APPENDIX G

Monitoring Methods and Protocols

Monitoring Methods and Protocols

Acronyms and Abbreviations

A

AVHRR	Advanced Very High Resolution Radiometer
AOI	area of interest

C

CAL FIRE	California Department of Forestry and Fire Protection
CCH2	Consortium of California Herbaria 2
CCRWQCB	Central Coast Regional Water Quality Control Board
CDFW	California Department of Fish and Wildlife
CNPS	California Native Plant Society
CSE	Common Stand Exam

D

DBH	diameter at breast height
DEM	Digital Elevation Model
DSM	Digital Surface Model
DTM	Digital Terrain Model

E

EDDR	Early Detection Rapid Response

F

FAM	National Division of Fire and Aviation Management
FGDC	Federal Geographic Data Committee
FVS	Forest Visualization Simulator

G

GEE	Google Earth Engine
GIS	Geographic Information Systems
GPS	Global Positioning System

GRTS	Generalized Random Tesselation Stratified

I

ICF	ICF International
IPMP	Integrated Pest Management Program

M

MMU	minimum mapping unit
MODIS	Moderate Resolution Imaging Spectroradiometer

N

NAIP	National Agriculture Imagery Program
NASA	National Aeronautics and Space Administration
NDVI	Normalized Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	National Resources Conservation Service

O

OBIA	object-based image analysis
OSP	Open Space Preserve
OWEB	Oregon Watershed Enhancement Board

R

RAWS	Remote Access Weather Stations
RdNBR	Relative Differenced Normalized Burn Ratio

S

SCCWRP	Southern California Coastal Water Research Project
SMAP	Soil Moisture Active Passive
SMMNRA	Santa Monica Mountains National Recreation Area
SWRCB	State Water Resources Control Board

T

TLS	Terrestrial LiDAR Systems

U

UAV	Unmanned Aerial Vehicle
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

V

VHP	Santa Clara Valley Habitat Plan

Purpose and this Document

The purpose of this document is to present several available protocols to monitor various parameters identified in the Wildland Fire Resiliency Program, Chapter 7. These protocols are only meant to be a resource and not all protocols may be required, nor are these the only protocols that may be implemented. Monitoring requirements will vary depending on the activity undertaken and the conditions in the area where the activity is to occur. Monitoring and reporting may also be required as part of the mitigation adopted with the Final Environmental Impact Report for the program or any permits obtained to perform specific work activities under the program. Individual monitoring protocols will be determined on a case-by-case basis for each project at the discretion of professional Midpen staff and/or as required by mitigation.

Monitoring Methods for Biodiversity and Wildlife Presence

Overview

The monitoring methods described here should be applied, as appropriate, to understand wildlife presence and diversity before, during, and after treatments or fire events. Key animals to be monitored include bird, butterfly, American badger, dusky-footed woodrat, and reptile and amphibian species.

Avian Monitoring

Overview

The standardization of avian monitoring began in earnest in the 1980s and has produced highly useful methods for estimating bird population sizes and changes over time. There is a deep literature on these subjects, and methods for population estimation can generally be split into those that involve distance sampling, and those that do not. Distance-sampling methods (such as point counts) are generally considered to produce robust density estimates because of the ability to calculate species detection probabilities. Conversely, non-distance sampling methods, such as area searches and produce abundance indices, until recently were not considered as statistically robust as distance-based density estimates. For all methods, techniques such as double-sampling and using double observers can improve estimates of population size (Bart et al. 2004). Ensuring that there is annual training in distance estimation and species identification is also critical. Overall, different monitoring methods are used depending on the goals of the monitoring, the terrain and vegetative cover of the study or management area, and the bird species to be monitored (see review in Buckland et al. 2001).

Both point count and area search methods could be utilized for collecting baseline information on avian populations on the open space preserves (OSPs) of Midpen. However, a thorough review of the goals of the monitoring, the species to be monitored, and the details of any planned monitoring method should be conducted before monitoring is started, so that the most rigorous program can be developed to detect changes in bird populations over time, given the funding available. The software package "Distance" (Thomas et al. 2010) provides a survey design feature, and helps managers consider all aspects of developing a statistically sound monitoring program.

Point counts that involve the measurement of distances to observed birds are useful for assessing species population trends and treatment responses because such sampling can produce density estimates in challenging field conditions, and because there are robust statistical tools for analyzing such data (e.g., program "Distance"; Buckland et al. 2001, Thomas et al. 2010). Point counts can also be modified to sample and estimate the population size of special-status bird species, such as rails or other birds requiring playback for counts, or can be conducted with driving between points instead of walking, so that wide-ranging raptor species can be counted (e.g., Fuller and Mosher 1981) or more area can be covered (e.g., as for Breeding Bird Surveys; Sauer et al. 2017). Thus, point counts offer a flexible method for application to many different situations. Statistical methods for analyzing count data for rare species now exist as well (e.g., N-mixture models; Royle 2004).

Bird area searches—which are not a distance-sampling method--are a method of determining bird species abundance and richness and can be conducted in a standardized way. N-mixture model analyses have been developed which can analyze abundance data for uncommon or rare species across spatially replicated counts (Royle 2004), and so this method has more utility now.

Both point count and area search methods require that observers be able to identify all birds on Midpen lands by sight, and for passerine counts, that observers also be able to identify breeding songbirds (and wintering birds, if desired) by vocalizations (e.g., songs and calls). Both methods can incorporate and train volunteers and Community Scientist participants. Volunteers can shadow primary observers during point counts and area searches to learn the methodology and to practice their identifications, as long as they do not add to or distract from the work of the primary observers. Both methods can be used as vehicles for Midpen to educate the public about science and natural history through their involvement in monitoring, which can translate to enhanced community support for Midpen.

Point Count Method for Bird Population Sampling

Background

The point count methodology has been standardized by various researchers, notably C.J. Ralph and colleagues (e.g., Ralph et al. 1993, Ralph et al 1995). This methodology has been used by researchers and others all over the world in thousands of projects designed to enumerate and monitor bird populations. The method is recommended especially for areas with rugged topography and/or dense vegetation, where physical exertion and/or difficulty seeing birds make using a point-sampling method desirable (Ralph et al. 1995). However, the point count method (also referred to as the point transect method) is also effective in open areas, including along roads, and has been the method used across the U.S., Canada, and Mexico since the 1960s for the Breeding Bird Survey (Sauer et al. 2017; although in Breeding Bird Survey, distances to observed birds are not measured, which encouraged the development of N-mixture model analysis; Royle 2004). Analyses of bird data collected via the point count method were improved with the development of software that calculates densities using species- and observer-specific detection probabilities (detectability curves; Buckland et al. 2001). As discussed above, updated N-mixture analyses that can estimate abundances for species with small population sizes and fewer detections have also been developed (e.g., Yuichi et al. 2016).

The NPS, Channel Islands National Park, California (hereafter "the Park"), has been monitoring terrestrial birds on five Channel Islands since 1993. Transects were established on Anacapa, Santa Barbara, Santa Cruz, San Miguel, and Santa Rosa in 1993, but in 2000, the Park underwent a comprehensive review of its monitoring program. As a result, the Park established point count stations across the five islands, retaining some transects for long-term data comparisons. The resulting monitoring program is comprised of more than 300-point count stations and 10 transects across five islands, with points stratified by vegetation type (Fancy et al. 2009, Coonan et al. 2011, Coonan and Dye 2016, Hall et al. 2018). The associated monitoring protocol was developed based on material from the NPS National Inventory and Monitoring Program and at least six other protocols published between 2004 and 2010 and covering the Sonoran Desert, North Coast and Cascades, Great Lakes, Klamath area, and Sierra Nevada (Coonan et al. 2011). The Channel Islands point count protocol has become a model for the NPS and, in 2016, was adopted for avian monitoring in the Santa Monica Mountains National Recreation Area (SMMNRA; Hall and Mateos 2018). Although the SMMNRA counting protocol is the same, the method for point establishment was updated (a Generalized Random Tesselation Stratified [GRTS] analysis [Stevens and Olsen 2004] was used to randomly generate 1,500 spatially-balanced point locations in the Santa Monica Mountains along secondary and tertiary trails). Community Scientists are currently monitoring birds at one hundred of these points annually (Hall and Mateos 2018).

Thus, the point count protocol used by the NPS at two Park Units in California has been vetted and utilized over the past 20 years and provides a standardized methodology for Midpen. The point count method lends itself well to the great variety of OSPs in Midpen, as well as to the variability in trails, vegetation types, and topography, and will be a useful avian monitoring system for Midpen.

Methodology

Point counts involve an observer standing in one spot and recording all birds seen or heard at a fixed or unlimited distance from the center of the point. Point establishment was discussed initially in Ralph et al (1993, 1995), and included the recommendation that the minimum distance between point count stations in wooded (or otherwise dense) vegetation types be 250 m. In open environments, this minimum distance should be increased because of the greater detectability of birds; and along roads, where travel by vehicle is possible, distances of 500 m or more should be used (Ralph et al. 1993). Recent variations on establishing points have been developed, including points arranged in 4 x 4 grids of 16 points, with 250 m spacing between points, and with grids selected using a spatially balanced sampling algorithm (McLaren et al. 2019). Stratification of points by vegetation type or another factor is common (e.g., Coonan et al. 2011), but is not always used (e.g., McLaren et al. 2019). Once points are established, the following point count protocol can be used (from Coonan et al. 2011, from the NPS Channel Islands National Park Landbird Monitoring Protocol). It is recommended that all points be counted at least three times per season (Ralph et al. 1995), but this also depends on the goals of the monitoring project.

Point Count Sampling Protocol

1. Prior to the day of the counts, determine which plots will be sampled in which order, and make certain that the coordinates for those points are in the global positioning system (GPS) unit. As a backup, bring a list of coordinates for each point.
2. Wear earth-tone colors (browns, greens, dark blues, grays). Do not wear bright colors (reds, yellows, whites, etc.).
3. The point counts should only be conducted if conditions meet the following criteria:
    a. Visibility is greater than 150 m.
    b. Wind is 10 knots or less (i.e., less than 4 on the Beaufort scale).
    c. It is not raining.
    d. No one has walked or driven through the area to be counted within 30 minutes prior to the count.
    e. Only one observer is within the count circle (no additional persons may accompany the observer).
    f. The count must be the first priority. If anything else is done in addition (e.g., transporting some materials), it must not in any way detract from the time and attention you are giving the survey, nor should it affect the pace at which you cover the survey route.
4. Sampling will occur in the morning; monitoring begins when there is enough light to see a distance of at least 400 m and ending no later than 4 hours after official sunrise. Singing rate for most species is usually highest before or near official sunrise and then declines slowly for the next four hours.
5. Do not conduct the count during high winds or heavy rains because these conditions inhibit bird activity and impair your ability to see and hear birds. Counts should not be conducted if wind strength on the Beaufort Scale is a sustained 4 or greater (see below), or if it is raining hard or snowing (rain code $\geq$4 below). If you encounter these conditions, wait until the weather improves or else cancel the sampling for today and try again on another day.
6. Navigate to the coordinates of the next plot on the list using the GPS. If the hike to the point was extremely strenuous, rest away from the point (e.g., 100 m) for a few minutes, then continue to the point. At the first point on each survey day, fill in the survey information at the top of the form. At the first and last survey points, fill in the survey condition data.
7. Conduct the point as a “snapshot” in time. The survey results should represent the actual distribution of the birds relative to the point. The underlying theory of distance sampling requires that each point be recorded as close to a “snapshot in time” as possible. Some movement is acceptable, as long as a bird is only counted

once and the observer does not cause movement. Any birds that flush upon approaching the point, or birds that seem to be attracted by the presence of the surveyors, should be noted in the comments.

8. Use a laser rangefinder to estimate distances to birds whenever possible; the closer the bird, the more accurate the distance estimation should be.
9. Remember: **The goal is not the largest count possible, but the most accurate count possible. Stick to the methodology described in this protocol.** Do not bend the rules to include more birds because you think that you do not have enough. Do not list a bird unless you are sure of its identification.
10. The accuracy and integrity of the count can only be maintained by minimizing variations in methodology. This is accomplished by rigorously following the established count procedures.

Weather Conditions During the Survey

The following information must be filled in at the beginning of each survey morning:

- **Temperature (°C):** Record the ambient temperature during the ten-minute count in degrees Celsius, rounded off to the nearest degree. The thermometer should be placed above the ground and allowed to adjust to ambient air temperature.
- **Wind (0–6):** Record the wind code (0 through 6) as it applies to the strength of the wind during the first and last eight-minute count. Record the average wind conditions for each count, not the maximum condition (e.g., periods of gusty winds) (Table 1). **Do not count when winds are 4 or greater.**
- **Rain (0–5):** Record the appropriate code (Table 2).
- **Cloud cover (%)**: Visual estimate of the percent cloud cover, rounded off to the nearest 10%. This should be a number between 0 (no clouds) and 100 (completely overcast). If there are patches of clouds in different areas of the sky, try to picture gathering all of them together into one part of the sky and recording what percent of cloud cover that would represent. If you are in thick fog, record 100 percent, even if it is a bright sunny day up above the fog layer that you are conducting the count in (keeping in mind the 150-meter visibility minimum for sampling).
- **Noise (0–3):** Record the noise code that applies to background-noise conditions during the count, as it affects your ability to hear birds (Table 3).

Table 1 Wind Codes - Beaufort scale (used to record wind strength during bird counts)

Wind Code	Definition
0	calm, smoke rises vertically (< 2 km/h)
1	smoke drifts (2-5 km/h)
2	light breeze felt on face, leaves rustle (6-12 km/h)
3	leaves and twigs in constant motion (13-19 km/h)
4	small branches move, raises loose paper, dust rises (20-29 km/h)
5	fresh breeze, small trees sway (30-39 km/h)

6	strong breeze, large branches moving, wind whistling (40-50 km/h)

Table 2 Rain Codes (used to record precipitation during bird counts)

Rain Code	Definition
0	no rain
1	mist or fog
2	light drizzle
3	light rain
4	heavy rain; difficult to hear birds
5	Snow

Table 3 Noise Codes (used to record level of background noise as it affects the observer's ability to hear birds)

Noise Code	Definition
0	quiet; normal background noises; no interference
1	low noise; might be missing some high-pitched songs/calls of distant birds
2	medium noise; detection radius is probably substantially reduced
3	high noise; probably detecting only the loudest/closest birds

Approaching the Point and Beginning the Count

1. Approach the plot vigilantly, and if you observe a bird close to the center of the plot that flushes as a result of you approaching the plot, you should record the initial distance from the plot center to that bird on the data form. The reason for this is that a critical assumption of the distance methodology is that any bird directly at (or very close to, e.g., <5-10 m) the plot center will always be detected, i.e., $g(0) = 1$. If the data are analyzed as grouped data (as recommended), this is not a problem if the bird does not move beyond the first grouping interval. However, if a bird that otherwise would have been recorded in the plot during the count flushes prior to the beginning of the count as a result of the approach of the observer, abundance will be underestimated for that species. The alternative approach is to wait for several minutes after reaching the plot before starting the count, but this approach is likely to underestimate bird density near the plot because of birds flushing as the observer approaches. This latter approach may be necessary if you created a lot of disturbance getting into the site in dense vegetation.
2. Once you arrive at the plot center, begin the count as soon as possible. You should have time to fill in the location, event, and weather conditions information at the top of the form during the count. If not, these can be filled in at the end of the 10-minute count.

3. Use your watch and record the time for each observation. Make sure you determine the end of 10 minutes, stopping the count at the end of the tenth minute.
4. Conduct the 10-minute count without interruption, being sure to fill in all the fields for each bird/flock detected. Occasionally, aircraft noise can be loud and can last for up to 30 seconds. In these instances, increase the count period by the amount of time for which the count was disturbed. If excessive noise interrupts the count for more than 2 minutes, then start the survey again after the disturbance has passed.
5. Once you have noted the time and begun the 10-minute counting period, record all birds heard or seen during the ten minutes, regardless of their distance from the center of the point. At each point, you will record the following information only once for each bird or flock of birds observed during the 10-minute active period:
    a. **Time** (hh:mm): Write in the hour and minute in which the bird was detected. Use military time format for times after noon (e.g., 13:05, 14:26, unlikely with morning count limits).
    b. **Species**: Record the four-character code for the species detected. Examples are WEME for Western Meadowlark, HOLA for horned lark, and WIWA for Wilson's Warbler. If no birds are detected during the 10-minute count, you should enter data for the first line of the form and record the code "NONE" in the Species column. Birds that you cannot positively identify to species should be recorded as "UNKN" for unknown bird (you may be able to identify it later during the 10-minute count, and you will have the proper time of detection recorded for it). When you review and then turn in data sheets later the day of sampling, cross out any UNKN that were not identified during the count or before you review your data sheet.
    c. **Distance (m):** Record the horizontal distance in meters between the point center (where you are standing), and the location of the bird where you first detect it. Use a laser rangefinder whenever possible to get as accurate a distance as possible. **Do not round off numbers to the nearest five meters; estimate the distance to the nearest meter**. Many birds are heard and not seen. If you cannot see the bird, estimate the distance to some object (tree, bush, rock) near where you think the bird is located. If the bird is flying directly at you and then lands nearby, record the distance to where you first saw it flying toward you, not the distance to where it landed. For species that occur in clusters or flocks, record the distance from the observer to the center of the flock. If a bird is high in a tree, imagine dropping a plumb bob from the bird down to the ground, and measure the horizontal distance to that spot on the ground. Indicate flyovers (birds that fly above the top of the vegetation canopy, never

touch down in your field of view, and do not appear to be foraging, displaying, or behaving in any other way that might suggest a link to the habitat below them or the habitat you are sampling) by entering -9999 in the distance column.

d. **DT (Detection type):** The detection type corresponds to the first detection of that individual (refer to Attachment 1, Area Search Data Form). The three possible entries for the first detection are "C" for Call, "S" for Song, and "V" for Visual. If you hear the bird and then later see it, add a "V" to the right of the "C" or "S" that you initially recorded, so that the Detection Type becomes "CV" or "SV". The detection type code will be used later in various analyses. For example, distances to birds that are seen are probably more accurate than those to birds that are only heard. Recording the detection type makes it possible to develop distance histograms to compare birds seen versus those that are only heard.
e. **Flock Size**: For most observations, each individual bird will be treated independently as a separate observation with a Flock Size of one (1), but for species that usually occur in clusters or flocks, the appropriate unit is the cluster or flock size, and not the individual bird. For example, if you observe a flock of 15 house finches moving as a group during a count, it is not appropriate to record 15 distances and treat them as independent observations in the analysis. For flocking species, record the distance to the center of the flock and the number of birds in the flock, rather than the distance to each individual bird.
f. **Sex**: If you are able to see a sexually dimorphic species, record either "M" (male) or "F" (female) on the form; otherwise, leave blank. Leave the "sex" field blank for all auditory detections and for flocks that contain both males and females.
g. **Age (Class):** If you are able to determine that a bird is a juvenile based on its plumage or vocalization, enter a "J" for Juvenile; otherwise, leave blank.
h. **Prev(ious) Point**: Place an "X" in this column if the bird was already detected at a previous point. Bias caused by repeated counting of the same individual from more than one point is usually small unless repeated counting is common during a survey (Buckland et al. 2001:37) or in cases where a rare bird is counted from multiple points. By recording whether a bird is thought to have been counted at a previous point, the data can later be analyzed in two different ways, depending on which is most appropriate.
i. **Comments**: Record any comments that seem appropriate and that might help someone interpret and analyze the data correctly.

After the 10-Minute Active Period

1. Review the data form and fill in all fields on the data form before departing for the next point. Also, search the area to ensure that no equipment is left behind.
2. Record observations of other notable plant and animal species on a separate "Incidental Observations" data form, or at the bottom of your datasheet (see Attachment 1 for datasheet).

Area Search Method for Bird Population Sampling

Background

The area search methodology was described by Ralph et al. (1993). This methodology is essentially a timed, intensive survey of a delineated area. The area search method does not involve estimating distances to birds, so does not give an estimate of density, but it can be used to determine the number (or abundance) of birds per species per sampling unit, which can be converted to a density value (i.e., number of birds/unit area). These values can be used to examine trends in species' abundances over time. Area searches can also be used to make species lists and determine richness for survey units (Ralph et al. 1993).

The National Protocol Framework for the Inventory and Monitoring of Nonbreeding Waterbirds and Their Habitats (Loges et al. 2017) recommended the use of direct whole-area counts for tallying the number of individual waterbirds by species (where waterbirds were defined as predominantly waterfowl, shorebirds, wading birds, and other birds closely associated with wetland habitats). Many other species can be sampled by this methodology—passerines and terrestrial non-passerines, including raptors—if the unit sizes are large enough to accommodate their activity areas.

Methodology

Ralph et al (1993) recommended that three 20-minute counts be conducted in standardized areas across the region; this way, comparisons can be made among sampled units. A review of sampling units shows projects conducting searches in <1 hectare to >10-hectare blocks or circles. For water birds, Loges et al. (2017) recommended that an observer be able to visually assess >70 percent of the surface area of a management unit, and if the observer cannot visually assess that much area, additional vantage points should be added in lieu of splitting the management unit into multiple survey units. Loges et al. further recommended that while multiple observation points can be established around the perimeter of the unit to meet this criterion, observers should bear in mind the need to complete the count on the unit within a single morning and to minimize multiple counting of individual birds. During each area search, the observer moves consistently and methodically through the unit, identifying all birds observed, tracking down unfamiliar calls, and looking particularly for quiet, secretive, or rare birds.

Ralph et al. (1993) recommended that at least three sampling plots be established per vegetation type for adequate representation. They suggested that plot sizes of about 3 hectares in forest or dense woodland, 10 hectares or more in more open habitats, and 1 to 2 hectares in very dense forest. The search areas can have adjoining boundaries or can be in completely separate regions of the plot. More than three search areas can be established within a plot, but as for all methods that provide bird data for trend analyses, the boundaries (or points, or transects, etc.) should be fixed through the sampling season and across years to ensure data comparability (Loges et al. 2017).

Similar to point counts, the time of day when counts are conducted must be standardized annually to allow for comparisons across years. Ralph et al. (1993) suggested that because of the intensive nature of this method it could be carried out longer into the morning than other methods. However, it should continue no later than 5 hours after dawn. In addition, Ralph et al. recommended that the observer should walk through each sampling plot for exactly 20 minutes in each search area, stopping or moving to investigate sightings or calls when appropriate. The observer should record numbers of birds of each species seen, heard, or both seen and heard in the search area during this time, and concentrate on finding as many birds as possible within the plot.

In 2010 Klamath Bird Observatory developed standard protocols for their monitoring program, in cooperation with the NPS, Klamath Network, and they have shared their widely used protocols through the Avian Knowledge Network (http://avianknowledge.net). Their "Landbird Monitoring Area Search Protocol" is provided below (from Stephens et al. 2010).

Area Search Sampling Protocol
One or more observers walk a 20-minute route, noting all birds seen or heard. The person who is the best birder should conduct the survey; the other surveyors should practice as time allows. The observer should be reasonably familiar with most (if not all) bird species likely to be encountered at the site. This method allows the observer to track down unfamiliar birds. Walking the site before a survey with a person familiar with the birds allows the less experienced observer to be more efficient.

Walk in an approximate circle or oval for exactly 20 minutes in each search area, stopping or moving to investigate sightings or calls when appropriate. Do not spend more than a minute looking for a difficult bird. If there is an unknown bird that cannot be identified, record it on your form as unknown (UNKN). Record numbers of birds of each species detected within and outside the search area as appropriate on the Area Search Data Form (Attachment 1). Record birds outside the search area, as defined by the route you take, separately on your data sheet, but concentrate on finding as many birds as possible within the site.

The form includes separate boxes within each row for recording distinct detection events with a detection type code and number of individual birds so detected. A detection event is any single detection (e.g., V, S, F, etc.) that may include any number of individuals. For example, a bird singing would be recorded as S1 in a single box; then, two birds (not including the first detected individual) of the same species seen would be recorded as V2 in a subsequent box of that species' row. If all boxes of a species' row are used then a second, and more as necessary, row for that species should be used. The detection type recorded is the first behavioral cue that alerted the observer to the presence of the species. If subsequent behavior observed has a greater hierarchal breeding status category than the initial observation, then it should be noted as such in the Breeding Status field. The location of the initial detection determines whether it was "On" or "Off" the area. The bird's location at the time of detection is determined as a flat plane from the observer (i.e., imagine a plumb bob suspended from the bird to the ground). For birds heard singing or calling, you may have to estimate whether they are inside your area or not. Note that this 20-minute time constraint is an extremely important component of the technique, as the data are to be used for monitoring.

Regional Avian Monitoring

There are current regional land bird monitoring efforts conducted by Point Blue Conservation Science (formerly the Point Reyes Bird Observatory) and the National Park Service. The data from this monitoring provides valuable regional information, which may help with monitoring efforts on Midpen lands. The Landbird Monitoring Program includes protocol documents and monitoring/trend reports (NPS 2018).

Assessment of Butterfly Relative Abundance

Butterfly abundance may be assessed using timed area surveys or linear transects. The methods to conduct these surveys are outlined by Kadlec et al. (2012).

Assessment of American Badger Populations

American badger density may be assessed using trapping and radiotelemetry or camera traps and individual identification. These methods for surveys are outlined in Gould and Harrison (2018) and Brehme et al. (2014).

Assessment of Woodrat Populations

Dusky-footed woodrat density may be assessed locating woodrat houses and then using trapping and identification of individuals. These methods for surveys are outlined in Innes et al. (2007), Sakai and Noon (1993), and similar studies.

Assessment of Reptile and Amphibian Species

Several methods are available to determine populations of reptiles and amphibians. Methods may include time-constrained searches, surveys of coarse woody debris, coverboard, or pitfall trapping as laid out in USFS (1990). Each method varies in success dependent upon the species and overall accuracy.

Trail Camera Monitoring of Mammalian Species

Midpen is in the process of developing a camera monitoring program. Monitoring protocols will be developed as part of the Wildland Fire Resiliency Program.

Wildlife Mortality Monitoring Methods

Locations of known wildlife mortality helpful in identifying larger scale potential issues. This can include mortality due to vehicles, domestic animals (dogs), or potential incidental poisoning. The locations of dead wildlife can be mapped using ESRI Arc Collector (https://www.esri.com/en-us/arcgis/products/collector-for-arcgis/overview). Collector for the GIS application, ArcGIS, provides intuitive map centric field data collection. Most of your time in Collector for ArcGIS will be spent interacting with the map, which typically contains a basemap and at least one editable feature layer. When viewing the map, you can collect data, get directions, measure features, and initiate other capabilities of the application.

The general workflow for ArcGIS Collector is shown below and can be applied to known locations in the field, beyond wildlife mortality mapping.

1. Identify data to be collected.
2. Create an empty feature class
3. Share the feature class as an editable feature layer
4. Create a web map for data collection
5. Collect the data; The high-level steps for collecting data with Collector for ArcGIS are as follows:
    a. Sign into your ArcGIS Online organizational account.
    b. Open the web map you have created to be used for data collection.
    c. Collect data (features and attributes).
        i. Manually (without GPS), by tapping the location on the map with your finger
        ii. Automatically, by using your current position as identified by your phone's built-in GPS (location services)
    d. Save your data to ArcGIS Online.

Special-Status Species Protocols for Monitoring

Several special-status plants and animals may be found on Midpen land. Certain methods and protocols should be used when monitoring or surveying for individual species. Some special-status species could be surveyed using methods outlined for wildlife, such as those identified for butterflies and birds. A selection of the methods for the most likely species that may require monitoring are as follows:

- Special-status plants and sensitive vegetation communities – Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Sensitive Natural Communities (CDFW 2018)
- San Francisco garter snakes – Distribution and Demography of San Francisco Gartersnakes (*Thamnophis sirtalis tetrataenia*) at Mindego Ranch, Russian Ridge Open Space Preserve, San Mateo County, California (Kim et al. 2017)
- California red-legged frog – Revised Guidance on Site Assessments and Field Surveys for the California Reg-legged Frog (USFWS 2005b)
- Foothill yellow-legged frog – A standardized Approach for Habitat Assessments and Visual Encounter Surveys for the Foothill Yellow-Legged Frog (*Rana boylii*) (Seltenrich and Pool 2002)
- California tiger salamander – Interim Guidance on Site Assessment and Field Surveys for Determining Presence or a Negative Finding of the California Tiger Salamander (USFWS 2003)
- Western pond turtle – USGS Western Pond Turtle (*Emys marmorata*) Visual Survey Protocol for the Southcoast Ecoregion and USGS Western Pond Turtle (*Emys*

marmorata) Trapping Survey Protocol for the Southcoast Ecoregion (USGS 2006a, USGS 2006b)

- Special-status bats – Assessing Bat Detectability and Occupancy with Multiple Automated Echolocation Detectors (Gorresen, et al. 2008) and Mist Net Effort Required to Inventory a Forest Bat Species Assemblage (Weller and Lee 2007)

Vegetation and Habitat Monitoring Methods and Protocols

Overview

Monitoring of vegetation is important to understand short- and long-term changes to vegetation structure, type, and associated habitat values and fire risk. Vegetation monitoring can occur at the local (stand or individual tree or plant level) up to the county or region of interest. The methods below describe a range of approaches which can be used to monitor vegetation at a range of scales. Ultimately the method(s) selected should produce the types of information within available fiscal and temporal constraints.

Available Mapping and Data

Global Information System

Use of available GIS data is one method to monitor vegetation condition, distribution, and changes. A variety of data is available or will be available that Midpen can use, as summarized here.

- **Existing Organizational (Midpen) Enterprise Geodatabase:** At the core of the Midpen monitoring effort is the existing Midpen Enterprise Geodatabase. This database contains all known spatial data associated with Midpen lands as well as other ancillary datasets (streams, roads, buildings) produced by non-Midpen entities but relevant to Midpen land stewardship. Within this geodatabase, all data are stored within feature datasets, which enforce a specific and uniform spatial data projection. For metadata, users should fill attribute data as completely as possible, understanding that they may not know everything. Most feature classes have editor tracking enabled, and the geodatabase is running in a versioned environment. It is essential to keep this database updated with up to date treatment activity information as well as any other planned or unplanned changes or projects occurring on Midpen lands. Further discussion is needed on data editing standards and other protocols related to the Enterprise Geodatabase. The overall goal of the database is to create web-based applications where subject matter specific experts can take ownership of specific feature classes.
- **Existing Vegetation Map:** An up to date, LiDAR-based and ground-truthed detailed vegetation map is in progress for Santa Clara and Santa Cruz Counties. The map will include the information below and used to represent current vegetation conditions once available.
  - Fine scale vegetation map
  - Vegetation classification scheme development, key, and description

  - ¼ acre minimum mapping unit (MMU) for wetlands and riparian areas, 1-acre MMU for upland areas
  - 60-80 vegetation classes
  - Lifeform mapping (e.g. trees, shrubs, grasslands)
  - Relative hardwood vs conifer cover for forested stands
- **Google Earth Engine®:** Google Earth Engine® ("GEE") is a free to use online platform for remote sensing applications. Google has archived extensive satellite imagery from NASA onto their own servers, allowing users to develop change detection algorithms on any of the available imagery. Of interest to Midpen would be the Landsat 5, 7, & 8 data sets which begins in 1984 and is updated regularly (~2 weeks) at 30 m spatial resolution. Additionally, Sentinel-2 imagery from the ESA is available which provides coverage at 10m resolution beginning in mid-2015. Earlier Landsat missions provide imagery back to 1972. Though it should be noted this imagery is at 80 m resolution and has different spectral resolutions than the other Landsat missions, which is more applicable to a coarser scale analysis. Analysis of vegetation change in GEE allow analysis of trends in vegetation cover back in time (to 1984) and automated regular monitoring into the future. Examples of Google Earth Engine® based analysis tools can be found here (https://sig-gis.com/service-applications/) with more information here https://developers.google.com/earth-engine/datasets
- **Planet Labs®:** Planet Labs® is a private company that provides high resolution satellite imagery taken at regular intervals. Currently they offer daily imagery at 3 m and 72 cm resolution for any place on the planet. Similar to Google Earth Engine, they also have an online platform that can be used to detect change of desired attributes (vegetation, bare soil) between image sets. This system is proprietary and requires additional cost to purchase imagery and use the platform. Planet Labs® is one alternative for accessing near real time imagery after a major disturbance event such as a wildfire, landslide, or flood. (https://www.planet.com/). Planet Labs® does allow access to imagery for research and non-commercial use to university affiliated faculty, students and researchers through its Education and Research Program https://www.planet.com/markets/education-and-research/
- **Relative Differenced Normalized Burn Ratio (RdNBR):** The RdNBR is a measure of burn severity in vegetation. It can be expressed as the percent loss of canopy cover or basal area using commonly accepted analysis approach (Miller et al 2009). The RdNBR maps are produced for fires over 1,000 acres, with the data made public at this site https://www.mtbs.gov/ or https://www.fs.usda.gov/detail/r5/landmanagement/gis/?cid=STELPRDB5327833 (see various datasets under "Vegetation Burn Severity). RdNBR may also be calculated using the following methods (Miller et al. 2009)
- **Online Dashboards for Ecosystem Health, Project Implementation, and Monitoring:** ESRI® provides an easy way to summarize geospatial data into

dashboards. These can be used to monitor implementation of projects by OSP or any other spatial data collected over time. This requires data be captured in Midpen's enterprise geodatabase and is why centralization of spatial data is so imperative for business continuity (see Attachment 2).

- A dashboard is data driven view of geographic information that helps you monitor event and activities. Dashboards are composed of elements, such as maps, lists, charts, gauges, and indicators, and occupy 100 percent of the application browser window. Elements can be stacked or grouped together in various ways. You can either create a blank dashboard using an existing template or you can be created from Map Viewer or the gallery, content, or item page. Once it's created you have several configuration options.
- Elements from the library of charts, indicators, gauges, lists, maps, and more can be easily added. These visual elements can be moved, docked, resized, grouped, and stacked. The only elements that can't be rearranged are the header and side panels. These occupy a predefined space on a dashboard (although a side panel can be retractable at run time), and a dashboard can only have one of each. These dashboards can be built in ArcGIS® for Portal® using the operations dashboard template (https://www.esri.com/en-us/arcgis/products/operations-dashboard/overview) (see Figure 1).

Figure 1 ESRI® Dashboard Showing Fuel Treatment Acres Accomplished for Region 5 of the United States Forest Service

Aerial LiDAR

On Midpen management areas of interest (AOIs), existing LiDAR imagery may be used to assess stand structure before treatment using the general steps below (Figure 2 through Figure

4) with post-treatment updates provided by three-dimensional point cloud data generated by a Unmanned Aerial Vehicles (UAV).

1. Utilize LANDFIRE Total Fuel Change tool (LFTFC) to update/improve LANDFIRE fuels layers in Midpen AOIs where high density LiDAR has been acquired.
2. Perform an EcObject segmentation in Midpen management AOIs where high density LiDAR has been acquired.
3. Calculate direct LiDAR derivatives (i.e., canopy cover and different height slices) and assimilate into EcObject segmentation.
4. Synthesize updated fuel information and any other meaningful raster-based vegetation information with EcObject segmentation.
5. Apply satellite-based vegetation disturbance and recovery tracking workflows to assess where substantial vegetation changes have occurred (both disturbed and recovered).
6. Utilize UAV technologies to then fly those areas to generate a PhoDAR based point cloud.
7. Run EcObject and LFTFC workflows on PhoDAR point clouds.
8. Stitch new information in existing EcObject dataset.
9. Analyze, package, and present changes.

Figure 2 LiDAR Based EcObject Classification of Canopy Cover

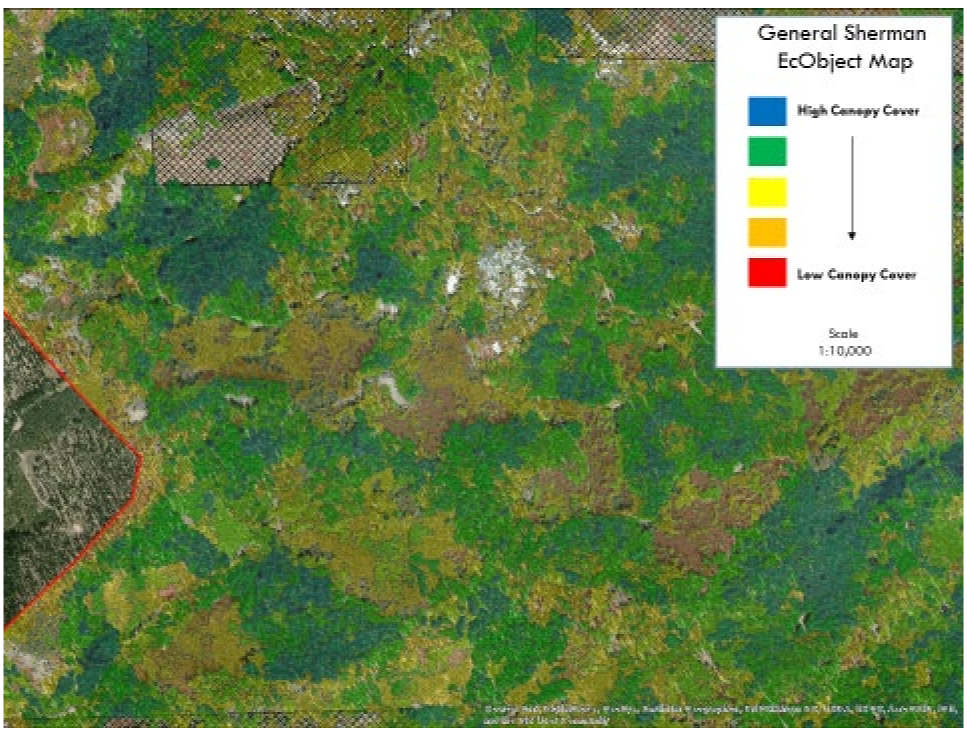


Figure 3 LiDAR based EcObject Classification of Forest Clump Distribution

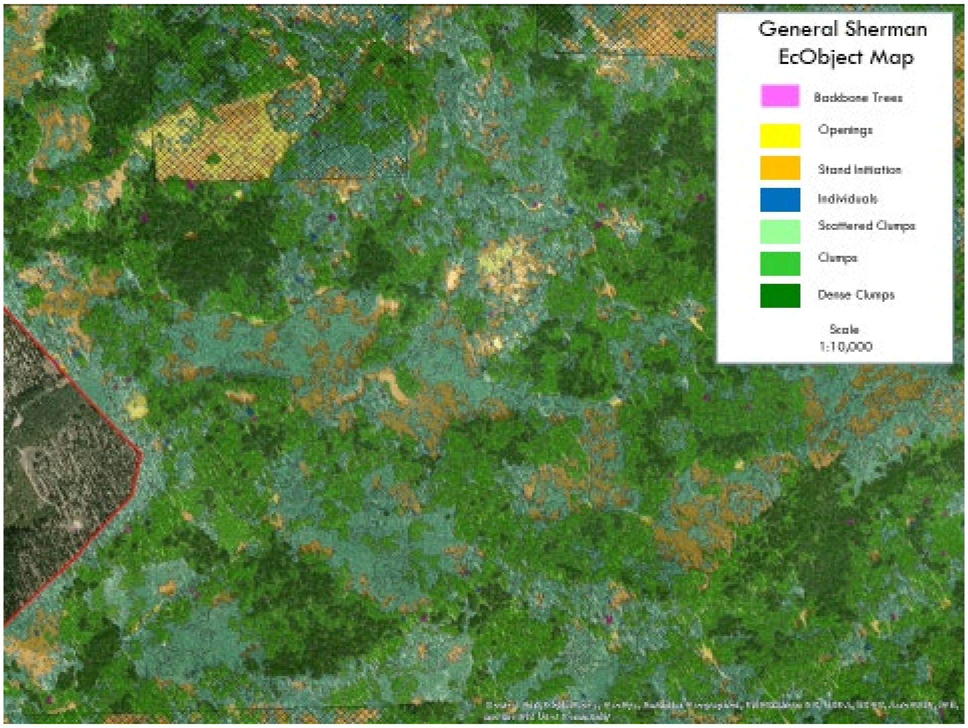
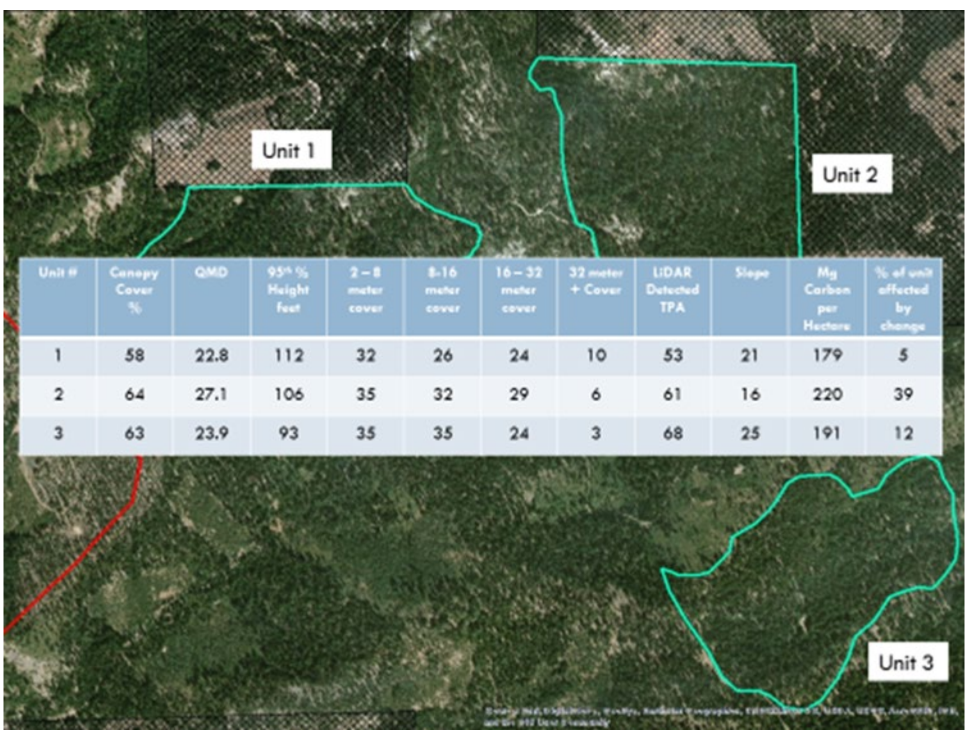


Figure 4 LiDAR based EcObject Classification of Treatment Unit Level Stand Structure



Unit #	Canopy Cover %	QMD	95th % Height feet	2 – 8 meter cover	8-16 meter cover	16 – 32 meter cover	32 meter + Cover	LiDAR Detected TPA	Slope	Mg Carbon per Hectare	% of unit affected by change
1	58	22.8	112	32	26	24	10	53	21	179	5
2	64	27.1	106	35	32	29	6	61	16	220	39
3	63	23.9	93	35	35	24	3	68	25	191	12

Methods to Collect Data

Species and Guild Data Collection

Specific to characterization of natural communities and rare plant habitat during monitoring efforts, data categories will include plant taxa and guild information as preferred by Midpen. This will provide a richer dataset from which to analyze vegetation and rare plant population recovery, and/or change, resulting from vegetation management.

Guild categories include native status (native, non-native), life history (annual, biannual, perennial), and stature (forb, grass, rush/sedge, shrub, and tree). Since this program may encounter pyrophytic plant species, an additional guild for fire followers should be included based on Keeley and Davis (2007), the fire follower database developed by Bartosh and Peterson (2014), and locally rare plant lists (Corelli and Bartosh 2019; Neubauer 2013).

Species and guild categories will be assigned vegetative cover values by plot. Cover is measured by estimating the aerial extent of the living plants, or the "bird's-eye view" looking from above. Cover estimates exclude the openings plants may have in the interstitial spaces (e.g., between leaves or branches). Generally, cover can be reliably estimated by polygons. The California Native Plant Society (CNPS) provides a diagram to aid in estimating cover (CNPS 2001).

Relevé Sampling Method

The preferred method in California for mapping, classifying, and monitoring change detection of Natural Communities, endorsed by CNPS and CDFW, is based on National Vegetation Classification System's (FDGC 2008) hierarchy of alliances and associations (Sawyer et al. 2009). This method can be applied to all vegetation types (forest, woodland, riparian, shrub, herbaceous, etc.) using a relevé. A relevé is a record of a sample of vegetation that is homogenous in species composition and structure, is in a uniform habitat, and is sufficiently large to contain a large proportion of the species typically occurring in the stand being sampled. The relevé sample method is plot based, with each species in the plot and its cover being recorded along with other environmental related data such as geology, soils, etc. Relevé sizes are adjusted based on the structure of the natural communities being sampled (CNPS and CDFW 2019).

Post-Fire Monitoring for Pyrophytic Plant Species

In the event prescribed burning is implemented as a part of this program, a specific monitoring methodology should be employed (primarily for chaparral) for the purpose of evaluating the presence of fire following plant species, vegetation recovery, possible type conversion of shrub composition, geophyte response, response of stump sprouting species, and invasive weed establishment. This methodology employs use of belt transects for measuring fire severity, species richness, and vegetative cover (Bartosh and Peterson 2014).

Technology Available to Collect Data

UAVs may be used to collect data to monitor vegetation and habitats. The use of UAVs shall be conducted within compliance of Federal Aviation Administration (FAA) rules, as well as Midpen policy. Two primary UAVs may be used to conduct monitoring.

- **Quadcopter UAV:** A quadcopter (Figure 5) is generally the lowest cost approach to acquiring imagery over a relatively small area. UAVs can also come in hex (6), octo (8) and other rotor configurations These UAV's can capture imagery down to an area of ~1/10th acre up to 25 acres in a single flight. Quadcopters, such as The Mavic Pro®, can take high resolution imagery that can be used to generate point clouds over 25 acres in a 30-minute flight (one battery). Lower resolution imagery (no point cloud) can be acquired over ~40 acres over the same duration (30 minutes). Multiple flights can be implemented to cover larger areas but generally total area for a quadcopter to cover in a day over 3 flights is ~100 acres.
- **Fixed Wing UAV:** A fixed wing UAV (Figure 6) allows data capture over a larger area when compared to a quadcopter. The Ebee can take high resolution imagery that can be used to generate vegetation cover and topography over 200 acres in a 45-minute flight (one battery). Higher resolution imagery 100 acres over the same duration (45minutes), which can be used to generate three-dimensional point clouds and Digital Surface Models (DSMs). Multiple flights can be implemented to cover larger areas but generally total area for an Ebee® to cover in a day over 3 flights is ~300-600 acres depending on resolution of imagery taken.

Both UAV types (fixed wing and quadcopter) can be used to generate the different geospatial products described below:

- ***High-resolution Orthomosaics*** – Creates extremely crisp and clear aerial photographs (~3cm resolution) that are accurately aligned with the earth's surface. These images provide a clear top-down view of the ground surface or tree canopies over that surface.
- ***Digital Surface Model (DSM)*** – A DSM captures the natural and built features on the Earth's surface and are useful in 3-dimensional modeling. DSM give you the elevation value of each pixel for aboveground features.
- ***Digital Elevation Model (DEM)/Digital Terrain Model (DTM)*** – A DEM is synonymous with Digital Terrain Model and is a 3-dimensional representation of the bare earth's surface. When you filter out non-ground points such as trees, bridges, buildings, and roads, you get a smooth digital elevation model. Like DSM, DEM/DTM gives the elevation value of each pixel.
- ***Contour Lines*** – Utilize DSM/DTM/DEM data to provide a simplified representation of topography, and display with elevation values. From the UAS data one can produce a DTM which interpolates the ground level from the point cloud. The DTM produced is what is used to create the contours in Pix4D.

- ***Three-Dimensional (3D) Textured Model*** – Generation of a full three-dimensional triangular mesh with a photo draped texture allows for three-dimensional visualization of urban and natural settings. This provides a continuous image surface draped over a 2.5-dimensional surface constructed from the methods outlined above.
- ***Volume Calculations and Cross-Sections*** – For landslide debris volume applications, pile volumes can be calculated to improve project planning. For stream restoration practitioners, DEM/DTM may be used to rapidly characterize channel morphology (cross sections) along any point interest along a stream.
- ***Image Timeseries and Change Detection*** – Repeat visits to a site of interest can be used to: 1) verify project progress, 2) compliance with regulatory and safety requirements, or 3) to monitor and quantify change in features of interest (e.g., aquatic invasive species abundance and distribution, stream channel morphology, riparian and forest vegetation, or recovery from natural disturbance such as wildfire or flooding, etc.).
- ***Custom Feature Extraction, Mapping, and Quantification*** – Using object-based image analysis (OBIA) procedures, including automated feature extraction, or manual feature delineation that integrates other GIS data can generate monitoring information.

APPENDIX G

Figure 5 The Mavic Pro® quadracopter UAV

Figure 6 The Ebee® Fixed wing UAV

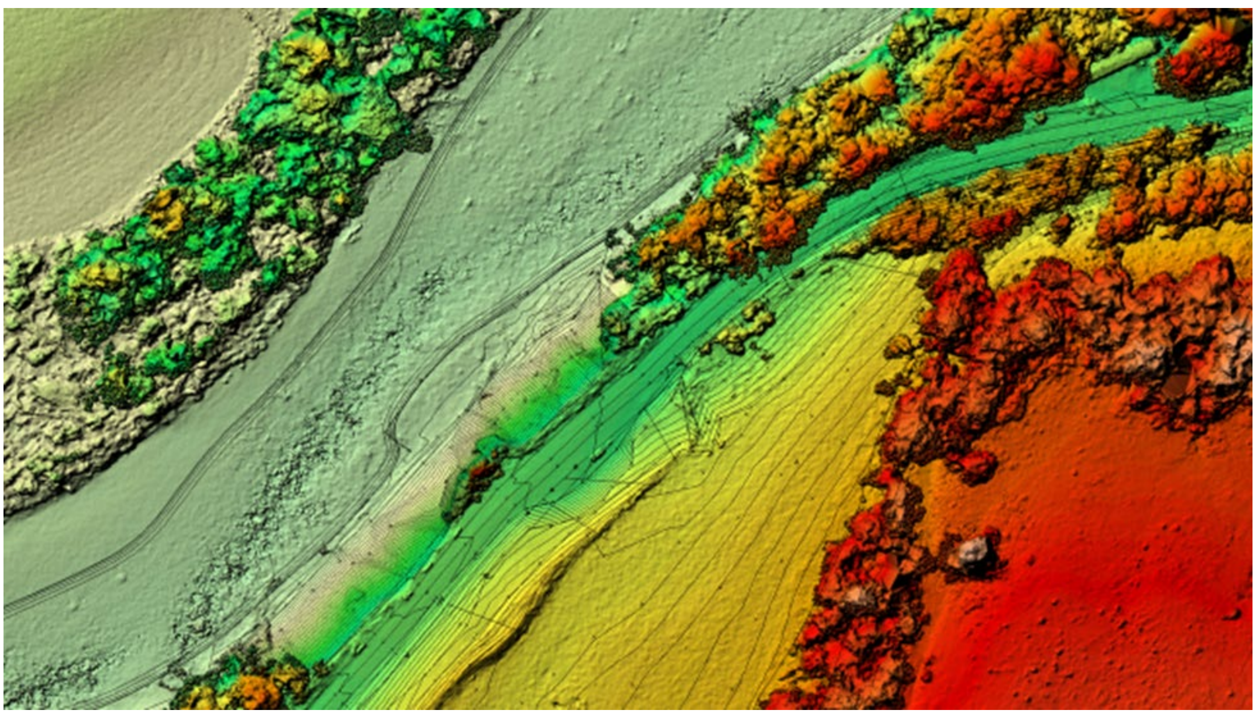
- *360-degree View* – The Hangar 360 application (free) to produce a 360-degree view of your area of interest from 300 feet aboveground. The finished product, a 360-degree panoramic image, allows user to pan side to side and up and down, and scroll in and out for a unique birds-eye view. Examples of Hanger 360 images from Midpen lands can be found at the following links:
  - Russian Ridge: https://viewer.hangar.com/360?productId=krqkZy8Y
  - Teague Hill: https://viewer.hangar.com/360?productId=6reOGwKY
  - Windy Hill: https://viewer.hangar.com/360?productId=drgwNZQr
- ***Aerial video and still images*** – The UAV can capture professional quality aerial video and/or photos to complement your visualization or other needs.

Use of UAVs also allows for the safe and rapid collection of change detection and site monitoring data before, during, and after treatments or disturbance. The imagery can be used to develop not only a high-resolution photographic record but can also be used to create changes in topography due to landslides, flooding, or three-dimensional point clouds that can be used to update LiDAR based calculations. UAV-based imagery can provide high resolution imagery and topography beyond that available to standard online two-dimensional imagery (Figure 7 through Figure 9). These images can be an improvement over National Agriculture Imagery Program (NAIP), as with other imagery sources, are available at specific temporal scales, and my not be appropriate for the desired application. For instance, a slip-out may have happened since the date of the imagery. The increased spatial resolution and color balance are key advantages of UAV-acquired images. Three-dimensional images from UAVs can be used to compute volumes, heights, and other changes in topography and vegetation.

Figure 7 Riverside Image with Topography over Standard NAIP Imagery Available Online

Figure 8 Riverside Image with Topography over UAV-Acquired Image

Figure 9 Riverside Image with Topography Represented in Three-Dimensions as Captured Using an UAV



Emerging Analysis, Sensor, or Software Applications for Monitoring

There are a wide range of additional techniques that can be utilized to detect current vegetation or changes to vegetation at multiple scales. Various sensors and approaches are always being developed and deployed. Prior to undertaking a remote sensing-based monitoring effort, a brief review of current or emerging technology and its application to specific monitoring goals should be explored.

Monitoring Target Rare Plant Species Methods and Protocols

Monitoring by Geography

The information in Table 4 summarizes the various target species and data sources of location information for these targets by geographic area.

Table 4 Target Plant Species by Geographic Area

Geographic Area	Target Species	Data Sources
Entire Midpen Preserve System	Federally and State Listed rare plant species	USFWS 2019 CDFW 2019
	California Rare Plant Rank Species	CNPS 2019 CDFW 2019
	Sensitive Natural Communities	CDFW 2018
	Biologically-Highly Significant Communities	Midpen 2014a
San Mateo County	Locally Rare Plants List	Corelli and Bartosh 2019 CCH2 2019
Santa Clara County	Covered Plants of the Santa Clara Valley Habitat Plan: Tiburon Indian paintbrush (*Castilleja affinis* subsp. *neglecta*), coyote ceanothus (*Ceanothus ferriseae*), Mount Hamilton thistle (*Cirsium foniniale* var. *campylon*), Santa Clara Valley dudleya (*Dudleya abramsii* subsp. *setchelii*), fragrant fritillary (*Fritillaria liliacea*), Loma Prieta hoita (*Hoita strobilina*), smooth lessingia (*Lessingia micradenia* var. *glabrata*), Metcalf Canyon jewelflower (*Streptanthus albidus* subsp. *albidus*), *most beautiful jewelflower* (*Strepthanthus albidus* subsp. *peramoenus*).	ICF 2012
Santa Cruz County	Locally Rare Plants List	Neubauer 2013 CCH2 2019

To voluntarily assist the Santa Clara Valley Habitat Agency with collecting status and distribution information on these covered plants species within Midpen OSPs, data collected in the field would need to conform to reporting requirements appearing in Chapter 5 of the VHP, "Incorporating Covered Plant Populations in the Reserve System" (ICF 2012). The following information is excerpted from the VHP (ICF 2012). To ensure that the VHP adequately protects covered plants, site inventories conducted in reserves will document the presence, absence, and condition (as defined below) of occurrences of covered plants.

The VHP aims to have covered plant occurrences, within the Reserve System, that are in good condition. A covered plant occurrence that is in "good condition" is defined as an occurrence that has a high potential to increase in size with improved management. The condition of a plant occurrence is to be assessed in the field by a qualified botanist on the basis of the characteristics listed below. The six relevant characteristics include:

- ***Physical Health:*** Individuals in good or excellent physical health (e.g., little or no signs of disease, viruses, severe herbivory, nutrient deficiencies) are more likely to survive, achieve an average or above-average lifespan, and reproduce successfully than individuals in poor physical condition. Plants in good physical health generally also indicate a highly suitable site.
- ***Age Structure:*** Occurrences of perennial species with an age distribution that includes many seedlings or juvenile plants relative to adults suggests a stable or positive rate of occurrence growth. Additionally, for annual and perennial species, seeds or bulbs in the soil (i.e., the seed bank) are also part of a plant occurrence's age structure, but this component is generally very difficult to assess.
- ***Reproductive Success:*** Occurrences with evidence of average or above average reproductive success for the species (e.g., production of flowers per plant, seed production per flower or per plant, proportion of seeds that appear to be viable based on visual observations) are more likely to be increasing than occurrences with below-average reproductive success, because this is often a key component of occurrence growth rate. If reproductive success cannot be measured, plant size or other physical features may be an appropriate surrogate in some covered species.
- ***Availability of Suitable Habitat:*** In order for a plant occurrence to remain stable or grow, enough suitable habitat must be present. Occurrences near unoccupied suitable habitat or without evidence of shrinking suitable habitat areas (e.g., nonnative plant populations that may be expanding, native shrubs that may be advancing) will be considered in better condition than occurrences without these indicators.
- ***Diversity of Suitable Habitat:*** Occurrences that occupy a wide range of microhabitats for the species may exhibit relatively high genetic diversity and therefore occurrence condition. Occurrences that occupy unusual microhabitats for the species may indicate unusual genetic composition or adaptations that should be protected.
- ***Threats:*** Threats to occurrences within the Reserve System will be assessed to ensure that protection and improved management will not be undermined by external factors such as disease, severe herbivory, recreational uses, or adjacent land uses. Occurrences in danger from threats that can be addressed should be considered in better condition than those that cannot be addressed.

APPENDIX G

Monitoring by Lifeform

Rare Annual Plant Population Monitoring

Overview of Methods

The monitoring methods for annual rare plant populations will depend on the size of the population, the area a population occupies, and the goal of monitoring. In most cases the number of individuals is a suitable metric for evaluating long-term persistence of an annual plant population, as number of individuals infers fecundity of the current season and seed set into the seed bank for subsequent generations. However, due to annual population fluctuations including an evaluation of a nearby reference population is an important part of monitoring annual and geophytic rare plant species. This ensures the size of the population observed in a treatment area are relative to the size of the reference population because seasonal precipitation and climate patterns can influence germination, abundance, and plant size. An evaluation of reference populations using one of the methodologies below should be paired with populations in an affected area.

Direct Count (Small Area of Occupancy)

In cases where a population occupies a very small area counting each individual by hand is the simplest way to monitor an annual plant population. This can be aided by flagging, establishing transects, or laying out grids to avoid miscounting individuals.

Simple Random Coordinate Method (Moderate Sized Area of Occupancy) (Elzinga et al. 1998)

For rare plant populations of moderate size, occupying approximately 0.5 to 1 acre a simple random coordinate method should be employed. This method utilizes x and y axes to cover the occupied area. Random coordinates are derived within these axes to randomly sample the number of individuals within that quadrat location in the grid. The number of individuals is then extrapolated for the occupied habitat based on a representative number of sampling locations.

Grid Cell Method (Large Area of Occupancy) (Elzinga et al. 1998)

When a rare plant population is multiple acres in size, a two-stage sampling methodology should be utilized. This is done by establishing a necessary number of macroplots, derived in GIS, to cover the monitoring area in a grid. Within these macro plots, quadrats are randomly placed, and the target species is enumerated within the quadrats. The number of individuals is then extrapolated based on a representative number of sampling locations by the area sampled.

Remote Sensing Method Using Multispectral Imagery Analysis (Landscape-scale Area of Occupancy) (Nomad 2017)

In few cases, rare plant populations occur on a landscape-scale and are visible to high resolution multispectral aerial imagery, such as smooth lessingia. Although impacts to this grassland species from this program are not likely, this methodology could be employed. The methodology relies on the availability of on-demand aerial imagery which is then examined using image analysis software through an object-based approach. This utilizes segmentation algorithms to cluster pixels into like polygons that may then be analyzed for various attributes like spectral band averages and heterogeneity of pixel values. Data collected in the field on cover and abundance at a relevant number of data points is utilized to extrapolate the population size.

Rare Geophyte Population Monitoring (Elzinga et al. 1998)
Monitoring of geophyte populations with the goal of abundance tracking can follow the above methodologies for annual plant species based on area of occupancy. However, it should be noted that in some years, resulting from annual precipitation and climate conditions or physiological factors, geophytes will not become reproductive. Instead they will only produce basal leaves to recharge their bulbs. In these cases, it may not be possible to conduct monitoring of these taxa if a positive identification of the individual, based on leaf morphology alone, is not possible. Therefore, it is important to also pair monitoring plots of geophytes with reference populations.

Depending on the rarity and endangerment of the geophyte, it may also be necessary to assess the reproductive success and seed set for each individual. This would be accomplished by including the number of inflorescences or flower, which could then be used to estimate the number of seeds potentially set by each plant for that growing season.

Rare Herbaceous Perennial Population Monitoring
Occurrence
In most cases rare herbaceous perennials occur on the landscape as discrete individuals that are easily enumerated using the area of occupancy methodologies described above. However, some types of herbaceous perennials require different monitoring methodologies. This is because rhizomatous individuals are difficult to determine without digging them up and accounting for mature and immature biennials implies fecundity of a population.

Rhizomatous Herbaceous Perennial Monitoring (Nomad 2017)
The goals of this monitoring method are to get an estimate of the area of occupancy by percent cover of the area occupied and the number of inflorescences produced of the entire population. Estimating vegetative cover can be accomplished utilizing the relevé method above. Counting individuals can be accomplished using a modified grid cell method.

Biennial Monitoring (Elzinga et al. 1998; Nomad 2017)
The goal of biennial monitoring is to understand the age and reproductive success of a population that has an approximately 2-year life cycle. To accomplish this any of the population monitoring techniques described above for annuals can be utilized but the addition of the number of vegetative versus reproductively mature individuals is necessary. A visual estimate of the number of flowers of the population is also beneficial to estimate seed set for subsequent generations.

Rare Shrub Population Monitoring
Occurrence
Rare shrubs known to occur on the San Francisco Peninsula include several manzanita bush mallow, and ceanothus species. Often, species of these genera form impenetrable vegetation communities of their own which makes monitoring difficult. In these situations, monitoring

utilizing a combination of remote sensing data and ground-based field work is necessary. If rare shrub communities are subject to vegetation management activities, especially prescribed fire, it is important to evaluate germination response of the soil seed bank as well. When rare shrubs do not form these communities monitoring can be accomplished utilizing the methods described above.

Aerial Imagery Supported Monitoring (Nomad 2016)
The goals of rare shrub monitoring, when these communities are left largely intact after management activities, is to get an accurate estimate of population health (including potential Phytophthora infestations from unintentional introductions) and number of individuals in these communities. This monitoring can be accomplished utilizing existing aerial imagery (satellite or piloted) or drone produced imagery in tandem with ground-based field measurements. Data collected on the ground requires taking length and width measurements of a representative number of individual shrubs to get an average area each individual occupies. Utilizing aerial imagery to calculate the percent cover of individuals (if visible on the imagery), within population boundaries, will give a refined area of occupancy. The number of individuals can be calculated comparing average area an individual occupies to refined area of occupancy. This can be especially efficient in shrub communities in more than 2 years of post-fire recovery.

Seedling and Stump Sprout Monitoring (Elzinga et al. 1998)
The goal of seedling and stump sprout monitoring is to assess germination response of the seed bank and stump sprouting of lignotubers of rare shrub species to evaluate regeneration response to fire (or other vegetation management activities) and any potential type conversion of the community from one shrub species to another. This can be accomplished using a modified grid cell method by estimating cover of seedlings and stump sprouts by species.

Rare Tree Population Monitoring
A small number of rare tree species are growing in Midpen lands. These trees are fire adapted conifers therefore the goals of monitoring are to evaluate the number and condition of mature trees left unaffected, as well as any seedlings resulting from vegetation management activities, especially prescribed fire. Seedling recruitment can be assessed using the seedling and stump sprout monitoring methodology (Elzinga et al. 1998).

Ground or Field-Based Methods for Monitoring Vegetation Condition, Distribution, and Change in Rare Plants

The approach to sensitive botanical resources monitoring described below assumes that project-level rare plant surveys have been conducted prior to vegetation management activities associated with the Wildland Fire Resiliency Program. As a result of these surveys, rare plant species presence within prescription areas would be known and applicable monitoring methods applied. However, in the event that a management activity occurs in a vegetation type that is not feasible to conduct rare plant surveys (e.g., chaparral), or rare plants emerge from the soil as a result of the management activity, a two-step approach should be applied. Following the management activity, the first step would be to conduct rare plant surveys during the appropriate blooming period(s) if suitable rare plant habitat is present. If rare plant populations are observed during appropriately timed surveys, the second step is to select the appropriate monitoring methodology, generally based on lifeform, and carry out the relevant method. If rare plant surveys are not observed during these surveys, then vegetation monitoring can either follow the suggested methodologies for natural communities monitoring. However, if sensitive natural communities are affected by vegetation management activities the natural communities Monitoring methods below should be employed. All monitoring related to rare plants, fire followers, and sensitive natural communities should occur for a minimum of three years following management activities.

Spanning three counties (San Mateo, Santa Clara, and Santa Cruz), the habitats that Midpen lands include support a large number of rare plant species. These rare plants represent a variety of lifeforms such as trees, shrubs, herbaceous perennials, geophytes, and annuals. Monitoring various types of rare plants require specific methodologies based on lifeform, size of the population, area a population occupies, and conservation status. In addition to utilization of specific monitoring protocols for statewide and locally rare plant species and sensitive natural communities, the Santa Clara Valley Habitat Plan outlines monitoring methods for specific species that are covered in this plan. The following information is first categorized by geography to indicate what should be considered as monitoring targets, followed by monitoring methods addressing each lifeform (ICF 2012).

Hydrology, Soil Infiltration, and Sedimentation Monitoring Methods

Overview

Wildfires alter land surfaces, land-atmosphere interactions, and runoff (Debano 2000; Moody and Martin 2001; Beringer et al. 2003; Prater and DeLucia 2006; Cydzik and Hogue 2009; Pierson et al. 2008; Montes-Helu et al. 2009; Burke et al. 2010 as cited in Kinoshita et al 2013). Following high-intensity fires, soil hydrology is altered, and duff, litter, and vegetation layers are removed exposing soil to rapid erosion events, which in turn overwhelm riparian areas, streams, and rivers (Campbell et al. 1977 as cited in Amato et al 2011). These extreme changes in the landscape can drastically influence surface runoff and sediment transportation. Removal of the forest duff layer causes increased runoff and subsequent increases in peak flow and sediment transport (Foltz et al 2009). Post-wildfire hazards and impacts related to erosions include (General Accounting Office 2003, cited in Robichaud and Elliot 2006):

- Flood runoff
- Peakflows
- On-site erosion
- Off-site sedimentation
- Mud and debris flows
- Damage to natural habitats
- Damage to roads, bridges, reservoirs, and irrigation systems

Erosion in the first year after a wildfire can be up to three orders of magnitude greater than the erosion from undisturbed forests (Robichaud and Elliot 2006).

Wildfire alters both vegetation and soil, which are factors that are directly related to erosion. Vegetation reduces erosion on the landscape by intercepting precipitation, covering bare ground with liter and duff that captures and facilitates infiltration, and roots stabilize the soils. Heat from wildfire increases and deepen hydrophobicity in the soil layer. Soil hydrophobicity is the tendency of the soil to resist wetting or infiltration of moisture. A relatively thin hydrophobic layer can form in an unburned forest, due to the leaching of organic matter from the duff into the soil. During wildfire, the hydrophobic layer can shift downward in the soil and increase in thickness (USDA 2016). These factors contributed to increased runoff and erosion post-wildfire. Monitoring methods related to erosion have been grouped into three categories 1) hydrology – to quantify the increase in runoff and peak flows post-wildfire, 2) soil infiltration – to quantify the decrease in infiltration of precipitation into the soil, and 3) sedimentation – to quantify the increase in material that is eroded off of the landscape post-wildfire in the following sections.

Hydrology Monitoring

Changes in the hydrology downstream of burned areas can be identified by looking at gage data. Few watersheds have active gages, even in urban areas. Hydrology models are used to predict discharge in watersheds that are not gaged. Methods are provided in the table below to quantify hydrology in catchments for both gaged and ungagged streams. After a fire, peak flow flood potential is 10 to 10,000 times greater than pre-fire levels (Berry et al 2014). The following table lists methods for assessing impacts from wildfire (Table 5).

Table 5 Hydrology Monitoring

Method	Direct Measurement or Indirect Indicator	Spatial Scale	Reference
Stage measurement at gaging stations	Direct measurements	Local, regional	Sauer, V.B., and Turnipseed, D.P., 2010
Discharge measurements at gaging stations	Direct measurements	Local, regional	Turnipseed, D.P., and Sauer, V.B., 2010
V-notch weirs	Direct measurement	Local, regional	Rantz, S.E., and others. 1982
Water Erosion Prediction Project (WEPP)	Indirect indicator	Local, regional	Elliot et al 2000–2002
Models	Indirect indicator	Local, regional	Foltz et al 2009, USDA 2016, Kinoshita et al 2013

Soil Infiltration Monitoring

Quantification of soil infiltration is easier measured in the field. A summary of methods is provided in the table below (Table 6). Systematic sampling should be conducted throughout the Midpen management area to identify pre-wildfire conditions.

Table 6 Soil Monitoring

Method	Direct Measurement or Indirect Indicator	Spatial Scale	Reference
Soil Hydrophobic Conditions	Direct Measurement	Local	USDA 2016
Single-ring infiltrometer	Direct Measurement	Local	Herrick et al. 2005

Sedimentation Monitoring

Direct measurement of erosion is time consuming, can be expensive (depending on the method), and dependent on pre- and post-wildfire water year types (dry, normal, or wet). Models are often also used to quantify impacts from wildfire. Methods for both direct observation and measurement and modeling are provided in the table below to quantify sediment impacts pre- and post-wildfire (Table 7). Systematic sampling could be conducted throughout the Midpen management area to identify pre-wildfire sedimentation rates and to calibrate pre-wildfire modeling results. Post-fire erosion rates may be up to more 100 times greater than rates on a well-vegetated watershed (Radtke, 1983 as cited in Berry et al 2014). Sediment from increased erosion, clogs, dams, and changes water courses, add to flooding hazards (Berry et al 2014).

Table 7 Sedimentation Monitoring

Method	Direct Measurement or Indirect Indicator	Spatial Scale	Reference
Visual indicators of erosion	Indirect indicator	Local, regional, and national	Ypsilantis, W.G. 2011
Erosion bridge	Direct measurement	Local	
Erosion plots	Direct measurement	Local	
Close-range photogrammetry	Direct measurement	Local	
Silt fence catchments	Direct measurement	Local	Robichaud, P. R. and R. E. Brown. 2002, Robichaud, P. R. 2005
Water Erosion Prediction Project (WEPP) Erosion Risk Management Tool (ERMT)	Indirect indicator	Regional	Elliot et al. 2000–2002

Method	Direct Measurement or Indirect Indicator	Spatial Scale	Reference
Erosion Risk Management Tool (ERMT)	Indirect indicator	Regional	Robichaud et al. 2006

Soil Temperature Monitoring

Soil temperatures can be assessed in the field at the soil surface or at desired depths in the soil profile based on the monitoring question. For surface measurements (single point in time) a simple handheld Infrared Thermometer or soil thermometer can be used (Figure 10). These units allow the user to point the temperature "gun" at any surface and obtain a reading of temperature of that surface. Additional single point in time readings at shallow depths can be obtained by using a traditional glass or digital soil thermometer. For recordings over time, digital thermometers that record data continuously or at set intervals over time are available from such brands as Hobo®.

Figure 10 Soil Sample Plot Showing Soil Corer, temperature, and in this Photo, Nitrogen Sampling Bags

Soil Moisture Monitoring

As with soil temperature, soil moisture can be assessed in the field at single point in time measurements or over time with a data recorder and probe. A range of off the shelf equipment to assess soil moisture is available.

In 2015, NASA launched the "Soil Moisture Active Passive" (SMAP) satellite. This transmits available data on soil moisture and other variables globally (Figure 11), though the resolution (3 km) prevents it from being easily applied at fine scale in the field. More information is available here https://smap.jpl.nasa.gov/data/.

Figure 11 Data available from the NASAs SMAP satellite

Product	Description	Gridding (Resolution)	Latency**	
L1A_Radiometer	Radiometer Data in Time-Order	-	12 hrs	Instrument Data
L1A_Radar	Radar Data in Time-Order	-	12 hrs	
L1B_TB	Radiometer T_B in Time-Order	(36x47 km)	12 hrs	
L1B_TB_E	Radiometer T_B Optimally Interpolated on EASE2.0 grid	9 km	12 hrs	
L1B_S0_LoRes*	Low Resolution Radar σ_o in Time-Order	(5x30 km)	12 hrs	
L1C_S0_HiRes*	High Resolution Radar σ_o in Half-Orbits	1 km (1-3 km)	12 hrs	
L1C_TB	Radiometer T_B in Half-Orbits	36 km	12 hrs	
L1C_TB_E	Radiometer T_B in Half-Orbits, Enhanced	9 km	12 hrs	
L2_SM_A*	Soil Moisture (Radar)	3 km	24 hrs	Science Data (Half-Orbit)
L2_SM_P	Soil Moisture (Radiometer)	36 km	24 hrs	
L2_SM_P_E	Soil Moisture (Radiometer, Enhanced)	9 km	24 hrs	
L2_SM_AP*	Soil Moisture (Radar + Radiometer)	9 km	24 hrs	
L2_SM_SP	Soil Moisture (Sentinel Radar + Radiometer)	3 km	Best effort	
L3_FT_A*	Freeze/Thaw State (Radar)	3 km	50 hrs	Science Data (Daily Composite)
L3_FT_P	Freeze/Thaw State (Radiometer)	36 km	50 hrs	
L3_FT_P_E	Freeze/Thaw State (Radiometer, Enhanced)	9 km	50 hrs	
L3_SM_A*	Soil Moisture (Radar)	3 km	50 hrs	
L3_SM_P	Soil Moisture (Radiometer)	36 km	50 hrs	
L3_SM_P_E	Soil Moisture (Radiometer, Enhanced)	9 km	50 hrs	
L3_SM_AP*	Soil Moisture (Radar + Radiometer)	9 km	50 hrs	
L4_SM	Soil Moisture (Surface and Root Zone)	9 km	7 days	Science Value-Added
L4_C	Carbon Net Ecosystem Exchange (NEE)	9 km	14 days	

Compaction (Bulk Density) Monitoring

Compaction of soils is typically assessed by measuring the bulk density of soils in a core of fixed volume and depth. Cores are extracted using a soil core sampler (Figure 10). Soil compaction may also be measured in the field using a soil penetrometer (Figure 12). These units provide a continuous measure of compaction to a fixed depth at any point a sample is taken. Both measures can require either extensive time to prepare and analyze. Soil cores are typically weighed, dried, and re-weighed to calculate moisture and bulk density. Soil penetrometer data must be analyzed using additional statistical analysis to determine compaction levels at varying depths (Moghaddas and Stephens 2008; Moghaddas and Stephens 2007).

Figure 12 A Soil Penetrometer Being Used in the Field to Assess Compaction in Forested Ecosystems.

Water Quality Monitoring Methods

Prescribed burns and other fire management approaches are designed to decrease the intensity of future wildfires by reducing fuel reserves. Prescribed burns have the added benefit of returning ecosystems back to a condition under which they operated for thousands of years (or more) before European influence. However, prescribed burns could also present short-term and long-term water quality impacts. The goal of this section is to describe and reference generally accepted protocols for monitoring water quality before and after prescribed burn related activities. The following steps are intended as an outline to guide the necessary water quality monitoring efforts:

1. Develop a focused water quality sampling plan (OWEB 2000). Consideration should be given to the following factors:
   a. Monitoring objectives and questions to be answered
   b. Scale of monitoring activity
   c. How management activities might impact water quality

2. Select sites according to best practices (OWEB 2000)
3. Determine stated beneficial uses, impairments, and water quality criteria of potentially impacted water bodies (SFBRWQCB 2017, CCRWQCB 2019, SWRCB 2019)
4. Finalize list of constituents to be measured based on monitoring questions (OWEB 2000, SCCWRP 2009)
5. Where applicable, compare constituent method detection limits to basin plan criteria to make sure the chosen methods can detect concentrations below established criteria
6. Collect water quality data according to water quality sampling plan (OWEB 2000, USGS 2019, NRCS 2003 (part 614)). Consideration should be given to the following factors:
    a. Collection of data to establish baseline prior to fire management activities
    b. Collection of data over multiple seasons to account for seasonal variability
    c. Collection of data over multiple years to account for annual variability and progression over time
    d. Collection of data during the same season, time of day, and similar stream flow for comparisons between baseline and post-project conditions
7. Data analysis and reporting (OWEB 2000, NRCS 2003 (part 615))

These steps are meant to provide general guidance and should be revisited as focused water quality monitoring plans are developed and further consideration is given to the objectives of the sampling efforts. This will help guide the selection of monitoring sites, constituents that should be monitored, as well as, timing and duration of the sampling effort. A summary of references that may be used to guide development of water quality monitoring plans and collection of sample data is provided in Table 8.

Table 8 Water Quality Monitoring References

Subject	Reference
Guidance on creating a water quality sampling plan	OWEB 2000
Guidance for the collection of water quality data	OWEB 2000, USGS 2019, NRCS 2003 (part 614)
Guidance for post-fire water quality monitoring	SCCWRP 2009
Guidance for data quality, storage, and analysis	OWEB 2000, NRCS 2003 (part 615)
Beneficial uses of water bodies	SFBRWQCB 2017, CCRWQCB 2019
Clean Water Act list of impaired water bodies	SWRCB 2019

Forest Inventory, Surface Fuel Loading, Large Woody Debris, and Disease Monitoring Methods

Several methods can be employed to conduct forest inventories and monitor for surface fuel loading, large wood debris, and spread of forest diseases.

Plot Level Vegetation Monitoring Using Terrestrial LiDAR Systems

Ground-based or Terrestrial LiDAR Systems (TLS) can be used to augment or replace traditional forest transects and inventory plots in more open vegetation types, such as redwood or mature oak. Terrestrial LiDAR produces a high-resolution LiDAR image at the ground level (Figure 13), allowing monitoring for the following conditions.

- Detailed quantification of unique tree (diameter at breast height [DBH], height) and fuel metrics (surface fuel loading) critical for vegetation and fire behavior analysis
- Automation of workflows, analysis, and summary of TLS data into usable information as specified for a particular project.
- Integration of TLS information with aerial LiDAR data to produce a comprehensive and highly accurate dataset across Midpen management areas.

Figure 13 A Terrestrial LiDAR Unit Used to Capture Post Treatment Data in a Treated Forest Stand

Forest Inventory

The Common Stand Exam (CSE) Protocols (USDA 2019a) provide a comprehensive approach to measuring forest and woodland vegetation. These protocols are set to allow easy conversion of files into the Forest Visualization Simulator (FVS) (USDA 2019b), which in turn can be used to quantify forest carbon, fire risk, stand structure data, model treatment, with near endless functionality. There is some training required to use these systems, but they are free and updated at no cost to the user.

Surface Fuel Loading and Large Woody Debris Monitoring

Surface fuel loading can be assessed using fuel transects as described by Brown (1974) and Brown and Johnston (1982). Large woody debris can be assessed using methods described in Stephens and Moghaddas (2005). Both methods allow for plot-level assessments of surface fuel and large woody debris.

Disease Monitoring

Tree mortality can be monitored at no cost using data provided by via the California Tree Mortality Task Force (CAL FIRE 2018). Data is available from 2012 through 2018 and is typically based on annual aerial surveys. Monitoring of tree mortality pre- and post-treatment at smaller scales (<250 acres) can be completed using a fixed wing UAV or quadracopter type UAV for areas <50 acres.

Forest Carbon Monitoring

The State of California has official protocols for assessing forest carbon (Climate Action Reserve 2019). It should be noted that while carbon calculations can be made using the CSE inventories with data processed in FVS, developing forest carbon values that are verifiable and marketable within the states cap and trade system are highly complex and costly to complete.

Photo Points Monitoring

Photo points can range in complexity and application but can quickly convey change from treatments, disturbance, or time. Photo monitoring can be utilized with historic photos, where they can be retaken using features in the photo that exist today (Figure 14 and Figure 15). Photo monitoring may also be conducted by establishing fixed photo point or taking photos from locations that are easily relocated within 5 to 10 years. In general, it is recommended to at a minimum take pre-/post-treatment photos from a location that is readily revisited, such as a point along a trail, from a powerline, or along a road. More detailed photo monitoring protocols are described by Hall (2001).

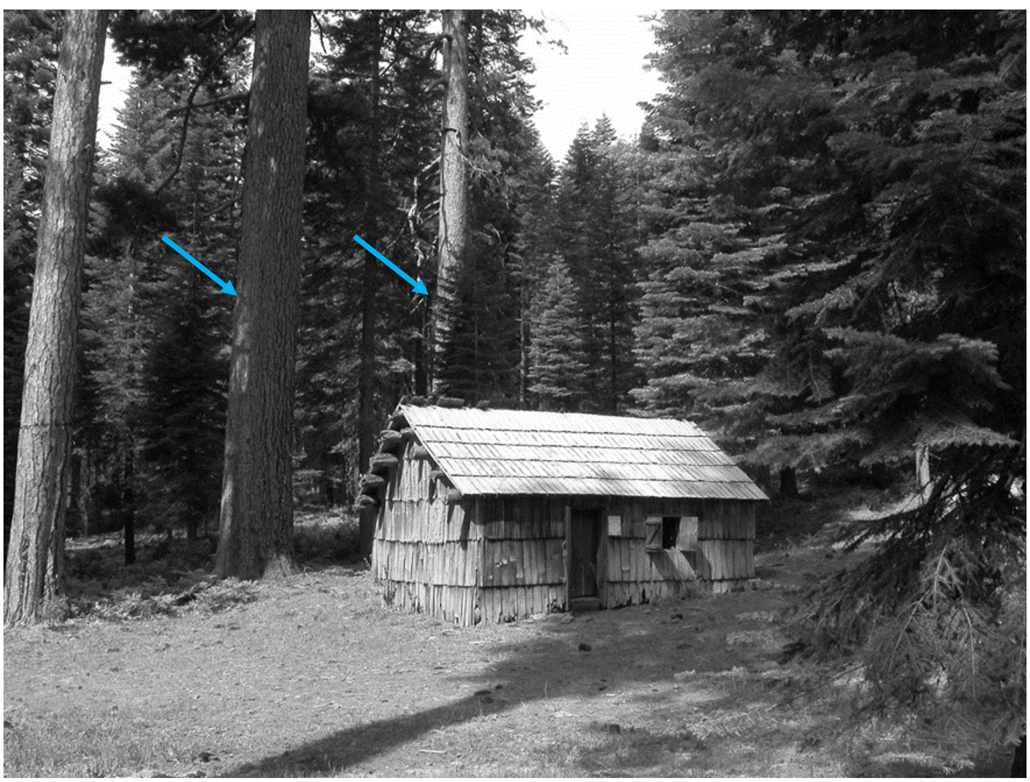
Custom Photo Series or Photo Books Monitoring

For vegetation condition assessments, custom or existing photo series can be utilized to help estimate indicators such as fuel load, stem or tree density, and canopy cover. Photo series have been built for many vegetation types across California, including the East Bay Hills (Wright and Vihnanek, 2014). The photo points and associated data for the existing photo series can be viewed and utilized at this website https://depts.washington.edu/nwfire/dps/.

For training local field staff, it may be useful to create a simple local (Midpen) custom photo series that show areas of potential high fire risk for different vegetation types, post treatment desired conditions, or high levels of mortality.

Figure 14 Photo of the Historic Bear Creek Guard Station on the Plumas National Forest ~1915

Figure 15 Photo of the historic Bear Creek Guard Station on the Plumas National Forest ~2005



Invasive and Nonnative Species Monitoring Method

Invasive species may be observed during monitoring for special-status and rare plants. Specific monitoring for invasive species is conducted using the Early Detection Rapid Response (EDRR) method. The EDRR method involves conducting regular surveys of those areas where weed invasion is most likely, and periodic surveys in remote areas where new weed invasions are likely to be less frequent. The surveys are performed by trained surveyors and weed locations are mapped in GIS. EDRR staff pull, cut, or dig out newly discovered invasions. A database of all EDRR populations is maintained and used to facilitate follow-up visits ensuring that the invasion was eliminated. Sites are revisited and retreated annually until there are 5 consecutive years with no weed observations recorded. Midpen's ongoing control of the invasive species population is accomplished through implementation of methods identified in the IPMP (Midpen 2014b).

Wildfire Location Monitoring Methods

Many tools and sources of information are available to monitor for locations of new wildfires, which can also be used to identify the ignition source. The following bullets provide details on the variety of tools and data sources.

- **Local Online Cameras:** Local online camera can be used to monitor smoke conditions or potential wildfires in the area (Figure 17). There are currently four cameras covering areas in vicinity of Midpen lands, but there may be potential to add more. The camera feeds can be accessed at this site: http://www.alertwildfire.org/southeastbay/index.html.
- **Monitoring Fire Intensity (Flame Length):** Flame lengths can be monitored using a camera placed at a location that allows near complete view of a burn unit. Within a burn unit, T-post can be placed at fixed locations within the field of view to determine flame length as recorded at the point where the T-post is placed. It should be noted that this method can be easily impacted by smoke when it obscures the cameras view. Passive flame height sensors may be used-there are variations of this method but generally a string is saturated with borate and placed on a secure re-bar post. The varying levels of burning and scorch of the string can be translated to flame height as described by Ryan (1981) and Kobziar and Moghaddas (2007). It should be noted that this method can be very labor intensive.
- **MODIS (or Moderate Resolution Imaging Spectroradiometer):** MODIS is a key instrument aboard the Terra (originally known as EOS AM-1) and Aqua (originally known as EOS PM-1) satellites. Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning, while Aqua passes south to north over the equator in the afternoon. Terra MODIS and Aqua MODIS are viewing the entire Earth's surface at least once every 24 hours. This is a public dataset that provides regular estimated areas that are burning or have recently burned and have a detectable heat signature (Figure 17) (NASA 2019).

- **Google Online Crisis Mapping:** Google® provides free online maps for wildfires and weather event warnings (Figure 18). These can be viewed here: https://www.google.org/crisismap/weather_and_events.
- **Inciweb (Federal Incidents):** Inciweb typically provides the most consistent up to date summaries of wildfire incidents where a federal agency is the lead agency. Inciweb can be found here https://inciweb.nwcg.gov/.
- **CAL FIRE Incidents:** Incidents where CAL FIRE is the lead agency can be found here. https://www.fire.ca.gov/incidents/.
- **Local Social Media:** Most local sheriffs' departments, highway patrol, and fire agencies may post a range of evacuation or incident updates on their own Facebook® and Twitter® Feeds. Sometimes specific Twitter® or Facebook® pages will be set up for a specific incident. These sources often provide near real time information, though it is not always organized in an easy structure to decipher and take action from, as it can be hundreds or thousands of individual posts.
- **Local Fire Incident Radio Feed:** During major incidents, a separate live radio feed from the incident can be accessed at Broadcastify® (https://www.broadcastify.com/listen/). These can be a bit confusing to decipher given the volume of radio traffic, but also can be useful for very localized on the ground current conditions. In previous incidents (2017 Tubbs Fire), volunteers hand typed the entire radio feed into Facebook posts so it could easily be followed by anyone with internet access. The current Kincade Fire transcribed radio feed can be found here https://www.facebook.com/SCScanner/posts/3616036398410243?__tn__=K-R.
- **Historical Ignition Sources:** Understanding historical and current trends in wildfire ignition sources (i.e. human or lighting caused fires) can be useful in preventing future ignitions. Historical ignition patterns have been analyzed regionally for the State of California by Keeley and Syphard (2018). These regional trends in ignitions are broadly applicable to Midpen lands and the South Bay Region. Additional local or OSP level analysis of ignitions can be completed using ignition data (1970 through 2018) available from the National Division of Fire and Aviation Management (FAM 2019).

Figure 16 Screenshot from Online Local Alert Wildfire® Camera Feed

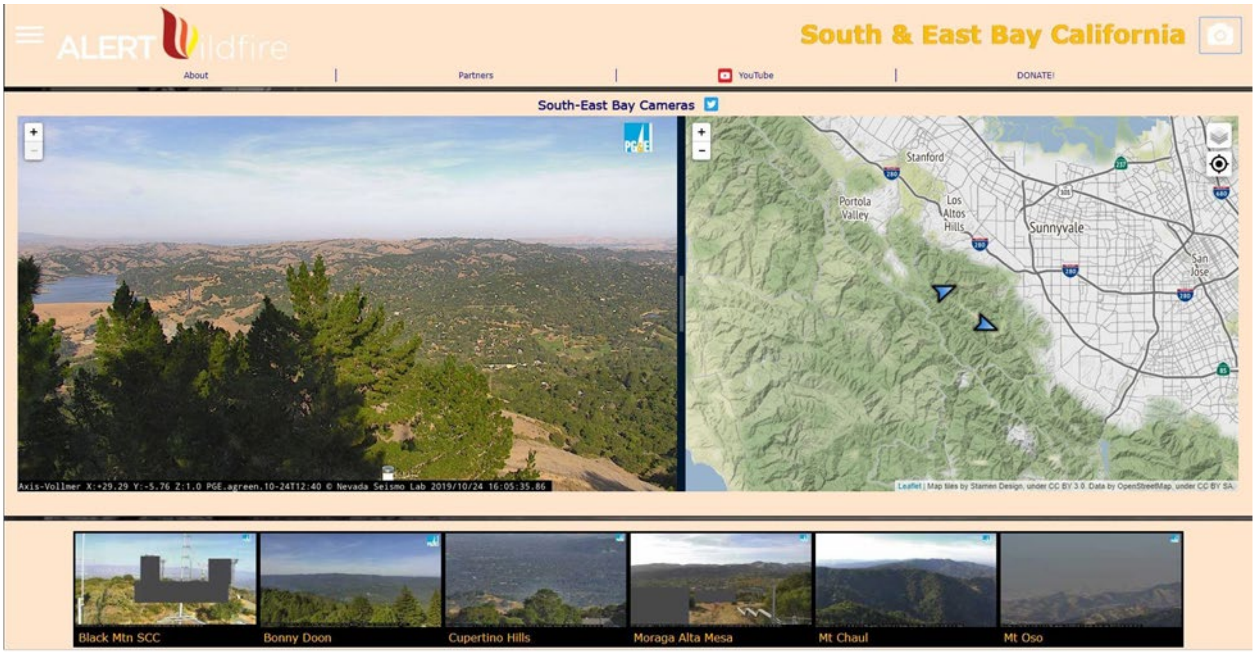


Figure 17 MODIS Imagery Showing 2019 Kincade Fire

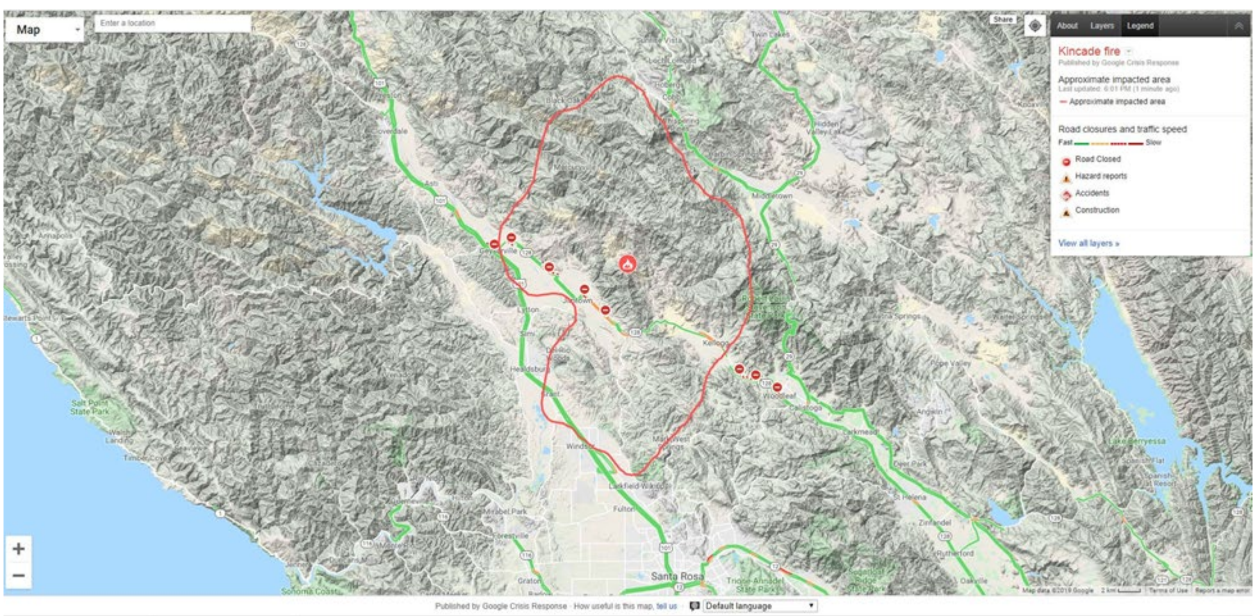
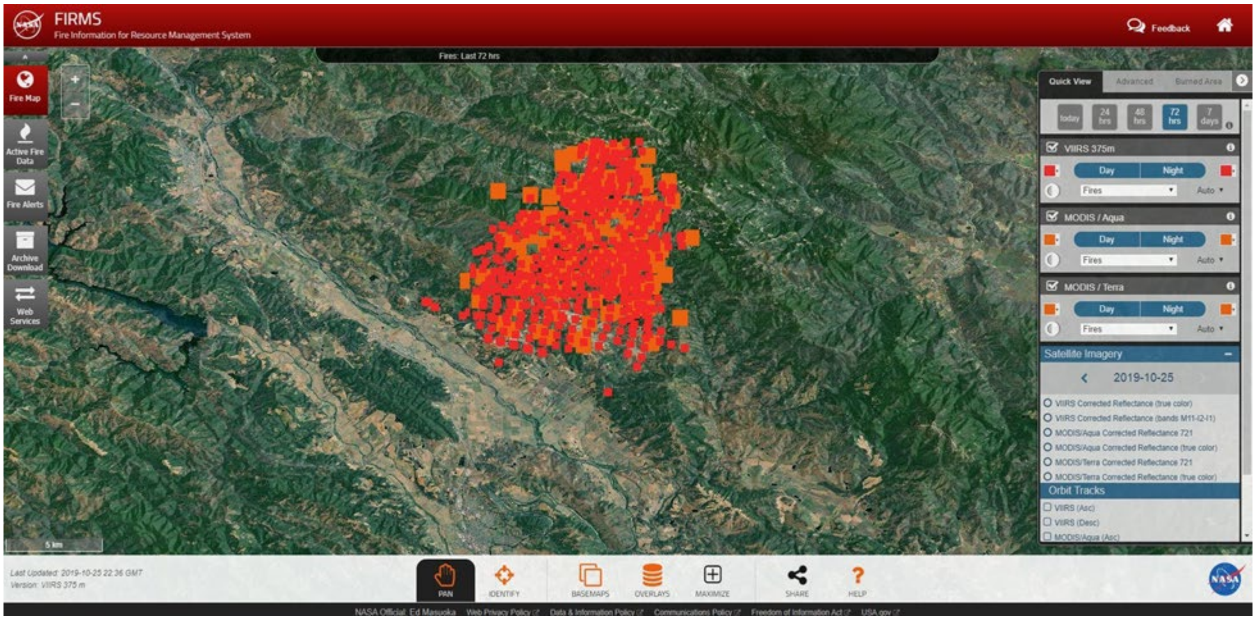


Figure 18 Google Crisis map showing the Kincade fire



Weather and Fire Weather Monitoring Methods

Overview

Three factors contribute to an increased potential for wildfire ignition, including the weather, topography, and fuel load. Monitoring to identify days when fire risk is greater can be conducted using real-time data and forecasts.

Point in Time Measures of Weather Indicators

Weather indicators such as temperature, relative humidity, and windspeed can be measured at single points using simple to use handheld devices. These types of instruments are useful when assessing project level local conditions for project implementation.

Fuel Moistures (Live and Dead)

Live and dead fuel moistures can be obtained from field level measurements, some RAWS stations, as well as satellite imagery. Local measures of live fuel moisture include collection, weighing, drying, and re-weighing samples to determine live fuel moisture content. Digital moisture meters and probes may also be used to assess point in time fuel moistures. Fuel sticks may be used to assess 10-hour fuel moistures as well. At a landscape scale, satellite imagery can be used to assess overall live fuel moistures (USFS 2019a).

Remote Access Weather Stations (RAWS)

Local RAWS stations can provide historical and near real time weather readings, including windspeed, direction, air temperature, relative humidity, and in some cases fuel moisture. RAWS data may be downloaded and analyzed locally using Fire Family Plus (Main et al. 1990). RAWS stations may be part of a larger existing network or new local RAWS can be established on a temporary or permanent basis (NOAA 2019a).

Fire Weather Forecast

The local fire weather forecast provides fire specific weather forecasts typically for morning and afternoon periods (NOAA 2019b).

Fire Danger and Related Metrics

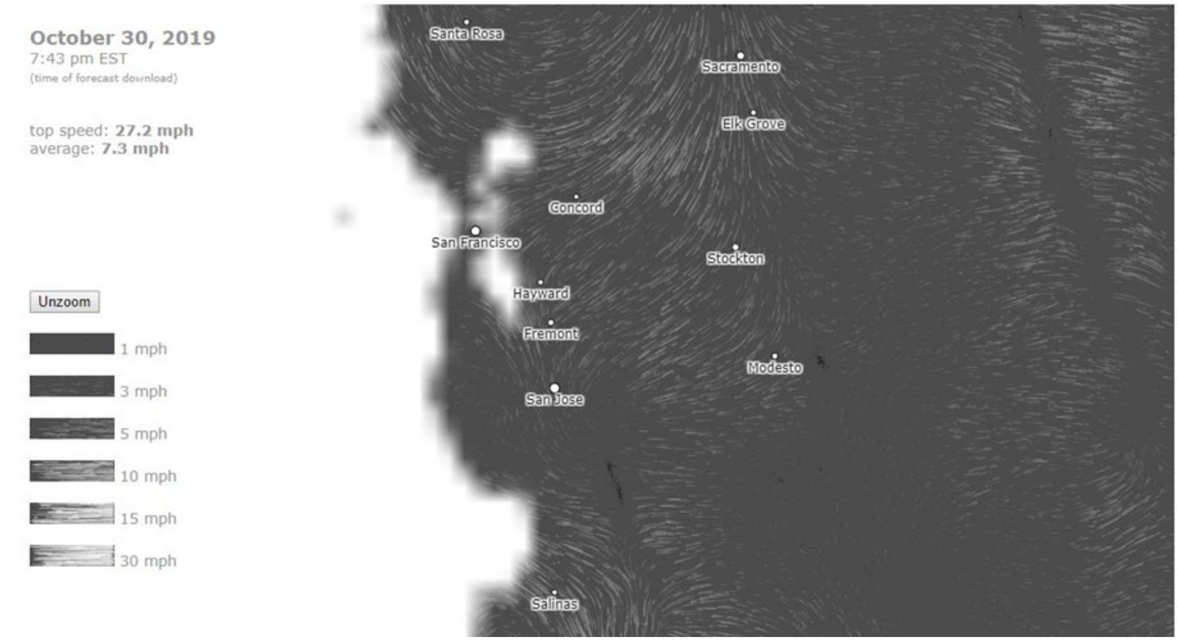
The Wildland Fire Assessment System (USFS 2019b) provides regularly updated information on a range of fire danger and related metrics including:

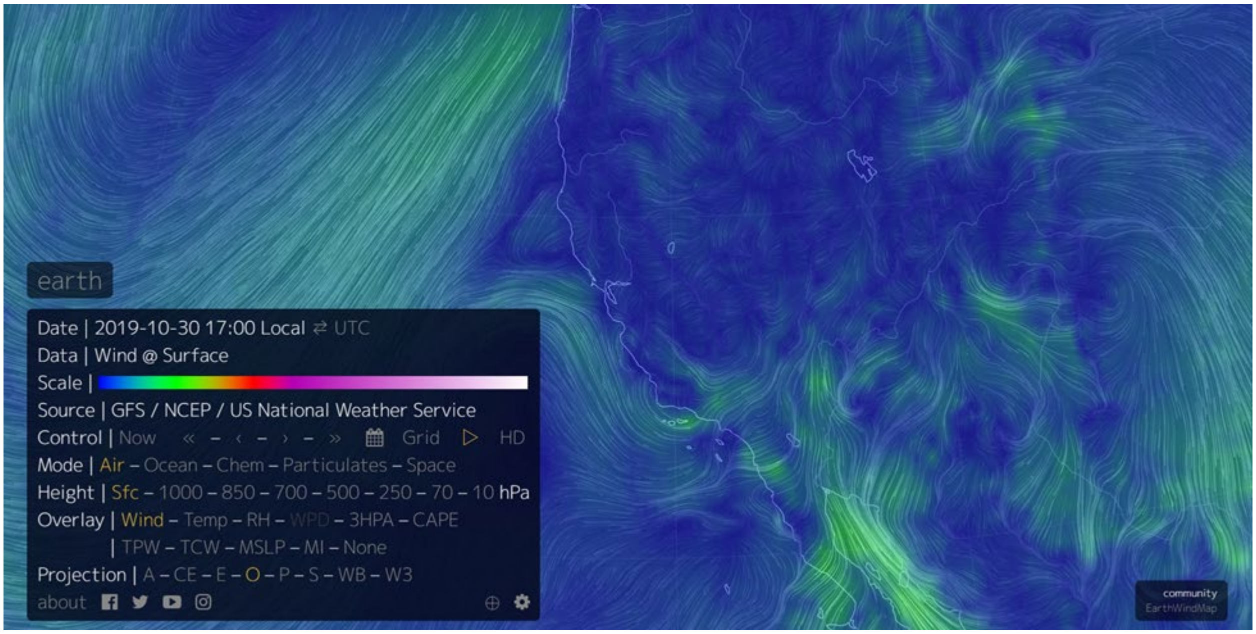
- **Fire Potential / Danger**
  - Fire Danger Rating
  - Haines Index
  - Dry Lightning
  - Potential Lightning Ignition
  - Lightning Efficiency
  - NDFD Fire Danger Forecasts
- **Weather**
  - Fire Weather
  - Map Data
  - Google Earth Map Data
- **Moisture / Drought**
  - Dead Fuel Moisture
  - Growing Season Index
  - AVHRR NDVI
  - Keetch-Byram Index
  - Palmer Index
  - National Fuel Moisture Database

Wind Data

Earth® and Windmap® are two sites that provide maps of local windspeeds and directions that incorporate topography (Earth 2019; Windmap 2019) (Figure 19). While the data is mostly for visualization purposes, it is useful to monitor the site during high wind events to gain improved understanding of the local effects of topography on local windspeeds.

Figure 19 Examples of Windmaps from Earth® and Windmap®





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APPENDIX G, ATTACHMENT 1

Avian Sampling Data Sheets

CHIS Landbird Surveys Point Counts

Figure SOP 5-1

Island: ______ Site Code: _______ **LT PC** Date (mm/dd/yyyy): ____________ Observer Name: __________________

Conditions: Temp. (C): ________ Clouds (0-100): ________ Wind (0-6): ________ Noise (0-3): ________ Precip (0-5): ________

Start Time (hh:mm): _____________ Weather Comments ____

Time	Species	Dist. (m)	DT	Flock Size	Sex	Age	Prev. Point	Comments

Area Search Data Form

Month-Day-Year: The date of the survey using two numbers for month and day and four numbers for year.

Obs. Initials: The first, middle, and last name initials of the observer.

Secondary Obs. Initials: The first, middle, and last name initials of secondary observers.

Temp. (C): The temperature at the beginning of the survey recorded in degrees Celsius.

Cloud Cover %: The estimated percent of cloud cover at the beginning of the survey.

Ppt: The type of precipitation at the beginning of the survey. N = None, F = Fog, M = Mist, D = Drizzle, R = Rain.

Wind: The wind at the beginning of the survey using the Beaufort Wind Scale class. 0 = calm, 0-1 mph, smoke rises vertically, and the sea is mirror smooth. 1 = light air, smoke moves slightly with breeze and shows direction of wind. 2 = you can feel wind on your face and hear the leaves start to rustle. 3 = gentle breeze, small branches start to sway, wind extends a light flag. 4 = moderate breeze, loose dust or sand on the ground will move and larger branches will sway. >4 = Do not survey, too much wind.

Start Time: The time (using a 24-hour clock) that you started your 20-minute search.

Duration: Duration of survey in minutes, 20.

Species Code: The standard four-letter species code.

Species Name Abr: The full common name or a clear abbreviation for the bird.

On Area Detection Type and Count: The detection type and count for a single detection event on or within the search area should be recorded in each box. The detection type [S = Song, C = Call, V = Visual, W = Wing (e.g., Mourning Dove or Hummingbird wing whir), D = Drumming, F = Fly over] followed by the total number of individuals involved in the detection event, (e.g., V2, S1, F57).

Off Area Detection Type and Count: The detection type and count for a single detection event off or outside of the search area should be recorded in each box. The detection type [S = Song, C = Call, V = Visual, W = Wing (e.g., Mourning Dove or Hummingbird wing whir), D = Drumming, F = Fly over] followed by the total number of individuals involved in the detection event, (e.g., V2, S1, F57). Birds flying over the site (excluding those aerial foraging within the search area) should be counted here.

Breeding Status: Any breeding evidence observed during the count. N = current year's Nest found in the study area with eggs or young, in the process of being built, or already depredated or abandoned. M = adult seen gathering or carrying nesting Material to a likely nest site in the study area. F = adult seen carrying Food or Fecal sac to or from a likely nest site in the study area. D = Distraction display or injury feigning by an adult bird. L = a young bird incapable of sustained flight (a "Local") in the study area or very young (stub-tailed) fledglings being fed by parents in the study area. Y = local (incapable of sustained flight) Young detected. C = Copulation or Courtship observed of a species within its breeding range. T = other Territorial behavior observed. S = territorial Song or drumming heard.

Notes: Record any survey notes here (e.g., noise disturbance, location information, other sightings, etc.).

Observer's Full Names: The full name (first, middle initial, and last) in the Obs. Initials and Secondary Obs. Initials fields.

Checked: The first, middle, and last name initials of the observer who has checked the current survey page for completeness and accuracy.

Copied: The first, middle, and last name initials of the observer who has made a photocopy of the current survey page.

Entered: The first, middle, and last name initials of the observer who has entered the current survey page into a digital source file.

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Area Search Data Form

Page ___ of ___

State ___ Project/Region ___ Site Code ___ Site Name ___ Point ___ Month ___ Day ___ Year ___

Obs. Initials ___ Secondary Obs. Initials ___ Temp. (C) ___ Cloud Cover (%) ___ Ppt ___ Wind ___ Start Time (24 hr) ___ Duration (minutes) ___

		On Area		Off Area		
Species Code	Species Name Abr.	Detection Type	Total	Detection Type	Total	Breeding Status

Notes:

rev. 20070424 JLS

Precipitation (Ppt): **N** = **N**one, **F** = **F**og, **M** = **M**ist, **D** = **D**rizzle, **R** = **R**ain. Wind (Beaufort): **0** = calm, **1** = light air, **2** = leaves start to rustle, **3** = small branches start to sway, **4** = moderate breeze, >4 Do not survey

Detection Type: **S** = **S**ong, **C** = **C**all, **V** = **V**isual, **W** = **W**ing, **D** = **D**rumming, **F** = **F**ly over.

Breeding Status: **N** = active **N**est, **M** = carrying nesting **M**aterial, **F** = carrying **F**ood or **F**ecal sac, **D** = **D**istraction display/feigning, **L** = **L**ocal young (limited flight or stub-tailed fed by parents), **C** = **C**opulation or **C**ourtship observed, **T** = **T**erritorial behavior, **S** = territorial **S**ong or drumming.

Observer's Full Names ______________________ Checked ________ Copied ________ Entered ______

APPENDIX G, ATTACHMENT 2

List of Geospatial Datasets Useful for Vegetation, Wildfire, Wildlife, Hydrology, Soils, and Carbon Monitoring

ATTACHMENT 2

The table below includes a list of potential geospatial datasets relevant to monitoring, including the data set name, scale, description, and current website. This list is intended to provide report users sources of geospatial data relevant to the overall question of fuel treatments and forest carbon dynamics covered in this assessment.

Dataset Name	Spatial Scale	Description of Dataset	Source Website
LANDFIRE	Landscape	LANDFIRE delivers vegetation, fuel, disturbance, and fire regimes geospatial data products for the entire nation. Methods are based on peer-reviewed science from multiple fields. LANDFIRE products are consistent, comprehensive, and standardized, resulting in multiple applications to fire, fuel, and natural resources.	http://www.landfire.gov/version_comparison.php
LANDFIRE, Vegetation	Landscape	LF existing vegetation layers describe the following elements: existing vegetation type (EVT), existing vegetation canopy cover (EVC), and existing vegetation height (EVH). These layers are created using predictive landscape models based on extensive field-referenced data, satellite imagery and biophysical gradient layers using classification and regression trees. LF potential vegetation layers describe the following elements: bio-physical settings (BPS) and environmental site potential (ESP). These layers are created using predictive landscape models based on extensive field-referenced data and biophysical gradient layers using classification and regression trees.	http://www.landfire.gov/vegetation.php
LANDFIRE, Disturbance	Landscape	Disturbance products are developed to help inform updates to LANDFIRE data to reflect change on the landscape caused by management activities and natural disturbance. They are a compilation of data from: Landsat satellite imagery, Burned Area Reflectance Classification (BARC), Rapid Assessment of Vegetation Condition after Wildfire (RAVG), Monitoring Trends in Burn Severity (MTBS), LANDFIRE Refresh events, User contributed data, Other ancillary data	http://www.landfire.gov/disturbance.php
LANDFIRE, Fuel	Landscape	LANDFIRE fuel data describe the composition and characteristics of surface and canopy fuel. LANDFIRE fuel products provide consistent fuel data to support fire planning, analysis, and budgeting to evaluate fire management alternatives and supplement strategic and tactical planning for fire operations	http://www.landfire.gov/fuel.php

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Dataset Name	Spatial Scale	Description of Dataset	Source Website
LANDFIRE, Topographic	Landscape	Topographic data serve as input to the Landscape (.LCP) file which is used in models to predict wildland fire behavior and effects.	http://www.landfire.gov/topographic.php
The Web-Enabled Landsat Data (WELD) 5-year Land Cover Land Use Change (LCLUC)	Landscape	The Web-Enabled Landsat Data (WELD) 5-year Land Cover Land Use Change (LCLUC) is a composite of 30 m land use land change product for the contiguous United States (CONUS). The data were generated from five years of consecutive growing season WELD weekly composite inputs from April 15, 2006, to November 17, 2010. WELD data are created using Landsat Thematic Mapper Plus (ETM+) Terrain Corrected data. This product includes data about tree cover loss and bare ground gain, which are composited over the five year period. WELD LCLUC is distributed in Hierarchical Data Format 4 (HDF4). The WELD project is funded by the National Aeronautics and Space Administration (NASA) and is a collaboration between the United States Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center and the South Dakota State University (SDSU) Geospatial Sciences Center of Excellence (GSCE).	EarthExplorer: http://earthexplorer.usgs.gov/
Global Land Survey (GLS)	Landscape	The Global Land Survey (GLS) collection of Landsat imagery is designed to meet a need from scientists to use a carefully coordinated collection of high resolution imagery for global modeling, including for the climate and carbon cycles. GLS replaces GeoCover, which was collected first into three epochs around 1975, 1990 and 2000. The GLS collection improves upon GeoCover by using more accurate elevation data (SRTM) for terrain correction and also by adding another epoch centered around 2005. Imagery from all seven Landsat sensors, plus the Landsat experimental sensor, ALI, are included in the collection.	EarthExplorer: http://earthexplorer.usgs.gov/ or GloVis: http://glovis.usgs.gov/

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Dataset Name	Spatial Scale	Description of Dataset	Source Website
Global Land Cover	Landscape	These global land cover layers are the product of a collaboration between USGS and the University of Maryland, Department of Geographical Sciences. 30-m resolution raster data layers for circa 2010 tree cover and bare ground and a persistent surface water layer 2000-2012, have been derived from Landsat 7 ETM+ data. The tree cover and bare ground data are per pixel estimates, 1 to 100% (given as integers values 1-100), the water layer is a thematic layer (2 = water). Hansen et. al 2013	http://landcover.usgs.gov/glc/
Hazardous Fuel Treatment Reduction	Stand	The Forest Service's Natural Resource Manager (NRM) Forest Activity Tracking System (FACTS) is the agency standard for managing information about activities related to fire/fuels, silviculture, and invasive species. FACTS is an activity tracking application for all levels of the Forest Service. This layer represents activities of hazardous fuel treatment reduction that are polygons. All accomplishments toward the unified hazardous fuels reduction target must meet the following definition: "Vegetative manipulation designed to create and maintain resilient and sustainable landscapes, including burning, mechanical treatments, and/or other methods that reduce the quantity or change the arrangement of living or dead fuel so that the intensity, severity, or effects of wildland fire are reduced within acceptable ecological parameters and consistent with land management plan objectives, or activities that maintain desired fuel conditions. These conditions should be measurable or predictable using fire behavior prediction models or fire effects models."	ESRI geodatabase: http://data.fs.usda.gov/geodata/edw/edw_resources/fc/S_USA.Activity_HazFuelTrt_PL.gdb.zip Shapefile: http://data.fs.usda.gov/geodata/edw/edw_resources/shp/S_USA.Activity_HazFuelTrt_PL.zip
Timber Harvests	Stand	Depicts the area planned and accomplished acres treated as a part of the timber harvest program of work, funded through the budget allocation process and reported through the FACTS database. Activities are self-reported by Forest Service Units.	ESRI geodatabase: http://data.fs.usda.gov/geodata/edw/edw_resources/fc/S_USA.Activity_TimberHarvest.gdb.zip Shapefile: http://data.fs.usda.gov/geodata/edw/edw_resources/shp/S_USA.Activity_TimberHarvest.zip

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Dataset Name	Spatial Scale	Description of Dataset	Source Website
FRAP Vegetation (FVEG15_1)	Landscape	An accurate depiction of the spatial distribution of habitat types within California is required for a variety of legislatively-mandated government functions. The California Department of Forestry and Fire Protection's CALFIRE Fire and Resource Assessment Program (FRAP), in cooperation with California Department of Fish and Wildlife VegCamp program and extensive use of USDA Forest Service Region 5 Remote Sensing Laboratory (RSL) data, has compiled the "best available" land cover data available for California into a single comprehensive statewide data set. The data span a period from approximately 1990 to 2014. Typically the most current, detailed and consistent data were collected for various regions of the state. Decision rules were developed that controlled which layers were given priority in areas of overlap. Cross-walks were used to compile the various sources into the common classification scheme, the California Wildlife Habitat Relationships (CWHR) system.	http://frap.fire.ca.gov/data/frapgisdata-sw-fveg_download
Existing Vegetation-CALVEG	Landscape	A mapping methodology has been developed to capture vegetation characteristics using automated, systematic procedures that efficiently and cost-effectively map large areas of the state with minimal bias and is supplemented with onsite field visits when appropriate. Map attributes consist of vegetation types using the CALVEG classification system and forest structural characteristics such as tree and shrub canopy cover and tree stem diameters.	http://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192
West Wide Fire Assessment	Landscape	The Council of Western State Foresters and the Western Forestry Leadership Coalition (WFLC) are developing a wildfire risk assessment of all lands for the 17 western states and selected Pacific Islands. This assessment is known as the "West Wide Wildfire Risk Assessment, or "WWA".	https://www.thewflc.org/resources/west-wide-wildfire-risk-assessment-final-report
CalAdapt Climate Tools	Landscape/Region	Explore charts, maps, and data of observed and projected climate variables for California. The tools show projections for two possible climate futures, one in which emissions peak around 2040 and then decline (RCP 4.5) and another in which emissions continue to rise throughout the 21st century (RCP 8.5).	http://cal-adapt.org/data

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Dataset Name	Spatial Scale	Description of Dataset	Source Website
Modis Burned Area Product	Landscape	The Burned Area product contains burning and quality information on a per-pixel basis. Produced from both the Terra and Aqua MODIS-derived daily surface reflectance inputs, the algorithm analyzes the daily surface reflectance dynamics to locate rapid changes and uses that information to detect the approximate date of burning, mapping the spatial extent of recent fires only.	https://modis.gsfc.nasa.gov/data/dataprod/mod45.php
Georgetown Climate Center Adaptation Clearinghouse	State/City/ Municipality	The Adaptation Clearinghouse seeks to assist policymakers, resource managers, academics, and others who are working to help communities adapt to climate change. Content in the Adaptation Clearinghouse is focused on the resources that help policymakers at all levels of governments reduce or avoid the impacts of climate change to communities in the United States. The Adaptation Clearinghouse tends to focus on climate change impacts that adversely affect people and our built environment.	http://www.adaptationclearinghouse.org/
Fire Return Interval Departure	Landscape	This polygon layer consists of information compiled about fire return intervals for major vegetation types on the 18 National Forests in California and adjacent land jurisdictions. Comparisons are made between pre-Euroamerican settlement and contemporary fire return intervals (FRIs). Current departures from the pre-Euroamerican settlement FRIs are calculated based on mean, median, minimum, and maximum FRI values. This map is a project of the USFS Pacific Southwest Region Ecology Program.	https://www.fs.usda.gov/detail/r5/landmanagement/gis/?cid=STELPRDB5327836
Web Soil Survey (SSURGO)	Landscape	Operated by the USDA Natural Resources Conservation Service (NRCS), this data portal contains spatially-explicit information about soil type and tree productivity site index across the United States and its territories that can be used for: growth and yield modeling when investigating above- and belowground carbon sequestration or fuels treatment effectiveness & longevity; identifying limitations affecting recreational or structural development; water capacity and flooding frequency. Soil data was collected on a geographic scale ranging from 1:12,000 - 1:63,360.	https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

ATTACHMENT 2

Dataset Name	Spatial Scale	Description of Dataset	Source Website
MTBS: Fire Occurrence, Extent, and Burn Severity Mosaic	Landscape	Monitoring Trends in Burn Severity (MTBS) is an interagency program that offers free geospatial products related to wildfire management in the United States, including Alaska and Hawaii. Users are able to download fire perimeters of all fires, both wildfires and prescribed fires, from 1984 to present that burned 1000 acres or more. Fire severity mosaics derived from 30m Landsat data, is also available for those fires.	https://www.mtbs.gov/viewer/index.html
FIA Database	Landscape	Information about a region's forest structure and composition can be obtained from the USDA Forest Service's Forest Inventory and Analysis program. This tabular data is quantified from annual on-ground vegetation sampling plots with approximate ("fuzzed") survey locations. Data includes overstory and understory species, size, mortality status, and harvest removals, plus coarse woody debris loading.	https://apps.fs.usda.gov/fia/datamart/datamart.html
PRISM Climate Data	Landscape	Oregon State University's Northwest Alliance for Computational Science and Engineering hosts climate data of the conterminous United States. Geospatial climate data is available summarized monthly or by 30-year "normals" at a resolution of 4km - 800m resolution. This data is central to time series comparisons and can serve as important variables when modeling drivers of contemporary forest structure or conditions under climate change. Note, interpolation between weather stations may be less accurate than localized data collection.	http://prism.oregonstate.edu/
RAWS Weather Data	Landscape	The Western Regional Climate Center hosts Remote Automated Weather Stations (RAWS) data for western United States, including daily and monthly weather summaries and station metadata. Weather reports contain measurements on air temperature, solar radiation, wind speed and direction, fuel moisture, relative humidity, and precipitation. These metrics are useful for understanding fire weather, climatology, air quality management, planning for noxious weed control; and other natural resource management goals.	https://wrcc.dri.edu/

ATTACHMENT 2

Dataset Name	Spatial Scale	Description of Dataset	Source Website
National Geospatial Data Asset (NGDA) Datasets	Landscape	Other Geospatial Datasets available are county lines, roads/rails, national structure database, wetlands, hydrography (incl. dams), and other information that may impact where/when fuels treatments are conducted	https://www.fgdc.gov/ngda-reports/NGDA_Datasets.html

Variable	Description	Source
Forest Carbon	Fire Lab Tree List: This dataset was built using a modified Random Forests technique to impute FIA plot data to 30-meter grid cells for all forested areas in the western U.S. Each forested grid cell contains reference to one FIA plot. The tree list for each plot is contained in the associated database. Users will need to adapt tree lists and generate associated stand-level info for use in the growth model, or CAL FIRE can provide data for a user's project area in FVS-ready format. Users should note that the dataset is intended to provide accurate estimates of tree size and species composition for a specific year (2009 for the current version).	GGRF meth: https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/calfire-fh-finalqm-17-18.pdf 6:55 PM Fire lab tree list: https://www.fs.usda.gov/rds/archive/Product/RDS-2018-0003
	Carbon mapper web application	https://web.tplgis.org/carbonmap/