A TEST OF THE STRATEGIC FUELS MANAGEMENT MODEL VDDT USING HISTORICAL DATA FROM YOSEMITE NATIONAL PARK

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ABSTRACT

The Vegetation Dynamics Development Tool (VDDT) is a vegetation simulation model developed to examine the impacts of a variety of landscape scale disturbances on vegetation succession and development. It assumes that the ecosystem exists in a discrete number of states, and pathways are defined to be links between vegetation states. Transitions between states may be due to disturbances or successional change in the absence of disturbances. Historical data gathered in the mid-1930's for Yosemite National Park was used to examine the ability of VDDT to predict the amount of wildland fire that occurred between 1937 and 1996. Data from the 1930's was used to define initial stand conditions, and fire regimes were derived from National Forest data for the Sierra Nevada. Preliminary results indicate that VDDT can predict the total area of vegetation burned by wildland fires for larger vegetation areas if adequate data exists to define fire frequencies and there have not been any management changes.

Keywords: forest, fire, model, simulation, Yosemite

INTRODUCTION

Increasing forest stand density due to historical fire suppression has altered forest composition and increased fuel loading relative to pre-Euroamerican settlement. Several methods for managing increased fuels and altered stand structures are available, including mechanical and hand treatments, various types of fuel breaks and prescribed fire. The best mixture of amount, type and combination of treatments is difficult to determine, and is complicated by management restrictions due to species conservation, recreation, air quality and other issues. Application of simulation models to this problem has advantages because multiple disturbance types and intensities can be incorporated into a framework to examine different scenarios of forest change.

Several models are presently being examined for use in understanding and predicting the effect of fuels management strategies on forest health, smoke emissions, and commercial harvest in a comparative study funded through the Joint Fire Science Program (JFS) and other agencies. All of the models included in the study, including the Vegetation Dynamics Development Tool (VDDT), have been applied only at a few locations. As part of the JFS study VDDT and several other models will be parameterized at 7 locations representative of major fuel types found on lands managed by USDA, USDI, DOD, and state agencies. This will include two sites where the models will be implemented with historical information to conduct model validation.

In this report preliminary simulations using historical information from Yosemite National Park (YNP) were conducted to determine the ability of VDDT to predict stand replacement fires between 1937 and 1996. Dominant (in cover) forest vegetation types present in the YNP were determined from historical plots and maps (Weislander 1946), then simulated through 1996 with general fire regime information (McKelvey and Busse 1996) from the Sierra Nevada. Model results were then compared to YNP fire history information to determine the ability of VDDT to predict the amount of burned area, and the sensitivity of the model to management differences that exist between YNP and National Forests in the Sierra Nevada.

MODEL DESCRIPTION

VDDT was developed, in part, for the Interior Columbia River Basin Assessment. Since that time model development has been continued through funding with Forest Service Region 6. VDDT and its spatially explicit companion model Tool for Exploratory Landscape Scale Assessments (TELSA) uses successional pathway diagrams to examine the role of various disturbance agents and management actions on vegetation change through time. In VDDT, landscape is partitioned into pixels (grid cells) and each is assigned a separate successional class and age. Each pixel has a probability of being affected by a disturbance. Disturbance probabilities depend only on the current state of the pixel, thus the model does not simulate contagion in space or time. The model is intended to simulate changes to landscape-level indicators of ecosystem health, such as frequency distribution of successional classes and the total area affected by each disturbance type. Diagrams developed with the Vegetation Dynamics Development Tool (VDDT) define the transition times between various succession classes (combinations of species composition and stand development stage) and the probabilities and impacts of disturbance by insects, fire or other agents. These diagrams also define the impacts of forest management actions on stand structure and composition. The area disturbed annually, and the size and types of disturbances respond to landscape changes from succession or management.

STUDY APPROACH

Yosemite National Park was chosen for use as a retrospective model study because of the availability of historical plot and map data (Wieslander 1946). This data consists of a combination of plot data and mapped areas of vegetation gathered in the mid-1930's. Both data sets have been digitized to form a complete picture of historical vegetation structure and composition. The availability of digital data also reduces the effort required by investigators to utilize this information for integrated studies.

In addition to historical vegetation data, YNP has a complete set of mapped fire areas and locations for fires greater than 1 ha. Both human and lightening caused fires were included on GIS map layers.

The approach used for this exercise was to parameterize the model using reported information and expert knowledge. Pathways were developed using experts from USGS-BRD, and vegetation data gathered by Wieslander (1946). Separate models were developed for interior live oak (*Quercus wislizenii*) (INL) and canyon live oak (*Quercus chrysolepis*) (CLO) in the foothill woodlands; Ponderosa pine (*Pinus ponderosa*) (PP), Jeffrey pine (*Pinus jeffreyi*) (JP), Douglas fir (*Pseudotsuga mezziesii*) (DF), mixed conifer forest dominated by white fir (*Abies glauca*) (MCW) and mixed conifer forest dominated by incense cedar (*Calocedrus decrrens*) (MCI) in the lower montane forest; western white pine (*Pinus monitcola*) (WWF), red fir (*Abies magnifica*) (RF), and lodgepole pine (*Pinus contorta* ssp. *murrayana*) (LP) in the upper montane forest; mountain hemlock (*Tsuga mertensiana*) (MH), lodgepole pine, and whitebark pine (*Pinus albicaulis*) (WBP) in the subalpine forests. These vegetation types account for about 85% of the vegetated area of YNP.

Each vegetation model had four age classes that corresponded to stand initiation, sapling, young mature and old mature age/structures (Fig. 1). Time within classes were determined by expert knowledge. Multiple spe-

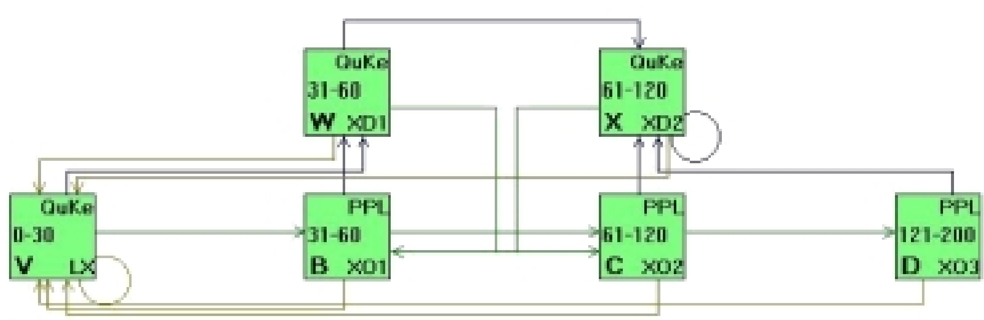

Figure 1. Example pathways for VDDT simulation of ponderosa pine. Green pathways indicate succession in the absence of disturbance, brown pathways indicate the effects of stand replacing fires, and blue pathways low intensity fire.

cies successional patterns were also simulated as needed. Areas included in each model were determined by examination of digitized maps developed by Weislander (1946). Each mapped polygon contained a list of dominant species (by percent cover). Dominant species composition was used to assign the area to a VDDT model. All polygon areas were summed for each model. All forest areas were assumed in mature forest stages of development.

Stand replacing fire frequencies were derived from McKelvey and Busse (1996). This study summarized fire patterns on National Forest lands of the Sierra Nevada over the twentieth-century. Management of YNP was similar to National Forests through 1974, but diverged for some forest types afterward (van Wagtendonk 1974). No data outside of YNP was available to simulate this management change, so National Forest fire frequencies were used, and the model was evaluated to understand the sensitivity of model forecasts to management changes.

The measure used for this study was to compare total model predicted acres burned in stand replacing fires with actual totals calculated from YNP fire history maps. All fires, both human and non-human caused fires 5 Ha. or greater in area between 1937 and 1996 were used for comparison.

The subalpine forest had little recorded fire on either National Forest or National Parks lands, so were omitted for this analysis.

Vegetation Type	Hectares of forest in 1937	% over- (+) or under- (-) estimation by model
ILO	362	-40%
CLO	9,127	-2%
PP	32,373	5%
JP	20,428	1%
DF	2,048	70%
MCI	4,147	48%
MCW	21,192	35%
JP	8,043	38%
WWP	8,871	-15%
JP/RF	20,742	-90%
RF	20,806	-75%
LP/RF	12,992	-71%
All RF	54,540	-84%
LP	56,995	0%

Table 1. Vegetation types modeled, and the percent over or underestimation of fires predicted by VDDT. Vegetation types are ordered from low to high elevation (subalpine omitted due to the lack of data).

RESULTS AND DISCUSSION

There are several general patterns apparent in the results. The first pattern is that forest types were simulated more accurately at lower elevations than at higher elevations (Table 1). This may be due to several reasons. Shorter fire return intervals at lower elevation result in more historical data to determine fire frequencies (McKelvey and Busse 1996). Historical management of National Forest Service lands at lower elevations is comparable to historical, and present fire management at YNP. Low elevation areas within YNP are contained in two fire management zones, routine suppression and conditional suppression.

Vegetation represented in smaller areas was poorly predicted by VDDT at all elevations. This may be due to a larger stochastic influence fire on these stands. The presence or absence of a single large fire can greatly alter the proportion of area burned for small areas of vegetation. Small areas also may be affected more by neighboring vegetation, resulting in altered fire return intervals relative to larger stands.

At higher elevations, especially in the red fir forest types, VDDT estimated much less fire than actually occurred. This difference is due to a management change from the historical fire suppression to prescribed natural fire in 1974. Most of the upper montane and subalpine forests are included in a prescribed natural fire zone (Fig. 2). This management change resulted in a dramatic increase in the area burned after 1974 in YNP (Fig. 3), not reflected in National Forest fire frequency information.
In summary we found that VDDT's ability to estimate the amount of area burned depends on three general factors including:

- Adequate area represented by the vegetation so that fire frequencies are not dominated by extraneous factors.

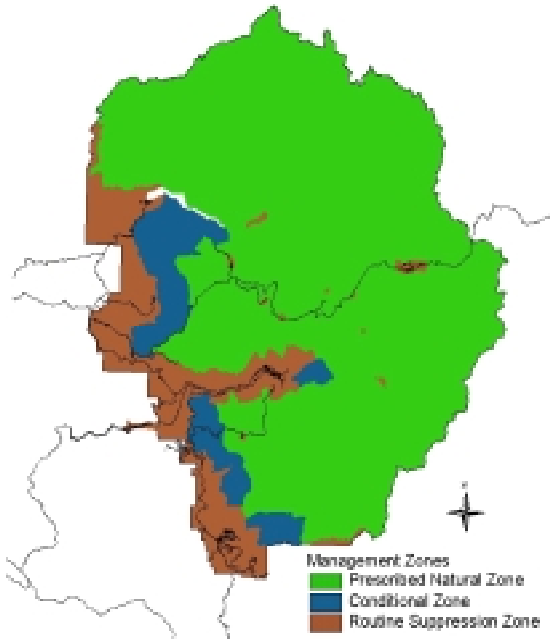

Figure 2. Fire Management Zones of Yosemite National Park. These were established in 1974, and prior to that year all fires were routinely suppressed.

- Adequate historical information to develop the fire probabilities.
- Allowance for changes in management that significantly affect the fire regime.

FUTURE MODELING EFFORTS

In the future, both the stochastic effects of weather on fire size and the effects of altered management will be included in the model. In addition, a bulk smoke emissions component will be added to enable the model to estimate long-term tradeoffs between prescribed fire and wildland fire on smoke emissions and vegetation change in Yosemite National Park.

Further testing will also be conducted to compare modeled vegetation changes to observed vegetation changes in YNP between 1937-1999. An assessment of current vegetation in YNP is not presently available, but is expected to be completed by 2000.

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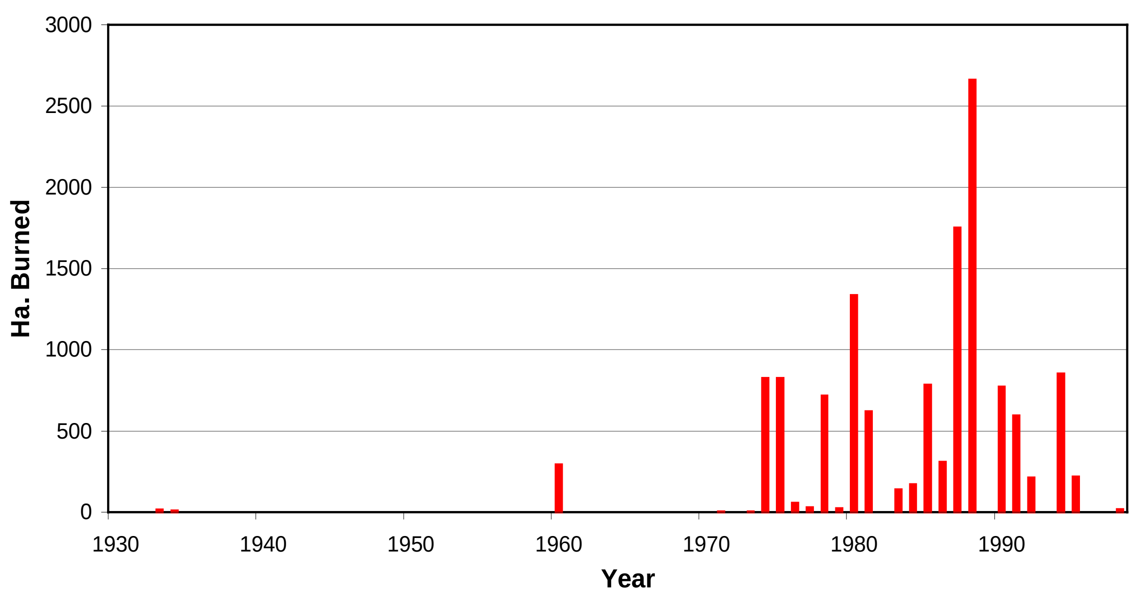

Figure 3. Hectares of red fir forest burned through time in Yosemite National Park. A management change in 1974 resulted in large increases in the area burned for this vegetation type.

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