USING HERBICIDES TO CONTROL INTERFERING UNDERSTORIES IN ALLEGHENY HARDWOOD STANDS

1. EARLY DEVELOPMENT OF PRESCRIPTIONS

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Insights for Managers

- **The first two decades of research into using herbicides to control understories that interfered with establishment of advance regeneration in Allegheny hardwood stands showed that time of application was critically important. Optimum dates of application were:**
  - **Hay-scented and New York fern: Early July to leaf yellowing in mid-September**
  - **Short husk grass: Early June to mid-September**
  - **Striped maple and beech: Early August to mid-September**
- **In addition to removing interfering plants, we recommended overstory treatments such as shelterwood seed cuts to ensure enough light reached the forest floor in these dense stands.**
- **Partial overstory removals disturb the forest floor, releasing grass and sedge seedbanks where present. Thus, timing herbicide treatments to follow partial overstory harvests increased control of seedbank species.**

I came to work at the Forestry Sciences Laboratory in 1973, about 10 years after harvest cutting had begun in the maturing second-growth Allegheny hardwood forest. Clearcutting had been selected as the forest regeneration technique because it seemed to have worked well in the turn of the 20th century harvests on the Allegheny Plateau. But at this time, only about half the stands regenerated to desirable species; the other half regenerated to hay-scented fern (*Dennstaedtia punctilobula*), New York fern (*Thelypteris noveboracensis*), grasses and sedges, or to shade-tolerant understory trees such as striped maple (*Acer pensylvanicum*) and American beech (*Fagus grandifolia*).

Abundant small seedlings were required to regenerate these stands. Small seedlings were typically either inadequate or absent. Instead, ground cover was of hay-scented and New York fern, grasses and sedges, or understory trees of striped maple and American beech.

We knew that deer played a role in reducing abundance of advance regeneration of desirable species and establishing unpalatable interfering vegetation, but the dynamics were not yet clear (see Horsley and Marquis 1983, Marquis 2019, Royo and Stout 2019).

Early studies (Horsley 1986) showed that interfering plants interrupted the regeneration process and had to be removed for this process to continue. The ferns regenerated with an underground stem, or rhizome; grasses and sedges regenerated from seed or rhizomes; striped maple from seed, and beech primarily from root suckers.

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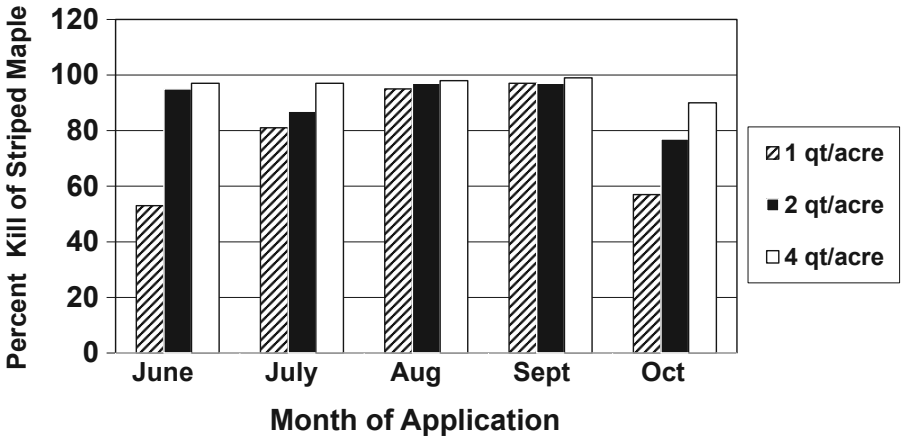

Figure 1.—Striped maple control results by rate and time of application of Roundup®.

In 1976, we began a series of studies with herbicides to develop methods to remove interfering vegetation and establish advance regeneration of desirable species. We initially worked on small plots. After tests that included prescribed fire and manual weeding showed that herbicides were far more effective and efficient, we tested several herbicides on plots with complete ground covers of fern, grass and sedge, striped maple, or beech as follows:

- Three applied rates
- A control
- Several months of application during the growing season

These studies showed that Monsanto's Roundup®[2] herbicide, a 4-pound active ingredient per gallon herbicide containing glyphosate and a surfactant (the surfactant was later marketed as Entry-2), controlled all the target species. We also learned the importance of time of herbicide application in determining the rate of application for effective control. This was particularly true at low rates of application. Our strategy was to use time of application to control the rate of herbicide application. By applying herbicide when the target species was most susceptible, we could minimize the rate of application. This was important from economic and environmental standpoints.

For example, 95 percent or better control of 1- to 5-foot striped maple could be achieved by applying 1, 2, or 4 quarts per acre of Roundup® in early August or early September (Fig. 1). But 2-4 quarts per acre were required to achieve this level of control in early June or early July. By applying Roundup® in early August or early September, the amount of herbicide could be minimized to reduce the cost of this remedial action.

The same sensitivity to time of application occurred when 1 quart per acre was applied to striped maple stems of increasing size. More than 90 percent control of trees shorter than 1 foot could be obtained with any application date between early June and early October. However, control of larger trees was strongly dependent on application time. Optimal control was achieved with early August to early September applications and was reduced when the application was made earlier or later in the year (Horsley 1981, 1982; Horsley and Bjorkbom 1983).

[2] The use of trade, firm, or corporate names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable. In addition, trade names of many of products change over time, as do the formulations available under the same names. See Ristau 2019 for results reflecting current product names.

Time effects also were related to phenology of plant development. A cool spring often delays plant development and susceptibility to Roundup® control. Likewise in the fall, when leaf yellowing begins, uptake and translocation of Roundup® declines. Applications made after this time yielded less control in all species tested. The time of leaf yellowing, mid-September in northwestern Pennsylvania, is a practical limit to Roundup® application. A high level of plant control with the 1 quart per acre rate of Roundup® could be achieved by restricting the time of application.

Optimum dates of application for the 1 quart per acre rate of Roundup® were as follows:

- Hay-scented and New York fern: Early July to leaf yellowing in mid-September
- Short husk grass: Early June to mid-September
- Striped maple and beech: Early August to mid-September

Once interfering plants were removed, the regeneration process could continue. The most important factor in the success of regeneration was the establishment of large numbers of desirable seedlings before the final removal cut. A shelterwood seed cut leaving about 60 percent overstory stocking hastened the development of large numbers of small seedlings. These seedlings did not grow much because of the overstory light limitation, but as deer impact was high, this was an advantage because small seedlings were less attractive to deer. Within 3-5 years, large numbers of seedlings usually became established though the process sometimes took longer.

Black cherry (*Prunus serotina*) and red maple (*Acer rubrum*) regeneration usually predominated in northwestern Pennsylvania stands. The speed of regeneration development depended on the basal area of black cherry taller than 8 inches diameter at breast height; stands with at least 25 square feet of black cherry basal area per acre usually developed adequate regeneration in a few years. Once adequate regeneration was developed, the remaining overstory could be removed.

Refinements in the Initial Prescription

Commercial application of Roundup® in an herbicide-shelterwood cut system began in 1979. As widespread use of these prescriptions began, I partnered with Sandy Cochran of the Pennsylvania State University forestry extension team to convene annual meetings of those using the prescriptions to share experiences and identify research or application needs. These applications used air-blast spray equipment mounted on tracked or rubber-tired vehicles. During the first 5 years, it became apparent that refinements were required. Three problems developed as a result of application techniques and subsequent shelterwood cutting in treated stands.

Inadequate Control of Ferns

Ferns were inadequately controlled in the area traversed by the vehicle carrying the sprayer; instead, "fern tracks" were formed. Apparently, the metal cleats on tracked vehicles and the sharp edges of new rubber tires broke off small segments of fern rhizome at the time of treatment, preventing translocation of Roundup® into them and creating what we referred to as fern tracks. In the second year, these ferns began to fill in the tracks. By the third year, they had moved out into the stand. In as little as 4-6 years, shelterwood cut stands were reoccupied by ferns, which prevented desirable hardwood seedlings from becoming established. Ferns also became re-established from variable numbers of small, isolated fern plants that developed from single unkilled rhizome buds, probably as a result of incomplete coverage or incomplete translocation of herbicide within the plant.

Grass and Sedge Regeneration

Following the shelterwood seed cut, the stand sometimes regenerated to grasses and sedges rather than tree seedlings. The forest floor of most Allegheny hardwood stands contains a seed bank of grasses and sedges that germinate after disturbance. The skidding activities associated with the shelterwood seed cut provided the stimulus for germination in disturbed areas. Little grass and sedge developed on undisturbed areas, even when a large seed bank was present. Most germination occurred in the growing season after disturbance with plants growing to full size in the following year; little expansion occurred after the second year. However, once grass and sedge ground cover developed, the regeneration process was slowed so dramatically that few tree seedlings became established under our conditions, which included an extremely high deer population.

Striped Maple Stems Were Resistant

Under commercial operating conditions, striped maple stems were not always controlled by Roundup® to the extent that might be predicted from small plot experiments. Stems were almost always defoliated but were not killed and refoliated the following year from unkilled axillary buds. Increasing the rate of Roundup® application from 1 to 4 quarts per acre resulted in complete striped maple kill—but at an unacceptably high cost.

Revised Solutions Using Oust® Herbicide Alone and in Combination with Roundup®

These problems generated a new round of small and medium plot experiments using residual herbicides alone and in tank mix with Roundup®. The Dupont herbicide Oust®[3], in which the active ingredient was sulfumeturon methyl, emerged from these experiments as the most useful product.

In a rate and time experiment, we applied Oust® at 2, 4, and 8 ounces per acre. Oust® gave excellent control of the ferns at 2 ounces per acre when applied between early July and early October (Fig. 2). Results were not as good and were rate-dependent outside these time constraints. Because of its residual activity in the soil, fern tracks and isolated fern plants no longer presented a problem (Horsley 1988).

Oust® alone did not adequately control mature grass plants, but it reduced the amount of grass and sedge emerging from the forest floor seed bank by 66-75 percent. When combined with Roundup® in tank mix, mature grass plants were also controlled. The study also pointed out that on sites where grass and sedge seed banks were large, herbicide alone was inadequate to reduce reinvasion of the site; steps also were required to reduce the amount of forest floor disturbance on these sites (Horsley 1990a, 1990b).

Tests on a variety of hardwood species showed that woody plants vary considerably in their sensitivity to Oust®. Striped maple and beech were not sensitive to Oust® at any rate we tested. Black cherry and white ash were very sensitive to Oust®, particularly when it was applied early in the growing season. Red maple showed little sensitivity. Damage to sensitive species decreased later in the growing season. Treating areas with black cherry regeneration late in the growing season resulted in survival of many seedlings. Adding surfactant to Oust®

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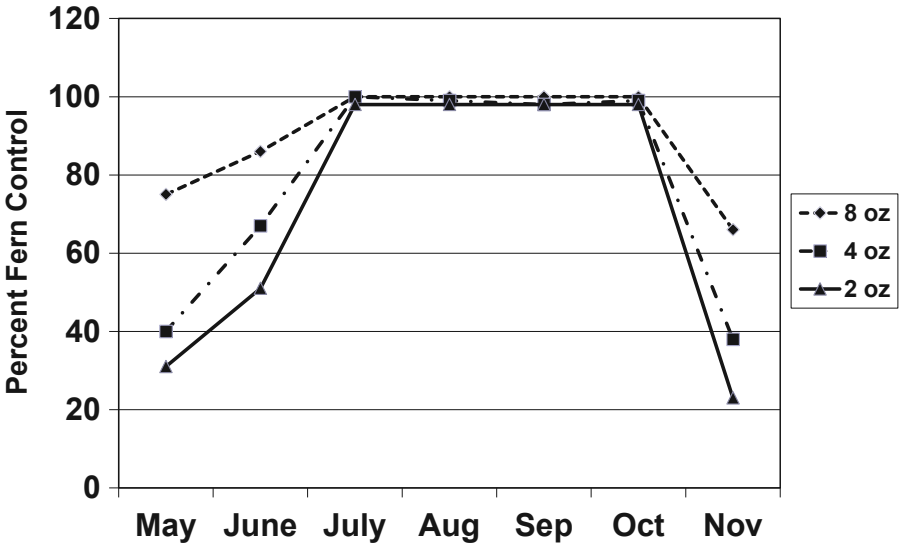

Figure 2.—Fern control results by rate and time of application of Oust®.

increased damage to all species. This research was done in partnership with Larry McCormick at Pennsylvania State University, who tested similar prescriptions in stands with a higher proportion of oak (Horsley et al. 1992).

Efforts to increase the activity of Roundup® on striped maple by adding surfactants or other adjuvants into the tank with Roundup® did not give results that were statistically different than Roundup® alone. The most important factor controlling the proportion of striped maple stems killed by Roundup® was distribution of the herbicide.

The dilemma in ground spray operations with most air-blast spray equipment in use at the time was that the sprayer volute allowed the main blast of spray to be directed to vegetation in a limited vertical space. Aiming the volute horizontally resulted in good coverage of vegetation up to about 10 feet in height; aiming the volute at an upward angle resulted in good coverage from 5-20 feet in height, but shorter vegetation was not well covered, because much of the spray was intercepted by the larger vegetation.

This problem was solved by the use of improved spray apparatus by the major forest landowners on the Allegheny Plateau. About 1987, International Paper Company (successor to Hammermill Paper Company) purchased a Friend air-blast sprayer (Friend Manufacturing, Gasport, NY) mounted on an FMC tracked vehicle. The volute on the Friend had a vertical stack of nozzles that filled the air space with spray from the ground to about 20 feet in height. This machine was set up to spray out one side. The air blast from its squirrel-cage fan shook the leaves of understory trees, resulting in good herbicide penetration and distribution, with swath width about 50 feet in brush and 70 feet in fern and grass. Exceptionally good control of short and tall vegetation in this space was obtained in commercial spray operations using a tank mix of Roundup® and Oust®. Other landowners and commercial contractors also purchased or developed new equipment for their herbicide operations.

SUMMARY

Our results have shown that two herbicides are useful in obtaining regeneration of Allegheny hardwoods on the Allegheny Plateau: Roundup® applied at the rate of 1 quart of product per acre or 1 pound active ingredient per acre; and Oust® applied at the rate of 2 ounces of product per acre or 1.5 ounces active ingredient per acre. Optimum dates of application for Roundup® were early June to mid-September for grass and sedge, early July to mid-September for ferns, and early August to mid-September for striped maple and beech. Oust® could be applied from early July to early October for ferns and for pre-emergent reduction of grasses and sedges from the forest floor seed bank. Oust® has no effect on striped maple and beech.

The Allegheny Plateau mostly has a mixture of fern, grass, striped maple, and beech, so we recommended a tank mix of Roundup® and Oust®. Where ferns or ferns and a grass and sedge seed bank are the only target species, Oust® could be used alone. Where striped maple and beech are the only target species, Roundup® alone could be used.

Usually, sites with interfering vegetation lacked adequate regeneration of desirable species, even before herbicide is applied, so we needed to take steps to obtain it before a final overstory removal cut could be made. Usually, we recommended applying the herbicide in uncut stands followed by shelterwood cutting. This left 60 percent relative density to encourage establishment of advance regeneration. Where there were large grass and sedge seed banks, steps needed to be taken to reduce disturbance to the site. This was accomplished by reversing the herbicide and shelterwood operations and doing the shelterwood seed cut first, then applying the herbicide a year or two later, after grass and sedge had germinated. Then with no further disturbance in the stand, advance regeneration could become established. We developed a third alternative that we called herbicide-delay cut-clearcut, which was also intended to reduce forest floor disturbance. It was intended for stands with less than 75 percent of full stocking, as they did not require a shelterwood seed cut.

In recent years the SILVAH science team has worked to update these guidelines. Information about more recent herbicide research can be found in Ristau (2019), and research concerning silviculture for stands affected by recent forest health challenges and ecological changes is ongoing.

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