4) (b)]. Specifically, the critical questions related to restoring the quality and connectivity of fish habitat will be addressed:

- (b) Are FPRs and associated regulations effective in maintaining and restoring the distribution of foraging, rearing and spawning habitat for anadromous salmonids?

Theme 6: Wildfire hazard and has the potential to provide valuable information for other projects related to fish and wildlife habitat.

Prior work has elucidated that forest mitigation strategies to encourage forest health and diversity (14 CCR § 897), which can reduce the risk of severe fires (Safford et al. 2012, North et al. 2009, Omi and Martinson 2004, Martinson and Omi 2003). However, less work has been done to couple treatment types to habitat response and stream health. The Sagehen basin offers the opportunity to provide information that is transferable across the state for ongoing and future forest treatment activites. Critical questions that we will address in this theme include:

- (b) Are the FPRs and associated regulations effective in treating post-harvest slash and retaining wildlife habitat structures, including snags and large woody debris?
- (c) Are the FPRs and associated regulations effective in managing fuel loads, vegetation patterns and fuel breaks for fire hazard reduction?

4. Research Methods

4.1 Study Area

The Sagehen basin is ~16 km north of Truckee, California and 32 km north of Lake Tahoe, on the eastern side of the Sierra Nevada. The Sagehen Creek Field Station and Sagehen Experimental Forest were established in 1951 and are operated by UC Berkeley. The 36 km² watershed has high biodiversity and is home to large alpine fens, including the largest Mason Fen (USDA & USFS, 2011). There are over 680 plant and 200 vertebrate species documented in the area. There has been active fire suppression, resulting in dense forest growth in over half of the basin. A catastrophic wildfire in this area would have adverse impacts on the diverse biota, natural and cultural resources and the ecohydrology of Sagehen Creek and ultimately the Little Truckee River and Truckee River, which are considered “water quality limited” (Section 303 (d) of the Clean Water Act).

There are four treatments being undertaken within Sagehen: aspen restoration, plantation thin, underburn, and variable thin (Figure 1), each have a specific objective. Initial SPLAT treatments began in 2016. The majority of the treatments were completed during the summer of 2018; with ongoing chipping and mulching still occurring. Given this timeline, we currently have ~4 years of pre-treatment monitoring data and ~3 years of post-treatment monitoring data.

4.2 Sub-watershed and Basin-scale Monitoring after Forest Structure Change

4.2.1 Monitoring Water Quantity

This task involves extensive monitoring, data collection, database compilation and analysis of the collected observations relative to treatment type. An important attribute of Sagehen is the extensive pre-existing climate and hydrological instrumentation, allowing an evaluation of spatial and temporal trends and patterns for historical (~50 years) and contemporary (~10 years) periods. The USGS has monitored stream flow at the outlet since 1953 and Sagehen is instrumented with 11 automated weather stations and flux towers that record a range of parameters at varying elevations throughout the basin. We have also established a pressure transducer sensor network to monitor sub-catchment streamflow since 2012 (Figure 1), which will be used to capture the hydrologic response based on different treatment types. The installed Colorado School of Mines (CSM) network of pressure transducers records stage height and temperature observations every fifteen minutes (installed October 2012) (Figure 1). Sites will be visited 2-4 times per year to gather data and manually measure discharge for rating curves, ultimately providing continuous discharge at each sub-basin and to increase the accuracy of the rating curves.

To maintain accuracy in streamflow measurements, channel cross sections will be re-surveyed as needed when there is significant geomorphic and channel structure change (sediment deposition or scour). Our post-treatment observations will be compared to any relevant surveys such as the USDA Forest Service Stream Survey, 2002 that catalogued bank instability, temperature, pool and riffle surveys, and habitat and fish

surveys (<https://sagehen.ucnrs.org/research/resources-data/>). Available precipitation and other meteorological variables will serve to establish rainfall-runoff relationships within treatments and sub-basin areas. All data gathered from our observational network as well as collected and processed remote sensing data will be available from this study.

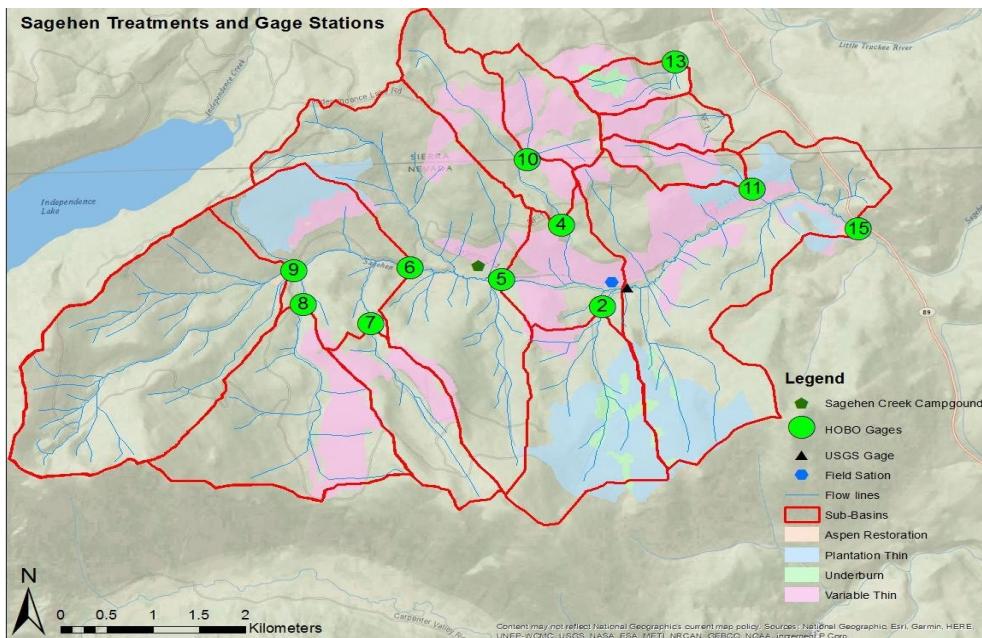


Figure 1. Sagehen watershed, fuel treatments, and instrumentation

4.2.2 Stream Health

Climate change will impact streamflow and stream temperatures, changing thermal stream habitat, reducing cold water habitat and ultimately fish species distributions (van Vliet et al. 2013; Caldwell et al. 2015). Other models agree that aquatic life will experience more frequent extreme low flow events coupled with warmer stream temperatures in a changing climate (Arismendi et al. 2012). In addition to climate change, wildfires or changes to forest canopy can remove riparian shading and allow an increase in light flux, driving a short or long-term increase in stream temperature altering thermal habitat, which impacts algal growth and ultimately macroinvertebrate and fish viability. Increased water temperature changes fish biochemical reactions, requiring them to eat additional prey to survive in warmer temperatures (Beakes et al. 2013; van Vliet et al. 2013).

The diversity and number of aquatic species in the Western U.S. is already on the decline (Williams et al. 2011). Freshwater fauna are going extinct five times faster in the United States than mammals (Bernhardt et al 2005). Conserving the many threatened and endangered species, to ensure their survival, requires addressing habitat destruction, invasive species, and other human influences on water quality. Federal and state agencies along with conservation groups work throughout the Western US to

restore native fish habitat. Wildfires are often seen as random disturbances affecting stream habitat. However, mitigation strategies that would reduce the impacts of fire on water resources, such as those ongoing in Sagehen, could impact the short and long-term stream health.

To quantify the response of geochemical and biological measures of water quality to stream habitat changes after forest treatments, we will utilize existing data and collect new observations. The USGS has monitored stream temperature at the outlet since 2008 at fifteen minute frequency and specific conductivity at 25°C at fifteen minute frequency from 2008 to 2016. This information will compliment our distributed fifteen minute temperature and streamflow data. Additionally, we will also take measurements to evaluate sediment flux (total dissolved solids and turbidity) during field site visits. Water quality data will be acquired and synthesized with periodic observations from previous studies by the U.S. Geological Survey stream flow & chemistry data (infrequently since 1968), National Water Quality Assessment Program (~2011-2016), and ambient temperature and DO (2000-2016) to develop an understanding of baseline conditions and to provide a reference for changes observed during our study.

One of the most important measures of ecosystem health is the response of in-stream biota to perturbations. The State of California is in the process of setting consistent methods to assess biological integrity (“bioassessment”) for policy and decision-making. Bioassessment will be incorporated into our monitoring efforts to fill an important gap in our knowledge of how forest restoration efforts influence biological integrity of the stream. In years 1 and 2 of the proposed project, biological assessment of benthic macroinvertebrate communities will be performed based on the California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) sampling protocols. Biological collection of benthic macroinvertebrate communities will be performed using SWAMP field protocols for wadeable streams. In brief, sampling along with stream habitat characterization will be performed. Samples will be collected at upstream and downstream locations on the mainstem of Sagehen to represent non-treated and treated areas, respectively. Macroinvertebrate samples will be sent to a taxonomy laboratory for classification. Common metrics that we will calculate to characterize the biodiversity include Ephemeroptera Plecoptera Trichoptera (EPT) and percent taxa. We will submit all relevant permit applications to the California Department of Fish and Game for macroinvertebrate sampling. If feasible, we will compare our data to the assemblages from previous studies performed in Sagehen ~2004-2013 (<https://sagehen.ucnrs.org/research/resources-data/>). Although we hypothesize a recovery in the number of insects following the treatments, we expect that reduced canopy may alter the macroinvertebrate species that are present. This could result in a decrease in biodiversity, where there could be a potential shift in the population, with a loss of rare and sensitive species.

4.3 Remote Sensing of Vegetation

To understand the relations between vegetation cover and streamflow and habitat conditions, a compilation of remote sensing data and analyses will be related to vegetation processes. Remote sensing products can provide spatial and temporal information to monitor seasonal and annual vegetation patterns and detect changes in forest canopy and vegetation structure. These datasets will be used to develop a framework to predict the seasonal and annual hydrologic response to forest treatments and management in the Sierra Nevada.

4.3.1 Normalized Difference Vegetation Index

In our prior work we have applied Normalized Difference Vegetation Index (NDVI), which is a proxy of green biomass or vegetation activity. NDVI uses the normalized difference between red and near-infrared channels and is sensitive to vegetation fraction and the rate of absorption of photosynthetic solar radiation (Gitelson et al., 1996). NDVI is a well-established vegetation index that correlates with photosynthetically active plant material. Indices vary from 0 to 1, where 0 represents no vegetation and 1 is fully vegetated. Landsat derived NDVI has been acquired at 30 m and evaluated from 1996 to present.

Initial work at Sagehen includes seasonal and annual analysis with NDVI and basin outlet discharge, and highlights that there are noticeable trends between vegetation indices and climate patterns (seasonality and dry periods) (Figure 2).

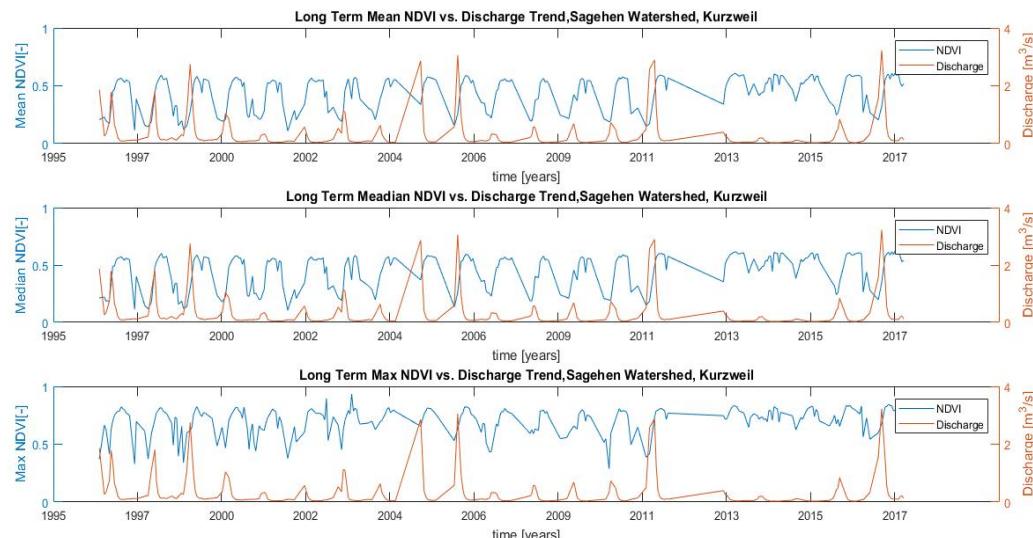


Figure 2: NDVI derived from Landsat (Mean, Median, Max values) and relationship to discharge at the outlet of the Sagehen basin (USGS gage) for water years 1986 to 2017.

We hypothesize that due to drought stress in 2011-2015 there was a decrease in canopy cover, potentially allowing undergrowth and higher growth (green) productivity. Understory species such as *Carax* and *Juncus* are thought to have much higher NDVI values than the coniferous canopy cover (Ramsey et al., 2002). Seasonal variation in the

trend of NDVI indicates that additional ground-based and higher resolution information are needed to monitor canopy and vegetation cover and validate and calibrate our remote sensing work. Additional analyses on factors driving these patterns are needed to understand the influence of basin-wide vegetation and discharge variability.

4.3.2 Leaf Area Index

Additional metrics such as Leaf Area Index (LAI) and Light Detection and Ranging (LiDAR) will be incorporated into the vegetation analysis. Leaf area is strongly related to the total amount of plant to atmosphere exchange processes such as photosynthesis, evapotranspiration, rainfall interception, and carbon flux. Canopy leaf area can be estimated by leaf area index (LAI), which is a measure for the total area of leaves per unit ground area and is related to the amount of light that can be intercepted by plants and is an important climate and biodiversity variable (WMO, 2016). An active area of research is working towards evaluating the sensitivity of LAI to forested regions and understory vegetation (Meyer et al., 2019). We will obtain relevant LAI from Landsat scenes (30 m) with no cloud cover from USGS Earth Explorer. LAI will be acquired from 2012 to the end of the proposed project for Sagehen to represent baseline and post-treatment conditions.

4.3.3 Light Detection and Ranging (LiDAR)

Airborne LiDAR data are playing an increasingly important role in forest survey, monitoring, and management (i.e. Jakubowski et al. 2013; Ma et al., 2018) because of their capabilities in characterizing three-dimensional tree structures (Coops et al. 2007). Many studies have demonstrated the efficiency and accuracy of using LiDAR data to estimate forest structure parameters, which we will estimate in the proposed study. These include tree height (Holmgren et al., 2003), canopy cover (CC) (Korhonen et al. 2011), biomass (Tao et al. 2014), percent canopy cover (Griffin et al., 2008), and leaf area index (Jensen et al., 2008; 2011).

We proposed to incorporate available aerial LiDAR data to detect vegetation structure change with respect to the treatments and LAI information described in Section 4.3.2. Sagehen has been part of several aerial LiDAR surveys, which are available from the UC Berkeley Center for Forestry on OpenTopography and the National Center for Airborne Laser Mapping (NCALM). Repetitive point cloud data collection can be used to quantify disturbance-related changes over time and may aid in understanding responses after forest treatments. We will acquire the point cloud data for a pre- and post-treatment LiDAR image. It is anticipated that the point density coverage for these data sets may vary temporally and spatially due to survey conditions such as snow or missing flight swaths. When available, pre-processed data such as derived vegetation height may be used in our analysis, otherwise, a four-part workflow will be used to acquire, process, interpret, and quantify error in the obtained LiDAR datasets similar to Nourbakhsh-beidokhti et al. (2019). Occasional field reconnaissance throughout the proposed study period will be used to help corroborate LiDAR. For example, based on the first quarter of

work, we will note areas that require field reconnaissance or points of interest to investigate and spot-check the remotely-sensed vegetation.

Available aerial LiDAR data will be used to derive digital terrain model (DTM), digital surface model (DSM), and canopy height model (CHM) to generate tree height and forest parameters. The DTM and DSM for each dataset will be interpolated from ground and first returns using the ordinary Kriging algorithm (Ma et al., 2019). CHM will be calculated as the difference between the DSM and DTM with a resolution of 0.5 meters, which can be interpolated to relevant cell sizes for comparison with other remote sensing products in this study.

4.3.4 Synthesis of Remote Sensing Data

The forest type in Sagehen and each sub-basin will be classified using the U.S. Forest Service Pacific Southwest Region (R5) Classification and Assessment with Landsat of Visible Ecological Groupings (CALVEG). The vegetation and management type will guide analysis. The remote sensing products, LAI and LiDAR, will be compared for each sub-catchment based on treatment application. Derived information will be incorporated with our understanding of vegetation patterns based on NDVI. Additionally, to validate and supplement the findings above, Landtrendr algorithms will be utilized in the Google Earth Engine interface to evaluate gain or loss of vegetative structure in the watershed (Kennedy et al., 2010; 2018). Landtrendr evaluates the change in the spectral trajectory of individual pixels at 30 m. This method allows for the extraction of the year a change process began, the year a change process ended, the magnitude of change, and the duration of that change, among other calculations.

4.4 Statistical Analysis and Framework Development

In summary, two primary data sets will be collected in Sagehen: 1) surface water data (discharge and water quality) collected via stilling wells, a United States Geological Survey (USGS) station #10343500, in situ weirs, geochemical sampling and macroinvertebrate analysis; and 2) remotely sensed vegetation and canopy information (NDVI, Landtrendr, LAI, LiDAR).

We will assemble sub-catchment data to characterize physical conditions that influence streamflow, habitat conditions, sediment flux and vegetation relations such as hillslope, treatment applications, and other metrics that quantify vegetation biomass loss.

Synthesized LAI and LiDAR information with seasonal and timeseries data (i.e. NDVI and streamflow) will be used to construct the framework for predicting restoration impacts on watershed processes.

Discharge data collected in the eleven subwatersheds, from 2012 to present, will be used to evaluate the hydrologic and habitat response to forest management practices. Building upon past research conducted in the Hogue research group (Kinoshita & Hogue, 2015; Saxe et al., 2016; Slinski et al., 2016), we will utilize statistical approaches to evaluate changes in annual runoff ratios, low flows, high flow, peak flows, base flow

index, changes in return periods, Richards-Baker Flashiness index, and timing of the center of mass of the annual flow. To determine annual variations in discharge from the pre-treatment mean, climate elasticity models will be used to evaluate the contributions of climate and other disturbances to the observed change in discharge (Hallema et al., 2018). We will also apply time series analysis and statistical metrics to gathered sediment parameters and remote sensing data. These statistical methods have been successful in our previous research in the Ashland basin, demonstrating that at low treatment levels, climate is dominating the hydrologic response in this area (Figure 3).

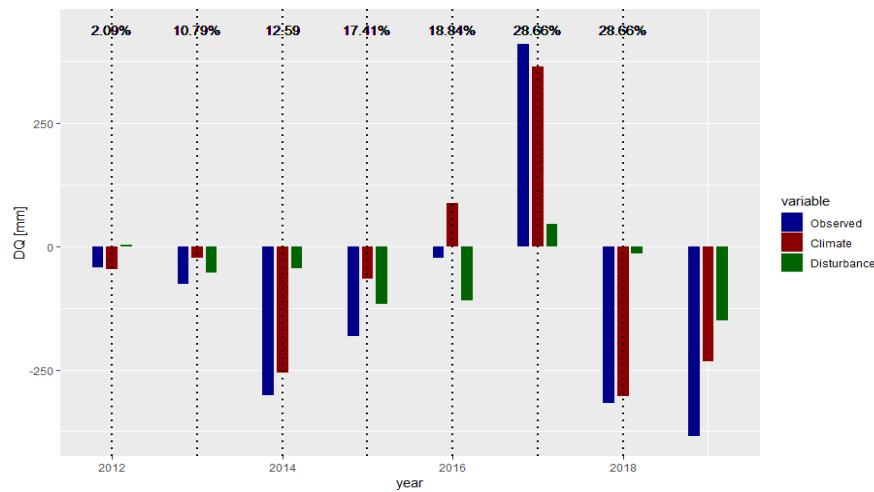


Figure 3. Climate Elasticity Model (CEM) applied to a watershed near Ashland, OR.

Additionally this collected data will be used for statistical regression and conditional inference tree analysis to determine the driving factors to predict change in discharge from upstream mitigation treatments. Discharge from the outlet of the watershed will be compared with vegetation indices to observe how the greenness signal responds to basin treatments and to determine which vegetation index is representative of hydrologic changes. Preliminary results in the Sagehen watershed demonstrate that there is no distinct trend in streamflow by treatment types. While there are some relationships between NDVI and stage, these parameters do not show a distinct response for each treatment type.

Establishing relations between forest structure change and hydrologic response for each treatment type will provide a basis for a management tool. Statistical models that can reliably predict water yield changes relative to climate and forest management will allow land and resource managers to better plan for more diverse and fire resilient forests, while also improving water yield forecasts in a critical mountain range. It is the goal to take the statistical framework above, and create an integrated statistical package in R that will allow for ecohydrologic monitoring in any desired basin. This package will include functions to calculate statistical changes in runoff ratios, seven day minimum flows, high flows, timing of the center of mass, seasonal hydrologic regime shifts, and timing of peak flow. These metrics have been used in a range of studies to

evaluate change in hydrologic systems (del Campo et al., 2018; Hallema et al., 2018; Helsel & Hirsch, 2002; Hunt et al., 2018; Podolak et al., 2015). This package will also include inference tree functions to aid in understanding what ecological functions are influencing streamflow.

The package will have a user-friendly interface that can be implemented on any operating systems (PC, MACS, etc.) and can also be easily updated with statistical metrics and data streams specific to the user's site of interest. A range of outputs will be available, including timeseries of remote-sensing and hydrologic variables, hydrographs, and statistical reports. The proposed work will also provide a method to upscale the basin results to larger areas by relating field-scale information to remote sensing products. This will improve our management of not only water quality and quantity, but also forest resiliency to natural hazards and extreme fire events of different scales.

5. Scientific Uncertainty and Geographic Application

The statistical methods used to evaluate the monitoring efforts will utilize non-parametric test to evaluate the significance of observed trends and changes. The significance will be determined by well-established methods that recognize uncertainty and will be conducted at a ninety five percent confidence interval (Helsel & Hirsch, 2002). The final packaged framework will provide the needed uncertainty bounds for decision-makers.

The developed framework is applicable to Sierra Nevada watersheds and other similar hydroclimatic regimes. We expect that the analysis and metrics developed in the final framework (described above) can be readily transferred to watersheds in the vicinity of the test basin, Sagehen experimental watershed located in the northern Sierra Nevada, as well as other watersheds along both the western and eastern slopes of this mountain range. The developed framework will allow user-input of data streams and spatial information specific to watersheds undergoing treatments and forest mitigation. Our goal is that the tools and framework developed in this proposal are readily accessible and usable by a range of resource managers and stakeholders to evaluate both historical and predicted forest mitigation and treatment impacts on hydrologic response across the Sierra Nevada range.

6. Collaborations and Project Feasibility

The proposed work builds upon the PIs extensive research on understanding and predicting hydrologic behavior in altered watersheds, using ground-based observations, satellite imagery and predictive frameworks which includes a range of collaborations with local, state and regional stakeholders and resource managers (Atchley et al., 2018; Blount et al., 2019; Burke et al., 2013; Chin et al., 2019; Florsheim et al., 2017; Kinoshita & Hogue, 2011; 2015; Kinoshita et al., 2013 ; 2014; Knipper et al., 2016; Micheletty et al., 2014; Nourbakhsh-beidokhti et al., 2019; Poon & Kinoshita, 2018a; 2018b; Rust et al., 2018; 2019a; 2019b; Saxe et al., 2018; Slinski et al., 2016; Stein et al., 2012). In addition to our prior work, both project PIs have ongoing projects on forest disturbance

across the western U.S. Hogue has ongoing forest-related projects in the Ashland watershed to evaluate treatments strategies on hydrologic response (funded by Oregon TNC); in Durango, Colorado, evaluating the impact of the 416 fire on water quality and in downstream ecosystems (in collaboration with Mountain Studies Institute; and a project in the upper Rio Grande watershed, evaluating the long-term impacts of the West Fork Fire complex fire on water quantity and quality and post-fire hydrologic modeling (funded by a local stakeholder group, RWEACT (<https://www.rweact.org/>) and the BLM Joint Fire Science Program). PI Kinoshita currently has projects focused on understanding hydrologic impacts after vegetation restoration activities and understanding the potential for contamination events in the San Diego River Watershed (supported by the San Diego River Conservancy and the City of San Diego Water Board); hydrologic modeling to support integrated land use planning for climate resilient ecosystems and local communities (numerous stakeholders and supported by the California Strategic Growth Council); understanding the impacts of fires in urban and Mediterranean streams (National Science Foundation); and improving predictions for post-wildfire streamflow (in collaboration with CGS and CalFire).

In the Sagehen basin, we build upon prior and ongoing collaborations with the Tahoe National Forest, TNC and the Bella Vista Foundation, as well as our ongoing research activities in Sagehen. We have been active in this basin since 2004 as an educational site (for UCLA courses) and as a research site since 2012, when funding was obtained by the Bella Vista foundation to support installation of a distributed network of channel stage recorders (pressure transducer) (Figure 1). The new recorders were strategically placed to capture discharge of basins varying in treatment type and geomorphic parameters (based on collaborations and discussions with the USFS). In 2015, funding was obtained from TNC (\$50,000) to support travel to the Sagehen basin for data monitoring and data collection of the installed sensors. The TNC proposal focused on preliminary data collection activities and providing logistical support such as travel, equipment, and lodging. The TNC funding was utilized until this fall (September 2019) when funds were expired. As described above, funding from EMC provides a unique opportunity to continue critical post-treatment monitoring, coupling of ground-based observations with satellite imagery, rigorous statistical analysis and quantification of hydrologic response relative to treatment strategies, and development of a parsimonious, user-friendly framework that can detect and quantify change in altered forests systems and their impacts on hydrologic behavior and downstream ecosystems.

7. Project Deliverables

We expect a range of products and tools developed through this proposal. Specifically we plan to provide the following deliverables:

- Database of ground-based monitoring observations including streamflow and temperature data collected below a range of forest mitigation strategies
- Remote sensing data, both LIDAR and Landsat-based, that quantifies forest canopy structure after forest thinning and mitigation

- Statistical tools and algorithms that integrate the monitoring data and satellite-based products and can elucidate relationships between forest canopy change and hydrologic response
- A user-friendly, integrated framework package that is downloadable and usable by stakeholders, resource managers and decision-makers
- Scientific papers and reports outlining results from this work

All products will be available for download by websites hosted by the PIs at their respective institutions. We also plan to distribute the final package/framework to interested agencies and stakeholders (EMC, USFS, TNC, etc.) for distribution to their stakeholders and relevant constituents. We will also produce scientific papers and reports that overview results and findings from this study.

8. Detailed Project Timeline

Table 1. Project Tasks and Associated Timeline

Task Descriptions	June-Aug	Sept-Nov	Dec-Feb	March-May	June-Aug	Sept-Nov	Dec-Feb	March-May
Monitoring / Field Data Collection								
Field-based monitoring (discharge, water quality parameters, bug sampling, etc.)								
Vegetation observations spot-check								
Collection of satellite-based data (LAI, NDVI, LIDAR)								
Data Analysis and Synthesis								
Statistical analysis of individual data streams								
Integration/models of satellite and ground-based data								
Framework / Tool Development								
Integration of R packages								
Framework / GUI development / Testing								
Outreach and Dissemination								
Project Updates from the field								
AGU Fall Annual Meeting								
Annual Reports								
Final Report and Documentation								
Dissemination of tool to EMC and stakeholders								
Scientific Papers								

9. Requested Funding

We are requesting \$156,665 in funding for the two years of proposed work under this project. This total includes \$81,887 to Colorado School of Mines (lead) and \$74,788 to San Diego State University (subaward through CSM). IDC total for the proposal is \$23,276 (14.8% of total costs). A detailed budget and relevant documents are included with this proposal.

PIs Hogue and Kinoshita are uniquely qualified to undertake the proposed work. They have extensive experience in monitoring and predicting disturbance hydrology and have a history of engagement with local and regional stakeholders and managers that results in usable decision-making tools and data products.

PI Hogue will be primarily responsible for monitoring of the ground-based observations at Sagehen, including discharge, geochemistry, stream temperature, channel cross sections for rating curves, and other related data. PI Hogue will also be lead on integration of data products (including those from SDSU), relevant statistical analysis

and development of the R-package framework that will be developed for stakeholders. Hogue will also be responsible for budget oversight, annual and final reporting, and communication and outreach with EMC.

PI Kinoshita will supervise the workplan at SDSU to acquire 1) treatment maps and delineations; 2) leaf area index (LAI); and 3) pre- and post-treatment Light Detection and Ranging (LiDAR) remote sensing data. PI Kinoshita will be primarily responsible for preparing, processing, analyzing, and synthesizing the LAI and LiDAR data. She will also serve as lead for communications between SDSU and CSM and will collaborate with CSM to complete field work and to develop a framework to provide a science-based management tool.

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Research Interests

Urbanization and sustainability, catchment response to wildfire, climate variability and watershed response, modeling of watershed and snowmelt processes, development and application of remote sensing products.

Professional Preparation

University of Wisconsin, Eau Claire, WI	B.S. Geology, Summa cum Laude	May 1995
University of Arizona, Tucson, AZ	M.S. Hydrology and Water Resources	Dec. 1998
University of Arizona, Tucson, AZ	Ph.D. Hydrology and Water Resources	May 2003

Appointments

Department Head, CEE Department, Colorado School of Mines, Jan. 2018-present
Professor, CEE Department, Colorado School of Mines, July 2015-present
Director, Hydrologic Sciences and Engineering Program, CSM, August 2014-Dec. 2017
Associate Professor, Colorado School of Mines, CSM, July 2012-June 2015
Vice Chair for Undergraduate Affairs, CEE Department, CSM, October 2012-August 2014
Associate Director, Hydrologic Sciences and Engineering Program, CSM, July 2012-present
Associate Professor, University of California, Los Angeles, July 2009-June 2012
Assistant Professor, University of California, Los Angeles, July 2003-June 2009
Lecturer, University of Arizona, January 2001-May 2003
Graduate Student Researcher, University of Arizona, August 1995-May 2003
Graduate Teaching Assistant, University of Arizona, August 1999-December 2000

Relevant Publications:

1. Blount, W.K., C. Ruybal, K. Franz and **T.S. Hogue**, 2019: Increased water yield and altered water partitioning follow wildfire in a forested catchment in the western U.S., *Ecohydrology* (in press)
2. Rust, A.J., J. Randell, A. Todd, and **T S. Hogue**, 2019: Wildfire Impacts on Water Quality, Insect, and Trout Populations in the Upper Rio Grande, *Forest Ecology and Management*, <https://doi.org/10.1016/j.foreco.2019.117636>
3. Rust, A.J., S Saxe, J. McCray, C. C. Rhoades, and **T.S. Hogue**, 2019: Evaluating the Factors Responsible for Post-Fire Water Quality Response in Forests of the Western USA, *International Journal of Wildland Fire*, <https://doi.org/10.1071/WF18191>
4. Saxe, S., **T.S. Hogue** and L. Hay, 2018: Characterization and evaluation of controls on post-fire streamflow response across western U.S. watersheds, *Hydrology and Earth System Science*, 22, 1221-1237, <https://doi.org/10.5194/hess-22-1221-2018>.

5. Rust, A.J., **T.S. Hogue**, S. Saxe, and J. McCray, 2018: Post-fire Water Quality Response in the Western United States, *International Journal of Wildland Fire*, 27(3) 203-216, doi: 10.1071/WF17115
6. Kinoshita, A.M., A. Chin, G.L. Simon, C. Briles, **T.S. Hogue**, A.P. O'Dowd, A.K. Gerlak, A.U. Albornoz, 2016: Wildfire, Water, and Society: Toward Integrative Research in the "Anthropocene", *Anthropocene*, (16) 16-27. DOI: 10.1016/j.ancene.2016.09.001
7. Kinoshita, A.M., and **T.S. Hogue**, 2015: Increased Dry Season Water Yield in Burned Watersheds in Southern California, *Environmental Research Letters*, 10 014003, doi:10.1088/1748-9326/10/1/014003
8. Kinoshita, A.M., **T. S. Hogue** and C. Napper, 2014: Evaluating Pre- and Post-fire Peak Discharge Predictions across Western U.S. Watersheds, *Journal of the American Water Resources Association*, 50(6), 1540–1557, doi: 10.1111/jawr.12226
9. Slinski, K., T.S. Hogue, A.T. Porter, J. E. McCray, 2016: Recent Bark Beetle Impacts have Little Impact on Streamflow in the Western U.S., *Environmental Research Letters*, 11(2016)074010
10. Knipper, K., **T.S. Hogue**, and A. Kinoshita, 2016: Evaluation of a MODIS Triangle-based Algorithm for Evapotranspiration Estimates in Sub-alpine Regions, *Journal of Applied Remote Sensing*, 10(1), 16002, 1-20, DOI: 10.1117/1.JRS.10.016002.
11. Knipper, K., **T.S. Hogue**, K. Franz and R. Scott, 2017: Evapotranspiration Estimates Derived Using Multi-Platform Remote Sensing in a Semiarid Region, *Remote Sens.* 9(3), 184; doi:10.3390/rs9030184.
12. Micheletty, P.D., A.M. Kinoshita, and **T.S. Hogue**, 2014: Application of MODSCAG and MODIS snow cover products in post-fire watersheds in the Sierra Nevada, *Hydrology and Earth System Science*, 18, 4601-4615.
13. Burke, M., **T.S. Hogue**, A. Kinoshita, J. Barco, C. Wessel, and E. Stein, 2013: Pre- and Post-fire Pollutant Loads in an Urban Fringe Watershed in Southern California, *Environmental Monitoring and Assessment*, 10.1007/s10661-013-3318-9.
14. Stein, E.D, J. S. Brown, **T. S. Hogue**, M. P. Burke, and A. Kinoshita, 2012: Regional Patterns of Storm Water Contaminant Loading Following Southern California Wildfires, *Environmental Toxicology and Chemistry*, 31 (11), 2625-2638.

Synergistic Activities:

AGU Water Resources Research Editorial Board (April 2017-April 2018)
 Colorado School of Mines Board of Trustees Member (Jan 2017-Dec. 2018)
 National Academies Decadal Survey Panel Member, (May 2016-May 2018)
 National Academies Board on Atmospheric Science and Climate (Oct. 2013-present)
 AGU Council Task Force on Science Trends (April 2014-Aug. 2015)
 American Geophysical Union Hydrology Section Secretary (Jan. 2013-Dec. 2016)
 AGU Surface Water Committee, Chair (2010-2012); Deputy Chair (2008-2010)
 NSF Hydrologic Sciences Program Proposal Panels (2010-present)
 NSF EPSCoR Review Panel and Wyoming WyCHEG site review (2013, 2016)

Advisees

- Graduated 17 PhD students, 20 MS Thesis, and mentored 6 post-doctoral fellows
- Currently supervising 9 PhD students and 4 post-doctoral fellows
- Mentored over 40 undergraduate researchers and scholars

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A. Professional Preparation

University of California, Los Angeles (UCLA)	Civil Engineering	B.S., 2007
University of California, Los Angeles	Civil Engineering	M.S., 2009
University of California, Los Angeles	Civil Engineering	Ph.D., 2012
Colorado School of Mines (CSM) Fellow,	Civil Engineering	Postdoctoral
		2012-2014

B. Appointments

2019 – present	Associate Professor, Civil, Construction, & Environmental Engineering San Diego State University
2014 – 2019	Assistant Professor, Civil, Construction, & Environmental Engineering San Diego State University

C. Products

(i) Five publications most closely related to the proposed project (*indicates SDSU advisee)

1. **Kinoshita, A.M.**, and T.S. Hogue, 2011: Spatial and Temporal Controls on Post-fire Hydrologic Recovery in Southern California Watersheds, *Catena*, 87, 240-252.
2. **Kinoshita A.M.** and T.S. Hogue, 2015: Increased Dry Season Water Yield in Burned Watersheds in Southern California. *Environmental Research Letters*, 10(1).
3. Florsheim, J.L., A. Chin, **A.M. Kinoshita**, S. Nourbakhshbeidokhti*, 2017: Effect of storms during drought on post-wildfire recovery of channel sediment dynamics and habitat in the southern California chaparral, USA. *Earth Surface Processes and Landforms*.
4. Nourbakhsh-beidokhti, S., **A.M. Kinoshita**, A. Chin, J.L. Florsheim, 2019: A Workflow to Estimate Topographic and Volumetric Changes and Errors in Channel Sedimentation after Disturbance. *Remote Sensing*, 11(5), p.586.
5. Chin, A., A.P. Solverson, A.P, O'Dowd, J.L. Florsheim, **A.M. Kinoshita**, S. Nourbakhsh-beidokhti*, S.M Sellers, L. Tyner, and R. Gidley, 2019. Interacting geomorphic and ecological response of step-pool streams after wildfire. *Geological Society of America Bulletin*.

(ii) Five other relevant and significant publications

1. Knipper, K. R., **Kinoshita, A. M.**, and Hogue, T. S., 2016: Evaluation of a moderate resolution imaging spectroradiometer triangle-based algorithm for evapotranspiration estimates in subalpine regions. *Journal of Applied Remote Sensing*,
2. Micheletty, P.D., **A.M. Kinoshita**, T.S. Hogue, 2014: Application of MODIS snow cover products: Wildfire impacts on snow and melt in the Sierra Nevada. *Hydrology and Earth System Sciences*, 18, 4601-4615.
3. Poon, P.K.*, **A.M. Kinoshita**, 2018. Spatial and temporal evapotranspiration trends after wildfire in semi-arid landscapes. *Journal of Hydrology*. Landforms.
4. Stein, E.D, J.S. Brown, T.S. Hogue, M.P. Burke, and **A. Kinoshita**, 2012: Stormwater contaminant loading following southern California wildfires, *Environmental Toxicology and Chemistry*, 31(11), 2625-2638.
5. Burke, M.P., T.S. Hogue, **A.M. Kinoshita**, J. Barco, C. Wessel, and E. Stein, 2013: Pre- and Post-fire Pollutant Loads in an Urban Fringe Watershed in Southern California. *Environ Monit Assess*.

D. Synergistic Activities

1. **Principle Investigator:** CAREER: Coupling post-fire vegetation and volumetric sediment regimes in urban Mediterranean systems, National Science Foundation (NSF) Faculty Early Career Development Program, 06/01/2019-05/31/2024, current award (\$571,796). The goal of this research is to understand and predict changes in vegetation, soil, and stream processes that occur after fires using remote sensing and field methods. This work will also increase community education opportunities and interactions through public seminars and outreach events.
2. **Lead Senior Personnel for Water Sustainability:** Integrated land use planning to support climate resilient ecosystems and local communities: planning for fire risk, water sustainability, and biodiversity, California Strategic Growth Council Climate Change Research Program, 10/1/2018-03/30/2021, current award (\$1,790,000). This project utilizes funding to form a diverse partner network on developing an integrated land-use planning approach to protect rural communities, mitigate wildfire risk, support water sustainability, and protect biodiversity.
3. **Student Advising and Mentoring at SDSU.** Four M.S. Thesis Advisor and Chair (I. Crano; A. Mirhosseini; P. Poon; S. Nourbakhshbeidokhti); seven M.S. thesis currently advised; and over fifteen undergraduate students advised.
4. **Fellow, Center for Research, Excellence, and Diversity in Team Science, 2016.** *Living with Climate Change*, UCLA Lake Arrowhead Conference Center in Lake Arrowhead, CA.
5. **Burned Area Emergency Response (BAER) Hydrologic Modeling Training Workshop, 2011.** Bureau of Land Management BAER National Meeting, Lakewood, CO, June 7, 2011. This workshop was organized and led by A.M. Kinoshita and T.S. Hogue.

Proposed Budget
June 1, 2020 - May 31, 2022

	<u>Year 1</u>	<u>Year 2</u>	<u>Total</u>
A. SALARIES AND WAGES			
1. Terri Hogue, PI - 1 summer day	\$991	\$1,021	\$2,012
2. 1 Graduate Research Assistant - 8 AY months @ 50%	12,000	12,360	24,360
	—————	—————	—————
Subtotal	\$12,991	\$13,381	\$26,372
B. FRINGE BENEFITS			
1. 42.2%* of A1	\$418	\$438	\$856
2. GRA tuition, fees, health ins. - 2 semesters/reduced tuition	11,948	12,425	24,374
	—————	—————	—————
Subtotal	\$12,366	\$12,864	\$25,229
C. OTHER DIRECT COSTS			
1. Travel - Travel to Sagehen (domestic) 3 trips/year; 2 people, \$1000/trip	\$3,000	\$3,000	\$6,000
2. Expendable field supplies	500	500	1,000
3. Subcontract: South Dakota State University	37,350	37,438	74,788
	—————	—————	—————
Subtotal	\$40,850	\$40,938	\$81,788
D. TOTAL DIRECT COSTS	\$66,207	\$67,182	\$133,389
E. MODIFIED TOTAL DIRECT COSTS**	\$41,910	\$17,319	\$59,229
F. INDIRECT COSTS - 39.3% of E***	16,471	6,806	23,276
	—————	—————	—————
G. TOTAL AMOUNT REQUESTED	\$82,677	\$73,989	\$156,665

*rate increases .67 annually

**Line D not including B2 or subcontract costs C3 exceeding \$25,000

BUDGET JUSTIFICATION
Terri S. Hogue
Colorado School of Mines

PERSONNEL COSTS:

Dr. Terri Hogue will be responsible for overseeing the research at the Colorado School of Mines (CSM) under this grant. Dr. Hogue will be responsible for supervision of the graduate student, Jake Kurzweil. PI Hogue will be primarily responsible for monitoring of the ground-based observations at Sagehen, including discharge, geochemistry, stream temperature, channel cross sections for rating curves, and other related data. PI Hogue will also be lead on integration of data products (including those from SDSU), relevant statistical analysis and development of the R-package framework that will be developed for stakeholders. Hogue will also be responsible for budget oversight, annual and final reporting, and communication and outreach with EMC. The graduate student will work with Dr. Hogue on this project and will undertake field monitoring, data analysis and framework development.

Salaries and wages have been calculated on the basis of the Colorado School of Mines Policies. Employee benefits have been estimated using the current federal rate agreement, including 42.2% for the PI and graduate tuition, fees and health insurance for the graduate student.

OTHER DIRECT COSTS

Projected costs in this category are based on historical data for projects of similar scope. Expendable field supplies are estimated at \$500/year for CSM on this project.

TRAVEL

Funds are requested for the PI and graduate student to travel to the field site 3x/year. Approximate costs of \$500 per person per trip includes airfare, lodging, rental car and per diem costs.

Indirect Costs (Facilities & Administrative Costs)

The indirect costs are estimated at just under 15% of total direct costs in accordance with the EMC overhead rate agreement for these proposals.

Title / Agency Name / Solicitation Number

Dr. Alicia Kinoshita

Project Dates

1.03

YEAR 1 YEAR 2 TOTAL

A & B. PERSONNEL

1	PI: Alicia Kinoshita	X	AY	Key Indicators						\$	-	\$	-	\$	-
				Base	Monthly	# of Mos	FTE	Person Months							
		SU	10291	\$ 123,492	\$ 13,721	9	0.00%	0.00	\$	-	\$	-	\$	-	\$
				\$ 41,164	\$ 13,721	3	5.00%	0.15		2,058	\$ 2,120	\$ 4,178			
									subtotal	\$ 2,058	\$ 2,120	\$ 4,178			
	PI fringe benefits*	AY		57.4%					\$	-	\$	-	\$	-	\$
		SU		25.0%						515	\$ 530	\$ 1,045			
									subtotal	\$ 515	\$ 530	\$ 1,045			
2	Co-PI	AY		\$ -	\$ -	9	0.00%	0.00	\$	-	\$	-	\$	-	\$
		SU		\$ -	\$ -	3	0.00%	0.00		515	\$ 530	\$ 1,045			
									subtotal	\$ -	\$ -	\$ -			
	Co-PI fringe benefits*	AY		57.4%					\$	-	\$	-	\$	-	\$
		SU		25.0%						515	\$ 530	\$ 1,045			
									subtotal	\$ -	\$ -	\$ -			
3	Program Director Prog Dir fringe*	CY		\$ -	\$ -	12	0.00%	0.00	\$	-	\$	-	\$	-	\$
		CY		46.0%						515	\$ 530	\$ 1,045			
4	Graduate Student Graduate Student	1	AY	19	\$ 29,639	\$ 3,293	9	50.00%	4.50	\$ 14,820	\$ 14,820	\$ 29,640			
		1	SU	19	\$ 9,880	\$ 3,293	3	100.00%	3.00	\$ 9,880	\$ 9,880	\$ 19,760			
									subtotal	\$ 24,700	\$ 24,700	\$ 49,400			
	Grad Student fringe*			15.0%						\$ 3,705	\$ 3,705	\$ 69,160			
									Total Salaries	\$ 26,758	\$ 26,820	\$ 53,578			
									Total Fringe Benefits	\$ 4,220	\$ 4,235	\$ 8,455			
									TOTAL PERSONNEL	\$ 30,978	\$ 31,055	\$ 62,033			

*rates reflect 3% escalation

C. EQUIPMENT

1									\$	-	\$	-	\$	-	
2										515	\$ 530	\$ 1,045			
									TOTAL EQUIPMENT	\$ -	\$ -	\$ -			

D. TRAVEL

1	Domestic Travel								\$	1,500	\$ 1,500	\$ 3,000			
2	International Travel									-	\$ -	\$ -			
									TOTAL TRAVEL	\$ 1,500	\$ 1,500	\$ 3,000			

E. PARTICIPANT/TRAINEE SUPPORT COSTS (NIH - ONLY if specifically allowed by your PA/PAR/RFA)

1	Tuition/Fees/Health Insurance								\$	-	\$	-	\$	-	
2	Stipends									515	\$ 530	\$ 1,045			
3	Travel									-	\$ -	\$ -			
4	Subsistence									515	\$ 530	\$ 1,045			
5	Other														
									TOTAL PARTICIPANT COSTS	\$ -	\$ -	\$ -			

F. OTHER DIRECT COSTS

1	Materials and Supplies								\$	-	\$	-	\$	-	
2	Publication Costs									515	\$ 530	\$ 1,045			
3	Consultant Services									-	\$ -	\$ -			
4	ADP/Computer Services									515	\$ 530	\$ 1,045			
5	Subawards/Consortium/Contractual Costs														
									direct costs	\$ -	\$ -	\$ -			
									F&A	\$ -	\$ -	\$ -			
6	Equipment or Facility Rental/User Fees									515	\$ 530	\$ 1,045			
7	Alterations and Renovations									-	\$ -	\$ -			
8	Other 1									515	\$ 530	\$ 1,045			
9	Other 2									-	\$ -	\$ -			
10	Other 3									515	\$ 530	\$ 1,045			
									TOTAL OTHER DIRECT COSTS	\$ -	\$ -	\$ -			

TOTAL DIRECT COSTS

									\$	32,478	\$ 32,555	\$ 65,033			
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									\$	32,478	\$ 32,555	\$ 65,033			
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									\$	4,872	\$ 4,883	\$ 9,755	Per Sponsor Indirect Not to Exceed 15%		
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									\$	37,350	\$ 37,438	\$ 74,788			
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Excludes equipment over \$5K, capital expenditures (A&R), patient care, tuition remission, rental costs of off-site facilities, scholarships & fellowships, and Limited to the first \$25K of each subcontract

NIH policy provides for exclusion of consortium/contractual F&A when determining if an applicant is in compliance with a direct cost limitation. This policy extends to all applications involving consortium/contractual facilities and administrative (F&A) costs, regardless of budget amount or budget format (e.g., modular and non-modular).

									\$	32,478	\$ 32,555	\$ 65,033			
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SDSU Budget Justification

The budget includes:

1. Salary and benefits for 0.5 month summer salary for Co-PI Alicia Kinoshita for two years (\$4,178 salary plus \$1,045 fringe benefits based on the current benefit rate of 25%). Salary will support Kinoshita to supervise the workplan at SDSU to acquire 1) treatment maps and delineations from CSM; 2) leaf area index (LAI) since 2012 through current for Sagehen from remote sensing hosting platforms and 3) pre- and post-treatment Light Detection and Ranging (LiDAR) remote sensing data for Sagehen from OpenTopography. Kinoshita will supervise her graduate student in preparing, processing, and analyzing the relevant remote sensing data and two field reconnaissance trips per year. She will also serve as lead for communications between SDSU and CSM and will collaborate with CSM to develop a framework to provide a science-based management tool primarily in Year 2.
- 1) Salary and benefits for 1 graduate student for two years (\$49,400 salary plus \$7,410 fringe benefits based on the current benefit rate of 15%). Salary requested will support a graduate student to acquire remote sensing products (LAI and LiDAR), prepare and process the data, analyze the information with respect to treatments and in collaboration with CSM vegetation products. The graduate student will also be supported to participate in 2 field site visits per year to corroborate remote sensing results. They student will also be engaged in developing a framework with CSM.
- 2) Travel for the Co-PI and student to the field site for two years (\$3,000)
It is estimated that roundtrip flight from San Diego to Reno is ~\$300/person/trip (based on previous trip to the field site in 2016) plus \$80/person /trip for meals and incidentals (total of ~\$760/trip). For two trips to the field site in Year 1, the total is anticipated to be ~\$1,500 for the PI and student. For Year 2, the total is anticipated to be ~\$1,500 for the PI and student.
- 3) F&A calculated at the rate allowable by EMC for this proposal agreement (\$9,755 at 15%).