BURNING FOR CONSERVATION VALUES: SHOULD THE GOAL BE TO MIMIC A NATURAL FIRE REGIME?

Sharon M. Hermann, John S. Kush, John C. Gilbert, and Rebecca J. Barlow[1]

Abstract--Managers are often asked to include conservation values in forest management plans. In the upland coastal plain of the southeastern United States, fire is an important natural process and a vital land management tool. Many native ecosystems are dependent on frequent burns. It is often suggested that mimicking a natural fire regime is the best way to improve and maintain conservation values in many forest types. Unfortunately, fire return interval has been the primary component of a fire regime historically considered, with seasonality of fire generally playing a lesser role. Here, we review what constitutes a fire regime and present data from two long-term burn treatments based in naturally regenerated loblolly-shortleaf pine (*Pinus taeda* L. - *P. echinata* Mill.) and longleaf pine (*P. palustris* Mill.). The information is used to: (1) consider how fire return interval and/or season of burn influence stand structure, and (2) determine if applying one or both of these components of a natural fire regime is likely to meet desired outcomes for conservation concerns. Data from the long-term studies indicate that limiting consideration to frequency is unlikely to produce desired results. In addition, the combination of natural frequency and season of burn may not always be successful. A more productive goal is to mimic long-term outcomes of natural fire regimes. In the modern landscape this will likely require innovative uses of prescribed fire and, at times, supplemental treatments to meet the needs of conservation concerns in upland coastal plain pine forests.

INTRODUCTION

The importance of fire in restoring and maintaining numerous native ecosystems is well recognized. When a significant management goal is to promote conservation values, a common recommendation is to implement burn plans that mimic natural fire regimes. While this appears to make intuitive sense there is increasing evidence that promoting this goal may be unproductive and/or impossible in the modern landscape. This issue coincides with increasing anthropogenic pressures on many natural landscapes and so enhancing even more our need to improve management to promote conservation concerns. An expanding wildland-urban interface coupled with growing concerns for the ecological quality of remaining natural areas means prescribed fire must be used in the most productive ways possible. At the national level, efforts have increased to assess whether the effects of prescribed burns are adequate replacement for natural fires (c.f. Nesmith and others 2011). Increasing concerns for conservation and management of fire-maintained ecosystems in the U.S. southeastern coastal plain suggest a need to consider where the regional goal for prescribed burning in conservation areas will benefit from attempting to mimic a natural fire regime.

In this paper we consider whether a goal of mimicking natural fire regimes is likely to be effective in promoting conservation values in the coastal plain of the southeastern United States. We provide a short overview of relevant data from two long-term fire studies in the lower coastal plain: (1) Tall Timbers Research Station in north Florida, where the Stoddard fire plots support loblolly-shortleaf pine in the overstory; and (2) Escambia Experimental Forest in south Alabama, where fire plots are dominated by an overstory of longleaf pine. Although targets for sampling differed between the two case studies, the overall results provide a useful basis for comparison. We discuss selected results from each case study and consider what this information reveals about the utility of the goal of mimicking a natural fire regime to promote conservation values.

Prescribed burning is an especially significant management tool in longleaf pine (*Pinus palustris* Mill.) and loblolly-shortleaf mixed pine (*P. taeda* L.-*P. echinata* Mill.) forests; without frequent application of fire these ecosystems experience hardwood encroachment and eventually lose the open canopy and unobstructed midstory required by specialist species of these forests such as the red-cockaded woodpecker [*Picoides borealis* (Vieillot)] and gopher tortoise [*Gopherus polyphemus* (Daudin)]. Van Lear and others (2005) noted that most federally listed southeastern vertebrate species were

[1]Assistant Professor, Auburn University, Department Biological Sciences, Auburn University, AL 36849; Research Fellow and Research Associate, respectively, Auburn University, School of Forestry and Wildlife Sciences, Auburn University, AL 36849; and Associate Extension Professor, Auburn University, Alabama Cooperative Extension System, School of Forestry and Wildlife Sciences, Auburn University, AL 36849.

Citation for proceedings: Holley, A. Gordon; Connor, Kristina F.; Haywood, James D., eds. 2015. Proceedings of the 17th biennial southern silvicultural research conference. e–Gen. Tech. Rep. SRS–203. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 551 p.

associated with longleaf pine ecosystems, and Hermann and others (2007) determined that this relationship was likely related, in large part, to the species need for habitat structure provided by these native forests. Almost 225 years ago Bartram (1791) described the coastal plain as "… mostly a forest of the great long-leaved pine, the earth covered with grass, interspersed with an infinite variety of herbaceous plants …". It is this habitat structure and not the specific species of tree that is required by many of the vertebrate species of conservation concern, and it is widely accepted that to maintain open habitat structure there must be frequent burns. Because restoring and maintaining habitat structure are significant goals of land management and conservation efforts, it is important to understand the effects of fire on this critical forest element. In longleaf and loblolly-shortleaf pine forests, encroachment by hardwood species is mitigated by fire. Fire also indirectly influences canopy openness. Although there is some debate on the desired minimum level of openness, a general rule of thumb currently applied is 50 percent or greater for upland pine habitats (e.g. Florida Fish and Wildlife Conservation Commission 2007).

FIRE REGIMES

Before delving into details of specific fire regimes, it is useful to define the topic and consider various components that are often listed as descriptors or factors. Unless fires are very uncommon in an ecosystem (e.g. once in many decades to centuries), consideration of the effects of a single fire may not reveal much about the likely ecological trajectory of the habitat. In other words, it is often not only productive but often necessary to consider the effects of a series of burns over time. A simple definition of a fire regime is the range of factors that describe multiple burns over a designated time period. We base our list of factors that make up a fire regime, in part, on the glossary of the Fire Effects Information System (2013); these factors include:

- frequency (mean number of fires/time period) or return interval (mean time between fires)
- season or month of burn
- day of burn conditions
- ignition pattern
- area and/or placement in the landscape
- intensity (heat/unit time)
- severity (impact on the ecosystem)
- synergism (interactions with other disturbances such as drought or windstorm)

Early in the history of prescribed fire, return interval (frequency) was the primary concern in burning for its ability to reduce fuels and enhance conservation values. In recent years, seasonality has been added as an additional target especially when conservation values are involved. General considerations of natural fire regimes, especially on large blocks of public lands, are often limited to frequency or return interval while plans for specific sites may include seasonality. One of our case studies is based on only differing burn frequencies while the other combines frequency and season of burn (in this case spring). It is widely understood that burns in the growing season were more likely on the landscape prior to European settlement than were dormant season (winter) burns.

ESTIMATES OF NATURAL FIRE RETURN INTERVALS (FREQUENCIES)

There have been a number of efforts to map coarse-scale general estimates of fire return intervals across the United States. We discuss three of them in relation to our two case studies.

1. An often-cited map used by many agency programs is found in Brown (2000). This map provides estimates of fire return intervals and general fire types related to pre-European settlement conditions based on Kuchler's Potential Natural Vegetation Types. It is, by design, coarse-scaled and almost all of the coastal plain falls under the category of "understory fires 0 to 10 years".
2. Frost (1998) created a map based on historical documentation and topography. It provides a more ecological and detailed classification system compared to Brown (2000). Frost (1998) suggests a fire return of 1 to 3 years for the lower coastal plain and 4 to 6 years for the upper coastal plain.
3. Guyette and others (2012) base fire return intervals primarily on plant chemistry of natural vegetation and climate. In this map, a mean fire return interval estimated at < 2 years is indicated for portions of the lower coastal plain of peninsular Florida, extending north into central Georgia. A mean fire return interval of 2 to 4 years

is estimated for almost all of the remainder of the coastal plain.

Although differences in fire return interval are small among the three maps, when the fire return interval is short, a shift of even one or two more burns every decade results in significantly more fire on the ground over a few decades. This is important to remember when considering the results of the two case studies. In addition, it is important to note that none of the three fire maps pays direct attention to seasonality of burn. Guyette and others (2012) indirectly address the issue when they employ proxies for mean maximum temperature, and Frost (1998) discusses the fire regime factor. However, it is generally recognized that season of burn is an important aspect of natural fire regimes; this may be especially true in the regimes that are based on frequent burns.

TWO CASE STUDIES

Tall Timbers Research Station (Stoddard Fire Plots): Fire Return Interval Treatments

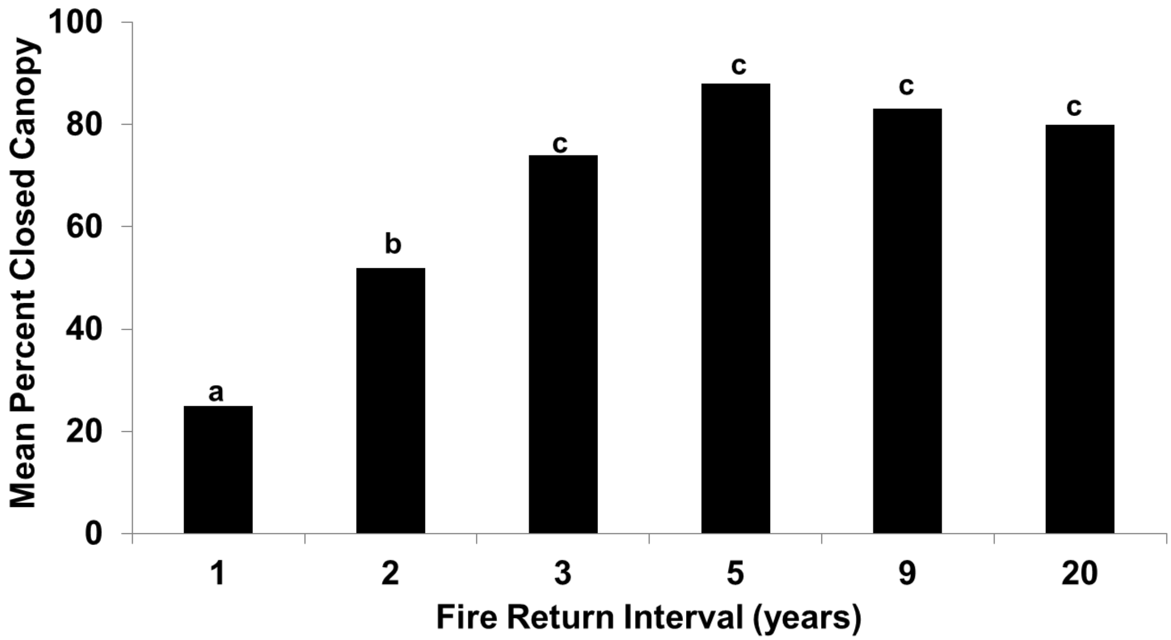
Background--Tall Timbers Research Station is located in Leon County, FL. The long-term Stoddard fire plots were established in naturally regenerated loblolly-shortleaf pine with mature old-field ground cover following agricultural use 50 years or more before the study began. Although wiregrass (*Aristida beyrichiana* Trin. & Rupr.) is found on nearby properties, past land use may have eliminated this species from the fuel base of this site. Glitzenstein and others (2012) provide detailed information on the plots and the site. In this study, the only fire regime factor that was varied was fire return interval. All burns occurred in the dormant season (late February to early March). Plans for this project included burns later in the spring, but after the first set of burns it was decided to eliminate that treatment. The fire crew reported that it was difficult to burn effectively during spring because once "greened up" occurred, old field herbaceous plants did not readily burn in the higher humidity conditions of the season.

We targeted six of the treatments: fires every 1, 2, 3, 5, 9, and 20 years. We do not consider the influence of time since last burn. Data presented here were collected 35 years after the beginning of the study and do not include fires that were conducted following recent modification of the plots (Glitzenstein and others 2012). We document effects of fire frequency on three aspects of habitat structure: mean percent canopy cover, mean shrub height, and mean grass height. See Glitzenstein and others (2012) for information on fire frequency and plant species composition on the Stoddard fire plots.

Methods--Each fire frequency treatment was administered to three replicate plots (0.5 acre each). Measurements of percent canopy cover were made using a hemispherical densitometer approximately every 3 feet along a 60-foot diagonal transect in the center of the plot. Height of shrubs and grasses was assessed using the same diagonal transect but as a 3-foot wide belt placed on one side of each transect.

Results

Habitat structure--Figure 1a illustrates the estimated mean percent canopy cover averaged over three plots/fire frequency. Burns applied every 3 years or less frequently resulted in 75 percent or greater canopy cover after 35 years. Burns every 2 years maintained canopy cover at approximately 50 percent, generally considered to be along the borderline acceptable conditions for conservation lands. Annual fire maintained an open canopy with approximately 25 percent cover. Heights of hardwood stems averaged over 4-feet tall for burns applied less often than every 1 or 2 years (fig.1b) and was significantly different from more frequently burned plots. Conversely, the mean maximum height of grasses generally declined with increasing time between fires (fig. 1b).



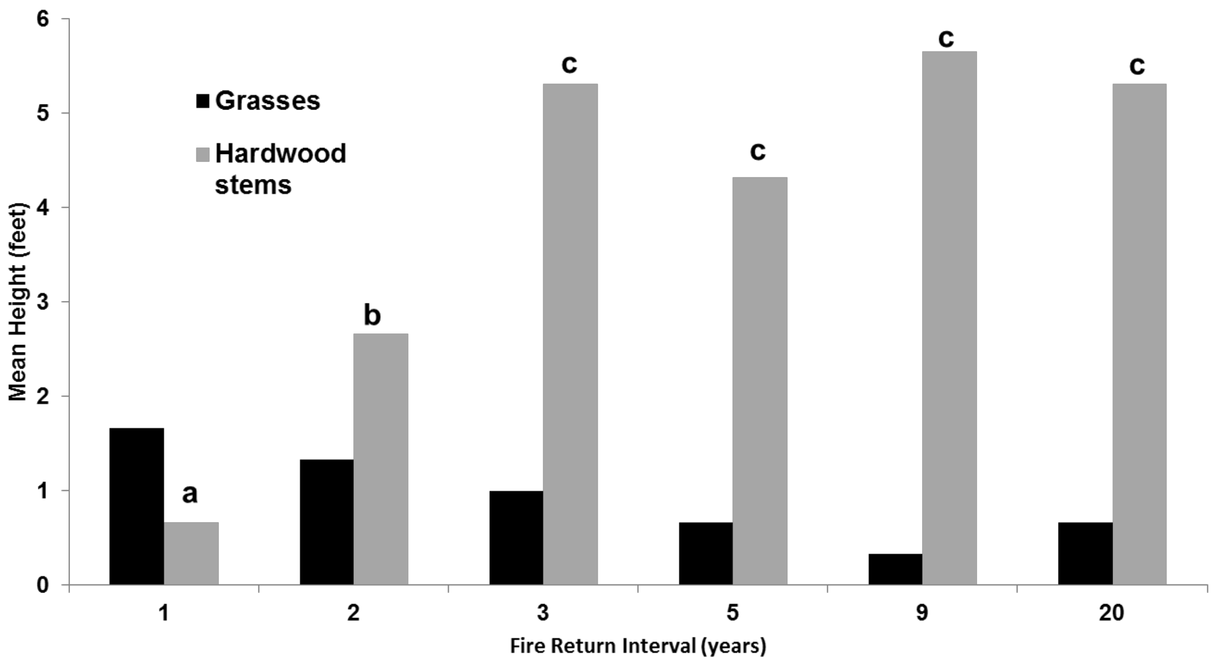


Figure 1--Relationship between fire return interval and measures of vegetation structure after 35 years of burn treatments on the Stoddard fire plots at Tall Timbers Research Station, Leon Co, FL. Fire return intervals were 1, 2, 3, 5, 9, and 20 years. Different small letters indicate significant difference among treatments ($p \leq 0.05$). (A) Percent canopy cover. (B) Maximum height of grasses and hardwood stems.

Natural fire return intervals--The location of the Tall Timbers Stoddard Fire Plots falls within: (a) the 0 to 10 year fire return interval proposed by Brown (2000); (b) the 1 to 3 year fire return interval indicated by Frost (1998); and (c) on the border of the < 2 years and the 2 to 4 year return interval proposed by Guyette and others (2012). Results of 35 years of fire frequency treatments indicate that a fire frequency of every 3 years or less does not maintain desired habitat structure. This is despite fire every 3 years falling within estimates of the natural fire regime proposed by

Brown (2000) and Frost (1998). The maintenance of desired habitat structure does appear to fit with one of two shortest fire return intervals indicated by Guyette and others (2012). Unfortunately, burning every 2 years does not appear to result in ideal canopy cover.

Escambia Experimental Forest: Fire Return Combined with Season of Burn Treatments

Background--Escambia Experimental Forest is a USDA Forest Service research site located in Escambia County, AL. The long-term fire plots were established in naturally regenerated longleaf pine with native ground cover on land that has never been in agriculture. There is no record of wiregrass ever occurring on the site. In this study, both fire return interval and season of burn were considered. Fire return intervals were limited to 2-, 3-, and 5-year treatments combined with two seasons of burn: winter (W) and spring (S). This resulted in six treatments (W2, W3, W5, S2, S3, and S5). In the current paper, we do not consider time since burn; data present in the current paper were collected 25 years after the beginning of the study. We evaluate effects of fire frequency coupled with month of burn on two habitat variables: number of hardwood stems per acre and basal area of hardwood stems per acre. Both number and size of hardwood stems may be important in determining habitat value to species of special conservation concern.

Methods--Each fire-frequency-by- season treatment was represented by three replicate plots (0.5 acre each). Number of hardwoods stems ≥ 1 inch d.b.h. (diameter at breast height) was tallied, stem diameters were measured, and basal area was calculated. No hardwood stem exceeded 10 inches d.b.h.

Results

Hardwood encroachment--After 25 years, density of hardwood stems was significantly different among treatments. Winter burns were associated with more hardwood stems (fig. 2a) compared to spring burns, and a 5-year fire return interval also resulted in more hardwood stems than did shorter fire return intervals. In addition, plots with higher density of hardwood stems also supported a higher basal area (fig. 2b). Although we have not yet assessed canopy cover, we predict that winter-burned plots will also have greater cover than spring-burned plots.

Comparison to natural fire return intervals-- The location of the Escambia Experimental Forest fire plots falls within: (a) the 0 to 10 year fire return interval proposed by Brown (2000); (b) the 1 to 3 year fire return interval indicated by Frost (1998); and (3) the 2 to 4 year return interval proposed by Guyette and others (2012). Two of the fire frequencies applied to the Escambia plots fall within the range of all three estimates of natural fire frequencies (every 2 or 3 years); only the 5-year burn cycle is viewed as unnatural. Burning every 2 or 3 years results in fewer hardwood stems and lower basal area compared to burning every 5 years. However, all winter burn plots support more and larger hardwoods than are desired. Only spring burns are effective in controlling encroachment over the 25-year period.

DISCUSSION

Although the two long-term fire studies differ in land use history and dominant canopy species, the general result is the same. Frequent fires (1-year to, at most, 3-year return intervals) are required to maintain ecologically desirable forest structure. Growing season burns may enhance effects produced by high frequency but only if the type of ground layer vegetation permits effective fire during that time of the year and only if local situations permit burning in the growing season on a consistent basis. It should also be noted that prolonged periods of annual fires will also not produce desired results because of lack of regeneration of most plant species. Adaptive management is critical.

If Tall Timbers Research Station plots are representative of the coastal plain that has been altered by agriculture, then the desired fire return interval for such sites may be as narrow as burns every 1 to 2 years. This is the same frequency that is often applied on many quail-hunting properties across the region and is shorter than the 3-year frequency that appears in many agency burn plans. Masters and others (2007) noted that “Less than a 3-year interval is recommended if hardwoods are problematic …” Although most individual burns do not result in drastic changes, effects of slightly less frequent

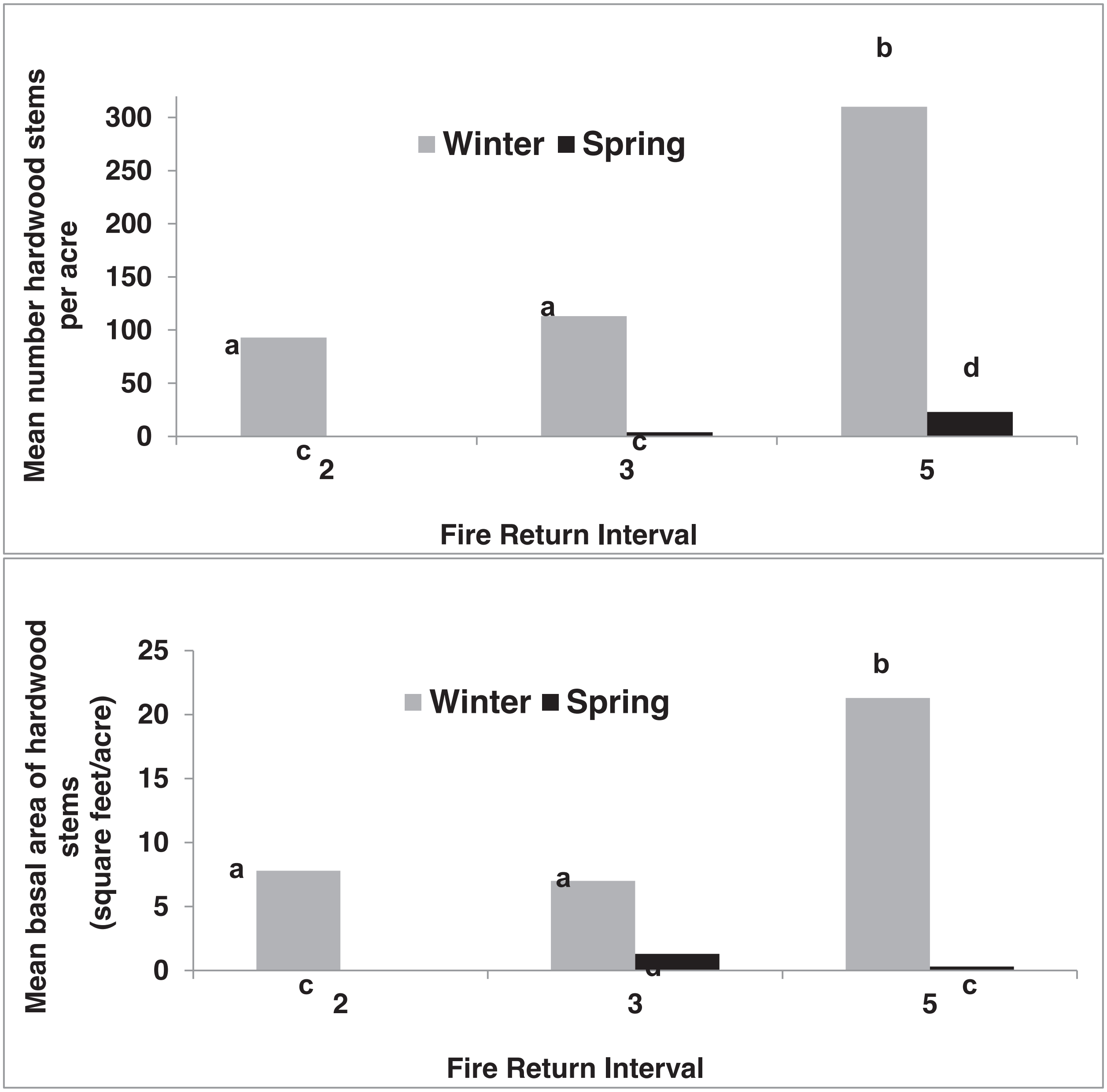


Figure 2--Relationship between fire return interval couple with season of burn treatments and hardwood stems after 25 years of treatments on plots at Escambia Experimental Forest, Escambia Co, AL. Fire return intervals were 2, 3, and 5 years; seasons were winter (W) and spring (S). Treatments were W2, S2, W3, S3, W5, and S5. Different small letters indicate significant difference among treatments ($p \leq 0.05$). (A) Estimated density (number of stems per acre) of hardwood stems ≥ 1 inch d.b.h. (B) Estimated basal area (square inches) of hardwood stems ≥ 1 inch d.b.h.

Fires are likely compounded over time. This is, in part, because "… fire season appears to have less of an influence on hardwood encroachment where the understory is dominated by bluestems or is the result of old-field succession" (Masters and others 2007). The Tall Timber plots also provide insight into the frequency of fire that may be required to maintain canopy openness at 50 percent or greater; only two treatments (annual and biennial fires) met those criteria after 35 years of treatment.

Escambia Experimental Forest fire plots integrate both frequency and season of burn in the long-term study of fire effects. Additionally, this site is less disturbed than the Tall Timbers site. It should also be remembered that different metrics assess fire effects at the two sites. At this point in time, it is not possible to determine if any one of the measurements is more important than the others in understanding the varying results. However, it appears as if the combination of two factors of a natural fire regime (frequency and season) may be related to maintaining a desired forest structure over long periods of time.

If adding growing-season burns to the tool box of prescribed fire enhances desired outcomes, then why is it not always used? There are many logistical and economic reasons including: (1) smoke management and air quality issues, (2) concerns for wildlife, (3) staffing conflicts related to wildfire season, and (4) the number of available legal burn days during the growing season. Of course there are more factors in a fire regime in addition to frequency and season but unfortunately adding more realistic day-of-burn conditions or more natural fuel types is not always possible. In fact, the day-of-burn conditions that would result in the best hardwood control may not be appropriate burn days because of the associated extreme weather (high temperature, low relative humidity, etc.). In addition, although a natural fire regime may be able to maintain a site in a desired ecological condition, it may not be adequate to recover a site once hardwoods have encroached.

The goal of applying a natural fire regime is laudable but perhaps not realistic in the modern landscape. However, understanding what such a goal would entail provides us with important ways to assess the outcomes of burn plans. Schmidt (1996) asked “Can we restore the fire process?” and “What awaits us if we don’t?” He concluded that the goal should not be to replicate the past but to consider the future. In other words, the goal should not be to apply a natural fire regime but rather to obtain desired results of either: (1) maintaining current high-quality habitat conditions, or (2) nudging the current conditions to an improved state. Improved understanding of natural fire regimes can provide valuable information for meeting those goals and can guide adaptive management.

By necessity large public lands may rely on general canned burned plans. Sometimes this means that all units under fire management will be treated in a similar fashion. This, coupled with applying a natural frequency of fire in an unnatural season, may mean that conditions at ecologically valuable sites will degrade slowly over time. Hiers and others (2003) provide a useful and pragmatic approach to prioritizing sites for prescribed burning. Such an approach, coupled with a better understanding of natural fire regimes, could improve management and conservation efforts on many sites. Important regional efforts, such as those to restore longleaf pine, will ultimately fail to benefit conservation efforts if long-term effects of prescribed fire are not improved. When planted trees are large enough to contribute to the desired habitat structure, fire must be applied in ways to maintain critical ecological values or significant ecological benefits expected from the effort will not materialize.

Given all of the challenges imposed by a modern landscape, is the future for prescribed fire as a primary tool for ecological management hopeless? No! However, adaptive management must be implemented to enhance desired fire effects of prescribed burning programs. Additional tools may need to be added to the fire management tool box, including mechanical and chemical treatments. We do not promote using these treatments as on-going surrogates for fire but rather as a way to periodically boost the effectiveness of fire. Again, adaptive management is critical.

Even if fire ecologists can adequately describe a natural fire regime for the southeastern coastal plain, the goal should not be to implement it. Fuels loads and vegetation composition probably differ from natural conditions at many, if not most, sites. In addition, conditions of the surrounding landscape, coupled with social concerns, often limit growing-season burns. If only one factor of a natural fire regime, such as frequency, is consistently applied, then the outcome expected of a natural fire regime cannot be obtained over a long time period. However, if fire practitioners focus on obtaining outcomes of a natural fire regime rather than the process itself, then use of adaptive management will promote desired ecological values.

ACKNOWLEDGEMENTS
Two very different institutions and their staffs conceived, designed, and maintained the long-term fire plots for many decades. We appreciate their foresight and dedication. H. Stoddard and R. Komarek planned the Tall Timbers Stoddard fire plots, and many dedicated land

management staff maintained them. We thank station Directors of Research J.L. Landers and R.E. Masters for support and access to the site. At the Escambia Experimental Forest W.D. Boyer (USDA Forest Service Researcher, retired) initiated the long-term fire study, and Forest Service staff of the Escambia Experimental Forest continues to maintain the plots. We thank Boyer for his insight and interest in studying complex fire regime. The Forest Service granted access to the plots. C. Guyer provided helpful suggestions on an earlier version of our paper.

LITERATURE CITED

Bartram, W. 1791. Travels through North and South Carolina, Georgia, East and West Florida [1955 reprint]. New York: Dover Publications. 414 p.

Brown, J.K. 2000. Introduction and fire regimes. In: Brown, J.K.; Smith, J.K., eds. Wildland fire in ecosystems: effects of fire on flora . Vol. 2. Gen. Tech. Rep. RMRS-GTR-42. Fort Collins, CO: U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station: 1-8. Chapter 1.

Fire effects information system. 2013. Glossary. http://www.fs.fed.us/database/feis/glossary. [Date accessed: June 2013].

Florida Fish and Wildlife Conservation Commission. 2007. Gopher tortoise management plan. Tallahassee, FL: Florida Fish and Wildlife Conservation Commission. 143 p.

Frost, C.C. 1998. Presettlement fire frequency regimes of the United States: a first approximation. In: Pruden, T.L.; Brennan, L.A., eds. Fire in ecosystem management: shifting the paradigm from suppression to prescription. Proceedings, 20th Tall Timbers fire ecology conference. Tallahassee, FL: Tall Timbers Research Station: 70-81.

Glitzenstein, J.S.; Streng, D.R.; Masters, R.E. [and others]. 2012. Fire-frequency effects on vegetation in north Florida pinelands: another look at the long-term Stoddard fire research plots at Tall Timbers Research Station. Forest Ecology and Management. 64: 197-209.

Guyette, R.P.; Stambaugh, M.C.; Dey, D.C.; Muzika,R. 2012. Predicting fire frequency with chemistry and climate. Ecosystems. 15: 322–335

Hermann, S.M.; Kush, J.S.; Gjerstad, D. 2007. Emerging issues in forest health and their significance for rare species of the southeastern United States. In: HydroGeoLogic, eds. Proceedings from the Southeast Region threatened, endangered, and at-risk species workshop. Reston, VA: Department of Defense Legacy Resource Management Program: E3-E22.

Hiers, J.K.; Laine, S.C.; Bachant, J.J. [and others]. 2003. Simple spatial modeling tool for prioritizing prescribed burning activity at the landscape scale. Conservation Biology. 17(6): 1571-1578.

Masters, R.E.; Robertson, K.M.; Palmer, W.E. [and others]. 2007. Red Hills forest stewardship guide - 2007. Misc. Series No. 12. Tallahassee, FL: Tall Timbers Research Station. 78 p.

Nesmith, J.C.B.; Caprio, A.C.; Pfaff, A.H. [and others]. 2011. A comparison of effects from prescribed fires and wildfires managed for resource objectives in Sequoia and Kings Canyon National Parks. Forest Ecology and Management. 261(7): 1275-1282.

Schmidt, R. G. 1996. Can we restore the fire process? What awaits us if we don't? In: Hardy, C.C.; Arno, S.F., eds. The use of fire in forest restoration. Gen. Tech. Rep. INT-GTR-341. Ogden, UT: U.S. Department of Agriculture Forest Service, Intermountain Research Station: 85-86.

Van Lear, D.H.; Carroll, W.D.; Kapeluck, P.R.; Johnson, R. 2005. History and restoration of the longleaf pine–grassland ecosystem: implications for species at risk. Forest Ecology and Management. 211: 150–165.