COMPARISON OF ALTERNATIVE MAINTENANCE TREATMENTS FOR AN ELECTRIC TRANSMISSION RIGHT-OF-WAY ON STEEP MOUNTAINOUS TERRAIN

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Abstract. A study has been initiated to evaluate some alternative vegetation management techniques on an electrical transmission right-of-way in the Blue Ridge Mountains of North Carolina. Three years after right-of-way clearing, four treatments and a control were blocked on south-facing slopes at three locations. The treatments consisted of 1) clearcutting by chainsaw, 2) a selective low-volume basal application of herbicide to tall-growing species, 3) clearcutting followed by a selective application of a tree growth regulator to cut stumps, and 4) clearcutting followed by a nonselective application of a tree growth regulator to cut stumps. After two growing seasons, mean tree heights for the chainsaw clearing and selective herbicide treatments were not significantly different from the untreated control. Treatments consisting of chainsaw clearing followed by application of a growth regulator provided the lowest mean tree height. However, areas treated with a growth regulator exhibited the largest increase of undesirable tall-growing tree seedlings. The chainsaw cutting treatment resulted in the greatest mean height for those species considered to be undesirable components of a right-of-way plant community, and yielded the largest number of sprouting stumps with the highest average number of sprouts per stump. Although the long-term treatment effects cannot clearly be determined after two growing seasons, the selective low-volume basal herbicide method has produced a tendency toward increasing the relative dominance of desirable species within the right-of-way

Utility companies confront a variety of public concerns that complicate the task of managing the vegetation beneath electric transmission lines. Increased public awareness of environmental quality and the aesthetics of rights-of-way has resulted in greater attention to vegetation management practices. This is especially true in mountain landscapes, where utility rights-of-way on mountain slopes are highly visible to the public. On a newly constructed electric transmission right-of-way in the Blue Ridge mountains of North Carolina, the steep terrain, high public visibility and concerns for the protection of sensitive watersheds have led to the consideration of some alternative vegetation management techniques.

A long-term study is being conducted on the new right-of-way which was constructed in 1989. The right-of-way is approximately 150 feet wide, and traverses the Blue Ridge mountains in North Carolina in a south-north direction. Vegetation management options for the new right-of-way are limited by the terrain. Mowing and tree shearing equipment cannot operate safely on the steep slopes. Laborers with hand tools can be used to cut woody vegetation, but manual tree cutting operations are labor intensive and can be hazardous to workers. Another alternative would be to apply herbicides using low flying aircraft, but the disadvantages of broadcasting herbicides from aircraft include the high volumes of chemicals required, the high degree of public visibility, and issues concerning off-site chemical drift.

The long-term study has been initiated to compare some alternative low-impact vegetation management techniques. Alternative vegetation treatments being tested in this experiment are aimed at developing a right-of-way plant community dominated by low-growing trees and shrubs. Also, a vegetative management technique is being sought that, in addition to being economical, would be considered environmentally safe, visually acceptable to the public, and hinders the establishment of tall-growing tree species capable of interfering with electrical transmission lines.

Due to concerns about erosion and water quality, soil disturbance during construction was limited as much as practicable. For the most part, the transmission towers were placed on the tops of

ridges, with conductor cables spanning the intervening stream drainages. Tree felling, stump removal, site grading, and seeding of grasses was implemented only within a limited construction zone around the base of the towers. In many of the stream drainages between the transmission towers, the topography provided adequate clearance between tree tops and the conductor cables such that the forest could be left undisturbed. Some upper slope areas, however, lacked sufficient line clearance. In these areas, all trees that were sapling size or greater were felled by chainsaw and left on the ground at the time of construction. Most shrubs and seedling sized trees were left undisturbed. These areas, in which the vegetation must be periodically treated to control tree heights, have been designated as "special management areas".

Materials and Methods

The study was initiated in 1991. Three 1/20 hectare study sites were selected on south-facing slopes near the tops of ridges that supported transmission towers. The study sites were located within the special management areas that had been cleared by chainsaw during construction in 1989. In February of1991, vegetation on the selected sites consisted of 1) stump and root sprouts from trees cut during initial line clearance, 2) sapling trees originating from stems which had not been cut during line clearance, 3) new seedling ingrowth, and 4) woody shrubs that were present prior to right-of-way clearance.

Each of the three study sites was used as a block for testing treatments. Five 1/100 hectare treatment units were established within each block utilizing a randomized complete block design. Four maintenance treatments and a control were assigned within each block. Treatments were applied between March and May of 1991. The treatments were:

Control. No vegetation treatment after the initial line clearance in 1989.

Selective Herbicide. A selective application of Pathfinder herbicide, a commercially prepared ready-to-use mixture of 16.7% triclopyr in solution with oil, to tall-growing species only. Preferred right-of-way species were not treated. The herbicide solution was sprayed to the basal portion of tree stems and sprouting stumps at a rate of 2.2 ml of active ingredient per inch of ground diameter.

Chainsaw Cut. All tree stems were severed with a chainsaw to a stump height of less than one decimeter. No chemical treatments were applied.

Chainsaw Cut/Selective TGR. A tree growth regulator (TGR) was applied to selected species in a formulation prepared by dissolving Cutless powder (active ingredient flurprimidol) in isopropyl alcohol, and then mixing with Rite-Way oil to create a basal bark solution continuing 25 grams active ingredient per liter. Prior to chemical treatment, all stems were cut with a chainsaw to a stump height of less than one decimeter. Immediately after cutting, the Cutless solution was applied to the stumps of tall-growing species only at a rate of 0.66g of active ingredient per inch of ground diameter.

Chainsaw Cut/Complete TGR. Immediately after cutting all stems to a height of less than one decimeter, the Cutless solution, as described previously, was applied to all stumps within the treatment area.

Measurements on live seedlings, saplings, and sprouting stumps were taken on each treatment unit prior to treatment application and after each growing season for two years. All trees tallied in this experiment were classed as either desirable or undesirable (Table 1). Trees known to exhibit slow growth, a decurrent crown form, or a potential height of less than 10 meters were considered to be desirable components of a right-of-way vegetation community, while trees that exhibit rapid and tall growth were considered to be undesirable.

Data for stem height, ground-line diameter, crown diameter, stump diameter, and the number of sprouts per stump were summarized for each treatment. Crown profile area, an expression of the competitive size of a tree that combines tree height and crown diameter, was calculated as:

$$\mathbf{CPA = CD(H)}$$

where CPA = crown profile area (dm^2)
CD = average of two crown diameter measurements (dm)
H = tree height of each tree (dm).

Table 1. Classification of trees based upon whether a species was considered to be a desired component of a low-maintenance right-of-way vegetation community. Desirable species are trees which exhibit either a slow growth rate or a maximum height of less than 10 meters. Undesirable species are those trees which exhibit rapid growth and a tall height on rights-of ways in the Blue Ridge mountains.

Tree name	Scientific name
Desirable species	
American beech	Fagus grandifolia
American chestnut	Castanea dentata
American holly	Ilex opaca
black tupelo	Nyssa sylvatica
flowering dogwood	Cornus florida
hickory	Carya spp.
mountain laurel	Kalmia latifolia
oaks	Quercus spp.
rhododendron	Rhododendron spp.
sassafras	Sassafras albidum
serviceberry	Amelanchier arborea
silverbell	Halesia carolina
sourwood	Oxydendrum arboreum
sweetleaf	Symplocos tinctora
Undesirable species	
birch	Betula spp.
black locust	Robinia pseudoacacia
Eastern white pine	Pinus strobus
Fraser magnolia	Magnolia fraseri
red maple	Acer rubrum
shortleaf pine	Pinus echinata
yellow poplar	Liriodendron tulipifera

Subsampling was utilized to assess treatment effects on woody shrub coverage. Subsampling was done by measuring five systematically spaced meter-square subplots within each treatment unit.

Two years after application of treatments, means for height growth, crown profile area, and for the percent coverage of woody shrubs were tested for significant differences at the 0.05 level by analysis of variance techniques using Tukey's HSD (Honestly Significantly Different) test (4).

Results and Discussion

Table 2 lists sample tree frequency prior to application of treatments and after two growing seasons following treatment. All treatments exhibited an increase in tree frequency after two years from the ingrowth of new seedlings. The ingrowth of new tree seedlings was lowest in the control areas, while the number of new trees was greatest for treatments receiving a TGR application after a chainsaw clearing.

The chainsaw cut/complete TGR and selective herbicide treatments produced the greatest reduction in the number of live sprouting stumps, while the chainsaw cut treatment resulted in the least reduction in the number of sprouting stumps over the study period. The average number of sprouts per stump decreased on all treatments except the chainsaw cut treatment. Two years after treatment, the average number of sprouts per stump was 12.2 for stumps in chainsaw cut areas, compared with 6.1 sprouts per stump in the control areas.

Notable changes in tree frequency occurred for four species (Table 3). Increases in sassafras seedlings and root suckers occurred in all treat-

Table 2. Pre-treatment and post-treatment frequency of seedlings/saplings, frequency of live sprouting stumps, and total count of stump sprouts prior to application of right-of-way maintenance treatments in 1991, and two years after treatment applications in 1993.

	Control		Selective herbicide		Chainsaw Cut only		Chainsaw Cut +Selective TGR		Chainsaw Cut +Complete TGR	
	1991	1993	1991	1993	1991	1993	1991	1993	1991	1993
Seedlings/saplings	551	730	248	574	335	722	667	1148	405	879
Sprouting stumps	70	30	46	4	72	70	43	22	50	5
Stump sprouts	613	182	631	43	817	854	447	149	413	15

Table 3. Stem density per hectare, by treatment and year, for four species on an electric transmission right-of-way in North Carolina.

Species	Tree density per hectare 1991	1993	% Change
black tupelo			
Control	567	1200	112%
Select Herbicide	667	1467	120%
Select TGR	1100	1533	39%
Complete TGR	733	633	-14%
Saw Cut	400	1300	225%
red maple			
Control	1033	1767	71%
Select Herbicide	667	1000	50%
Select TGR	1400	1167	-17%
Complete TGR	567	933	64%
Saw Cut	200	700	250%
sassafrass			
Control	10933	6933	-37%
Select Herbicide	3233	8133	152%
Select TGR	10967	16567	51%
Complete TGR	6233	15367	146%
Saw Cut	3400	11300	232%
yellow poplar			
Control	1067	5333	400%
Select Herbicide	100	1167	1067%
Select TGR	100	900	800%
Complete TGR	233	6533	2704%
Saw Cut	133	900	577%

ment areas, but decreased during the same period in the control areas. Red maple, black tupelo, and sassafras exhibited the greatest increase in stem numbers on the chainsaw cut areas. Yellow poplar increased substantially on all treatment areas, with the most pronounced increases occurring on the chainsaw cut/complete TGR treatment.

Mean tree height before and after treatment are presented in Figure 1. After two growing seasons, the lowest mean height was produced by treatments consisting of chainsaw clearing followed by an application of a tree growth regulator.

From an electric transmission right-of-way maintenance perspective, however, mean tree height along a right-of-way section is less important than the maximum height of the tallest trees. Decisions to perform maintenance are often based upon a few trees infringing into the critical areas near the electrical conductors. Consequently, the mean height of the tallest 10% of trees from each treatment was calculated (Figure 2). As shown in Figure 2, the chainsaw cut/TGR treatments produced the lowest mean height for the tallest 10% of trees. No significant difference could be detected between the selective herbicide treatment and the control for this data subset after two growing seasons.

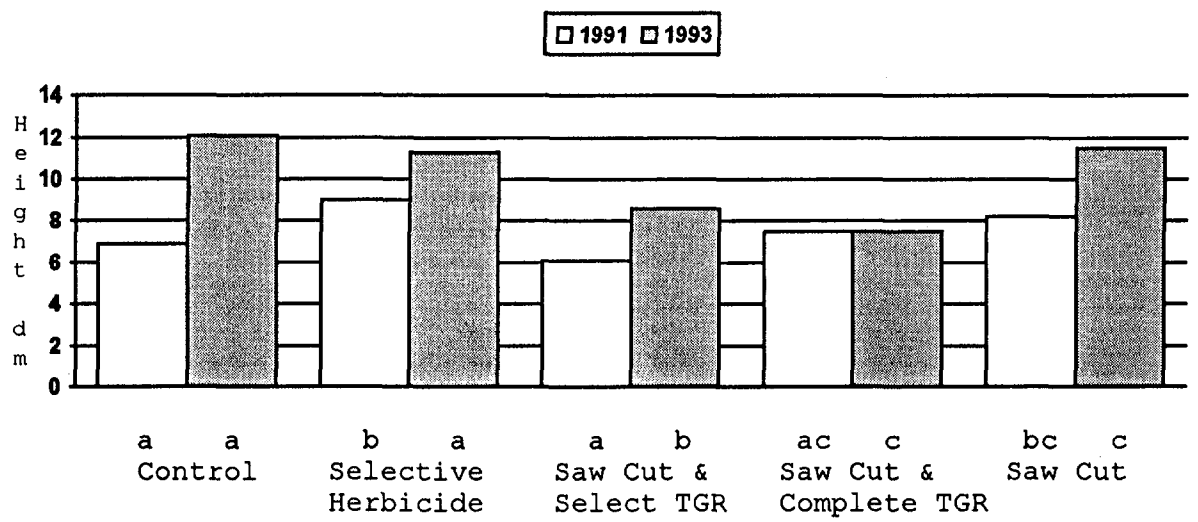

Figure 1. Mean tree height by treatment, prior to application of treatments in 1991, and after two growing seasons in 1993. Means within a comparison year followed by the same letter are not statistically different (alpha 0.05 Tukey's HSD Test).

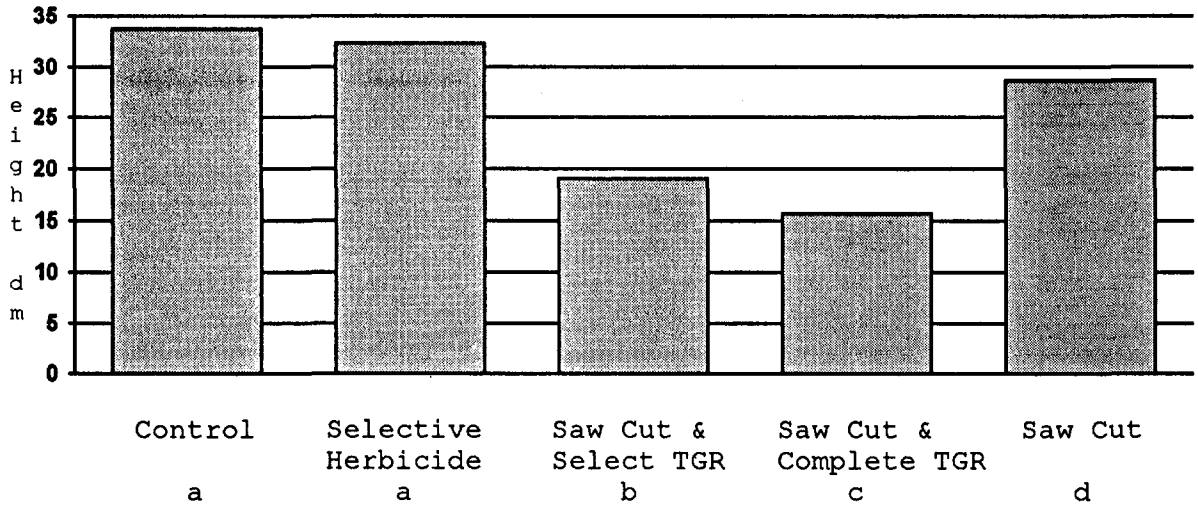

Figure 2. Mean height of the tallest 10% of sample trees two years after treatment. Treatment groups indicated by the same letter are not significantly different at the 0.05 level.

Treatments were also assessed for their ability to manipulate the species composition within a right-of-way. The analysis of height data by tree class showed that the chainsaw/cut complete TGR treatment yielded the lowest mean height for the undesirable species class, but the treatment was not significantly different from the chainsaw cut/select TGR or selective herbicide treatments (Table 4). The chainsaw cut treatment resulted in a significantly higher tree height for undesirable species after two growing seasons and, as shown in Table 4, the chainsaw cut treatment was the only treatment to produce a mean height for undesirable species greater than that for desirable species.

Treatment effects on the growth of undesirable right-of-way species was assessed by plotting the pre-treatment and post-treatment sums of crown profile area for trees in the undesirable class. As seen in Figure 3, crown profile area for the undesirable species class increased for the control and chainsaw cut treatments after two growing seasons, yet decreased on all other treatment areas. During this period, crown profile area for undesirable species increased 289% on control areas, increased 104% on chainsaw cut areas, and decreased from 27 to 47% on areas receiving a chemical treatment.

Treatment effects on the competitive status of trees in the desirable class was assessed by computing the ratio of desirable to undesirable crown profile area sums for each treatment (Figure 4). This ratio increased substantially on areas treated by the selective herbicide treatment and the chainsaw cut/selective TGR treatments. During the same period, the ratios of crown profile area by tree class increased slightly on the chainsaw cut areas, and decreased on the control area.

Woody shrub coverage on treatment blocks consisted primarily of *Kalmia latifolia* and

Table 4. Mean tree height for desirable and undesirable tree classes, by treatment and year, prior to application of treatments in 1991, and after two growing seasons in 1993. Means within a column followed by the same letter are not statistically different (alpha 0.05 Tukey's HSD Test).

	Height 1991(dm)		Height 1993(dm)	
Treatment	Desired species	Undesired species	Desired species	Undesired species
Control	6.5 a	8.4 a	12.8 a	10.9 a
Selective herbicide	8.2 a	12.9 ab	11.6 a	9.4 ab
Chainsaw cut	7.1 a	15.3 b	10.8 a	16.2 c
Chainsaw cut/ Select TGR	5.8 a	9.0 ac	8.6 b	8.5 b
Chainsaw cut/ Complete TGR	6.8 a	12.3 bc	7.5 c	7.5 b

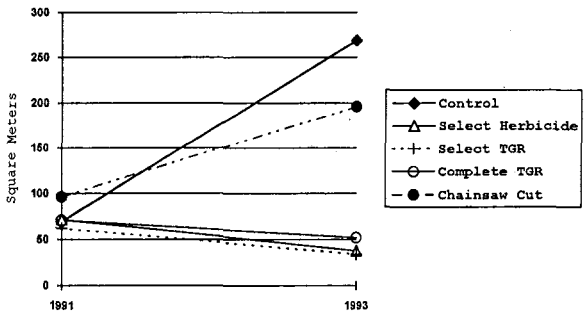

Figure 3. Plot of crown profile area sums per hectare for undesirable right-of-way species, prior to treatment in 1991, and two years after treatment in 1993.

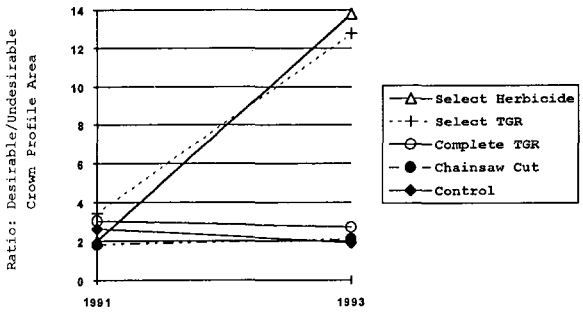

Figure 4. Ratio of desirable/undesirable crown profile area prior to treatments in 1991, and two years after treatment in 1993.

Vaccinium vacillans. Increases in shrub coverage was less than four percent for all treatments during the two year study period, with no evidence of treatment effects.

Summary

Treatments consisting of a chainsaw cut followed by application of the growth regulator flurprimidol provided a lower mean tree height after two growing seasons than any other treatment. However, increases in the frequency of undesirable species, especially yellow poplar, may result in the development of an undesirable vegetation community exhibiting rapid height growth. Additionally, the growth regulating effects of flurprimidol will eventually diminish and more normal growth flushes from affected trees will begin to occur. Therefore, methods employing a TGR application after a cutting treatment may simply delay height growth, allow the invasion of undesirable tree species, and prove to be an unsound choice over the long term.

Excluding the growth regulator treatments, the selective basal application of triclopyr herbicide resulted in the lowest mean tree height, as well as the lowest mean height for undesirable species, and the lowest total number of sprouting stumps. Despite the lower means, analysis of variance showed that mean height measures for the selective herbicide treatment did not differ significantly from the control after two years.

Even though the effect of the selective herbicide treatment on mean height cannot yet be distinguished from the control, the treatment did exhibit some characteristic results that could be interpreted as a trend toward creating a desirable vegetation community. Crown profile area for trees in the undesirable species class decreased on areas receiving the selective herbicide treatment, while increasing on control areas and on areas receiving the chainsaw cutting treatment. The selective herbicide treatment also resulted in the largest increase in the ratio of desirable to undesirable crown profile area, which indicated a trend towards the dominance of tree species favored within a right-of-way.

The ingrowth of undesirable tree species was influenced by treatment. The greatest increase of new tree seedlings in the undesirable class occurred where chainsaw cutting combined with the suppression of plant regrowth by flurprimidol provided the best opportunity for seed germination. At some threshold level of vegetation cover, ingrowth of undesirable species such as yellow poplar is sufficiently suppressed so that more desirable species can flourish. For this reason, any vegetation management technique utilized on a forested right-of-way should not reduce vegetation cover to the point where the ingrowth of undesirable species would occur.

Selective low volume herbicide applications could possibly manipulate the species composition so that desirable shrubs and slow growing trees could become more dominant. When used as an intensive treatment to eliminate the tall-growing tree species, this technique may also have the potential to increase the length of time between vegetation control treatments. Besides lengthening the treatment cycle, a technique which reduces the density of undesirable tree stems

would also lessen the intensity of future right-of-way treatments. As a result, the long term cost of right-of-way treatments could eventually be lowered. Any vegetation management treatment that increases the frequency of stumps and stump sprouts within a right-of-way will have a negative impact on future maintenance efforts. The selective herbicide treatment produced the lowest total number of sprouting stumps. In contrast, the chainsaw cutting treatment resulted in the largest total number of sprouting stumps at the end of the study period, with highest average number of sprouts per stump.

Selective low-volume basal herbicide is a vegetation management technique that is already being used by some right-of-way managers (1,3). This technique has gained popularity because of low application cost, selectivity of application, and effectiveness in controlling unwanted trees (2).

Based on data from two growing seasons, it is not possible to predict treatment effects on the height growth and species composition that will result in the future. Since the potential height growth for a particular species will change with age, no conclusions can be made from these two year trends in growth. Promising signs that a positive effect has been achieved by the selective herbicide treatment are a reduction in mean height and relative crown profile area for trees in the undesirable category. The competitive position of trees in the desirable category has therefore been improved. Future monitoring of treatment units established by this study will be performed to evaluate the stability of the right-of-way plant community.

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Résumé. Nous avons évalué des techniques alternatives de gestion de la végétation sur une emprise de ligne électrique de transport. Les traitements consistaient à 1) une coupe à blanc rase à la scie mécanique, 2) une application sélective en petite quantité d'un herbicide à la base des espèces à grand déploiement, 3) une coupe à blanc rase suivie d'une application sélective de régulateur de croissance sur les souches d'arbres, et 4) une coupe à blanc rase suivie d'une application non sélective de régulateur de croissance. Malgré que les effets à long terme ne peuvent être déterminés après deux années de croissance, l'application sélective en petite quantité d'herbicide à la base a produit une tendance envers un accroissement de la dominance relative d'espèces désirables dans l'emprise de la ligne.

Zusammenfassung. Wir bewerteten alternative Methoden der Grünanlagenpflege entlang einer elektrischen Überlandleitung. Die Maßnahmen bestanden aus 1. Freischneiden mit Motorsäge, 2. eine basale Herbizidenwendung in geringer Dosierung speziell für hochwachsende Arten, 3. Freischneiden mit anschließender selektiver Anwendung eines Baumwachstumsregulators, welches auf die Wurzelstöcke aufgebracht wurde und 4. Freischneiden gefolgt von einer Applikation mit einem nicht selektiven Baumwachstumregulator. Obwohl die langfristige Auswirkung der Maßnahmen nach zwei Wachstumsperioden noch nicht klar zu bestimmen sind, so zeigte doch die Behandlung mit einem selektiven, schwachdosierten Herbizid, welches basal aufgebracht wurde, eine Tendenz hinsichtlich einer Förderung der Dominanz von erwünschten Pflanzenarten innerhalb des Korridors.