Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

Springtime prescribed fire in pitch pine. Photo by David Crary.

The Impossible Summer Burn: Techniques for Fuel Reduction, Habitat Restoration and Happy Locals in Northeastern Pine Barrens

Summary

New England pine barrens are highly flammable, fire dependent and critically imperiled ecosystems. The last remaining pockets of this vegetation type are woven through cherished historic sites, prestigious resort communities and some of America's most popular seashores. Fire exclusion has all but eliminated the periodic fires this landscape requires for rejuvenation and maintenance. Unlike many other wildland-urban interface regions however, there are no regular, high profile wildfires to serve as reminders of the urgent need for fuels management. Because fires are so infrequent, local governments, residents and visitors tend to think of wildfire fire as something that happens somewhere else. Building on previous work, scientists and managers collaborated to design and demonstrate innovative, multi-season, culturally acceptable combinations of fuel treatments to reduce wildfire hazard and restore habitats for endangered plants and wildlife. They also convinced local fire fighting agencies, residents and visitors of the value of prescribed fire by demonstrating how it protects and enhances their communities, economies, property values, safety, and the ecosystem in which they live.

Key Findings

- Spring and summer combination treatments that include prescribed fire mimic conditions and effects that shaped pine barrens habitats throughout millennia.
- Treatments applied during the growing season—whether mowing, burning or in combination—are more effective than dormant season treatments for reducing fuel loads and inhibiting re-growth of undesirable vegetation.
- Reducing fuel bed depth through mechanical treatments prior to prescribe burning is more effective in reducing fire behavior than reducing fuels alone.
- Mechanical treatment followed by prescribed fire significantly reduces the time required to restore vigorous, young pitch pine/scrub oak stands.
- Use of prescribed fire alone in mature, untreated scrub oak fuels is accompanied by increased risk of escape and/or smoke management problems. Mechanical pretreatment reduces the risk of escape in subsequent prescribed burning.
- Re-burns of areas treated with prescribed fire alone burn more intensely, spread faster and have higher potential for spotting than prescribed burns that follow mechanical treatments.

Fire's disappearing act

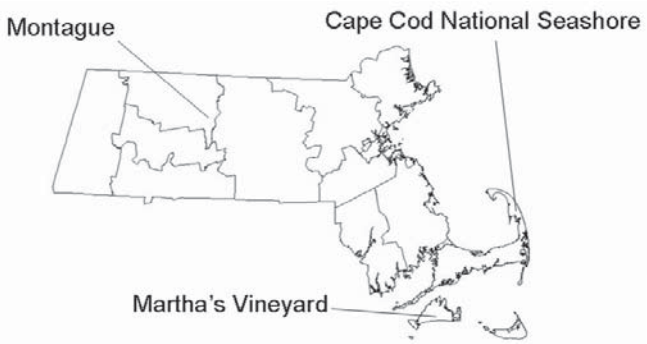
Plymouth Rock…Cape Cod…Martha's Vineyard…Nantucket Island…Quick! What comes to mind? Maybe pilgrims, beaches, lobster, expensive real estate, the Kennedy clan, and perhaps the most famous shark in movie history.

How about risk of severe wildfire in critically imperiled habitat, embedded in wildland urban interface? This probably wasn't on your list. Until recently, many residents of these coastal resort areas didn't realize the magnitude of fire hazard in and around their communities. Land managers and scientists had a challenge on their hands determining the best methods for restoring and maintaining the last remaining acres of Northeastern Pine Barrens—an endangered, fire-adapted vegetation type found only in isolated pockets of New England, eastern New York, and Long Island. But there was an added component to the task: convincing three generations of residents and government leaders, most who had never witnessed east coast wildfire and never expected to, that they were sitting on a tinderbox consisting of the last remnants of a perilously rare ecosystem. Action was required in order to prevent destruction of property, lives and vulnerable habitat. The job called for a couple of locals who knew the culture and the Pine Barrens like the backs of their hands.

Although born a generation apart, William Patterson and David Crary, Jr. both grew up on or near the hook-shaped archipelago of Cape Cod, Massachusetts; one of three study sites where this extensive research took place. 'The Cape' is home to historic small towns, exclusive resort communities, and some of the most popular beaches in America including the 42,000 acre Cape Cod National Seashore where Crary has been Fire Management Officer since 1989. Crary started his career as a student in Patterson's fire and ecology classes at the University of Massachusetts at Amherst (UMass) in 1978, when Patterson was just beginning to think of applying the concept of wildfire management and prescribed burning in New England. At the time there was no prescribed burning whatsoever in the region.

Patterson witnessed the effects of the 1957 Plymouth Fire on Cape Cod as a boy. The fire, which burned 15,000 acres in one day, was far and away the largest fire in Massachusetts during the last half of the 20th century. But for residents and vacationers alike, the flames have faded from memory. Patterson sites this as an ongoing challenge. "This area is very different from the West where fires burn nearly every month of the year and regularly make headlines. Wildfires now occur so infrequently here that people tend to think they can't occur at all. We really had to educate people about the fact that fire will almost certainly occur again and that things can be done to mitigate risk."

From 2000 through 2005, with combined funding from the Commonwealth of Massachusetts, the University of Massachusetts, The Nature Conservancy and the Joint Fire Science Program, Patterson and Crary took the work they began in1985 to a new level and in so doing have reshaped fire management policy in the Northeast.



Locations of the three study areas.

The research took place in three separate pine barrens sites: The Lombard-Paradise Hollow Fire Management Research Area at Cape National Seashore, the Manuel F. Corellus State Forest on the island of Martha's Vineyard, and the Montague Plains Wildlife Management Area on mainland Massachusetts. Each location provided a set of

conditions and constraints that strengthened the research and made the results more widely applicable. The resulting suite of techniques, guidelines and models transformed the understanding of fire behavior, fuel modification and habitat restoration in northeastern pine barrens. In addition, their educational efforts converted public perception of fire from negative and impossible—to positive and essential. No small feat in the case of so much skepticism and so little remaining habitat.

Mounting fuels await fire's return

Fire behavior in barrens vegetation is comparable to the southern rough of the Southeast and chaparral of the West. Severe fires are fueled by loosely piled pine needles, leaves and twigs mingled with flammable shrubs like huckleberry and scrub oak. Ice storms and coastal gales contribute by generating deadwood that ends up hanging in the branches of standing trees or layered on the ground. Decomposition is slow because the soil is acidic, dry and sandy. Another player is the ericaceous shrub layer. Ericaceous plants contain highly flammable waxes and oils that protect them from insect attack and desiccating North Atlantic winds. They ignite easily and burn hot, but vigorous new growth after fire provides an essential food source for endangered butterflies and moths.

Over the last century the potential for crown fires has become high in dense stands of "dog-hair" pitch pine, where ladder fuels have accumulated and low springtime humidity combines with strong continental winds. Crown fires are tough to control and radiate intense heat which makes structure protection more difficult for firefighters. This is of exceptional concern for managers in the densely developed vacation areas where much of the study took place.

Prior to the exclusion of fire from the landscape, fires typically burned every fifteen to twenty five years in pine barrens. Spring fires burned after snowmelt but before leaf-out. Summer fires burned during dry years, sometimes severely. The vast majority of fires have been caused by humans. Evidence suggests that for 9,000 years before European settlement, Native Americans used fire as a multi-season, multi-purpose survival and landscape management tool in ways that benefited the forest as well as themselves.

Spring and summer fires: Two sides of the same solution

When Patterson and Crary began their work in the mid 1980s, management consisted of occasional springtime, dormant season prescribed burns. Summer burns were not permitted in Massachusetts at the time because of potential smoke impacts on summer tourism. In addition, most of the fuel is live in summer and fuel moistures are high, so getting a viable fire going isn't easy.

Spring is when barrens fuels are at their driest, so the dormant season burns were risky. They were also inadequate when it came to fuel and fire hazard reduction and desired ecosystem effects. So Patterson and Crary considered the ecological role and effects of summer fires that occurred

Pine barrens vegetation woven in and among residential development in the village of Truro, on Cape Cod.

before fire exclusion became the norm. They knew that historic, severe summer fires had helped shape pine barrens habitats, generating effects that enhanced those of dormant season burns. They realized that limiting prescribed fire to springtime was probably leaving out half the ingredients of the restoration recipe, and that the laws prohibiting summer burns were likely contributing to the both habitat loss and fuels accumulation.

"We had homogenized the fire regime for over 100 years by excluding fire." Patterson explains. "Then by reintroducing it—but only during certain times of the year—we were producing only a certain effect and homogenizing it even more."

Reduced fuel depth transforms possibilities

So the team set out to create safe, productive, culturally and legally acceptable ways to return fire to the landscape in both spring and summer. Somehow they had to make spring burns more predictable and easier to control, and summer burns hot enough to replicate historic growing season fires without damaging the overstory or creating too much smoke.

The key to it all, they discovered, was to cut the fuel bed down to size. They tested a variety of multi-stage techniques and different seasonal applications to shrink fuel bed depth. Shallow fuel bed depths result in lower flame lengths that are more controllable and less destructive to the overstory. The team demonstrated that when fuels are treated first to reduce depth—either in spring or summer—then burned in the growing season and/or in combination with brush cutting or grazing, it's safer, more efficient and less expensive than prevention alone or reliance on dormant season treatments. The technique drastically reduced fire hazard while maintaining rare species habitats and proved to be a much more effective way to moderate fire behavior and smoke production than fuels reduction alone.

This approach enables managers to put fire where they need it, *when* they need it, with almost no risk of it getting

up into the crowns of trees they want to keep. Crary spells out the concept: "Let's say we have an area where we have eight tons of shrub fuels that are five feet high. Then we cut it all down with brush cutters or we grind it up. We've turned that same eight ton, five foot tall fuel into something that's now only eight inches high and far more compact. The same volume of fuel is now much shallower; with much less airspace in it so fire burns much more slowly."

(1) A years' growth after initial mowing and spring burn.

(2) Subsequent summer prescribed burn with leaves on.

(3) A year later there is little re-growth. The ecosystem is starting a new seral stage. Photos by David Crary.

Slowing the rate of fire spread is everything, adds Patterson, especially around busy resort towns with multi-million dollar "cottages" and 300-year-old historic buildings. The lower rate of spread, up to 80% slower is some cases, provides a solution for fire problems in both seasons. Spring fires are safer and more controllable. Summer burns are possible and productive because heat stays put under moist foliage for longer periods, facilitating combustion.

Patterson is satisfied that this approach comes much closer to replicating the historical fire regime that pine barrens habitats have been lacking since the Pilgrims arrived. It also prompted a complete change in management philosophy. "We're just reinventing the wheel by implementing what Native Americans practiced for millennia in the northeast before the Europeans arrived," he says. "The result is a significant shift in the seasonality of management burning because we now have a better understanding of the ecological effects of fires at different times—and it's much safer in terms of reducing the threat of a major wildfire from escapes."

Bonus material: Custom fuel and crown fire prediction models

Patterson and Crary expanded the utility of the research further by putting 23 years worth of fuel sampling and measurements together to create custom BEHAVE fuel models. Previous fuel models for pine barrens vegetation significantly underestimated fire behavior.

The project was the first to directly measure fuel bulk density (load divided by depth) and fuel moistures in pitch pine forests, resulting in a model based on empirical data rather than estimates. As suspected, they found that live pitch pine needles were at their driest at the beginning of May—the time when managers had been most likely to conduct prescribed burns. Knowledge of the seasonal fluctuations in needle moisture is important, because the risk of crown fire goes up as fuel moisture goes down.

Potential crown fire hazard generated yet another component of the project—an evaluation of the effectiveness of thinning mature pitch pine stands to reduce risk. Crary says, "We all know that the thinner a stand is the less chance there is for crown fire—but we couldn't exactly go to the local fire department in one of these little towns and say, 'Hey Chief! Can we come into your town and light a crown fire to get some measurements?' So we had to model it." Using methods developed at the Missoula Fire Lab, UMass graduate student Matthew Duveneck analyzed and documented the canopy bulk density of pitch pine stands before and after thinning.

The result was a crown fire prediction model specific to this forest type. It indicates that when pitch pine stands are thinned to 20–30 square feet of basal area per acre, the wind speed required for crown fire initiation increases from 20 miles per hour to over 60 miles per hour. When the wind blows that hard in the region it's generally a component of rainy thunderstorms, hurricanes or blizzards, which bring

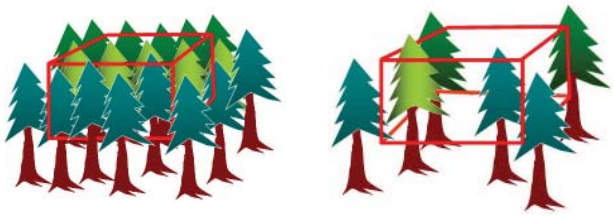
so much precipitation that any fire initiation at all is highly unlikely.

Details at your fingertips

The project web site contains detailed descriptions of all research methods, results, models and demonstration sites, as well as extensive management guidelines. A wealth of graphics and photographic comparisons effectively communicate all the techniques and how they were developed. A canopy bulk density workbook, details of model development and use, and links to over 40 related scientific studies round out the cyber-pine barrens management experience.

When prompted to elaborate on the scope and impact of the work, Dave Crary prefers to emphasize the simplicity of its intent. "We're not working to prevent fire. We're working to prevent the rapid spread of destructive fires while attempting to return fire to a fire-dependent ecosystem. That's the big distinction. We still need firefighters. We still need to respond and put out unplanned ignitions, malicious or accidental. But we don't need to sit back and let our wildlands accumulate fuel that allows fast moving fires and huge flame lengths that have to be aggressively suppressed. We can reduce the fuel, maintain the ecosystem and do it relatively easily and safely."

"The project has been a very useful marriage of management and research," adds Patterson. "We had some hypotheses we thought would work on a management scale—a scale where we could ask practical and economic questions over time about treatments and combinations we wouldn't even have thought about in our initial work 20 years ago."



Example of pine barrens crown density before and after thinning. The model suggests that thinning pitch pine stands to 20–30 sq. ft. of basal area per acre increases the wind speed required for crown fire development from 20 miles per hour to over 60 miles per hour. These wind speeds do occur in the region, but they're generally a component of rainy thunderstorms, hurricanes or blizzards, which bring so much precipitation that fire initiation is unlikely. The model helps fire managers anticipate and predict how hot and fast a fire might burn if it did reach the canopy and provides specific information to guide stand thinning activities.

Their techniques are now widely employed at several pine barrens ecosystems in the northeast including their demonstration sites at Montague, Cape Cod, and Martha's Vineyard. Future work will focus on documenting rates of recovery in fuel load and depth. A primary goal is to determine the treatment frequency required to maintain reduced fire hazard conditions while preserving species diversity. Implementation of the guidelines is currently providing a profit to the Commonwealth of Massachusetts (at Montague) while further decreasing wildfire risk and enhancing threatened and endangered species habitats.

Making the impossible possible and pleasing everybody all of the time—from endangered moths and huckleberries to managers and skeptical locals. History is made once again at Plymouth Rock.

Management Implications

- Applying treatments at 3–4 year intervals is the most cost-efficient way to reduce fuels and prevent severe wildfires while maintaining the ecological integrity of barrens.
- Thinning pitch pine to a residual stand of approximately 30 square feet of basal area per acre dramatically reduces the predicted risk of crown fire.
- Combinations of mowing followed by burning, applied in a single summer, quickly reduce fuel load and fuelbed depth and hence fire hazard (i.e., extreme fire behavior) on subsequent burns.
- Mechanical pretreatment of fuels to reduce fuelbed depth followed by growing season burning, and/or in combination with additional burning, brush cutting and/or grazing is safer and more efficient and cost effective than prevention alone or reliance on dormant-season treatments.
- Custom BEHAVE fuel models and crown fire predictors support increased management success and efficiency.

Further Information: Publications and Web Resources

All papers and project details available through the University of Massachusetts website: Managing Fuels in Northeastern Barrens. http://www.umass.edu/necbarrensfuels

Final Report – Joint Fire Science Program. http://www.firescience.gov/projects/01C-3-1-05/01C-3-1-05_final_report.pdf

Duveneck, Matthew J. Characterizing Canopy Fuels as They Affect Fire Behavior in Pitch Pine. http://www.umass.edu/nebarrensfuels/publications/pdfs/duveneck_thesis_2005.pdf. (2005).

Scientist Profiles

Dr. William A. Patterson III is a Professor of Forest Ecology and Measurements, Fire Control, and Fire Management at the University of Massachusetts at Amherst. He has served as an Instructor for The Nature Conservancy's Ecological Burning Workshops, and as a member of working groups involved with FRCC and LANDFIRE analyses for northeastern U.S. vegetation types. His research during the past 28 years began with fire history studies in northwest Alaska and New England, and currently involves prescribed burning experiments in North Atlantic pine-oak forests and barrens. He has taken sabbaticals as a Bullard Fellow at Harvard University and as a visiting research scientist at CSIRO, Canberra, Australia. For his work in implementing prescribed fire in New England, he received The Nature Conservancy's President's Stewardship Award and the New England Wildflower Society's Conservation Award.

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David W. Crary, Jr. began his career as a Biological Technician and Wildland Firefighter in the early 1980s. He was the recipient of the 2003 National Fire Plan Award for Excellence in Firefighter Preparedness, Training and Safety, and has served as the Fire Management Officer at Cape Cod National Seashore for 19 years.

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