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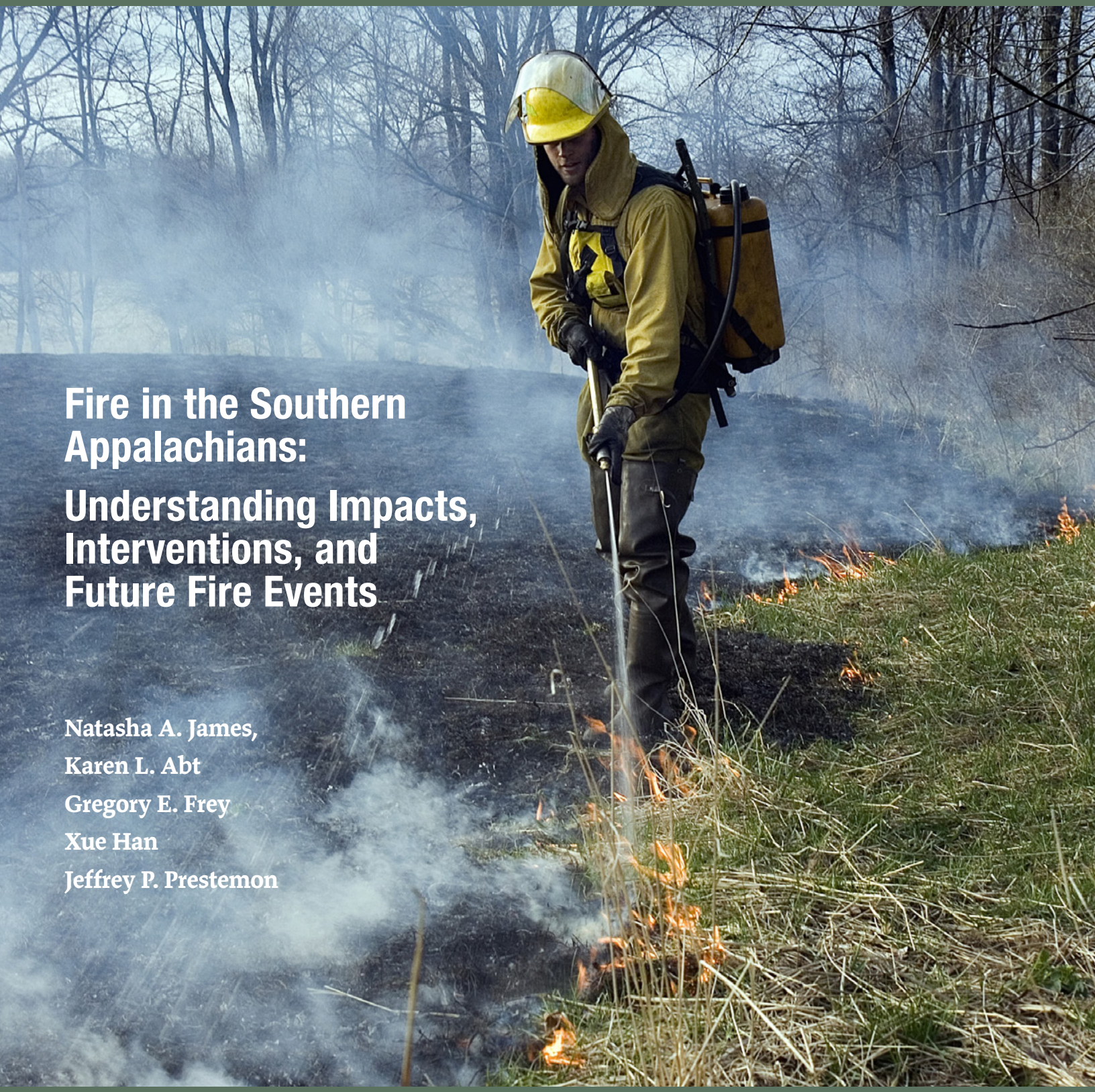

Fire in the Southern Appalachians:

Understanding Impacts, Interventions, and Future Fire Events

Natasha A. James,
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Abstract

From October to December of 2016, a confluence of human and environmental factors led to an outbreak of wildfires across the Southern Appalachian Mountains. This report examines the time trends of fire in the Southern Appalachian region, including mitigation activities and forecasting acres burned. The introduction (ch. 1) of this report describes the 2016 Southern Appalachian fires on public lands and provides a brief description of the methodology used to understand economic impacts of fire. Chapters 2 and 3 examine how prescribed fire is used in this region. The final chapter (ch. 4) describes how we can expect area burned by both human- and lightning-caused fires to change given increases in global temperatures, fuels, and wildland fire management.

Keywords: Economics, prescribed fire, Southern Appalachia, wildfire.

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CHAPTER 1
Introduction

Natasha A. James, Karen L. Abt, Gregory E. Frey, and Jeffrey P. Prestemon

Fire is considered endemic to the Southern Appalachian region, and fire occurrence and extent are generally lowest in the summer and highest in the fall, with spring providing a secondary peak (Keyser and others 2014). In 2016, an exceptional drought that lasted through the summer and into the fall affected the Southern Appalachian region and contributed to an above-normal fall fire season (NICC 2016a). Below we examine these fires on public lands and briefly describe the methodology used by economists to measure the impacts of fire. Elsewhere, this report examines the time trends of fire in the Southern Appalachian region, including mitigation activities and forecasting acres burned.

The 2016 Fire Season in the Southern Appalachian Region

From October to December of 2016, a confluence of human and environmental factors led to an outbreak of fires across the Southern Appalachian Mountains. From mid-October through mid-November, the Southern Area Coordination Center[1] was operating at level 5, the highest level of preparedness. The Southern Appalachian fires resulted in loss of life and loss of structures, as well as damage to natural resources and infrastructure (NICC 2016b).

Nationwide in 2016, there were 1,251 significant wildfires (defined as >100 acres in timber or >300 acres in grass) (see fig. 1.1) (NICC 2016a). Of these, 621 (nearly 50 percent) were in the South (the 13 Southern States from Kentucky to Florida to Oklahoma and Texas) (NICC 2016a). These fires contributed to only 29 percent of the nationwide area burned in significant fires in 2016, implying that fires in the South are on average smaller than fires in other regions of the United States (NICC 2016a). Nationally in 2016, there were 3,192 residences and 78 commercial structures burned; of these, 2,121 residences and 53 commercial structures burned in Tennessee alone (NICC 2016a).

To examine the fires on public lands in the Southern Appalachian region in more detail, we use data from two public sources, the fire occurrence database (Short 2017) and fire records maintained by the National Wildfire Coordinating Group (2017), and evaluate the fire records by year and by cause on national forest lands and national park lands in the Southern Appalachian region. We first focus on fire records for the national forests (land managed by the U.S. Department of Agriculture Forest Service) in the Southern Appalachian region, including the Chattahoochee-Oconee National Forest, the Cherokee National Forest, and the National Forests of North Carolina (the lands of the Nantahala and Pisgah National Forests only), followed by an evaluation of fires in the Great Smoky Mountains National Park (GSMNP; land managed by the U.S. Department of the Interior National Park Service). These fire records are only for wildfires and do not include prescribed fires unless they escaped and were declared wildfires.

[1] The Southern Area Coordination Center (https://gacc.nifc.gov/sacc/) is the focal point for mobilization of emergency resources between 13 Southern States, Puerto Rico, and the U.S. Virgin Islands.

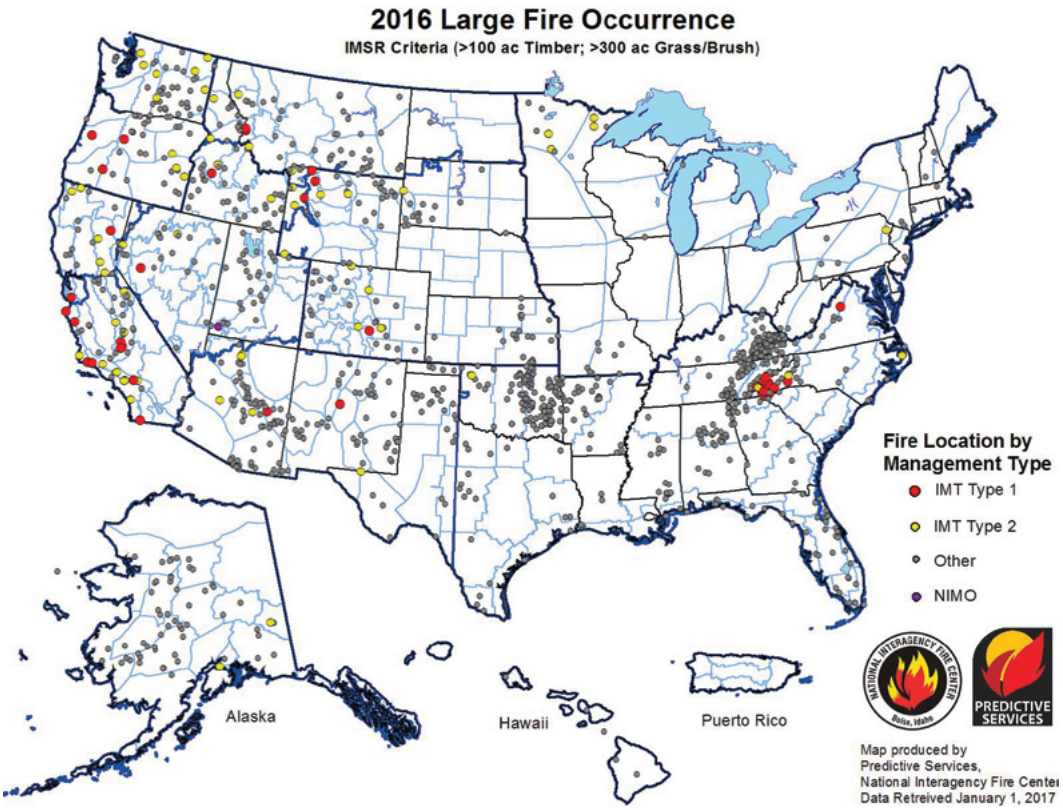

Figure 1.1—Large fire occurrence and location by Incident Management Team (IMT) type in 2016 (Type 1, Type 2, Other, and National Incident Management Organization [NIMO]). Map source: National Interagency Coordination Center 2016a. Data source: Incident Management Situation Report (IMSR) from National Wildfire Coordinating Group 2017.

Fires on the Chattahoochee-Oconee National Forest, Cherokee National Forest, and National Forests of North Carolina

Since 1992, more than 337,000 acres have burned in fires that started on national forest lands on the Chattahoochee-Oconee National Forest, Cherokee National Forest, and National Forests of North Carolina (Nantahala and Pisgah). In 2016, 116,909 acres burned on these forests, 35 percent of the total acres burned since 1992. Figure 1.2 shows the area burned on these forests by year, as well as the number of fires started. The average fire size for these forests over the 26 years in the dataset was 90 acres, with the average size of 664 acres in 2016 the largest over these 26 years.

Examining area burned by season from 1992 through 2017, figure 1.3 shows that 2016 was the largest fall burning year, but fall burning also dominated the years from 1999 through 2001. Figures 1.4 and 1.5 show the number of fires and acres burned by cause, respectively, over time for these national forests. Humans are the dominant cause of fires in these national forests (Chattahoochee-Oconee, Cherokee, and North Carolina [Nantahala and Pisgah]) with >56 percent of acres burned resulting from arson and 18 percent from other human causes.

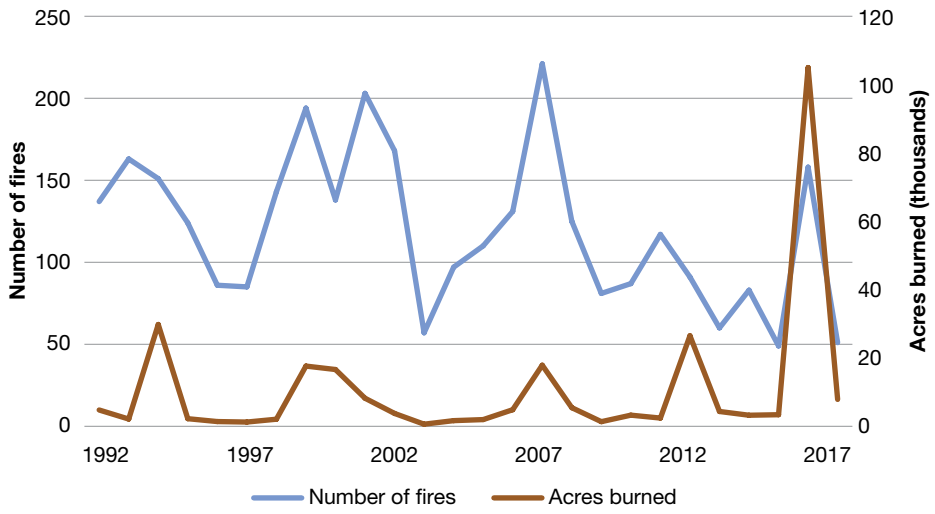

Figure 1.2—Number of fires and total acres burned from fires ignited on the Chattahoochee-Oconee National Forest, Cherokee National Forest, and National Forests of North Carolina (Nantahala and Pisgah), 1992–2017. Data sources: Short 2017; National Wildfire Coordinating Group 2017.

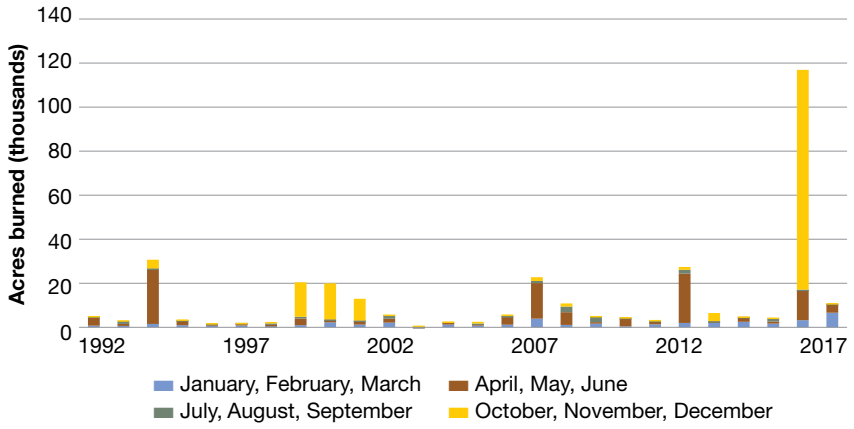

Figure 1.3—Acres burned by quarter for 1992–2017 from fires ignited on the Chattahoochee-Oconee National Forest, Cherokee National Forest, and National Forests of North Carolina (Nantahala and Pisgah). Data sources: Short 2017; National Wildfire Coordinating Group 2017.

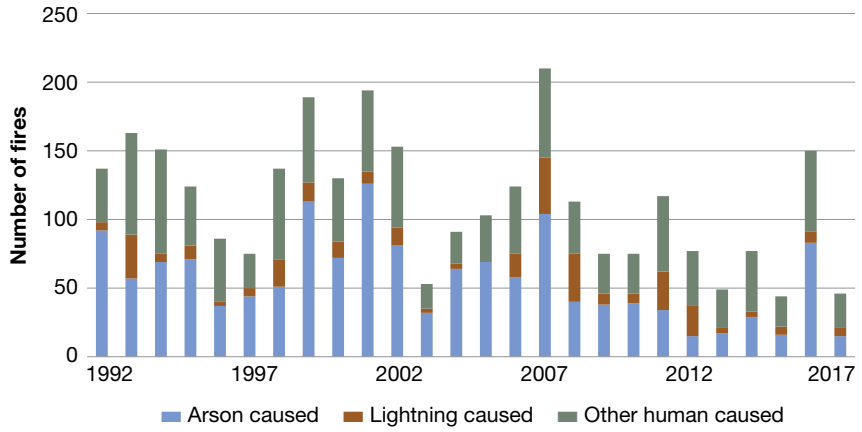

Figure 1.4—Number of fire starts by cause on the Chattahoochee-Oconee National Forest, Cherokee National Forest, and National Forests of North Carolina (Nantahala and Pisgah), 1992–2017, excluding fires with unknown causes. Data sources: Short 2017; National Wildfire Coordinating Group 2017.

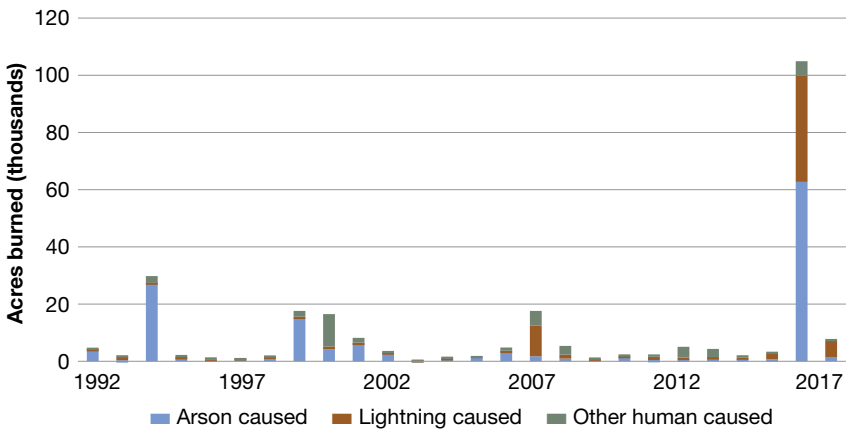

Figure 1.5—Acres burned by cause on the Chattahoochee-Oconee National Forest, Cherokee National Forest, and National Forests of North Carolina (Nantahala and Pisgah), 1992–2017, excluding fires with unknown causes. Data sources: Short 2017; National Wildfire Coordinating Group 2017.

Fires in the Great Smoky Mountains National Park

Similar to the national forest lands, 2016 was primarily a fall fire event in the Great Smoky Mountains National Park (GSMNP). While the fires on the national forests in the Southern Appalachians were notable, it was a fire that started in the GSMNP, and ultimately burned through parts of Gatlinburg, TN, that brought the 2016 fire season national notice (Hanna and others 2016). Records on fires in GSMNP show that 2016 was remarkably different from all previous years in our data, largely as a result of this one fire—Chimney Tops 2.

Figure 1.6 shows that of the nearly 35,370 acres that burned in the GSMNP between 1992 and 2017, 52 percent burned in 2016 (18,332 acres). Of the 2016 area burned, 17,140 acres (93 percent) were burned in the Chimney Tops 2 Fire. The GSMNP had a total of 256 fires over these 26 years, with an average overall size of 138 acres.

Except for 2011 and 2016, there were so few fires and acres burned in GSMNP between 1992 and 2017 that it is not possible to identify trends by season or cause. There was a single large arson-caused fire (the Sharp Fire) in 2011 and a single large children-caused fire[2] in 2016 (the Chimney Tops 2 Fire).

[2] Children-caused fires are included in the "Other human caused" category (see figs. 1.4 and 1.5).

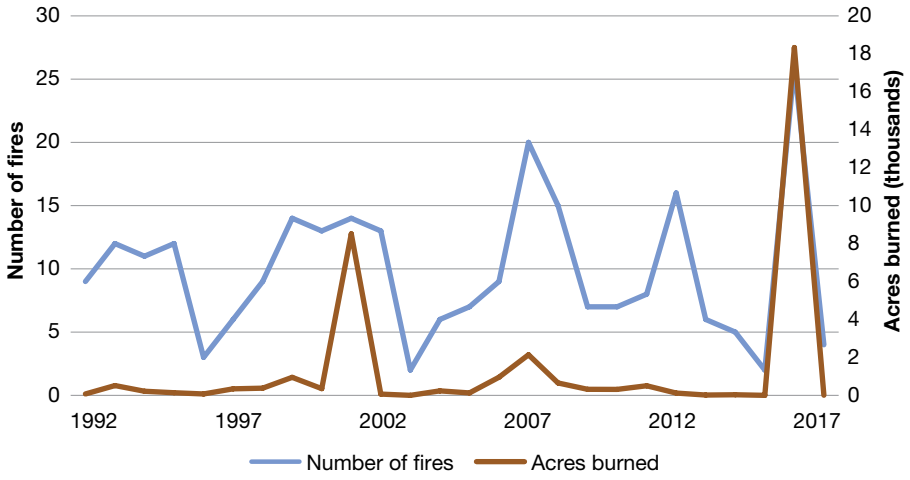

Figure 1.6—Number of fires and acres burned in fires started in the Great Smoky Mountains National Park, 1992–2017. Data sources: Short 2017; National Wildfire Coordinating Group 2017.

Understanding the Impacts of Fires

Economists measure the impacts of natural disasters, such as damage from wildfires, as changes in economic welfare. A framework for accounting for economic costs and losses from disasters is often used to enumerate direct losses in quantities of physical capital, as well as what are called "indirect losses" which include business losses owing to damages to capital, labor, and supply chains; premature mortality resulting from damages to human health; losses due to averting behavior by consumers (recreation shifts, evacuation); and losses due to changes in perception of a community leading to changes in trade and investment (Abt and others 2008, Botzen and others 2019).

Economic analysis does not focus on just the impact during and after a fire—economists also study the costs and benefits of interventions that could be undertaken before the fires ignite. Interventions include activities designed to reduce ignitions such as fire prevention education (e.g., Abt and others 2015, Butry and others 2010, Prestemon and others 2010) and to reduce damages from fire such as fuel treatments and averting behavior (e.g., Abt and others 2011, Dickie 2017, Huggett and others 2008, Prestemon and others 2008). These interventions are often analyzed in the context of minimizing the costs (e.g., prevention, treatment, and suppression) and losses (e.g., damage to timber, infrastructure, and human health), where all input and output prices as well as effects on the forest and fire are known or assumed (Gebert and others 2008, Prestemon and others 2012).

The objective of this report is to examine the time trends of fire in the Southern Appalachian region, including intervention activities and forecasting acres burned. Specifically, we will analyze how controlled burning is used in the region (chaps. 2 and 3) and how area burned from wildfire may change in the future (ch. 4).

Report Summary

Forest managers can utilize low-intensity fires under the appropriate environmental conditions and management to reduce fuel loads in forests, thereby reducing wildfire hazard over time. **Chapter 2** discusses the State-level laws and regulations surrounding the use of such controlled burns on private lands in the Southern Appalachian region. These laws and regulations are organized into two types: open burn laws and certified prescribed burn laws. Open burn laws are older, are directed at the burn implementation phase, and have criminal penalties for noncompliance. Certified prescribed burn laws are newer, are directed at both the planning and implementation phase, and have no criminal penalties, but compliance can reduce burn managers' liability to civil claims. The chapter describes differences in these requirements, liability standards, and other incentives across States in the region.

Chapter 3 utilizes available burn notification data from the United States to understand potential geographic and time trends in hazard-reduction burns. There were no consistent increases or decreases in fire utilization over time through the region, indicating relatively stable burning conditions and policy context. However, there were geographic trends. Among the States for which data were available, Georgia tended to have the most hazard-reduction burns overall and largest percent of total forest land burned each year. Within States, counties in the Appalachian ecological zone had a smaller area of hazard-reduction burns than counties in the Piedmont and Coastal Plain regions.

Chapter 4 discusses forecasts of fire activity in the Southern Appalachian region. Based on research models reported in Prestemon and others (2016), we projected annual area burned due

to human and lightning ignitions, 2011 through 2060, for the 32 counties in our study area of the Southern Appalachians. Projections were done for three alternative scenarios developed for the 2010 Resources Planning Act Assessment (USDA Forest Service 2014a, 2014b). As in Prestemon and others (2016), we used a Monte Carlo approach to generate envelopes of projected areas burned by these aggregate wildfire cause categories, which provides a picture of the plausible ranges of areas burned in the coming decades. This modeling indicates that median area burned by lightning-caused wildfires would increase by 236 percent, comparing 5-year windows 2016–2020 and 2056–2060. Human-caused median area burned would decrease by 80 percent between those two 5-year windows. In total, median area burned would decline by 30 percent. These shifts imply that wildfire management approaches may change over the coming years to address the increase in the projected acres burned.

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CHAPTER 2

Controlled Burning Laws and Regulations for Private Lands in the Southern Appalachian States

Gregory E. Frey and Xue Han

ABSTRACT

Managed burning of forests under favorable conditions, or "controlled burning," can reduce fuel loads so that intense wildfires, such as those in the Southern Appalachians in 2016, are less likely. Southern Appalachian States have laws and regulations for two legal levels of controlled burning, open burning and certified prescribed burning, on private lands, which seek to address and mitigate the risks of damages from escaped fire and smoke. We generated a baseline of information about controlled burn policy by reviewing and comparing laws and regulations governing the use of open and certified prescribed burning on private forest lands in the Southern Appalachian States. Open burning laws have criminal penalties for noncompliance, are directed at the burn implementation stage, and are relatively older, whereas certified prescribed burning laws reduce burners' liability and are directed at both the planning and implementation stages. The States of South Carolina, Alabama, and Tennessee had the most requirements for open burning, whereas Georgia, Kentucky, and a North Carolina substate region had the fewest. South Carolina, Alabama, and Virginia had the most requirements for certified prescribed burning, whereas Georgia, North Carolina, and Tennessee had the fewest. Georgia applied a gross negligence standard to liability for smoke and escaped fire damages, and South Carolina applied a gross negligence standard for smoke damages, but all the other States applied a simple negligence standard.

Keywords: Administrative regulation, certified prescribed burn, open burn, statutory law.

Introduction

Fire has long been utilized as a forest land management tool under favorable environmental conditions; such fire is called "controlled burning." It may be used for wildfire hazard reduction, competition control, wildlife habitat improvement, and site preparation; however, there are associated risks. Escaped fire can cause damage to property, injury, or death. Likewise, smoke can negatively impact public health or impair visibility affecting transportation. Because of these risks, governments have strong incentive to regulate fire. On the other hand, because of the benefits of controlled burning, governments also seek to incentivize its use under careful management. This has led to a bifurcated system of controlled burning policy in most Southern States—one layer of open burning statutory laws and administrative regulations ("laws" and "regulations," respectively) that delineate minimum requirements for fires to be used legally, subject to criminal penalties for noncompliance, and a second layer of optional certified prescribed burning laws and regulations that hold burn managers to a higher standard of care and provide legal incentives such as limitation of liability for escaped fire. Further, States may provide additional incentives for careful certified prescribed fire, including monetary incentives and subsidized training.

Historically, States have had laws and regulations that criminalized certain risky behaviors related to open burning. Over time, beginning in the 1990s, Southeastern States from Florida to Kentucky have enacted and implemented laws and regulations for certified prescribed burns, which seek to incentivize use of more planning and care. There continue to be significant differences among States in the regulation of open and certified prescribed burns, which may affect how and where fires are implemented (Haines and Cleaves 1999, Haines and others 2001, Sun and Tolver 2012, Wonkka and others 2015).

Past research has reviewed and compared State laws and regulations regarding certified prescribed burns, and classified them by level of strictness of requirements or by level of liability for escaped fires (Haines and Cleaves 1999; Hauenstein and Siegel 1981; Hodges 1997; Siegel 1984; Sun 2006, 2007; Sun and Tolver 2012; Wonkka and others 2015; Yoder 2008). Other research has explored the economic benefits and costs of certified prescribed burns at the social and individual levels (Hesseln 2000; Mercer and others 2007, 2008; Pye and others 2003; Yoder 2008; Yoder and others 2003). Finally, quantitative analysis has been used to examine the factors that have influenced the existing certified prescribed burning laws and regulations in a State (Sun 2006, Wonkka and others 2015). However, to our knowledge, past research has not clearly distinguished between the levels of requirements for open versus certified prescribed burning among States.

Objectives

The purpose of this research was to understand controlled burn legal and regulatory policy for private lands in the Southern Appalachian States. We assessed laws and regulations related to two types of controlled burns: "open burns" that meet minimum requirements and "certified prescribed burns" that are incentivized and have a higher standard of care. We sought to:

- Identify and describe the difference between open burning and certified prescribed burning regulations
- Update and improve the current knowledge about controlled burning laws and regulations in the Southern Appalachian region
- Compare laws and regulations between States
- Understand how laws and regulations have changed over time

Methods

Region of Interest

The region of interest for this research is the Southern Appalachian States, which we define as Alabama, Georgia, Kentucky, North Carolina, South Carolina, Tennessee, and Virginia.

Legal and Regulatory Analysis and Comparison

We sought to distinguish between the statutory laws and administrative regulations ("laws" and "regulations," respectively) of open burning from that related to certified prescribed burning, focusing specifically on burning to reduce future wildfire risk (fuel

load-reduction or hazard-reduction burns). For the purposes of this research, we define open burning as those practices that meet the minimum legal standard of care, subject to criminal penalties for noncompliance. Certified prescribed burning meets a higher standard of care and is incentivized by limits on civil liability for damages.

We began our research by first contacting State forestry agency fire chiefs or designees in each of the seven States to understand the general policy landscape for controlled burning in each State. We then conducted a detailed review of laws and regulations in each State related to open and certified prescribed burning. Such were typically found among the chapters of each State's statutory and regulatory codes for the State forestry agency and State environmental agency.

To analyze and compare the laws and regulations in the seven States, we used a modified version of the policy comparison matrices presented in Sun and Tolver (2012) and Haines and Cleaves (1999), combining the two and eliminating a few unnecessary categories. We maintained and added to the numbering system used by Sun and Tolver (2012) to ease comparison. The primary innovation in this research was that we distinguished between laws and regulations for open burning versus those for certified prescribed burning. In addition, we added information related to the incentive/penalty system for compliance and noncompliance with open and certified prescribed burning rules. The categories of laws and regulations we assessed are given in table 2.1. Results of our analysis of the laws and regulations were then provided to the State agency contacts for their validation. All States except one (Alabama) verified the analysis, and in some cases provided minor corrections.

Data Limitations

The data on laws and regulations are relatively complete but can be complex, so they require simplification in some cases. Further, we did not delve into the case law and other contextual factors, which can create some differences in the ways similar laws and regulations are interpreted and implemented from State to State. For example, there may be slight differences in the definition and meaning of specific legal terms (e.g., "gross negligence" and "simple negligence") from State to State.[3] These seven States are similar enough in context that we assumed limited definitional or interpretation issues.

Results

Table 2.2 presents the legal and regulatory requirements and incentive structure for open burning and certified prescribed burning by State. Two of the States have multiple legal structures either separate for geographic regions within the State (North Carolina) or for different time periods within the year (Tennessee). North Carolina has a higher level of legal and regulatory requirements for fire in 19 "high-hazard" counties (designated NC1 in table 2.2)[4] and a lower level for the other 81 counties (NC2). Tennessee has a higher level of

[3] According to Sun (2007, p. 565), "Simple negligence, also known as negligence, is carelessness or lack of the exercise of due care toward others or their properties. The standard for measuring whether or not a person is simply negligent is the reasonable prudent person. Gross negligence is the lack of even slight care of a defendant to carry out a duty toward others or their properties with a reckless disregard for the consequences of the activity. Compared with simple negligence, gross negligence just needs a slight diligence and entails a much smaller amount of carefulness. The standard of care for gross negligence is much lower than that for simple negligence." Negligence, gross negligence, and their respective defenses depend on common law in each State and can vary slightly. (Personal communication. 2019. William Cary, Partner, Brooks Pierce Law Firm, Greensboro, NC 27401).

[4] The 19 North Carolina "high-hazard" counties located near the eastern coastline are: Beaufort, Bladen, Brunswick, Camden, Carteret, Chowan, Craven, Currituck, Dare, Duplin, Gates, Hyde, Jones, Onslow, Pamlico, Pasquotank, Perquimans, Tyrrell, and Washington.

Table 2.1—Legal and regulatory requirements for open and certified prescribed burning[a] at the State level

Requirements		Description
PLANNING STAGE		
Certification		
P01.	Certified burner	State manages program to certify prescribed burn managers
P02.	Training	Require training to become a certified burn manager
P03.	Experience	Require burning experience to become a certified burn manager
P04.	Recertification	Specify recertification procedures for burners
P05.	Decertification	Specify procedures for decertification or revocation
P06.	Insurance	Require purchase of liability insurance for burn manager
Prescription		
P07.	Prescription–prepared	Require a written prescription to be prepared
P08.	Prescription–notarized	Require the prescription to be notarized or witnessed
P09.	Prescription–approved	Require the prescription to be approved by an agency
P10.	Prescription–minimum	Require minimum items for the prescription
P11.	Prescription–smoke	Require smoke management plan in the prescription
P12.	Prescription–weather	Require weather conditions stated in the prescription
P13.	Prescription–urgent	Require emergency treatment plan in the prescription
IMPLEMENTATION STAGE		
Pre-burn preparation		
M01a.	Fire line–present	Require area around burn to be cleared of flammable material
M01b.	Fire line–inspect	Inspect fire control lines by agency
M02a.	Equipment–available	Require certain equipment to be available at burn site
M02b.	Equipment–inspect	Inspect equipment preparation by agency
Smoke		
M14.	Screening	Fire is screened to check potential air quality or visibility issues
M15.	Set-back	Set-back requirements from roads and highways
M16.	Windrow	Windrow restrictions as to size, number, or soil content
M17.	Starter fuels	Certain starter fuels prohibited
Burn execution		
M03a.	Notification–neighbors	Require notification of adjacent landowners prior to burn
M03b.	Notification–agency	Require notification of State agency prior to burn
M03c.	Notification–responders	Require notification of local fire department
M03d.	Permit/authorization	Require burn permit (agency has authority to deny permit)
M04.	Time	Specify burning seasons, hours, or bans
M05a.	Site–attend	Require presence on site until burn fully extinguished
M05b.	Site–cert. burner	Require a certified prescribed burn manager on site
M06.	Site–prescription	Require a written prescription on site at all times
M07.	Site–agency	Inspect and supervise burning on site by agency
Post-burn evaluation		
M08.	Evaluation–now	Require evaluation on burn immediately by burner
M09.	Evaluation–post-fire	Require evaluation during first post-fire season by burner
M10.	Evaluation–agency	Perform post-burn evaluation by agency
INCENTIVES		
Assistance		
I01.	Financial assistance	Financial assistance available from State (yes or no)
I02.	Technical assistance	Technical assistance available from State free or below cost (yes or no)
Liability		
I03a.	Criminal penalty level	Criminal penalty level for noncompliance with minimum fire requirements
I03b.	Maximum imprisonment	Maximum imprisonment (months) associated with the criminal level in I03a, for first offense (if applicable)
I03c.	Maximum fine	Maximum fine (USD) associated with the criminal level in I03a, for first offense
I04a.	Liability–suppression cost	Civil liability for cost of suppression
I04d.	Liability–damages	Civil liability for cost of damages under compliance with certified prescribed fire requirements

[a] For the purposes of this research, we define "open burning" as those practices that meet the minimum legal standard of care, subject to criminal penalties for noncompliance. "Certified prescribed burning" meets a higher standard of care and is incentivized by limits on civil liability for damages.

Table 2.2—Comparison and summary of legal and regulatory requirements and incentive structure for open burning and certified prescribed burning by State

Requirements[a,b]		O	P	N	AL	GA	KY	NC (NC1)[c]	NC (NC2)[c]	SC	TN (TN1)[d]	TN (TN2)[d]	VA
Open burn (O)					8	3	3	6	2	9	7	5	4
Certified prescribed burn (P)					9	3	13	10	12	9	8	10	13
None (N)					16	27	17	17	19	15	18	18	16
PLANNING STAGE													
P01.	Certified burner	0	8	1	P	N	P	P	P	P	P	P	P
P02.	Training	0	9	0	P	P	P	P	P	P	P	P	P
P03.	Experience	0	6	3	N	P	P	P	P	P	N	N	P
P04.	Recertification	0	3	6	P	N	N	N	N	N	P	P	N
P05.	Decertification	0	2	7	N	N	P	N	N	N	N	N	P
P06.	Insurance	0	0	9	N	N	N	N	N	N	N	N	N
P07.	Prescription–prepared	0	8	1	P	N	P	P	P	P	P	P	P
P08.	Prescription–notarized	0	1	8	P	N	N	N	N	N	N	N	N
P09.	Prescription–approved	0	1	8	N	N	N	N	N	N	N	N	P
P10.	Prescription–minimum	0	6	3	P	N	P	P	P	P	N	N	P
P11.	Prescription–smoke	0	6	3	P	N	P	P	P	P	N	N	P
P12.	Prescription–weather	0	6	3	P	N	P	P	P	P	N	N	P
P13.	Prescription–urgent	0	3	6	N	N	P	N	N	N	P	P	N
IMPLEMENTATION STAGE													
M01a.	Fire line–present	6	0	3	O	N	O	N	N	O	O	O	O
M01b.	Fire line–inspect	0	0	9	N	N	N	N	N	N	N	N	N
M02a.	Equipment–available	2	0	7	O	N	N	N	N	O	N	N	N
M02b.	Equipment–inspect	0	0	9	N	N	N	N	N	N	N	N	N
M14.	Screening	4	3	2	O	N	N	O	O	O	P	P	P
M15.	Set-back	1	0	8	N	N	N	N	N	O	N	N	N
M16.	Windrow	2	0	7	N	N	N	O	N	O	N	N	N
M17.	Starter fuels	5	0	4	O	N	N	O	N	O	O	O	N
M03a.	Notification–neighbors	4	3	2	O	N	P	P	P	N	O	O	O
M03b.	Notification–agency	5	4	0	O	O	P	O	P	O	O	P	P
M03c.	Notification–responders	0	1	8	N	N	P	N	N	N	N	N	N
M03d.	Permit/authorization	5	2	2	O	O	N	O	P	O	O	P	N
M04.	Time	7	0	2	N	O	O	O	O	N	O	O	O
M05a.	Site–attend	6	1	2	O	P	O	N	N	O	O	O	O
M05b.	Site–cert. burner	0	8	1	P	N	P	P	P	P	P	P	P
M06.	Site–prescription	0	6	3	N	N	N	P	P	P	P	P	P
M07.	Site–agency	0	0	9	N	N	N	N	N	N	N	N	N
M08.	Evaluation–now	0	0	9	N	N	N	N	N	N	N	N	N
M09.	Evaluation–post-fire	0	0	9	N	N	N	N	N	N	N	N	N
M10.	Evaluation–agency	0	0	9	N	N	N	N	N	N	N	N	N
INCENTIVES													
I01.	Financial assistance				no	yes	no	yes	yes	yes	no	no	no
I02.	Technical assistance				Unk.	yes	no	yes	yes	yes	yes	yes	yes
I03a.	Criminal penalty level				Mis.–B	Mis.	Not specified[e]	Mis.–3	Mis. –3	Mis.	Mis. –B/C	Mis. –B	Mis.– 3/4
I03b.	Maximum imprisonment (months)				6	12	6	0.33	0.33	1	6	6	0
I03c.	Maximum fine (USD)				3,000	1,000	500	200	200	200	500	500	500
I04a.	Liability–suppression cost				Simp. neg.	Simp. neg.	Simp. neg.	Simp. neg.	Simp. neg.	None	Simp. neg.	Simp. neg.	Simp. neg.
I04d.	Liability–damages				Simp. neg.	Gross neg.	Simp. neg.	Simp. neg.	Simp. neg.	Depends on damages[f]	Simp. neg.	Simp. neg.	Simp. neg.

O = open burn requirement; P = certified prescribed burn requirement; N = no such requirement in State law or regulation.

Unk. = unknown; Mis. = misdemeanor, followed by the class/level of offense; Simp. neg. = simple negligence; Gross neg. = gross negligence (see footnote 1).

[a] See table 2.1 for description of each requirement. Legal open burns must meet requirements indicated by O. Certified prescribed burns by definition must meet all requirements indicated by O and P.

[b] Columns with O, P, and N headers indicate the sum of States/substate regions that have that particular open burn requirement, certified prescribed burn requirement, or no requirement. Likewise, rows with O, P, and N headers indicate the sum of requirements within a particular State or substate region.

[c] NC1 and NC2 represent different policies regarding separate geographic regions within North Carolina: NC1 pertains to 19 counties in the eastern part of the State designated as "high-hazard" counties, whereas NC2 pertains to the remaining 81 counties.

[d] TN1 and TN2 represent different policies in Tennessee for different times of year: TN1 is in effect October 15–May 15, whereas TN2 is in effect May 16–October 14 each year.

[e] Kentucky did not specify if violation was a felony or misdemeanor, but the penalty levels were consistent with what would generally be considered a misdemeanor in most States.

[f] South Carolina applies a gross negligence standard to liability for smoke-related damages and a simple negligence standard for other types of potential damages.

requirements from October 15 through May 15 each year (TN1) and a lower level from May 16 through October 14 (TN2). Including these two legal structures for North Carolina and Tennessee meant that nine distinct legal structures were considered for the seven States.

Legal and Regulatory Requirements for Open Burning

In all States, open burn laws and regulations only applied to the implementation stage; that is, there were no planning-stage requirements that carried a criminal penalty for noncompliance. To meet the minimum standards for open burning, the most common requirements were for time of day or season (seven of nine legal structures), establishing a fire line/fire break (six of nine), and having a person present on site until the fire is fully extinguished (six of nine), followed by limitations on the types of starter fuels allowed (five of nine), notifying the State agency (five of nine), and receiving a permit from the State agency (five of nine).

The State with the most requirements for open burning is South Carolina (nine), followed by Alabama (eight), and TN1 (seven). The States with the fewest legal and regulatory requirements for open burning are NC2 (two), Georgia (three), and Kentucky (three). The three States/substate regions with the fewest requirements share one common rule: to observe certain time-of-year or time-of-day burn bans for air quality reasons.

Legal and Regulatory Requirements for Certified Prescribed Burning

Certified prescribed burning laws and regulations were applicable at both the planning stage and implementation stage. The one requirement for certified prescribed burning in all States was training of the burn manager.[5] The next most common certified prescribed burning requirements were having a certified burn manager to oversee the burn (eight of nine legal structures), preparation of a burn prescription or plan (eight of nine), and having the certified burn manager present on site until the fire is fully extinguished (eight of nine), followed by having minimum standards for the burn prescription (six of nine), which include smoke management plans (six of nine) and weather conditions (six of nine), as well as having the prescription present on site during the burn (six of nine).

Because open burn requirements are a legal minimum, certified prescribed burns must first meet those requirements, so the requirements listed as P in table 2.2 would be in addition to those listed as O. Therefore, to compare the number of requirements for certified prescribed burning, we must sum the open burn and certified prescribed burn requirements, which is equivalent to subtracting the number of requirements not imposed from the total number analyzed ($O + P = 33 - N$). Using this method, South Carolina has the most total requirements for certified prescribed burn (18), followed by Alabama and Virginia (17 each), then Kentucky and NC1 (16 each). Georgia has the fewest total requirements for certified prescribed burn (six), followed by NC2 (14) and Tennessee (15 each for TN1 and TN2).

Incentives, Including Penalties and Liability

Noncompliance with open burn laws and regulations makes burners subject to criminal penalties in all States (table 2.2). The criminal penalties were classified as misdemeanors

[5] In some cases, such as in Georgia, the requirement is to have either training or equivalent experience.

in all the States;[6] however, the category of misdemeanor and level of punishments varied widely. Maximum imprisonment for first offense had a median time of 6 months across States but varied from no imprisonment in Virginia to 10 days in North Carolina to 12 months in Georgia. However, some States do not specify punishment maximums for first versus subsequent offenses and may allow judges to consider (lack of) prior offenses along with other factors in sentencing. Maximum fines for noncompliance had a median of $500 but ranged from $200 in North Carolina and South Carolina to $3,000 in Alabama.

Following certified prescribed burn laws and regulations is presumed to help burners prove they have not been negligent in a court of law, should they be fined for suppression costs or sued for civil damages. In the area of liability for reimbursement of suppression costs, in the case of an escaped fire which a local fire department must suppress, all States except South Carolina applied a simple negligence standard to liability. In South Carolina, the burner cannot be held liable for suppression costs. In the case of civil damages, all States except Georgia and South Carolina applied a simple negligence standard. Georgia applied a gross negligence standard to liability for all types of potential damages. South Carolina applied a gross negligence standard to smoke-related damages and a simple negligence standard to other types of potential damages.

Some States provide financial incentives and/or technical assistance to encourage certified prescribed burning. There are few laws or regulations regarding the use of these tools to support the use of prescribed fire. We contacted the State forestry agency fire chief (or designee) in each of the seven States to better understand practical financial and technical assistance for fire management. All States except one (Alabama) confirmed our conclusions.

Three out of seven States offer some type of financial assistance—generally cost-sharing reimbursement payments for certified prescribed burns that meet program criteria. Five out of seven States offer some type of free or below-cost technical assistance for landowners, which includes educational workshops, site visits by State foresters to provide advice with burns, or assistance writing a burn prescription. For example, North Carolina Forest Service indicated that free technical assistance is offered to landowners wishing to do their own burning. This includes making a site visit, preparing a burn plan, and going over the plan with the landowner prior to the burn, as well as loaning of hand tools, such as drip torches, fire rakes, etc. However, a program for plowing firelines at no cost to the landowner was suspended for several years for budget reasons and has not been reinstated as of the time of writing, but the firelines can still be plowed for a fee.

Legal History

Table 2.3 presents a list of the primary laws in each State governing open and certified prescribed burning. The list is not comprehensive in terms of all relevant laws to burning; however, the laws indicated are the most directly relevant to each type of burn. We also do not include administrative regulations in table 2.3.

Table 2.3 also presents the year that each of these laws was first enacted. This shows that open burn laws have generally been part of the legal code in each State much earlier than the certified prescribed burn law. Open burn laws were adopted between 1923 (Alabama) and 1989 (Tennessee), with four enacted between 1950 and 1964. It is possible that there

[6] Kentucky did not specify if violation was a felony or misdemeanor, but the penalty levels were consistent with what would generally be considered a misdemeanor in most States.

Table 2.3—List of primary laws governing open and prescribed burning, and dates first enacted

State	Primary laws	Year earliest version(s) enacted	Primary law	Year earliest version(s) enacted
Alabama	§9-13-11 to 13	1923, 1939	§9-13-273	1995
Georgia	§12-6-90	1956	§12-6-148	1992
Kentucky	§149.375 to 430	1964, 1966	§149.175	2016
North Carolina	§106-942 to 943	1981	§106-968	1999
South Carolina	§48-35-10	1962	§48-34-40	1994
Tennessee	§39-14-305 to 306	1989	§11-4-1003	2012
Virginia	§10.1-1141 to 1142	1950	§10.1-1150	1998

were predecessor laws under a previous codification system in some States that dealt with similar open burning issues, but our review was restricted to laws currently in force, so they are not listed here. All certified prescribed burn laws are more recent, having been enacted between 1992 and 2016.

Discussion

Bifurcation of Controlled Burn Laws and Regulations

The laws and regulations regarding controlled burns in the Southern Appalachian States address two primary risks: the risk of escaped fire causing direct damage to property or injuring people, and the risk of harm due to smoke, particularly indirect injury or health issues. To address these risks, we found that most of the States had two types of systems, often codified separately: open burning laws and regulations, and certified prescribed burning laws and regulations. For example, in Alabama, the open burning laws are codified primarily in the Code of Alabama (C.O.A.) §9-13-11 to 13 and regulation in Alabama Administrative Code (A.A.C.) §335-3-3-.01, whereas the certified prescribed burning laws are codified in C.O.A. §9-13-273 and regulations in A.A.C. §390-X-6. Similarly, open burning is codified in the Official Code of Georgia Annotated (O.C.G.A.) §12-6-90 and regulated in Georgia Rules and Regulations 391-3-1, but certified prescribed burning in O.C.G.A. §12-6-148.

This separation or bifurcation of law and regulation between open burn versus certified prescribed burn, on top of the natural division of requirements and agencies involved along with the two types of risks (smoke versus escaped fire risk), creates a complex legal environment. Such a system can be confusing to the uninitiated and may present a barrier to landowners who are interested but not educated on the system. Most of the States do provide technical assistance,[7] and the population of trained certified prescribed burn managers in each State[8] may help educate landowners about their options and obligations.

[7] Kentucky does not provide technical assistance at time of writing, and Alabama is not known.

[8] An exception is Kentucky, which has not certified any prescribed burn managers at time of writing.

Law and Regulation Trends over Time

The most notable trend over time regarding controlled burn law and regulation is that open burn laws are older and have been supplemented in the State codes with certified prescribed burn laws over time. Florida, which is adjacent to our study area, has been one of the leading States to manage forest land using controlled burns. In 1990, Florida passed a prominent statute on certified prescribed fire which limited certified prescribed burners' liability unless simple negligence could be proven. In 1999, Florida modified the simple negligence standard to gross negligence for certified prescribed fire (Brenner and Wade 2003).

Not surprisingly, some administrative regulations that Florida adopted have influenced the attitudes and perceptions of stakeholders on fire management in other States, which have in turn modified their laws and regulations. We identified a trend that laws and regulations among the States have become more consistent over time, as more and more States adopt a certified prescribed burn model to limit burners' liability.

No two States have the same natural conditions or economic, cultural, political, and legal environment. They also differ in air pollution laws and regulations, certified professionals, and landowners' perceptions and concerns, each of which requires a customized fire management strategy. The biggest challenge for fire management depends on the analysis of the demand of fire regimes in different areas required for ecosystem restoration and management, as well as fuel reduction. One of the main issues that different States need to resolve is how to incorporate and consider all components for the use of certified prescribed fire, rather than managing individual fire use only by following other precedent cases (Penman and others 2011).

Financial and Technical Assistance

Controlled burning is a complex management tool that varies by vegetation type, topography, landscape heterogeneity, and weather, all of which affect the efficiency of fire management. Furthermore, fire is inherently dangerous and may inflict severe damages or injuries upon humans and properties. However, there is little discussion in the scientific literature about the impact of technical assistance programs to support landowners or burners and promote further understanding of fire management.

From an economic perspective, a landowner considering the use of controlled burning in land management will perceive benefits, operational costs, risks, and risk mitigation costs. If the landowner's expected net benefit considering all these factors is not positive, they will choose not to implement the burn (Yoder and others 2004). Financial assistance may be important in making the net benefit positive for some landowners (Schultz and others 2018).

Conclusions

Southern Appalachian States have laws and regulations for open burning and certified prescribed burning, which seek to address and mitigate the risks of damages from escaped fire and smoke. Open burning laws and regulations are the legal minimum requirements for the implementation of burning on forest land, and burners are subject to criminal misdemeanor penalties including imprisonment up to 12 months and fines ranging from $200 to $3,000. Certified prescribed burning laws and regulations are optional rules in addition to the open burning rules for both the preparation and implementation of burning on forest land that burners can follow to help limit their civil liability in case of escaped

fire or smoke issues. Open burning laws are relatively older and codified separately from certified prescribed burning laws.

Of the Southern Appalachian States for which we have relevant information, Georgia has the fewest requirements for open and prescribed burning and is also the State with gross negligence standards (rather than simple negligence) for liability from all types of damages due to burns; South Carolina has the most total rules.

Future research is needed for a better understanding of how laws and regulations vary within States due to local ordinances, location of urban populations, and other factors.

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CHAPTER 3

A Recent History of Controlled Burning for Wildfire Risk Mitigation in the Southern Appalachian States

Gregory E. Frey and Xue Han

ABSTRACT

Controlled burns in forest ecosystems are one tool for reducing fuel loads thereby mitigating risks of future wildfire. We assessed data on certified burners and burn notifications or authorizations for trends between and within Southern Appalachian States for which data were available, and over time. Georgia and South Carolina had the most certified burners, followed by Alabama and Virginia, then North Carolina and Tennessee. Of the States for which we had data, Georgia had the most open burning, but data were inadequate to derive conclusions about the States with the most certified prescribed burning. Fires tended to be fewer and had smaller total acreage in Appalachian counties compared to non-Appalachian counties within the same State. In all, this baseline should prove useful for future researchers, but more research is needed, including detailed spatial analysis.

Keywords: Certified prescribed burn, fuel load, hazard reduction, open burn, wildfire risk.

Introduction

Fall 2016 was particularly dry in the Southern Appalachian region, with numerous wildfires, none of which was more consequential than the Chimney Tops 2 Fire, first reported on November 23 in the Great Smoky Mountains National Park. On November 28, winds caused the fire to spread explosively north into Gatlinburg, TN, burning approximately 17,000 acres and causing damage to or destruction of about 2,500 structures, and most tragically, the loss of 14 lives (USDOI NPS 2017). Other fires in the region during 2016, on both public and private lands, also generated losses.

These losses have led some to wonder if more can be done to prevent future wildfires in the Southern Appalachians. One tool to mitigate potential wildfire risk on certain forest lands is the use of controlled burns to reduce fuel loads during periods of low risk. The U.S. South has been a leading region in the trend towards utilization of controlled burns (Ryan and others 2013). Past research has examined the factors that have influenced the existing controlled burning laws in a State (Sun 2006, Wonkka and others 2015). However, to our knowledge, recent past research has not compared time and geographic trends for burning between and within Southern Appalachian States.

Objectives

The purpose of the research presented in this chapter was to create a baseline of knowledge about the current state and recent history of implementation of controlled burning in the Southern Appalachian States, with a particular emphasis on its use as a wildfire

risk mitigation tool. We assess two types of controlled burns: "open burns" that meet minimum legal requirements and "certified prescribed burns" that are incentivized and have a higher standard of care (see ch. 2 for detailed descriptions). This includes:

- Quantifying certification of burn managers by State
- Identifying trends in implementation of controlled fires over time
- Understanding the spatial distribution of controlled fires in Southern Appalachian States

Methods

Region of Interest

The region of interest for this research is the Southern Appalachian States, which we define as Alabama, Georgia, Kentucky, North Carolina, South Carolina, Tennessee, and Virginia. Data were acquired for the States of Alabama, Georgia, North Carolina, and South Carolina. When highlighting differences between Appalachian and non-Appalachian areas within these States, we utilize the Food and Agriculture Organization of the United Nations (FAO) delimitation of Temperate Mountain Systems in these States (FAO 2012) (fig. 3.1).

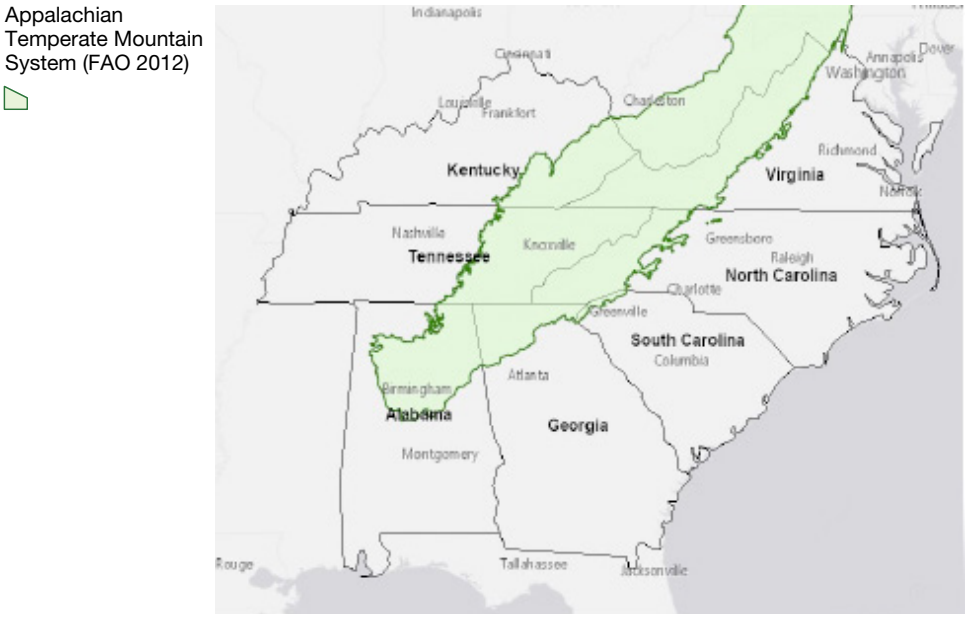

Figure 3.1—Seven Southern Appalachian States, within the Appalachian ecological zone, as defined by the "Temperate Mountain System" delimitation of the Food and Agriculture Organization of the United Nations (FAO 2012) highlighted in green.

Data and Analysis of Controlled Burning Authorizations

Implementation of controlled burns can be influenced by numerous factors, including policy, total forest area in a State, forest type, topography, and human population location and density. We used total forest area by State to control for the differences in forested acreage, and mapping to derive a basic understanding of spatial trends.

Certified prescribed burn managers are those who meet the requirements to undertake certified prescribed burning in a given State. The number of certified prescribed burn managers in a State is influenced by policy choices and can also influence how burning is implemented in the State. State fire chiefs or designees provided information about the number of certified burners in each State.

Many States have online systems to register burn notifications or permit applications, or otherwise keep a database of all burn notifications/permits in the State. In the States where notice is required for all controlled burns (not just certified prescribed burns), we approached State agencies to obtain data on all notifications/permits as far back in time as available. The data requested included date of burn, county, planned area of burn, purpose of burn, whether the permit was granted, and whether the burn met the standards of a certified prescribed burn. This information was available to varying degrees.

Kentucky, Tennessee, and Virginia had no statewide database with burn notification or permit information. Each of the four remaining States (Alabama, Georgia, North Carolina, and South Carolina) had some type of notification system that grouped burns into categories by purpose. Our analysis included all controlled burns, with a specific focus on hazard-reduction burns for wildfire mitigation (sometimes called fuel load-reduction burns). Several other controlled burn types were also included in the State databases. Each State had a slightly different categorization system, so we relabeled these into four forestry-related purpose categories (table 3.1): hazard reduction, site preparation, wildlife, and other silviculture. We included only burns from these categories in our analysis. Most States also had categories related to agricultural and residential burning, which we did not include in our analysis.

We focused only on controlled burns that were categorized with forestry-related purposes (i.e., not agricultural, residential, land clearing, or other purposes) and affected non-negligible forest land area with an acreage >0 acres. Zero-acre fires may represent small pile fires and were not the focus of this study. Finally, we excluded fires where a permit or authorization to burn was denied for any reason.

Table 3.1—Recategorization of State controlled burn forestry-related purpose categories

Categories used in this research	State burn purpose categories			
	Alabama	**Georgia**	**South Carolina**	**North Carolina**
Hazard reduction	Fuel reduction	Hazard reduction	Hazard reduction	Hazard reduction
Site preparation	Site preparation–piled debris	Site preparation	Site preparation	Site preparation for tree planting
	Site preparation–scattered debris			
Wildlife	Wildlife	Wildlife management	Wildlife management	Wildlife habitat
Other silviculture	Hardwood control	Silviculture	Hardwood control	Silviculture
	Understory		Disease control	Other
	Other understory			

We identified potential time trends and State-by-State differences in burns. To test for time trends (overall increases or decreases in average number or area of burns over time), we regressed burns on year, using $\alpha = 0.05$ to test for statistical significance.

For Alabama, Georgia, and South Carolina, we compared total number of burns and burn area as a percent of total forest cover area (Oswalt and others 2018) by State. We used this approach first to compare all open burns that fall in one of the four categories in table 3.1, then to compare only hazard-reduction burns. We also looked at certified prescribed burns by State.

To understand how hazard-reduction burns are distributed within the States, we used ArcGIS online to map the sum of acreage of hazard-reduction burns by county for the period 2014–2016, which we overlaid with the Appalachian Temperate Mountain System (FAO 2012).

Data Limitations

As noted previously, Kentucky, Tennessee, and Virginia had no statewide database with burn notification or permit information. North Carolina had a partial database of number of open burn notifications by county and month; however, this information did not include all notifications since many are kept as paper records in locations throughout each county, and we did not have resources to access those records. An online smoke management tool in North Carolina, which includes the variables of interest, must be completed only for certified prescribed burns. Georgia and Alabama require notification for all open burns and keep databases, but they do not distinguish in the database between general open burns and certified prescribed burns. In the case of Alabama, it is possible to infer a lower bound on the number of certified prescribed burns, since only certified prescribed burn managers are allowed to input their burn notification directly online. South Carolina maintains a database with all the variables requested and distinguishes between certified prescribed burns and other open legal burns.

It is not clear if and when double counting may occur, for example if a burn does not go forward on the date for which notification is given or the permit is requested, and a new notification is given or permit is requested at a later date. Also, the area of land notified to be burned and/or permitted by the State may not be an accurate measure of the area that is actually burned because areas may change to adapt to changing field conditions or other unforeseen circumstances.

Alabama stopped categorizing “fuel-reduction” fires in 2014, and it appears these were grouped together with “other understory” fires in a new “understory” category that began the same year. Since we could not separate the “fuel-reduction” fires from “other understory” fires after 2014, our data series for Alabama hazard-reduction fires ends in 2014.

Results

Certified Prescribed Burn Managers by State

The number of certified burn managers in a State could affect the number of certified prescribed burns in a State by limiting landowners' access to this service (or driving up the cost), particularly if the numbers are extremely low or not well distributed throughout the State. Figure 3.2 compares the number of certified burn managers on an absolute basis and per unit of forest land area across the seven States. The States with the highest numbers and numbers per 10,000 acres of forest land were Georgia and South Carolina, followed by Alabama and Virginia, then North Carolina and Tennessee. As of summer 2018, Kentucky was still in the process of beginning implementation of the certification program and had not yet certified any burn managers.

Differences in the number of certified burn managers could be due to both supply and demand factors. First, the relative proportion of different forest types, some of which may be fire-dependent, could drive demand for certified burners. If this were the only factor, however, one might expect North Carolina, which has substantial longleaf pine (*Pinus palustris)* habitat, to have more certified burners than Virginia, which has relatively little. Other State actions to promote certified prescribed burning, such as financial incentives, education of landowners, etc., could drive greater demand for certified burn managers. Policy and programmatic factors are likely to play a role in the supply of certified burn managers. For example, a high level of requirements to become enrolled (see ch. 2 in this report), including number of days of training, registration fee, whether previous burn experience is required, etc., could deter some potential applicants. Also, some States issue certification "for life," while others require recertification. This implies a tradeoff: higher levels of requirements may generate fewer, but perhaps higher quality, certified burn managers.

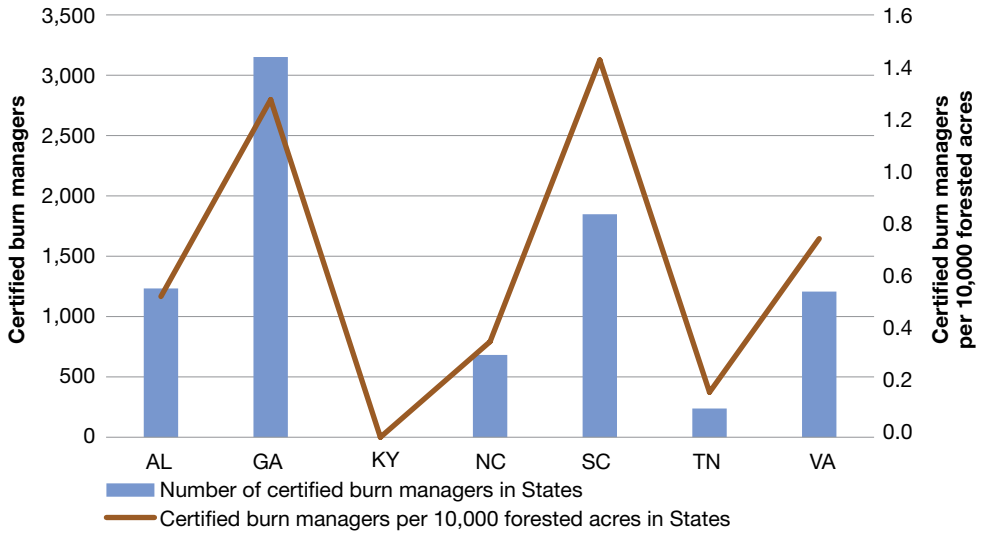

Figure 3.2—Certified burn managers by State: absolute number and per unit of forest land area.

Open Burn Authorizations by State

Three States out of the seven in our region of interest had relatively complete data on open burns through their notification or permitting system. Alabama provided data for 2008–2017, Georgia 2010–2017, and South Carolina 2009–2017. North Carolina had partial data on open burns for 2007–2017 because it is not required to use an online notification system or call a centralized office which inputs data into a database. Therefore, North Carolina data are not shown in figures 3.3–3.5. The North Carolina partial data do show an increasing trend in number of burns; however, that might simply represent an increasing tendency to utilize internet notification options over other notification options.

Total number of open burns is shown for Alabama, Georgia, and South Carolina in figure 3.3. Over the period indicated, Georgia had the most fires, averaging 23,875 open burns per year. Alabama averaged 7,137 burns, and South Carolina averaged 5,611 burns. Alabama showed a statistically significant positive time trend in number of burns over time ($R2 = 0.46$), indicating that the mean number of fires has been increasing in Alabama by about 248 burns per year. However, Georgia and South Carolina had no statistically significant time trend, suggesting that the average number of burns in those States has been relatively stable over the period.

States with a larger forest area, all else equal, would be expected to have more burns. Therefore, we normalized the burn area by dividing by the forest area in the State. This gives us a simple proportion, which we report as percent of State's forested acreage that is burned per year. Figure 3.4 shows percent of forest land burned by legal open burns each year in Alabama, Georgia, and South Carolina. Since Georgia has a larger forest area than Alabama and South Carolina, this reduces some of the difference between the States seen in figure 3.3. Still, Georgia averaged the highest percentage of burn area, at 4.3 percent of forested area annually, whereas Alabama and South Carolina both averaged 3.3 percent (fig. 3.4). None of the States showed a statistically significant time trend when tested over this data.

Hazard-reduction or fuel load-reduction burns are the most common type of open burning. As noted previously, these data for Alabama end in 2014. Hazard-reduction open burns, as a percent of State total forest area, are shown in figure 3.5. Hazard-reduction fires during the relevant period averaged 3.4 percent of State forest area in Georgia, and 2.1 percent in both Alabama and South Carolina. Georgia and Alabama did not have a statistically significant time trend; however, South Carolina had a statistically significant decrease in hazard-reduction burns over time, estimated at -0.07 percent per year over this period.

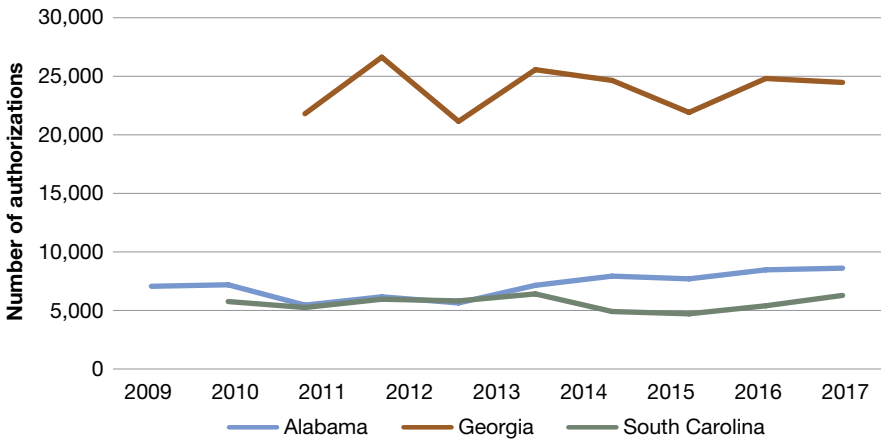

Figure 3.3—Number of legal open burn authorizations per year in State.

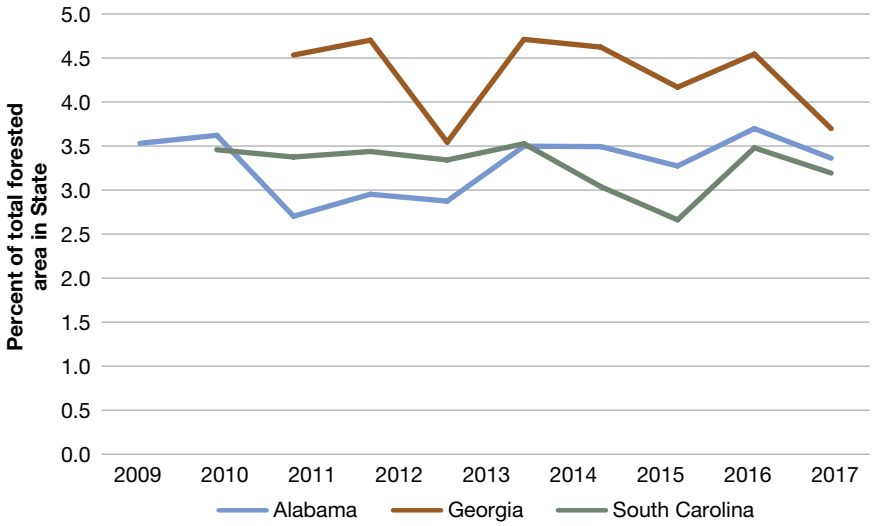

Figure 3.4—Authorized legal open burn area per year as a percent of total forested area in State.

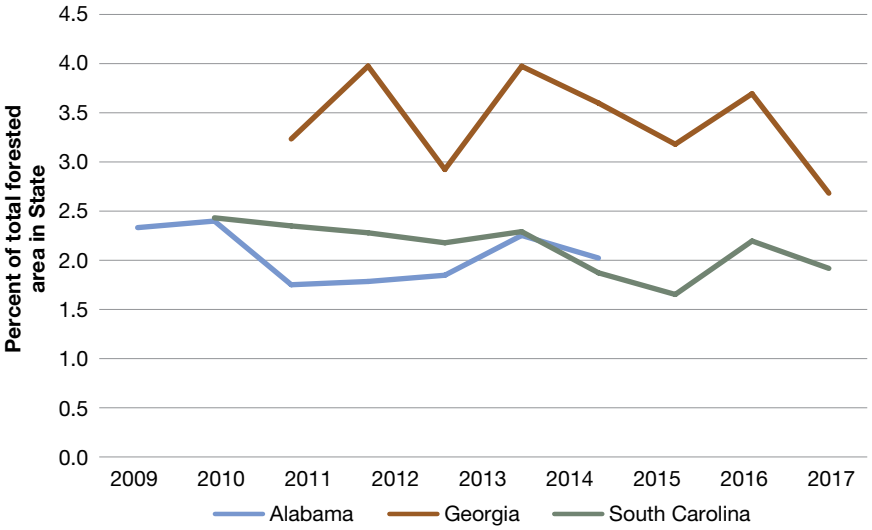

Figure 3.5—Authorized legal open hazard-reduction (fuel load-reduction) burn area per year as a percent of total forested area in State.

Certified Prescribed Burn Authorizations by State

Neither Georgia nor Alabama specifically designates certified prescribed burns in their database. In Alabama, it is possible to infer a lower bound on the number of certified prescribed burns, because non-certified burn managers are not allowed to provide notification to/request authorization from the State forestry agency via the online web tool, and all State forestry agency employees that are burn managers would be certified. Therefore, as a minimum, all internet and agency employee authorization requests are certified prescribed burns. North Carolina does not track all open burn notifications in a digital database but does require certified prescribed burners to complete an online smoke management tool, so data can be obtained from that source about certified prescribed burns.

Certified prescribed burns as a percent of State total forest area per year are given in figure 3.6. North Carolina averaged 0.4 percent and had smaller average area of certified prescribed burns as a percent of total forested area than Alabama or South Carolina over the time period covered by the data. Alabama appears to have fewer certified prescribed burns than South Carolina, but the Alabama data are a minimum, because we do not know how many certified prescribed burn managers call in their burn authorization requests. South Carolina averaged 2.3 percent of forest area per year over the period. None of the States had a statistically significant time trend.

Of the States for which data are available, only South Carolina tracks all open and certified prescribed burns and can therefore give us a reasonably reliable estimate of the proportion of open burns that are certified prescribed burns. Over the period 2009–2017, 70 percent of the area of open burns were certified prescribed burns. This showed a positive time trend, increasing by an average of 0.7 percent per year over the period.

Certified prescribed hazard-reduction burns as a percent of total forested area are given in figure 3.7. Over the periods for which data are available in the respective States, South Carolina averaged certified prescribed hazard-reduction burns on 1.6 percent of State forest area, Alabama 0.5 percent (lower bound), and North Carolina 0.2 percent.

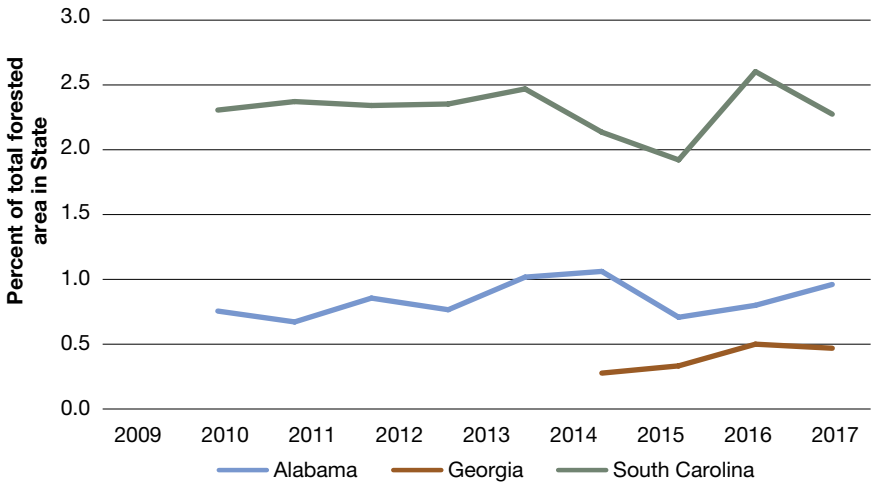

Figure 3.6—Certified prescribed burn area per year as a percent of total forested area in State. Data for Alabama represent burn authorization requests by State agency employees and via an online authorization tool, which can be interpreted as a lower bound.

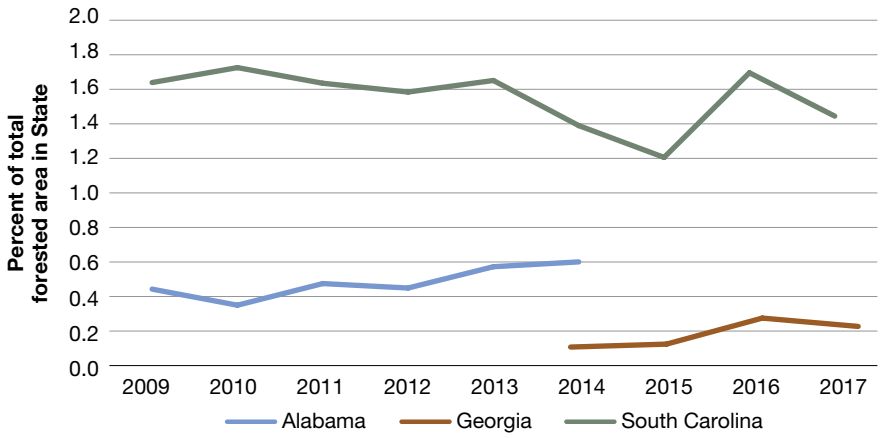

Figure 3.7—Certified prescribed hazard-reduction burn area per year as a percent of total forested area in State. Data for Alabama represent burn authorization requests by State agency employees and via an online authorization tool, which can be interpreted as a lower bound.

Distribution of Fire Authorizations within States

Although laws and regulations may drive differences between States, other factors may generate differences in burn implementation within States. Factors that are most obviously likely to create differences in the extent of burns include forest area, human population density, forest type, and topography. The first two are linked, with larger forest area tending to coincide with lower population density. Forest type and topography within a State may also be linked to an extent. In particular, the States in our study tend to have a large portion of loblolly (*Pinus taeda)* and longleaf pine associations in the Piedmont and Coastal Plain regions, whereas the Appalachian Mountain region is more heavily oak (*Quercus* spp.) and other hardwood associations, and has steeper slopes that can make managing burns more costly. In general, then, we would expect fewer fires overall within the Appalachian regions of each State.

In Alabama (fig. 3.8), the counties with the largest area of hazard-reduction burns are not in the Appalachian region. However, there were still a few Appalachian counties with relatively large areas of burns totaled over the period 2014–2016 including Cleburne (17,869 acres), Bibb (17,440 acres), and Winston (17,296 acres). This compares to the counties with the largest area of hazard-reduction burns, Escambia (38,875 acres), Covington (31,341 acres), and Washington (20,916 acres), which are all in the south of the State. Still the Appalachian counties with the largest acreage of burns had more area burned than the median non-Appalachian county.

In Georgia (fig. 3.9), there is a much clearer difference between the Appalachian counties in the north and west, and the non-Appalachian counties in the south and east. The Appalachian county with the largest hazard-reduction burn area totaled over the period 2014–2016 was Lumpkin with 12,045 acres. The county with the largest hazard-reduction burn area overall was Thomas, in southern Georgia, with 184,209 acres.

Similarly, Appalachian counties in South Carolina had substantially smaller area of hazard-reduction burns in general than many non-Appalachian counties to the south and east (fig. 3.10). Among Appalachian counties, Oconee in the northwest corner of the State had the largest area with 13,289 acres of hazard-reduction burn. On the other hand, Berkeley County, in the east and outside the Appalachian region, had 124,066 acres of hazard burn, and numerous other counties outside the Appalachian region had >30,000 acres.

Acres of permitted hazard-reduction burns by county, 2014–2016

- 21,000–39,000
- 12,000–21,000
- 5,000–12,000
- 1,000–5,000
- 0–1,000

Appalachian Temperate Mountain System (FAO 2012)

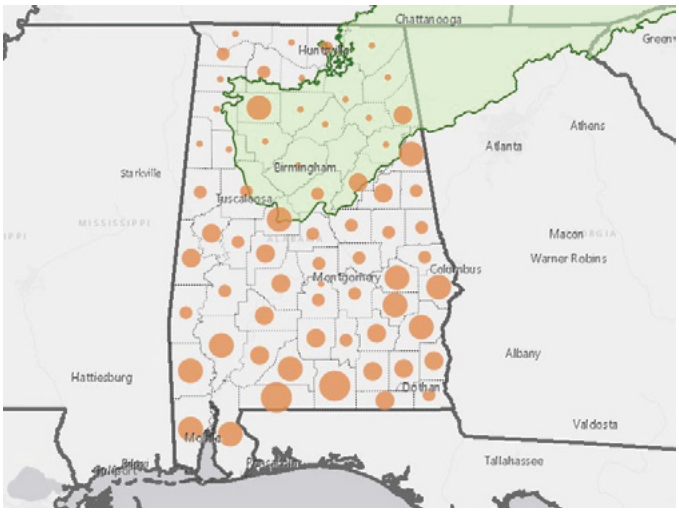

Figure 3.8—Area of permitted hazard-reduction burns by county in Alabama, 2014–2016.

Acres of permitted hazard-reduction burns by county, 2014–2016

- 74,000–185,000
- 37,000–74,000
- 19,000–37,000
- 8,000–19,000
- 0–8,000

Appalachian Temperate Mountain System (FAO 2012)

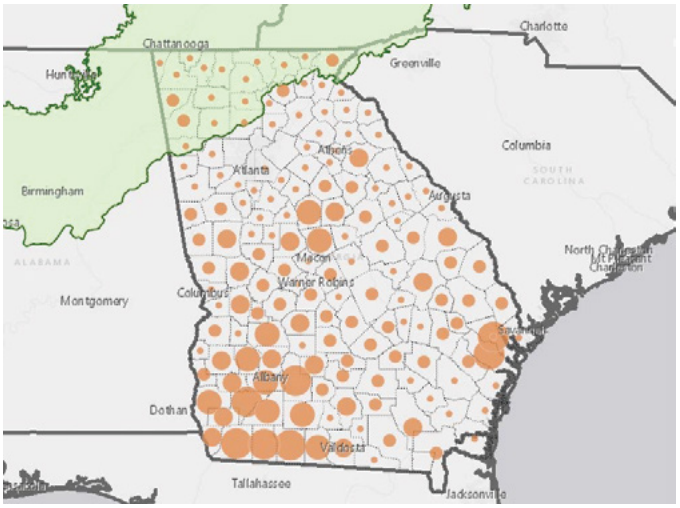

Figure 3.9—Area of permitted hazard-reduction burns by county in Georgia, 2014–2016.

Acres of permitted hazard-reduction burns by county, 2014–2016

- 46,000–125,000
- 27,000–46,000
- 13,000–27,000
- 5,000–13,000
- 0–5,000

Appalachian Temperate Mountain System (FAO 2012)

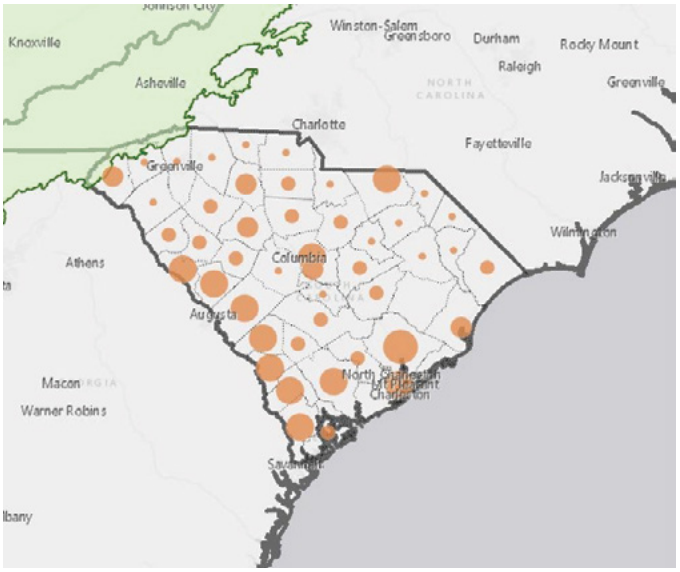

Figure 3.10—Area of permitted hazard-reduction burns by county in South Carolina, 2014–2016.

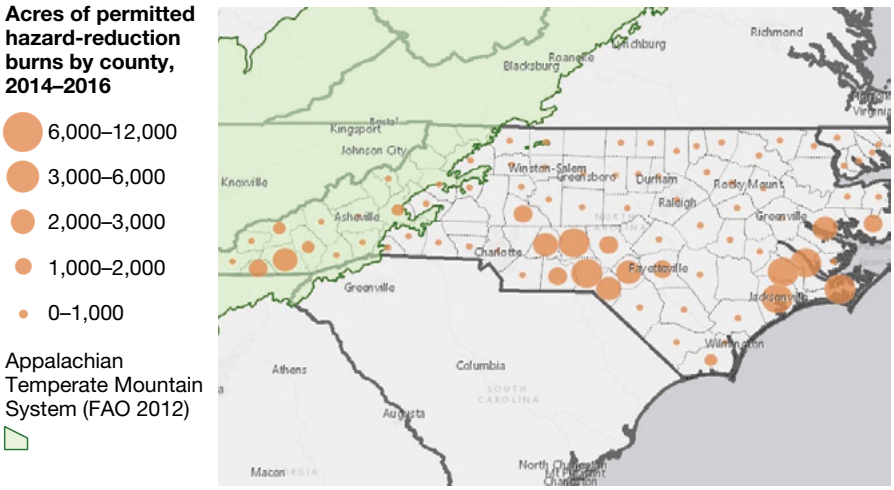

Figure 3.11—Area of certified prescribed hazard-reduction burns by county in North Carolina, 2014–2016.

North Carolina did not have data on all open hazard-reduction burns but did have data on certified prescribed hazard-reduction burns (fig. 3.11), which is a subset of the open burns. Within this subset, a few Appalachian counties in the southwest corner of the State had reasonably large areas of burns: Macon (5,731 acres), Clay (2,003), and Swain (1,906). Outside Appalachia, counties in the east and south-central parts of the State had larger areas burned including Onslow (11,722 acres), Carteret (11,495), Craven (8,636), Montgomery (8,051), Jones (8,012), and Dare (7,576).

In summary, all four States tended to have larger areas of burning outside Appalachia. However, Alabama and North Carolina had a few Appalachian counties with relatively large areas of burn, whereas Georgia and South Carolina Appalachian counties almost all had relatively small areas.

Discussion

Implementation Trends over Time

There are few trends of note in the use of open burning or certified prescribed burning for hazard reduction over time since the late 2000s/early 2010s to today. Of the States for which we have relatively complete data (Alabama, Georgia, South Carolina), there was significant year-to-year variation in the number and area of controlled burns, likely due to changing weather and other factors. Because there were no consistent trends among or within States, we do not believe the few statistically significant trends were particularly noteworthy.

Geographic Trends

Many flora and fauna species require periodic fire regimes for successful reproduction, control of competing vegetation, or other needs (Brockway and Lewis 1997, Piatek and McGill 2010). Four States in the region (Alabama, Georgia, North Carolina, South Carolina) have substantial area of forest containing longleaf pine, which is recognized as a fire-dependent species (Brockway and Lewis 1997). The same States with substantial longleaf pine also had data on open burns through their notification or permitting system, whereas

States with little longleaf had few data available.[9] Geographic analysis within these four States indicates that the use of hazard-reduction burning predominates in the Coastal Plain and Piedmont regions, rather than the Appalachian region, consistent with longleaf's distribution.

Although hazard-reduction burning is not equivalent to burning for longleaf restoration, common use of burning in these States for all purposes could be related to awareness of longleaf pine. Landowners may have learned about fire regimes (i.e., the frequency, intensity, seasonality, heterogeneity, and size of fires) and how to use burning to manage longleaf. This awareness could carry over to hazard-reduction burning. The use of burning as a management tool combines biological, ecological, political, economic, and social sciences, which require significant training. An increase in fire-related education may have contributed to the proper use of burning and its public acceptance.

Potential Influence of Burn Policy on Burn Implementation

Over the period 2010–2017, Georgia had more fires than other States in our region of interest, averaging 23,875 legal open burns per year, but also the fewest number of fire regulations (see ch. 2 in this report). Landowners or burners have concerns about the use of certified prescribed fire as a land management tool (Piatek and McGill 2010). First, even though awareness of the role of fire as a valuable tool has increased dramatically, many are concerned that escaped fires could cause property damage or even take people's lives. Second, private landowners worry about liability for air quality impacts and escaped fires (Haines and others 2001). To address these concerns, legal reforms have gradually changed liability burdens. Georgia followed Florida in applying a gross negligence rule in order to reduce liability of burners (Sun and Tolver 2012), which could be a cause of greater use of fires in Georgia.

In an ideal world, landowner decisions would be the result of a careful weighing of costs and benefits, informed by existing preferences. In reality, decisions are not always optimal due to limits on information, cognition, and time. Perceptions of risk are particularly challenging, as humans have difficulty internalizing costs associated with risks that have small probabilities. Level of risk aversion also varies from person to person. Policies designed to promote and incentivize the use of fire should consider these limits and behaviors. Future research should more fully explore how the regulations affect landowners' perceptions and attributes. In addition, better data on controlled burn use, controlled burn effects, landowner views, and public perceptions are needed to fully understand controlled burn policy (Haines and others 2001).

Conclusions

Over the period 2010–2017, Georgia had more fires than other States in our region of interest. South Carolina and Alabama had relatively fewer burns. These differences may be due to some combination of ecological, policy, and social factors.

For the States for which we have information, Appalachian counties tend to have fewer burns. This is generally expected due to forest ecology and topography in the Coastal Plain that lend themselves more to burning. However, even when considering controlled

[9] As previously noted, North Carolina had partial data on open burns for 2007–2017 because it is not required to use an online notification system or call a centralized office which inputs data into a database.

burns strictly for hazard reduction, which has more to do with reducing fuel loads than improving forest ecological conditions, the difference between Appalachian and non-Appalachian counties is still striking, particularly in Georgia and South Carolina. These within-State differences suggest that the biggest impediment to more hazard-reduction burns in the Appalachian region may be less about laws and regulations, and more about awareness of burning as a tool in hardwood ecosystems and the cost of conducting burns in mountainous areas.

A better understanding is needed of the factors that influence the decision to adopt open and prescribed burning as a forest management tool. A thorough spatial analysis could help control for forest type, topography, human population, and educational programs as well as peer-to-peer diffusion as factors that may influence adoption.

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CHAPTER 4

Wildfire Project for the Southern Appalachian Region, 2011–2060

Jeffrey P. Prestemon

ABSTRACT

The 2016 wildfires in the Southern Appalachian region were unusual for their relatively large extent and the damages, human morbidity, and mortality that they generated. To put these wildfires into context, we used information and data on wildfire projections for the region that were developed by Prestemon and others (2016) in their study of the future of wildfire in the Southern United States.

Keywords: Monte Carlo simulation, Southern Appalachia, wildfire projections.

Approach

Expected area burned by wildfire in the study area of the Southern Appalachians is likely to change in the future, given changes in fuels, wildland fire management, and climate. A study by Prestemon and others (2016) projected wildfire area burned by county for the Southern United States from 2011 through 2060 under a variety of possible population growth, economic growth, land use change, and climate futures. Projections were made with statistical models built using observed wildfire area burned at the county level and variables used to predict wildfire area burned, also at the county level, from 1992 to 2010. The statistical models related annual area burned in the county to disposable income per capita, population, area of forest, and monthly precipitation, maximum temperature, and potential evapotranspiration observed in the county. Observations were assembled into county groupings according to their location within ecoregion provinces (Bailey 1995) using county attributions constructed by Butry (2003). For each of the county groupings, models were estimated that projected area burned by one of two broad causes of wildfire: lightning and humans (all other wildfire causes besides lightning).

When making projections of wildfire area burned through 2060, driving variables were needed. We used Intergovernmental Panel on Climate Change (IPCC)-based projections under scenario-storylines developed for the Third Assessment Report (Nakicenovic and Steward 2000). Three different emission scenarios were used in each of three general circulation models to generate nine realizations of future climate. The three emissions scenarios were A1B and A2 from the IPCC Third Assessment Report, and B2 from an earlier model (see Joyce and others 2014). Projections of land use, population, and personal income were provided by the 2010 Resources Planning Act (RPA) Assessment (USDA Forest Service 2014a, 2014b) for each of these three scenarios and then combined to enable modeling to generate envelopes of possible futures of wildfire area burned, annually through 2060, by county.

The authors (Prestemon and others 2016) used a Monte Carlo approach when making projections of area burned. They randomly sampled from all possible input data for the statistical models and made projections using the input data for all nine possible futures. For each of the nine, 250 random futures were generated. These 9 x 250 = 2,250 random futures were summarized by median projected area burned and a 90-percent uncertainty band around those. Output from the Monte Carlo simulations, added up across the 32 counties in our study area of the Southern Appalachians (7 in Georgia, 15 in North Carolina, and 10 in Tennessee), was used in figures 4.1, 4.2, and 4.3. By summarizing the results only for the study area, we offer a perspective of how the area burned in 2016 departed from what might be expected for wildfire in the future in the region.

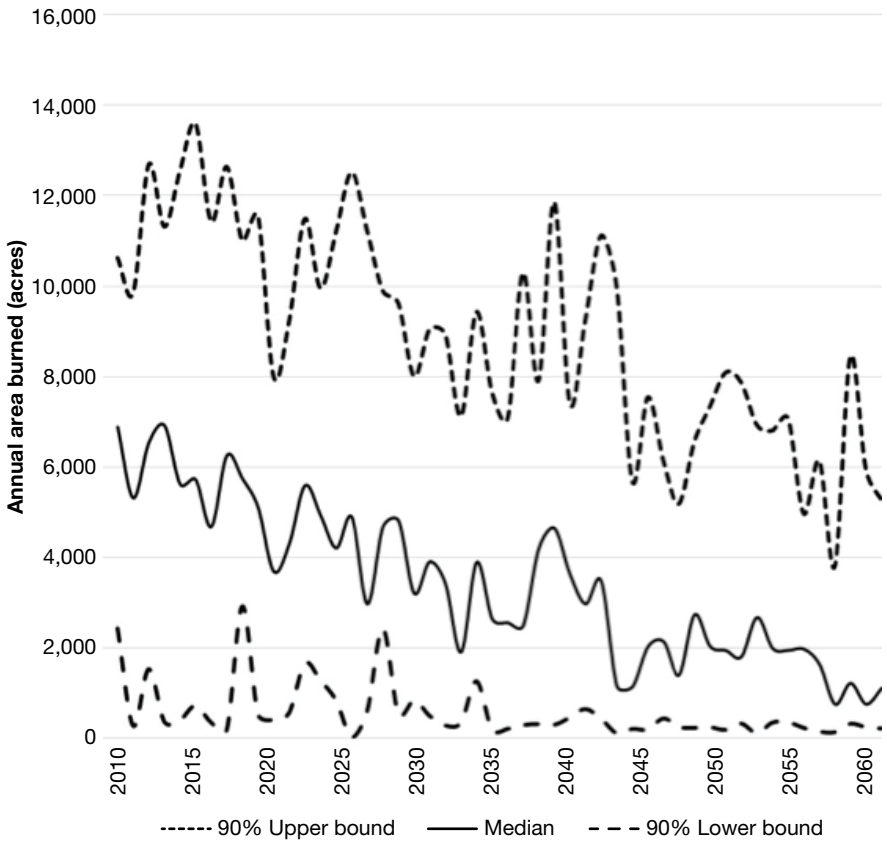

Figure 4.1—Projected area burned by human-ignited wildfire in the Southern Appalachian study area, 2011–2060.

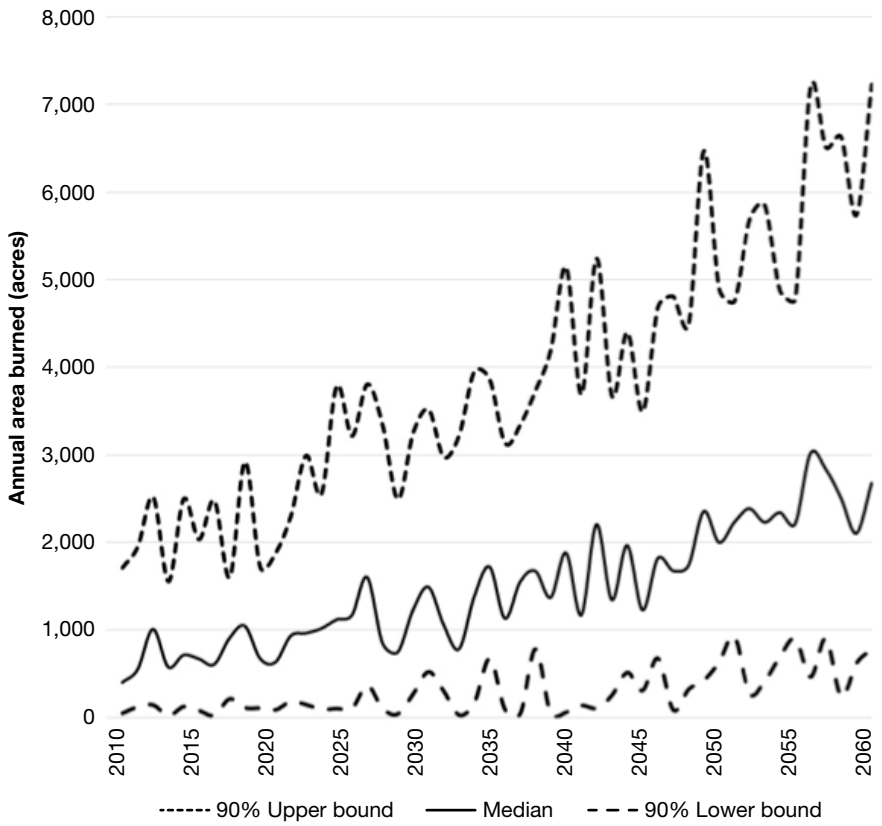

Figure 4.2—Projected area burned by lightning-ignited wildfire in the Southern Appalachian study area, 2011–2060.

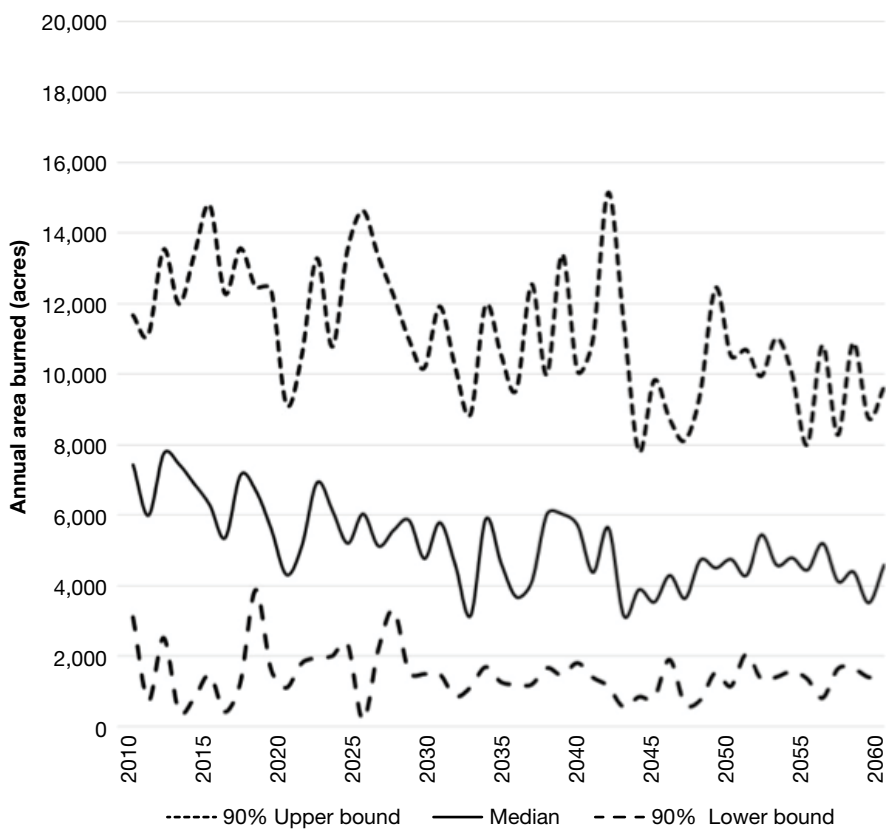

Figure 4.3—Projected area burned by all causes of wildfire in the Southern Appalachian study area, 2011–2060.

Results

Projections show that, overall, human-ignited wildfire area burned is likely to decline over the coming 40 years, while lightning-ignited wildfire is likely to increase. In the 2016–2020 half decade, median annual area burned by human-ignited wildfires is 5,498 acres, falling to 1,093 acres for 2056–2060, representing a decline of 80 percent (table 4.1). In contrast, lightning-ignited wildfire median annual area burned increases from 783 acres to 2,629 acres, a 236-percent increase. In other words, lightning is projected to replace human ignitions as the primary cause for area burned in the 32-county study area by mid-century. The reason for the increase in lightning-ignited wildfire is that lightning wildfires respond primarily to fuels and weather factors, and those factors are projected to broadly favor more wildfire ignitions by that cause. Human-ignited wildfires are driven not just by fuels and weather but also by changes in socioeconomic conditions. Generally, as the study area increases in wealth and population, fire prevention efforts, including suppression efforts, are projected to offset the effects of more favorable fire weather and fuels.

Uncertainty in the projections, given the nine scenarios and underlying projected data and model uncertainty, is illustrated in figures 4.1–4.3. Given the wide 90-percent uncertainty band around projected median areas burned from both lighting- and human-ignited wildfires (and in total), it would be incorrect to assert with high confidence that future wildfire area burned will be lower or higher compared to recent history. The weight of the evidence, however, points to increased area burned due to lightning ignitions, decreased area burned by human causes, and a decline in overall wildfire.

According to the estimated statistical models, factors behind the negative changes in area burned by human causes are the projected loss of forest and rise in per capita income in the region, both variables assumed to be associated with greater efforts to prevent wildfire occurrence and suppress the spread of wildfires that occur, rational responses to overall increases over time in values at risk. Projected increases in area burned due to lightning ignitions, in contrast, are driven in the models by projected changes in climatic conditions that favor lightning ignitions (i.e., drier fuels caused by warmer temperatures during times of the year when lightning-caused wildfires ignite), while changes in values at risk have a much smaller role in affecting area burned, likely because lightning-ignited wildfires tend to burn in more remote locations where such values are lower (and possibly where suppression resources are more difficult to apply).

Table 4.1—Projected areas burned by wildfires ignited by lightning and human causes, early and late in the wildfire projection time period

Wildfire cause	Average of median area burned, 2016–2020 acres	Average of median area burned, 2056–2060 acres	Percent change in median area burned
Lightning	783	2,629	236
Human	5,498	1,093	-80
All (lightning and human)	6,214	4,361	-30

Note: The sum of median areas burned by cause will not be same as the median of the summed total area burned. Source of the projection data: Prestemon and others (2016).

Conclusions

Projected area burned in the region is unusual, compared to the amounts observed in 2016. The earliest years of the projections indicate that 2016 was outside the 90-percent confidence band. In other words, only about 1 out of 20 years would be expected to have wildfire area burned above the 90-percent confidence band upper limit shown in figure 4.3 (about 13,000 acres). We can conclude, then, that 2016, in which the Chimney Tops 2 Fire alone burned approximately 17,000 acres, was anomalous. But we can also conclude that such anomalies in the future will occur, as well, with a few additional years in the coming 40 possibly also experiencing area burned comparable to what was observed in 2016. Communities in the region that could be affected by wildfires in these more extreme years could reduce their overall expected losses from future wildfires by augmenting wildfire prevention efforts so that wildfires are less likely to be ignited, using fire-resistant building materials in new and retrofitted construction, upgrading wildfire evacuation notification systems, and creating more efficient evacuation routes. Wildland managers might also anticipate greater frequencies of lightning-ignited wildfires that start farther from values at risk and consider how such wildfires might be quickly and efficiently managed so that they do less damage to a sparser immediate building infrastructure and also do not grow so large that they spread into nearby communities.

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From October to December of 2016, a confluence of human and environmental factors led to an outbreak of wildfires across the Southern Appalachian Mountains. This report examines the time trends of fire in the Southern Appalachian region, including mitigation activities and forecasting acres burned. The introduction (ch. 1) of this report describes the 2016 Southern Appalachian fires on public lands and provides a brief description of the methodology used to understand economic impacts of fire. Chapters 2 and 3 examine how prescribed fire is used in this region. The final chapter (ch. 4) describes how we can expect area burned by both human- and lightning-caused fires to change given increases in global temperatures, fuels, and wildland fire management.

Keywords: Economics, prescribed fire, Southern Appalachia, wildfire.

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