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Using Fire to Control Invasive Plants: What's New, What Works in the Northeast 2003 Workshop Proceedings

UNIVERSITY of NEW HAMPSHIRE
COOPERATIVE EXTENSION

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Julie Richburg

Using Fire to Control Invasive Plants: What's New, What Works in the Northeast? was held on January 24, 2003 at the Urban Forestry Center, Portsmouth, NH. Over one hundred natural resource professionals gathered to hear from researchers and fire managers whose observations might not have been summarized elsewhere. These papers were not peer-reviewed or edited. They were compiled by Karen P. Bennett, University of New Hampshire Cooperative Extension, Dr. Alison C. Dibble, USDA Forest Service, Northeastern Research Station, and Dr. William A. Patterson III, University of Massachusetts. These proceedings are available at http://www.ceinfo.unh.edu/forestry/documents/WPUFCI03.pdf

Workshop Agenda

Can Northeastern Woody Invasive Plants Be Controlled With Cutting and Burning Treatments? Julie Richburg, University of Massachusetts
Stereo Photo Series for Quantifying Natural Fuels in the Americas Robert Vihnanek, USDA Forest Service, Pacific Northwest Research Station (see poster)
Lessons Learned from Eleven Years of Prescribed Fire at the Albany Pine Bush Preserve Tom Dooley, Albany Pine Bush Preserve
Regional Climate and Fire Danger Modeling Specific to the Pine Barrens Dr. John Hom, USDA Forest Service, Northeast Research Station
Panel: Using Fire to Control Invasive Plants- What's New, What Works in the Northeast?
David Crary, Cape Cod National Sea Shore
Dr. Michael Ciaranca, Camp Edwards
Tom Dooley, Albany Pine Bush Preserve
Jessie Murray, The Nature Conservancy
Dr. Ernie Steinauer, Mass Audubon
Gerald Vickers, US Fish and Wildlife Service
Dr. Betsy Von Holle, Harvard Forest
Policy Changes and Funding Opportunities Affecting Fire Managers and Researchers Allen Carter, USDI Fish and Wildlife Service, Northeast Region
Use of Prescribed Fire for Management of Old Fields in the Northeast Laura Mitchell, US Fish and Wildlife Service, Prime Hook National Wildlife Refuge
Fuel Bed Characteristics of Invaded Forest Stands Dr. Alison C. Dibble, USDA Forest Service, Northeastern Research Station
Modifying the Behave Fuel Model for Northeast Conditions: Research Needs for Managing Invasives Dr. Mark J. Ducey, University of New Hampshire
Overview and Synthesis Dr. William A. Patterson III, University of Massachusetts

This meeting was sponsored in part by the Joint Fire Science Program, NIFC, Boise, ID, which provided support for a 3-year fire/invasive plants study. Others sponsors include USDA Forest Service, Northeastern Research Station; University of NH Cooperative Extension; University of Massachusetts.

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Can northeastern woody invasive plants be controlled with cutting and burning treatments?

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Woody invasive species, both native and non-native, are the focus of management actions on many protected lands. They compete with other species directly, alter ecosystem processes and fire regimes, change local hydrological characteristics, and, in the case of non-native species, may hybridize with natives and thereby degrade gene pools. Resource managers are currently working to control or eliminate invasive woody species on their properties to restore and maintain habitat structure and composition for wildlife, rare species, and aesthetic values. Activities include mowing, burning, removing individual plants, and applying herbicides. Treatments may be applied singly or in combination (Randall & Marinelli 1996). Burning may be more natural in the sense that it is a process that has long affected the evolution of species and functioning of ecosystems, but its application in the Northeast is sometimes problematic. Both mechanical treatments and herbicide applications may alter fuel bed characteristics to increase the intensity of wildfires burning through treated vegetation. The success and effects of these management treatments is often related to the biology of the individual species, the timing of the treatment, and the extent of the invasive species problem at the site.

Mowing, grazing and burning have been used for centuries in the northeastern U.S. to keep agricultural fields and other open lands free from woody invaders. Native Americans burned fields to keep them open (Olson 1978), and this practice was continued by European settlers. Shifts in agriculture to the Midwest, increased effectiveness of fire suppression efforts, and increased concern over the effects of open burning on air quality have resulted in increased opportunities for woody species to invade grasslands, old fields, and, in some cases, wooded tracts. During the last few decades of the 20th century, mowing and prescribed fire were performed primarily during the dormant season, when many wildlife species, especially ground-nesting birds, are least likely to be negatively impacted. Unfortunately this timing has had minimal success in controlling woody plants. Although above-ground stems may be killed by dormant season cut or burn treatments, below-ground carbohydrate reserves remain available to support growth of new sprouts. These sprouts quickly grow and the population recovers, sometimes with more stems than before treatment.

Carbohydrate reserves provide an energy source to support growth and respiration when plants are leafless [e.g. prior to leaf-out in the spring or after disturbances like herbivory or fire (Loescher *et al*. 1990, Kozlowski 1992)]. The extent and availability of reserves contributes to the vigor of individual plants. The more reserves, the better an individual will be able to survive stress, whereas depleted reserves can lead to plant death (Kozlowski 1992, Johansson 1993). Carbohydrate reserves vary seasonally (Johansson 1993, Droege 1996). In the Northeast, reserves are normally depleted by the growth of new leaves and shoots in the spring, are replenished during the summer, and are used in respiration during the winter. Management actions such as mowing or burning can have differing long-term effects on plant vigor depending on when they are applied during this cycle (Loescher *et al*. 1990, Kays & Canham 1991). Late-season defoliation can cause a decrease in carbohydrate reserves that can impact the vigor of the individual at the beginning of the next growing season (Gregory & Wargo 1986, Loescher *et al*. 1990).

With the support of the Joint Fire Science Program funded by the Congress through the U.S. Departments of Interior and Agriculture, we are evaluating two key topics regarding fire and invasive species in the Northeast: how cutting and prescribed fire treatments, timed to the phenology of carbohydrate depletion and recovery, affect the survival of several woody invasive species; and how treatments alter fuel beds and affect fire behavior in invaded and uninvaded landscapes. We have applied dormant and growing season cut and burn treatments to seven different woody invasive species: multiflora rose - *Rosa multiflora*, common buckthorn - *Rhamnus cathartica*, gray dogwood - *Cornus racemosa*, Asian honeysuckles - *Lonicera* spp., Japanese barberry - *Berberis thunbergii*, Scotch broom - *Cytisus scoparius*, and catbrier - *Smilax rotundifolia*. Of these, catbrier and gray dogwood are native to the Northeast, but are undesirable in certain habitats. To determine which treatments have been most effective, we are comparing root carbohydrate levels through time and across treatments.

For each species, we established four, 0.2 hectare (40 m x 40 m) plots located in areas with similar overstory and understory vegetation. One plot serves as a control. We cut the target species in a second plot after leaf-out, followed this treatment with a late-season prescribed burn the first year, and a second early-season cut the following spring. On a third plot, we cut the target invasive species at least two times: after leaf-out in the first year and early in the following growing season. The fourth plot was either burned or cut during the dormant season. Plots were cut with hand-held brush cutters or a tractor with a mowing deck.

To determine total non-structural carbohydrate (TNC) phenology and plant response to alterations in stored resources following above ground treatments, we collected sections of roots of the invasive species from each plot approximately monthly during the growing season. From each plot, four-to-six plants were randomly selected and a sample of their roots collected. Samples were handled and evaluated for TNC as described in Droege 1996. TNC (expressed as a percentage) is calculated as grams of TNC per gram of root.

Preliminary results and implications for management

We have completed two years of treatments and have preliminary TNC data for some species. Results indicate that all of our treatments impact root TNC levels, but growing season treatments have the greatest multiple-year impact. Droege (1996) found that TNC in huckleberry roots reacted similarly to cutting and burning treatments, but that a single growing-season treatment did not have a lasting impact on rhizome TNC levels. We followed up on her results by treating our growing season plots twice in our first growing season, followed with at least one treatment in the second year. These multiple treatments appear to prevent recovery of TNC to pre-treatment levels for at least two years. We will continue to follow recovery of TNC for a third year without additional treatments. Although he did not look at below-ground TNC levels, Patterson (unpublished data) found a decline in sprouting vigor and above-ground biomass of shrubs in plots repeatedly treated during the growing season but not during the dormant season. His study, encompassing a series of plots with treatments every 1, 2, 3 or 4 years over the last 17 years, evaluates the effects of growing and dormant season cutting and burning on huckleberry, blueberry, and other shrubs and trees in an oak-pine forest at Cape Cod National Seashore. Mitchell (2000) studied the effects of growing versus dormant season treatments on shrubs in old fields in New York State. Her results support those reported here and of Patterson (unpublished data), in suggesting that growing season treatments can be successful in reducing woody stem vigor, whereas dormant season treatments are ineffective. The implications for management are that the timing of treatments may be even more important than the type of activity (cutting versus burning) when evaluating the success of the treatments in controlling invasive species. To have the greatest success at reducing woody stems, a treatment should be conducted during periods of low below-ground carbohydrate storage (such as immediately after spring flushing and growth) and should be followed with a second growing season treatment before TNC levels are replenished. We hope to demonstrate the longer-term effectiveness of this protocal by our continued sampling in 2003.

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Stereo Photo Series for Quantifying Natural Fuels in the Americas

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The natural fuels photo series is a set of data and photographs that collectively display a range of natural conditions and fuel loadings in a wide variety of ecosystem types throughout the Americas from central Alaska to central Brazil. Fire managers are the primary target audience of the natural fuels photo series, although the data presented will also prove useful for scientists and managers in other natural resource fields.

The first six volumes of the natural fuels photo series are grouped and published by geographical region of the United States. Volume I included sites in mixed-conifer, western juniper, sagebrush, and grassland ecosystem types in the interior Pacific Northwest. Volume II included sites in black spruce and white spruce ecosystem types in Alaska. Volume III included sites in lodgepole pine, quaking aspen, and gambel oak ecosystem types in the Rocky Mountains. Volume IV included sites in pinyon-juniper, sagebrush, and chaparral ecosystem types in the Southwest. Volume V included sites in red and white pine, northern tallgrass prairie, and mixed-oak ecosystem types in the Midwest. Volume VI included sites in longleaf pine, pocosin, and marsh grass ecosystem types in the Southeast.

Additional published or in press volumes include sites in grassland, shrubland, woodland and forest types in Hawaii; jack pine in the Lake States; hardwoods with spruce succession in Alaska; and sand hill, sand pine scrub and hardwoods with white pine types in the Southeast. A volume to characterize western oaks and manzanita/ceanothus types is currently being compiled and field work is ongoing in pitch pine, balsam fir/red spruce, and mixed hardwoods types in the northeast U.S. While the primary focus has been on ecosystems found throughout the United States, a volume has also been produced for savannah (*cerrado*) ecosystem types in central Brazil and a volume is under development for pine forest and other types in Mexico.

Generally, sites include wide-angle and stereo-pair photographs supplemented with information on living and dead fuels and vegetation, and where appropriate, stand structure and composition within the area visible in the photographs. The sites in each volume provide a basis for appraising and describing woody material, vegetation, and stand conditions in different ecosystems across the United States.

WHY IS THE PHOTO SERIES NEEDED?

The natural fuels photo series are land management tools that can be used to assess landscapes through appraisal of living and dead woody material and vegetation (i.e., fuels) and stand characteristics. Once an assessment has been completed, stand treatment options, such as prescribed fire or harvesting, can be planned and implemented to better achieve desired effects while minimizing negative impacts on other resources.

The photo series has application in several branches of natural resource science and management. Inventory data found in each volume can be used as inputs for evaluating animal and insect habitat, nutrient cycling, and microclimate, for example. Fire managers will find the photo series useful for predicting fuel consumption, smoke production, fire behavior, and fire effects during wildfires and prescribed fires. In addition, the photo series can be used to appraise carbon sequestration, an important factor in predictions of future climate, and to link remotely sensed signatures to live and dead fuels on the ground.

Ground inventory procedures that directly measure site conditions (e.g., fuel loading and arrangement, vegetation structure and composition, etc.) exist for most ecosystem types and are useful when a high degree of accuracy is required. Ground inventory is time-consuming and expensive, however, and photo series can be used to make quick, easy, and inexpensive determinations of fuel quantities and stand conditions when less precise estimates are acceptable.

How Was The Photo Series Developed?

Sites photographed for the various series are selected to show ranges of important ecosystem characteristics (e.g., down and dead woody material loading, understory composition, overstory development, etc.).

Photographs And Information Arrangement

Stereo-pair photographs are included in each photo series volume. The three-dimensional image obtained by viewing the photographs with a stereoscope improves the ability of the land manager to appraise natural fuel, vegetation, and stand structure conditions. Larger, wide-angle photographs are included for additional comparisons.

The photographs and accompanying data summaries are presented as single sites organized into series. Each site is arranged to occupy two facing pages. In most cases the upper page contains the wide-angle (50mm) photograph, and general site and stand information. The lower page typically includes the stereo-pair photographs and summaries of overstory structure and composition, understory vegetation structure and composition, forest floor composition and loading, and dead and down woody material loading and density by size class.

Using The Photo Series

To use the photo series one makes a visual inventory of the site by observing fuel and stand conditions within their field of view and comparing them with the stereo-pair photographs. The user observes each characteristic of interest (e.g., 3.1-9.0-inch woody material loading) and selects a photo series site (or sites) that nearly matches or brackets the observed characteristics. The quantitative value of the characteristic being estimated can then be read from the data summary accompanying the selected photo series site, or a value can be interpolated using the data from more than one site. These steps are repeated for each size class or stand characteristic of interest and the total loading or stand condition can then be calculated by summing the estimates.

HOW DO I GET THE PHOTO SERIES?

Volumes I-VI are available for purchase from the National Interagency Fire Center, Great Basin Cache Supply office, Publication Management System working team in Boise, Idaho (Fax: 208-387-5573 or http://www.fire.blm.gov/gbk/pms.htm). The Hawaii and Brazil volumes are available upon request from the Pacific Northwest Research Station, Seattle Forestry Sciences Laboratory.

Photo Series Citations

Ottmar, Roger D.; Vihnanek, Robert E.; Wright, Clinton S. 1998. Stereo photo series for quantifying natural fuels. Volume I: mixed-conifer with mortality, western juniper, sagebrush, and grassland types in the interior Pacific Northwest. PMS-830. Boise, ID: National Wildfire Coordinating Group, National Interagency Fire Center. 73 p. Order Number – NFES #2580 $33.07

Ottmar, Roger D.; Vihnanek, Robert E. 1998. Stereo photo series for quantifying natural fuels. Volume II: black spruce and white spruce types in Alaska. PMS-831. Boise, ID: National Wildfire Coordinating Group, National Interagency Fire Center. 65 p. Order Number – NFES #2581 $32.21

Ottmar, Roger D.; Vihnanek, Robert E.; Wright, Clinton S. 2000. Stereo photo series for quantifying natural fuels. Volume III: lodgepole pine, quaking aspen, and gambel oak types in the Rocky Mountains. PMS-832. Boise, ID: National Wildfire Coordinating Group, National Interagency Fire Center. 85 p. Order Number – NFES #2629 $36.82

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Lesson Learned from Eleven Years of Prescribed Fire at the Albany Pine Bush Preserve

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The Albany Pine Bush Preserve is globally rare inland pitch pine-scrub oak barrens. This ecosystem is dependent on frequent disturbance to maintain its unique character. The primary ecological force that maintains this natural community is fire. The Pine Bush supports a variety of elements that are rare in New York state: 3 rare plant species, another rare plant community (pine barrens vernal pond), and 13 rare insect species including the federally endangered Karner blue butterfly (*Lycaeides melissa samuelis*). Fragmentation from urbanization and development has resulted in a landscape dissected into disjunct parcels of protected lands. Development also resulted in the exclusion of fire and consequently altered the historic fire regime, eliminating fire as the driving force for the pine barrens communities. Plants and animals in the Pine Bush, particularly those directly or indirectly influenced by fire, thus experience adverse effects. The fragmentation and urbanization of the Preserve make the use of prescribed fire extremely complex. Smoke management, strict prescription parameters, residential housing, commercial properties, and applying fire in a high visibility area (Albany, NY) constrain the use of fire as a management tool. Not only has fragmentation altered the historic fire regime, but it also created a greater "edge" effect, where habitat is exposed to the invasion of exotic plant species. Exclusion of fire and the invasion of exotic plants are closely related. In the absence of fire, deep leaf and needle layers create seedbeds unsuitable for germination of native plants, but favorable for invading species, some of which rapidly grow and are difficult to eradicate. Invasive species control is a high priority in the Albany Pine Bush Preserve due to the degrading effects of invasives on the viability of the Karner blue butterfly and the inland pitch pine scrub oak barrens and related community variants.

This presentation will look at three of the top invasive plant threats to the Pine Bush community: black locust (*Robinia pseudoacacia*), quaking aspen (*Populus tremuloides*) and bigtooth aspen (*Populus grandidentata*). All three species in some way disrupt the natural communities found in the Albany Pine Bush. Black locust trees pose the greatest threat to the integrity of the Pine Bush because they spread rapidly by both seeds and roots. Black locust dominates and excludes most other plants in areas where colonization occurs, virtually eliminating all other native pine barrens vegetation. Other invasive species can be found as associates of locust clones in the Preserve. These species include bush honeysuckle (*Lonicera tatarica*), raspberry (*Rubus* spp.), barberry (*Berberis vulgaris*), and garlic mustard (*Alliaria petiolata*). The native, but highly invasive aspen (*Populus* spp.) trees also dominate large areas of the Preserve. Not unlike black locust, aspen vegetative propagation accounts for most reproduction. Stump sprouting is less frequent. Root suckering sometimes occurs within undisturbed clones, but survival is low. Suckering is most profuse following disturbance (Converse and Eckardt 1984,98). However, most pine barrens vegetation is able to survive in the understory of aspen clones, although they are significantly reduced.

Prescribed fire has been determined to be the primary management tool used for shaping and maintaining the Albany Pine Bush pine barrens vegetation. **Prescribed burns have proven**

successful in maintaining native pine barrens species, however, due to the ecology of black locust, quaking and bigtooth aspen prescribed burns in the Albany Pine Bush Preserve are extremely limited in their ability to restore areas dominated by invasive species.

Black locust sprouts rapidly from the roots and/or bole after any disturbance. After a fire, dense sucker shoots may be produced on sites occupied by even minor amounts of black locust. Also, this prolific sucker producer can colonize a burned site if it is present in the adjacent, unburned forest as well. Locust increases soil nitrogen through high rates of nitrogen fixation, altering soil chemistry to the detriment of native species. The result of the nitrogen enriched soils, uncommon to pine barrens habitat, paves the way for other invasive species, e.g., bush honeysuckle (*Lonicera tatarica*), raspberry (*Rubus* spp.), barberry (*Berberis vulgaris*), and garlic mustard (*Alliaria petiolata*). Black locust litter on the forest floor tends to lie flat and stay relatively damp due to closed canopy conditions created by clones. Shading by the canopy results in higher live-to-dead fuel ratios and higher fuel moistures, which effectively slow surface fires, thus altering the fire regime. To this end, the Albany Pine Bush Preserve actively removes locust clones, applies herbicide to stumps, and permanently removes stumps. Replanting of local genotype native vegetation occurs after removal with the goal of reintroducing fire into the area in the following years. The planting of native warm season grasses and wildflowers also benefits state and federal recovery goals for the Karner blue butterfly. Stump removal sites are extensively monitored prior to logging. Information on species composition, structure, and soils is gathered throughout the process. A 4-acre pilot project for removal of locust was conducted and currently 25 acres (9 clones) are being completed. Some studies suggest burning may reduce black locust resprouts in subsequent years (Dubis, et al 1988 and Cocking et al 1979). To effectively control locust sprouts burning should occur on a strict return interval, during the late spring/early summer, under strict prescription parameters, and on a targeted unit. This intensive form of fire management however, is not feasible for the Albany Pine Bush, given the landscape context, urban interface issues, smoke management issues, strict prescription parameters, limited resources, and higher priority areas targeted for fire management.

Aspen species (*P. tremuloides* and *P. grandidentata*) are also of concern in the Albany Pine Bush Preserve. Due to similarities in response to fire and ecology aspen will refer to both bigtooth and quaking aspen species. The Commission's goal is to reduce aspen densities to resemble its historical abundance so that it no longer poses a threat to pitch pine scrub oak and Karner blue butterfly viability within the Preserve. Although aspen is a prolific seed producer (a single tree may produce more than 1.5 million seeds), it mostly regenerates vegetatively through root suckers (Laidly 1990). When the parent stem is top-killed, suckers develop from an extensive network of shallow lateral roots. Laidly (1990) found that after a mature aspen stand is destroyed by fire or logging, roots may produce 3,200 to 24,000 suckers per acre. Fire also creates a suitable seedbed and reduces competition for the suckers (Squiers and Klosterman 1981). The abundance of aspen within the Preserve reduces the effective number of fire manageable acres. Aspen-dominated forests do not readily burn, especially when young and healthy. The clones shade out the understory creating a moist microclimate with little or no fine fuels sufficient to sustain a surface fire. Even a fairly intense fire can easily die out at the edge of an aspen clone due to compact or nonexistent fuels. The ability of aspen to resprout after disturbance and an extremely fire-resistant situation led the Commission to adopt a policy of not burning management units with abundant aspen until the species is controlled to eliminate resprouting. Girdling of aspen clones is currently the preferred method of controlling and removing aspen. Aspen clones are girdled beginning the first week of May through July 15th. Girdling severs the phloem, which is part of the bark, but does not affect the xylem. The roots will continue to move water and minerals up to the tops through the xylem, but the leaves will be unable to translocate photosynthate back down to the roots. The leaves will stay green and appear healthy, but there will gradually be fewer of them as the root reserves are used up. Since physiological processes occur largely in the canopy (apical meristems), as long as the crowns are still there and apparently healthy the roots are "fooled" and do not sprout suckers. By the time the leaves and tops die back (the normal signal for suckering to occur), the root reserves are depleted and unable to support suckers (Converse and Eckardt 1984,98). Cochrane (1984) highlights a suggested method of control using fire. Mow or brushcut suckers at the clone periphery, use a chain saw to cut down larger trees, pile all the brush and trunks at the clone center and allow them to cure for a year, then run a fire through the following year. In practice this is possible, but it is extremely labor and cost intensive.

Black locust, quaking aspen, and bigtooth aspen disrupt the natural communities found in the Albany Pine Bush. Invasive species control is a high priority due to the degrading effects of invasives on the viability of the Karner blue butterfly and the inland pitch pine scrub oak barrens and community variants. For over eleven years the Albany Pine Bush Preserve has used fire as the primary management tool to maintain and restore the rare inland pitch pine scrub oak community and Karner blue butterfly habitat. Fragmentation and development resulted in the exclusion of fire and consequently altered the historic fire regime. The altered fire regime combined with the fragmentation has exposed the Preserve to the invasion of exotic plant species. The challenging landscape context (urbanization and fragmentation) of the Preserve complicates the use of fire as a tool to control invasive species. Also, fire is not the tool of choice for combating these three species due to the potential for exacerbating the problem. Other control strategies (locust cut-stump herbicide application and removal of stumps after treatments and girdling of aspen clones) were tested. Once proven to be an effective control these strategies were implemented. To date we have been successful in our goals of increasing pitch pine scrub oak and Karner blue butterfly habitat. Until a site is free from invasive species the Pine Bush will not use prescribed fire as a treatment. Once an area is restored, then fire is employed a maintenance tool.

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Regional climate and fire danger modeling specific to the Pine Barrens

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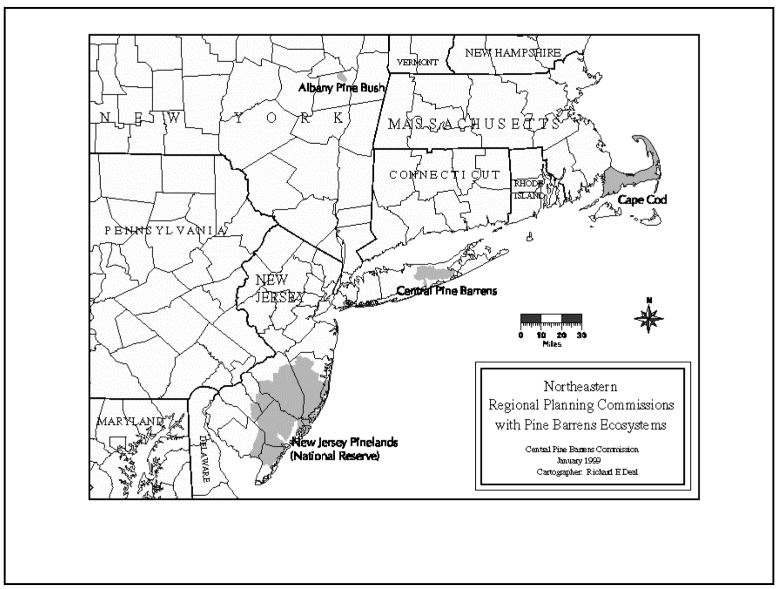
Introduction

This research will develop a more responsive fire danger rating system specific to the New Jersey pine barrens by focusing on the interaction between climate, fire and vegetation. The New Jersey Pinelands has an unique ecosystem with over a thousand species of plants and animals--almost 100 of which are threatened or endangered. It was designated as the first National Preserve in the U.S. and recognized globally as a United Nations Man and the Biosphere Preserve. The 1.1 million acres of the pine barrens represents 22% of the land area of New Jersey.



Pine barren ecosystems in New Jersey and the Northeast

It is characterized by highly volatile fuels, historically having a fire return cycle of 25 years, with large 100,000+ acre fires common prior to fire suppression practices. Without fire, the pinelands will convert to hardwood forests. Pitch pine and oak forests differ in their susceptibility to fire, with oaks having thinner bark, so less heat is required to kill their cambium. Fire adaptations for pitch pine include serotinous cones, stump sprouting, thick, fire resistant bark, and quick maturity for the production of seed. Frequent, severe fires eventually eliminate all other tree species except for pitch pine and scrub oak. However, the fire rotation period has greatly increased due to successful fire-suppression.

Pinelands Fire Cycle Vegetation Types and the Fire Return Interval to Maintain Them

• dwarf pine plains	5-15 years
• pitch pine-shrub oak barrens	15-25 years
• pine-oak woodlands	20-30 years
• pine-oak forest	30-60 years
• oak-pine forest	60-100 years
• oak or oak-hickory forest	100-200 years

The existing fire danger rating system does not meet the needs of the wildfire managers in this part of the U.S. (Burgan, 1988). According to David Harrison, former NJ State Fire Warden: " It can rain in the morning and I can light it on fire in the afternoon." This may be due to several possible factors; the unique characteristics of the vegetation, low water holding capacity of the soil, and high humidity levels from the maritime influence.

Extensive Fires in the Pine Barrens

1963	Pinelands burned **190,000** acres
1930	Eight large wildfires, **172,000** acres
1923	Approximately **1,000,000** acres
1915	Approximately **102,000** acres
1894	One fire, **125,000** acres
1885	**127,500** acres burned
1870	**50,000** acres in Bass River Twp
1755	One fire, **30 miles long** (Barnegat to Little Egg Harbor)
19th Century:	Not unusual for 1,000,000 acres to burn in a year

Foreman and Roener

We will take a multi-discipline approach to improve this fuel model. This includes enhancing the fire weather monitoring for the region, analysis of historic fire climate records, sensitivity analysis and modeling of component indices in the National Fire Danger Rating System (NFDRS), and experimental monitoring of prescribed burns over a range of climate and humidity conditions. A network of fire weather stations and towers for monitoring fire weather conditions, as well as prescribed burns, will produce detailed measurements for the region to determine the processes that are distinctive for the pine barrens.

Implications for Managers

In the New Jersey Pinelands, humans cause 99% of the fires. The changing land use and increased development has created a complex wildland urban interface. The combination of volatile pitch pine-scrub oak fire cycle vegetation, fuel build up from decades of fire suppression, and human factors has increased the fire danger in the Pinelands. Fire managers have identified the need for a reliable fire danger rating system for this region as their number one priority. An improved fire danger rating system specific to the pine barrens would strategically place their fire fighting resources of manpower and machinery more cost effectively in responding to potential fires. Improving the prediction of longer-term fire weather conditions and fire season severity would help in long term planning and budgeting of resources.

We will refine the fuel model and NFDRS so that it is specific for the NJ Pinelands. The research will develop a framework to identify and potentially correct problems in the fire danger rating system to other fuel models. Improving long term prediction of fire weather conditions and fire season severity will help in planning for the fire season. We plan to test the modified fuel model and NFDRS to similar regional pine barren forest types in Long Island and Cape Cod.

The New Jersey Forest Fire Service is the primary partner and user of the improved NFDRS for the Pine Barrens. They will provide fire history and fire management treatment mapping for the research area as well as conduct yearly prescribed burns for research purposes. The Pinelands Field Station, Rutgers University, will provide facilities and research on nutrient cycling in prescribed burns. Fire-weather and fire-climate products developed in collaboration with the Eastern Area Modeling Consortium (EAMC) will be utilized to address long-term regional climate and weather impacts on fire and fire danger in the Pine Barrens.

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Foremen, R.T and R.E Roerner. unpublished manuscript on Fire Frequency in the New Jersey Pine Barrens

See the following websites for more information on fire research in the New Jersey pine barrens, fire climate mapping, and the Rutgers Pinelands Field Station.

http://www.fs.fed.us/ne/global/research/fire.html

http://www.ncrs.fs.fed.us/eamc/products/maps.asp

http://celebes.rutgers.edu/index.htm

Highlights from the Panel Discussion
Fire and Invasive Plants in the Northeast: What Works?

Panel Organizer David Crary, Jr., Fire Management Officer at Cape Cod National Seashore, MA, introduced each speaker in turn and posed questions which the panelists had seen beforehand. Panelists illustrated their points with powerpoint slides and took questions after each short talk.

Summary prepared by Alison C. Dibble, Catherine A. Rees, David Crary, Jr., William A. Patterson III, and the participants in the Panel Discussion.

To Dr. Ernie Steinauer, Director of Massachusetts Audubon on Nantucket, MA, he asked: "Are invasives always exotic species, or can native species be involved?"

Ernie replied that emphatically YES, native species can be invasive. However, he mentioned that he recently reviewed MA Audubon's invasive species management plan and they do not include natives. The matter is habitat-driven, and depends on management goals. A species might be invasive in some places but not others. On Nantucket, sand plain grasslands and coastal heathlands are priority habitats because of their high species diversity and some rare plants that need fire or other intense disturbance. They conduct Rx fire every 5 years or so.

Scrub oak (*Quercus ilicifolia*) barrens are a native and desirable community in many places, but on Nantucket this vegetation type invades coastal heathland. Scrub oak prevents regeneration of regionally and globally rare plants, so Rx fire is used to restore the heathland. There is a question of scale regarding monitoring and quantifying large woody plants, but at least with scrub oak one can distinguish an individual plant, whereas with black huckleberry it may be necessary to quantify using a pin frame as one can't tell where one clone starts and another stops. Once the woody component is in place for a while, a thick duff layer builds up, soil characteristics and chemistry change and the duff limits grassland and heath regeneration; this is one reason why they must burn regularly.

Pitch pine (*Pinus rigida*) is considered invasive in the heath. This very fire-tolerant species may topkill, or it may resprout, or seed heavily following fire. It was introduced on Nantucket in 1848 as a windbreak, and so is exotic there. But probably long ago it grew on Nantucket and might have been eradicated by Native Americans.

Ernie finds monitoring to be particularly important. Because land managers are limited regarding time, money, and staff, it is best to keep the monitoring program quick, cheap, and fairy simple, but repeatable. For example, people with relatively little expertise can be taught to do stem counts by species in a shrub heath. Pin frames are somewhat objective and useful in certain types of vegetation. He measures canopy cover on 1 m sq plots, along 700 m transects with 10 plots each. He recommends a method of monitoring used by the National Park Service that involves an herb plot nested within a shrub plot, which in turn is nested within a tree plot. An adaptive management strategy allows him to decide whether Mass. Audubon should continue with the same management scheme or change treatments. However, monitoring is time consuming, and requires expertise. It is best if the same person (people) collect data year after year to maintain consistency. Ernie does the measurements himself because in his experience leaving the monitoring to inexperienced help can cause the results to go haywire and one can even lose an entire season of data. For sampling trees, diameter at breast height works, but Ernie suggests resolving methods on a case-by-case basis.

Whatever you do, Ernie said, document it well. Explain what you did and why you did it. Think of those who will come and look at the area later. If the area is small, your documentation could consist of good notes, but if large, then it may be necessary to put out plots. Make the monitoring as scientific as you can, e.g., (1) include control plots which remain untreated as something you can compare to; (2) provide replication – not two large plots but enough replication that you can study factors that influence the results, such as the interaction of fire with topography, soil type, etc.; (3) randomize plots if possible; (4) conduct pre- and post-treatment sampling; (5) consult a professional(s) prior to conducting the work, especially a statistician to help design the study – this short term investment pays off over the long term.

A member of the audience asked how long the seed bank is viable under woody vegetation that encroaches on grasslands. Ernie said that the seed bank on Nantucket tends to be short-lived. After a treatment, remnant patches of rhizomatous species spread but seed dispersal is slow. They do not find it cost effective to seed large areas as they are doing about 1000 acres of restoration on Nantucket and they had to focus on a low cost per acre.

Gerald Vickers, US Fish and Wildlife Service, Cambridge, MD, is Wildland Urban Interface Coordinator for the region, and has a large project at Prime Hook NWR in Delaware funded in part by the National Fire Plan. Dave Crary asked him "Is timing of burns to control invasives a problem and what is/are the solutions?"

Gerald polled managers and found that not only is timing burns to control invasive vegetation difficult but trying to conduct burns for almost any objective is a problem. In the Northeast often managers and firefighters are constricted by accomplishing the burn when it is the easiest and the safest. This may not be during the time of year, or under the conditions, that fire historically occurred in an ecosystem. Timing of the burn is affected by the weather, resources available, an agency's burn plan review process and wildland urban interface issues.

Gerald recommended that it is important to set up good monitoring projects and recommended Gary Kemp, Regional Fire Ecologist of Suffolk, VA who has expertise on this. Gerald also pointed out that the weather drives decisions on when to burn; the number of good burning days in the Northeast is limited and a lot of planning is needed. This is especially so since some Rx fires got out of control; now an extensive review process is involved and the Fire Management Officer (FMO) must organize ahead, must have extensive training for self and crew, must get the crew pack-tested and on the payroll early, get the crew on the ground early, must involve partners early in order to get permits and produce documentation, and must have a good funding source available. Not so obvious is that the FMO must get the media involved early. Although the media accepts fire, it's best to assure that there will be no headaches.

Prescribed fire is expensive; managers and supporters need more politicking now to get more dollars so that timing of fires can be appropriate. At Prime Hook NWR, Phragmites (*Phragmites* *australis*) control involves 2500-4000 acres, which will be treated in 2003. The area to be burned was sprayed in fall 2002 with Rodeo, followed by mowing, and the Rx fire is to be conducted in February 2003. There are 700 homes in the three communities, 60% of which are year round, and narrow roads allow just one way in and one way out of the area. Recent fire history suggests that the fire return interval is about 10 years and unless Rx fire is conducted, wildfire could return soon. In this area, a 1969 wildfire burned 1500 at Broadkill, in 1977, 1000 acres burned at Prime Hook, in 1985 an arson fire burned 900 acres at Prime Hook, and in 2002, there was a 1400 acre arson fire at Slaughter.

The Delaware fire suppression forces are willing and well-trained but they have big equipment that can't turn or maneuver easily in the Refuge or in nearby residential areas. Homeowners frequently plant bushes and trees near their homes, adding to fuels. Politicians and local folks are prompted by the recent wildfires to want to see something done to control the Phragmites fuel bed, and the USFWS received funds for specialized equipment, monitoring, public education, and resources to conduct the burn itself.

Gerald has held three public meetings where there was voiced some concern about residual effects from Rodeo but not so much about the burn itself. A two-day workshop for practitioners was part of the outreach effort. One more public meeting will be held soon to inform the community about how the burn is to be conducted.

In short, timing a burn depends on money, and should be accompanied by press releases prior to the burn.

A member of the audience wanted to know if remote sensing can be used to inventory Phragmites. Gerald said that Annabelle Larson's monitoring plan uses some of this, but the information is hard to find and he is trying to get that. Laura Mitchell said that another grass, Walter's millet (*Echinochloa walteri*) can give the same signal as Phragmites. Tom Poole has experience burning Phragmites and said the fire can burn very intensively. He is concerned about the fire hazard of a huge stand of Phragmites along highways west of Boston, MA and suggested that smoke could be a tremendous safety issue in the wildland urban interface.

Dr. Michael Ciaranca, Environmental Readiness Center, Camp Edwards, MA, addressed this question: "Is it always appropriate for use of fire only (does using fire only) to control invasives or does fire have to be used in conjunction with other treatments (e.g., mow, burn, burn, mow, etc.)?"

Michael manages almost 20,000 acres of the 22,000 acre Massachusetts Military Reservation. Urban interface surrounds this area, and some of the worst invasive plants, including Japanese knotweed (a.k.a. "bamboo", *Fallopia japonica*), are associated with development surrounding the reservation. Invasives that cross the border into the Reservation from private property include Japanese knotweed, bittersweet, scotch broom, black locust, and barberry. Fire alone does not work, and a lot of sociology comes into play. Permitting is especially time-consuming; it took Michael 2.5 years to get a 5 year permit to conduct Rx fire, but he is still restricted from burning between 1 July and 15 Sept except by special request. The smoke may impact the tourist season.

He is especially concerned by woody succession in a grassland area. They have managed this by eliminating woody vegetation, but spotted knapweed is now a problem that must be controlled there. A hot, early season fire is necessary to control knapweed but Michael is restricted from burning at that time in the summer. With an F16 air base next to the grassland, and residences on the base, fire is not necessarily feasible, nor is it practical to use fire near developments. So, how to treat the invasive plants?

Mowing is the method they have used most. They can request funding from the Forest Reserve Account and the Conservation Account, and this is how they will obtain a brontosaurus mower. At the interior of the Reservation, they have used herbicide by stumping and painting, but with caution due to ground water issues. But at the borders, this is not a popular choice, as the public watches everything they do and they must conduct a lot of public affairs outreach.

As for knapweed, this is a big problem. At Fort Carson in CO, a biocontrol is in use, but Michael would probably need to do an Environmental Impact Assessment before he could introduce a biocontrol at Camp Edwards.

Besides the grassland, there is an extensive pitch pine forest at Camp Edwards. A primary management goal is to maintain a given amount of pitch pine and of scrub oak. Since 1909 there has been artillery practice with many burns started as a consequence of this activity resulting in a pure scrub oak barren. The otherwise mostly unbroken forest contains fire breaks built with a bulldozer, and in the break, density of pitch pine is extremely high, even 2000-10,000 trees/acre. They have begun to see pitch pine as an invasive plant. If they mow with the brontosaurus year after year, they can achieve a heath-like vegetation, but only if the mowing takes place every year. They use a combination of mechanical, chemical, and fire treatments. Especially in the high population area, this seems to be necessary. Timing is critical – they can't burn knapweed without yet another permit. Timing of treatments to accommodate nesting birds and other wildlife is problematic, and advocates for bird conservation sometimes do not accept that some wildlife must be lost in order to maintain good habitat conditions over a large area. Upland sandpiper nests in grasslands where knapweed is a problem. In summary, at Camp Edwards, they try to use various management techniques in conjunction with each other.

In the question and answer period, Tom Poole said that he is treating 100 acres of knapweed. The Department of Defense manages 25 million acres in the Northeast, and has been managing invasives for many years. He reminded everyone that GIS was developed by the natural resources arm of the DOD to monitor vegetation changes in response to various treatments.

Another participant wondered how to time the repeat mowing of shrubs, and Michael said that it is important to mow when the plants are most vulnerable – not too early, or too late.

The question of seed bank longevity was addressed briefly by Bill Patterson who noted that in the upper Midwest the seed bank is much longer-lived than here in the Northeast due in part to soil type. Alison Dibble mentioned that red raspberry seeds have been shown to germinate after 90 years and that sedges typically have long-persisting seeds. Mark Ducey recommended the Woody Plant Seed Manual, available on the web at http://wpsm.net/ which has information on many common woody species, both native and exotic, including their adaptation to seed banking if known.

Jessie Murray, The Nature Conservancy, is involved with the Berkshire Taconic Landscape Program in the eastern Taconic watershed, which is in western MA, northern CT, and eastern NY. She addressed this question: "Has anyone been burning successfully (over a number of years in the same location) and actually increased or noted the new presence of invasives?"

In November 2001, a dormant season burn was conducted at Schenob Brook, which is a significant rare plant site consisting of a fen that is reverting to shrubs. Prior to the burn, they cut 25% of the shrub and tree cover. They sought to maintain an earlier successional stage with a greater abundance of fine sedge species. Before the November burn, the non-native wetland grass, reed canary grass (*Phalaris arundinacea*) was present, and after the burn, TNC observed that the reed canary grass seemed to increase in vigor, density and size. Since that time, two new clumps of reed canary grass have been found where the plant was not seen before.

Mowing and the use of herbicide has been used on this species in Oregon but this hasn't been tried at the site yet. Jessie thought that a mow prior to burning *Phalaris* would reduce the seed source of the grass. For Phragmites (*Phragmites australis*), where cutting and herbicide was used there was a lot of dead biomass at the site. Unfortunately the fire died when it reached the wettest area which contained the Phragmites and therefore did not reduce the dead biomass of the Phragmites. They have used chemical treatments to reduce the density of the Phragmites at that site for the past three years.

There are other problems at the site, including crown vetch which has encroached from a nearby landscaped garden. While this species was essentially overlooked before treatment, it now covers about 50% of available habitat on a hillside. The question here is how to quantify the effects of prescribed fire on this plant so that control efforts can be monitored.

At another site called Jug End, part of the wetland contains a sloping fen that is also reverting to shrubs. It is a portion of the area owned jointly by the State and The Nature Conservancy. A neighbor was responsible for a wildfire on April 9, 2000. This was an opportunity to evaluate the effects of the fire as the managers had hoped to have Rx fire at that site. The fire consumed 9 acres in just 15 minutes.

In 1996 this area had been mapped, and so it was possible to compare pre- to post-burn vegetation. The wildfire had the greatest immediate effect on the tall fen or *Typha latifolia-Carex lacustris* community and the least effect on the harsh or short fen and the rich wet meadow. There was also an unquantified reduction of woody species which limits conclusions that can be drawn in relation to successional issues. They found that reed canary grass increased on the site since 1996 although the reed canary grass was not quantified in the 1996 survey. This species had spread even more in just two years since the fire. Fire had no effect on multiflora rose at this site. The plant is apparently able to withstand such a hot, quick fire and was not top killed. Species that did decrease from the wildfire were eastern white pine, steeple-bush (*Spiraea tomentosa*), meadowsweet *(Spiraea alba var. latifolia)*, and bryophyte cover. Swamp loosestrife (*Lysimachia thrysiflora*), a perennial forb, was greatly reduce in 2002 although it had been fairly dominant in the 1996 survey. Red dogwood (*Cornus sericea*) was reduced by the fire but they anticipate that it will come back in future years.

Jessie has experience with other wetland restoration burns but the data are not yet ready for emulation elsewhere.

Dr. Betsy Von Holle, Harvard Forest, MA, addressed this question: "Is anyone surprised that burning has not increased the amount of invasive species in an area?"

She is analyzing plant data in a pitch pine vegetation dataset that was prepared by David Foster and Glenn Motzkin over 3 years from Cape Cod to Long Island. The data were collected on plots 20 m in diameter, and include current vegetation, stand age, historic land use, and soil characteristics, especially macroscopic charcoal. She wants to see how nonindigenous species establish in relation to land use, to identify any resistant plant communities, and to figure out which factors contribute to invasion. It is known that Native Americans burned for some centuries prior to European settlement. Also, macroscopic carbon is only reliable on sites that were forested when they sustained a fire, rather than open vegetation, which may indicate a bias in the macroscopic charcoal data.

In an initial look at the data, Betsy found that there are more plots that are unburned than burned containing one or more nonindigenous plant species. However where plots contain only native species, there are more burned than unburned plots. Betsy concluded that plots that had fire seem to contain fewer exotic species than plots that had not burned. She is investigating historic structures, current and historic roads, and certain soil types as factors of invasibility. She suspects that land that had been cropped was more likely to have invasives than land that had been used for woodlots. Betsy plans to pursue additional study sites in the Northeast and asked for suggestions regarding where else she can collect data.

Tom Dooley, The Nature Conservancy, Albany Pine Bush Preserve, Albany, NY answered this question: "Are there regional differences in the response of invasives to fire that are of concern to us?"

His first impression is that probably, yes, but then he recalled that issues to do with invasion by black locust (*Robinia pseudoacacia*) are similar at Shenandoah National Forest as they are at Albany Pine Bush.

He reviewed a guide for managing invasive species that was prepared by John J. Randall (Weed Specialist, The Nature Conservancy, Wildland and Weeds Management and Research, U.C. Davis, Davis, CA). This guide can be summarized as a flow chart, and Tom related this to black locust management at Albany Pine Bush (APB). These are the steps Randall recommends:

1. Establish management goals -- e.g., at APB they are seeking to completely restore pitch pine-scrub oak stands and Karner blue butterfly habitats that are now completely taken over by locust.
2. Identify and prioritize species that interfere with management goals -- so, locust.

3. Assess control techniques -- They have tried cutting, herbiciding stumps, girdling, basal bark treatment of locust with Tricolpyr, injection treatment with glyphosate (Round-Up), cut-stump/herbicide, and burning.
4. Develop and implement the management plan -- What works best? Cut-Stump/Herbicide, which is cutting the locust tree, treating the stump with glyphosate, pulling the stump out, and removing the bole and stump from the site, then bulldozing/root raking the soil and replanting with native grasses and forbs. Maintenance of the habitat created is ideally with fire. However, mechanical treatments such as mowing may be used early on. Apply fire on a regular rotation of maintenance burns
5. Monitor and assess the impacts of management decisions
6. Review management goals, control practices, and control techniques

Tom recommended applying this guide to your area of concern and it never fails because you are always reviewing and revising to meet the situation. Nothing is final, Tom said, something better could come along. We are learning new things every day. His final advice was to "Take it in stride and work from your goals."

In the question and answer period that followed, someone asked about controlling black swallowwort (*Vincetoxicum* sp.) on Long Island. Suggestions were made that control might be effected by herbicide, spot burning with a propane torch, and biocontrol.

Policy Changes and Funding Opportunities Affecting Fire Managers and Researchers

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The increasing severity and impact of wildland fires in the United States, particularly in the past decade, have precipitated major changes in fire management policy as well as the financial resources dedicated to addressing this challenge. Public and political attention has focused primarily on the Western states, but the Northeast has its own unique challenges and opportunities related to the management of wildland fire.

Within the past 25 years we have seen four landmark fire seasons which produced significant changes in policy and funding, due to the loss of life and/or property. As a result of the Greater Yellowstone fires, the Secretaries of Agriculture and Interior were charged with evaluating existing national fire policies and recommending actions to address problems experienced during the 1988 fire season. Significant recommendations came from this review and dealt with the need to have fire management plans; public input into fire management plans; appropriate level and qualified personnel; development of realistic prescriptions for prescribed burning; preparedness planning; and agency administrator involvement and training.

During the past decade, the most significant policy changes were made after the 1994 fire season during which 34 firefighters died, including 14 in the South Canyon Fire. At the request of the Secretaries of Agriculture and Interior, the federal wildland fire agencies closely re-examined their programs. The December 18, 1995 final report, *Federal Wildland Fire Management Policy and Program Review,* became the first interagency policy for the federal wildland fire management program. The 1995 Fire Policy affirmed the valuable role fire plays in managing ecosystem health and reducing the risk of catastrophic fires. The 1995 Policy included 9 guiding principles, 13 policy statements, and 83 action items which were categorized into four major policy areas:

- The role of fire in resource management
- The use of wildland fire
- Preparedness and suppression
- Coordinated program management

In a re-emphasis of the 1988 recommendations, fire management plans were identified as a priority item to complete and/or update.

Following the Cerro Grande Fire in May 2000 – which burned over 47,000 acres and destroyed 235 structures in and around Los Alamos, New Mexico – the Secretaries requested that the federal wildland fire community review the 1995 policy and its implementation. A work group found that the 1995 recommendations were basically sound but that some aspects were unclear, incomplete, unrealistic, or no longer appropriate. As a result, several modifications and additions were added to the 1995 policy. Policy statements were revised and five new policy statements were added in 2001 to supplement the 1995 Fire Policy. The new 2001 Federal Fire Policy statements address:

- The role of fire in ensuring ecosystem sustainability
- The need for restoration and rehabilitation of fire-damaged lands and ecosystems

- The role of science in developing and implementing fire management programs
- The importance of communication and education internally and externally
- The critical need for regular, ongoing evaluation of policies and procedures

The list of 83 action items in the 1995 Fire Policy was replaced with a shorter more strategic list of 11 implementation actions by listing similar actions together.

The Thirtymile Fire of July 10, 2001 near Winthrop, Washington resulted in 16 firefighter entrapments and four fatalities. The subsequent findings, review team recommendations, Prevention Action Plan, and Hazard Abatement Plan required by OSHA produced numerous policy changes pertaining to operational safety and tactics on suppression incidents. Since this was a Forest Service incident, the policy changes have been largely limited to that agency although the Interior bureaus and states have adopted many of the same policies to varying degrees. Major policy changes implemented in 2002 included improved work-rest guidelines and fatigue awareness; improved briefings to incident personnel; revised training in fire shelter deployment and entrapment avoidance; more effective transition from initial attack to extended attack; better monitoring and interpretation of fire danger; and leadership training.

The beginning of the 21st century witnessed an initiative of major significance to the entire wildland fire community. The National Fire Plan was initiated during the final days of the Clinton administration in response to the devastating 2000 fire season. With support from Congress, the two Departments received substantial financial resources in fiscal year 2001 with direction for aggressive planning and implementation to reduce risks of wildland fire in Wildland Urban Interface areas. The subsequent implementation plan, released in August 2001, is titled *10-Year Comprehensive Strategy – A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment.* The Comprehensive Strategy contains four goals:

- Improve fire prevention and suppression
- Reduce hazardous fuels
- Restore fire-adapted ecosystems
- Promote community assistance

"Guiding Principles" of the Comprehensive Strategy include priority setting that emphasizes the protection of communities and high-priority watersheds; collaboration among governments and broadly representative stakeholders; and accountability through performance measures and monitoring for results. Specific implementation tasks include such items as preparing and implementing a common preparedness planning and budgeting model for all agencies; awareness and training in minimum impact suppression tactics; treating hazardous fuels threatening communities; adopting a common interagency fire management planning template; and providing research and developing products that promote post-fire rehabilitation and restoration.

Prior to 1998 most wildland fire research funding was directed toward improving safety and efficiency of suppression operations such as fire behavior prediction systems and equipment technology and development. Implementation requirements associated with the 1995 Federal Fire Policy and the National Fire Plan have greatly increased the opportunities and funding resources dedicated to wildland fire research. Today there are three new funding conduits available to fire scientists. The Department of Interior maintains a relatively recent and rapidly growing wildland fire research program through the U.S. Geological Survey, but support is limited largely to USGS scientists. The U.S. Forest Service supports a large 26 million dollar

National Fire Plan research program which provides funding to Forest Service researchers and their cooperators in the areas of firefighting, rehabilitation and restoration, hazardous fuel reduction, and community assistance (this is in addition to the longer-standing Forest Service base fire science program funded at 14 million dollars). The Joint Fire Science Program (JFSP) was established in January 1998 as a combined effort of the USDA Forest Service and the Department of Interior. Currently each Department contributes 8 million dollars to the JFSP for a total annual program budget of 16 million.

The JFSP is managed by a 10-person Governing Board consisting of representatives from the Forest Service and the five Interior bureaus. Day to day business is administered by a small Program Manager office at the National Interagency Fire Center in Boise, Idaho. Customer input is provided by a Stakeholder Advisory Group chartered by the Secretaries. Focus is on fuels treatments including inventory, evaluation of impacts, scheduling of treatments, and approaches for monitoring and evaluation. Additional focus since 2001 has been on local and regional research needs, rapid response projects for assessment of fire behavior and post-fire effects, emergency stabilization and rehabilitation, aircraft-based remote sensing, increased emphasis on technology transfer, and response to the National Fire Plan. Announcements for Proposals (AFPs) are developed by the Board and posted on the JFSP website, and are typically open for 60 days. Proposals are received by the Program Office and reviewed by 3 independent peer reviewers and at least 2 Board members. Proposals are favored which indicate land manager-scientist collaboration (including signed letters of support), partnerships, strong technology transfer, specific deliverables and timelines, and reasonable budgets. Scientists in the Northeast may benefit from continued JFSP emphasis on the effects of fuels management practices, ecosystem restoration, and local research needs.

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Use of Prescribed Fire for Management of Old Fields in the Northeast

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Abstract

Wildlife managers use prescribed fires are to restore or maintain early successional habitat for declining grassland breeding birds, by reducing the importance of invading shrubs and late-season perennials. In the northeastern U.S., such fires have been restricted to spring and fall, when most vegetation is dormant. Dormant-season fires have been reported to increase the frequency of goldenrod (*Solidago* spp.) and top-kill invading shrubs, which resprout following fire. We examined the effects of alternative prescribed fire treatments in old fields in central and western New York. As predicted, dormant-season fire failed to kill shrubs, reduce shrub frequency or height, or increase cool-season grass frequency and composition. In contrast, growing-season fire, preceded by growing season mowing, killed some shrubs, reduced shrub frequency and height, and increased cool-season grass frequency and composition. This treatment also reduced *Solidago* spp. frequency and composition, compared to the dormant-season fire. Combination treatments involving dormant season mowing followed by growing season or dormant season burning reduced shrub frequency, but failed to increase frequency and composition of cool season grasses. No treatments reduced shrub stem density. Two years of consecutive growing-season mowing applications, combined with a burn the second summer, reduced stem density in a resprouting shrub, gray dogwood (C*ornus racemosa*). Phenological timing of treatment was more important than intensity of fires to increasing the frequency and composition of cool season grasses, and decreasing the importance of goldenrod and shrubs.

Implications For Managers

Dormant-season burns, alone, do not appear to be effective at restoring or maintaining early successional grassland habitats in northeastern old fields, and may hasten vegetation shifts to dense shrub thickets, > 1 m tall, with higher frequency and composition of *Solidago* spp. than cool season grasses. Summer treatments were found to change vegetation structure in shrubby old fields to more closely resemble typical grassland breeding bird habitat in the Northeast, one growing season after treatments. Immediate reductions in shrub frequency were about the same in fields in early stages of shrub invasion (minimum 2-4 years of invasion) as older fields (minimum 15 years of invasion). Nevertheless, summer mow/burn treatments are likely to reduce stem density of shrubs in early successional fields earlier than in older fields.

C. racemosa is a resilient shrub. One summer mow/burn application fails to kill this species, and also fails to reduce stem density, 1 growing season after treatment. Two years of consecutive growing-season treatments (late summer mow followed by a summer mow/burn application) appear to be necessary to reduce the number of resprouted *C. racemosa* stems and to kill some shrubs. Summer fire, when augmented by treating fields with sickle-bar mowing, can be as intense as traditional spring fires. If a comparably intense fire were timed to destroy shrub resprouts following the mowing (about a month), this treatment could likely severely affect resilient shrubs such as *C. racemosa*.

Keywords: *Cornus racemosa*, cool-season grass, dormant-season fire, grassland bird, growing-season fire, New York, old field, prescribed fire, *Solidago*

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Fuel bed characteristics of invaded forest stands

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To managers in the Northeast, the term "invasive" can apply to native as well as exotic species. Native species sometimes considered invasive include shrubby cinquefoil (Jacobson et al. 1991), goldenrod, gray dogwood, and even red maple. Our focus is on invasive exotic species such as Japanese barberry, Oriental bittersweet, and Asian honeysuckle, which can form dense populations in forested habitats. Included are species native to North America but not endemic to the Northeast. For example, pitch pine is vulnerable to conversion to black locust, a tree native as far north as PA but introduced widely in the Northeast since colonial times.

We are comparing infestations to nearby uninvaded stands because fuel loads, fire return intervals (see Lorimer 2001), understory plant diversity, wildlife habitat, and tree regeneration may be altered when invasive species are especially abundant. We know relatively little about the interactions between fire and some of the most problematic invasive species in the Northeast, but have summarized what is known in Richburg et al. (2001).

At 11 sites in 2001-02 (Table 1) we compared forests with invasive species to nearby or contiguous stands that lack the species in question. We included sites with pitch pine (3), spruce-fir (1), and mixed hardwoods or hardwoods (7). At all sites, we established five plots in the invaded and five in the uninvaded conditions and sampled downed fuels following a modification of Brown's (1974) planar intersect method. Variables included fuel depth, fuel load by size class, duff depth, basal area for the stand as a whole, percent cover by vegetation stratum, abundance of all vascular plants by species, woody seedling abundance, soil pH, and litter load.

Table 1. Sites studied in 2001-02. * = fire-adapted pitch pine ecosystem

Code	Site	Town and state
AC	Acadia National Park	Bar Harbor, ME
AF	Albany Pine Bush Preserve - Friendly area	Albany, NY*
AL	Albany Pine Bush Preserve - Locust and Chubb areas	Albany, NY*
AN	Antietam National Battlefield	Sharpsburg, MD
CC	Cape Cod National Sea Shore	Wellfleet, MA*
HI	Holbrook Island Sanctuary	Brooksville, ME
MA	Manassas National Battlefield	Manassas, VA
MEF	Massabesic Experimental Forest	Lyman, ME
MK	Merck Forest and Farmland Center	Rupert, VT
PE	Penobscot Experimental Forest	Bradley, ME
RC	Rachel Carson NWR – Kittery Division	Kittery, ME

We found significantly greater mass of nonwoody litter in uninvaded pitch pine than in the invaded pine sites and in all other forest types combined (Fig. 1)

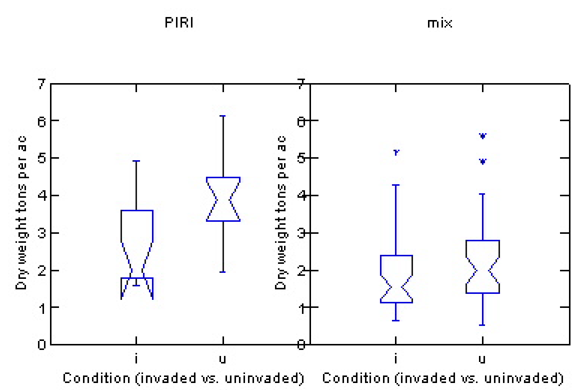


Fig. 1. Nonwoody litter in tons/ac at three pitch pine sites (PIRI) and at seven sites with mixed woods or hardwoods (mix). I = five plots in invaded, u=five plots in uninvaded conditions. If notched portion of box does not overlap on horizontal plane, then groups are significantly different.

In 8 of the 11 sites, duff depth was greater in uninvaded forests (Fig. 2). This suggests that bare soil in invaded stands might provide a niche for seeds of invasive plants and be less conducive to germination of seeds of native species which often require humus in which to stratify over winter. It will be more difficult to burn invaded habitats where surface fuels are sparse, but response to fire differs by species and it seems likely that application of fire could be effective as a control of invasive plants in some cases.

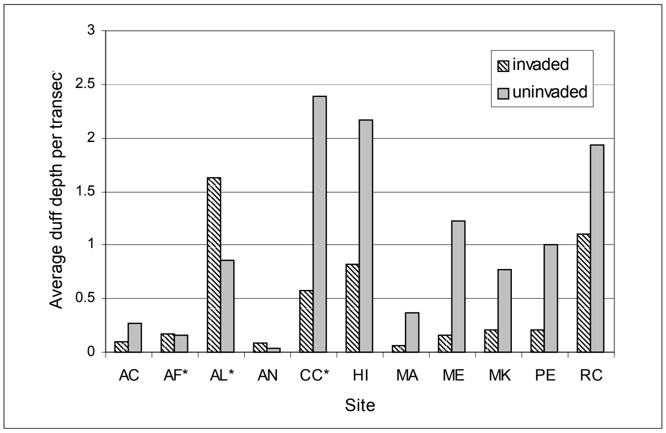
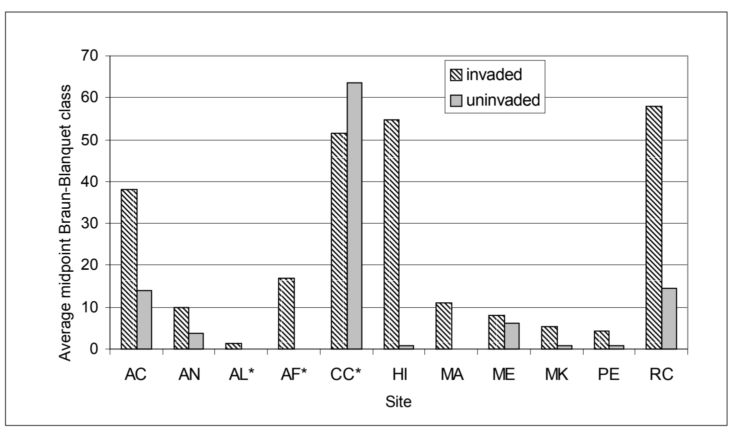


Fig. 2. Average duff depth at 11 sites in MA, MD, ME, NY, VA, and VT (for list of sites, see Table 1). Data are from 227 Brown planar intercepts on 109 plots. * = fire-adapted pitch pine ecosystem

At 8 of 11 sites, 1-hr fuels were at least slightly more abundant in invaded stands than in uninvaded (data not shown). This could be due to the increased shrub density in invaded stands as many of these invasives are shrubs. In 6 of the 11 sites, graminoid cover was at least 10 percent more abundant in invaded stands, and some of these differences are prominent (Fig. 3). At Cape Cod, the uninvaded stand had abundant *Carex pennsylvanica*, a native sedge. The graminoids in the invaded stands tend to be invasive exotic grasses, especially *Poa nemoralis*, *Anthoxanthum odoratum*, and at Acadia National Park, *Festuca filiformis* as well as other introduced grasses.

Fig. 3. Graminoid cover, summarized as average midpoint of Braun-Blanquet cover classes, at 109 plots and 11 sites in MA, MD, ME, NY, VA, and VT (for list of sites, see Table 1). *=fire-adapted pitch pine ecosystem



To summarize, we found distinct differences in the fuels of invaded versus uninvaded forest conditions, but it is difficult to generalize across sites. Pitch pine stands invaded by black locust are vulnerable to loss of the fire-adapted plant community, and litter and duff layers are greatly reduced under locust. Stands invaded by grasses have continuity of fine fuels that suggest these stands might burn more frequently, as fine fuel recovery is quicker following a fire. Where invasive exotic shrubs dominate, there are generally more 1-hr fuels, less litter and duff, more bare ground, and abundant seedlings of some invasive species (e.g., one square meter can have up to 137 smooth buckthorn seedlings, or 343 Norway maple seedlings). These results suggest that the invasive species are likely to persist and that fire regimes may be permanent without intervention. Whether treatments should include fire, herbicide, or cutting depends on, among other things, vegetation type, invasive plant of interest, management goals, proximity to a water body, recreational use by the public, and presence of rare plants and animals. If burning is considered, fuels may require pretreatment to increase the flammability of some invaded stands.

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Modifying the BEHAVE Fuel Model for Northeastern Conditions: Research Needs for Managing Invasives

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For years the BEHAVE fire model (Burgan and Rothermel 1984, Andrews 1986, Andrews and Chase 1989), based on the mathematical model of Rothermel (1972), has been the "gold standard" for managers predicting the effects of prescribed or wildfire. A refined model, BEHAVE-Plus (Carlton *et al.* 2001), is readily available and easy to use. Fortunately for the managers of large fires on public lands in the western United States, a significant research investment has produced an array of fuel bed descriptions, or "fuel models," suitable for vegetation types of the arid west. Numerous studies have evaluated the predictions of BEHAVE and its sub-models under western, southern, and boreal conditions (*e.g.* Sneeuwjagt and Frandsen 1977, Hough and Albini 1978, Norum 1982, Catchpole *et al.* 1993, Grabner *et al.* 1997). Unfortunately for managers in the northeastern U.S., the published literature is much more limited. This is especially true for invaded fuel beds, which are by definition novel. In this talk, I'll review the basic structure and assumptions of the BEHAVE model, including those that aren't exactly followed by invaded fuel beds in the Northeast. I'll discuss the parameters required for developing custom fuel models, and the availability of data for Northeastern fuel beds. Finally, I'll ask the question: what aspects of the fuel bed are most important, and how important are they relative to other considerations (such as weather) in planning prescribed burns?

How do BEHAVE and related models characterize the fuel bed? BEHAVE describes fuel conditions using a "three-dead, two-live" approach. The entire fuel bed is characterized by the abundance of dead fuels (in 1-hour, 10-hour, and 100-hour size classes), and live fuels (divided into herbaceous and woody fuels). The fire itself is assumed to be a line fire burning at a steady rate, and its behavior is assumed to be governed by the fine fuels heating and igniting at the fire front. The fuel bed, and the fire, are assumed to be more or less uniform and continuous (Burgan and Rothermel 1984). This is a simple picture of a simple fire burning through a simple fuel bed. But we know many of our fuel beds, such as grasslands being invaded by woody shrubs, are far from simple: there are multiple kinds of fuels, they are not necessarily distributed uniformly, and they tend to be patchy rather than continuous. How does BEHAVE deal with this situation?

Constructing a "simple" fuel model that *acts like* a complex fuel bed within BEHAVE requires something of both art and a science. BEHAVE allows users to construct new fuel models using a program called NEWMDL (Burgan and Rothermel 1984); a revised procedure is on the "wish list" for BEHAVE-Plus (Carlton *et al.* 2001). NEWMDL constructs a new fuel model by "hashing" information from up to four components of the fuel bed: litter, slash, shrubs, and grasses. For each layer, the user needs information about:

1. The total load (tons per acre) of material, and its breakdown by size class and live or dead material
2. The average depth of the fuel component. For uniform shrubby material, this is considered to be about 70% of the maximum shrub height.

3. Percent of area covered by each fuel component.
4. The surface-to-volume ratio of each fuel component.
5. The heat content (B.T.U.'s /lb) of each fuel component.
6. Moisture content, by size class, for live and dead material.

The process by which NEWMDL condenses information from four fuel bed categories to a single "three-dead, two-live" description is an ugly weighted averaging procedure – it requires 3 pages of equations in Burgan and Rothermel's (1984) paper just to explain it! And this procedure does not account for variability *within* each of the four categories. Two examples where this might well occur in invaded northeastern fuel beds include:

- Grasslands containing a fine-grained mix of native and non-native grasses and shrubs with different characteristics, so that the fuel bed is a matrix of small patches of widely varying load, height, surface-to-volume ratio, and flammability
- Pitch pine stands being invaded following fire suppression, with multiple "shrub" layers: low, uniform cover (such as low-bush blueberry) intermixed with patchy higher cover (such as oaks, white pines, and any number of woody competitors scrambling to form a mid-story).

To deal with these situations we'll need a new averaging procedure – and that procedure needs to be *tested* against actual fire behavior.

How much of the information listed above is available for Northeastern species – native or invasive? Not much! For example, in the U.S.D.A. Fire Effects Information System database, (http://www.fs.fed.us/database/feis), the "Fire Management Considerations" section lists "information for estimating fuel loadings, if available." Of the 76 species listed in FEIS as invasive in January 2003 (note that of these, many do not occur in the Northeast), only *Bromus madritensis*, *Bromus tectorum*, *Centaurea stoebe* ssp. *micranthos*, *Cirsium arvense*, and *Taeniatherum caput-medusae* list references to fuel models or even partial information for constructing fuel models. Clearly, the lack of information about the fuel properties of invasives is a national gap, not just a northeastern one. There is no information on such common invasives as *Eleagnus angustifolia* or *Rosa multiflora*. We are allowed to hope that invaded fuel beds will behave much like the "standard" fuel beds composed of native vegetation (*e.g.* Anderson 1982), but some data confirming that this is so would be reassuring.

Which parameters of the fuel model are most important? A *sensitivity analysis* of the BEHAVE model suggests that, at least under the benign conditions associated with prescribed fires, some parameters are relatively unimportant, while others have a disproportionate effect. Consider the case of 5-mph winds, on a 5% slope, with moderate fuel moisture conditions, using some standard models that approximate many invaded fuel beds:

- Using Anderson's (1982) "Model 2", which includes grasslands with scattered shrubs and other woody components, the surface-to-volume ratio of 1-hour fuels has a disproportionately large effect (a 10% increase results in a 16% increase in the rate of spread). Fuel bed depth as a proportionate effect (a 10% increase results in a 10%

increase in rate of spread) – but fuel bed depth is very sensitive to how the shrub and grass components are averaged.

- Using "Model 9", which approximates the understory conditions in a closed hardwood stand, both the 1-hour surface-to-volume ratio and the fuel bed depth have disproportionately large effects on rate of spread. In addition, the dead fuel heat content has a proportionate effect on both rate of spread and flame height. As noted above, we have almost no data on the heat content of dead fuels derived from the litter of invasive species.
- Using "Model 10", which includes forested types with a shrubby understory, the 1-hour surface-to-volume ratio and the fuel bed depth have similar effects as in Model 9. The 1-hour fuel loading now has a proportional effect, because fine twigs in the understory can carry the fire. Unfortunately, we are only beginning to understand the short-term and long-term effects of invasives on understory conditions – including the direct effects of their own presence, and the indirect effects they have by changing the structure and development of plant communities.

Does all this mean we should be afraid to take a drip torch to grasslands and forests that contain invasive species? Probably not. There is one additional parameter that has a disproportionate effect on both rate of spread and flame height – and it has nothing to do with the fuel bed. It's wind speed. As your basic fire training would tell you, one of the most important factors to drive fire behavior is the weather, and it can swamp out the variability imposed by species variations in the fuel bed. (There may be some exceptions for hot-burning invasives like *Phragmites* – but that's another species for which we have virtually no data to construct a fuel model.) So *do* use the model where it is appropriate, to help guide prescribed fire planning. But *also* take note of unusual fire behavior (invasive vegetation that just won't burn, even though it seems like it should; or flames that run more than a bit hotter and faster than you would expect when they hit a patch of something strange). And be sure to communicate it to the rest of the fire community. That will help all of us improve our management – and the models we use to support it.

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Relative flammability of native and invasive exotic plants of the Northeastern U.S.

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We are comparing the ease with which a plant fuel catches fire – its flammability, or combustibility, for native versus invasive exotic plants. In the Northeast, some of the worst invasives might have different fuel characteristics than the native species they sometimes displace. We seek to improve effectiveness of prescribed fire and assessment of fire hazards. Risk of wildfire could be greater in the wildland-urban interface if invasive plants are dense and have higher flammability than their native counterparts. Conversely, a fire-prone ecosystem invaded by exotics might have less frequent fire return and lower severity, with consequences for fire-dependent species, e.g., federally endangered Karner Blue butterfly and its host plant, a native lupine of pitch pine forests.

For the Joint Fire Science Program (JFSP) we, with Mark J. Ducey of University of New Hampshire, are modifying the Rothermel fuel models to better represent conditions in the Northeast. Heat content is a missing link, especially regarding common shrubs and herbs, and some invasive exotic plants. These data can be used in BEHAVE Plus, FARSITE, and the Emissions Production Model (EPM) so that models better represent the local vegetation, and will added to the Fuel Characteristic Classification System (Cushon et al 2002), which is a clearinghouse of fuels information.

We sampled flammability of plants in a cone calorimeter (ASTM 2002) to quantify effective heat of combustion (HOC) as a measure of heat content in dried (60°C), unground leaves and twigs. We compared 14 invasives, 12 of which are exotic, to 13 native species (Table 1) which might be displaced in disturbed habitats. Based on five replicates per species and two fluxes, we found a range from 6-17 Mj/kg, which is overall lower than for green and dry plant fuels from California and Colorado.

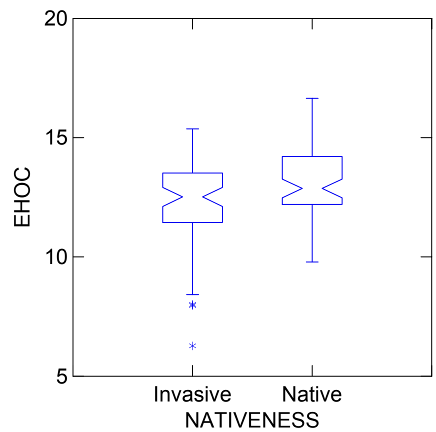
Highest average heat content (Table 1) was in speckled alder. Among shrubs and vines, it was relatively high in highbush blueberry, purple nightshade, common barberry, and Japanese honeysuckle, and lowest in smooth buckthorn and Oriental bittersweet. Among six herbs, rough-stemmed goldenrod had the highest heat content while Japanese stiltgrass and Japanese knotweed were lowest. Quaking aspen had higher heat content than invasive trees, while Norway maple and apple were lower than the others.

Table 1. Plants included in the cone calorimeter data of Fig. 1, with average heat of combustion (heat content) from five replicates.

Plant type	Nativeness	Common name	Species	Avg HOC
Shrub	Native	Speckled alder	*Alnus incana*	15.98
Shrub	Native	Eastern serviceberry	*Amelanchier cf. canadensis*	13.10
Shrub	Native	Pasture rose	*Rosa carolina*	13.28
Shrub	Native	Highbush blueberry	*Vaccinium corymbosum*	14.45
Shrub	Native	Maple-leaved viburnum	*Viburnum acerifolium*	13.68
Shrub	Native	Arrowwood	*Viburnum dentatum*	12.30
Vine	Native	Grape	*Vitis sp.*	11.40
Vine	Exotic	Purple nightshade	*Solanum dulcamara*	14.24.
Shrub	Exotic	Common barberry	*Berberis vulgaris*	14.04
Shrub	exotic in N.E.	Eastern ninebark	*Physocarpus orbiculatus*	13.05
Shrub	Exotic	Smooth buckthorn	*Frangula alnus*	11.23
Shrub	Exotic	Russian olive	*Elaeagnus angustifolia*	13.42
Shrub	Exotic	Multiflora rose	*Rosa multiflora*	12.30
Vine	Exotic	Oriental bittersweet	*Celastrus orbiculatus*	11.44
Vine	Exotic	Japanese honeysuckle	*Lonicera japonica*	14.34
Herb	Native	Interrupted fern	*Osmunda claytoniana*	11.732
Herb	Native	Rough-stemmed goldenrod	*Solidago rugosa*	13.388
Herb	Exotic	Japanese stiltgrass	*Microstegium vimineum*	11.138
Herb	Exotic	Japanese knotweed	*Fallopia japonica*	11.344
Herb	Exotic	Purple loosestrife	*Lythrum salicaria*	12.444
Tree	Native	Red maple	*Acer rubrum*	12.612
Tree	Native	Quaking aspen	*Populus tremuloides*	13.654
Tree	Native	Chokecherry	*Prunus virginiana*	12.854
Tree	Exotic	Norway maple	*Acer platanoides*	11.112
Tree	Introd. n of PA	Black locust	*Robinia pseudoacacia*	10.882
Tree	Exotic	Domestic apple	*Malus sp.*	11.53

Overall, invasive plants tended to have lower heat content than native species (Fig. 1).

Fig. 1. Notched box plots summarizing heat content, Effective Heat of Combustion, in 27 plant species of the Northeast (Table 1), half of which are native. Data are from 5 cone calorimeter tests per species. Overlap of the notched portions of the two boxes on the horizontal plane means that the groups do not differ significantly.



When broken out as a subset, three invasive trees are significantly LESS flammable than three native trees (Fig. 2).

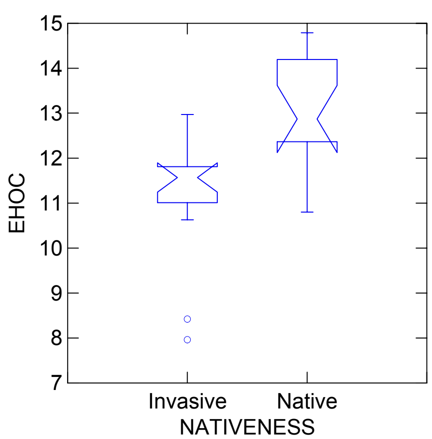


Fig. 2. Notched box plots summarizing heat content, expressed as Effective Heat of Combustion, in six trees sampled in the Northeast. Because the notches of the two boxes (and the boxes in their entirety) do not overlap on a horizontal plane, the two groups are significantly different.

Our sample is small. In January 2003 Dibble, Ducey and White applied to the JFSP to conduct a nation-wide combustibility survey of native and invasive exotic plants.

We conclude that (1) use of fire to control undesirable vegetation can be more effective if a species-by-species approach is taken to meet management objectives in a particular stand; (2) flammability also involves leaf surface to volume ratio and moisture content (which is being measured in another study), and these should be quantified to improve modeling fire behavior; and (3) comparison of combustibility data from other regions will increase our understanding of fuels in the Northeast.

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Using Fire to Control Invasive Plants: What's New, What Works in the Northeast? "Overview and Synthesis"

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Invasive species, which may be either native or exotic, are increasingly being recognized as degrading natural as well as human–altered ecosystems in the Northeast (Richburg et al 2001). Non-native species once planted to enhance wildlife habitat or for landscape purposes are invading grasslands, deciduous and conifer forests, whereas native species like white pine and aspen, which are valuable as timber in some settings, are degrading habitat for rare species in pine barrens and old fields. Many of the degraded habitats are dominated by early successional species whose place on the landscape was once maintained by fire. Invasive species have the potential for altering fire regimes (D'Antonio 2000), and their presence complicates management. Although we do not have instances, such as the invasion of western systems by cheat grass, where fire regimes have been altered over extensive portions of our landscapes, species such as gray birch, autumn olive, honeysuckle and locust reduce the flammability of old fields, deciduous forests and pine barrens; whereas cat brier and Scotch broom cause higher intensity fires in our coastal grasslands. Prior to becoming dominated by invasive species, many of these communities supported species of plants, birds and insects which are now rare on the landscape. We assume that many of these systems were maintained by fire, but it is becoming apparent that fire applied at frequencies and in seasons different than when it was applied in the past is hastening the conversion to invasive-dominated shrubby communities. Proper management of these systems depends not only on knowledge of the ecology of individual species but on an understanding of fuel bed dynamics as well.

Speakers at the workshop examined the scope of the invasive problem with respect to fire management in the Northeast, and discussed solutions to the most pressing problems.

Allen Carter provided an overview of the National Fire Plan. Although perhaps not obvious to practitioners in the field, programs such as the NFP are substantially enhancing wildland fire suppression and use programs at the federal and state levels. The Joint Fire Science Program, which supports the work described by Alison Dibble, Mark Ducey and Julie Richburg, is advancing our knowledge of how fire and invasive species interact. Although funding for these programs is often thought to be focused on Western problems, three projects are currently funded in the Northeast. Two of these (Dibble and Patterson's Fire and Invasive Species project, and Patterson and Crary's Fuels Demonstration Project) address questions of concern to managers dealing with invasive species. A focus on the needs of land managers and technical transfer is an important component of all JFSP projects as evidenced by today's workshop, which is a product of the Fire and Invasives Project now in its third year.

Invaded sites may become more or less flammable depending on the invasive species involved and the inherent flammability of the invaded community. Alison Dibble presented a poster on flammability of invasive exotics in comparison to native species they displace, and an oral presentation comparing fuelbeds in invaded forests to nearby uninvaded stands. She, Bill Patterson, and Robert White have tested oven-dried, unground leaves and twigs from 27 species in a cone calorimeter. Native species tend to have slightly higher heat content than exotics, with native goldenrod having the highest values and smooth buckthorn low values. Alison Dibble, with Mark Ducey and Bill Patterson, found that in three pitch pine and eight mixed wood or hardwood sites invaded stands typically have less duff but more fine fuels especially when invasive grasses are present. Seedlings of native woody plants are few in invaded stands.

The abundance and availability of fuels influence fire behavior in both natural and invaded fuel beds. Bob Vihnanek described a national-level effort to provide photo series to help managers identify fuel beds characteristic of forest, shrub and grassland vegetation. Unlike previous photo series, the new effort incorporates stereophotography, which greatly increases the ease of identifying differences in the smaller fuel classes between photos. Prescribed fire as a tool for managing invasive species is often accompanied by mechanical treatments which, when properly applied, can enhance the flammability of fuel beds degraded by the presence of invasive species (e.g., the sickle mower cutting of gray dogwood in New York old fields described by Mitchell and Richburg). Inclusion of invaded fuel beds in future photo series would aid managers who must write burn prescriptions for fuel beds that have been altered by the presence of invasive species. Although it will be some months before photo series are available for the Northeast, managers can refer to Lynch and Horton's 1983 photo series published by the USFS Northeastern Area, for eastern white pine and pitch pine fuel beds.

Fire managers use fuel models with BEHAVE (a fire behavior prediction system) to predict fire behavior on specific sites (Burgan and Rothermel 1984, Andrews 1986, Andrews and Chase 1989). Mark Ducey provided an overview of the system. Managers who recognize that invasive-altered fuel beds have the potential for supporting fire behavior not predicted by 13 "standard" fuel models have the option of developing custom fuel models. Ducey's research identifies which fuel bed components influence model outputs most strongly. JFSP funded efforts to develop custom fuel models for invaded vegetation, both in the "natural" and managed state (i.e., following mechanical treatments) are underway at the University of Massachusetts.

Like BEHAVE, the National Fire Danger Rating System (NFDRS) is a predictive model which describes the hazard associated with interactions between wildland fuels and weather parameters such as wind speed, relative humidity and drought. Using a separate set of 20 "NFDRS fuel models" the NFDRS assesses fire risk and potential wildfire behavior at the landscape level (Deeming et al. 1977, Burgan 1988). But NFDRS models are notorious in the Northeast for poorly predicting fire danger in pine barrens. John Hom described National Fire Plan funded research at the Northeastern Research Station to develop a new fuel model to better predict fire behavior in barrens like those in New Jersey, on Long Island, and in southeastern Massachusetts. Until a new model is developed, managers dealing with prescribed fire issues in pine barrens might consider using NFDRS fuel model "O" (originally conceived for dense, brushlike fuels of the Southeast), which adequately accounts for the very rapid rise in flammability of barrens fuels soon after precipitation events (Patterson, unpublished data). Hom's research and my own experience highlight the importance to prescribed fire managers of monitoring fire weather and NFDRS indices.

Tom Dooley, Laura Mitchell and Julie Richburg discussed their success with using fire, mechanical and herbicide techniques to control invasive species and restore and maintain desired conditions. Dooley reported that at the Albany Pine Bush herbicide application, sometimes in conjunction with mechanical treatments, is more effective than prescribed fire in reducing the vigor of the native, invasive species black locust and aspen. Mitchell found that growing season mechanical and prescribed fire treatments, especially when applied over the course of more than a single growing season, are more effective than dormant season treatments in reducing the vigor of invasive, native shrub species in old fields in central New York. Not only do dormant season treatments fail to inhibit gray dogwood, a clonal woody shrub, but they encourage undesirable non-woody native species like goldenrod. Richburg, who will complete her work in 2003, is providing a physiological basis for evaluating the effectiveness of treatments timed during the growing season to correspond with a reduced ability to resprout in several woody invasive species. Top-killing stems, either mechanically or with growing season prescribed fire, when root reserves of stored carbohydrates are low results in reduced sprouting vigor. Determining the optimum time to apply treatments is a goal of Richburg's ongoing research.

A panel of scientists and resource managers discussed several aspects of invasive species management. Ernie Steinauer stressed the importance of documenting, through monitoring, what works and what does not. To be useful, monitoring needs to be objective, repeatable and efficient enough to ensure that monitoring is continued over the several years that may be required to determine the long-term effectiveness of treatments. The results of many efforts in the Northeast highlight the importance of using an adaptive management strategy, in which the key to success is monitoring to determine if management goals are being met. Many speakers cited evidence that dormant season burning facilitates rather than discourages invasive plant establishment and spread. Spring burning is effective in controlling non-sprouting conifers such as white pine in old fields (Patterson, unpublished data) and larch in alkaline fens (Murray, unpublished data). In addition to timing affecting the success of various treatments on invasive plants, historic landscape disturbances and landscape-scale variations in soils and topography also can affect initial establishment and treatment success. Alison Dibble, Betsy von Holle, and others working at several locations on Cape Cod, the Berkshires of western Massachusetts and in New York State are trying to determine how these factors influence the occurrence and persistence of invasives. Although our best efforts to control invasives need to be based on species biology and site conditions, Gerald Vickers, Tom Dooley and Mike Ciaranca cautioned that regulatory agencies also influence which management activities are available. For example, summer burning, which is known to be more effective than dormant burns in controlling many species, may be prohibited in certain areas (such as is generally the case in Massachusetts air quality regulations restrict most burning to the spring). The challenge to resource managers is to find acceptable substitute protocols when best management practices are prohibited.

In conclusion, workshop speakers and members of the audience challenged us all to examine carefully our current management practices and to adopt new techniques and protocols if present practices do not seem to be gaining the desired effects. A thorough knowledge of the ecological requirements of individual species and of how management should be adapted to invasive-altered ecosystems is a prerequisite to successful management of native communities which support rare species and important habitat for wildlife, and are an important aesthetic component of our New England landscapes.

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Resources on the Web:

Fire Effects Information System (FEIS – Invasive Plants):
http://svinet2.fs.fed.us/database/feis/plants/weed/weedpage.html

The Nature Conservancy's "Invasives on the Web" page:
http://tncweeds.ucdavis.edu/

Natural Areas Association's "Invasive and Exotic Species Compendium—CD ROM" see the fall 2002 (Vol.6, No.3) Newsletter for ordering information:
http://www.naturalarea.org/

Questions from the Fire and Invasives Workshop
January 24, 2003, Portsmouth, NH

Prior to the workshop, Alison C. Dibble and Karen Bennett invited the registrants to send their single most compelling question regarding fire and invasive species so that we, as organizers, could be sure the Workshop addressed their information needs. A summary of answers developed by Julie A. Richburg and William A. Patterson III, both of the University of Massachusetts at Amherst, follows.

<u>Question:</u> *Can invasives really be stopped?*

<u>Answer:</u> This question is often asked by land managers and researchers who face the overwhelming task of dealing with an extensive invasive species problem. Because native and non-native species can both be invasive, an answer might be that we wouldn't want to stop all invasive species. Many native invasive species, such as aspen, gray birch, and gray dogwood, are components of early successional systems and contribute to the development of these systems into later successional habitats. Other invasive species, such as the non-native shrub species, alter habitats to an extent that native species are no longer able to thrive. In either case, we may want to stop or eliminate the invasive species in order to preserve something that we perceive is of more value (i.e., rare species, native habitats, natural processes). Ideally, non-native species would not be degrading our natural systems, and we should do all that we can to prevent future introductions, but our management efforts cannot be focused on "stopping" all invasives, rather controlling or eliminating them in specific situations. Although we may never be able to eradicate all invasive species from the landscape, we can target our management actions to successfully protect those habitats, species, and ecosystem characteristics that are important to us. As people we influence our natural surroundings in many ways – both desirable and undesirable – and as land managers we are faced with making decisions about what we should manage for. Maintenance of early successional habitats for rare species, elimination of invasive species from key habitats, control of ground water fluctuations, and planting of desirable species are all activities where managers have made a decision to influence the natural system to achieve a desired result.

The Fire and Invasives Workshop focused on sharing knowledge of what has worked (and has not) when using fire to control invasive species. We heard about techniques that are successful at controlling invasives such as burning old fields to eliminate white pine seedlings, and alternative techniques (such as girdling of black locust at the Albany Pine Bush) that were developed once fire was determined to be ineffective. All of our management decisions are constrained by time, money, and regulatory requirements, and we shared information on those constraints as well the biological effectiveness of various treatments. Following is a compilation of the questions (along with some answers) that were asked by the participants prior to the workshop. Many of the answers are incomplete or qualified by lack of specific knowledge which demonstrates that researchers and managers need to work together to find feasible techniques for controlling invasive species in the habitats of the Northeast.

Fire as a control technique

Questions:

- *How effective is fire compared to other control techniques?*
- *Which species are most effectively controlled by fire?*
- *How often does burning need to occur? Is repeated application of prescribed fire needed to keep invasives in check?*
- *How can fire be used to enhance native species and reduce invasives?*
- *What is the potential for fire to be used to control invasives at the landscape scale in forested settings?*

Answer:

In the Northeast, fire alone will rarely solve an invasive species problem. The ecology and biology of invasive species often contributes to their ability to survive fire and rapidly spread through a disturbed landscape. For example, the ability of many woody invasive species to sprout from roots, rhizomes, and/or root collars allows then to not only survive fire but also increase the number of above ground stems following the disturbance. Other invasive species have long-lived seeds that quickly germinate following fire (e.g., garlic mustard, Scotch broom). Although fire is considered more "natural" in some situations, many factors affect the success or failure of fire to control invasive species. These include: the size of the infestation, the extent to which the system has been degraded before invasion or by invasives themselves, available fuel to support a fire, season when fire is applied, intensity of fire, site characteristics, and the species involved (especially their method of dispersal, mode of regeneration, and reaction to disturbance). Fire as a tool may not be practical in some situations due to the equipment, personnel, and regulatory requirements involved in implementing prescribed burns.

In some situations, however, fire may be used along with mechanical treatments and/or herbicides to increase the success of control. Prescribed fire has been used to remove dense thatch after herbicide application to *Phragmites* allowing native species to revegetate. By timing mechanical treatments and prescribed fire to the phenology of the target species, the vigor of sprouters can be reduced. Growing season treatments have the greatest success in reducing some invasive species. In most situations, repeated treatments are necessary, although repeated fire is constrained by the lack of fine fuels. We have found that a 3- to 4-year accumulation of litter is necessary to generate enough fine fuels to support a reburn in barrens dominated by scrub oak. Waiting for these fuels to accumulate may not be desirable when managing invasives, as the plants may be able to fully recover prior to the next treatment. Finally, due to the configuration of land ownerships in the Northeast, landscape scale use of prescribed fire is limited. Our use of prescribed fire and other treatments should focus on high priority sites and/or problems.

Question: *How has fire been used in New England?*

Answer: Traditionally fire has been used during the dormant season to control the woody component of open habitats. It has been very effective at controlling pine invasions in old fields, but for other woody species dormant season burning is at best a temporary solution. Recent research and management burns conducted during the growing season have resulted in decreased vigor of some sprouting species (see Richburg & Patterson abstract).

Question: *What am I likely to run into during prescribed burns?*

Answer: When conducting prescribed burns in invaded habitats, fire behavior may be greater or lesser than expected depending on the invasive species involved and the fuel bed altered by their presence.

Question: *Who can I hire to conduct the burn?*

Answer: Burn bosses are available depending on the landowner and state. Agencies such as the U.S. Fish and Wildlife Service, the U.S. Forest Service, and state fire control organizations may have burn bosses, crews, and equipment available for prescribed fire on their properties. Private landowners may be able to work with The Nature Conservancy, state or federal agencies, or independent contractors (of whom there are only a few in the Northeast) depending on the location of the property and the species involved.

Question: *How does one convince community members that fire is the best strategy to control invasives and preserve native species?*

Answer: Fire alone rarely is the best strategy, but it may be preferable to herbicides in some situations (e.g., watersheds protecting public drinking supplies) and mechanical treatments on some types of surfaces (e.g., steep/rocky).

Question: *How do you handle the presence of poison ivy in a field that's been designated for burning?*

Answer: Depending on the amount of poison ivy, you may be able to burn it and protect control personnel from the smoke (e.g., when there are dependable winds and natural firebreaks down wind). You may also try treating with herbicide prior to burning, although this could increase flammability of the fuel bed and the dermatitis-causing compounds in poison ivy and poison sumac remain present in the dead vegetation. Burning during the dormant season is another option (although the oils are still present in live poison ivy stems), but this may not accomplish other objectives. Poison ivy will resprout prolifically following fire. It is important to keep personnel out of the smoke as breathing it may result in serious respiratory problems that could require hospitalization.

Question: *How do we deal with wildland urban interface issues?*

Answer: Fire is not always practical or acceptable in the wildland urban interface. Fuels often need to be managed by a variety of techniques including mechanical treatments. A three-year fuels demonstration project on Cape Cod (initiated in 2002 by University of Massachusetts, the Massachusetts Department of Environmental Management, and Cape Cod National Seashore personnel and partially funded by the Joint Fire Science Program) is evaluating fire break maintenance using mechanical treatments, prescribed fire, and sheep grazing.

Question: *Can we control invasive plants on bounded lands if invasive plants on adjacent lands aren't treated as well?*

Answer: Control of any invasive plant is possible in defined areas but will require long-term management to prevent reinvasion from outside areas.

Question: *How can we scientifically measure and monitor our success and failures when using fire to control invasive plants?*

Answer: The success of any monitoring program depends on its ability to answer key questions and its ability to be carried out repeatedly over time. As Dr. Steinauer outlined in his presentation at the workshop, monitoring programs are often limited by time, money, and turnover of experienced staff. Effective monitoring programs should involve rapid, easy to implement procedures that are inexpensive and repeatable with good documentation. When dealing with invasive plants, it is often useful to focus more on the number of individual plants (not ramets or cover) if possible. Repeat photography is among the most effective methods of documentting change at the landscape scale. It is important to monitor the effectiveness of meeting resource management objectives beyond simply controlling invasives.

Question: *How effective has spot-burning been on woody invasives?*

Answer: We know very little about spot-burning, although some managers have tried to girdle invasives by burning them with propane torches. We are not aware of specific examples of the use of this technique at this time.

Question: *How can cooperation between state and federal agencies concerning fire and invasive species be best fostered?*

Answer: Several federal, state and university (extension) programs fund research and promote technology transfer. In addition, some federal agencies have equipment and personnel available to help with prescribed fire. States and private organizations are more likely to be available to assist with prescribed fire on private lands. Many states in the Northeast have formed invasive plant councils to address the most problematic non-native species. The Northeast Forest Fire

Protection Commission, a.k.a. Northeast Compact, should be included in region-wide efforts to establish a cooperation of this kind.

Reaction of plants to fire/ impacts of fire on communities

Questions:

- *How do the plants react to burning?*
- *Are there seasonal and intensity differences?*
- *Does fire encourage or deter growth?*
- *Does fire inhibit or facilitate establishment of non-native species in the Northeast?*
- *What invasive species are controlled by fire and what is the biological (long/short) impact to the plant /animal communities frequently associated with these species?*
- *What is the role of fire in the ecology of the invasive plant?*
- *At what time of year or what stage of growth is fire most effective?*
- *Can we generalize about groups of invasives that can or cannot be adequately controlled by fire?*
- *In what types of natural communities can fire be used safely (without harming the ecosystem) to control invasives?*

Answer: Disturbance, including fire, often facilitates invasion of plant communities, although the extent of invasions depends on the habitat type and past disturbances. In the Northeast, deciduous forests, rivershores, fresh and brackish swamps, and old fields appear more susceptible than sandplain grasslands, spruce-fir forests, and barren communities. On wetter soils and where fine fuels are sparse, fire might not be an effective treatment. Most invasive species have traits (e.g., large and long-lived seed banks, ability to resprout, and dispersal methods such as by birds or wind) that make them difficult to control using fire alone. In general species that do not reproduce vegetatively, such as most conifers, are most easily controlled by fire. Species with vegetative reproduction including clonal species and resprouters can be temporarily set back by fire, especially if the type of fire and season maximize damage (e.g., severe growing season fires). Those species which reproduce from seed – in addition to or as opposed to vegetatively – may proliferate or not depending on how long-lived their seeds are in the soil and whether fire impacts the seed bank. Dispersers (birds) are often attracted to burned areas so burning may facilitate invasion of plants that bear fleshy fruits. Invasion after a fire may also occur if fire negatively impacts the vigor of native competitors.

To maximize the impact of fire on invasive woody species, the plants should be treated shortly after leaf flush and then again before hardening off of resprouts (i.e., early enough to allow them to once again resprout). Growing season treatments likely have the greatest impacts on invasive species, whether by reducing energy stores within the plants or preventing seed production. The ability to conduct fires at these preferred times depends on the fuel bed within which they occur. Cat brier and multiflora rose are two species that burn well during the growing season without prior treatment, whereas the Asian honeysuckles and gray dogwood may need to have their fuel beds increased artificially (such as by sickle-mower cutting followed by burning when the slash has cured). Flammability can be enhanced by certain non-mulching types of mechanical treatments.

Questions:

- *What effect does fire have on Maine's spruce-fir forest?*
- *Will fire exclusion change this?*

Answer: Maine has a history of infrequent but large fires in the spruce-fir type, and managers are wise to continue to plan for wildland fire. In general, fire will regenerate deciduous species within the spruce-fir forest, at least initially. The exact effect depends on the age of the forest and the intensity and severity of the fire. If fire is excluded for many years, live fuels will gradually increase in biomass. Disturbances such as catastrophic windstorms, spruce budworm outbreaks, the spreading balsam woolly adelgid infestation, or some types of timber harvest activities, could significantly increase hazard fuels. Because the Maine climate typically has abundant rainfall, this might not be a major problem except in an extreme dry year. An intense fire in a mature spruce-fir forest could destroy seed trees, and because conifer seeds are short-lived, hardwoods would dominate. The young mixed hardwood stand would then presumably be somewhat non-flammable for decades. Conifers would seed in eventually from the edge of the burn or from unburned patches. (This answer includes comments by Alison C. Dibble).

Question: *Are there publications/research that can be cited in planning documents for burning invasives?*

Answer: There are several sources of good information regarding fire effects on plant species (native and non-native, invasive and non-invasive). Below are a few examples, but there are also some state agencies that have similar information.

Fire Effects Information System (FEIS):
http://www.fs.fed.us/database/feis/

The Nature Conservancy's "Invasives on the Web" page:
http://tncweeds.ucdavis.edu/

Natural Areas Association's "Invasive and Exotic Species Compendium—CD ROM" see the fall 2002 (Vol.6, No.3) Newsletter for ordering information:
http://www.naturalarea.org/

Question: *How do we make the most of prescribed fire in a very swampy environment?*

Answer: Some groups in the Northeast have recently burned wetland habitats. The Nature Conservancy's Berkshire Taconic Program based in Sheffield, Massachusetts has conducted several burns in fen wetlands. To assist their burns within the wetlands they have tried: 1) running a higher intensity fire from the upland into the wetland, 2) cutting shrubs and letting them cure prior to burning, and 3) using propane torches to target flammable fuels. In most cases, the fires were not very hot, but may have achieved some of their objectives. Phragmites control at Dismal Swamp NWR in southeastern Virginia and northeastern North Carolina is an example of a new effort to manage fuels by burning in swamp habitat (see Gerald Vickers' section of the summary from the Panel Discussion).

Question: *I would like to hear about specific examples of the use of fire to eradicate invasive plants.*

Answer: See abstracts by Richburg & Patterson, Mitchell, Murray, and Dooley. The term "eradicate" suggests that expectations are high. Even with consistent and repeated efforts it might be realistic to think, instead, in terms of "control". A major challenge will be to prevent re-infestation from populations of invasive plants that are on land over which you have no jurisdiction.

Question: *What are the different techniques for various species?*

Answer: Species specific comments follow:

Japanese knotweed (*Polygonum cuspidatum*): We are not aware of any specific cases of burning Japanese knotweed. Repeated hand pulling and herbicide use have had some limited success in certain areas (Acadia NP, Vermont TNC lands).

Giant reed or *Phragmites* (*Phragmites australis*): In some situations, especially with pre-burn herbicide treatment, fire has been successful. Fire by itself has generally not been successful due to the large underground network of rhizomes from which the plants sprout. Fire has been used to reduce thatch following herbicide application to allow other species to establish.

Purple loosestrife (*Lythrum salicaria*): Fire has not been used to control loosestrife, mostly due to problems with burning in wetlands and the lack of continuous fuels to carry a fire. Recent partial success with biocontrols, cutting and persistent hand-pulling before flowering offer some hope.

Asiatic bittersweet (*Celastrus orbiculata*): Bittersweet will resprout following cutting and probably after burning also. In some sites, large dense clusters of vines may serve as ladder fuels.

Spotted knapweed (*Centaurea maculosa*): Knapweed often dominates areas, but does not produce a lot of litter and therefore it may be difficult to burn large infestations. Patterson burned fields dominated by knapweed at Saratoga NHP. High winds are required to propagate fire through fuel-depauperate stands. Although burning prior to seed ripening would be optimal, it probably is not possible to burn this species during the growing season unless mowed with a sickle type mower beforehand with burning when the thatch has dried. Another possibility is to add fuel such as hay.

Canada thistle (*Cirsium arvense*): See the Fire Effects Information System for a detailed discussion of this species. In general, fire often facilitates establishment of thistle when a seed source is available. Late spring burns may be effective in controlling established plants.

Honeysuckle (*Lonicera* spp.): Shrub honeysuckles resprout profusely after cutting and burning. Burning in dense honeysuckle stands can be difficult due to moist fuel conditions. Richburg has cut and burned shrub honeysuckles. Repeated treatments may decrease the vigor of sprouts, although data have not been evaluated at this point. There are informal reports about successful burning of honeysuckle in the Upper Midwest when the leaves are just expanding. Followup treatments are probably necessary.

Perenial pepperweed (*Lepidium latifolium*): We know of no information regarding burning of this species.

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