Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

Fire-scarred cross section collected from the Kelly Mountain site in the George Washington National Forest.
Credit: Henri Grissino-Mayer.

Pine Chronologies in Central Appalachian Forests: Fiery Implications

Summary

Eastern forests are lush, humid and dominated by hardwoods, relative to fire-prone forests of the West. But until recently, there was little clear evidence for the fire history of central Appalachia. Specifically, there were no tree-ring chronologies depicting fire history. Dr. Henri Grissino-Mayer of the University of Tennessee and Dr. Charles Lafon of Texas A&M University along with their colleagues found remnant pine stands hidden in the George Washington and Jefferson National Forests of Virginia. They painstakingly acquired more than 600 pine cross sections, and discovered that not only did fire once occur in these forests, but it was very common. Fire mostly stopped in the early 1930s, in close conjunction with the establishment of National Forests in the area. Current stand structure, they found, is closely linked to fire history and the relative lack of fire over the last hundred years. Pine and pine-oak stands may disappear without restorative fire. And burgeoning shrub communities—especially mountain laurels that serve as ladder fuel—contribute to increase the risk of severe wildfire.

Key Findings

- Direct, visual evidence from tree rings shows that fire was both frequent and common in central Appalachian forests for hundreds of years.
- Low-intensity fires occurred on average every four years prior to the 1930s. Higher intensity fires burned every 8–10 years, but evidence suggests only moderate severity fires ever occurred—probably because there was never a chance for fuel accumulation.
- Fire, for the most part, abruptly terminated in the early 1930s with the establishment of the National Forests. Fires that occurred after that date were small and did not spread.
- There are major shifts in stand structure of both trees and shrubs underway since the early 1930s.
- There is a shift towards hardwoods away from pine and pine-oak stands.
- Shrub species are thriving.
- The forest community is consistent with a forest shifting towards a moister community (i.e., "mesophication").

Introduction

Most forested areas of the western United States are known as fire-adapted ecosystems thanks to the ongoing work of fire ecologists, managers, planners, and others. As a result, many immediate and long-term conservation and restoration goals in the West now include fire—either in the form of accepted wildfire or controlled prescribed fire.

Fire is frequent and obvious in the West. It is quite dry compared to the fairly humid East and it has been settled relatively recently in American history. As a result fire is fresher in people's memories as well as on the landscape—it is recalled prominently in the mind as well as by clear visual signs like fire scars in many Western forests. There is a sense that wildfire is a given in the dry, lightning-prone West where fire-adapted species of trees, shrubs, and animals dominate.

The East, on the other hand, is mysterious when it comes to fire. Like a lush novel filled with digressions, descriptions, and subplots, the East guards its fire history. Its humidity, rich vegetation, dominance by hardwoods, and relative paucity of fire-adapted species make it easy to assume the region is fairly naïve to wildfire. But if the East's fire history is shrouded in mystery, what is the true answer hidden in its book of secrets? More importantly, what does this answer mean for managers and planners of Eastern forests?

Dr. Henri Grissino-Mayer of the University of Tennessee came to that institution after rigorous experience in the Southwest using tree rings to track fire history. When he arrived in the East, he confronted a surprising shortage of tree-ring research on Eastern fire history. He says, "I've always been curious about why there has been a paucity of tree-ring studies to look at fire history in the Eastern U.S." He goes on, "There is a general paradigm that says the East is 'too wet to burn,' and I have always wondered if that was really true."

Remarkably, it wasn't until quite recently—1993—according to Grissino-Mayer, that research showed conclusively that one *could* use tree rings in the East to track fire history. What's more, the Eastern forests do foster some trees suspected to require fire for regeneration—namely oaks and pines. These trees suggest fire adaptation with thick bark, serotinous cones that require melting to free their seeds from resin, or vigorous sprouting. Still, precious little evidence existed on the actual fire history of these forests.

Henri Grissino-Mayer shows Steve Croy, ecologist for the George Washington and Jefferson National Forests, fire scars on a small sample recently collected at the Brush Mountain site in the Jefferson National Forest. Credit: Georgina DeWeese.

Knowing all this Grissino-Mayer teamed up with Dr. Charles Lafon, of Texas A&M University, as a kind of dendroecological (tree-ring) duo. The two shared a driving interest in uncovering actual data on Eastern fire history—and they knew tree rings were a surefire way to get it.

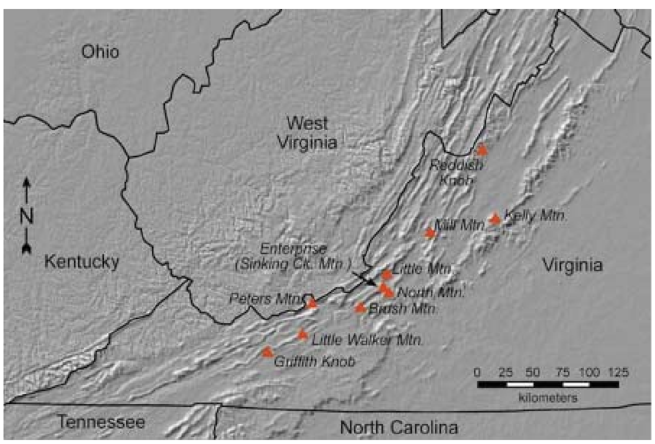
With a Joint Fire Science Program (JFSP)-funded proposal in hand, they set out to find hundreds of pine trees in remote areas of central Appalachian forests. But like venturing into a powerful narrative, they "didn't know what (they) were in for," says Grissino-Mayer. "It was a study of unknowns—nothing like this had ever been done before in Eastern forests."

Journey to the rings: Stellar science holds sway over enigmatic forest

"Nothing can prepare you for hiking in the remote areas of the Eastern U.S." says Grissino-Mayer. He and his team spent hundreds of hours walking into extremely remote, nearly forgotten spots of pine forest hidden in the central Appalachians. “The humidity, snakes, thunderstorms, lightning, yellow jackets, insects, and dense underbrush made our work a lot harder than we anticipated,” says Grissino-Mayer. “Now I know what it feels like to be a cow standing outside during a thunderstorm.”

In some ways, that’s the good news. The team had found a way to access areas of forest remote enough to sustain remnant tracts of pine forest in a matrix of hardwoods that are transitioning not only away from pines altogether, but towards a hardwood community clearly unfamiliar with fire. To get tree-ring data that would yield the fire history they were after, they needed pine trees—these are the trees known to track fire history with their visually evident scarring. To find them, says Grissino-Mayer, “We used aerial photos to search for areas that were minimally disturbed. And we talked to old-timers from around the forest.”

It turns out the George Washington and Jefferson National Forest (GWJNF) of Virginia offered the team both the remote sites and the pines. Over the course of five demanding summers, they acquired samples from more than 600 trees. “We sampled in eight major locations in the National Forests,” says Grissino-Mayer, “The sites were physically rugged, minimally disturbed, and far away from roads, urban areas, and clear cutting. They were not easy to get to! But they were all absolutely beautiful.”



Locations of study sites within the GWJNF. Two supplementary sites were added to the original eight sites. These are Enterprise and North Mountain. These were added with the intention according to the JFSP report, “to characterize the historic variability in fire regimes within a small, relatively homogeneous area.” Credit: JFSP Final Report.

This demanding work to get into vegetation-choked sites was just the beginning. Once on site, the researchers had tedious and careful work ahead. Each pine tree had to be sampled by chainsaw to acquire the cross section for later tree-ring analysis. The researchers cut full or partial cross sections from both living and dead fire-scarred trees, according to their final JFSP report. They marked the location of their samples with a GPS unit, and note in their report that despite the humidity the quality of the samples was quite good—they found trees with measurable fire scar events dating back to the 1700s. They write in their report that, “Many individual trees bore multiple fire scars, which facilitated the development of long fire chronologies.”


Henri Grissino-Mayer saws into a Table Mountain pine snag on Brush Mountain in the Jefferson National Forest in Virginia. Credit: Georgina DeWeese.

Meanwhile, the researchers subsampled 20 by 50 meter plots at all the main study sites in the often choked, overgrown vegetation. They measured tree composition and age structure. “For each tree with diameter at breast height (dbh) greater than or equal to 5.0 centimeters, we identified species, measured dbh, and used an increment borer to obtain one to two cores at the base of the tree. We also counted and identified to species all the saplings (dbh less than 5.0 centimeters, height greater than or equal to 50 centimeters) in the plot. The saplings were too small to core, but branch nodes of the pine saplings were counted to age the trees.” The researchers measured a host of other vegetation characteristics on the sites as well, including duff measurements and the timing of shrub establishment.

Once back in the lab, each of the woody cores cut from the trees were painstakingly sanded down with very fine grit to reveal in tremendous detail the fine labyrinth of tree rings. Then the team began the tedious work of dating each growth ring on every cross section, and further, to analyze every fire scar for its location and season of occurrence on the particular scarred ring.



(Left) As part of her Ph.D. project, Dr. Georgina DeWeese inspects a Table Mountain pine log with multiple scars (lines seen laying in the direction of the viewer) sampled on Reddish Knob in the George Washington National Forest. (Right) Dr. Charles Lafon, Principal Investigator on this project, with sawyer Dr. David Mann, next to a Table Mountain pine showing multiple ridges indicating numerous past fires at the Reddish Knob site on the GWNF. Credit: Henri Grissino-Mayer.

Fire once common, now gone

"The biggest result and surprise of our work is just huge," says Grissino-Mayer. "Pretty much the last fire scar dates to 1934 across all our sites, and through hundreds of trees and samples. It's like a light switch got turned off—there was fire and then there wasn't." According to Grissino-Mayer the visual impact of this result is almost overpowering. He says, "The last fire in one of the sites—Mill Mountain—occurred in the same year that these forests became National Forests. Since then, there've been almost no fires. There was lots of technology being used to suppress it."

For deeper understanding of both the historic and modern fire history, the team also reviewed the contemporary fire regime using data from the National Interagency Fire Management Integrated Database (NIFMID) for the period 1970–2003. "Most fires that occurred after the 1930s were recorded only on a few trees, probably indicating that either (1) the fires were suppressed quickly, before they could spread throughout the entire study site or (2) the fires were low-severity or patchy fires that were not hot enough to scar most of the trees. At one site, Mill Mountain, the effect of fire control efforts is especially pronounced—no fires were recorded after 1930."

Henri Grissino-Mayer (left), Georgina DeWeese (center), with sawyer Daniel Lewis, at the North Mountain site in the Jefferson National Forest, showing a fire-scarred Table Mountain pine snag. Credit: Charles W. Lafon.

"The second, and equally big result," says Grissino-Mayer, "is that *before* 1934 fire was very common and very frequent in these forests. For the 250 years before the formation of the National Forests—all the way back to 1650—low impact fire burned, on average, *once every four years*." And, he goes on, "bigger, more significant fires that spread some distance occurred once every 8–10 years."

These results point to "a major, major change," says Grissino-Mayer. "We are not sure of the origin of the fires—it could be they resulted from intentional burns set by Europeans or Native Americans, or from lightning, or from some combination of all three. But at this point, we don't really care about the fire's origins—what's important here is the clear evidence for once very common fire that is now just gone."

Serena Aldrich of Texas A&M University next to one of the oldest fire-scarred samples collected for this project, located on Mill Mountain in the George Washington National Forest of Virginia. Credit: Georgina DeWeese.

Current forest structure and its link to fire history

Meanwhile, says Grissino-Mayer, "Current forest conditions result from the lack of fire. The understory is now absolutely choked with mountain laurel. This stuff is made to burn—like chaparral—but now instead of it being 8 feet tall it's grown to be 20–25 feet tall. The whole understory is choked with ericaceous shrubs like mountain laurel, rhododendron, and blueberries."

Grissino-Mayer is understandably concerned. He goes on, "Most of the fire models for this area suggest that fuels will become less flammable as the forest transitions even further away from pine and more towards hardwoods—the fuels are just less flammable. But," he stresses, "these models don't really account for the shrubs—and these shrubs are highly flammable ladder fuels that can send flames right to the crowns. They are a recipe for disaster. Colleagues of mine reported 200 feet high flames in the St. Mary's Wilderness fire in the GWJNF just this last April 2008."

Meanwhile, it's true that fire control has created a "whole new fuels complex" that on the surface, at least, appears wetter. That's because without fire, pine establishment has literally vanished. The results of the team's study show that the last pine seedlings were established shortly after the formation of the National Forests—and subsequent fire control. Meanwhile, the hardwoods and shrubs continue to dominate and expand. Indeed, they write, "All the mountain laurels became established following the decline in burning." This series of changes, along with many others, is now known as the mesophication of the eastern forest—the "moisturizing" of the forest.

In a recent *BioScience* article (February 2008), Gregory Nowacki and Marc Abrams, stress the effects of mesophication in Eastern forests as follows, "Plant communities are undergoing rapid compositional and structural changes, some with no ecological antecedent. Stand-level species richness is declining, and will decline further, as numerous fire-adapted plants are replaced by a limited set of shade-tolerant, fire-sensitive species. As this process continues, the effort and cost required to restore fire-adapted ecosystems escalate rapidly."

In other words, the effects of fire exclusion on the Eastern forests are profound. Without fire, whole communities are changing. Until the details of this study by Grissino-Mayer and Lafon emerged, managers and planners had precious little information on actual fire history to guide any effort to restore fire to the system.

Explosive insights: Central Appalachians at risk?

But what's crucial here, says Grissino-Mayer, is that "things could explode given the right short-term weather and long-term climate conditions. We've got 80 years of shrubs, debris, and fuel build up that have created a homogeneous fuels complex across the landscape. If a fire breaks out under the right conditions, it could literally be a recipe for disaster."

Furthermore, he continues, "We've got extremely useful information here for managers and planners. Our evidence is so clear: we've got fire-adapted species living in a fire-adapted ecosystem. The old paradigm that says Eastern forests are 'too wet to burn' is just not true. What *is* true is that there needs to be a re-education of people's way of thinking (about these forests). We need to educate people about the *need* for fire."

In Eastern forests surrounding and embedded in the growing urban populations of the Atlantic Seaboard—populations that are now very nearly linked by urban sprawl from Maine to Florida—incorporating this information on fire into management practices will be no small feat. "Yes," says Grissino-Mayer. "Fire would introduce major air quality and health concerns here. It's not clear how to bring fire back, but the forests, meanwhile, are heading towards major, out-of-control wildfire."

What is immediately possible, he says, is that the research, "lays a framework for understanding the history of fire, the current state of the forest, and the actual risk of fire." With all that, he adds, comes a clearer picture of future fire behavior.

Likewise, the data on current forest structure clearly points to an imminent loss of pines from the forest. They write in their report, "Our results suggest that a critical need exists for resource managers to restore Appalachian pine and pine-oak stands through the use of fire before the window of opportunity is closed. The dominant pine age-groups are aging and will be lost in coming decades. When these seed-producing trees are gone, restoration will be far more difficult."

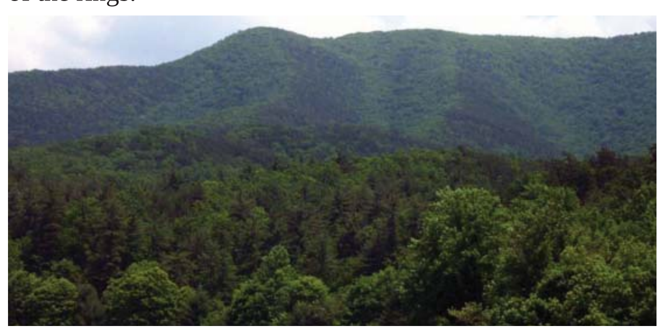
Management policies at the GWJNF are now incorporating the results of Lafon's and Grissino-Mayer's work, and should make for healthier forests that are less prone to intense wildfire. Grissino-Mayer says, "And these policies, we hope, will begin to restore endemic species of plants and animals that depend on fire in this ecosystem."

Perhaps the greatest contribution of the team's work is not the alarm bell about Appalachian forests at risk of fire (although this, too, is very significant), but the breathtaking visual evidence of fire itself in forests thought to be too wet to burn. Indeed, once the pine trees are gone (and they may well disappear without restorative fire) creating a fire history based on tree-ring chronology would have been nearly impossible.

Now, thanks to these researchers and the scores of pine tree cross sections they painstakingly acquired, the once-hidden secrets of fire history in the central Appalachians are preserved and revealed in the unmistakable black and white of the rings.

Management Implications

- Changes in fire history and stand composition of the central Appalachian forest point towards intense wildfire unless management practices can mitigate this potential.
- Recognizing the importance of fire can support management plans to restore fire to these forests.
- Without fire, pine and pine-oak stands in the central Appalachians may disappear. Populations are old and no new seedlings are evident. With shrub-choked undergrowth, and no fire, these populations will not have a chance to regenerate.
- Tracking down remaining pine populations to create fire chronologies for all of the Appalachian forests of the Eastern seaboard could be vital to managers and planners who need more understanding of fire history across this region to address the mesophication of Eastern forests.



Pine stands on the west-facing slopes of Brush Mountain, Virginia. Credit: JFSP Final Report.

Further Information: Publications and Web Resources

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Scientist Profile

Henri D. Grissino-Mayer is an Associate Professor in the Department of Geography at the University of Tennessee and Director of the University's Laboratory of Tree-Ring Science. He is interested in ecosystem disturbance processes and the use of dendrochronology to address changes in these processes both spatially and temporally. His research concentrates on analyzing the history of past wildfires and the history of past climate, and how climate change possibly mediates changes in wildfire regimes.

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Results presented in JFSP Final Reports may not have been peer-reviewed and should be interpreted as tentative until published in a peer-reviewed source.

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