Fire Model using weighting system from multiple themes
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Extreme Fire Hazard Analysis
For a Predominately Chaparral/Chamise System

National Park Service
Pinnacles National Monument
California

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Summary

The outlined process shows the steps taken to evaluate extreme fire hazard for Pinnacles National Monument. These preliminary steps were taken to designate areas with an extreme fire rating.

1) Assign an ISFL Fuel Model to all areas within the Monument boundary.

2) Redo present fuel model and convert information into a GIS shapefile.

3) Categorize all lands within the NPS boundary according to slope.

4) Categorize all lands within the NPS boundary according to aspect.

5) Determine 90th percent hottest, driest weather conditions for the study area coming from representative weather station (WIMS data).

6) Adjust those 90th percent weather conditions for aspects and slopes not representative of weather station.

7) Evaluate fireline intensity into a GIS shapefile at 90th percent hottest, driest weather for all fuel models, slope, aspect combinations.

8) Convert estimated fireline intensity information into extreme fire hazard GIS shapefile.

Introduction:

There is a need for an updated fire management plan for Pinnacles National Monument. The existing management plan is from 1986, making it older than the Stonewall fire, the largest recent fire that burned 2500 park acres in 1998. An extreme fire model on a landscape scale could be used by the park as a guide for areas to focus on. While larger fires in the past may have burned huge portions of the park, the hope is to prevent catastrophic large fires from burning over the park. More managers are seeing the need for a mix of vegetation ages in the landscape.
The old FMO and other fire managers endorsed this idea to target areas of extreme fire concern. Resource management has seen the need for creating this extreme fire model. The NPS FMP Planning Direction flow chart shows GIS support as an important step for information gathering. The model may be able to direct discussion for the new Fire Management Plan (FMP).

Objectives:

*Update fuel model to include recent fires in Pinnacles National Monument, and vegetation changes reflected in the IKONOS Satellite Imagery.

*Assign 90th percent weather conditions to fuel build-ups using local weather station

*Run behave from weather data to assign BTU value to each area of the park

*Display resulting extreme fire behavior as a shapefile and summarize results.

*Use model to direct Fire Management Plan (FMP) and include the results/maps in the Pinnacles FMP.

*Future objectives include expanding the model to outside the park boundary and onto private lands.

Description of Area:

Pinnacles National Monument was designated in1908 as the first National Monument under Theodore Roosevelt. Presently the park is 24,000 acres with roughly 2,000 acres of private land falling within the legislated boundary. The boundary contains 16,000 acres of designated wilderness. Situated in the Gabilan Mountains between the Salinas and San Benito Valleys, the monument is approximately 150 miles south-southeast of San Francisco and 40 miles east of Monterey. The landscape is primarily composed of chaparral (80%), oak woodlands (7%) and mixed riparian vegetation in the valley bottoms (7%), grassland (3%), and rock outcrops (3%).

The main vegetation type throughout the Monument is thick chaparral (Fuel Model 4) of varying age and composition. Chamise tends to be the main shrub species dominating chaparral stands while Grey Pines and Oak Woodlands (Live, Blue, Valley Oaks) make up most of the local trees. Summer temperatures from June 1st to September 31st regularly climb into the 90's with normally low humidity, 20% and lower. Possibility of extreme fire danger can exist throughout much of the year, however the largest affected acreage of non-prescribed fire occurs in August. Pinnacles preserves a unique mixture of the remains of a 23 million-year-old Miocene volcano. Rocky terrain and thin soils dominate much of the monument due to the erosion of volcanic breccia and rhyolite. While the monument receives an average of 16.3 cm of rainfall per year, the monument is semi-arid and most rain falls from November to May.

Hand crews have had little effectiveness against past fires in the park and changing winds, humidity, and temperatures usually do the most to stop fire spread (Leatherman, personal communication). Fire hand lines and bulldozer lines have been constructed for past fires and scars still remain closely resembling old trails and roads. Two main paved roads on the east and west sides of the park provide access with limited passable dirt roads.

Methodology:

Assign an ISFL Fuel Model to all areas within the Monument boundary.

There was an existing shapefile called FuelMod with three fuel models and bare rock (unburnable).
The present fuel model was redone and converted into a GIS shapefile with new NFFL codes 0-13. The Existing NFRD codes were cross-walked using web site information. Used past fire history layer digitized from a map in Gablian mountains fire paper (Greenlee and Moldenke 1982), 2000 IKONOS satellite imagery, fire monitoring plots and GPS points with digital photos. By using satellite imagery, not available in 1983, the fuel model was adjusted to match vegetation to fuel type. Pictures were taken in the field to verify fuel model designations and display during presentation. Future refining is required after vegetation mapping group records data from new BLM lands acquired in 2000. Forest Service general technical report INT-122 was primarily used in Fuel Coding (Anderson, 1982).

Categorize all lands within the NPS boundary according to slope.
With 10 ft pixel size DEM ran Arc8 DEM classify for 0-24=low slope, 25-49=medium slope, 50 and greater=steep slope. Used raster to feature conversion, reclassified slope ranges and created shapefile after dissolving.

Categorize all lands within the NPS boundary according to aspect.
With 10 ft pixel size DEM ran Arc8 DEM classifies. 8 cardinal directions N, NE, E, SE, S, SW, W, NW. Used raster to feature conversion, reclassified aspects to cardinal directions and created shapefile after dissolving.

Determine 90th percent hottest, driest weather conditions for the study area. Weather data coming from representative local weather station (station ID #044410) at 1300 ft. data from 2002 was used from May 1-Oct.31 WIMS data. Used SW as wind direction and plugged into Fire Family with associated .fwx files gathered from KCFAST. Then run values in Behave to get associated Fireline Intensity and 20 ft. wind speed values.

By running FireFamily and Behave evaluate fireline intensity into a GIS shapefile at 90th percent hottest, driest weather for all fuel models, slope, aspect combinations.

In order to account for the effects of aspect on potential fireline intensity, corrections were made to the 90th percentile weather conditions. Corrections to represent a warmer and drier condition were made to areas having a south or southwest aspect. Corrections were made to reflect a cooler wetter condition on northwest, north and northeast aspects. All other aspects were assumed to be represented by the level ground 90th percentile condition.

The amount of correction on the hotter and cooler aspects were determined by running a series of 27 BEHAVE Plus moisture runs.

While there was some variation in the results of the moisture runs, a simple correction Of minus 1% fuel moisture on the 1, 10 and 100 hour timelag fuels was made on the south

and southwest aspect fuels. Additionally a plus 1 correction was added to fuel moistures on the northwest, north and Northeast aspects. Ran Behave Plus with Direction of Wind Vector(from upslope)=0 (blowing the fire north).
The low slope was = 15, medium slope = 35, steep slope = 55.

Used .4 reduction factor for decreasing 20 ft wind speed to midflame wind speed more closely approximating true conditions in the vegetation.

Convert estimated fireline intensity information into extreme fire hazard GIS shapefile.

Fireline intensity values helped determine extreme fire hazard areas. Fire Behavior Nomograms (Rothermel 1983) display handcrews generally effective below 100 BTU/ft/sec and mechanical attack(bulldozers, blades) less effective after 400 BTU/ft/sec approximating blowup conditions. Areas less than 100 BTU/ft/sec=low value, 101-399BTU/ft/sec=moderate, 400 BTU/ft/sec and over = extreme rating.

<u>Behave runs for:</u>

Fuel Model 1 at 3 aspects with 15%, 35%, 55% slopes

Fuel Model 4 at 3 aspects with 15%, 35%, 55% slopes

Fuel Model 6 at 3 aspects with 15%, 35%, 55% slopes

Data gathered from GIS for thought:

Of largest 15 fires in and around the Pinnacles National Monument, 6 started in August.

August Data gathered from weather station #044410.

2001-Ave. Max temp 96.5, 13 days over 100, Ave. Min humidity 17
2002-Ave. Max temp 95.6, 9 days 100 or greater, Ave. Min humidity 14

Results of GIS For Extreme Fire Hazard

The process involved unioning fuel model layer with aspect layer, then union the resulting layer with slope layer. Queried 27 different combinations from Behave Plus runs to assign fireline intensity value. 3 of those 27 Behave Plus runs had no acreage. Then dissolved on the rating field to get total fire hazard acres within the monument. Areas less than 100 BTU/ft./sec.=low value, 101-399BTU/ft./sec.=moderate, 400

BTU/ft./sec and over = extreme rating. Steady wind reduction factor of .4 for all Behave runs.

BTU ranges of severity

Extreme Fire Hazard (400-9039 BTU/ft./sec.) = 19,320 acres

Medium Fire Hazard (101-399 BTU/ft./sec.) = 6,281 acres

Low Fire Hazard (less than 100 BTU/ft./sec.) = 1,494 acres

Things to work on for Future

*Updated fire layer from new vegetation mapping information.

*Adjust fuel model more from ages, intensity, and ground truth of fire

*More updated weather information

*Extend same methodology to neighboring private lands

What model doesn't do?

Does not account for fire in the third dimension which is the time scale of active fires changing with conditions (i.e. humidity, temperature, wind diection). Does not use long range weather information, only weather station data from 2002 was used from May 1-Oct. 31. Could be applied to longer range weather data for the future. It keeps static wind directions and wind reduction factor.

References

Anderson, Hal A., Aids To Determining Fuel Models for Estimating Fire Behavior, General Technical Report INT-122, 1982.

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Husari and DeBenedetti, Pinnacles National Monument Fire Management Plan Amendment, (rev) 1986

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Leatherman, Thomas (Pinnacles Natural Resource Chief), personal communication, 2003

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Rothermel, R. How to predict the Spread and Intensity of Forest and Range Fires, 1983

Appendix for FireFamily Plus Results

FireFamily Plus Percentile Weather Report for RERAP

Station: 044410: PINNACLES Variable: ERC
Model: 7B3PD2
Data Years: 2002 - 2002
Date Range: May 1 - October 31

Percentiles, Probabilities, and Mid-Points

Variable/Component	Low	Mod	High	Ext
Percentile Range	0 - 15	16 - 89	90 - 97	98 - 100
matol. Probability	15	75	7	3
Mid-Point ERC	32 - 32	74 - 74	104 - 104	114 - 114
Num Observations	3	2	1	2
Calculated Spread Comp.	119	119	119	119
Calculated ERC	262	262	262	262

Fuel Moistures

1 Hour Fuel Moisture	4.88	2.88	1.62	1.16
10 Hour Fuel Moisture	6.78	4.07	2.28	1.92
100 Hour Fuel Moisture	14.36	8.86	4.92	4.99
Herbaceous Fuel Moisture	56.41	47.82	54.18	36.15
Woody Fuel Moisture	94.38	70.73	65.32	63.39
20' Wind Speed	8.33	6.50	7.00	8.00
1000 Hour Fuel Moisture	12.12	9.24	8.58	8.34

179 Weather Records Used, 41 Days With Wind (22.91%)

Appendix for 27 Behave Plus Runs

Fuel Site Variables	FM 1(BTU/ft/sec)	FM 1(Flame Length)(Ft.)
North, Low	93	3.6
North, Med	139	4.3
North, Steep	221	5.4
Reg, Low	127	4.2
Reg, Med	190	5
Reg, Steep	302	6.2
South, Low	190	5
South, Med	284	6.1
South, Steep	453	7.5

Fuel Site Variables	FM 6(BTU/ft/sec)	FM 6(Flame Length)(Ft.)
North, Low	268	5.9
North, Med	344	6.6
North, Steep	586	7.7
Reg, Low	333	6.5
Reg, Med	427	7.3
Reg, Steep	597	8.5
South, Low	420	7.2
South, Med	539	8.1
South, Steep	754	9.5

Fuel Site Variables	FM 4(BTU/ft/sec)	FM 4(Flame Length)(Ft.)
North, Low	3654	20
North, Med	4762	22
North, Steep	6757	26
Reg, Low	4188	21
Reg, Med	5458	24
Reg, Steep	7745	28
South, Low	4887	22
South, Med	6369	25
South, Steep	9036	30

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