Comparison of the performance of two Rodeo® herbicide application methods on

Lonicera x bella

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BIOS 35502: Practicum in Environmental Field Biology

July 24, 2006

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Abstract

The exotic shrub Bell's honeysuckle, *Lonicera x bella*, is an aggressive invader of woodlands in the north and northeastern United States. High environment adaptability has made this species prolific and difficult to control efficiently. This study explored two different treatment methods to kill Bell's honeysuckle in two different light environments using the herbicide Rodeo®. The two methods, cut and paint and hack and squirt, were compared based on their effectiveness and efficiency, combined called the performance. Both methods were equally effective at killing honeysuckle, and there was no significant effect of habitat or treatment on efficiency. However, there was a trend for the cut and paint method to be more efficient for plants with a basal area $< 1500 mm^2$ (F-ratio: 3.810, $p = 0.069$).

Introduction

Invasive exotic plant species compete for resources with native plants, however, not all exotic plants are equally invasive, as some establish and spread rapidly and others may need a longer establishment time (United States National Arboretum 2005). Successful invaders usually demonstrate high net primary production, phenotypic plasticity, rapid growth rate, high fecundity, long-range seed dispersal and resistance to pathogens and pests (Collier et al. 2002). Invasive plants flourish in areas where the natural continuity of a system has been disturbed; this usually correlates with human activity, who often transport the non-native species commonly for ornamental landscape use (United States National Arboretum 2005). Additionally, early- to mid-successional communities may be more readily invaded than late-successional communities; this can result in a change in ecosystem structure and function, including a change in species composition, succession, net primary productions, and biomass and nutrient cycling (Collier et al. 2002).

Bush honeysuckle species can reach heights up to 7 m with leaves usually 2.5 to 6.3 cm long; flowers bloom in late May and early June. The fruit, ripening in late summer or early fall, is eaten by birds that disperse the seeds (USDA Forest Service 2006; Hutchison and Vankat 1998). Bushy honeysuckle prefers open habitats, including roadsides and forest edges (Woods 1993). Their phenotypic plasticity allows them to spread in a variety of habitats and enables them to outcompete and decrease the density of native tree seedlings and herbs (Schweitzer and Larson 1999). In Midwestern forests, bush honeysuckles form dense thickets in moderately open forest understories that previously had no abundant native shrubs and interfere with native herbaceous plant growth. Studies have shown that the presence of honeysuckle diminishes species richness and abundance and tree seedling density (Collier et al. 2002, Woods 1993).

Forest cover and disturbance are important factors in the spread of honeysuckle. Disturbances, caused either by humans or natural events that create canopy gaps, show a high susceptibility to invasion (Hutchison and Vankat 1998).

Because the germination rate and development of honeysuckle seeds are limited by light, forest edges are conducive to honeysuckle establishment and are often the site of honeysuckle introduction and establishment (Luken and Goessling 1995).

Because seed dispersal has made the control of honeysuckle difficult, efforts to eradicate honeysuckle are implemented before populations become well established. Once established, successful management requires repeated treatments in consecutive years. Some treatments may backfire: manual stem removal alone results in recruitment of new stems that are larger than the older stems. (Deering and Vankat 1999, Luken and Mattimoro 1991). However, manual stem removal in combination with glyphosphate herbicides such as Rodeo® has proven effective. Two methods of manual stem removal used with herbicides are cut and paint and stem hack and squirt. The cut and paint method has been found to be more effective, however, despite the fact that it is labor-intensive and time consuming (Ross 2005).

Bell's honeysuckle (Caprifoliaceae: *Lonicera x bella*) is a hybrid between *L. morrowii* and *L. tatarica*, both of which are native to Asia and were brought to North America as ornamental plants. These species have since increased in frequency and expanded into several habitats in eastern and northern North America (USDA Forest Service 2006; Hunter and Mattice 2002). Bell's Honeysuckle is an invader in the northern hardwood forests of the UNDERC

(University of Notre Dame Environmental Research Center) property in the Upper Peninsula of Michigan, where this project was performed. The 7500-acre property has multiple honeysuckle thickets that dominate the resources within those areas. The objective of this project was to assess the combined effectiveness (number of stems killed without regrowth) and efficiency (time it took to apply the method), hereafter the performance, of two methods of controlling *Lonicera x bella*: 1) the cut and paint method, and 2) the hack and squirt method. Both methods are a combination of mechanical and chemical control techniques. Additionally, the performance of each method was measured in an open habitats, where plants have high light availability (e.g., along roads or in open fields), and covered habitats, where light is limited (e.g., under forest canopies). My first null hypothesis stated that there was no difference in the performance of each treatment method, however I predicted that the hack and squirt method would perform better than cut and paint. My second null hypothesis stated that both covered and open honeysuckle would be equally affected by both treatment methods. My prediction for this hypothesis was that the performance of both control methods would improve on covered plants.

Methods

Thirty *L. x bella* plants were selected in open habitats (canopy cover < 25%) and 30 in covered habitats (canopy cover > 75%) across three sites on the UNDERC property (Figure 1). The percent canopy cover at each plant was determined using a spherical densiometer. Plants were selected within a size range such that both application methods could be performed. Total plant basal area and number of stems per plant were used as measures of plant size. The diameter (mm) of all woody stems per plant was measured using a caliper. Diameter measurements were converted to stem basal area measurements using the formula:

$$BA = (\pi /4) \times d^2$$

where *BA* is stem basal area and *d* is stem diameter. The basal area of each stem was summed for total plant basal area.

Within each habitat type (open, covered), plants were divided into six experimental groups containing 10 plants each. Each habitat type had a control which received no treatment, a cut and paint treatment, and a hack and squirt treatment. The cut and paint method used shrub clippers to remove each stem about 8 cm above the base followed by painting the herbicide on the stumps using a sponge brush. The hack and squirt method used a hatchet to slice into the stem and expose the cambium; herbicide was squirted into the wound with a squirt bottle. Both treatment methods used the herbicide Rodeo®, a 53.5% isopropylamine salt of glyphosphate solution (Dow Agrosciences, Indianapolis, IN).

Efficiency was defined as the amount of time needed to apply each method. Time (sec) was measured using a stopwatch. Effectiveness was measured by noting percent stem regrowth on each plant. The overall performance of each method was defined as the success per unit effort (specifically effectiveness/efficiency).

Statistical analyses were performed using SYSTAT 11.0 (Systat Software, Inc., Point Richmond, CA) and results were considered significant at the $p = 0.05$ level. To test consistency of plant size among replicates, a one-way analysis of variance (ANOVA) tested for differences in basal areas among replicates in different habitats and two separate one-way ANOVAs were used to determine if mean plant basal area differed between treatments in each habitat type. Analysis of the effects of treatment and habitat on performance was performed with a two-way ANOVA.

Results

The mean percent cover for open plants was 5% ± 1.2 SE. The mean percent cover for covered plants was 98% ± 0.4 SE. Although it would have been desirable to control for plant size among all replicates in the experiment, I observed that there were different growth forms between the open and covered habitat types. Covered plants had fewer stems and a less bushy appearance than open plants which grew in dense thickets. As a result, mean plant basal area was significantly larger for open plants (mean = 2770.41 ± 414.99 SE) than covered plants (mean = 1465.37 ± 232.66 SE; F-ratio: 7.524, $p = 0.008$; Figure 2). Basal area did not significantly differ among treatment groups (F-ratio: 1.146, p =

0.325). However, when grouped by habitat, the difference in basal area between the two treatment methods was biologically significant in the covered habitat (F-ratio: 4.071, $p = 0.059$), but not in the open habitat (F-ratio: 0.209, $p = 0.653$; Figure 2). To further ensure that the treatment groups were not biased by plant size, I used an ANOVA to test for differences in mean stem number among treatment methods and found no significant difference (F-ratio: 0.575, $p = 0.566$).

Both treatment methods were 100% effective. At three and five weeks after application no regrowth was recorded on any plants. Because there was no variation in effectiveness, I tested the hypotheses using efficiency instead of the combined result of effectiveness and efficiency (performance) as the dependent variable. I found no significant relationship between treatment type and efficiency (F-ratio: 0.252, $p = 0.619$), but there was a biological trend between habitat and efficiency (F-ratio: 3.201, $p = 0.082$; Figure 3).

Because I observed that the cut and paint method became more difficult as basal area increased and each treatment type showed variation in basal area among replicates, I categorized treatments into basal area categories ($< 1500 mm^2$, $> 1500 mm^2$). I then tested the *a posteriori* hypothesis that the cut and paint method would become increasingly less efficient as basal area increased. I used two one-way ANOVAs on the effect of treatment type on efficiency as grouped by basal category. For plants $< 1500 mm^2$, there was a biologically significant trend for the cut and paint method to be more efficient than the hack and squirt method, (F-ratio: 3.810, $p = 0.069$), but not for plants > 1500mm^2 (F-ratio: 0.262, $p = 0.615$; Figure 4).

Discussion

Both the cut and paint and the hack and squirt methods were equally and entirely effective at eradicating treated honeysuckle plants. This result was not expected because a previous study (Ross 2005) on effectiveness of application methods indicated that the two methods would differ, with cut and paint being the most effective. Perhaps I applied a greater quantity of herbicide than previous studies thus impacting plant mortality more intensely. Additionally, for the hack and squirt method, I might have exposed a larger area of cambium thus making the area of herbicide application larger resulting in greater effectiveness. I have also considered that I might have chosen smaller, less established plants than previous studies, and these plants could have been more susceptible to mortality.

The significance of the effect of basal area on efficiency is logical because more area will take more time to cut or hack. Because treatment type did not significantly influence efficiency ($p = 0.619$), it could be concluded that both are equally as efficient as well as effective. This refutes my prediction that there would be a difference in performance between the two methods. Again, this could be due to individual variation in treatment execution.

As I observed the different growth forms of honeysuckle between open and covered habitats, I inferred from my data that honeysuckle prefers open habitats because it grows more dense and larger. Luken and Mattimoro (1991) demonstrated that plants grown in covered habitats have less resilience than those in the open. They also found that repeated clipping (without herbicide) will kill off covered plants and will only promote growth on open grown plants. As well, when I was searching for honeysuckle stands on which to perform this experiment, it was easier for me to find honeysuckle growing in the open than it was for me to find it growing under cover. Luken et al. (1995) also found plasticity in leaf display and plant size of honeysuckle along a light variation continuum. They found that light environments had a significant effect on height, canopy width, and leaf mass of bush honeysuckles; generally, open grown plants were larger, wider, and possessed more leaves than those found in covered habitats. They further observed that bush honeysuckles grew fewer, long shoots in covered habitats because the plant was attempting height gain to reach areas of more light availability. Because of the difference in growth between the two habitats, more basal area uniformity could have been analyzed between treatments by having more replicates per habitat and then testing the data per habitat without combining the treatment groups. Continually, instead of more replicates, the same number of replicates could have been used, but with less variation in basal area. Based solely on the difficulty I had finding plants of similar size among treatments, treatment performance in this study may have been confounded by basal area. However, this uncertainty could serve as the basis of further studies designed test the influence of plant size (i.e., basal area) on treatment performance.

The lack of variation in stem number ($p = 0.566$) between treatments served mainly as reinforcement that treatments all had similar basal areas, but the variation in basal area within treatments was high. As well, there was a biologically significant difference ($p = 0.059$) in basal area between methods within the covered plants. These factors could have influenced my efficiency results for each treatment or habitat. Although stem number does not provide useful information about plant size among or between groups, the stem data is useful for long-term continuation of the project. If future studies entailed returning to each plant to determine possible regrowth, it is likely that plants with more or larger stems are more likely to have regrown. Returning to each tested plant in subsequent growing seasons might yield regrowth, depending if the plant root system survived. It could be that one or both methods are effective only on a per-growing-season level, meaning that the treatments removed or withered the branches and leaves for the summer they were applied, but that the root system remained dormant and able to spawn growth the next season. Analyzing any future regrowth might yield performance data for a long term such as between growing seasons.

Because field observations led me to believe the cut and paint method became more difficult as plant size increased, the *a posteriori* hypothesis was developed and tested, demonstrating a trend for cut and paint to become increasingly less efficient as basal area increased. Because this project was not originally designed to test the effect of size class on efficiency, the cutoff between basal area categories used to run the statistical tests was made at a point where the data was approximately split. That this cutoff decision was based mostly on the amount of data means that it was not necessarily biologically meaningful. Despite the approximation of basal area categories, the test to determine basal area category effect on efficiency was biologically significant ($p = 0.069$) for the cut and paint method. A study designed to test the effect of basal area category using more defined size classes has a chance of demonstrating a significant difference in application efficiency, particularly for the cut and paint method.

Based on my results, I conclude that both of these tested treatments are equally able to kill honeysuckle with similar effort involved. For dense honeysuckle thickets the cut and paint method might be preferred because shrub clippers have higher accessibility to stems where there might not be room to swing a hatchet for hack and squirt. In these cases, I would recommend cut and paint, however, the hack and squirt method might need to be used on plants too large to clip. Enhancing the cut and paint method to using a chainsaw instead of shrub clippers would increase efficiency immensely. If this were done, the cut and paint method might be the most efficient at every plant size. The cut and paint method also seems like it should be more preferred based on forest aesthetics. Whereas in the hack and squirt method the plant stays intact and all the branches die in place with the root system, the cut and paint method allows for brush removal. Being able to remove honeysuckle brush not only improves forest appearance but also frees ground for other plant species to re-establish. This would keep early successional tree species from persisting because of open-canopy maintenance by honeysuckle dominated shrublands (Collier et al. 2002). Clearing honeysuckle bushes would also significantly increase the percent of light reaching the forest floor as Woods (1993) noted that honeysuckle reduced light penetration by 60%.

Rodeo® has been demonstrated to be an effective, broadly-applicable herbicide that also has little to no ecological ramifications when used properly; it can even be used in semi-aquatic habitats. An herbicide need not even be used for covered plants as annual successive cutting will kill them off (Luken and Mattimoro 1991). With a safe and effective herbicide such as Rodeo® and an efficient method, controlling honeysuckle thickets is reduced down to manageable levels, but curtailing the spread of honeysuckle still remains difficult.

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Canopy	Method	Mean Basal Area	Mean Stem Number
Open	Control	2529.51	5.10
	Cut and Paint	2619.96	5.70
	Hack and Squirt	3161.76	5.10
Covered	Control	1362.98	4.40
	Cut and Paint	909.10	4.60
	Hack and Squirt	2124.03	5.70

Table 1. Mean plant size for treatment groups per habitat. The mean plant size between the six groups had little variation in stem number, but basal area between the two herbicide application method groups was higher in the hack and squirt ($p = 0.059$).

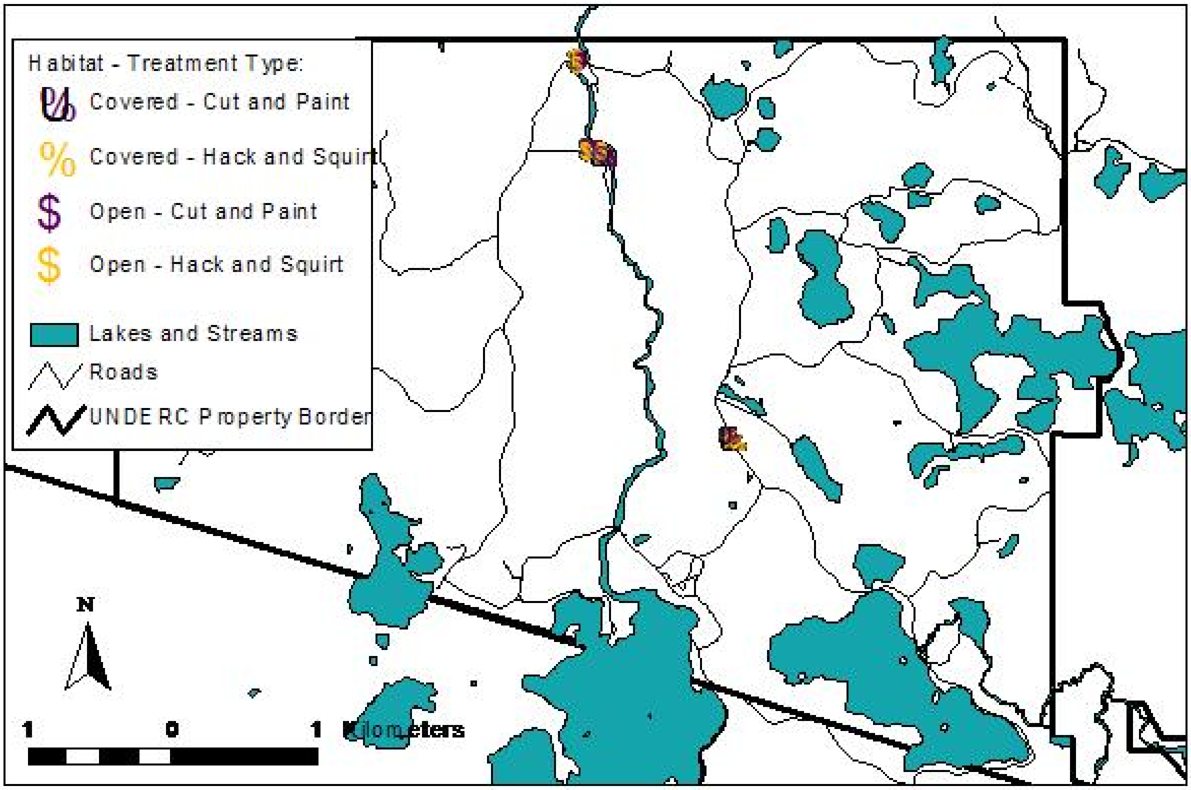

Figure 1. Map of the UNDERC property including honeysuckle research sites. Map shows the location, treatment, and habitat type of each honeysuckle plant in this study.

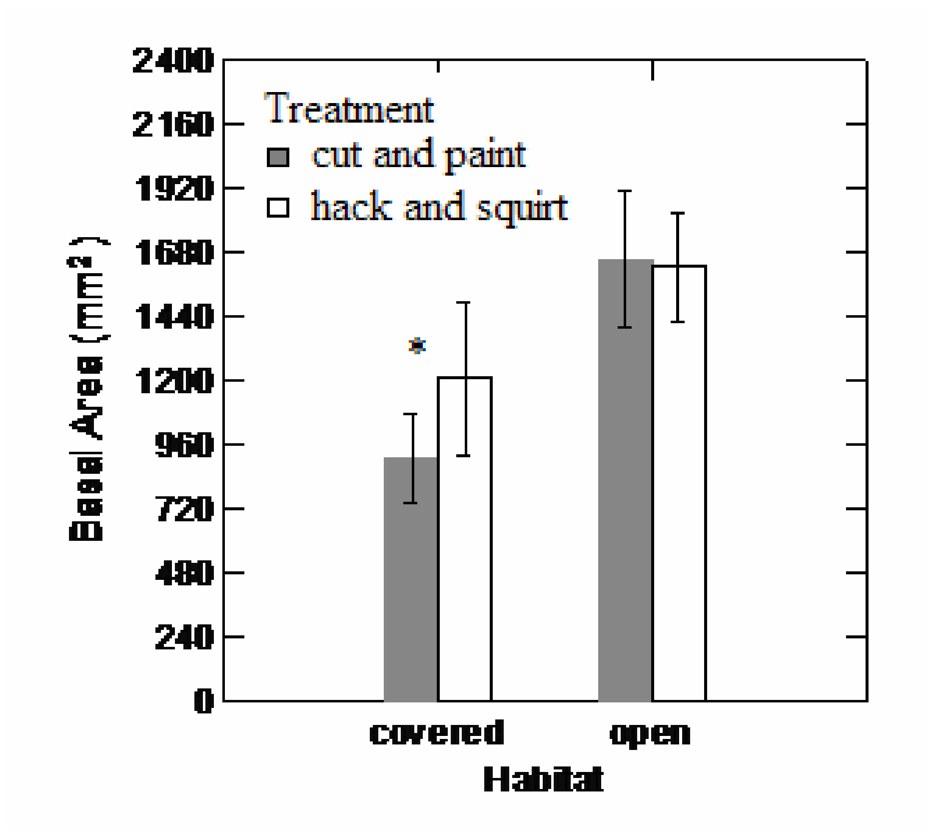

Figure 2. The effect of habitat on basal area for each method. There was a biologically significant difference (*p = 0.059) in basal area size between the two application methods for the covered habitat and habitat had an effect on basal area (p = 0.008), but there was no significant difference in basal area between the treatments (p = 0.325).

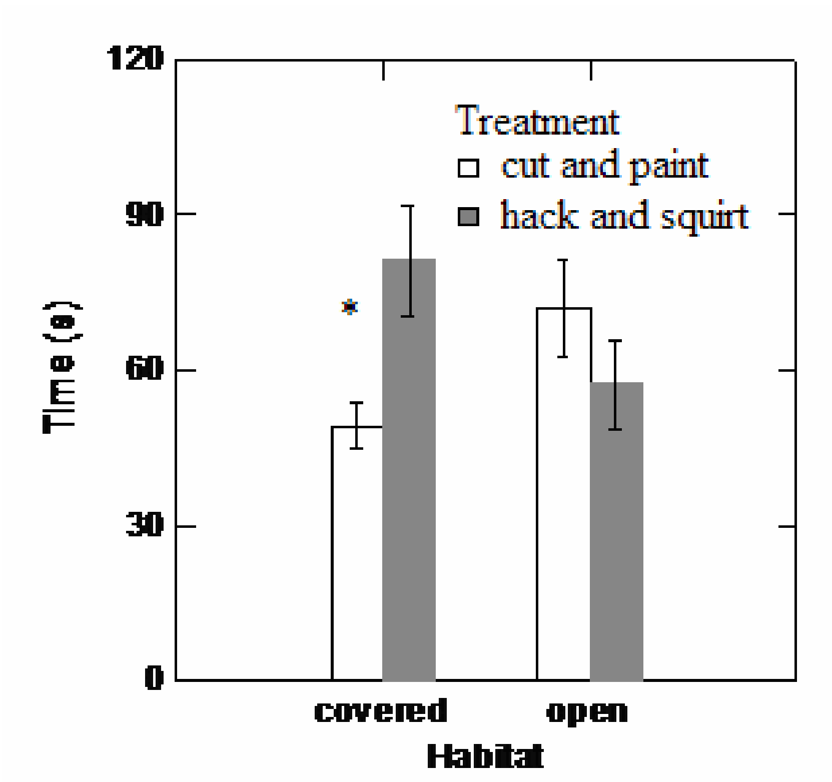

Figure 3. The effect of habitat on efficiency for each method. There was a biologically significant relationship between habitat and efficiency (*p = 0.082), but not between treatment type and efficiency (p = 0.619).

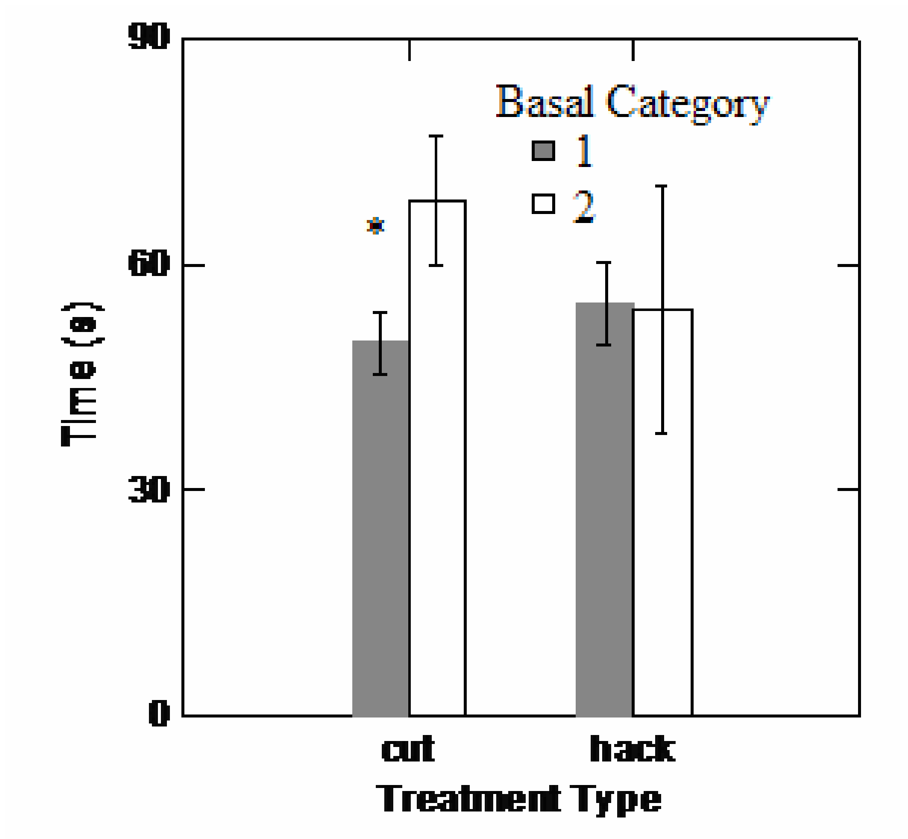

Figure 4. The effect of treatment on time grouped by basal area category. There was a biologically significant difference (*p = 0.069) in application time of treatments for basal category 1 (plants < 1500mm^2) but not for basal category 2 (p = 0.615).

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