MODELING REFERENCE CONDITIONS TO RESTORE ALTERED FIRE REGIMES IN OAK-HICKORY-PINE FORESTS: VALIDATING COARSE MODELS WITH LOCAL FIRE HISTORY DATA.

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1. INTRODUCTION

Altered fire regimes are a serious threat to biodiversity around the globe. Their restoration is dependent on understanding the natural ecological range of variability in fire frequency and severity and vegetation composition and structure. However, determining natural ranges of variability in fire regimes and vegetation can be difficult given the lack of reference landscapes to use as benchmarks. Historical interactions among humans, landscapes, and fire further complicates efforts to determine benchmarks; managers must often decide upon the role native Americans played in maintaining "natural" ecological conditions. Vegetation dynamics models are often necessary tools to determine natural and altered ranges of variability in ecosystem composition, structure, and function where long-term local reference data is unavailable. A procedure to model reference conditions for all vegetation types across the U.S. is currently being applied via the LANDFIRE (LF) project by the USDA Forest Service, Department of the Interior and The Nature Conservancy (Rollins et al. 2003). Model outputs describing the long-term mean percentages of seral stages by vegetation type (biophysical setting) are then used as coarse reference conditions for determining current fire regime conditions. Assessments of current fire regime conditions are being used by federal and state land management agencies and partners to drive fire, land management and biodiversity conservation priorities, objectives, and resource allocation (Hann et al 2003). Over 260 first iteration reference models for the United States have been developed to-date; by the end of the LF project, over 500 reference condition models will be available. Due to the vast spatial extent and accelerated schedule of the LF project (spatial mapping and modeling of current and historical fire regime conditions across the U.S. will be completed by 2009), validation of models with local fire history data cannot be accomplished for all landscapes. However, validation of these coarse resolution reference models is crucial to the scientific credibility of these important land management tools.

2. OBJECTIVES

This study aimed to compare outputs from a coarse resolution reference condition model for an oak-hickory-pine biophysical setting for the LF project to a comparable model using local empirical fire history data from the Current River Hills, Missouri. Validated reference conditions from this study will be used to improve local land management decision-making and modeling procedures for the LANDFIRE project as whole.

3. METHODS

Coarse resolution reference models representing fire regime and vegetation conditions for the pre-Euro-American settlement period for the LF project are being constructed from literature reviews and expert input using the Vegetation Dynamics Development Tool (VDDT; Beukema et al. 2003). VDDT is a quantitative, state-and-transition model that is relatively user-friendly, public domain, and downloadable from the internet for free. It is widely used for public land management planning, and has been recently improved through the LF project for greater utility to a broader and increasingly sophisticated set of users. Quantitative LF reference models for each biophysical setting are based on inputs such as native fire frequency and severity, the probability of other natural, user-defined disturbances, and the rate of vegetation growth. Inputs include probabilities of disturbance and rates of succession derived from literature review, data analysis and expert input during expert modeling workshops, and through subsequent peer-review by a broader suite of experts. Reference models simulate several centuries of vegetation dynamics and create outputs such as the long-term expected mean percent of a biophysical setting in each seral class and the mean frequencies of disturbance.

A coarse resolution reference model for the oak-hickory-pine biophysical setting was completed for the south central U.S. through an expert modeling workshop in February 2005. This model was attributed with central tendencies of historical fire frequencies and severities as interpreted from literature reviews by local managers and scientists. A comparative empirically-derived model was constructed for the current study using fire history data for an oak-hickory-pine system in the Current River Hills, Missouri. A description of the project area and fire history methods can be found in Guyette et al. (2002). This detailed model replaced the mean fire disturbance probabilities in the coarse oak-hickory-pine LF model with actual annual probabilities of fire disturbance for the period between 1620 and 1820, as documented by a fire chronology in the Current River Hills. Anthropogenically-ignited fire by native Americans is included in this fire history chronology.

Coarse and empirically-driven VDDT models for oak-hickory-pine were constructed with five structural states (Table 1). Table 2 summarizes fire-related model inputs for the coarse VDDT model. Annual probabilities of non-fire disturbances (e.g., windthrow, insects) were included in the model but are not displayed here. The coarse model was run for 1000 years over 10 Monte Carlo simulations to obtain long-term mean reference outputs for 1) the percentage of the biophysical setting in each of five structural stages and 2) the mean percentage of area burned each year in stand replacement, mixed and surface fire regimes. Stand replacement, mixed and surface fire regimes are defined as those resulting in >75, 25-75, and <25% overstory mortality, respectively.

Table 1. Successional states of coarse (south central U.S.) and empirically-driven (Current River Hills, Missouri) VDDT models developed for this study.

Seral state	Age range (years)
Early seral mixed forest	0-12
Mid-seral mixed forest; canopy cover >55%	13-70
Mid-seral mixed forest; canopy cover <55%	13-70
Late seral forest; >55% canopy cover; <2% cover of shortleaf pine	>70
Later seral forest; >55% canopy cover; >2% cover of shortleaf pine	>70

The empirically-driven model was attributed with the observed percentage of the Current River Hills landscape burned per year in the fire history record between 1620 and 1820 (Guyette et al. 2002). The percentage of the landscape burned in surface fires was assumed to be directly proportional to the number of sites burned in the fire history record. Since the fire history record does not distinguish between fire types, and stand replacement fires are not captured in tree ring chronologies (i.e., these fires kill trees, and hence remove the dendrochronological record of their occurrence), we assumed that the incidence of higher severity fires (mixed and replacement fires) would be related to years when a greater proportion of the landscape burned. Mixed fires were assumed to have burned when 25% or more of the landscape burned in any one year, and were assumed to burn 10% of the total area burned in those years (Guyette and Kabrick 2003). Stand replacement fires were assumed to have occurred when 40% or more of the landscape burned in any one year between 1620 and 1820 according to the documented fire chronology. When stand replacement fire occurred, we assumed 25% of the landscape would burn in this type of fire regime (Guyette and Kabrick 2003). The model was run for 200 years (1620-1820) starting with initial conditions representing the long-term reference condition for seral states obtained from the coarse model (see Figure 1 and Table 3).

4. RESULTS

Table 3 summarizes outputs from the coarse and empirically-driven models for the oak-hickory-pine ecosystem. In general, outcomes for the mean percentage of oak-hickory-pine composed by each seral state differed by less than 21% between the models for any analysis period. Outcomes for the percentage of the landscape burned by fire regime differed by less than 6% between the models for any analysis period. The greatest difference between the two models was

Table 2. Fire disturbance probabilities for a quantitative, coarse oak-hickory-pine state-and-transition (VDDT) reference condition model. See text for definition of stand replacement, mixed and surface fire regimes.

	Mean fire return interval by fire regime (resulting transition)		
Seral state	Stand replacement fire	Mixed severity fire	Surface fire
A. Early seral mixed forest	10 (A)	0	0
B. Mid-seral closed mixed forest (>55% tree cover)	200 (A)	167 (C)	11 (B)
C. Mid-seral open mixed forest (<55% tree cover)	0	0	5 (C)
D. Late seral closed forest (>55% tree cover); <2% cover of shortleaf pine	1000 (A)	0	10 (D)
E. Later seral closed forest (>55% tree cover); >2% cover of shortleaf pine	500 (A)	0	10 (E)

observed in the percentage of the oak-hickory-pine ecosystem made up of the mid-seral states, and in the percentage of the ecosystem burned by surface fires (Table 3). In general, since the empirically-driven model used actual fire events rather than mean fire frequencies, greater variation in the abundance of seral states through time was observed in the empirical model. This is due to time lags of ecosystem recovery following discrete fire events, which are not observed when mean fire frequencies are used, as in the coarse model.

Table 3. Comparison of outputs for coarse and empirically-driven oak-hickory-pine reference models. See Table 2 for definitions of seral states, and text for definitions of fire regimes. Mean outputs for the coarse model are displayed only for the entire 1000-year simulation period, and for the empirical model for three 50 to 100 year simulation periods.

Model Type	Simulation time range or years	Mean % of landscape in each seral state					% of landscape burned by fire regime		
		A	B	C	D	E	Stand replacement	Mixed	Surface
Coarse	1000 years	10	10	30	20	30	1	0.09	12
Empirical	1620-1670	2	31	16	23	28	0	0.1	7
Empirical	1670-1770	4	24	6	26	40	0.2	0.05	9
Empirical	1771-1820	11	30	16	17	26	1	0.5	18

5. CONCLUSIONS

Comparisons of models using detailed local fire history data versus those using coarse, mean fire regime data demonstrated that the coarse reference modeling procedure is reasonably accurate for the purposes of developing broad land management and restoration objectives. However, it is clear that mean reference conditions generalize the actual year-to-year variation that might be observed within an ecosystem type, and great caution should be used when coarse reference conditions are used to determine detailed land management objectives for specific landscapes.

Validated reference conditions such as those described here provide greater scientific certainty for local land management and conservation decision-making, and contribute to the justifications for using or refining coarser models elsewhere.

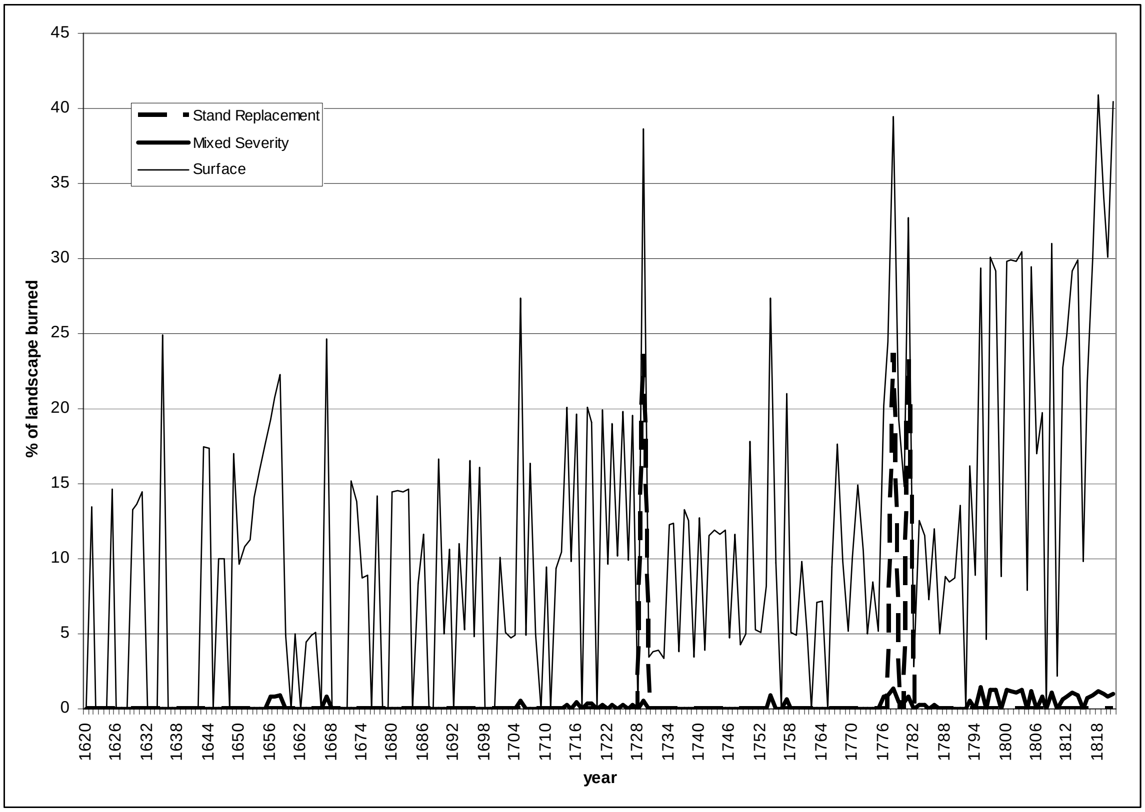

Figure 1. Percentage of Current River Hills landscape burned per year as attributed in the empirically-derived state-and-transition (VDDT) model.

6. REFERENCES

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7. PRIMARY AUTHOR BIBLIOGRAPHY

Dr. Shlisky is currently acting Director of TNCs Global Fire Initiative and leads the Conservancy's role in the LANDFIRE project, a collaborative 5-year project with DOI and USFS to develop geospatial data and ecological models for fire regime restoration, fire management, conservation planning, and hazardous fuels reduction nationwide. Prior to joining The Nature Conservancy, she worked for the USDA Forest Service for 12 years in the Pacific States. She has a Ph.D. in Ecosystem Sciences from the University of California, Berkeley, and also holds an MS in Range Management and a BS in Forest Management from UCB.