

## Forest Policy Impact Assessment in the Ouachita National Forest and the Valuation of Conserving Red-Cockaded Woodpeckers

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**Abstract:** **Problem statement:** 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. **Approach:** This study explored the effects of restoring an ecosystem, from changes in the growth patterns of individual trees to ecosystem valuation of the endangered red-cockaded woodpecker. It developed procedures for estimating the magnitude of economic impacts resulting from changes in timber production in the pine-bluestem management to project the value of conserving red-cockaded woodpeckers. **Results:** Over the entire simulation period, pine-bluestem management returns 75% of the undiscounted revenue generated by traditional management (660 versus 875 million dollars). For all 40,245 ha of the new management area managed for pine-bluestem, this cost amounts to \$2.9 million per year. When combined with the \$137 million decline in the present value of projected timber sale revenue from the area, the total cost rises to \$4.2 million per year. **Conclusion:** The implied value for each pair of woodpeckers is either \$10,550 per year for the desired 400 total pairs or \$16,880 per year for the 250 reproducing pairs. Judging from the changes resulting from the transition to pine-bluestem management, adopting the new scenario will not cause significant adverse regional economic consequences. The success of the pine-bluestem restoration requires the maintenance of a burning regime that prevents competing vegetation from occupying the middle canopy layer.

**Key words:** Pine-bluestem, red-cockaded woodpecker, ecosystem valuation, shortleaf pine, economic impact assessment, Ouachita national forest, *Pinus echinata Mill*

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### 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. 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.

This study 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 study explores the effects of restoring an ecosystem, from changes in the growth patterns of individual trees to ecosystem valuation of the endangered red-cockaded woodpecker. It develops procedures for estimating the magnitude of economic impacts resulting from changes in timber production in the pine-bluestem management to project the value of conserving red red-cockaded woodpeckers.

**Literature review:** Shortleaf pine (*Pinus echinata Mill*) has the widest range of southern pines which amounts to one-quarter of the southern pine volume and

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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<sup>2</sup>. The greatest concentration of shortleaf pine is found in the interior highlands of Arkansas and southeastern Oklahoma. However the research of shortleaf pine has been the most neglected among the major southern pines regarding growth and yield modeling. Several attempts have been made to analyze shortleaf pine growth and yield including Murphy (1982); (1986); Lynch (1991); Greene and Shilling (1987) and Lynch and Murphy (1995). Murphy and Farrar (1985) developed models for predicting projected basal areas and current and projected volumes for selection-managed stands of shortleaf pine. Murphy *et al.* (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 survival model for shortleaf pine trees growing in uneven-aged stands. Sets of growth equations were developed to simulate shortleaf pine annual growth based on different management scenarios using Ordinary Least-Squares (OLS) methods. In the Ouachitas and southern Ozarks, the Shortleaf Pine Stand Simulator model (Huebschmann *et al.*, 2004) 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.*, 2002). The model requires inputs such as stem density by diameter class. This facilitated scientists to predict growth over different time horizons of different intensities of treatment. Huebschmann *et al.* (2004) reasserts 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 using stem density by diameter class and then apply the growth and yield models to analyze the degree to which different treatments might develop the target diameter distribution. These models are especially meaningful in prescriptions that seek to accelerate mean stand diameter growth past a minimum threshold in a managed old growth context, to calculate changes in volume over time if leaving living relicts or snags of a given size and density (Huebschmann *et al.*, 2004).

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 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. They used the model to predict the annual growth rates for three experimental uneven-aged shortleaf pine watersheds in the Ouachita Mountains in Arkansas (Murphy *et al.*, 1991).

Schulte and Buongiorno (2004) concluded that shortleaf pine and other softwoods would be progressively replaced by hardwoods. These findings may be sensitive to the model specification and to the value of the parameters, a subject that needs more investigation (Schulte and Buongiorno, 2004). The model parameter estimation based on Ordinary Least-Squares (OLS) methods appeared unrealistic for an assumption of independent observations for individual trees. Ordinary or weighted least-squares or seemingly unrelated regression methods were used for growth models of shortleaf pine till this study. These were not helpful in plot level grouping of tree observations. The advantage of mixed-effects models is that they can be used to account for spatial and temporal correlation, providing improved parameter estimates. A mixed model for the shortleaf pine dbh-height relationship using a dataset in which plot specific random-effects were included (Lynch *et al.*, 1999).

Over 200 permanently established plots in shortleaf pine natural stands located in western Arkansas and eastern Oklahoma were used for data collection. It utilized mixed modeling techniques with growth data from three measurement times to develop a basal area growth model with improved parameter estimates relative to a model fitted by OLS to data from two measurement times by Lynch *et al.* (1999). For comparison purposes, this model was refitted using Generalized Least-Squares (GLS) with the additional third measurement data so that statistics such as Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) or Schwarz's Bayesian Criterion (SBC) could be obtained with S-Plus gnls function. This made it possible to compare a GLS model to a mixed-effects model using the same dataset.

Recently there have been several efforts internationally and especially in the US to assess the economic impact of restoring forest ecosystems, from different viewpoints. Garner (2008) examined the economic implications of the locations of forestry plantations in Queensland, Australia. This work was used to select from different properties for forestry development. Faham *et al.* (2008) conducted an analysis of socio-economic factors influencing forest dwellers' participation in reforestation and development of forest areas in west mazandaran, Iran. Michailidis (2006) examined the impact of irrigation projects using an application of contingent valuation method. Hanisah *et al.* (2008) made a detailed analysis on the determination of minimal duration essential for isolation of humic acids from soils in forest restoration while Snow and Ghaly (2007) made a comparative assessment of the characteristics of saturated wetland soil and a well drained forest soil. In Canada, other economic techniques for assessment were used (Alavalapati *et al.*, 1998). The goal was to make an economic model of conditions based on different active management forestry policies. They found that general equilibrium models were more effective than input-output models for addressing forestry policy and more flexible in terms of policy regulations and motivations. These findings were based on comparing models to an inter-industry study of forestry projects in and around Alberta, Canada.

In Minnesota, the oak wilt problem was modeled in terms of economic impact by (Haight *et al.*, 2009). A grid approach was employed to allow numeric techniques to simulate the evolution of an oak blight. While the spread of the wilt was perhaps straightforward to model, the authors conceded that an accurate estimation of the economic value of an individual tree, in terms of carbon sequestration, energy conservation, or wildlife habitat, is very difficult to ascertain. Economic analysis can also be an effective technique in addressing the effects of forest pests and effective abatement techniques. In Virginia, Gagnon and Johnson (2006) addressed the economic and environmental impact of small land owners in terms of forestry policy and specifically the growth of shortleaf pine. These authors considered the propensity of this local species to create wildlife habitat as well as for timber. Their assessment indicated that even small land owners could contribute economically and environmentally by growing the shortleaf pine, which has rapidly declined in population in Virginia. Bruce and Bruce (1999) made an economic and environmental impact assessment of forest Policy in Western Washington.

In Oklahoma, Zhang and Hiziroglu (2010) examined the adverse ecological and economic impacts of eastern redcedar and proposed the sustainable development of value-added panel products from the under-utilized invasive eastern redcedar and examined in what economic sectors the effects would be most noticed. The importance to expand the use of low quality eastern redcedar in value-added composite panel manufacture seems an alternative solution in the development of an environmentally sound and economically effective way to utilize this resource.

These economic impact assessment studies, though diverse in their locality and in their local concern, all indicated that economic modeling can be a potent tool for creating an effective forestry management decision making in restoring forest ecosystems.

## **MATERIALS AND METHODS**

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) conducting an impact assessment and derive the implicit value of red-cockaded woodpeckers. 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 carries over 13.8 m<sup>2</sup> ha<sup>-1</sup> of Basal Area (BA), with 80% of that BA in pine. Rotation lengths are set between 50 and 100 year, depending upon site quality. The Forest Plan calls for 2.3 m<sup>2</sup> ha<sup>-1</sup> 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 year, 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 described in accounts written by early European explorers and elsewhere (Du Pratz, 2006; Lewis, 1924; Nuttall, 1999; Foti and Glenn, 1991). Specifically pine BA will usually exceed 13.8 m<sup>2</sup> ha<sup>-1</sup>. Stands left uncut for several entry periods may accumulate over 23 m<sup>2</sup>

ha<sup>-1</sup>. Hardwoods comprise either 10-15% of a stand (in terms of stems per hectare if average diameter <12.7 cm), or 2.3-3.4 m<sup>2</sup> ha<sup>-1</sup> of BA (if average diameter <12.7 cm). The goal is to produce as many older (≥50 year) stands as possible with 13.8 m<sup>2</sup> per ha of pine BA and 2.3 m<sup>2</sup> ha<sup>-1</sup> of hardwood BA. Rotations are lengthened to 120 year. Regeneration cuts reduce pine BA to 9.2 m<sup>2</sup> ha<sup>-1</sup> 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 diameter class and species group) or inventory data from field plots. Each tree (or group of trees in a diameter-class increment) is grown on a year-by-year basis. Because no stand tables existed for the new management area at the outset of this project, other methods were used to create the input needed for the simulator. The simulator allows considerable flexibility in the execution of thinnings. Excess trees can be removed either via "low" thinnings, or by specifying the number of stems to remove in a particular diameter class. Low thinnings were used most often in this study to favor the largest-diameter stems. Only during the first thinning in a young stand that contained residual overstory trees was the residual stand table specified.

Stand growth and yield were simulated over a 100-year period, beginning in the year 2000. One set of simulations treated the stands with a traditional even-aged prescription, while the other set of simulations assumed a pine-bluestem prescription. For both scenarios, the simulated second-generation stands were assumed to contain the regeneration conditions shown in Table 1 by age 20, in addition to the overstory left at the end of the initial rotation. Of the 62,757 ha in the new management area, 40,246 ha will be managed as pine-bluestem stands. The remainder of the area consists of roads, riparian areas, or stands containing no shortleaf pine. Simulations were conducted on the 40,246 ha.

Table 2 displays the merchantability specifications used in this analysis. Statistically valid hardwood valuations could not be derived from the historical timber sales because so few contained hardwood volumes. Although the hardwood component is important from a competition standpoint when simulating stand growth, historically it has generally contributed a negligible amount to sale revenue. Consequently, the hardwood volumes predicted by the simulator will be ignored in the

economic analysis. Figure 1 compares the growth of a stand under the traditional and pine-bluestem scenarios. Both scenarios begin in 2000 with the same stand conditions: stand age = 20 year; SI<sub>pine</sub> = 18.3 m; approximately 1,250 pine and 75 hardwood stems per hectare; and pine and hardwood BA of 13.8 and 3.4 m<sup>2</sup> ha<sup>-1</sup>, respectively.

First thinning occurs in 2010 when the stands are 30 year old, reducing BA to the target residual levels. Up until the regeneration cut, virtually all of the pine volume removed in the traditional scenario is comprised of pulpwood, as evidenced by the relatively smooth increase of the pine sawlog volume curve. Only when the regeneration cut occurs in 2050, at stand age 70 year, is the pine volume primarily sawlog size. The overstory is reduced in 2060-2.3 m<sup>2</sup> ha<sup>-1</sup> each of pine and hardwood, decreasing the amount of competition exerted on the seedlings/saplings (age 10 year in 2060). In 2080, when the regeneration has reached age 30, the remaining mature stems are removed, leaving the younger trees to occupy the site.

By maintaining 2.3 m<sup>2</sup> ha<sup>-1</sup> less pine BA in the pine-bluestem scenario between stand ages 40 and 60 year, sawtimber volume accumulates slightly more quickly than in the traditional scenario. This assertion is supported by observing that more sawlog volume is removed from the pine-bluestem stand during the thinning at age 50 year than from the traditional stand. The two simulations shown in Fig. 1 are quite comparable in their cumulative sawtimber volume growth. By the end of the 100-year projection period, volume production in the pine-bluestem scenario is only 15% less than the traditional scenario. Projections begin at age 20 year, with initial shortleaf BA levels of 6.9, 13.8 or 20.7 m<sup>2</sup> ha<sup>-1</sup>. Pine SI is either 15 or 21 m (base age 50 year).

Table 1: Initial regeneration conditions assumed to exist in 20-year-old, subsequent-generation stands, by shortleaf pine site index class. These values were used for both pine-bluestem and traditional management scenarios

Site index class (m)	Basal area (m <sup>2</sup> ha <sup>-1</sup> )		hardwood BA in hard mast species (%)
	Shortleaf	Hardwood	
15	15.0	1.1	50
18	13.8	2.3	40
21	12.6	3.4	30
24	11.5	4.6	20

Table 2: Merchantability specifications used in this study

Attribute	Value	Attribute	Value
Stump height (m)		Minimum piece length (m)	
Pulpwood	0.15	Pulpwood	1.52
Saw log	0.30	Saw log	2.44
Top diameter limit (cm)*		Minimum tree length (m)	
Pulpwood (o.b.)	10.20	Pulpwood	4.57
Pine saw log (i.b.)	17.80	Pine saw log	4.88
Hardwood saw log (i.b.)	25.40	Hardwood saw log	3.66

\*o.b. is outside bark; i.b. is inside bark

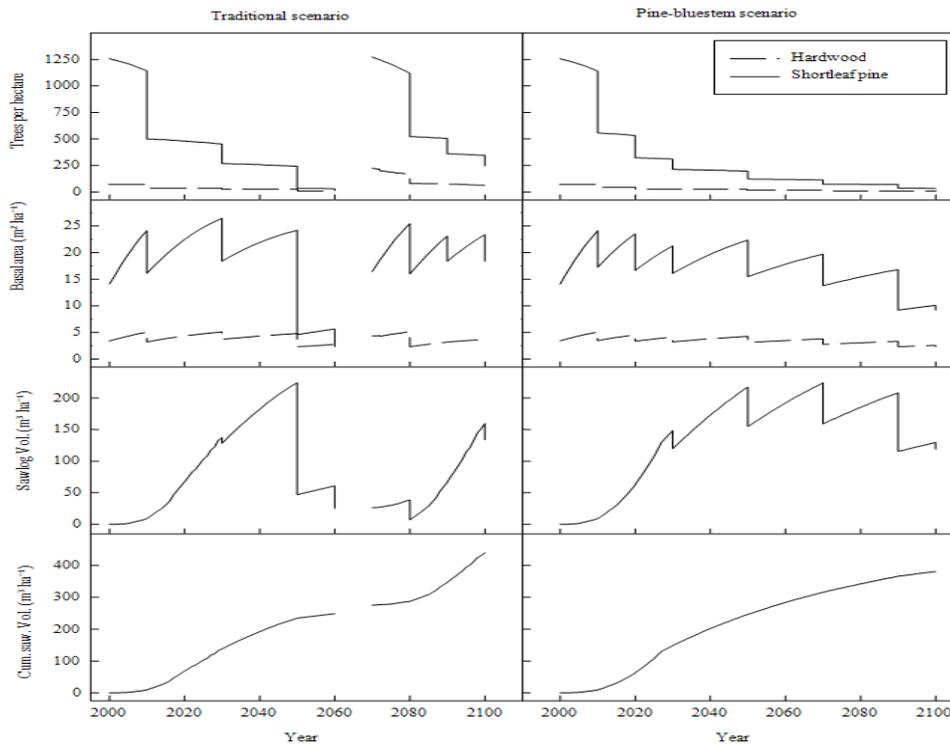


Fig. 1: Comparison of stand dynamics under traditional and pine-bluestem management of a stand with initial conditions: age 20 year,  $SI_{\text{pine}}$  18.3 m and 13.8 and  $3.4 \text{ m}^2 \text{ ha}^{-1}$ , respectively, of pine and hardwood BA

After completing growth simulations for the pine-bluestem and traditional management scenarios, the volumes of intermediate and final harvest volumes were aggregated into hypothetical timber sales. We compared the sawtimber and pulpwood (roundwood and topwood) harvest volumes produced by the traditional management and pine-bluestem scenarios during the 100-year simulation period. Harvest volumes vary from year to year, particularly under the traditional management scenario.

Over the entire period, by converting to the pine-bluestem management regime, sawtimber harvest volume drops by 26% (about 4.0 million  $\text{m}^3$ ); pulpwood harvest volume drops by 23% (about 943,000  $\text{m}^3$ ); and total (sawtimber and pulpwood) harvest volume drops by 25% (4.8 million  $\text{m}^3$ ). The proportion of total volume in sawtimber remains essentially stable at about 78%. The simulated harvests and their associated volume estimates provide the basis for the comparisons of value. Data from 150 Ouachita and Ozark National Forest timber sales, covering the period from June 1992 to December 1998, were used to derive a model relating the revenue generated by those sales to their characteristics (Huebschman *et al.*, 2002; 2004).

## RESULTS

The total revenue generated during each decade in the new management area under traditional and pine-bluestem management was obtained by summing the revenues from the simulated timber sales that occur in each scenario during that decade. The pine-bluestem scenario returns in 2000 only 16% of the revenue generated by traditional management. The greatest absolute disparity occurs in 2070 when the traditional scenario produces about \$170 million (undiscounted) more revenue than the pine-bluestem scenario. Traditional management does not return more revenue in every decade. However, over the entire simulation period, pine-bluestem management returns 75% of the undiscounted revenue generated by traditional management (660 versus 875 million dollars). In present-value terms, discounting the revenue streams back to 2000 at a real annual rate of 4%, the pine-bluestem scenario returns only half of the revenue generated by traditional management (131 versus 268 million dollars). The comparatively large harvests in 2000 and 2010 give traditional management a substantial present-value "advantage." The region under consideration for this part of the study includes 23

counties in western Arkansas and southeastern Oklahoma. Changes in regional output and value added were estimated for each decade of the simulation period. In present value terms, forestry products output declines by \$137 million during the entire 100-year simulation period; regional output, \$365 million; and total value added, \$167 million.

Judging from the changes resulting from the transition to pine-bluestem management, adopting the new scenario will not cause significant adverse regional economic consequences. In most years, the revenue foregone from the new management area could be recouped by offering a few additional sales elsewhere on the National Forest. In the new management area, we quantified differences in cost streams resulting from the transition from traditional to pine-bluestem management. For this analysis, cost comparisons were limited to timber marking and prescribed burning. Other costs are not expected to vary enough between management scenarios to warrant study. The Poteau District of the Ouachita National Forest follows a policy of entering each stand once per decade to determine if a timber sale is needed. The labor and materials expended to inventory and select the trees to be harvested comprise a substantial share of the cost associated with a timber sale.

The new management area under the pine-bluestem management will carry somewhat fewer stems for longer periods and will result in lower marking cost than in the traditional scenario. Over the entire simulation period, total undiscounted expenditures for marking pine-bluestem sales are 80% of the traditional scenario's costs (8 versus 10 million dollars). The difference in total expenditures has a present value of \$1.3 million.

**DISCUSSION**

One of the features of pine-bluestem management is a more aggressive (3 year) burning schedule. The Poteau Ranger District has traditionally attempted to maintain a 4-year burning cycle. During years of favorable weather, the district staff estimated in 2000 that they could burn 8,100 ha year<sup>-1</sup> given current staffing and resources. The area burned on an annual

basis under the two management scenarios and the present values (1996 dollars) of the burning expenditures incurred during the entire simulation period are displayed in Table 3.

During the simulation period, the pine-bluestem scenario burns 35% more area and expends 43% more funds than the traditional scenario. During an average year, district staff will need to burn 50% more than their capacity in 2000. The accumulated-volume production values demonstrate that traditional management yields the greatest overall volume. Once the new management Area has been converted to the pine-bluestem forest type, it will incur an additional implicit cost of \$72 ha<sup>-1</sup> year<sup>-1</sup> (applying the Forest Service's preferred discount rate) to maintain the red-cockaded woodpecker habitat. For all 40,245 ha of the new management area managed for pine-bluestem, this cost amounts to \$2.9 million year<sup>-1</sup>. When combined with the \$137 million decline in the present value of projected timber sale revenue from the area (or \$1.37 million per year), the total cost rises to \$4.2 million year<sup>-1</sup>. This translates into an implied value for each pair of woodpeckers of either \$10,550 per year (for the desired 400 total pairs) or \$16,880 year<sup>-1</sup> (for the 250 reproducing pairs). The success of the pine-bluestem restoration requires the maintenance of a burning regime that prevents competing vegetation from occupying the middle canopy layer (Table 3). Despite the Ouachita National Forest's adherence to smoke management policies, the capricious behavior of weather patterns can turn an otherwise successful burn into a public relations nightmare.

By adopting a more aggressive burning schedule, similar situations are more likely to occur. The substantial hardwood fuel load present in many new management area stands complicates smoke management. Burns in these stands smolder for several days, thereby increasing the opportunity for problems. Once the hardwood fuel is reduced and herbaceous vegetation comprises the bulk of the fuel, experience in other parts of the South indicates that smoke management problems improve.

Table 3: Comparison of hectares prescribed burned per year and present values (low and high estimates) of burning expenditures over the entire simulation period, by management scenario

Management scenario	Hectares burned per year				Present value of total expenditures (Millions of 1996 dollars)	
	Mean	Standard deviation	Minimum	Maximum	Low estimate	High estimate
Traditional	8,962	2,023	3,676	10,057	1.73	6.47
Pine-bluestem	12,359	1,227	9,996	13,410	2.47	9.24

## CONCLUSION

Because of the greater time between harvests and a more open stand structure, timber sale marking costs decline by 59% (present value terms) in the pine-bluestem scenario. However, prescribed burning expenditures will rise by 43% as a result of a shorter burning cycle.

A larger budgetary commitment will be required to maintain this fire-dependent ecosystem. By adopting the new management regime, timber harvests in the pine-bluestem area decline by 25% during the 100-year simulation period. This translates into a cumulative loss of timber sale revenue in present-value (1996 dollars) terms of \$137 million, or about half of what the area might have generated under traditional management. Total output of the 23 counties in the Ouachita National Forest area declines by \$365 million, in present-value terms, over the simulation period. The wood producing and processing industries account for 78% of the reduction in total output and 59% of decline in employment. Maintaining the pine-bluestem ecosystem will be difficult if environmental regulations become more stringent. Alternative methods of controlling competing vegetation may be used, but generally they are either less effective or more expensive than prescribed burning. It suggests that the pine bluestem management has significant economic consequences and that the plan may not be sustainable because of staffing and resource issues and other environmental issues such as smoke management.

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