Controlling Understory Fern Competition for Regeneration Success

David Jackson

Fern-dominated forest understories interfere with forest regeneration and provide poor habitat for wildlife.

Areas of hardwood forests in Pennsylvania, across the Great Lakes region, and throughout the Northeast contain dense understories of fern, including hay-scented fern (*Dennstaedtia punctilobula* Michx.), New York fern (*Thelypteris noveboracensis* L.), and bracken fern (*Pteridium aquilinum* L.). These characteristic fern understories have made Pennsylvania famous for the picturesque beauty they provide to our forests. Most people don't know that these dense fern understories are often biological deserts, lacking plant and wildlife diversity and providing little wildlife food or cover. Fern understories also interfere with the regeneration of hardwood forests, threatening their sustainability across the region.

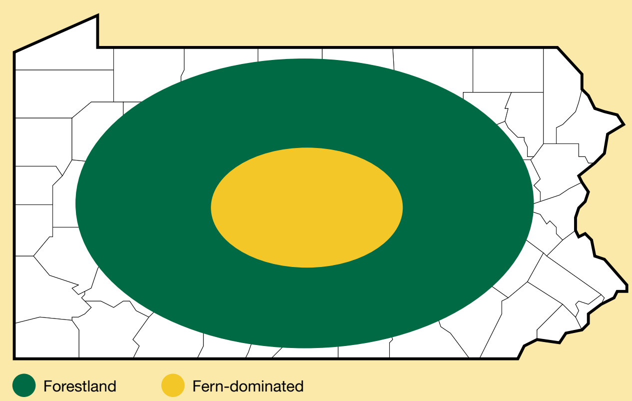
Are all ferns a problem?

Ferns fall into two general categories: those that grow in clumps and those that send up single fronds or leaves. Some common clump ferns include Christmas, interrupted, sword, and wood. These ferns often dot the forest understory, with multiple fronds forming a single clump. They spread slowly, rarely forming dense stands, and cast little shade across the forest floor.

Hay-scented, New York, and bracken ferns, on the other hand, are known as single-frond ferns. The fronds, or leaves, of these ferns grow singly with no obvious circular clumps. All three species originate as a single stem at ground level and have the ability to spread by aggressive rootlike structures known as rhizomes. Rhizomes elongate rapidly, sending up new shoots at intervals and forming impenetrable stands that cast dense shade on the forest floor, reducing plant and wildlife diversity and inhibiting tree seedling growth.

Hay-scented and New York ferns have single, heavily divided leaves or fronds. Bracken fern has a single stem that rises 2 or more feet above the ground before dividing into three fronds. A good plant identification guide is helpful for learning the different fern species.

Figure 1. Pennsylvania is 58 percent forested as illustrated by the green oval; the yellow oval represents the area of fern-dominated understory. In 2007, fern-dominated forest understory was estimated at 5,800 square miles (3.7 million acres), or just over 20 percent of the total forest area of the state. (Source: U.S. Forest Service Northern Forest Research Station, Forest Inventory and Analysis.)



PennState Extension

Hay-scented Fern

John Hilty

Hay-scented fern is a deciduous fern featuring lacy, triangular-shaped (broadest at the base), erect to arching, yellowish-green compound leaves (fronds). Fronds typically grow 1 to 3 feet tall and range from 4 to 12 inches wide. Fronds turn yellow in fall. The common name "hay-scented fern" comes from the fact that when crushed or bruised, the fronds produce an aroma similar to that of freshly mowed hay.

This fern species is native to eastern North America, ranging from Newfoundland west to Wisconsin and Arkansas and south in the Appalachian Mountains to northern Alabama. It is most abundant in the eastern part of its range with only scattered populations found in the West. It occurs in damp or dry, acidic soils in shaded or open woods, from sea level to over 4,000 feet in elevation. This fern often forms dense clonal colonies from the rhizomes or root system.

New York Fern

John Hilty

New York fern is a deciduous, yellow-green fern that stands 1 to 2 feet high with compound leaves (fronds) that are 4 to 6 inches wide and gradually tapered at both ends. The lowest leaflets are typically very small. Fronds emerge singly or in small clusters of three or more along a slightly scaly rhizome or root system. Leaves turn brown in autumn, usually before other wood ferns.

This native fern species is found throughout the eastern United States and Canada, ranging from Newfoundland west to Ontario and south to Louisiana and Georgia, and it is common throughout New England and the Atlantic coastal states. It does well in moist woodlands with filtered light occurring up to 5,000 feet in elevation in the Blue Ridge Mountains, often growing in large colonies carpeting the forest floor. It can become a dominant understory species on acidic soils.

Bracken Fern

John Hilty

Common bracken is an herbaceous perennial fern that is deciduous in winter. Large, triangular leaves (fronds) are produced singly, rise from deep-running underground rhizomes or root systems, and typically grow 3 feet tall and 4 feet wide. Each frond is three times pinnately compound (i.e., dividing into three fronds or leaves). Studies have shown this plant to contain carcinogenic compounds known as ptaquiloside.

This native fern has a global distribution, occurring on all continents except Antarctica. It is found on a wide variety of sites, including dry woodlands, fields, old pastures, thickets, burned-out areas, and marshes. Bracken fern grows best on deep, well-drained soils with good water-holding capacity; it may dominate other vegetation on such sites. A shade-intolerant pioneer, bracken fern readily colonizes disturbed areas, springing back quickly after fires or logging and often outcompeting other species. Its ability to expand rapidly, at the expense of other plants and wildlife, causes major problems for land managers.

Source: **U.S. Forest Service, "Index of Species Information," www.fs.fed.us/database/feis/plants/fern/thenov/all.html.**

Why so much fern?

To some, the occurrence of dense-fern understories is puzzling. Why are these native plants so extensive today when they weren't following the heavy harvests that took place during the late 1800s and early 1900s? For sure, all three species (hay-scented, New York, and bracken) were present in Penn's Woods then.

The answer centers heavily on white-tailed deer populations. Deer browsing has had profound impacts on the species composition of understory vegetation. Where deer impact is high, fern and other less-preferred browse species dominate forest understories. Fern-dominated understories tend to persist even if deer densities are brought into balance with their habitat. Some describe fern understories as a legacy effect of decades of overabundant deer herds.

As selective browsers, deer don't eat fern, but they do eat native hardwood seedlings, blackberry, and a host of other, now less-common herbaceous forbs (e.g., Canada mayflower, Indian cucumber, lady slippers, trillium) and woody species (e.g., hobblebush, native devils club). By selectively browsing preferred plants, deer allow nonpreferred plants, like fern, to proliferate and spread. Deer-browsing pressure on nonresilient plants can completely eliminate their presence in the understory. When deer populations are out of balance with the available habitat, forest understories become dominated by species deer avoid (e.g., fern, striped maple, and huckleberry). If hardwood seedlings, blackberry, and other species are abundant, they limit the spread of fern by successfully competing for light, moisture, and space.

David Jackson

This understory, dominated by bracken fern, developed following a logging operation to salvage oak trees killed by gypsy moths.

In the early 1900s, deer populations were at an all-time low. They had little impact on species composition and forest development. Hunting regulations, reintroductions from other states, and adundant habitat all contributed to Pennsylvania's deer population making a rapid comeback. As early as the 1940s, deer were having a significant effect on forest understory vegetation in parts of the state. Deer densities reached all-time highs in the 1960s and '70s. Even today, deer densities in many areas are above the habitat's carrying capacity, especially when fern and other less-desirable browse species dominate the understory. Even with low deer numbers, poor-quality habitat dominated by ferns will continue to decline as deer remove desired browse species and provide ferns further opportunities to expand in the understory. This same logic applies to other native and nonnative plant species expanding across forest lands.

These ferns also have the ability to grow in both shade and full sunlight, which gives them a competitive advantage. They are often well established in understories prior to any forest harvesting or disturbance. Once the canopy is disturbed and opened up, ferns respond rapidly to increased light by forming a dense groundcover. In a matter of years, they can completely dominate a site, outcompeting newly germinated seedlings for light and growing space.

How do ferns impact tree seedling regeneration?

These three species of fern (hay-scented, New York, and bracken) are referred to as “interfering plants.” Interfering plants limit the success, species diversity, and future timber value of forest regeneration by inhibiting the establishment and growth of desirable tree seedlings. These ferns form a dense subcanopy that shades the forest floor (Figures 2 and 3). Oaks, maples, and black cherry are some of the species that can’t develop under this dense, low shade. Interference by hay-scented and New York ferns is of particular concern because of their ability to spread rapidly and form dense stands that shade large expanses of forest understory.

Numerous studies have demonstrated the impact that ferns have on tree seedling germination, survival, and growth. A series of comprehensive field, greenhouse, and laboratory experiments conducted by U.S. Forest Service scientists in the mid-1980s and early 1990s evaluated how ferns interfered with tree seedling establishment. These studies considered allelopathy (i.e., plant-generated chemicals inhibiting the growth of other plants—for example, black walnut affecting tomatoes), soil water, phosphorus, nitrogen, and light. They concluded that hay-scented fern interferes with the survival and growth of black cherry seedlings by altering both the quantity and the quality of light close to the forest floor. The amount of light below ferns was less than 0.5 percent of full sunlight. Where fern foliage was present, few seedlings survived longer than two years.

James Finley

Fern has a dramatic impact on the quantity and quality of light reaching the forest floor. Light below fern can be less than 0.5 percent of full sunlight.

In the first study (Figure 4), stands were partially cut to stimulate seedling establishment and growth. Initially, the average number of desirable seedlings (e.g., black cherry, sugar maple, and red maple) was approximately 88,000 per acre. Inside fences used to exclude deer, half the plots were weeded annually to remove hay-scented fern cover. Where fern was removed, after five years the number of desirable seedlings increased to 106,000 per acre. Where the fern was not removed, the number of desirable seedlings decreased dramatically to just 19,000 per acre over the same time period.

In a second study (Figure 5 on page 4), U.S. Forest Service scientists examined seedling height growth following a final harvest. All study plots were fenced to exclude deer. In the presence of hay-scented fern, black cherry seedlings added just

Figure 2. Plant growth is most affected by blue and near red light. Plants respond the least to green light. Blue light fosters vegetative growth, while near red along with blue light encourages flowering. Fern canopies offer only reflected green light to seedlings and vegetation growing beneath them.

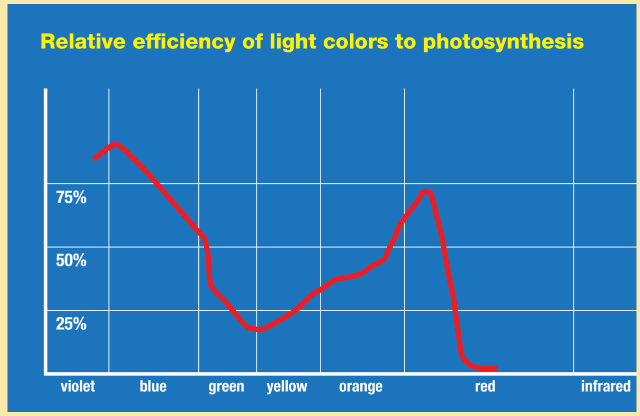


Figure 3. The sun emits light that travels past shade-casting objects. However, the closer an object is to the ground, the denser the shade it casts. Fern canopies, being close to the ground and nearly contiguous, cast dense shadows. You can easily test this by holding an object above your head and moving it toward the ground to witness the change in shade density.

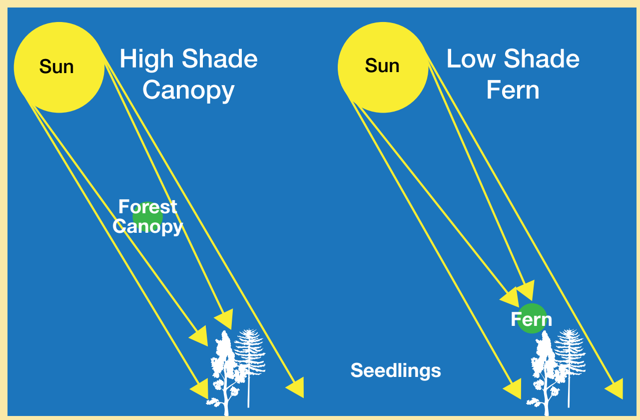
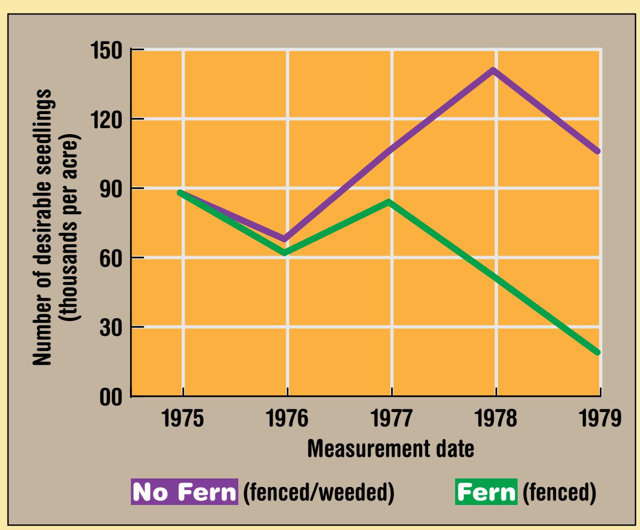
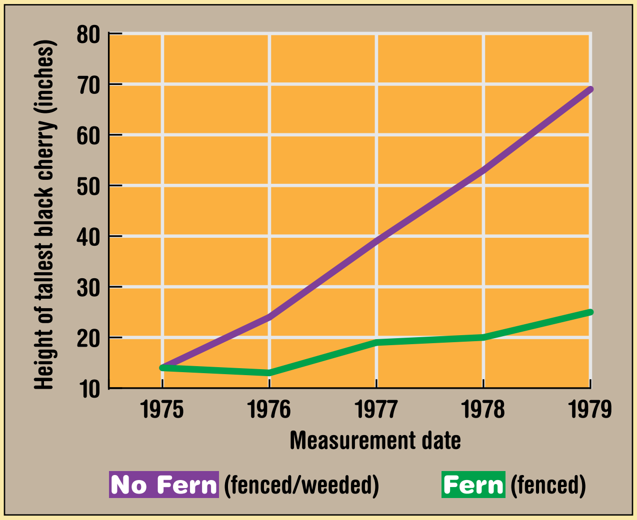


Figure 4. Where seedlings were fenced and weeded of ferns, there were 106,000 desirable seedlings per acre after five years. Where seedlings were fenced and ferns not removed, there were only 19,000 desirable seedlings per acre.



IF GREATER THAN 30 PERCENT OF AN AREA IS STOCKED WITH FERN, THEN FERN IS LIKELY TO DOMINATE THE UNDERSTORY FOLLOWING A HARVEST.

Figure 5. After an overstory-removal harvest, desirable seedlings, such as black cherry, grow less in the presence of fern. Once established, fern becomes the most important limiting factor to black cherry regeneration.



11 inches in height over a five-year period. Cherry seedlings growing on plots where fern had been removed grew 55 inches over the same time period.

The studies mentioned above demonstrated that dense fern groundcover can reduce the number of desirable seedlings by 50 to 90 percent and inhibit seedling height growth by 40 to 65 percent. These studies are evidence that fern inhibits tree seedling survival and growth—add deer populations that are out of balance with the available habitat, and few seedlings are able to replace harvested overstory trees. Research with other tree species has found similar results to fern competition.

In contrast to black cherry, seedlings of black birch, blackberry and black raspberry, and pin cherry grow rapidly through fern cover. Unfortunately, with heavy deer pressure, many species fail to emerge above fern-dominated understories. These same experiments found that hay-scented fern did not have direct allelopathic effects on seed germination, survival, or growth of black cherry. A competitive reduction in light was the key mechanism of fern interference with black cherry and other species.

How much fern is too much?

Sustaining hardwood forest species diversity and timber value requires recognizing when interfering plants, such as fern, are or will become a problem. Researchers have shown that when fern covers 30 percent or more of an area, it is likely to dominate the understory following a harvest or other disturbance and interfere with the establishment and development of tree seedling regeneration. Sometimes simply walking the area and making a visual assessment of current fern cover is sufficient. In other cases, taking an inventory is necessary.

Table 1. Minimum number of inventory plots necessary to assess amount of fern ground cover.

Harvest Area (Acres)	Minimum Number of Plots
25 or less	5
26–100	10
101–200	15
200 or more	20

Inventorying fern cover entails estimating the percent completely covered with fern in a $\frac{1}{10}$-acre plot (37.2-foot radius). The number of plots taken depends on the stand and variability across the treatment area. Larger and more varied areas require more plots. Table 1 provides guidelines for the minimum number of plots by treatment area. Plots must be spaced evenly across the area. If fern cover is 30 percent or greater on 30 percent or more of the plots, action should be taken to reduce or remove fern cover.

For more information on procedures for inventorying interfering plants, refer to the U.S. Forest Service publication *Managing Timber to Promote Sustainable Forests: A Second-Level Course for the Sustainable Forestry Initiative of Pennsylvania*, available at **www.nrs.fs.fed.us/pubs/gtr/gtr_nrs11.pdf**.

What is the best way to control fern?

Research has demonstrated that herbicides are an effective, practical, economical, and safe means of controlling fern understories. Fire, however, stimulates the spread of fern, and mechanical weeding is nearly impossible. The U.S. Forest Service began looking at herbicides to control fern in the mid-1970s. Commercial applications using the herbicide Roundup (glyphosate) began in 1979 using air-blast spray equipment mounted on tracked or rubber-tired vehicles.

David Jackson

Small patches of fern can be spot treated using a backpack sprayer.

Initial studies achieved high levels of fern control using a glyphosate herbicide (e.g., Roundup) at the rate of 1 quart per acre. Optimal dates for best control were from early July until fronds yel-

Howard Nuernberger

Tracked vehicle with an air-blast sprayer treating fern understory with an herbicide prior to harvest.

lowed in mid-September; however, a number of issues affected successful control.

The first was "fern tracks." Researchers found that metal cleats on tracked vehicles and the sharp edges of new rubber tires broke fern rhizomes during treatment. This prevented herbicide translocation to all parts of treated plants. Over a period of four to six years in partially cut stands, fern regenerated from the broken rhizomes to completely reoccupy the understory.

The second issue encountered in some stands treated with glyphosate herbicide was that grasses and sedges became a problem. Studies implemented in the 1980s found that the addition of a sulfometuron-methyl herbicide (e.g., Oust) resolved fern tracks as well as grass and sedge reinvasion. Sulfometuron-methyl is a soil-active herbicide that is readily taken up by fern rhizomes. It also has preemergent activity, which prevents undesirable grass and sedge seed from germinating.

Table 2. Herbicide prescriptions for controlling fern.

Active Ingredient	Application Equipment	Application Method	Mixture (Rate)	Time of Year
Glyphosate (e.g., Roundup) and sulfometuron-methyl (e.g., Oust)	Ground-based air-blast sprayer or backpack mist blower	Broadcast foliar application	1–2 quarts a.i. glyphosate (plus 0.5 percent nonionic surfactant) and 2 ounces a.i. sulfometuron-methyl per acre	Early July, following full leaf expansion, until early October *(If striped maple control is desired, optimal dates are from early August to fern and striped maple yellowing.)*
Glyphosate (e.g., Roundup)	Ground-based air-blast sprayer, backpack sprayer, or mist blower	Broadcast foliar or spray to wet foliage spot applications	1–2 quarts per acre or 2–5 percent solution (plus 0.5 percent nonionic surfactant)	Early July, following full leaf expansion, until leaf yellowing in mid-September *(Glyphosate has no residual preemergent soil activity and will not control grass or sedge seed on the forest floor.)*
Sulfometuron-methyl (e.g., Oust)	Ground-based air-blast sprayer, backpack sprayer, or mist blower	Broadcast foliar application	2 ounces per acre	Early July, following full leaf expansion, until early October *(Applications made from August to October have little effect on advanced regeneration. Sulfometuron-methyl has no herbicidal effect on striped maple or beech.)*

Caution: Desirable hardwood seedlings present at the time of application may be severely injured or killed by the active ingredient (a.i.) glyphosate. The a.i. sulfometuron-methyl may severely injure or kill desirable herbaceous understory plants, such as wildflowers.

Note: A ten-year (1994–2004) study conducted by the U.S. Forest Service, Northern Forest Research Station, concluded the herbaceous community is quite resilient following herbicide site preparation using a tank mix of glyphosate (e.g., Roundup) and sulfometuron methyl (e.g., Oust). The impact of a single application of herbicide on the herbaceous plant community was short lived. No species were lost from any site, and over the ten-year study period species diversity improved.

David Jackson

New black cherry seedlings following an herbicide treatment to control fern.

David Jackson

The fern in the foreground was treated with the herbicide glyphosate. The hardwood seedlings are early in their second growing season.

This work ultimately led to the prescription commercial applicators use today for controlling fern and other interfering plants, such as grasses and sedges, beech, and striped maple, in Allegheny hardwood forests (see Table 2). This research informed vegetation management in other forest types as well. These treatments are widely used today across much of Pennsylvania and the Northeast.

It's important to recognize and treat fern problems prior to performing timber harvests. Many landowners can relay stories of how diverse and valuable hardwoods were converted to fern fields when treatments were not made. Not every site that contains an undesirable fern understory is a candidate for herbicide treatment. Sites that have a combination of limiting factors, such as excessively wet or rocky soil, a lack of adequate seed sources, and/or high deer-browsing pressure, may not regenerate satisfactorily even when fern is removed. Be sure to consult with a professional forester to prepare an appropriate prescription before implementing treatments.

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