EFFICACY AND NON-TARGET IMPACT OF MIDSTORY INJECTION IN BOTTOMLAND HARDWOODS

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ABSTRACT

The need for midstory control in bottomland hardwood regeneration work has been well documented. However, only a few research efforts have documented the efficacy of such efforts and the potential negative effects on non-target stems. This potential negative impact is extremely important in these stands where individual stem values are characteristically high. As part of an oak regeneration project, this study is designed to evaluate the efficacy of midstory control on target species as well as incidental damage to non-target stems. During this study, approximately 72,000 midstory stems were injected during August and September, 2009. These stems were located on 90 acres of bottomland hardwood stands within minor stream bottoms in northern Mississippi. All midstory stems except oaks which were ≥1 inch diameter at breast height (d.b.h.) received one hack per three inches d.b.h. and one ml of a 20 percent volume to volume Arsenal AC aqueous solution per hack. Ninety 0.025-acre plots will be evaluated in August 2010 to determine the effectiveness of the injection. Injected midstory stems within a plot will be recorded as dead or alive. All non-target stems on the plots will be evaluated for mortality or damage. In addition, any damage noted on non-target stems across the study areas outside the measurement plots will be recorded and reported. Results will be reported as percentages by species and diameter class. This information will be of great value to hardwood mangers using the wide spacing imazapyr injection method for control of undesirables.

INTRODUCTION

Bottomland hardwood sites are known to have some of the most productive forest soils, and species richness tends to be high on these sites. Due to high species richness and associated stand stratification, competition control is often essential to hardwood regeneration efforts. Midstory injection has long been recognized as a viable and cost effective method in controlling undesirable stems (Williston and others 1976). Peairs and others (2004) reported that midstory/understory control treatment increased regeneration of desirable hardwood species such as oaks. Lockhart and others reported that advanced cherrybark oak (*Quercus pagoda* Raf.) regeneration released from midstory competition were 76.2-103.6 cm taller than non-released seedlings nine years after treatment. A variety of chemicals can be used for hardwood midstory injection, including imazapyr (Arsenal AC®). Although injection effectiveness can vary by species, tree size, and season of application (Peevey 1971, Star 1973), imazapyr has been shown to be nearly 100 percent effective on a wide range of species such as black cherry (*Prunus serotina* Ehrh.), blackgum (*Nyssa sylvatica* Marsh.), red maple (*Acer rubrum* L.), American beech (*Fagus grandifolia* Ehrh.), and hickory (*Carya* spp.) (Miller 1992, Nelson and others 1993).

Potential non-target impact can be a concern when using herbicide treatments in hardwoods. A study in Ohio found that injecting tree-of-heaven (*Ailanthus altissima* Mill.) with imazapyr resulted in 100 percent control (Lewis and McCarthy 2008). However, 17.5 percent of non-injected tree-of-heaven stems within three meters were also killed. A similar study reported that untreated striped maples (*Acer pensylvanicum* L.) were killed on sites where the midstory was injected with imazapyr (Kochenderfer and Kochenderfer 2008). Graham and Bormann stated interspecific root grafts are rare, and concluded herbicide was likely absorbed from the soil, which is in agreement with what Kochenderfer and others (2011) found in West Virginia. That study found midstory injection utilizing imazapyr to be over 99 percent effective in controlling target midstory stems (Kochenderfer and others 2011); however, imazapyr treatments damaged several crop trees. Damage could have occurred because the injection crew was inexperienced and may have allowed herbicide to reach the soil (Kochenderfer and others 2011). Imazapyr does exhibit some soil activity (Anderson 2006) and can be absorbed by roots (USDA Forest Service 1989). The chemical has a half-life of 7-180 days in soil, and typically remains active for over 40 days (Michael and Neary 1990). Therefore, if sufficient quantities of imazapyr reach the soil, impacts to non-target stems may occur.

Past studies of midstory injection utilizing imazapyr have yielded conflicting results concerning both the efficacy of the treatment and the potential impacts to non-target stems.

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The objectives of this study were to 1) evaluate treatment efficacy of imazapyr on target stems, and 2) to determine if imazapyr affected non-target stems in southern bottomland hardwood stands.

METHODS

SITE DESCRIPTION

The study utilized six 6.07-ha sites characteristic of typical southern bottomland hardwood stands along river systems in Mississippi. Sites had overstories containing a prominent component of sawtimber size (DBH ≥ 27.9 cm) oaks and midstories dominated by shade tolerant species. Due to canopy closure and midstory competition, there was limited herbaceous ground cover. All sites contained soils predominantly from the Wilcox association which are fine, montmorillonitic, thermic Vertic Hapludals. Soil pH levels ranged from 4.5-5.2.

Sites one and two were located on the John W. Starr Memorial Forest owned by Mississippi State University. Site one was located at 33° 17' 34.25" N, 88° 55' 19.56" W in Winston County, MS. Site two was located at 33° 20' 41.33" N, 88° 55' 17.18" W in Oktibbeha County, MS.

Sites three and four were located on land owned and operated by C.A. Barge Timberlands LP. Site three was located at 33° 10' 12.64" N, 88° 49' 19.98" W in Noxubee County, MS. Site four was located at 33° 10' 26.47" N, 88° 41' 37.57" W in Noxubee County, MS.

Sites five and six were located on the Noxubee National Wildlife Refuge owned and operated by the United States Fish and Wildlife Service. Site five was located at 33° 16' 35.75" N, 88° 44' 25.79" W in Noxubee County, MS. Site six was located at 33° 16' 53.45" N, 88° 46' 30.98" W in Noxubee County, MS.

Oaks present in the overstory included cherrybark (*Quercus pagoda* Ell.), southern red (*Q. falcata* Michx.), Nuttall (*Q. texana* Buckl.), white (*Q. alba* L.), Shumard (*Q. shumardii* Buckl.), post (*Q. stellata* Wangenh.), water (*Q. nigra* L.), swamp chestnut (*Q. michauxii* Nutt.), overcup (*Q. lyrata* Walt.), and willow (*Q. phellos* L.). There were also small overstory components of sweetgum (*Liquidambar styraciflua* L.), American beech (*Fagus grandifolia* Ehrh.), black gum (*Nyssa sylvatica* Marsh.), yellow-poplar (*Liriodendron tulipifera* L.), sycamore (*Platanus occidentallis* L.), loblolly pine (*Pinus taeda* L.), baldcypress (*Taxodium distichum* (L.) Rich), and hickory (*Carya* spp.). Midstories consisted of species such as American hornbeam (*Carpinus caroliniana* Walt.), pawpaw (*Asimina triloba* (L.) Dunal), American holly (*Ilex opaca* Ait.), slippery elm (*Ulmus rubra* Muhl.), red mulberry (*Morus rubra* L.), red maple (*Acer rubrum* L.), sugarberry (*Celtis laevigata* Willd.), Eastern hophornbean (*Ostrya virginiana* Mill.), and winged elm (*Ulmus alata* Michx.).

METHODOLOGY

Approximately 72,000 midstory stems were injected in August 2009. Injections were made using hatchets and adjustable spray bottles utilizing the "hack and squirt" method. Each non-oak stem in the midstory ≥1 inch DBH received one hack per three inches diameter. One ml of a 20 percent volume to volume Arsenal AC® aqueous solution was applied per hack.

Efficacy of the injection treatments was evaluated in August 2010 on ninety 0.010-ha. plots. Each midstory stem within a plot was identified by species and diameter and recorded as injected or non-injected. Percent crown reduction was recorded for all stems using ocular estimation.

Crown reduction estimates could range between 0-100 percent, with zero percent indicating no impact and 100 percent indicating a dead tree. Percent crown reduction was also recorded for all overstory stems. In addition, damage to non-target stems outside measurement plots was recorded. Recorded data for damaged trees outside measurement plots included percent crown reduction, diameter, and species.

RESULTS

All sites exhibited similar responses. Therefore, the results related to species and tree size were combined across sites. Overall crown reduction for injected midstory stems on sample plots averaged 96.8 percent (Table 1) indicating that injected stems were effectively controlled.

Average crown reduction exceeded 91.8 percent for all species across all sites (Table 2). While 100 percent crown reduction was not achieved, remaining trees will likely die by the next growing season.

Non-target midstory stem injection impact was minimal. While injected midstory stems exhibited 96.8 percent crown reduction, crown reduction on non-injected stems averaged only 0.7 percent. Based on these observations, it is surmised that chemical root transfer was minimal. It is likely that crown reduction was due to natural senescence and/or dieback common in midstory/understory stems. The likely cause of any impacts to non-target stems (if any occurred) was the inexperience of the injection personnel. Failure to properly apply herbicide solutions, and keep it in the injection frill could have resulted in imazapyr reaching the soil causing non-target impact.

Non-target overstory stems exhibited little injection damage. Only three overstory stems were observed to be adversely affected. All stems were sweetgum which is highly susceptible to imazapyr. Only minor symptoms were observed and no lasting effects are expected. It is

important to note that midstory sweetgum density was high where non-target damage occurred. Due to high stem density and numbers of stems injected; it is possible that the injection crew was responsible for herbicidal drip resulting in non-target damage. Also, these trees could have shared a common root system with injected stems. Root suckering is not common in southern hardwood species; however, both sweetgum and American beech (*Fagus grandifolia* Ehrh.) are species most often associated with this characteristic. While it is important to note that the damaged trees were in areas of high midstory density, high stem densities were characteristic of numerous other areas in the study which did not exhibit any overstory damage. Of the areas examined in this study, this was the only evidence of overstory damage noted. Additionally, this damage was in an area where a crew member was observed using poor injection technique. The lack of consistent non-target impact, considered in conjunction with undesirable injection work of one crew member, led to the assumption that damage was attributable to "operator error," not to herbicide translocation through root systems.

CONCLUSIONS

Midstory injection using imazapyr is very effective in controlling target stems. Crowns of injected stems were reduced by over 96 percent. Non-target impacts from the injection treatment were minimal, and were represented by only minor symptoms. Due to the lack of consistent non-target impact, root grafts were not considered a principal factor in herbicide transfer. Non-target stem damage can be attributed to an inexperienced injection crew. Injecting undesirable stems in hardwood stands using imazapyr was extremely effective, required substantially less labor than conventional injection (most trees receive only one hack), and resulted in virtually no damage to non-target stems. Although this is the first study to formally evaluate plots for non-target impact, hundreds of acres of hardwoods have been injected with imazapyr solutions with no observed non-target impact (Ezell and others 1999). In this study, many midstory sweetgum stems were missed during injection due to high stem density. These stems were excellent candidates to exhibit symptoms resulting from root graft transfer, however none were observed. Conducted properly, injection with imazapyr is a very effective tool for controlling undesirable stems in southern bottomland hardwoods.

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LITERATURE CITED

Anderson, W.P. 1996. Weed Science Principles and Applications. 3rd ed. West publishing Company, St. Paul, MN. 598 pp.

Ezell, A.W.; Lowery, J.; Leopold, B.; Minogue, P.J. 1999. Use of imazapyr injection to promote oak regeneration and wildlife stand improvement in bottomland hardwood stands. p. 151–153. In: Haywood, J.D. (ed.). Proceedings of the Tenth Biennial Southern Silvicultural Research Conference, USDA Forest Service General Technical Report. SRS-30.

Graham, B.F. Jr.; Bormann, F.H. 1966. Natural root grafts. Botanical Review. 32: 255-292.

Kochenderfer, J.S.; Zedaker, S.M.; Johnson, J.E.; Smith, D.W.; Miller, G.W. 2001. Herbicide hardwood crop tree release in central West Virginia. Northern Journal of Applied Forestry. 18: 46-54.

Kochenderfer, J.D.; Kochenderfer, J.D. 2008. Efficacy of stem injection treatments on striped maple in central West Virginia. Northern Journal of Applied Forestry. 25: 106-108.

Lewis, K.; McCarthy, B. 2008. Nontarget tree mortality after Tree-of-Heaven (*Ailanthus altissima*) injection with Imazapyr. Northern Journal of Applied Forestry. 25(2): 66-72.

Lockhart, B.R.; Hodges, J.D; Gardiner, E.S. 2000. Response of advanced cherrybark oak reproduction to midstory removal and shoot clipping. Sothern J. Ap. For. 24(1): 45-50.

Michael, J.L.; Neary, D.G. 1990. Fate and transport of forestry herbicides in the South: research knowledge and needs. p. 641-649. In: Coleman, S.S., and D.G. Neary (ed.). Proceedings of the sixth Biennial Southern Silvicultural Research Conference. 1990 October, 30, Memphis, TN.

Miller, J.H. 1992. Oak plantation establishment using mechanical, burning, and herbicide treatments. p. 264-286 In: Proceedings Oak Regeneration: Serious Problems, Practical Recommendations. USDA Forest Service, Southeastern Forest Experimental Station, Asheville, NC.

Nelson, L.R.; Ezell, A.W.; Schoenholtz, S.H.; Williams, J.G. 1993. Controlling undesirable stems using low intensity injections of imazapyr. Proceedings Southern Weed Science Society, Champaign, IL. 46: 168-171.

Pearis, S.E.; Ezell A.W.; Belli, K.L.; Hodges, J.D. 2004. A comparison of oak regeneration conditions following midstory injection and partial overstory removal in a Tombigbee River terrace. p. 499–501 in Connor, K.F. (ed.). Proceedings of the Twelfth biennial Southern Silvicultural Research Conference. Biloxi, MS. US Forest Service General Technical Report. SRS-71.

Peevey, F.A. 1971. Wide-spread injections of herbicidal mixtures for controlling weed trees. Proceedings Southern Weed Science Society. 24: 263-267.

Star, J.W. 1973. The use of wider spacing in tree injection. Proceedings Southern Weed Science Society. 26: 295-301.

USDA Forest Service. 1989. Vegetation management in the Appalachian Mountains. Vol 1. Management Bulletin. R8-MB38. 299 pp.

Williston, H.L.; Balmer, W.E.; Abrahamson, L.P. 1976. Chemical control of vegetation in southern forests. USDA Forest Service, S&PF For. Man. Bul. 6 pp.

Table 1—Percent crown reduction of injected midstory stems by site

Site	% Reduction
1	94.9
2	96.5
3	96.4
4	96.7
5	96.1
6	97.3
Overall	96.8

Table 2—Percent crown reduction of injected midstory stems by species

Species	% Reduction	N
American Hornbeam	100	302
Blackgum	99.8	21
Deciduous Holly	98	61
Green Ash	97.3	64
Hickory	95.2	470
Paw-Paw	99.8	45
Persimmon	97.5	2
Red Maple	92.3	108
Swamp Chestnut Oak	98.3	3
Sweet Gum	98.5	94
Winged Elm	91.8	214
Willow Oak	100	3