Forester's Co-Op
Professional Forestry &
GIS - Geographic Information Services

SUNRISE POWERLINK PROJECT

Fuel Inventory Cruise Plan

January 31, 2007

Introduction

FCO has systematically established firesheds along the proposed and alternative routes for the Sunrise Powerlink Project. The parameters for each fireshed were established using GIS topography data, vegetation strata, terrain, weather, historic fire perimeters, and California watershed boundaries. Fireshed vegetation strata were identified and mapped using California Wildlife Habitat Relationships (CHWR), Greystone-Arcadis ground vegetation typing, San Diego County vegetation geo-referenced bio-maps, and current aerial photos. Using these resources, eight dominant vegetation types have been identified within the firesheds to be inventoried: chaparral, scrub, live oak woodland, oak woodland, Sierra mixed conifer, desert wash woodland, desert scrub, and juniper woodland. All areas stratified as urban, water, marsh, agriculture, barren, or non-vegetated will not be inventoried. Fuel loading will be classified into three strata: high, moderate, and low. By coupling the vegetation type and the fuel loading, there are twenty four possible vegetation strata. Inventory plot frequency will be statistically determined by a correlation of ignition point sources, vegetation type, location of proposed and alternative routes, assets at risk, and property ownership. Any plot that is inaccessible due to private property ownership or safety concerns will not be inventoried. Inventory plots will be clustered in groups of three to optimize sampling efficiency. Each cluster of plots will consist of one primary plot and two secondary plots. The primary plot center will be randomly placed within the vegetation type and will serve as a reference point for the two secondary plots. Comprehensive vegetative inventory from each fireshed will be collected to provide accurate fuel load data for input into FlamMap 3.0 fire behavior models.

Plot Establishment

Primary plot (P plot)- P plot center point will be randomly placed within a vegetation stratum using HAWTHS Analysis Tools for ArcGIS 9.X. P plots will be located in the field using GeoXH/XT GPS devices with imported GIS shape files. Identification of primary plot center will be with a pink pin flag in the ground and yellow flagging at eye level. The ground pin flag will have primary plot #, date and cruisers initials.

Secondary plot (S plot)- Each secondary plot center will be four chains (264 ft.) distance from primary plot center. The standard azimuths used for secondary plot placement will be north (0˚) and west (270˚). If a corresponding plot falls outside the vegetation strata boundary or the terrain is inaccessible, then two cardinal directions will be chosen (with a relative 90˚ angle) that places both secondary plots inside the vegetation strata boundary. S plot centers will be identified with a

pink pin flag and yellow flagging. The plot center pins will have S plot #, date and cruiser's initials.

Data Records

Cruise data will be collected and recorded using a TDS Ranger data recorder. All GPS data will be collected and recorded using Trimble GeoXT/XH models and corrected in ArcGIS 9.X program. All data will be downloaded daily to the FCO server and backed-up on a USB external hard drive to ensure data protection.

CRUISE DESIGN

Pre-Cruise Strategy

The pre-cruise is an initial field assessment of the vegetation strata within each fireshed. Pre-determined vegetation polygon perimeters will be verified and adjusted on the ground to better delineate the vegetation strata to be sampled. Further more, pre-cruise cluster plots will be established within the dominant vegetation strata of each fireshed to determine variability within the strata. The cruise design protocol will be followed precisely for all pre-cruise plots conducted. Data sampled from the pre-cruise plots will be used to determine a "Coefficient of Variation" or CV factor for each of the specific vegetation strata to be sampled. The calculated strata plot sample size will be derived using this CV factor in a volume per area formula to meet the projects minimum statistical sampling error (SE) at a predetermined standard deviation for each vegetation strata to be sampled.

Stratum 1- Fuel Model-Vegetation Strata

The data collected within this stratum will include slope, aspect, elevation, percent canopy cover, fuel model, photo series model and vegetation code and will be sampled at both primary and secondary plots. Slope is determined by sighting the clinometer along a line parallel to the average decline. The slope is recorded in percent scale from the clinometer reading. Aspect is determined along the azimuth that slope was measured for land surfaces with at least 5 percent slope in a generally uniform direction. Elevation data will be collected by GPS units. If GPS satellite geometry is poor, then elevation data will be determined by topographic map. Percent canopy cover is measured using a convex spherical densiometer which contains 24 1/8"x 1/8" grid squares. Each grid square can be further divided visually into four equal quadrants. Each quadrant within a grid square represents an area of canopy opening (sky image) or canopy cover (vegetation image). The number of canopy opening quadrants is counted and multiplied

by 1.04 to calculate the percent canopy opening. This number is then subtracted from 100 to obtain the percent canopy cover. Densiometer readings are taken in all four cardinal directions and averaged at each plot center.

The fuel model series used is taken from the H.E. Anderson 1982 report, Aids to Determining Fuel Models for Estimating Fire Behavior. This report identifies thirteen different photo fuel models based on fuel complex and fuel loading. The model that best fits plot setting will be recorded (see Table_1). The following chart gives description of the photo fuel models. Note: Customized models will be built for vegetation strata that differ from the below thirteen models.

Table_1

Code	Description
Grass and Grass Dominated areas	
1	Short Grass (1 foot)
2	Timber (grass and under story)
3	Tall Grass (2.5 feet)
Chaparral and Shrub areas	
4	Chaparral (6 feet)
5	Brush (2 feet)
6	Dormant brush, Hardwood slash
7	Southern Rough
Timber Litter	
8	Closed timber litter
9	Hardwood litter
10	Timber (litter and under story)
Slash	
11	Light logging slash
12	Medium logging slash
13	Heavy logging slash

The published photo series to be used is Photo Series for Quantifying Natural Forest Residues in Common Vegetation Types Vol. IV &VII. These photo models are classified based on localized vegetation typing and fuel loading. The photo model that best fits plot setting and vegetation types present will be recorded.

A vegetation code will also be assigned at each plot. This code consists of two variables: vegetation type and fuel loading. The eight vegetation types (and their abbreviations) that have been identified are chaparral (C), scrub (S), live oak woodland (LOW), oak woodland (OW), Sierra mixed conifer (SMC), desert wash woodland (DWW), and desert scrub (DS). Fuel loading is classified into high (H), moderate (M), and low (L) and determined using the criteria outlined in Table_2.

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Table_2

FUEL LOAD CODE	TOTAL % COVER	HEIGHT CLASS	SPECIAL CONDITIONS
Low - "L"	< 30%	All Species < 6.1'	If all Species < 1.6' Irregardless of Total % Cover always = "Low"
Moderate - "M"	30% - 65%	2+ Species 1.6' >	Where % Dead is greater than 50% Upgrade to "High" If only one species is > than 1.6' then down grade to "Low"
High - "H"	65% +	2+ Species 1.6' >	If only one species is > than 1.6' then down grade to "Moderate". If no species are > 6.1' then downgrade to "Moderate".

The vegetation code is derived by coupling the vegetation type and fuel loading abbreviations together into one acronym (ex. DSM= desert scrub moderate). This acronym represents one of the twenty four possible vegetation strata that

Stratum 2- Overstory Variable Plot

At each plot center an overstory variable plot will be established using a basal area factor (BAF) of 10, 20 or 40 with a plot radius factor (PRF) value of 2.708, 1.902, or 1.333 respectively. BAF values used will differ depending on vegetation variables such as density and height class. Sampling begins at due north (0˚) and swings clockwise around plot center to complete one rotation. Overstory sampling will be measured at all primary and secondary plots when applicable. From existing data, it seems probable that there will be few plots where an overstory is present. In these cases, the overstory variable plot will not be inventoried. All trees counted within the plot will be inventoried as follows:

-Tree species (four letter code from binomial name)
Example: Quercus agrifolia= QUAG
-DBH is measured to the nearest $1/10^{th}$ inch at 4.5 feet from uphill side of tree.
-Total tree height is measured to the nearest foot
-Tree condition (live/dead)

If the measured tree is a conifer, the following data will also be collected:

-Height to crown is measured to the nearest foot from the base of the tree to the first live whorl of the crown.
-Crown Ratio (percent crown) is estimated as what percentage of total tree height the crown inhabits.

-Crown Class is recorded based on appearance of crown and tree position within the stand.

Examples: open-grown (OG), dominant (DO), co-dominant (CO), intermediate (IN), overtopped (OV), leader above brush (AB), leader in brush (IB), leader overtopped by brush (UB)

If the measured tree is dead, the following data will also be collected:

-Snag decay class (see Table_3)

Table_3

Code	Bark	Heartwood Decay	Sapwood Decay	Limbs	Top Breakage	Bole Form	Time Since Death
1	Tight, intact	Minor	None to incipient	Mostly Present	May be present	Intact	≤5 years
2	50% loose or missing	None to advanced	None to incipient	Small limbs missing	May be present	Intact	>5 years
3	75% missing	Incipient to advanced	None to 25%	Few remain	Approx. 1/3	Mostly intact	>5 years
4	75% missing	Incipient to advanced	25%+	Few remain	Approx. 1/3 to ½	Losing form, soft	>5 years
5	75%+ missing	Advanced to crumbly	50%+ advanced	Absent	Approx. ½+	Form mostly lost	>5 years

Stratum 3- Understory Fixed Area Plot

The fixed area plots cover a circular area of 1/50th acre. This area is established by a 16.7 foot radius swung clockwise around plot center to complete one rotation. Understory sampling occurs at all primary and secondary plots. All trees within the plot having a DBH less than 5" and total height greater than one foot will be inventoried as follows:

-Tree species (four letter code from binomial name)
-Total tree height is measured to the nearest foot.
-DBH is measured to the nearest 1/10th inch at 4.5 feet from uphill side of tree*
-Tree condition (live/dead)
*If DBH cannot be measured because sapling is too short, total height measurement and species identification is sufficient.
*If dense regeneration has occurred and trees less than 5" DBH are far too numerous to individually sample, then tree species may be recorded as a percent cover of dominant shrub species.

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Live shrubs within the fixed radius plot will be inventoried as follows:

-The three most dominant shrub species will be identified with binomial names.
-For each dominant shrub species identified, indicate percent cover of the 1/50th acre fixed plot.
-For each dominant shrub species identified, indicate height class (see Table_4)

Table_4

Height Class	Shrub Height (ft)
1	< 1.6'
2	1.6'- 6.0'
3	> 6.0'

Dead shrubs within the fixed radius plot will be inventoried as follows:

-Indicate percent cover dead of the 1/50th acre fixed plot (no species identification).
-Indicate height class

Stratum 4- Downed Woody Surface Fuel Transect

Brown's downed woody surface fuel transect is used to assess the fuel loading at a plot. The transect protocol was taken from Handbook for Inventorying Downed Woody Material, by J.K. Brown. From plot center, a standard azimuth of 150˚ is established as the transect line. Linear transect sampling begins 5 feet from plot center and ends at 52.6 feet from the plot center along the established azimuth. Downed woody surface fuels of varying diameters intersecting the transect line will be tallied at different length intervals. Table_5 shows which diameter fuels will be tallied at which length intervals:

Table_5

Twig type	Fuel Diameter (inches)	Length interval (ft)
Twig 1	0-.24	5-10
Twig 2	.24-.99	5-10
Twig 3	1.0-2.99	5-15
Downed Fuel	>3.00	5-52.6

Tally Rules for the Downed Fuel Inventory

-Particles qualifying for tally include downed, dead woody material (twigs, stems, branches, and bolewood) from trees and shrubs. Dead branches attached to boles of standing trees are omitted because they are not downed vegetation. Consider a particle "downed" if it has fallen to the ground, or is severed from its original

source of growth. Cones, bark flakes, needles, leaves, grass, and forbs are not counted. Dead woody stems and branches still attached to standing brush and trees are not counted.
-Twigs or branches lying in the litter layer and above are counted. However, they are not counted when the intersection between the central axis of the particle and the sampling plane lies in the duff (forest floor below the litter).
-If the sampling plane intersects the end of a piece, tally only if the central axis is crossed. If the plane exactly intersects the central axis, tally every other such piece.
-Don't tally any particle having a central axis that coincides perfectly with the sampling plane.
-If the sampling plane intersects a curved piece more than once, tally each intersection.

For all downed woody fuel that is 3" in diameter or greater, the following information is also collected:

-Diameter of fuel at crossing of transect to the nearest $1/10^{th}$ inch.
-Diameter of fuel at the small end to the closest $1/10^{th}$ inch.
-Diameter of fuel at large end to the nearest $1/10^{th}$ inch.
-Length of fuel to the closest $1/10^{th}$ inch.
-Decay class of fuel (see Table_6)

Table_6

Code	Bark	Twigs	Texture	Shape	Wood Color	Portion of log on ground
1	Intact	Present	Intact	Round	Original	None, elevated on supporting points
2	Intact	Absent	Intact to soft	Round	Original	Parts touch, still elevated, sagging slightly
3	Trace	Absent	Hard large pieces	Round	Original to faded	Bole on ground
4	Absent	Absent	Soft blocky pieces	Round to oval	Light brown to faded brown	Partially below ground
5	Absent	Absent	Soft, powdery	Oval	Faded light yellow or gray	Mostly below ground

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Quality Control

All established fuel inventory plots are subject to inspection by a RPF, FCO auditor, crew foreman, or project manager. Approximately 7-10% of plots will be checked for quality insurance purposes. Table_7 outlines the accuracy standards that each measurement will be held to.

Table_7

Variable	Accuracy Standard
Percent Canopy Cover	± 10% of cover
Tree Height	Nearest foot
Crown Ratio	± 10 %
DBH	Nearest 1/10th inch
Crown Height	Nearest foot
Downed Woody Fuel Tally	20%
Fuel Diameter	Nearest 1/10th inch
Length of fuel	Nearest 1/10th inch
1/50th Acre Brush Plot	± 10% of height and tally ± 10% cover

In the result that a fuel inventory plot does not meet the above specifications during the quality control check the technicians responsible for the data will be required to resample the plots that same day.

Equipment List

Each crew will need the following equipment:

Copy of the cruise plan
CPUC/SDG&E Inventory Plot Access Authorization
GPS/GIS maps
Road maps/atlas
Trimble GeoXT/XH GPS devices
Trimble Ranger data recorders
Paper data sheets (backup)
String distance measurer, with extra string spools
Pink pin flags w/ wire stakes
White vinyl flagging tape
Spencer's tape
D-Tape
Compass
Relascope

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Relascope BAF sheet
Clinometer
Densiometer
Calculator
Sharpies
Pencils
Photo Series Vegetation Type ID Manual Vol. IV & VII
Fuel Model Series ID Packet
Tally Counter
Go-no-go measuring device (Brown's line)
Southern California tree & shrub ID manual
Motorola hand radios (2)
Cellular phone
First Aid kit
Emergency contact information