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Growth projection and valuation of restoration of the shortleaf pine–bluestem grass ecosystem

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ABSTRACT

The fire-dependent shortleaf pine–bluestem grass ecosystem that existed prior to European settlement is being restored on approximately 62,700 ha in the Ouachita National Forest. The restoration effort's economic effects are not completely understood. This study will provide the Forest Service with a framework for better communicating the biological and economic impacts of future forest plans and amendments. It also seeks to provide information on how shortleaf pine responds to different management regimes and the implicit cost to maintain the endangered red cockaded woodpecker habitat, and the economic consequences of transitioning from the traditional management regime to a regime which restores the shortleaf pine–bluestem grass ecosystem. The paper suggests by adopting the new pine–bluestem management regime, timber harvests in the pine–bluestem area decline by 25% during the 100-year simulation period, which will incur an additional implicit cost of $72/ha/year to maintain the red cockaded woodpecker habitat. An implied value for each pair of woodpeckers amounts to either $10,550 per year (for the desired 400 total pairs) or $16,880 per year (for the 250 reproducing pairs). Timber sale marking costs decline, while prescribed burning costs increase. The success of the pine–bluestem restoration requires the maintenance of a burning regime that prevents competing vegetation from occupying the middle canopy layer. Maintaining the pine–bluestem ecosystem will be difficult if environmental regulations become more stringent.

1. Introduction

The Ouachita National Forest received approval in 1996 for an amendment to its Forest Plan that would allocate 10% of the Forest to long-rotation silviculture. The purpose of the new management area is to restore pre-European settlement forest conditions, and recreate habitat for the endangered red-cockaded woodpecker.

In this new management area, the fire-dependent shortleaf pine (*Pinus echinata* Mill.)–bluestem grass (*Andropogon* spp.) ecosystem that existed prior to European settlement is being restored on approximately 155,000 acres in the Ouachita National Forest. The restoration effort's economic effects are not completely understood.

The goal of this study is to answer the following questions: 1) Will the new silvicultural prescriptions imposed upon the new management area measurably alter the volume of timber available for removal? 2) To what degree will revenue and cost streams be affected? 3) What is the implied value of a breeding pair of red cockaded woodpeckers? This study will provide the Forest Service with a framework for better communicating the biological and economic impacts of future forest plans and amendments. It also seeks to provide information on how shortleaf pine trees respond to two different management regimes, and the economic consequences of transitioning from one regime to the other.

We hypothesize that by converting these stands to long-rotation (120 years) medium-density management, the Forest Service will lose some revenue, even though the stumpage harvested during the final thinning and the regeneration phase will be of higher-than-average quality and value. This hypothesis will be tested by simulating the growth and yield of stands managed under both the current and pine–bluestem systems and comparing the net present value of their respective cost and revenue streams.

This paper addresses the question of how the physical outputs from traditional even-aged and pine–bluestem management compare and if the slightly lower stocking and longer rotations of the pine–bluestem scenario will reduce volume production.

2. Previous work

Shortleaf pine (*Pinus echinata* Mill) has the widest range of southern pines which amounts to one-quarter of the southern pine volume and is second only to loblolly pine among the southern pines of the United States. It ranges from southeastern New York to eastern Texas and grows in 22 states over more than 1,139,600 km^2 (Willet, 1986). However, shortleaf pine growth and yield research has been the most neglected among the major southern pines. Several attempts have been made to analyze shortleaf pine growth and yield

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including Murphy (1982), Murphy (1986), Murphy (1986) and Lynch et al. (1999). In 1985, Murphy and Farrar (1982) developed models for predicting projected basal areas and current and projected volumes for selection-managed stands of shortleaf pine. Murphy and Baker (1991) also have reported volume growth data from three experimental watersheds in the Ouachita Mountains, Arkansas focusing on the selection management in shortleaf pine forests. Lynch et al. (1999) have developed a distance-independent individual tree growth model for naturally-occurring shortleaf pine forests. The model consists of individual tree basal area growth, survival, and dbh-height equations. In the Ouachitas and southern Ozarks, the Shortleaf Pine Stand Simulator model (Huebschmann et al., 1998) provided a tool to model the development of naturally regenerated shortleaf pine stands, whether even-aged (Lynch et al., 1999) or uneven-aged (Huebschmann et al., 2000). The model requires inputs such as stem density by diameter class. This enables users to predict growth over different time horizons for various treatment regimes of treatment. Guldin and Baker (1988) reassert the necessity to evaluate stand development alternatives under different levels of commercial thinning in a restoration prescription. Individual tree models generate stand and stock tables that contain data on diameter distributions in terms of stem density by size class. To apply growth and yield models in the context of restoration, foresters should quantify desired future conditions, and then apply the growth and yield models to analyze the degree to which different treatments might develop the target. A growth and yield model for naturally regenerated mixed shortleaf pine forests in the southern United States of America was developed by Schulte and Buongiorno (2004). Their attempt was to describe a site- and density-dependent, multi-species matrix model for predicting the development of naturally-regenerated shortleaf pine stands in the mid-south of the United States. Equations for three characteristics, tree growth, tree mortality, and recruitment were included in the model. The model structure was similar to that in Buongiorno et al. (1995). Density-dependent parameters and multiple species, as in Buongiorno et al. (1995), and site effects as in Kolbe et al. (1996) were taken into account. This model was very similar to the model for loblolly pine (*Pinus taeda* L.) in Lin et al. (1998). The major objective was to determine the form of the equations and the values of the parameters for mixed shortleaf pine forests. Schulte and Buongiorno (2004) found that the recruitment rate was related negatively to stand basal area, and positively to the number of trees of the same species group in the smallest diameter class. They compared this study with other growth models.

Shortleaf pine is one of the most important tree species in eastern Oklahoma as well as adjoining regions of Arkansas and southern Missouri. Shortleaf pine is important economically as a timber producing species. In southeast Oklahoma, sawmills use shortleaf pine to produce southern pine lumber, and shortleaf pine pulpwood is used to produce paper products. Shortleaf pine is also an important component of wildlife habitat for species such as the red cockaded woodpecker. The USDA Forest Service Ouachita National Forest is engaged on a project of restoring the shortleaf pine–bluestem grass ecosystem on a portion of its acreage. This forest type is thought to be the typical pre-settlement forest type on many acres of southeastern Oklahoma and southwestern Arkansas. These considerations underlie the importance of the study of the growth and development of shortleaf pine.

Since 1985 we have cooperated with the USDA Forest Service Southern Research Station and the Ozark and Ouachita National in Arkansas and Oklahoma to establish and maintain over 200 plots on which shortleaf pine growth data have been collected. The plots are located in Arkansas and Oklahoma on the Ozark and Ouachita National Forests. On each plot, tree measurements such as diameter and height are made on an approximately 5-year interval. Using these measurements, the growth of individual trees can be determined, as well as changes in the values of forest attributes such as green weight and number of trees per acre. These repeated tree measurements have been used to develop a computer-based simulator of the growth of shortleaf pine forests. The simulator is SLPSS or the Shortleaf Pine Stand Simulator (Huebschmann et al., 1998). The simulator can be used to predict shortleaf pine forest attributes such as green weight and number of trees per acre at future times. These attributes can be used to assess future economic values for shortleaf pine forests.

3. Methods

The economic impact of augmenting the endangered red cockaded woodpecker population by restoring the shortleaf pine–bluestem grass ecosystem on the Ouachita National Forest is explored. An individual-tree growth and yield simulation program was developed from equations for the purpose of comparing the timber harvest volumes available under the pine–bluestem management regime with those under traditional even-aged management. Data from historical timber sales on the Ouachita and Ozark National Forests were used to derive a valuation model for estimating the change in timber sale revenue resulting from the adoption of the pine–bluestem regime.

The methods for this study are developed as follows: 1) creating a system of equations that predicts how the growth and yield of shortleaf pine trees change under different conditions and management scenarios, and comparing the stumpage volume produced under pine–bluestem with that from traditional even-aged management; 2) estimating the revenue from timber harvest occurring under each management scheme; and 3) use these results to estimate the implied value of nesting pairs of red cockaded woodpeckers.

4. Growth and yield projections

Two major questions are addressed in the growth and yield projections: How do the physical outputs from traditional even-aged and pine–bluestem management compare and will the slightly lower stocking and longer rotations of the pine–bluestem scenario reduce volume production?

Traditional, even-aged natural stands on the Ouachita National Forest designated as "pine" or "pine–hardwood" typically carry over 13.8 m^2/ha of basal area (BA), with 80% of that BA in pine. Rotation lengths are set between 50 and 100 years, depending upon site quality (USDA Forest Service, 1990). The Forest Plan calls for 2.3 m^2/ha of overstory pine, and an equal amount of hardwood BA, to be carried over from one rotation into the next. The Forest Plan also stipulates that even-aged stands be burned every 4 years, except for stands in regeneration or when other extenuating circumstances exist. In the new management area, however, the Forest Service intends to replicate stand conditions similar to those pictured in Mattoon (1915) and described in accounts written by early European explorers and elsewhere (e.g., du Pratz, 1774; Lewis, 1924; Nuttall, 1980; Foti and Glenn, 1991). Specifically pine BA will usually exceed 13.8 m^2/ha. Stands left uncut for several entry periods may accumulate over 23 m^2/ha. Hardwoods comprise either 10% to 15% of a stand (in terms of stems per hectare if average diameter $<$ 12.7 cm.), or 2.3 to 3.4 m^2/ha of BA (if average diameter $\geq$ 12.7 cm.). The goal is to produce as many older ($\geq$ 50 years) stands as possible with 13.8 m^2/ha of pine BA and 2.3 m^2/ha of hardwood BA. Rotations are lengthened to 120 years. Regeneration cuts reduce pine BA to 9.2 m^2/ha, and that residual BA is carried over for an indeterminate length of time into the subsequent rotation.

In the absence of growth models specifically developed for the pine–bluestem forest type, this study combined published growth equations for even-aged, natural shortleaf pine in the Ouachita Highlands (Lynch et al., 1999) with their counterparts for hardwoods in the Ozark Mountains (Murphy and Graney, 1998) into a stand growth simulator. The basic input to the simulator consists of initial stand conditions in the form of either a stand table (number of trees by