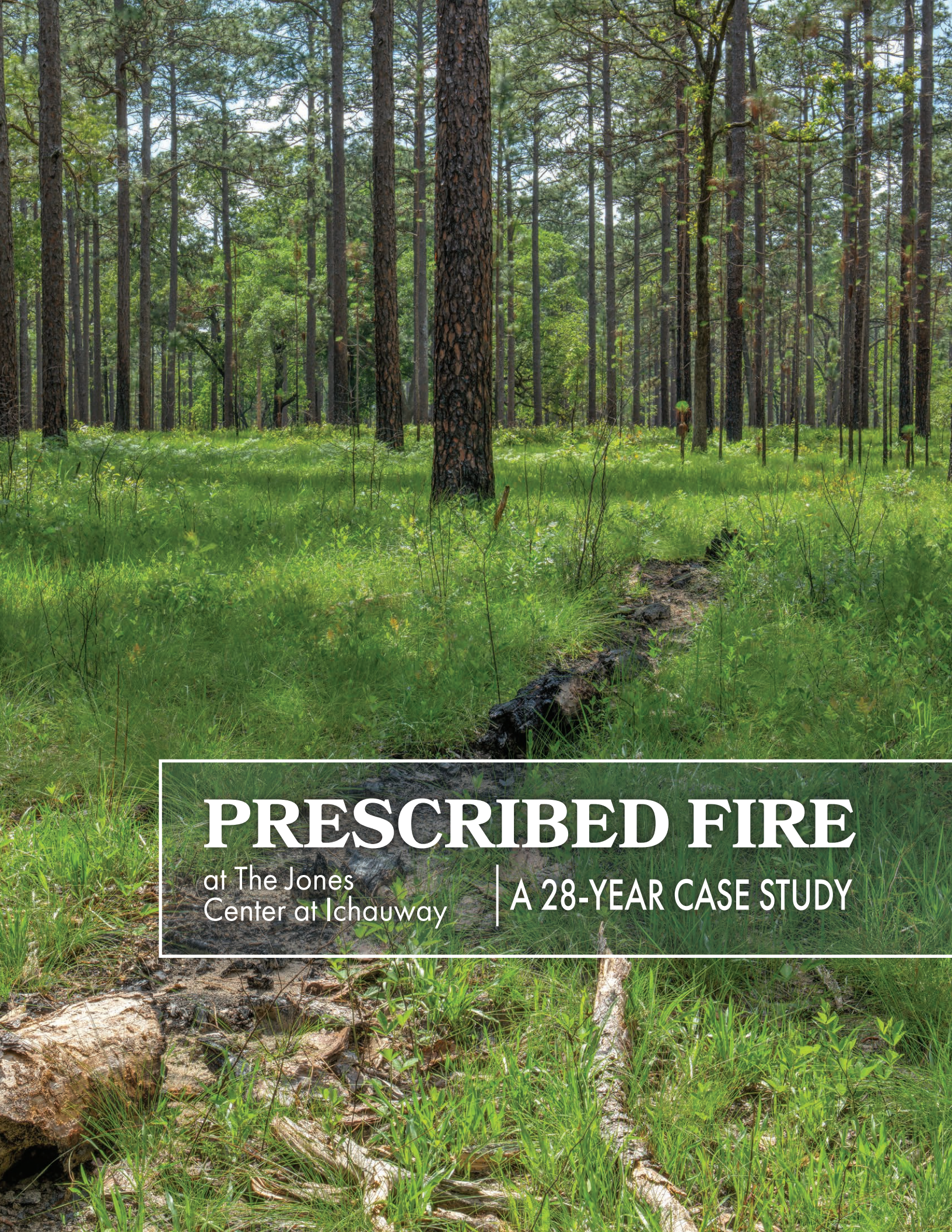
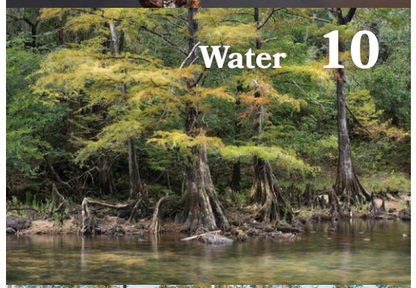


# PRESCRIBED FIRE

at The Jones Center at Ichauway

## A 28-YEAR CASE STUDY



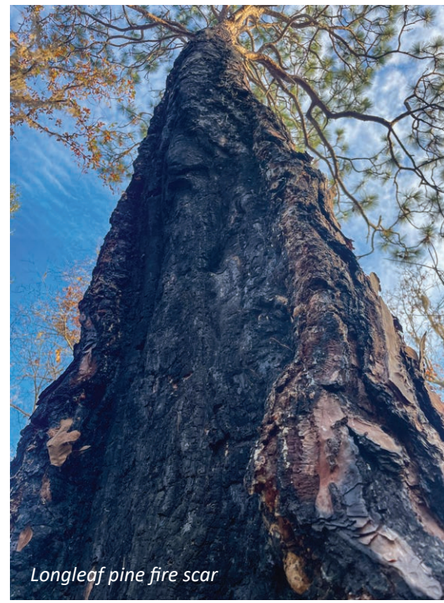



## Contents

# History of Fire on Ichauway

Fire has long been a part of the natural history of the longleaf pine ecosystem and the southeastern United States. The longleaf pine ecosystem once occupied a large portion of pre-settlement forests in the region, covering over 90 million acres from Virginia to Texas. During this time, fires occurred as a result of either lightning strikes or ignition by Native Americans. The ecosystem was maintained by frequently recurring fires from both sources of ignition. Native Americans benefited from fire and learned to use it as a management tool to improve habitat and hunting conditions, clear land for agriculture, promote important plant species, and facilitate travel. These historical fires occurred at a wide range of spatial scales, from a small spot fire started by lightning that was extinguished by rain from the same ignition source, to a landscape-level fire burning hundreds of thousands of acres and only suppressed by a creek, river, or other natural feature. These fires also burned with a broad range of intensity and severity. Extremely hot fires could consume all available fuel and kill many overstory trees, while low-intensity fires would burn in a mosaic fashion leaving patches of unburned fuels and forest canopies intact. The presence of fire across the landscape helped longleaf pine secure its dominance. Early travelers indicated areas where longleaf pine occurred on greater than 90% of the landscape.

The plants and animals of the longleaf pine ecosystem are fire adapted and thrive in the presence of fire. Many of these species are dependent on routine fire for some aspect of their natural history. The longleaf pine ecosystem also boasts some of the highest plant diversity in North America. The majority of this diversity is in the understory where plants supply abundant wildlife habitat and food resources in the form of legumes, other herbaceous species, and high-quality browse, in addition to providing the fuels necessary for frequent fire.



*Longleaf pine fire scar*

Research shows that over the last 500+ years fire has occurred very frequently across Ichauway. A recent dendrochronology study conducted at The Jones Center estimated that between the years 1600 and 1850, the average time span between fires was less than 1 year (average 0.7 years, minimum 0.25 years, maximum 5.25 years). When including all records and time after settlement (years 1514–2017), a fire occurred every 1.1 years on average (minimum 0.25 years). Additionally, about half of these fires occurred in what is now described as the growing season (~May and June) and during the time of year when thunderstorms are most prevalent. This extensive history of extremely frequent fire supported the maintenance of longleaf pine forests with herbaceous understories and helped shape the presence and location of Ichauway's other forest types and tree species.

In the late 1920s, Mr. Robert W. Woodruff began to assemble the properties that would eventually constitute Ichauway. Under his ownership, the northern bobwhite quail became the primary management objective. The importance of fire in quail management was recognized and annual, early spring burning of woodlands was used to facilitate propagation of wild quail. Almost all burning occurred after the end of quail hunting season and before quail nesting season began (March and April). These burns were also conducted from late afternoon into the night and under low fire intensity conditions. This 60-year regime of annual, dormant season burning also had an influence on Ichauway's longleaf pine forests and natural communities prior to the establishment of The Jones Center at Ichauway.

## Philosophy

Prescribed fire has been the cornerstone of natural resource management for The Jones Center at Ichauway since its founding, and an important component of the Center's science and outreach efforts. Many research and educational activities are focused on the importance of fire in longleaf pine and open-pine savanna systems. The implementation of routine prescribed fire on Ichauway has remained an institutional priority for the past 28 years with a solid commitment of resources to many fire-related activities.

The management of Ichauway is influenced by a conservation ethic. This ethic calls for stewardship that sustains the longleaf pine ecosystem, including embedded wetlands and streams, in its entirety and in perpetuity using management actions based upon the best available knowledge while adapting management actions as new understandings are gained, or as objectives and conditions change. Practices utilized to implement this conservation ethic, including frequent prescribed fire, are applied in a manner informed by patterns of natural disturbance to preserve the multiple ecosystem components.

Prescribed fire on Ichauway is considered both a resource management tool and a resource. Much like one would manage a forest to increase access to resources such as sunlight or water, it is necessary to manage the land intentionally to retain the ability to use the resource that is fire. It would be impossible to maintain the longleaf pine woodlands occurring on Ichauway without the ability to use fire as a management tool. The idea of retaining, or creating, conditions needed to maintain environments that support the appropriate use of prescribed fire should have application across ecological boundaries and on a broad geographic scale.

*Continued on page 6*



# Fire & Insects

As recent efforts in the southeastern United States have focused on restoring longleaf pine ecosystems, we are learning more about their complexity and biological diversity. In particular, the insects (and other arthropods) of this ecosystem are an immense and diverse, yet understudied, group. At The Jones Center, we recently conducted an exhaustive review of arthropods of the longleaf pine ecosystem, thoroughly searching the literature to find nearly 500 scientific references. We found reports of 51 orders, 477 families, 1,949 genera, and 3,032 species of arthropods occurring in longleaf pine ecosystems. Actual totals are assuredly much higher.

*Herbaceous understory diversity*

Our research has also explored the complex role that frequent fire plays in determining the arthropod community in longleaf pine. Fire-related effects include increases in biomass and diversity of the herbaceous understory, increases in landscape heterogeneity, negative impacts on competitors, the weakening of trees that serve as hosts for arthropods, and favorable microclimatic conditions that are all tremendously important to insects. However, fire can cause some negative impacts to insects through direct mortality (especially of those which cannot fly or move very effectively), short lived—but important—reductions in plant biomass and diversity, temporary exposure to predators, and positive impacts on non-insect competitors. Insects have, however, evolved survival strategies in fire-dominated ecosystems. These may include large population sizes that allow a species to experience high mortality in one area but recolonize from another unburned area, or seeking refuge in the soil, leaf litter, or other forest layers. Prescribed fire is a critical component of modern management for longleaf pine, and low-intensity fires are very effective at reducing fuel accumulation and encouraging a diverse understory, both critical to sustaining insect diversity in longleaf. Areas with varying burn cycles, and a diversity of burned and unburned habitats, also offer a wealth of refugia for insects and an increase in arthropod diversity. Another perspective on fire and insects in longleaf pine is the role that fire, and thinning, plays in forest health by mediating the potential impact of insect pests such as the southern pine beetle.

As longleaf pine ecosystem restoration efforts increase in coverage and scope, we must focus on understanding the identity and roles of the organisms that call it home. Likewise, it is critical that we understand the roles that frequent fire plays in restoring and maintaining diversity of species, guilds, and ecological services present in this vanishing ecosystem. Which species are essential to the success of a diverse ecosystem? How might we conserve species now, or introduce them during restoration processes? Which species are most critical to restoration efforts? Pollinators have received increasing attention and may be especially important. Species which are rare, threatened, or endangered (for example, the frosted elfin butterfly) may also serve as foci for restoration of specific habitats, associated species, and ecological community attributes. Insects may also serve as indicator species with deviations in number and distribution acting as warnings of changes (both positive and negative) in these ecosystems. Multidisciplinary approaches are necessary for this type of complex science, and likely to have great import and impact.

*Frosted elfin butterfly*

# Objectives

The overall prescribed fire management goal for the Jones Center is to maintain, enhance, and perpetuate fire-dependent communities on Ichauway. Due to the extensive history of fire on the landscape, many of Ichauway's natural communities are in excellent condition and are able to be maintained with only routine, low-intensity fire. The use of prescribed fire at the Jones Center is objective driven, and additional management objectives are determined for each burn unit and each prescribed burn.

These objectives integrate the current condition of the area to be burned with the reason for executing the prescribed fire. The overall management strategy is to burn individual units on a 2-year rotation, but this can range from 8 months to more than 5 years depending on the location, objectives, and conditions of the burn unit. Lightning-ignited fires are uncommon at Ichauway today; however, when these wildfires do occur, they are allowed to burn themselves out if no threat exists to important resources (e.g., research plots, wildlife, timber, water quality, etc.) and fall within the Georgia Forestry Commission weather guidelines. Such fires are always contained within the burn unit of origin. Wildfires that pose a threat are extinguished using the safest and most effective means available but with minimal disturbance to the ecosystem. Objectives may include one or more of the following:

## Fuel Reduction and Hardwood Control

Remove accumulated fuel loads and top kill small hardwoods. This is typically viewed as a maintenance fire.

## Perpetuate Fire Dependent Species & Restoration

Set fires that sustain the longleaf grassland ecosystems; the approach may be slightly more aggressive than used for a maintenance fire. These fires can be in areas where fire is being reintroduced or utilized to reclaim a fire-dependent system that is out of desired condition.

## Wildlife Habitat Management

Create habitat conditions that maintain and enhance wildlife populations (i.e., bobwhite quail, red-cockaded woodpecker, wild turkey, striped newt, gopher tortoise, pocket gopher, frosted elfin butterfly, overall biodiversity).


## Research

Implement prescribed fires for research projects with specific timing or conditions relative to prescribed fire as required to maintain or conduct studies.



## Education Demonstration

Set fires for groups hosted by the Center so they can experience prescribed fires as an introduction to the application of fire as a management tool.

## Seedbed or Planting Preparation

Create conditions to promote longleaf pine seedling establishment in mast events or create conditions to hand/machine plant seedlings successfully.

## Wiregrass Seed and Production

Burn areas during the late spring and early summer to create conditions to promote wiregrass flowering, seed harvest, or other objectives related to native understory plants.

## Wetland Management

Develop specialized prescriptions for the many fire-dependent wetlands on Ichauway.


## Boundary Security

Reduce fuel loads and address smoke management concerns through prescribed fires and defend against boundary ignition from adjacent landowners or public roads.

## Debris or Slash Burning

Burn piles of debris created through timber harvest or restoration activities.

## Forage or Hay Production

Create conditions for optimal forage production or to remove waste.

## Season & Frequency

Prescribed fires can be implemented during any month at Ichauway but are typically concentrated during the first seven months of the year, allowing vegetation to regrow sufficiently to provide wildlife cover during the winter. Burn units are targeted for burning by objective rather than season but planned for a specific season if that supports a given objective. Decisions are driven by maintaining manageable fuel loads and moving toward the desired future conditions for the burn unit. Most prescribed fire activities take place during March and April when weather conditions are the most favorable.

Much debate has surrounded whether prescribed fire managers should exclusively use growing (or summer) season burns in the Southeast. Ichauway's prescribed fire program takes advantage of the best burn days during both dormant and growing season, fostering diversity at a range of scales across the property. Dormant season weather patterns in the Southeast provide the most consistent weather to implement and control prescribed fires. Most prescribed fire managers use these conditions to meet yearly objectives for acreage burned. During the growing season drier conditions prevail, drought index values increase, and prescribed fires become more difficult to control and execute, especially if drought conditions occur or fuel loads are excessive. If management relied on prescribed fire use exclusively during the growing season, weather conditions would dictate the amount of acreage burned each year and decrease the likelihood of maintaining desired fire return intervals. Dormant season and growing season fires can, and do, produce different results for both vegetation and wildlife communities, and variability in season can foster diversity. For example, some important longleaf pine-associated plant species are dependent on growing season fire for flowering, and longleaf pine seed requires bare soil prior to seed fall, beginning in October, to germinate. Ichauway has been managed for over 90 years with predominantly March and April prescribed fires, which effectively span both dormant season (January–March; October–December) and growing season (April–September). This maintains and enhances longleaf pine grasslands on the property. Even with the prioritized focus on frequency, an average of 35% of all burning on Ichauway has been conducted during the growing season over the last 28 years (Table 1). Additionally, our practice of varying the season of burn in individual units over time promotes even greater diversity of benefits from prescribed fire.

*Longleaf pine regeneration*

Increased frequency presents more opportunities to vary the season, weather, and type of fire needed to move longleaf communities toward desired conditions. A 2-year burn rotation has been utilized on Ichauway since 1994, allowing for adequate reduction in fuels, propagation of fire dependent species, and the establishment of longleaf pine regeneration (Figure 1). A history of annual, cool season burning prior to the establishment of The Jones Center at Ichauway resulted in a lack of natural longleaf pine regeneration due to the vulnerability of newly germinated seedlings to fire during their first year. A 2-year rotation allows longleaf pine seedlings to become established before experiencing a fire and this has led to an increase in longleaf pine regeneration. Encroachment into the mid-story from woody species is also regulated with this fire regime, which also maintains relatively low fire intensities with only a 2-year, or less, accumulation of fuels (Table 3). Some areas on Ichauway have been periodically burned annually. Within these areas, a decline in the number of woody species has been documented.



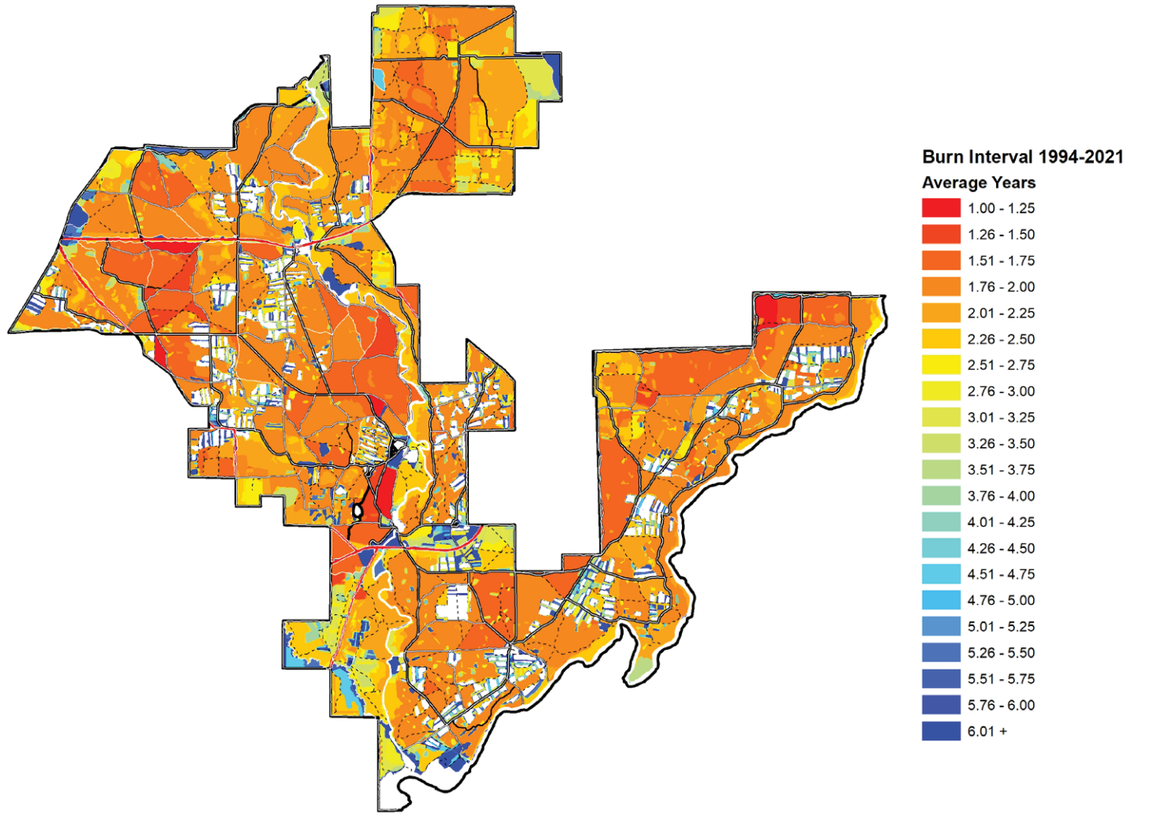



**Figure 1.** Average fire return interval for burn units on Ichauway from 1994–2021.

## Methods

Prescribed fires are conducted under permit from the Georgia Forestry Commission. A written fire prescription, including weather variables and smoke screening, is completed prior to any burning. Ground ignition with ATV mounted, or handheld, drip torches is used to conduct all prescribed burns on Ichauway by a burn crew of 3–5 people with prescribed fire training. A test fire is lit to check conditions, and if it behaves as expected the burn boss communicates assignments for each member of the team and executes the fire. Initially a downwind fire line is set with a backing fire to defend adjacent burn blocks or obstacles within the burn unit. Once the backing fire is secure, the unit is systematically ignited. Backing, flank, spot, head, and strip-head fires are all methods of ignition utilized depending on the objectives, fuel, and weather conditions. All prescribed fires must be extinguished by 5 PM in accordance with Georgia Forestry Commission permitting. An internal network of roads provides access across the site and serves as interior fire breaks. These roads divide the property into 144 different burn units ranging in size from less than 5 acres to over 900 acres. Boundaries and public right-of-ways are protected by harrowed firebreaks that are maintained throughout the year. In certain cases, particularly for small research plots, mowed firebreaks and fire-retardant foam are employed to conduct small-scale prescribed burns.

*Continued on page 12*

# Fire & Water

To many, the relationship between prescribed fire and water may not be obvious, but fire can play an important role in water conservation. Water scarcity is increasing around the world due to the combined effects of increased human demands and climate change. Severe and unpredictable droughts are even affecting regions that typically receive abundant precipitation, like the southeastern United States. Agriculture and cities are often blamed for water scarcity, and water withdrawals can be significant contributors to this problem. Highly successful practices that improve water use efficiency are already in place on many farms, and per capita household water use is declining in many large cities due to water conservation practices, but these measures are reaching their limits in terms of water savings.


Before: Two-year burn rotation


After: Nine years of fire exclusion

In many rural areas of the Southeast, forests still make up a substantial part of the land base, and forest management with prescribed fire can contribute to conservation of aquatic ecosystems. Like crops and cities, forests consume a tremendous amount of water. Excessive forest evapotranspiration—the total water consumption of a forest—can negatively affect streamflow, groundwater recharge, and the length of wetland inundation. Changes in forest management over the last century have greatly increased forest water consumption. Unmanaged forests, which results where fire has been passively removed from the landscape, have increased forest leaf area, and resulted in higher forest water use. Also, younger, denser forests managed for short-rotation fiber production are especially "thirsty" compared to native longleaf pine forests managed with frequent fire. Thus, prescribed fire may play an important role in sustaining, or even restoring, the health of the aquatic ecosystems that are adjacent to fire-adapted forests.

Research at the Jones Center shows the effects of removing prescribed fire from selected forest plots. After only 15 years of fire exclusion, groundcover is largely replaced by a dense thicket of saplings and woody shrubs. Warm-season grasses, which are highly efficient at using water, are replaced by fast-growing tree species like water oak, sassafras, and black cherry. This change in forest community and structure increases total forest leaf area and increases overall forest water use. Thus, more water is transpired—taken up by plants to be used for growth and metabolism—by these young trees and shrubs than would be the case with a grass-dominated understory. More rainfall is also lost to interception—water that hits plants' surfaces and evaporates directly back to the atmosphere. Overall, a fire-suppressed pine forest may use 20-30% more water than a similar forest managed with frequent prescribed fire. While streams and wetlands can withstand greater forest water use when rainfall is plentiful, this increased forest water consumption may have negative impacts on aquatic ecosystems during seasonal or longer droughts.

But can these differences in forest water use really affect wetlands and watersheds, and can these effects be reversed? Recent Jones Center research provides some answers to both questions. First, we looked at how hardwood removal and reintroduction of a frequent fire regime around a wetland impacted by hardwood encroachment affected wetland inundation length—called hydroperiod. Hydroperiod is the length of time ponded water is present and is a critical characteristic in wetlands for determining their value for wildlife. Using >10 years of climate and wetland water level data, we showed that removing hardwood and shrubs (~30% of the basal area) in a wetland drainage reduced the amount of water needed to start wetland flooding in the fall, and that inundation of the wetland lasted longer into the growing season.

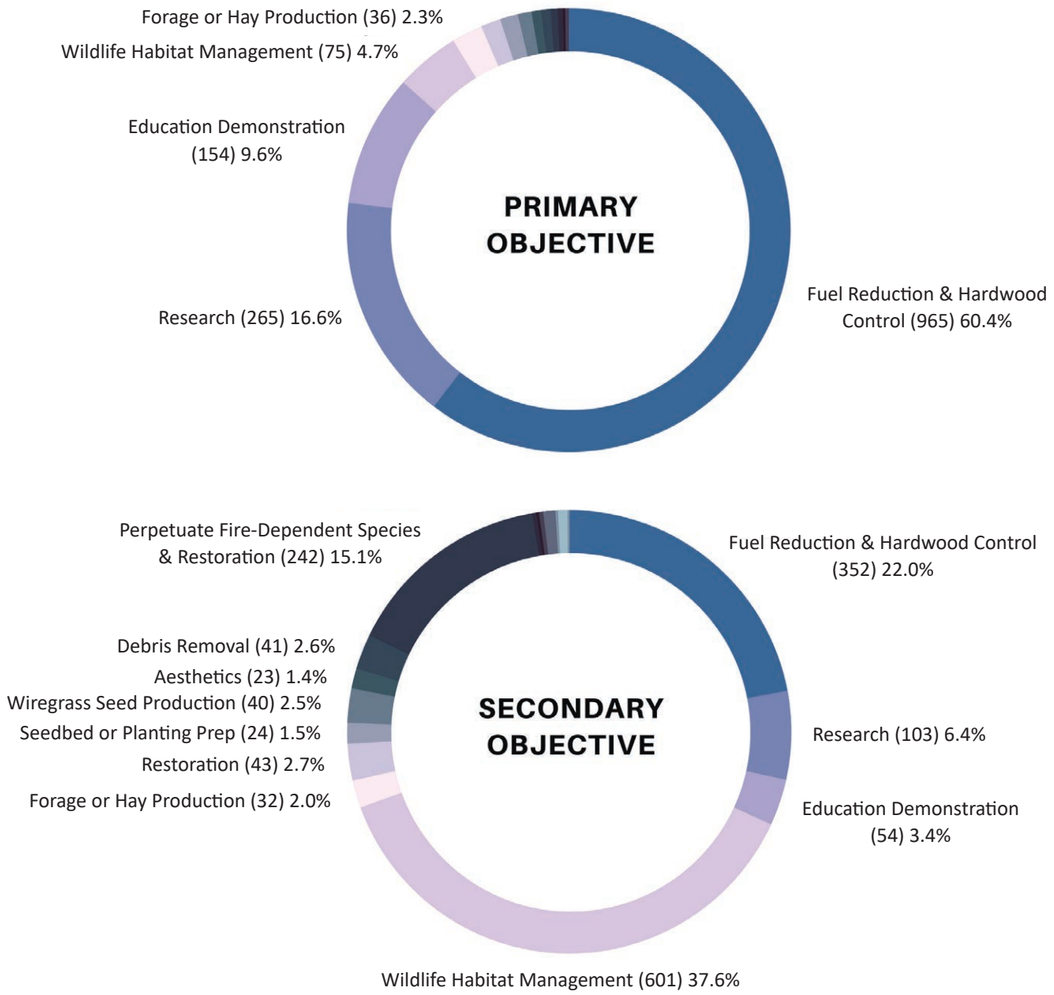
At a larger scale, we used USGS streamflow records and the Soil and Water Assessment Tool—a river basin model that simulates streamflow—to evaluate how longleaf restoration might restore streamflow. We simulated large-scale longleaf restoration in the Ichawaynochaway Creek basin, a major tributary of the lower Flint River. This basin has a long record of streamflow and climate data along with extensive forest land cover typical of the region. In our simulation, fire-suppressed mixed pine-hardwood forest and dense pine plantations were replaced with fire-maintained longleaf pine forest. Longleaf restoration was simulated using measurements of leaf area and tree responses to weather based on research conducted at The Jones Center. Our simulations projected reduced forest water use and may prove to be an effective way to increase streamflow, especially during drought when aquatic habitat is most vulnerable. For the driest months, simulated longleaf restoration increased streamflow about 10%. Thus, longleaf restoration, already a conservation priority, and the regular application of prescribed fire to maintain the forest in a water-friendly condition, may prove vitally important in maintaining quality in-stream habitat for imperiled aquatic organisms during periods of water scarcity.


Ichawaynochaway Creek

# Objective-Driven Burning

All prescribed fires conducted on Ichauway are driven by objectives. Both a primary and secondary burn objective are determined prior to the burn and recorded on the burn plan. From 1992–2021 (1,598 burn plans), the most common primary burn objective was fuel reduction and hardwood control in 60.4% of burns. The second and third ranked primary burn objectives were research (16.6%) and education demonstration (9.6%). Wildlife habitat was the most frequent secondary objective (37.6% of burns). Fuel reduction and hardwood control (22.0%) and perpetuation of fire-dependent species and restoration (15.1%) were the second and third most frequently occurring secondary objectives (Figure 2).

**Figure 2.** Number of permits (n) and percentage of permits by primary and secondary objectives for Ichauway from 1992–2021.






# Implementation of Ichauway Fire Regime

Ichauway contains approximately 25,000 burnable acres, with most burned on a 2-year fire return interval. This fire regime results in a goal of 12,000–14,000 acres burned each year. In 26 of the 28 years between 1994 and 2021, over 10,000 acres were burned. The long-term annual average was 12,280 acres burned with a range of 7,966 to 16,282 acres. When considered seasonally, an average of 8,046 acres have been burned annually in the dormant season (January–March; October–December), and 4,324 acres in the growing season (April–September). Dormant season burning has comprised 40%–80% of burning within a given year (65% average), while growing season burning has ranged from 12%–60% (35% average). In general, the use of growing season burning has been increasing since 1994 (Table 1).

**Table 1.** Acreage burned by year and season with percent and trend of growing season burns on Ichauway from 1994–2021.

| Year | Dormant Season | Growing Season | Total Acres | Percent Growing Season |
|---|---|---|---|---|
| 1994 | 13,473 | 1,850 | 15,323 | 12 |
| 1995 | 8,199 | 2,377 | 10,576 | 22 |
| 1996 | 4,994 | 5,706 | 10,700 | 53 |
| 1997 | 3,153 | 4,813 | 7,966 | 60 |
| 1998 | 4,943 | 5,449 | 10,393 | 52 |
| 1999 | 6,294 | 2,936 | 9,230 | 32 |
| 2000 | 8,796 | 2,740 | 11,535 | 24 |
| 2001 | 8,734 | 2,623 | 11,356 | 23 |
| 2002 | 6,830 | 3,196 | 10,026 | 32 |
| 2003 | 9,822 | 3,886 | 13,708 | 28 |
| 2004 | 7,054 | 4,175 | 11,229 | 37 |
| 2005 | 11,332 | 2,726 | 14,058 | 19 |
| 2006 | 7,765 | 5,868 | 13,632 | 43 |
| 2007 | 7,648 | 2,897 | 10,545 | 27 |
| 2008 | 9,274 | 3,966 | 13,240 | 30 |
| 2009 | 11,621 | 2,688 | 14,309 | 19 |
| 2010 | 8,110 | 4,470 | 12,580 | 35 |
| 2011 | 6,991 | 5,954 | 12,945 | 46 |
| 2012 | 7,978 | 3,962 | 11,940 | 33 |
| 2013 | 9,649 | 3,438 | 13,087 | 26 |
| 2014 | 7,495 | 4,870 | 12,365 | 39 |
| 2015 | 7,242 | 5,668 | 12,910 | 44 |
| 2016 | 10,031 | 4,042 | 14,073 | 29 |
| 2017 | 7,275 | 5,687 | 12,962 | 44 |
| 2018 | 7,483 | 4,593 | 12,076 | 38 |
| 2019 | 6,528 | 6,402 | 12,930 | 50 |
| 2020 | 7,382 | 4,474 | 11,856 | 38 |
| 2021 | 9,198 | 7,084 | 16,282 | 44 |
| **Averages** | **8,046** | **4,234** | **12,280** | **35** |

*Continued on page 16*

# Fire & Wind

Longleaf pine ecosystems naturally occur along both the Atlantic and Gulf coasts, exposing the ecosystem to occasional blowdowns from hurricane winds. Although land managers have long understood the importance of prescribed fire for maintaining biodiversity in longleaf pine forests, far less is known about how hurricanes and fire together shape longleaf ecosystems. Evidence of the historical occurrence of hurricanes and fire comes from coastal sediment cores which show layers of sand, charcoal, and pollen, suggesting the interplay between these disturbances may have shaped the current structure of longleaf pine forests for centuries. Hurricanes also cause changes that affect the behavior of fire and can lead to challenges for managing this ecosystem.

The most obvious fire-related change after a hurricane is the immense increase in coarse woody fuels (e.g., fallen trees), and a common management issue is dealing with the increased smoke emissions and smoldering combustion that occurs from the excess. In rare cases, large fuel accumulations can lead to intense wildfires and major shifts in forest structure and composition. However, hurricanes can simultaneously increase and decrease fire intensity in localized areas. Large woody fuels and downed tree crowns create localized areas where fire intensity can be very high. But in forests where leaf litter is an important driver of fire intensity, removal of overstory trees can lead to "fire shadows" where leaf litter input is low, and subsequent fire intensity is reduced. Because management goals in longleaf pine woodlands emphasize control of understory hardwood species using fire, these fire shadows reduce the effectiveness of hardwood control depending on gap size and severity. The Jones Center is currently conducting a long-term study with researchers from the University of Georgia to study how tree removal from hurricanes, or harvest, can alter the fuel landscape to better understand interactions among overstory disturbances and fire effects.

*Damage from Hurricane Michael*

A second way that hurricanes can complicate the management of forests with prescribed fire is by changing the competitive environment of regenerating saplings. Frequent prescribed fire controls hardwoods by causing mortality or top kill in small individuals, but as saplings grow and bark thickens, they begin to develop resistance to fire. Wind damage can accelerate the development of resistance by removing overstory competition and allowing smaller hardwood individuals to rapidly grow to fire-resistant sizes. If the hardwoods advance to the canopy, they may produce low-flammability litter, and further dampen fire intensity and effects. In longleaf pine forests, small gaps created by mortality (including wind) can also lead to dense pockets of regenerating longleaf pine seedlings and saplings called "regeneration domes." In collaboration with researchers from the University of Missouri and Tall Timbers Research Station, an ongoing study focuses on how regeneration domes influence fire behavior. Early results suggest that dense regeneration domes forming within gaps alter fuel composition and moisture in a way that reduces fire intensity and effects and may play a key role in fire resistance in early stages of longleaf pine development. Research conducted at Ichauway after Hurricane Michael in 2018 also demonstrated that trees were impacted differently by wind disturbance depending on species and soil type suggesting that tropical cyclones play a role in the position of trees on the landscape. More research is needed to unravel some of the complex interplay among overstory trees, fuels, and recruiting saplings in longleaf pine ecosystems.

A third way hurricanes complicate the management of longleaf pine is by creating tradeoffs for managing risk due to climate change. A long-term experiment at the Jones Center seeks to explore solutions for managing longleaf ecosystems in a changing climate. In the southeastern U.S., climate change models predict increasing severity of drought and hurricanes. Climate-focused silvicultural prescriptions in longleaf pine can include retaining xeric hardwood species such as southern red oak, sand post oak, and turkey oak, because they are suitable for management with prescribed fire and are also drought-resistant species. However, shortly after installing drought-focused silvicultural treatments, a rare and intense hurricane struck the experimental stands. Hurricane damage inventories revealed that longleaf pine was more resistant to hurricane winds compared to other pine species. However, xeric hardwood species—favored due to their drought resistance—were especially vulnerable to wind. This tradeoff poses a challenge for forest managers as increasing resistance to one disturbance (drought) may make forests more vulnerable to another disturbance (hurricanes). A better understanding of the expected frequency of natural disturbances and their impact on forest communities can help managers navigate these difficult tradeoffs.

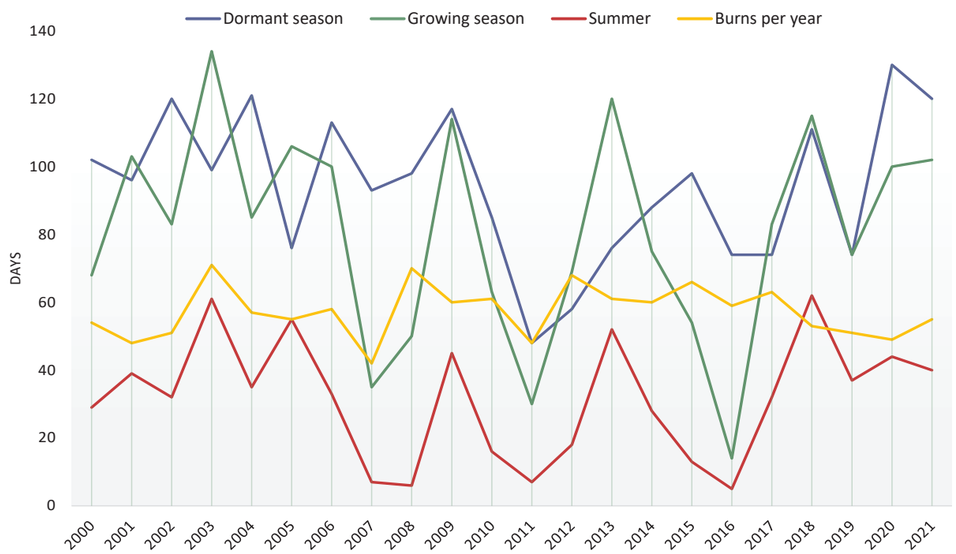
*Regeneration dome*

An ecological appreciation of the role of prescribed fire in longleaf pine ecosystems has greatly advanced its conservation and management. Like fire, hurricanes are historically associated with longleaf pine forests. Wind disturbance directly impacts longleaf pine forests, and it also complicates fire management by changing fuels, competitive environments, and risk considerations. Ongoing and upcoming research at the Jones Center aims to unravel some of the complex ways that wind and fire interact to better improve the conservation and management of longleaf pine forests.

From 2000–2021, an average of 57 days of burning were required to achieve annual burn objectives for Ichauway with an average of 213 acres burned per day. Seasonally, an average of 32 days of burning occurred in the dormant season, 25 days in the early growing season, and 6 days in the summer (June, July, and August). The amount of burned acreage per day was higher for the dormant season (250 acres) and lower for the growing season (162 acres) and summer (119 acres).

Data collected from a weather station at Ichauway were used to determine the number of possible burn days during a given year. Weather data collection occurred between the years 2000 and 2021. Different weather variables were used to eliminate days that would have been unsuitable for burning. Any days with a minimum relative humidity less than 25%, a Keech-Byram Drought Index (KBDI) above 450, wind speed greater than 20 miles per hour, or precipitation between the hours of 8 AM and 4 PM were not considered suitable burn days. However, not every unsuitable day could be removed due to the interaction of meteorological variables and weather variables not recorded by the weather station, such as smoke dispersion index and transport wind speed. During the 22-year period, there were an average of 175 days available (with suitable weather and conditions) for burning annually (48% of days in the year). In the dormant season, 94 days were available for burning (52% of days in the season), while in the growing season 81 days met the weather criteria (44% of days in the season). Summer had the least number and percentage of days available for burning with 32 days (34%). In most years (15 of 22), there were more days available for burning in the dormant season than the growing season. There were a limited number of days available for burning in the summer with an insufficient number of days to complete annual burning objectives in all but 2 years. Only 1 year occurred between the years 2000 and 2021 without enough available burn days in the dormant season to meet annual burn acreage objectives (Figure 3).

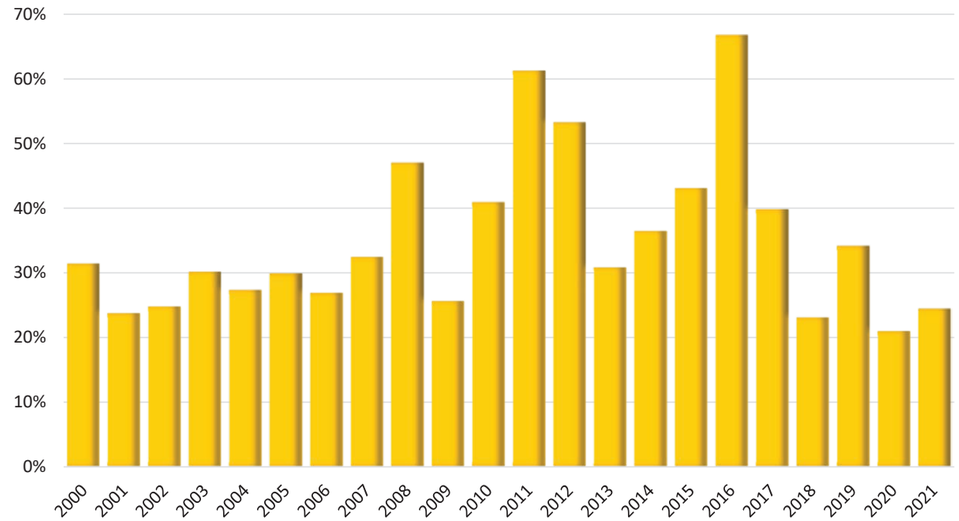
**Figure 3.** Number of available burn days in the dormant season (January–March; October–December), growing season (April–September), and summer (June, July, August) with number of days burned at Ichauway from 2000–2021.






On Ichauway, prescribed burns were conducted on 36% of available burn days annually, 34% of days in the dormant season, 31% of days in the growing season, and 20% of days in the summer. There was a wide range in the annual proportion of days burned to days available needed to complete objectives with a low of 21% and a high of 67%. These values represent the significant amount of days, and investment, needed to maintain a frequent fire regime. In years with poor fire weather conditions (e.g., drought) it was necessary to burn on most available days (e.g., 2016, Figure 4).

**Figure 4.** The percentage of available burn days with burns on Ichauway from 2000–2021 as determined from weather station data and prescribed burn records.




## Average Burn Conditions

Along with meteorological data, forecasts for smoke dispersion index (SDI), mixing height, and transport wind speed were recorded. When a burn permit was issued, these weather variables were recorded and entered into a database along with the permit. The average weather conditions under which burns have been conducted at Ichauway for 28 years (1994–2021) can be determined from these 1,598 burn permits. An average burn day had an ambient temperature between 68–75 degrees Fahrenheit, a low relative humidity of 32.9%, high wind speed of 11.4 miles per hour, an SDI of 61.2, mixing height of 6,210 feet, and transport wind speed of 13.7 miles per hour. Burns occurred under similar weather conditions among seasons. In the summer, there were much higher ambient temperatures, higher humidity, and lower wind speeds (Table 2).

**Table 2.** Average weather conditions on prescribed burn days by year and season at Ichauway from 1994–2021.

| | Low Temp | High Temp | Low RH | High RH | Low Wind Speed | High Wind Speed | SDI | Mixing Height | Transport Wind Speed |
|---|---|---|---|---|---|---|---|---|---|
| Dormant Season | 61 | 68 | 32 | 43 | 8 | 12 | 58 | 6086 | 14 |
| Growing Season | 77 | 84 | 34 | 46 | 7 | 11 | 66 | 6291 | 13 |
| Summer | 85 | 91 | 38 | 49 | 7 | 10 | 59 | 5738 | 12 |
| Annual | 68 | 75 | 33 | 44 | 8 | 11 | 61 | 6210 | 14 |

## Evaluation of Fire Effects

Approximately 3 weeks after a prescribed burn, an evaluation was completed to document each burn and monitor fire effects. As part of the evaluation, all burns were mapped and entered into a database. The amount and degree of crown scorch, top kill of woody understory plants, and fuel and duff consumption were visually evaluated. Any crown scorch of overstory was also mapped and separated into 4 categories based on degree: no scorch, 1/3–2/3 of crown scorched, 2/3 of crown scorched, and complete crown scorch. Primary crown scorch occurred over the largest portion of a prescribed burn while secondary scorch occurred over a smaller area. The proportion of woody understory plants top killed was categorized as "none," "little," "half," and "most." Fuel consumption of fine fuels (i.e., grass, pine needles, pine cones) was recorded as either "patchy" (< 100% consumed), or "clean" (100%). Any amount of fuel consumption less than 100% was classified as patchy. Duff consumption, or the consumption of fine fuels in direct contact with the soil, was recorded as "lots remaining," "little remaining," or "bare mineral soil."

Burn evaluations were completed on 4,056 prescribed fires occurring between 1994 and 2021. The typical prescribed fire resulted in no primary crown scorch (57% of burns), no secondary crown scorch (78% of burns), the top kill of most woody understory plants (82% of burns), an even distribution between patchy (53%) and clean (47%) fuel consumption, and little duff remaining for 84% of burns (Table 3).

**Table 3.** Percentage of crown scorch, woody top kill, fuel consumption, and duff consumption from prescribed fire evaluations conducted on 4,056 prescribed burns at Ichauway from 1994–2021.

| Primary Crown Scorch | | Secondary Crown Scorch | | Woody Topkill | | Fuel Consumption | | Duff Consumption | |
|---|---|---|---|---|---|---|---|---|---|
| None | 57% | None | 78% | Most | 82% | Patchy | 53% | Little remaining | 84% |
| 1/3 to 2/3 | 18% | 1/3 to 2/3 | 4% | Half | 14% | Clean | 47% | Bare mineral soil | 8% |
| Less than 1/3 | 13% | Less than 1/3 | 3% | Little | 3% | | | Lots remaining | 7% |
| Greater than 2/3 | 11% | Greater than 2/3 | 3% | None | 0.3% | | | | |
| Complete | 0.7% | Complete | 2% | | | | | | |

*Continued on page 21*



# Fire & Carbon

Prescribed burning in longleaf pine ecosystems can limit the amount of carbon that is accumulated in the soil organic horizon, coarse woody debris, and the aboveground portions of live vegetation. However, frequent low-intensity fire is important for reducing fuel loads and maintaining the characteristic structure of longleaf pine forests by limiting the recruitment of oaks to midstory canopy positions. This silvicultural treatment minimizes the risk of high-intensity crown fires and the associated release of large amounts of carbon into the atmosphere at any one point in time. Simulations of carbon dynamics over time using a forest landscape model and field data from Ichauway showed that a frequent prescribed fire scenario resulted in the least net carbon emissions from fire and the most stable aboveground biomass compared to wildfire scenarios.

Researchers at the Jones Center are also quantifying total ecosystem carbon stocks associated with permanent inventory plots in longleaf pine dominated stands with prescribed burning. As part of this study, we will be tracking decay class transitions of individual pieces of downed coarse woody debris. This information will be useful for modeling dead wood carbon stocks over time in longleaf pine ecosystems with frequent fires. Pyrogenic carbon (or black carbon) inputs to the mineral soil are also an important carbon pool. For a different study at Ichauway, we are quantifying changes in mineral soil carbon accumulation after 23 years of frequent prescribed burning in longleaf pine plantations and naturally regenerated stands.

At Ichauway, several short-term (≤ 3 years) studies using eddy covariance techniques and fuel combustion plots indicated that sites spanning a broad edaphic gradient can be sources of carbon emissions when fuel consumption is considered. Additionally, these studies showed that in about 30 days after prescribed burning, sites return to pre-burn rates of net carbon uptake. Researchers have suggested that the rapid recovery of the system is due to new needle production and the regrowth of grasses. The combination of these factors contributes to the resiliency of the ecosystem to short-term perturbations like prescribed burning.

*Post-burn needle production*

Other studies at Ichauway have shown that ground cover plants and soil organic horizon materials are important controls on the spread, intensity, and residence time of prescribed fire in longleaf pine ecosystems. For example, wiregrass supports pine needles above the forest floor, which reduces moisture content in fallen needles thereby increasing fire intensity. Pine cones and coarse woody debris that are partially or fully buried within organic horizons can generate fine-scale fire intensities and residence times that are greater than those generated by finer fuels. Prescribed fire behavior has also been observed to be less variable in stands with native ground cover plants compared with that of stands with old-field vegetation.

At Ichauway, our research aims to quantify ground cover fuels in secondary longleaf pine forests that were never tilled and in plantations where longleaf pine seedlings were planted on marginal agricultural lands. In some of these plantations, native ground cover plants were also sown after the first commercial thinning of pines. The success of the ground cover restoration efforts will be assessed by measuring the biomass and stocking of seeded species. Quantification of ground cover fuels will aid in management decisions involving prescribed fire and help elucidate conditions that might promote or hinder use of prescribed fire in longleaf pine ecosystems.

*Burning around an active red-cockaded woodpecker tree*

On average, only 5% of acres burned had crown scorch with most of the crown scorch occurring in less than 2/3 of the crown (67%). Twice the percentage of acreage scorched (12%) was observed for summer burns than dormant or growing season burns. Additionally, there was a higher average severity of scorch (> 2/3 of the crown) in the summer (41%) and growing season (41%) (Table 4).

The top kill of woody understory plants was slightly higher in the summer (88%) than for the average prescribed fire (82%) (Table 5).

These results reflect the use of frequent, low-intensity fire to successfully control woody understory plants with minimal scorch of the overstory. The control of woody understory plants is critically important in the maintenance of an understory beneficial to many species and habitats within longleaf pine and open-pine savanna woodlands. Prescribed burns with patchy fuel consumption also provide multiple benefits, through the provision of burned and unburned areas, for many organisms. Additionally, lower severity of crown scorch minimizes stress on overstory trees increasing their health and vigor.

**Table 4.** Average acreage of crown scorch by season and degree for 4,056 prescribed fires conducted on Ichauway between 1994 and 2021.

| | Dormant Season | | Growing Season | | Summer | | Annual | |
|---|---|---|---|---|---|---|---|---|
| | acres | % | acres | % | acres | % | acres | % |
| **Average Acreage Burned** | 8,087 | - | 4,023 | - | 738 | - | 12,111 | - |
| **Average Acreage Scorched** | 432 | - | 224 | - | 90 | - | 647 | - |
| **% of Burned Acres Scorched** | - | 5% | - | 6% | - | 12% | - | 5% |
| **1/3-2/3 of Crown Scorched** | 308 | 69% | 141 | 60% | 68 | 59% | 443 | 67% |
| **2/3 of Crown Scorched** | 123 | 27% | 86 | 37% | 44 | 38% | 202 | 30% |
| **Complete Crown Scorch** | 18 | 4% | 9 | 4% | 3 | 3% | 20 | 3% |

**Table 5.** Evaluation of woody top kill by season for 4,056 prescribed fires conducted on Ichauway between 1994 and 2021.

| WOODY TOP-KILL | Dormant Season | Growing Season | Summer | Annual |
|---|---|---|---|---|
| **Most** | 82% | 82% | 88% | 82% |
| **Half** | 14% | 15% | 15% | 14% |
| **Little** | 4% | 3% | 3% | 3% |
| **None** | 0.4% | 0.1% | 0.0% | 0.3% |

*Continued on page 24*

# Fire & Wildlife

The earliest accounts of native longleaf pine forests describe a structure characterized by moderate stocking, open canopies, little in the way of shrubs or midstory, and a grass-dominated herbaceous understory. This structure was maintained by frequent fire driven by both natural and anthropogenic ignitions. Over millennia, a unique suite of wildlife evolved to thrive in these forests; species such as the red-cockaded woodpecker, Bachman's sparrow, gopher tortoise, fox squirrel, and many others depend on this vegetative structure for habitat. With the decline in high-quality longleaf pine habitat, many of these species' populations have declined as well, with 32 species associated with longleaf pine currently listed as federally endangered or threatened and many more considered species of conservation concern. Frequent prescribed fire provides many of the resources necessary for these species to flourish. In the absence of fire, some of these fire dependent species decline while generalist species persist or thrive. The continued use of prescribed fire is critical for the management of many sensitive wildlife species.

Frequent fires that promote an open forest canopy, sparse midstory, and a diverse herbaceous ground cover are critically important to reptiles that need to bask in the sun to raise their body temperature. Our research has found that three species of snakes typically associated with longleaf pine forests, the Florida pine snake, eastern diamondback rattlesnake, and eastern coachwhip, prefer to use frequently burned sites (specifically, sites burned less than every 2.5 years) and that these snakes used sites within 2 years after a burn. This preference likely reflects their need for sunlight to bask and the effects of fire on their prey. Among southeastern amphibians and reptiles, direct effects of fire such as fire-induced mortality are rare because they have developed adaptations, like burrowing, to avoid injury or death from fire.

*Gopher tortoise exiting its burrow*

One of the most iconic wildlife species associated with the longleaf pine ecosystem is the gopher tortoise. These tortoises provide habitat for hundreds of other species through the construction of burrows. The burrows provide shelter from extreme temperatures for tortoises and are believed to also offer shelter to other animals during fires. As part of our research on the role of tortoise burrows in the longleaf pine forests, we placed game cameras in the entrance of burrows before, during, and shortly after a prescribed burn. Cameras detected more animals using burrows during and immediately after the fire indicating that animals sought shelter in tortoise burrows. Some lizard species remained close to burrows after a fire to take advantage of exposed invertebrate prey.

A reduced application of prescribed fire can lead to an increase in hardwood-dominated forests and ultimately result in fundamental changes in wildlife communities. Habitat-generalist species will replace species that specialize in open pine and associated herbaceous groundcover maintained by frequent fire. To investigate habitat relationships between fire dependent and generalist wildlife species, we studied both bird and mammal populations within a fire exclusion experiment. In fire exclusion plots, small mammal populations (mice and rats)–which are dependent on dense herbaceous groundcover–declined, and some species became absent in unburned plots. Similarly, avian communities began to shift toward more generalist species. In another study focused on tree squirrel use of hardwood-pine ecotones, research suggested that hardwood encroachment into pine uplands provided gray squirrels with a competitive advantage over Sherman's fox squirrels which are an open-pine specialist.

Burning during nesting season can destroy nests of ground and shrub nesting birds, and the timing of fire is often considered when ground nesting birds are a management priority. However, depending on objectives, some burn units may require prescribed fires during nesting season. Wild turkey research at The Jones Center has provided two valuable pieces of information regarding this issue. We observed turkey nests that were 'burned over' yet ultimately hatched. Additionally, when turkey hens did experience nest failure due to a fire event, they generally renested. Because a burned nest did not always result in a failed nest, and hens generally renested if their nest was destroyed, we concluded that prescribed fires during nesting season can be compatible with wild turkey management and the use of fire is essential in maintaining suitability of open-pine forests for wild turkeys.

We studied three small mammal species common to longleaf pine forests to investigate the dynamics between predators and prey created by prescribed fire. These dynamics significantly impact both animal behavior and populations. The cotton rat is the largest of the three small mammal species and localized densities can be quite high. They are also arguably the most important prey species on Ichauway. The cotton mouse and oldfield mouse are also quite common. These species generally find refuge, or move ahead of flames, such that direct mortality due to prescribed fire is rare. However, predation on cotton rats following fire is very high. It is often so great that cotton rats can be completely absent within one month of a fire event. In contrast, cotton mice and oldfield mice often experience increased survival and population growth immediately following fire events. It is quite possible that prescribed fire sets back densities of the larger sized cotton rat and ultimately contributes to the coexistence of all three species.

Prescribed fire also provides important dietary resources for wildlife species. New plant growth immediately following prescribed fires is more nutritious than vegetation a year or more following fire. White-tailed deer are frequently observed foraging on new plant growth as revegetation of burned areas occurs. We studied white-tailed deer fawning sites relative to prescribed fire events and found that does select unburned areas for fawning sites and maintained fawn rearing home ranges in areas that were largely unburned. Coyotes are the dominant wild predator of white-tailed deer fawns on Ichauway. They are both visual and cursorial (i.e., covering large distances) predators. The hunting strategy of coyotes and unburned site preference of deer for fawning–presumably where fawns would be less likely to be detected by coyotes–indicated that white-tailed deer chose safety over the nutritional value of recently burned areas when selecting fawn rearing sites.

## Lessons Learned & Management Suggestions

1 An institutional commitment of time and resources is critical to the success of the prescribed fire program at Ichauway. Full time staff is dedicated to performing prescribed fire activities as a major component of their job duties. Prescribed fire is fundamental to all aspects of The Jones Center and burning is of highest priority within the organization. It is recommended that an intentional and institutional focus be placed on the appropriate use of prescribed fire.

2 When possible, push prescribed burning decisions down to an operational level. At The Jones Center, the natural resource manager, or burn boss, is authorized to make all decisions on the implementation of prescribed burns. This provides local knowledge and experience, focus, and flexibility within burning activities.

3 Prescribed burning efforts should be tailored to fit site-specific objectives. Objective-based burning has been utilized by the Jones Center to maintain and enhance desired conditions on Ichauway for 28 years. The scale, frequency, and season of burns should be based on site conditions and objectives. Fire objectives can change over time depending on conditions. At Ichauway, a change from annual burning to 2-year burning was driven by the desire to increase longleaf pine regeneration. Our intentional focus on fire return interval (or frequency) over season of burn has allowed us to meet or surpass annual goals for acreage burned.

4 Monitoring and recordkeeping are fundamental to objective-based burning, and important components of any prescribed fire program. These activities allow managers to ensure objectives are being obtained and plan future prescribed fire efforts. Insight can also be gained into the long-term effects of fire on a given site.

5 Keeping fuels under control with routine burning makes the prescribed fire process easier. The centuries of fire use and fire history on Ichauway provides the Jones Center with an excellent starting condition for prescribed fire. More recently, high-frequency, low-intensity prescribed fire has been used to maintain longleaf pine and open-pine savanna woodlands on site. This current fire regime has been beneficial for the ecosystem, increasing wildlife populations, longleaf pine regeneration, and native ground cover.

6 Prescribed fire is best viewed as a process. One fire event is not going to achieve all objectives for a given site, property, stand, or burn unit. Over time, each fire (past, present, and future) plays a role in both short- and long-term conditions.

7 The development of working relationships with other agencies and organizations facilitates a successful prescribed fire program. The prescribed fire community, including state and federal agencies, prescribed fire organizations, prescribed fire associations, NGOs, foresters, wildlife biologists, and landowners can provide a wealth of guidance or assistance with prescribed burning. Prescribed fire managers should continue to increase interactions within the natural resource community.

8 The continued, careful use of prescribed fire is necessary for its survival. The future use of prescribed fire depends on the ability to adapt to changing cultural and environmental conditions. Without prescribed fire as a tool, many ecosystems dependent on fire will become unmanageable and other fire-related problems (i.e., wildfire, catastrophic fire, smoke and air quality issues) will increase exponentially. Managers should be well briefed in the current issues surrounding the implementation of, and obstacles confronting, prescribed fire and use it responsibly.

*Continued on page 27*



# Fire Education & Outreach

A century of frequent low-intensity fires, critical in sustaining Ichauway's longleaf pine woodlands, have produced an extraordinary example of a working forest managed with prescribed fire. The Jones Center's education and outreach program utilizes these fire-maintained habitats for demonstration and interpretation of the importance of prescribed fire. With few exceptions, all visitors are briefed on the ecological imperative of fire in longleaf systems. More targeted audiences take a deeper dive into the specifics and challenges around prescribed fire implementation. These groups can vary greatly and include private landowners, university students, practicing natural resource managers, or policymakers. Whether engaged in a conversation or observing live fire, the fire-maintained forest always serves as the backdrop for learning.

A range of university classes visit Ichauway to learn about the longleaf pine ecosystem and the importance of prescribed fire in its management. Students come to learn about forestry or wildlife management and the role of fire, while others focus on fire itself. For example, the Center's education efforts have included fire-specific programs for the University of Georgia, Abraham Baldwin Agricultural College, Florida State University, and others.

Other groups that visit include federal and state natural resource agencies. The National Prescribed Fire Training Center has brought their prescribed fire training modules to Ichauway for more than two decades. These mid-career wildland fire professionals, predominately from the western U.S., start their three-week detail with a day at Ichauway for an introduction into southeastern fuels and fire culture. This serves as the foundation of learning while burning on federal lands across the Southeast. Similar experiences are offered to other agencies; however, these groups often focus on fire ecology and the nuances of a fire program's sustainability.

The Center has also worked with the Southern Group of State Foresters and the U.S. Environmental Protection Agency (EPA) to address issues related to prescribed fire and air quality. These efforts have included convening partners from state forestry and environmental agencies to facilitate more effective communication on issues related to prescribed fire and air quality. We have also worked on these issues with EPA Region 4 senior air quality staff, state forestry fire chiefs, state air quality directors, and other regional partners. These efforts have helped inform emerging air quality issues related to prescribed fire smoke management on both regional and national scales.

The Jones Center outreach programs also impact offsite fire communities. The Center is a founding member of the Georgia Prescribed Fire Council (GPFC) and has served in leadership roles in the council since the beginning. The GPFC is the leading organization in the state promoting and protecting landowners' rights to use prescribed fire as a viable land management tool. Key issues focus on forest health, human health and safety, training standards, and technology transfer. Since its inception, the GPFC has grown membership and attendance at annual meetings and serves as a model for other councils throughout the nation.



## Conclusion

Ichauway, and other historic quail shooting preserves in the region, are unique examples of open-pine habitat from which fire was never removed. The role of frequent fire through time is self-evident across this land. The biodiversity, wildlife habitat, aesthetics, forest health, and other values of these ecosystems are directly attributable to the dominance of fire on the landscape. Although fire was an integral part of the natural world across North America, the southeastern Coastal Plain, and South Georgia and North Florida in particular, represent one of the few areas in which the historic range of variation in fire has remained largely intact.

The last 30 years has seen renewed interest and understanding of the role that fire plays in natural resource and land management. Issues ranging from endangered species recovery to excessive fuel loading and catastrophic wildfire all point to the need to accept, and more purposefully incorporate, prescribed fire into land management at larger scales. However, many barriers and challenges must be overcome to maintain current levels of fire use, much less to broaden the use of prescribed fire for natural resource management.

Maintaining and growing capacity is a critical need, especially in the face of increasingly complex circumstances in which prescribed fire is implemented. The need for well-trained, experienced practitioners will be critical in the future. Funding must be increased, both for maintaining and growing the ability to use fire, but also for fuels treatments and other steps necessary to mitigate decades of fuel accumulation on some lands. Social issues are also a factor, with air quality regulatory impediments and public health concerns increasing with population growth. This growth also drives land use change in the form of development and associated increases in the wildland-urban interface. In short, the "social license" to tolerate the use of prescribed fire to mitigate the potential of wildfire and its impacts is increasingly threatened and something that should not be taken for granted.

Ichauway and similar lands that are managed with frequent, low-intensity prescribed fire clearly illustrate the value of prescribed fire as part of a holistic approach to land management. The natural resource management community must work diligently to continue to make the case for the value of prescribed fire. Our hope is that this documentation of the Ichauway prescribed fire program as a case study is a contribution to the ongoing advocacy and promotion of prescribed fire at a larger scale.

**Credits**

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Ichauway dendrochronology fire history information was provided by Michael C. Stambaugh, University of Missouri. Figure 1 fire return interval map was provided by Jean C. Brock, The Jones Center at Ichauway.

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