DEVELOPMENT OF AN ARCGIS FIRE FREQUENCY, FUEL ACCUMULATION, SEASONALITY AND PRIORITIZATION TOOL TO FACILITATE PRESCRIBED FIRE DECISIONMAKING ON THE TALLADEGA NATIONAL FOREST, ALABAMA

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Abstract—Prescribed fire is used widely to mitigate wildfires and restore ecosystems. However, there are few tools developed to evaluate fire's cumulative impact, calculate frequency, examine seasonality, and estimate fuel accumulation to facilitate decisionmaking in targeting successive prescribed fire application. An ESRI shapefile of all wildfire and prescribed fire events was assimilated from 1978 to 2012 for the 235,000-acre Talladega Division in east central Alabama. A python script-based tool was developed for ArcGIS10 to calculate the annualized average fire return interval, years of fuel accumulation (i.e., date last burned), and frequency of growing to dormant season fire events. Development of a comprehensive fire database that can calculate generalized fuel accumulation will allow for more targeted pairing with appropriate smoke dispersion and better smoke management. Calculations of fire frequency will determine if adequate fire return intervals are occurring on the landscape and focus on areas that need increased effort to meet frequency targets for restoration.

INTRODUCTION

Prescribed fire is a fundamental tool for land managers to mitigate wildfires and restore ecosystems (Costanza and others 2013, Melvin 2012). While individual fire events are often the focus of managers, it is the cumulative impact of successive fires that lead to ecosystem restoration particularly in the Southeast. Fire frequency is the critical metric to determining if fire management goals are being achieved, whether the manager is managing fuels in a wildfire landscape of the West or a prescribed fire landscape of the Southeast. Such calculations have been made with Landsat data, ArcGIS model builder, or in Oracle databases (Hiers and others 2003), but each requires substantial time and resources, pose a steep learning curve, and often do not use specific recorded fire events in the calculation. ArcGIS is a commonly used program by most fire planners and managers; so, we developed a python script-based tool to evaluate our fire management program on the Talladega Division in east central Alabama.

The Talladega Division is the largest remaining tract of montane longleaf located among the highest points in Alabama on the terminus of the Appalachian chain. The Division is mandated with endangered species recovery and currently has 30 active red-cockaded woodpecker clusters. It is projected to have 230 clusters by 2050 to achieve recovery. Fire management is central to restoration of this unique ecosystem, and fuels management in the wildland-urban interface is also of concern. The Talladega's proximity to large metropolitan areas creates smoke management issues not unique to National forests throughout the Southeast. Currently only 150,000 acres or 60 percent of the Division has experienced active fire management in the last 22 years, and the frequency of fire is not achieving historic return intervals to create desired future conditions or manage smoke.

In 1823, cartographers of the day noted that the area consisted of an "extensive pine forest" (fig. 1). Subsequent land surveys circa 1832 (Shankman and Wills 1995), prior to settlement, indicate slopes and ridge tops were dominated by pines with steeper slopes dominated by longleaf, transitioning to shortleaf pine on more gentle slopes and broad ridge tops to loblolly pine in the bottoms. Fire-adapted hardwoods were intermixed in this pine matrix on differing slopes and aspects. Bale (2009) examined the fire scar dendrochronology record on two ridge systems on the Shoal Creek Ranger District and revealed that from 1653 to 1831, prior to Native American extirpation, the fire return interval was 2.7 to 3.2 years. After settlement, the fire frequency increased to a range of 2.5 to 2.6 years from 1832 to 1940. Bale also found that 97 percent of the fires occurred during the dormant season and that fuel bed analysis showed that three years post fire the fuel bed was saturated and capable of carrying a fire. The Forest Service, U.S. Department of Agriculturebegan acquisition in 1937 and

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promptly began controlling and suppressing all wildland fire, effectively removing fire out of a fire-dependent ecosystem. Prescribed fire began in the mid to late 1980s to manage fuels and comply with management for endangered species. Managers have utilized prescribed fire since then but had never systematically evaluated the fire program's extent or ability to achieve a fire frequency to manage fuels or mimic the natural disturbance regime. To evaluate the fire program, fire records were digitally recorded and an ArcGIS tool developed to summarize the cumulative effect of fire events through time.

METHODS

An ESRI shapefile of all wildfire and prescribed fire events from 1978 to the present was gathered for the Division by assimilating paper and digital records. The master shapefile with all fire records must have a 'date' field in the ESRI date field format. The master shapefile attributes included fire weather conditions, objectives, date, fire type, and location. From the master file, the fire history time period of interest was exported into a new shapefile and the Integrate tool in ArcGIS was used to unify concomitant roads, streams, and burn block boundaries to reduce polygon slivers. The tool was executed in ArcCatalog by identifying the shapefile, an output folder, and the beginning and ending dates of the growing season for the area. The result was a geodatabase containing a feature class that can be brought into ArcMap for display and interpretation of the frequency, seasonality, and recency of the fire program.

The output gives the user the total number of fire events in each polygon to calculate the annualized average fire return interval or fire frequency, years of fuel accumulation (i.e., date last burned), and frequency of growing and dormant season fire events and the relative dates they were last burned during those seasons. The tool also records the last date a fire occurred in each polygon, which can be used to create a fuel accumulation map with annualized rough accumulations. Further calculations can be made by examining the total acreage under fire management, the relative percentages of the fire frequencies across intervals. The extent of the fire program less the boundary of ownership will also illustrate areas missing fuels management. Going back to the master file summaries can be made for the timing of prescribed fires and wildfires to further expose trends in fire management history.

RESULTS AND DISCUSSION

By gathering and summarizing the fire management on the Talladega Division, we were able to see several critical trends. Figure 2 illustrates the annualized rough accumulation on the Division. This information can be used by managers in identifying areas in need of fuels treatment and pairing the relative fuel load with the best atmospheric conditions. For example, the middle of the Division has not been burned since before the year 2000. The liabilities of a fuel load in excess of 13 years and its proximity to highways, parks, and the public may merit that the area either falls out of fire management or that they are only attempted if frequent firing can be sustained into the future to reduce fuel loads and smoke emissions. The areas without fire history also illustrate the ecological and fuel management need to mitigate future wildfire events, a full third (36 percent) of the ownership has no record of fire management. The tool also identifies areas where fuel loads are diminished and moving towards maintenance conditions. For the manager and the decisionmaker, the tool illustrates the trade-off and aids in illustrating the decisions to be made in managing fuels and focusing management. Ultimately, fuels management works by reducing fire intensity and extent which is illustrated on the Division with a declining trend in dormant season (October to March) wildfire events from 1985 to 2012 (fig. 3).

Based on Bale's (2009) analysis, fires were considerably more common during the dormant season. However, lightning ignitions are a common event on the Division, and there is a place for periodic growing season fire events on the Talladega for site prep or top killing and shifting understory vegetation from shrubby hardwood to a more grassy herbaceous community. Growing season prescribed fires were first tested in 1998 and used in earnest since 2003 with a third of all prescribed fires occurring during the growing season. Seasonality expands the fire management window and has its place with current "fire deficit" across the landscape. Ultimately, the more important metric of successful fire management is fire frequency rather than seasonality.

Looking back over 22 years of fire management on the Division, the fire deficit on the landscape becomes apparent but the lack of frequent fire is of greater concern if smoke is to be mitigated and if ecosystem restoration is to be achieved. Table 1 shows a breakdown of annualized fire rotations across two-year intervals on a 150,000-acre basis (prescribed and wildfire fire extent) and under the entire ownership. On the 150,000-acre basis, only 40 percent is receiving prescribed fire on a return interval less than six years. Sixty percent has greater than a six-year fire return interval, is not restoring the ecosystem, and is marginally helpful with fuel and smoke management. When looking across the entire ownership on a 235,000-acre basis, the same pattern is illustrated with a third of the forest without any fire management, another third with very marginal fuel management, and a final third—where fire frequency is approaching historic norms—ecosystem restoration is eminent, fuel loads are being managed, and smoke is mitigated (fig. 4). Moving forward using this tool to summarize cumulative effect of fire events, managers will be able to improve decisions on where prescribed fire is utilized by concentrating resources where restoration can be achieved then expanding outward from a core of fire maintained habitats.

Fire management is constrained by resources, weather, personnel, air sheds, and smoke management concerns. In order to address these limitations, it is useful to know the legacy of previous fire management actions and a generalized knowledge of fuel accumulation, fire frequency, and seasonality of previous prescribed fire events when planning. Monitoring the extent and condition of fire events is critical information that can be used to make better decisions and focus limited resources to achieve desired future conditions.

Go to www.cafms.org/fft to download the tool.

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Table 1—Percentage of average annualized fire frequency by 2-year intervals for the 150,000 acres under fire management from 1990 to 2012 and for the entire 235,000 acre ownership

Fire frequency	150K	235K
	---- *percent* ----	
<2 years	1	1
2.1-4.0 years	16	10
4.1-6.0 years	17	10
6.1-8.0 years	30	19
8.1-12.0 years	2	1
12.1- 22 years	34	22
No fire	0	36
	100	100

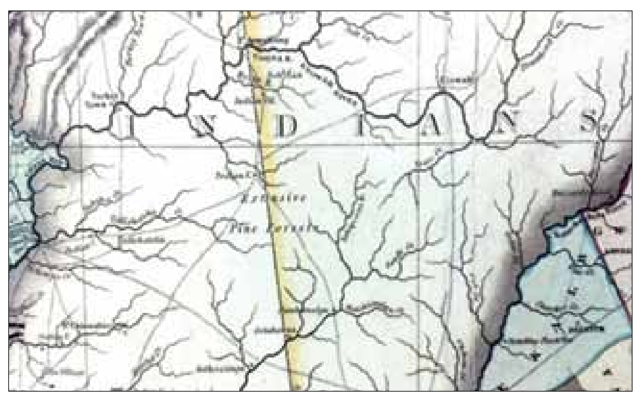

Figure 1—Map in 1823 prior to extirpation of Creek and Cherokee Indian Nations identifying the area as an "extensive pine forest."

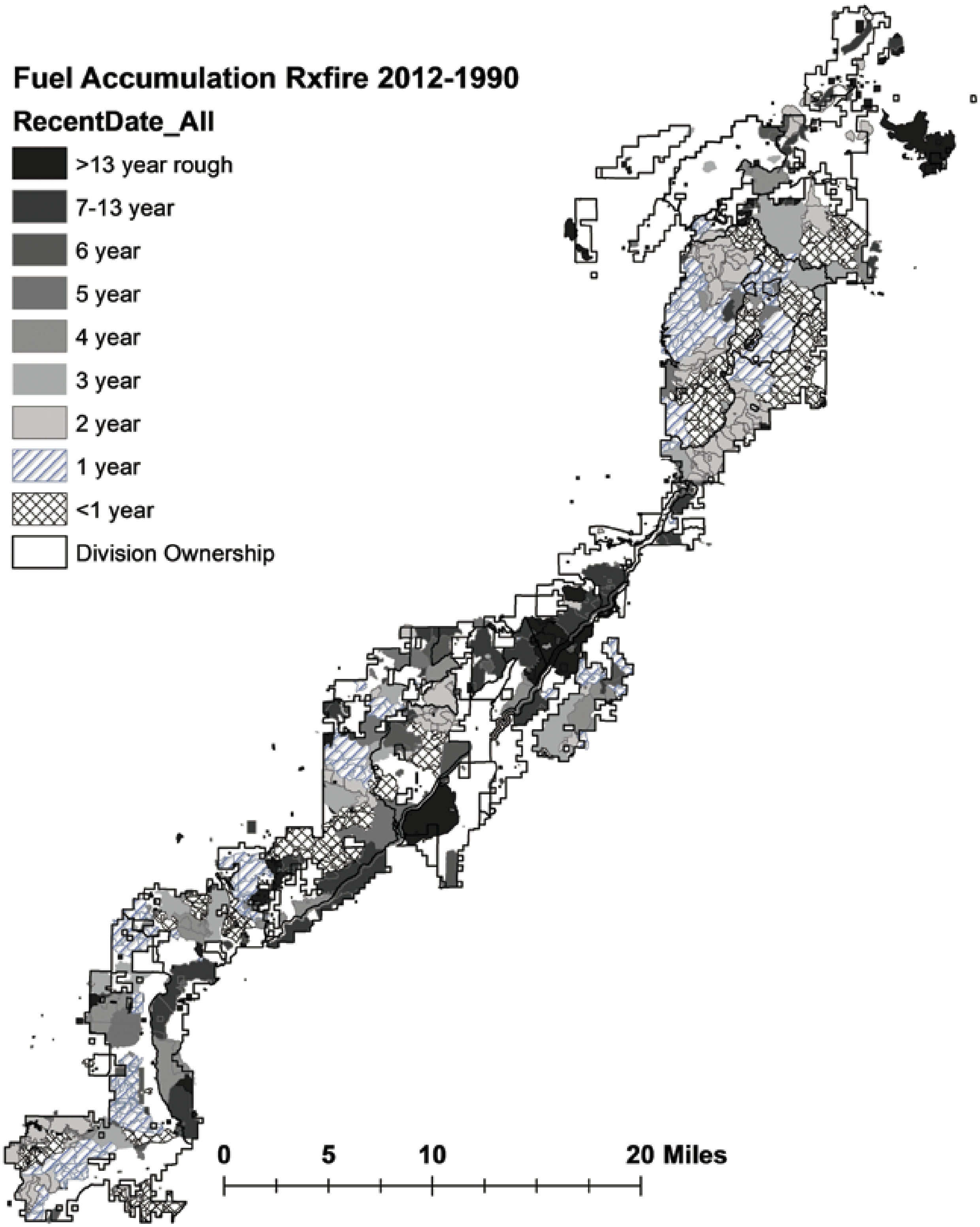

Figure 2—Fuel accumulation (rough accumulation) illustrated as time since last fired from 1990 to 2012.

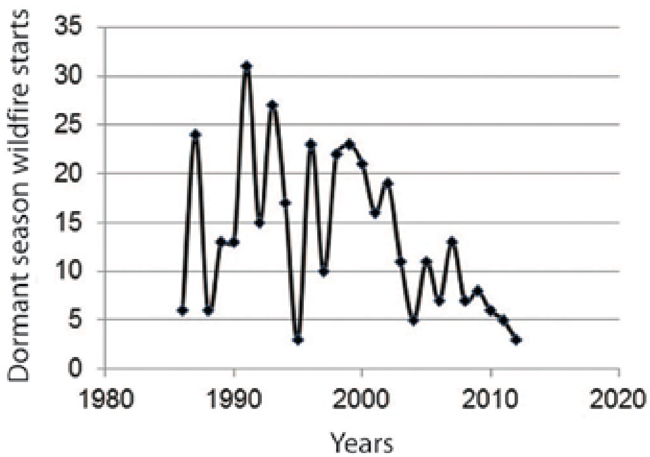

Figure 3—Declining trend in dormant season (October-March) wildfires from 1985 to 2012 illustrating the impact of fuels management on the Talladega Division.

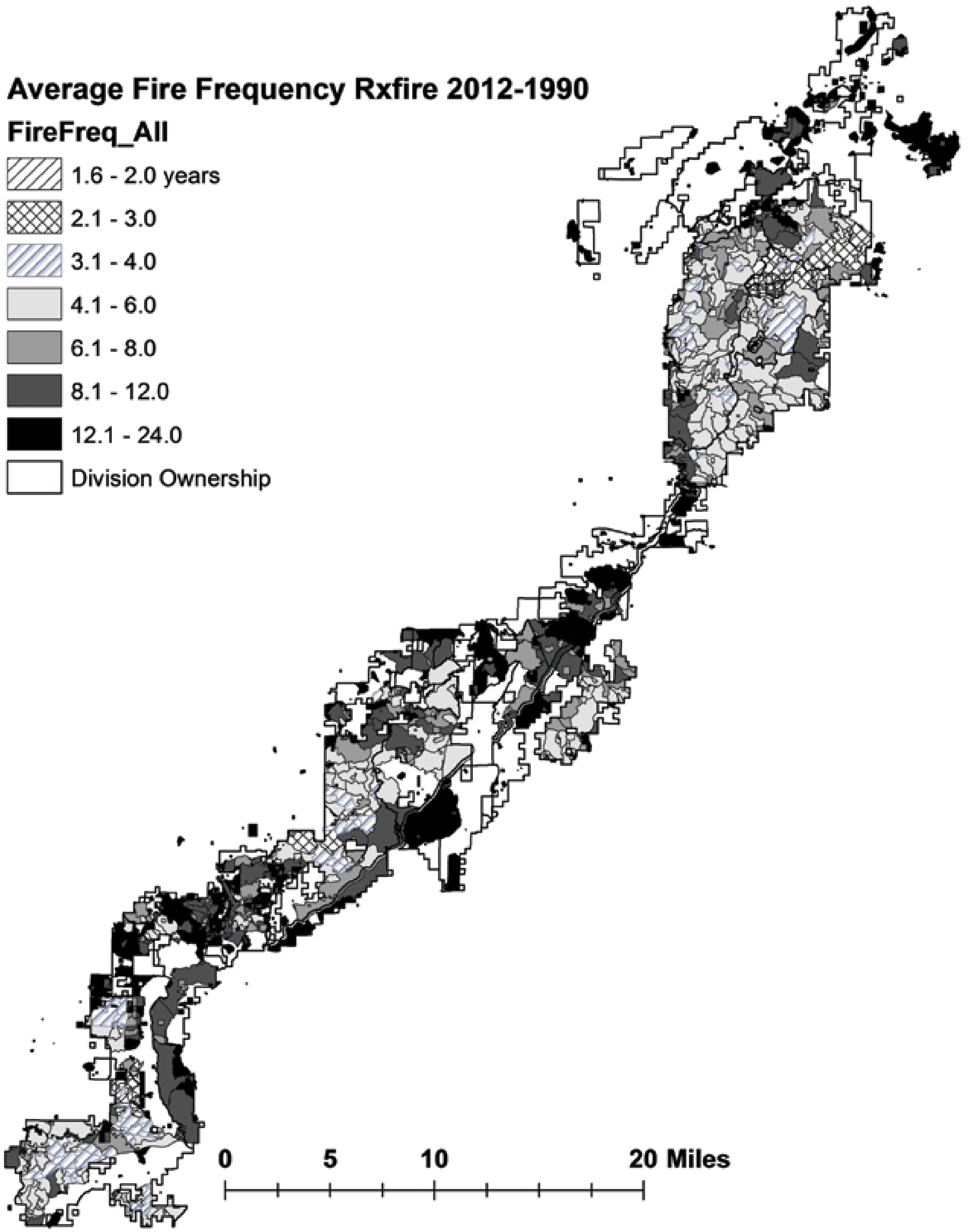

Figure 4—Annualized average fire frequency for the Talladega Division from 1990 to 2012.