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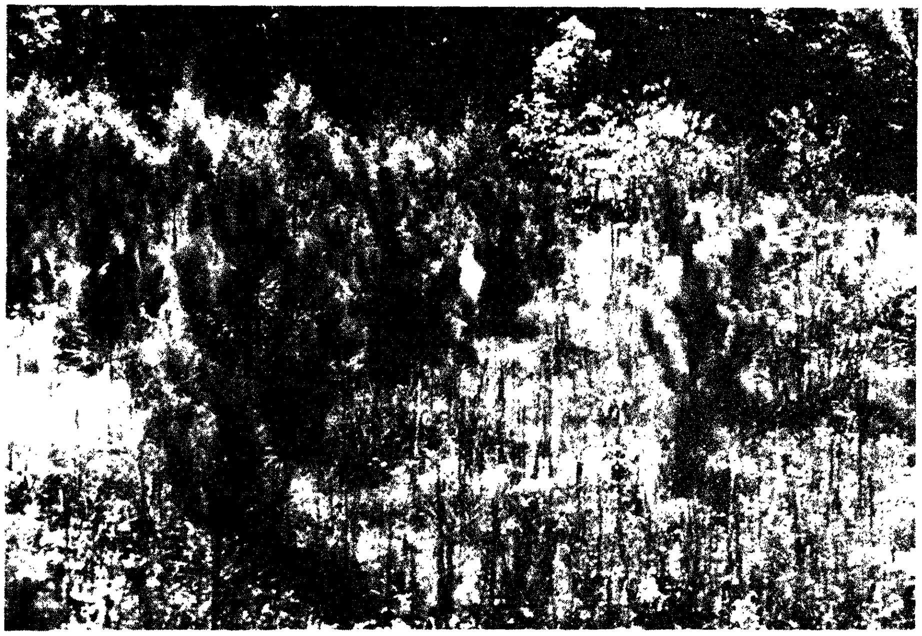

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Ground-Application Trial Of Hexazinone On The Ottawa National Forest

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Efforts to ease a predicted softwood shortage in the Lake States by the year 2000 have led National Forests in the region to establish conifer species on sites previously occupied by marginally growing hardwoods, and these sites generally require the control of competing vegetation until the conifer species become established. A 1984 ban on all aerial spraying of herbicides on National Forest land has had resounding ramifications on how the National Forests in the Lake States deal with this problem.

Before the aerial ban, herbicide use by the National Forests had been increasing since 1980. It then dropped back to the 1980 level in the 4 years after the ban was enacted (fig. 1) (U.S. Department of Agriculture, Forest Service 1981-1989). This general downward trend can initially be attributed directly to the aerial ban and the unavailability of alternate application methods and equipment. Due to increasing costs associated with preparing forest environmental impact management plans and responses to public comments about these plans, many National Forests have suspended all herbicide use as a weed control method in their reforestation programs.

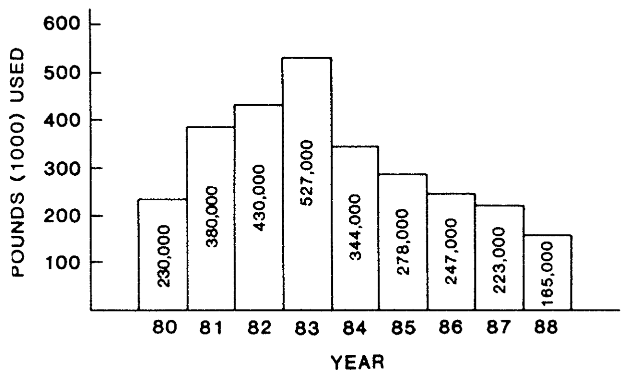

Figure 1.—*Herbicide use on the National Forests.*

From 1980 to 1983, when herbicide use on the National Forests was increasing, the use of hexazinone increased from 1.2 percent to 8.6 percent of all herbicides used. Then in 1984, hexazinone jumped to 40.3 percent of all herbicides used and has remained close to that level since then (fig. 2) (U.S. Department of Agriculture, Forest Service 1981-1989).

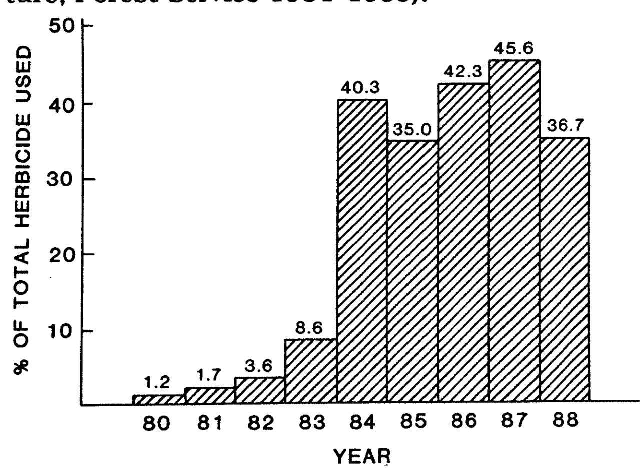

Figure 2.—*Hexazinone use on the National Forests.*

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Although farmers have used ground-application methods for many years, these techniques have had only limited use in forestry because the special equipment needed has not been available. Little has been published on current methods, effectiveness, and production capabilities.

Before the aerial ban, many National Forests—including Ottawa National Forest in the western Upper Peninsula of Michigan—had begun to look for other ways to carry out their forest plans for establishing conifer plantations. Influenced by first-year results of several apparently successful small test plots treated with mainly hexazinone in 1983 (Glas *et al.* 1986, Johnson 1984), the Iron River Ranger District of the Ottawa decided to complete its 1984 chemical treatment program of conifer plantation stands using experimental ground-application equipment and hexazinone.

This paper describes a cooperative study involving the Ottawa National Forest's Iron River Ranger District in Iron River, MI; Michigan Technological University's Forestry Department in Houghton, MI; and the Forestry Sciences Laboratory in Houghton, in which a ground-application system operation was time studied and the effectiveness of varying rates of liquid and granular hexazinone was evaluated for three growing seasons.

STUDY DESIGN

Eleven sites scheduled for chemical treatment in 1984 on the Iron River Ranger District of the Ottawa National Forest were selected for this study. (See Appendix A for site locations.) Site size ranged from 10 to 56 acres. Eight sites contained existing red pine plantings in need of release, and three sites were scheduled for site preparation treatments before planting. All the sites were judged to be suitable for ground application based on their soil conditions and topography. The competing vegetation was primarily aspen, raspberry, and heavy sod.

We applied several different rates of hexazinone on each site. The manufacturer recommends an application rate of 1 to 2 gallons of hexazinone per acre (2 pounds of active ingredients per gallon) based on the soil type for the release of red pine. We tested rates both within this range and below to evaluate the effectiveness of ground-based application systems and to obtain base line data on the minimum amount of chemical needed to effectively control competition. NOTE: Data obtained from these tests will not and should not be used as a recommendation for a specific chemical rate, but will be presented so that readers can make their own conclusions based on their specific sites.

Four of the eight red pine sites scheduled for release received 1/2, 1, and 1-1/2 gpa. Two additional release sites, on sandy soil, were treated with even lower rates of 1/4, 3/4, and 1-1/4 gpa. Because of the good possibility of failure at the lower rates of 1/4 and 1/2 gpa, we minimized the size of these areas. For economic consideration, the areas treated at the highest rates also were minimized.

The remaining two release sites were given special treatment plots not only to evaluate rate variations but also to compare the effectiveness of the two current formulations of hexazinone—one liquid, Velpar L[1], and the other granular, Pronone 10G. We wanted to determine if using a mechanical spreader is technically feasible in dispensing granular material, and to establish side-by-side plots for comparing the effectiveness of liquid and granular chemical formulations. If found to be as effective as the liquid, granular material could be used without the many common problems of liquids such as spray drift, variable droplet size, availability of adequate water quality and source, and winds that limit the amount of time when liquid application can occur. Granular material also has an advantage over liquid in that it filters to the ground and is not stopped by vegetation as much as sprays are.

The remaining three sites were scheduled for site preparation and were treated at rates of 1, 1-1/2, and 2 gpa. As with the release sites, the areas treated at the lowest and highest rates were

[1]*The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. It does not constitute an official endorsement or approval of any product or service by the United States Department of Agriculture to the exclusion of others that may be suitable.*

SITE	SIZE (AC)	TREATMENT REQUIRED	TREE AGE	PRIOR TREATMENT	SOIL TYPE	PRIMARY COMPETITION	TARGET RATES
DEAD EYE	19	SITE PREP	-	RAKED & PILED	HEAVY	ASPEN	1, 1 1/2 & 2 GPA
DEER CAMP	23	SITE PREP	-	RAKED & PILED	MEDIUM	ASPEN	1, 1 1/2 & 2 GPA
SIMON SALE	10	RELEASE	3 YR	RAKED/ROWS DISC TRENCHED	MEDIUM	RASPBERRY	1/2, 1 & 1 1/2 GPA 20, 30 & 40 PPA
DAM 10#5	35	RELEASE	2-3 YR	RAKED/ROWS DISC TRENCHED	SANDY LOAM	RASPBERRY	1/4, 3/4 & 1 1/4 GPA
MURPHY LAKE	32	RELEASE	2 YR	RAKED/ROWS DISC TRENCHED	HEAVY	ASPEN	1/2, 1 & 1 1/2 GPA
UPPER HOLMES	30	RELEASE	3 YR	RAKED & PILED	SANDY LOAM	SOD	1/2, 1 & 1 1/2 GPA
SPAULDING DAM #5	20	RELEASE	2 YR	RAKED & PILED DISC TRENCHED	MEDIUM	RASPBERRY	1/2, 1 & 1 1/2 GPA
MALLARD SHORES	20	SITE PREP	-	NONE	MEDIUM	ASPEN	1, 1 1/2 & 2 GPA
MALLARD CREEK	56	RELEASE	2 YR	RAKED & PILED DISC TRENCHED	SANDY LOAM	SOD	1/4, 3/4 & 1 1/4 GPA
BEAR PAW	20	RELEASE	2-3 YR	DISC TRENCHED	SANDY LOAM	ASPEN	1/2, 1 & 1 1/2 GPA
DRAGON POND	13	RELEASE	2-3 YR	RAKED & PILED DISC TRENCHED	SANDY LOAM	ASPEN	1/2, 1 & 1 1/2 GPA 20, 30 & 40 PPA

Figure 3.—*Site condition summary.*

limited in size because of economic considerations. All sites were included in the evaluation of chemical effectiveness regardless of treatment type or chemical rate. Figure 3 summarizes important site information.

The following guidelines were adopted for herbicide application and location and establishment of the measurement plots.

1. Areas treated with the extreme application rates of 1/4, 1/2, and 2 gpa were not to exceed 6 acres, and were not located along the edge of a site, so as to reduce any effects of site edge.

2. Machine travel was as straight and uniform as possible within the site. Within a single application rate, there were at least three parallel application swaths.

3. Each chemical rate area contained three measurement plots with centers located at the travel line of the sprayer. Plots were located in the middle swath of three adjacent single application strips, and in areas considered average or typical of the site. Figure 4 shows a typical site with plot centers indicated. Plots were not located within 100 feet of the start or end of a swath or near slash piles or other site features that might adversely affect chemical action.

4. Measurement plots consisted of six 1-foot-square measurement points located 5 feet apart (fig. 5). Data collection consisted of counting and measuring each identifiable item, alive or dead, within each measurement area.

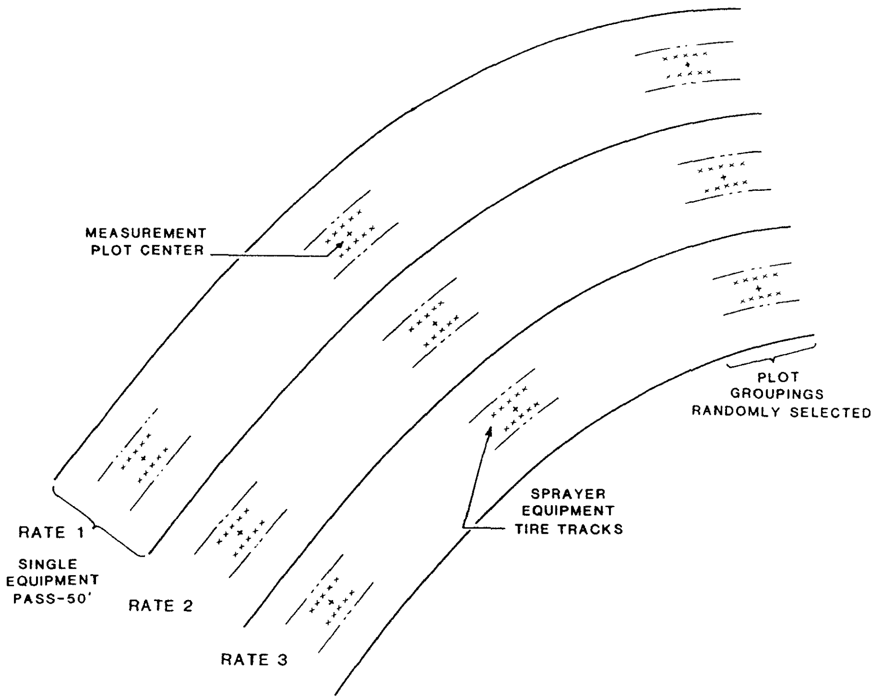

Figure 4.—*Typical site layout of measurement plot.*

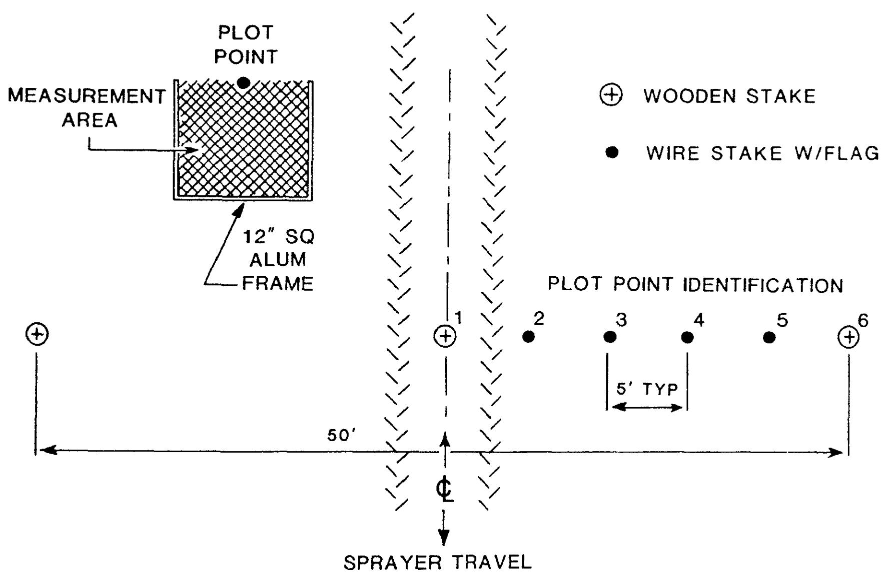

Figure 5.—*Typical test plot layout.*

The following is a summary of the sites and treatments.

Dead Eye—19 acres total, 6 acres each at 1 and 2 gpa, remaining area at 1-1/2 gpa
Deer Camp—23 acres total, 6 acres each at 1 and 2 gpa, remaining area at 1-1/2 gpa
Simon Sale—10 acres total, special treatments, 3/4-acre plots of 1/2, 1, and 1-1/2 gpa, and 20, 30, and 40 ppa, remaining area at 1 gpa
Dam 10 No. 5—35 acres total, 6 acres each at 1/4 and 1-1/4 gpa, remaining area at 3/4 gpa
Murphy Lake—32 acres total, 6 acres each at 1/2 and 1-1/2 gpa, remaining area at 1 gpa
Upper Holmes—20 acres total, 6 acres each at 1/2 and 1-1/2 gpa, remaining area at 3/4 gpa
Spaulding Dam No. 5 —20 acres total, 6 acres each at 1/2 and 1-1/2 gpa, remaining area at 1 gpa
Mallard Shores—20 acres total, 6 acres each at 1 and 2 gpa, remaining area at 1-1/2 gpa
Mallard Creek—56 acres total, 6 acres each at 1/4 and 1-1/4 gpa, remaining area at 3/4 gpa
Bear Paw—20 acres total, 6 acres each at 1/2 and 1-1/2 gpa, remaining area at 1 gpa
Dragon Pond—13 acres total, special treatments, 1/2-acre plots of 1/2, 1, and 1-1/2 gpa, and 20, 30, and 40 ppa, remaining area at 1 gpa

A skid-mounted spraying unit and a C5D Tree Farmer forwarder were used to apply the herbicide. The spraying unit was self-contained and included a 300-gallon stainless steel tank, pump, motor, and required valving. Once the spraying unit was fastened to the rear deck of the forwarder, a remotely located switch in the forwarder cab allowed the operator to turn the sprayer control valve on or off when required. Water was transported to the sites using a trailer-mounted 275-gallon tank towed by a Forest Service pickup equipped for fire fighting. This configuration provided an additional 75 gallons of water and pumping facilities for water transfer. The spraying unit came from the factory with a boomless or cluster spray nozzle, by Spraying Systems Company (BoomJet p/n-5880-3/4-2TOC40)[2]. Because this nozzle is a high-volume type that would consume large quantities of water at the projected travel speed, it was replaced with a similar type, a BoomJet 5880-3/4-2TOC10, modified to give a slightly different spray pattern (Wehr *et al.* 1985). The new nozzle configuration dispenses 25 gpa at 2.5 mph and allows a 300-gallon tankload to treat 12 acres.

STUDY EXECUTION

The Gallenberg 300-gallon sprayer system was mounted, tested, and calibrated on the C5D Tree Farmer forwarder (fig. 6). Ground speed tests were conducted on site to determine the optimum travel speeds based on terrain, engine rpm, and operator comfort. A throttle stop was installed so that machine travel would be easy to duplicate. Spraying tests were conducted to verify pattern width. As in the small plot tests conducted in 1983, the tests with water produced a static spray width of 72 feet when mounted 7 feet off the ground. Based on the 1983 results, the effective swath width was only 50 to 55 feet using a chemical mix. A 50-foot swath width was used for all calculations and site layouts.

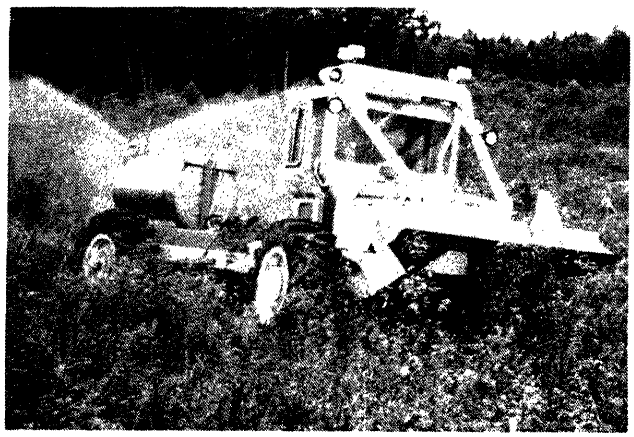

Figure 6.—*Tree Farmer forwarder at work with sprayer system.*

[2]*Spraying Systems Co. 1983. TeeJet spray manual catalog 37. Wheaton, IL. p. 22.*

Chemical application began on May 22, 1984, and is briefly described below. (See Appendix B for detailed site maps.)

Two major application methods, parallel-strip and block-strip, were used once site treatment began. The parallel-strip method employed application passes parallel to each other and was the desired method. When a site could not be traversed in long passes because of terrain or other interrupting features, the block-strip method was used. This method divided the site into three smaller areas, one for each spray rate, and the passes within each area were parallel with each other.

The first site treated was Dead Eye. Its long, narrow shape made it especially suitable for the parallel-strip method of application. Several large slash piles and two large buffer areas between the site and Forest Road FR 151 broke up the uniformity of the site.

The second site, Deer Camp, like Dead Eye, was well suited for the parallel-strip method. Three large slash piles and Forest Road FR 149, which angled through the center of the site, made it difficult at times to remain on the spraying track. Tall aspen in the northeast corner of the site interfered with the spray pattern, narrowing the effective width.

On the other hand, Dam 10 No. 5, with an access road running the full length of the site and along the interior end, was almost perfect for the parallel-strip technique. The site was level with brush raking in small windrows parallel to the access road.

Murphy Lake, the fourth site, was difficult to treat. The area north of the access road was reasonably level and free of slash. But aspen, 6 to 8 feet high, caused poor visibility and interfered with the spray swath. The terrain in the southern area was extremely rough with high stumps, a large swampy area, and clusters of tall aspen. The entire site was divided into three areas, and a block-strip application technique was used.

Upper Holmes was probably the most difficult site to treat because of streams, wet and steep areas, and small plots of planted oak. Like Murphy Lake, the site was divided into three areas as dictated by the stream beds and steep slopes, and a block-strip application technique was used.

Spaulding Dam No. 5 had a small creek and swampy area that made half the site inaccessible at that time of year. The site could not be treated with multiple rates as originally planned and was treated with the medium rate intended for that release site.

Mallard Shores was characterized by ridges and deep holes and was scattered with unrecovered birch. Because of the layout, it was treated with the block-strip technique. Some difficulty was experienced with steep slopes, high stumps, and forwarder traction on the logging slash that remained.

Mallard Creek, next to Mallard Shores, had gentler terrain but still was undulating. Many large slash piles and topographical ridges broke the site into three distinct areas. Consequently the block-strip method of application was also selected for this site.

Bear Paw was primarily a knob with a deep ravine in the northwest corner. Aspen was quite heavy, and visibility was poor at times. Because of terrain, the site was treated using the block-strip layout.

The remaining two sites, Simon Sale and Dragon Pond, were treated using the liquid and granular forms of hexazinone as previously discussed. These sites were level, but difficulty was experienced with high stumps and the smaller Holder tractor used on these two sites. Simon Sale had been brush raked into rows perpendicular to Forest Road FR 149, which made the layout simple. Dragon Pond was the more difficult to treat of the two because of dense aspen and logging slash left on the site. Both sites were treated with adjacent strips of Velpar L and Pronone at three different rates.

Once herbicide was applied on each site, measurement plot locations were determined (three per application rate) and plot center stakes were labeled and placed using the previously discussed procedure.

SITE EVALUATION

Each site was visited in August 1984, 3 months after treatment. The purpose of this visit was to evaluate each site for the chemical rate efficacy in the preliminary plots established earlier that year. A plot number was assigned to each plot, and plot measurement points were located. The previously located plot center stake and the equipment tire tracks in the soil were used to locate two wooden stakes 25 feet on either side of the center stake and at right angles to the tire track path. These outer stakes indicated the width of the sprayed area at that location. Between the center stake and one of the side stakes, and in line with these two stakes, wire stakes with flags were located at 5-foot intervals. This combination, two wooden stakes and four wire stakes, established a permanent measuring plot (fig. 5). So that plot measurement point location would be unbiased, the following procedure was used to determine which side of the spray pattern would receive these points. We selected the near side of the spray path when approaching from the side and selected the right side when approaching from the end.

The following procedure was used to obtain data at each measurement plot. At each plot point, six per measurement plot, a 1-foot-square "U" shaped frame was placed so that the plot point stake was centrally located between the open ends of the frame. Then, all living and dead vegetation within the bounds of the frame were identified when possible, counted, and measured for height. With the plot points located on the right, we always placed the frame on the near side of the stakes. Using this procedure meant that all subsequent evaluations at that plot would be in the same spots.

At each release site permanent plot, five pine trees were located relative to the measurement plot center (bearing and distance), and their height and vigor were recorded. "Vigor" in this context refers to tree appearance, including tree color, limb shape, form and size, amount of annual growth, etc. The trees selected for this visual examination were not necessarily the closest ones to the plot center; they were selected at random to give a range of starting qualities for analysis of future change.

In addition, photographs were taken of each plot area and two individual plot points to obtain a permanent record of each plot. These photographs were: (a) plot overview from left side spray swath stake to the right, (b) plot point 3 at 10 feet from plot center, and (c) plot point 5 at 20 feet from plot center. Figures 7 through 9 show a typical set of plot photos.

Figure 7.—*Plot 4 overview.*

Figure 8.—*Plot 4—plot measurement point 3.*

Figure 9.—*Plot 4—plot measurement point 5.*

Aerial photographs were taken of each site to get an overall view of how well the site had been covered (figs. 10-12). The stark contrast between treated and untreated areas proved invaluable in showing areas missed during the spraying operation. Where tall aspen interfered with the spray pattern, narrow strips of untreated areas were present; slash piles, although known to have been treated, usually appeared as untreated areas, probably because mineral soil buildup and dry slash had not allowed the chemical to reach the soil below.

In August 1985 the sites were visited again. Each plot was remeasured, and plot photographs were taken as in the previous year. The sites were visited again in the late summer of 1986 for a short visual inspection. At this time, three growing seasons after treatment, most of the short-term effects of the hexazinone had dissipated. Much of the ground cover had returned, and aspen suckers were beginning to appear. The release-site pine trees had grown an average of 3 feet taller since treatment; those in the control areas were still very difficult to find.

The sites were revisited again in November 1990 to remeasure the pine trees on the release sites. Although we could find only 60 percent of the plots, most of those trees averaged 7 to 10 feet tall.

Figure 10.—*Aerial view of Mallard Shores.*

Figure 11.—*Aerial view of Mallard Creek.*

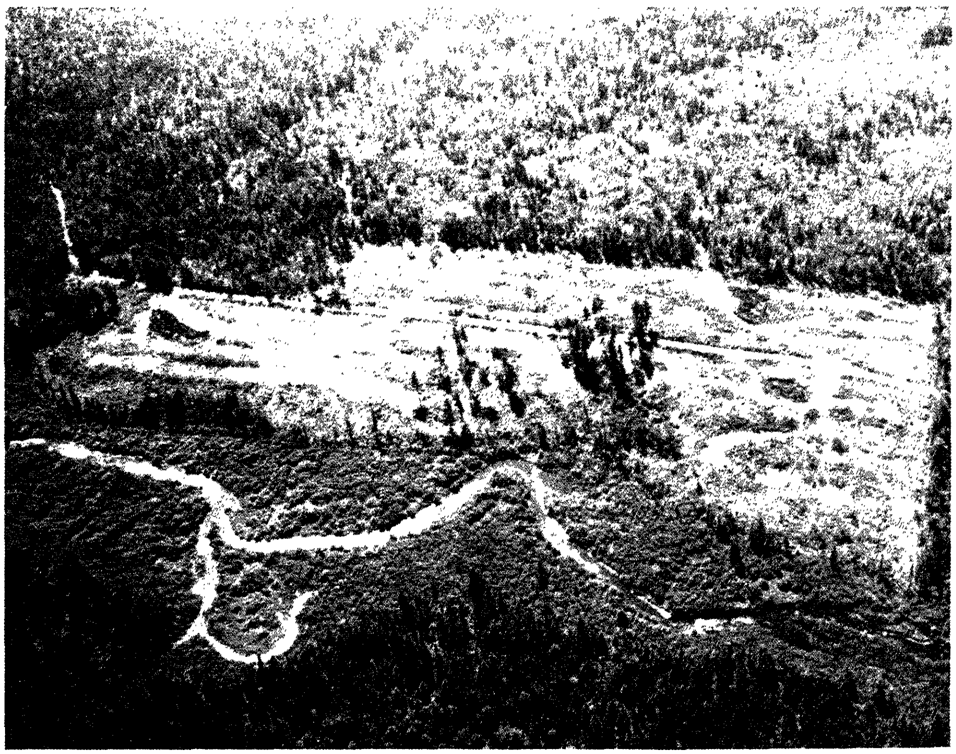

Figure 12.—*Aerial view of Deer Camp.*

DATA INTERPRETATION

The initial analysis necessary was to compare and evaluate any effects that the variable spray pattern might have had on the competition efficacy. This was required because the spray nozzle did not produce an even deposition over the width of the spray pattern. We were concerned because plot measurement points 1, 3, and 4 had received less chemical (20 percent on an average) than locations 2, 5, and 6 and might influence any further analysis. T-tests for independent groups were used to analyze and compare the data from the low points (1, 3, and 4) with those of the high-valued points for each spray rate. Comparisons were run for data results at the end of both years on all vegetation types for six sets of data—two treatments and three spray rates. At the 95-percent confidence level, few differences were found between the low and high points and were only significant as follows:

Grass at the end of year 1—twice
Sedge at the end of year 2—once
Raspberry at the end of years 1 and 2—once

After determining that the spray pattern did not influence the results at plot point locations, we could continue analyzing the effectiveness of the rate treatments. For this analysis, grass and sedge were considered only as to whether they were present or not, and all other vegetation classes—aspen, fern, raspberry, other (short—less than 9 inches in height), and other (tall—9 inches or taller in height)—were recorded as to the quantity per plot and height. All vegetation was grouped into subcategories of either alive or dead.

For each treatment type, release and site preparation, and for each spray rate level, paired T-tests were used to determine if there was a significant difference in vegetation between the "before" and "after 1 year" and between the "before" and "after 2 years." Preliminary results showed little difference between the 1/4-gpa steps used in treatments; i.e., the 3/4-gpa treatment results were similar to those of the 1-gpa treatment results. Therefore, the data were grouped into three spray rate groups: (a) low - 1/4 and 1/2 gpa, (b) medium - 3/4 and 1 gpa, and (c) high - 1-1/4 and 1-1/2 for each treatment. Combining the data increases the confidence level of the results and further simplifies the analysis because there are more observations for each treatment level.

On the two sites with special treatment plots, Simon Sale and Dragon Pond, the granular rates were compared with the equivalent liquid rates by means of T-tests for independent groups. The results showed that at a 95-percent confidence level, the only significant differences were in the amount of sedge at the end of year 2 when the chemical was applied at the medium rate of 1 gpa or 20 ppa; at the 90-percent confidence level, there were significant differences for the low rate (1/2 gpa or 10 ppa) in ferns at the end of year 1, and for the medium rate (1 gpa or 20 ppa) for both sedge and ferns at the end of both years 1 and 2. At the high rate (1-1/2 gpa or 30 ppa), there were no significant differences.

TREATMENT RESULTS

Most comparisons showed significant differences at the 90-percent confidence level; a summary of results for the individual vegetation types follows:

GRASS - Figure 13. The percentage of measurement plots that contained live grass after treatment was significantly lower at the end of the first year for both treatment types at all rates and significantly higher at the end of year 2 on release sites.

SEDGE - The percentage of plots that contained live sedge showed a significant reduction for all rates for both treatment classes (fig. 14).

FERNS - Figure 15. There were significantly fewer ferns in both year-end results for both treatment types at all spray rates except at the low rate at the end of year 2 on site preparation sites.

ASPEN - In general, the number of aspen in the plot measurement points was very low so the true effectiveness of the chemical was

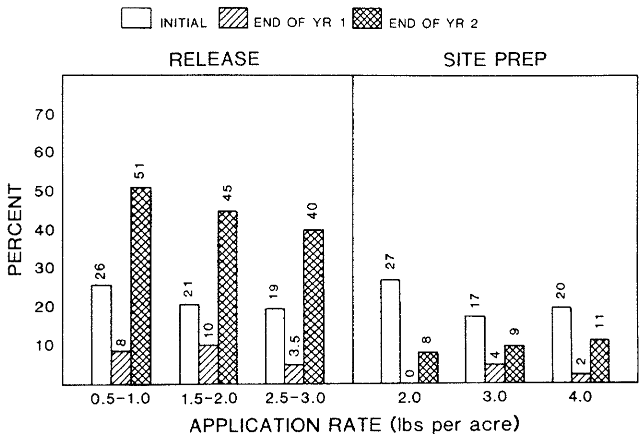

Figure 13.—*Plots containing live grass.*

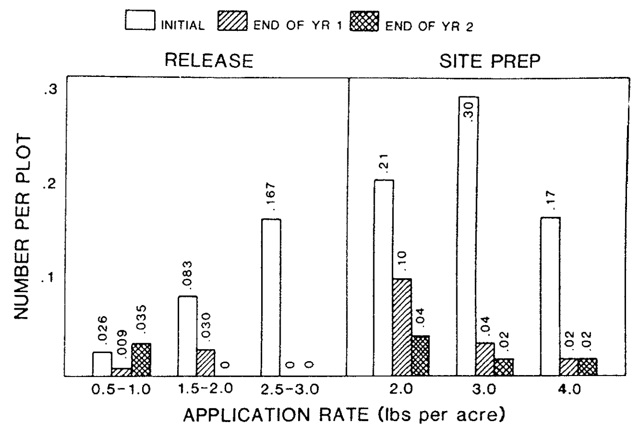

Figure 16.—*Average number of live aspen.*

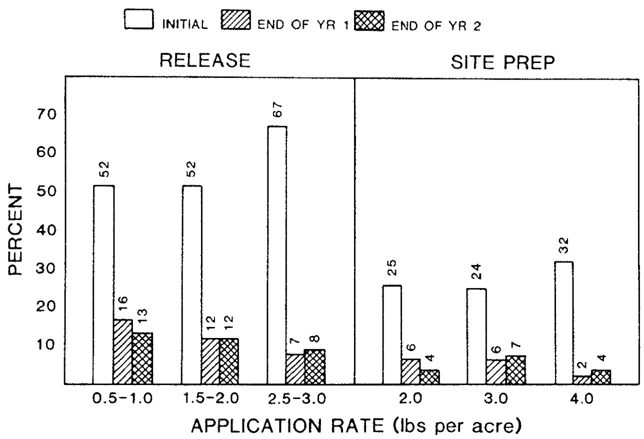

Figure 14.—*Plots with live sedge.*

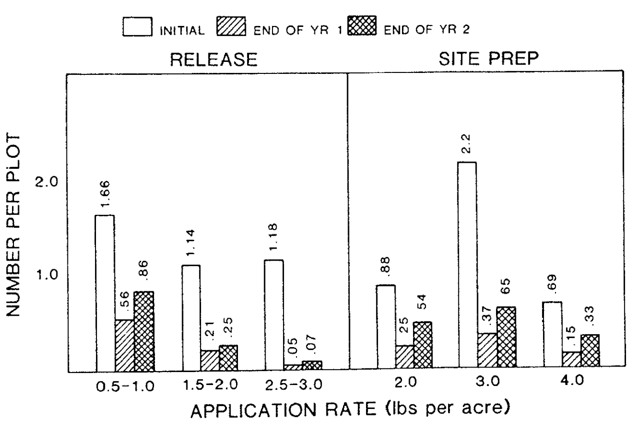

Figure 15.—*Average number of live ferns.*

difficult to determine. However, of those plots that did contain aspen, the trend indicated a reduction for both years except in the low-rate, release-site treatment (fig. 16).

RASPBERRY - Figure 17. All release treatments were very effective for all chemical rates. Site preparation sites did not contain enough raspberry to perform an effective analysis.

LIVE, SHORT PLANTS (Less than 9 inches tall) - This classification had mixed results but had a general decrease in year 1 followed by an increase in year 2. Only the heaviest site preparation rate showed a decrease in the second year (fig. 18).

LIVE, TALL PLANTS (9 inches and taller) - In general, the number of plot measurement points that contained live, tall plants was very low, and it was difficult to determine the true chemical effectiveness. It appears that the trend for this classification was unaffected by treatment type or treatment rate (fig. 19).

An analysis of like spray rates in release and site preparation treatments was conducted using T-tests for independent groups. Two corresponding rates were analyzed—1 and 1-1/2 gpa. There were major differences in the condition of the plots before treatment. Some of these differences were: (1) significantly less sedge and raspberries

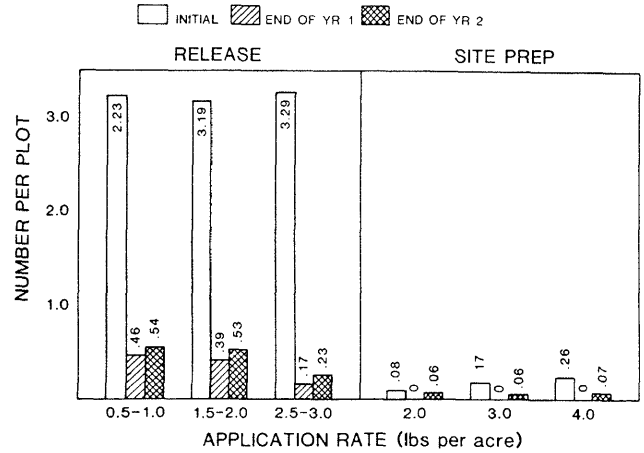

Figure 17.—*Average number of live raspberry.*

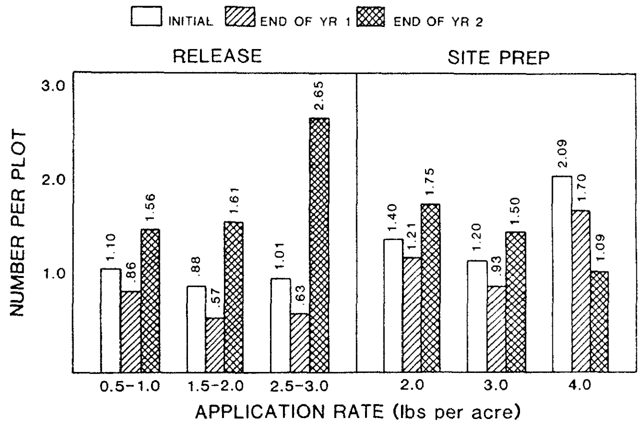

Figure 18.—*Live, short plants.*

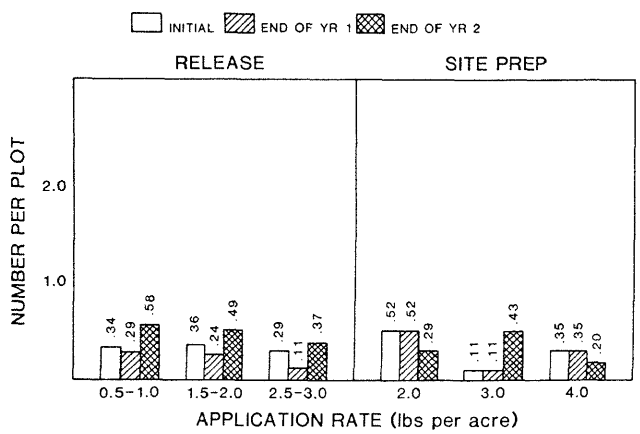

Figure 19.—*Live, tall plants.*

and more aspen in the site preparation plots before treatment, and (2) more ferns in the site preparation plots receiving the middle rate, but that probably was a random happening. Analysis after treatment showed several differences. The significant differences that were less likely to be a chance happening were: (1) less grass after the first year on site preparation sites and much more after the second year on release sites; (2) significantly less raspberry on site preparation sites at the end of both years, but these sites started out with less so the results are somewhat inconclusive.

An analysis of variance was used to determine any differences between spray rate levels for each treatment, release and site preparation, individually. In the release treatments, the lowest rate was not as effective on the ferns as the medium and high rates at the 99-percent confidence level. The low rate was also not as effective on aspen at the 90-percent confidence limit, but that can be attributed to the limited number of aspen in the measurement plots. Also, there were significantly more short plants at the end of 2 years at the 95-percent confidence level in the high spray rate areas. On the sites that were treated for site preparation, no significant differences were found between each of the spray rate levels.

The average tree height in the initial year was 1.4 feet. After one growing season, the average height was 2.1 feet; after 6 years the average height was 6.5 feet. This is an annual average growth of 10 inches per year. Figure 20 shows average tree red pine tree height versus chemical rate grouping for each of the three measurement periods.

Another interesting comparison (fig. 21) shows the 6-year incremental growth for each chemical rate group, with combined common rates of liquid and granular herbicide. The 3/4- and 1-1/2-gpa rates had the largest growth after treatment, 5.4 feet, and the 1/4- and 1-1/4-gpa rates showed the least growth during the 6 years after treatment, 4.5 feet. Because of the differences in 6-year growth, one might conclude that there was some sort of site or chemical influence on the red pine growth rate. Such influences could be soil-related, site index (SI) ratings, site harvesting method and preparation before planting,

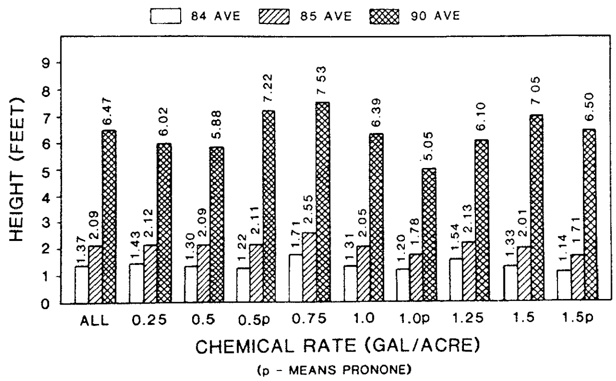

Figure 20.—*Red pine tree height*

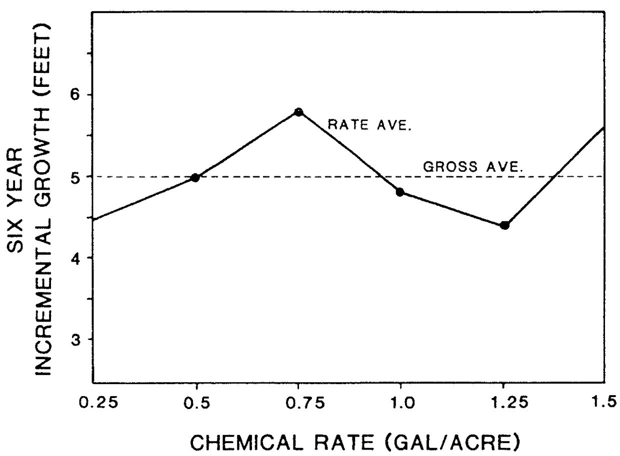

Figure 21.—*Six-year incremental growth of red pine.*

or the chemical rate itself. Information taken from the Landtype Association (LTA) mapping of the Iron River Ranger District shows that the site index averaged 72 +/- 3 for these particular sites, which practically eliminates soil differences as a factor affecting growth rate. Further analysis of growth patterns was not done because of lack of data on other variables.

TIME STUDY RESULTS

To estimate costs of a ground application process and to ascertain if ground application would be economically feasible in lieu of aerial application, complete and accurate records were maintained of the time consumed. The application process was divided into the following three major categories and their subgroups:

Productive time	**Mechanical delays**	**Nonmechanical delays**
Fill and mix	Start pump motor	Discuss
Travel loaded	Repair	Stuck
Spray	Shift gears	Calculate
Turn around		Observe
Travel empty		
Travel between areas		
General productive time		

All sites but Simon Sale and Dragon Pond were studied in this manner. These two sites which contained special treatment plots, were not part of the time study. An initial analysis showed that 33.4 hours were spent treating 161.8 acres on the nine sites. The productive time amounted to 27.6 hours or 83 percent of the total time. Production rates for the project were 4.8 acres/hour (total time element) and 5.9 acres/hour (productive time element). Actual spraying took place for 41 percent of the productive time.

All but one of the nine sites were treated with varying chemical rates, and as such, required travel trips to refill the tank with a new chemical mixture. In a commercial operation, these trips would have been unnecessary. Had each site been treated with a single mixture rate, the only return trips required would have been when the sprayer tank was empty. A 300-gallon tank allowed 12 acres to be treated per trip. Because the primary objective of our study was to obtain cost data on a simulated commercial ground applied herbicide operation, the time study data were modified to eliminate those times directly associated with the chemical rate performance portion of the application procedure but they do include return trips for each 12-acre block on each site. Times eliminated involved travel associated with changing the chemical mix, new mix compute time, and time involved with a press interview. This modification reduced the total project time to 25.5 hours and the productive time to 21.4 hours. The productive time/total time remains proportionally the same at 84 percent, but site production rates increased significantly to 6.4 and 7.5 acres per hour, respectively. This is a 30-percent increase in productivity over that obtained using the raw time study data.

A cost analysis for the system operation was completed to determine the cost/acre, exclusive of the chemical costs. (See Appendix C for time study machine rate calculations.) The ground application system consisted of: (a) a Tree Farmer, C5D, forwarder with operator, (b) a liquid herbicide application system, (c) a heavy-duty, 4x4, 1-ton pickup with a 75-gallon firefighting pump package and operator, and a utility trailer with a 275-gallon water tank. We found that the project costs/scheduled hour for the three components were: (a) forwarder, \$43.06; (b) sprayer, \$26.00; and (c) pickup, \$22.55, for a total of \$91.61 per scheduled hour. At 161.8 acres, modified total time of 25.5 hours, and productive time of 21.4 hours, the projected costs correspond to \$14.44 per acre and \$12.12 per acre, respectively.

SUMMARY

The primary objective of the chemical rate efficacy study was to document the effects that various hexazinone rates have on competing vegetation. Through micro-site analysis and visual site appraisal, we found that hexazinone at all rates appeared to adequately control the competition. Three years after herbicide application, most of the initial effects of the treatments had dissipated, and much of the ground cover was returning, as indicated by the micro-site analysis of the previous year. Red pine trees on release sites had grown to more than 3 feet tall and were quite visible, while those in the control areas were still difficult to find. Ground cover immediately around each tree was less than in the open areas due to increased shading by the taller trees. This reduces the amount of sunlight reaching adjacent competition, which in turn increases the amount of moisture available for further growth. Although we found that rates lower than those recommended by the manufacturer appear to adequately control competition, users should test these rates first to determine if they are suitable for specific sites.

The time study/cost analysis estimated the per acre application costs at \$14.44. This cost is well below that of recent aerial applications. A footnote to the time study/cost analysis: for the 4 years after the trials on the Ottawa National Forest one of the authors helped develop both liquid and granular herbicide computer-controlled applicating systems for the Chequamegon National Forest (Wehr *et al.* 1986). The liquid spray system cost about \$7,000, and application costs were \$15 per acre exclusive of herbicide cost. Contract spraying costs for fiscal year 1984 were \$40 per acre. These figures compared favorably with our time study/cost results here. The granular spreader cost \$2,500 and used the computer control module from the liquid system. Per acre costs of this unit were \$7 as compared to \$12 to \$14 for hand application. The systems have been so successful and cost effective that neighboring National Forests have been contracting with the Chequamegon for herbicide application.

When the release-site pine trees were remeasured in 1990, a distinct difference between sites was noted in the visual quality of the trees, as was previously mentioned. The observed quality differences were between sites and not within a site. There were some initial differences between the sites in the way in which the sites were harvested and mechanically prepared before the pine seedlings were planted, and there were differences in the chemical rates applied to the sites. Additional studies are needed to determine which factors influenced the growth rate the most.

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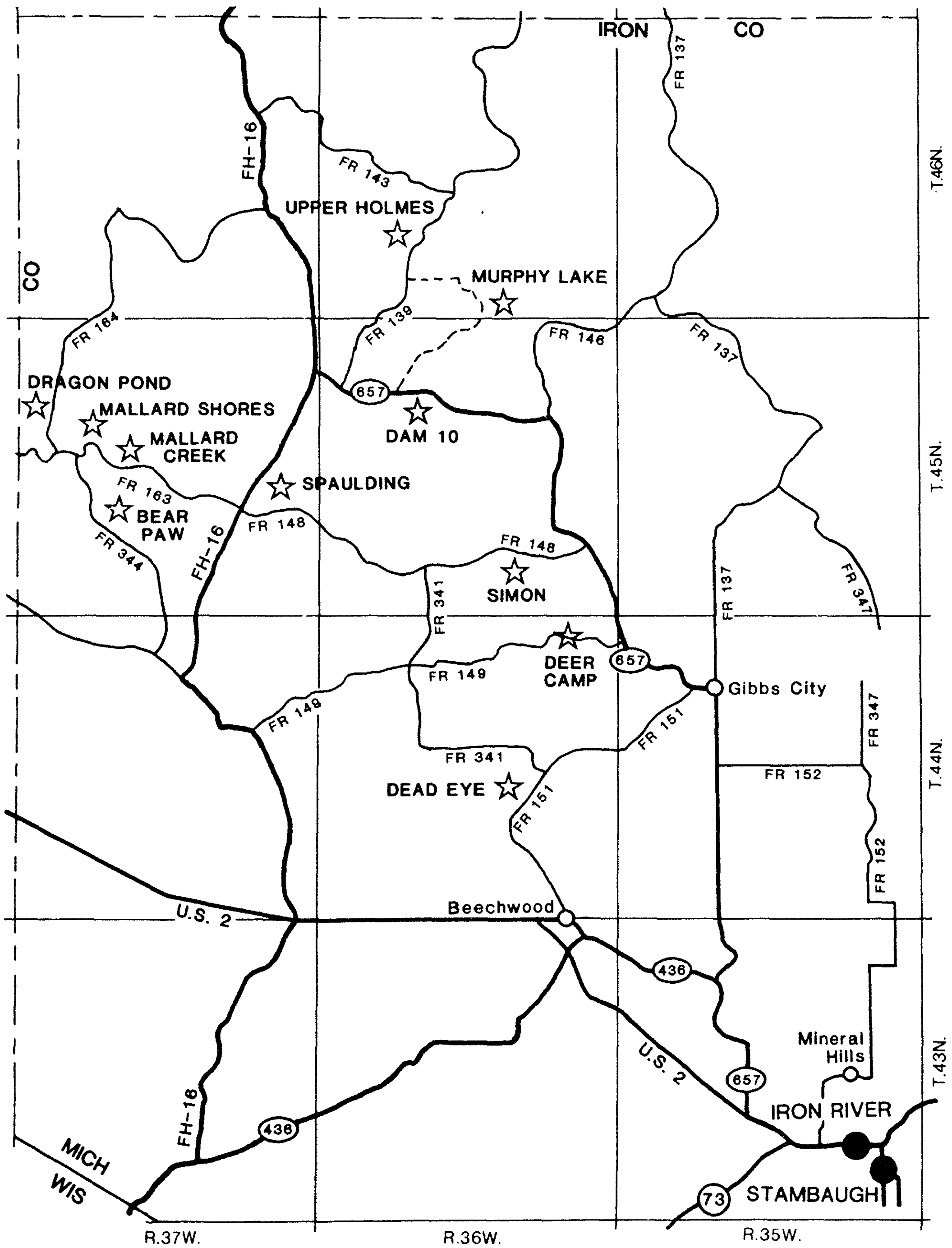
APPENDIX A

Site Location Map



APPENDIX B

Site Maps

Dead Eye

Deer Camp

Dam 10 No. 5

Murphy Lake

Upper Holmes

Spaulding Dam No. 5

Mallard Shores

Mallard Creek

Bear Paw

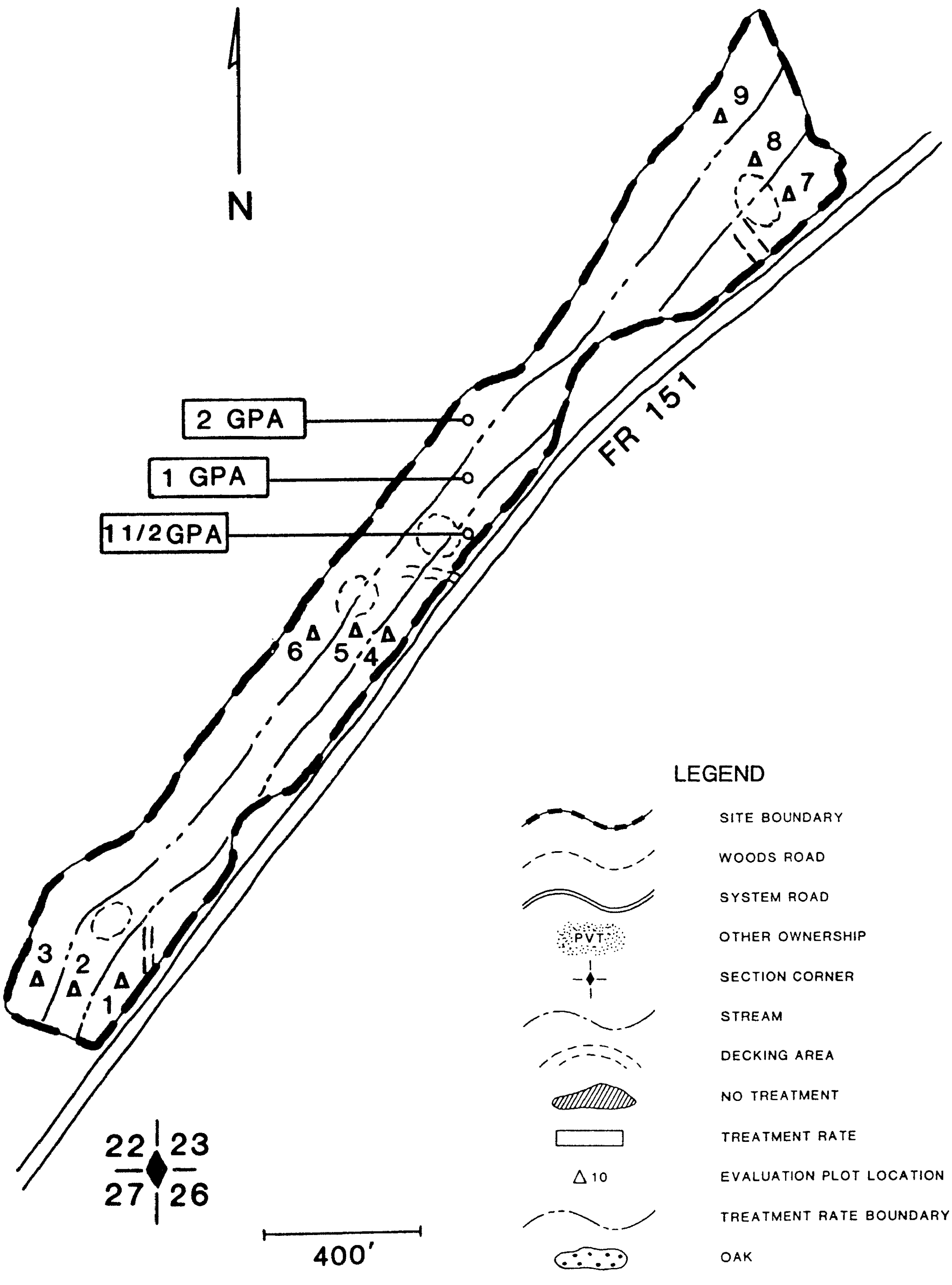
Simon Sale

Dragon Pond

OTTAWA N.F. IRON RIVER RANGER DISTRICT

T44N, R36W COMPARTMENT 86

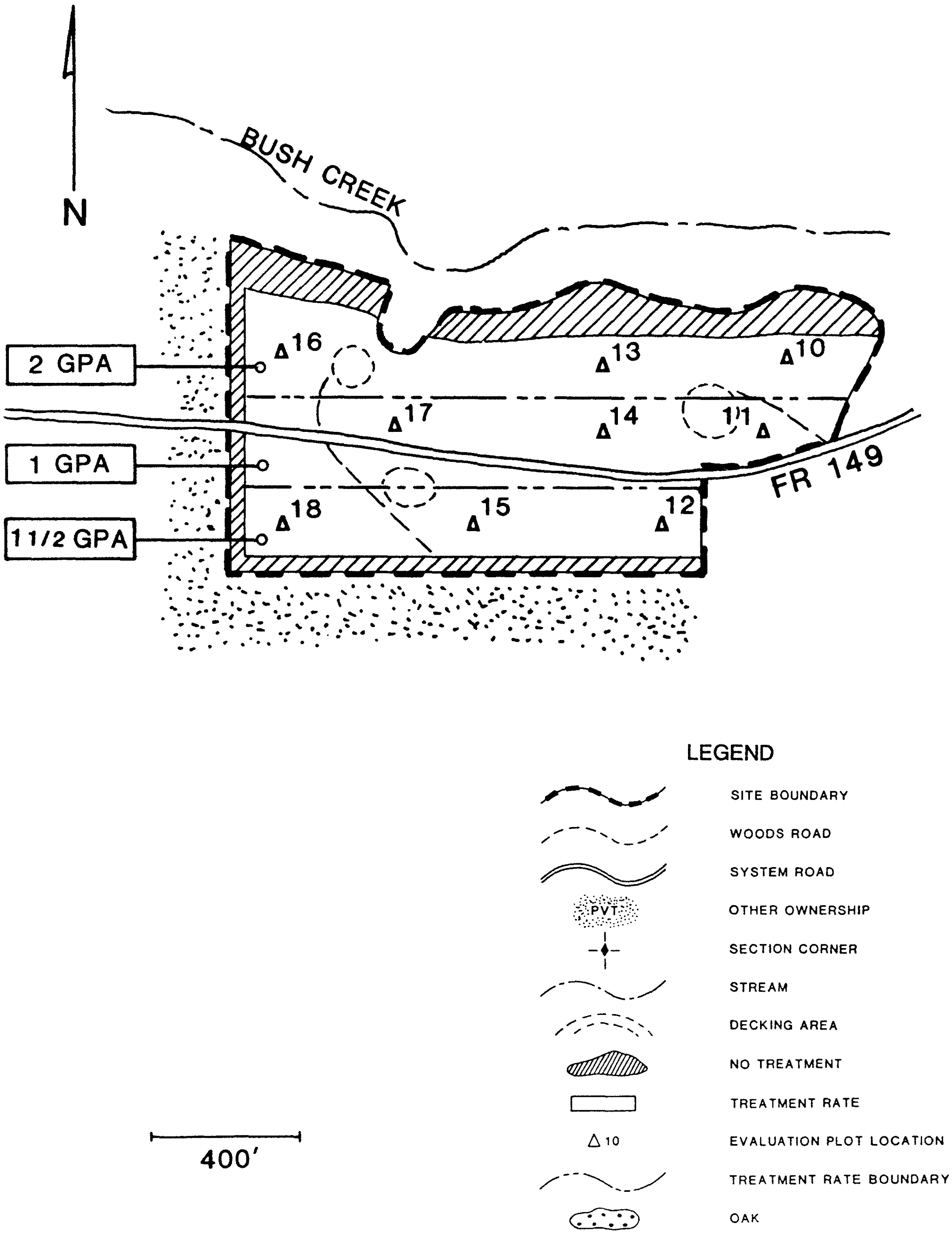
SECTION 23 DEAD EYE 19 ACRES



OTTAWA N.F. IRON RIVER RANGER DISTRICT

T44N, R36W COMPARTMENT 64

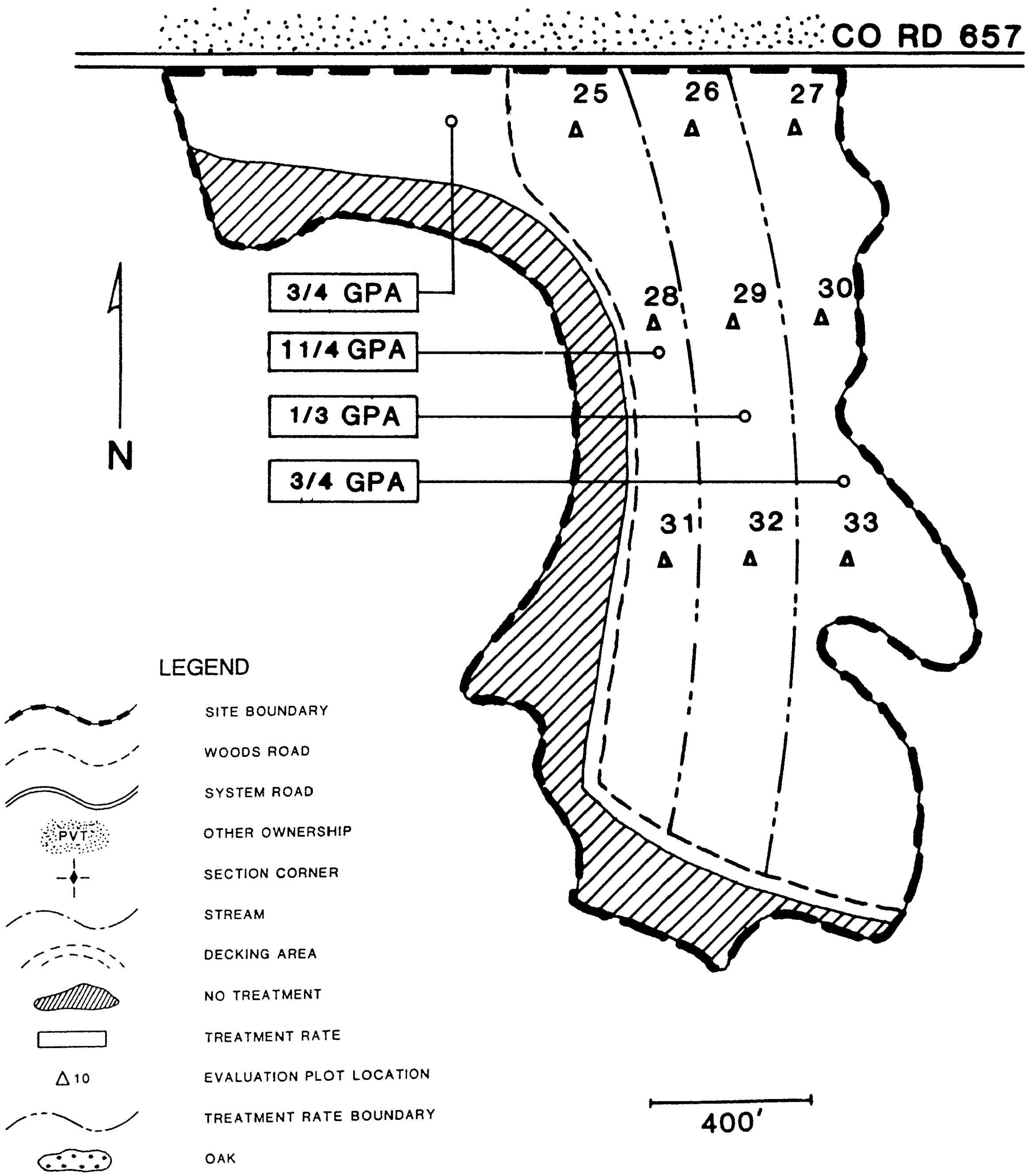
SECTION 1 DEER CAMP 23 ACRES



OTTAWA N.F. IRON RIVER RANGER DISTRICT

T45N, R36W COMPARTMENT 32

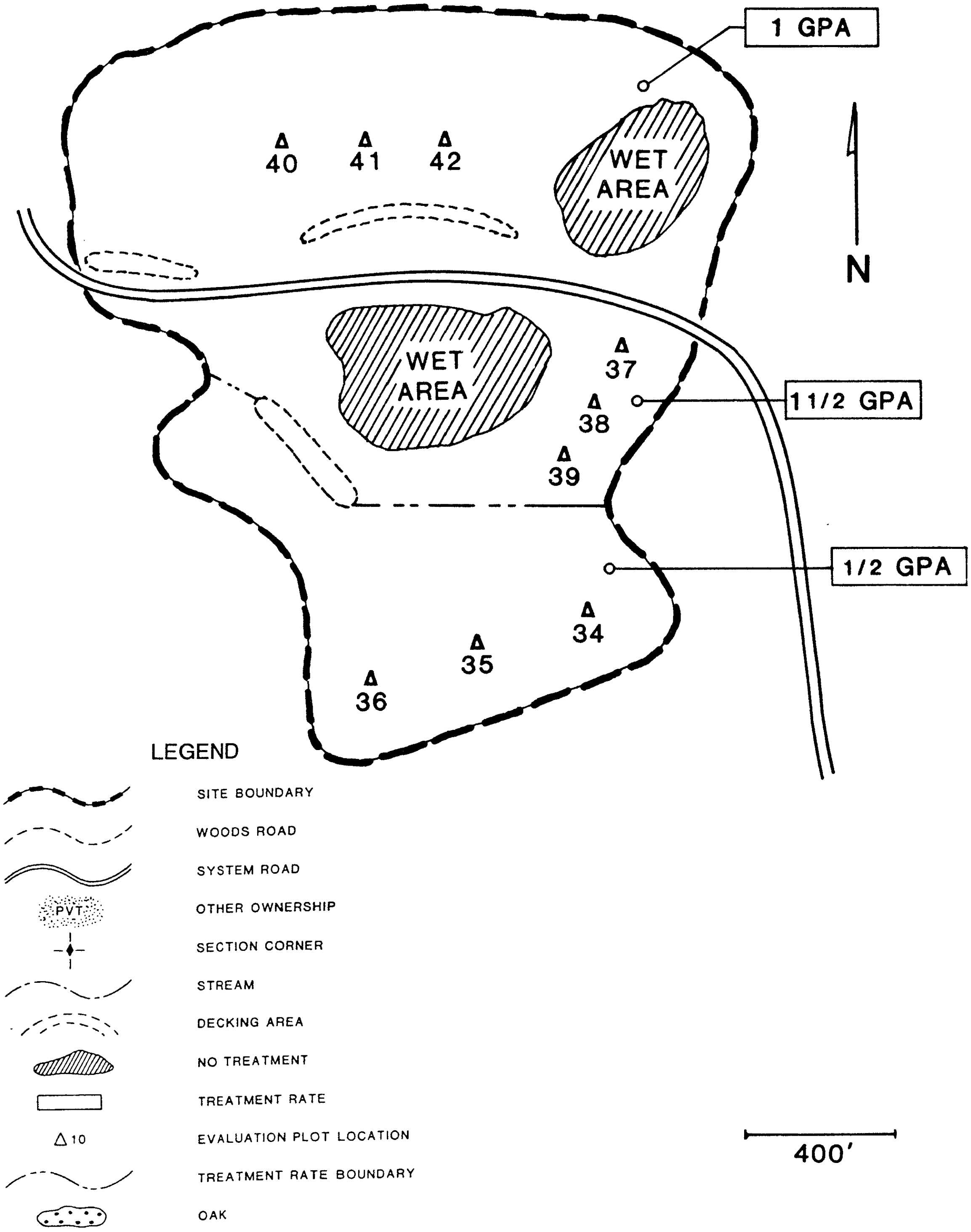
SECTION 9 DAM 10 #5 45 ACRES



OTTAWA N.F. IRON RIVER RANGER DISTRICT

T 46N, R36W **COMPARTMENT 8**

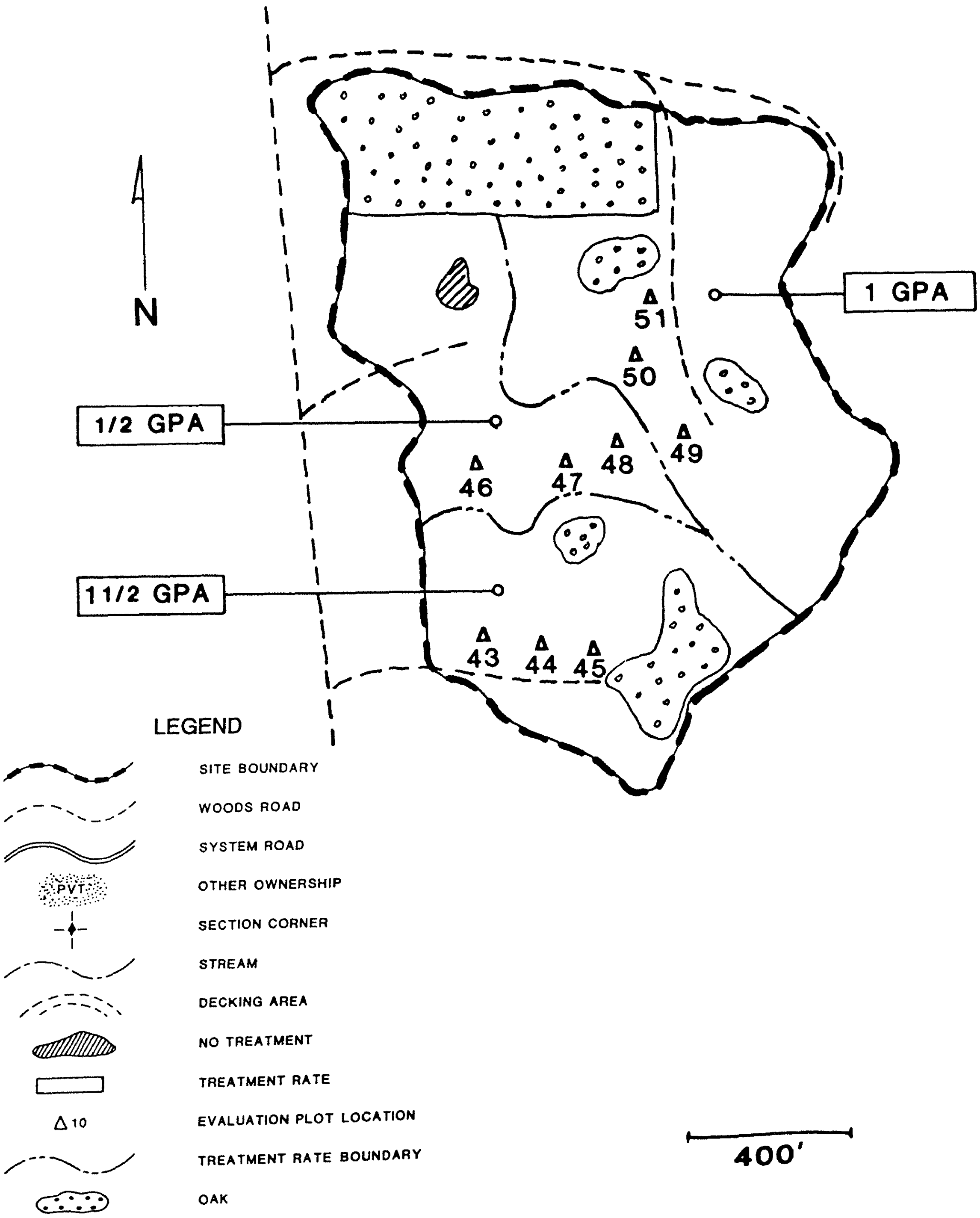
SECTION 33 **MURPHY LAKE** **32 ACRES**



OTTAWA N.F. IRON RIVER RANGER DISTRICT

T46W, R36W COMPARTMENT 9

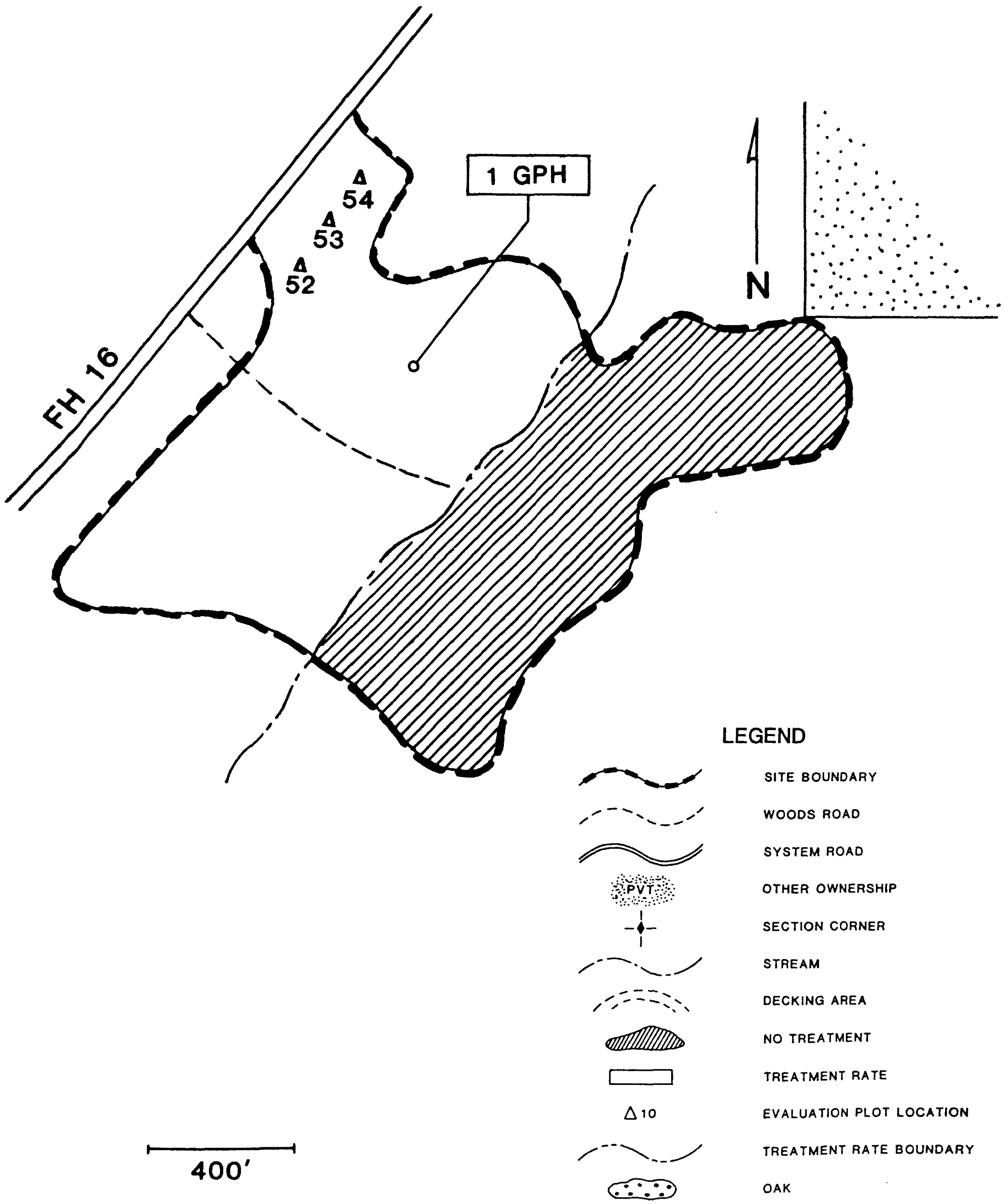
SECTION 29 UPPER HOLMES 30 ACRES



OTTAWA N.F. IRON RIVER RANGER DISTRICT

T45N, R37W **COMPARTMENT 41**

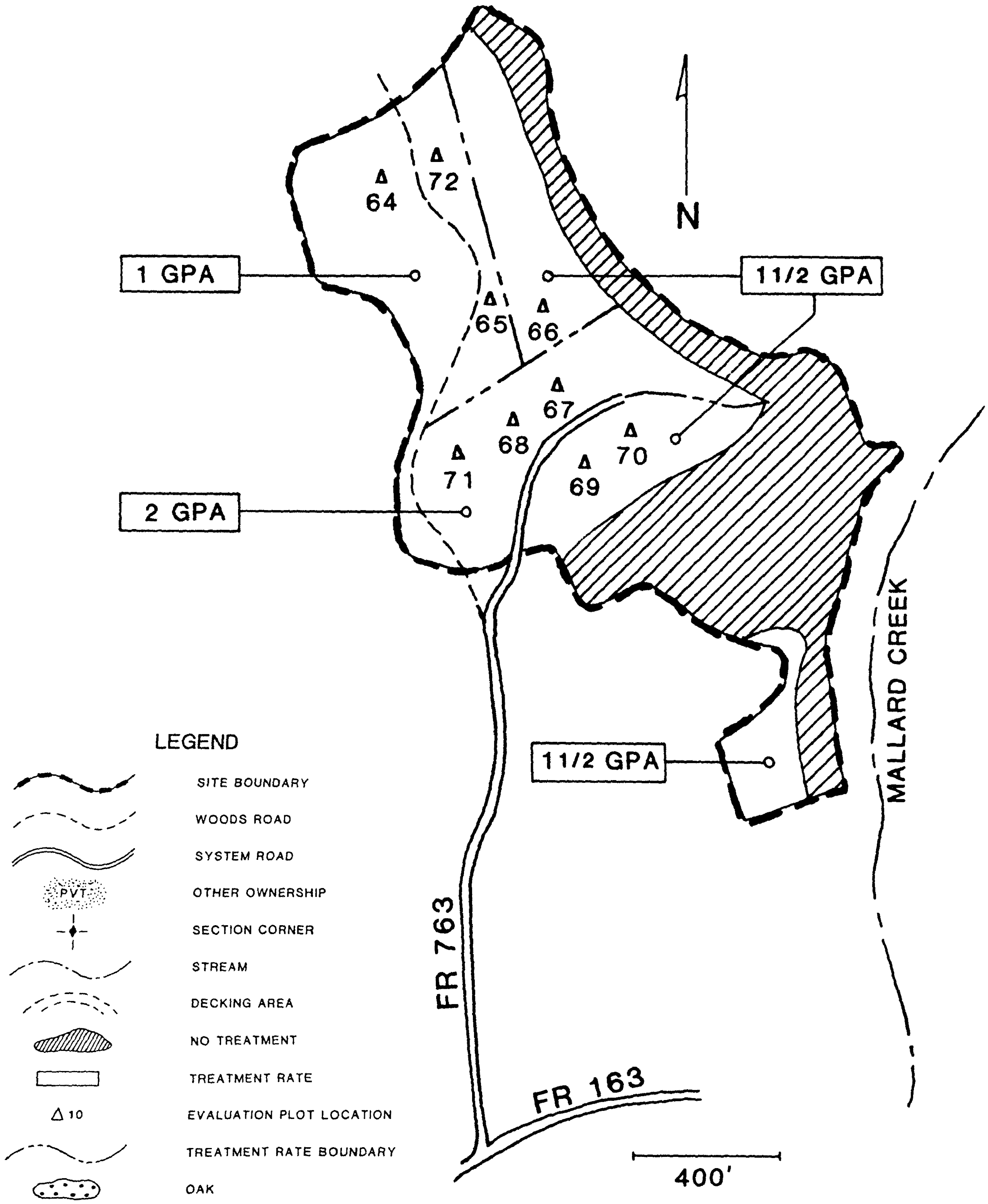
SECTION 24 **SPAULDING DAM #5** **20 ACRES**



OTTAWA N.F. IRON RIVER RANGER DISTRICT

T 45N, R37W COMPARTMENT 36

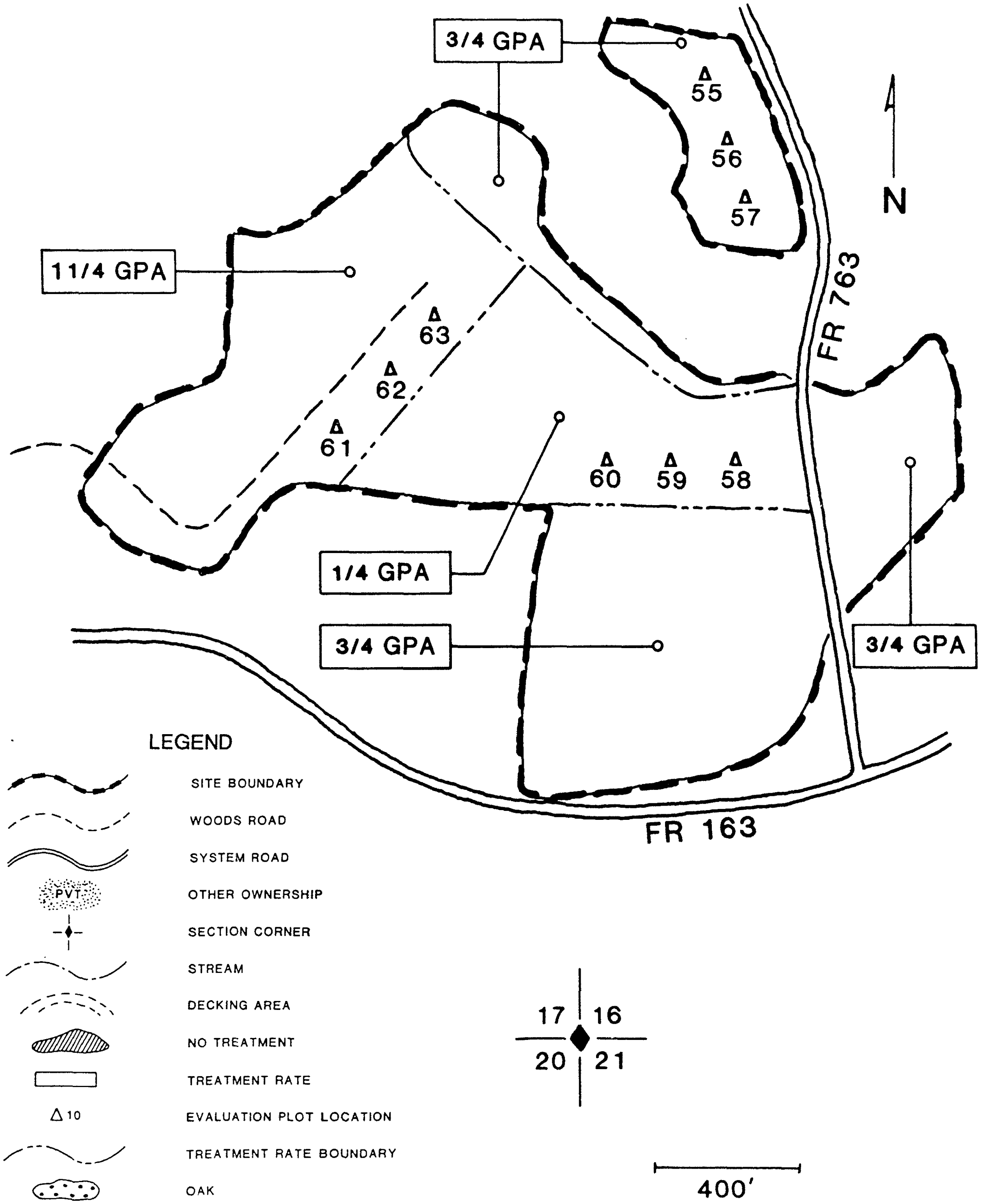
SECTION 16 MALLARD SHORES 20 ACRES



OTTAWA N.F. IRON RIVER RANGER DISTRICT

T45N, R37W COMPARTMENT 36

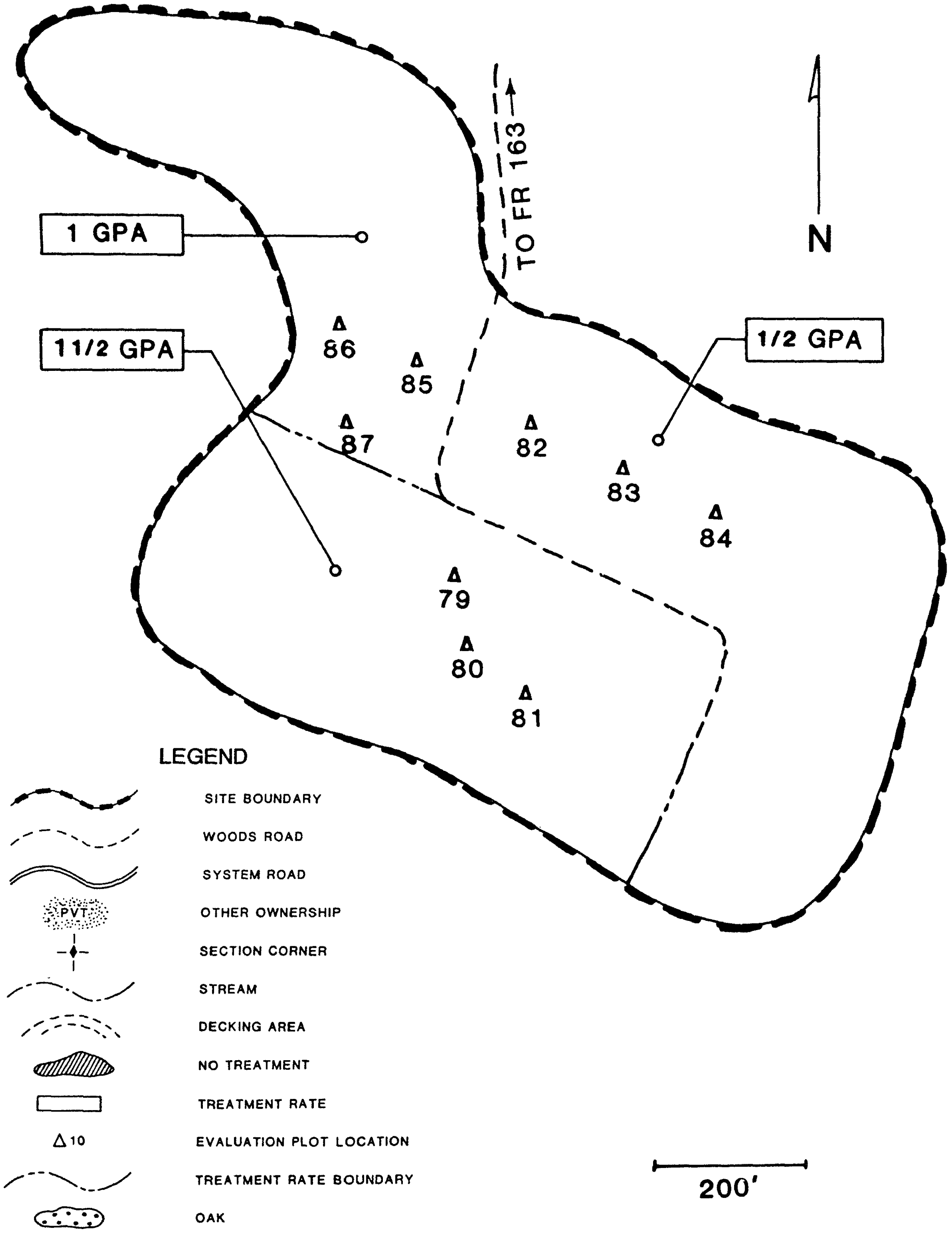
SECTIONS 16 & 17 MALLARD CREEK 56 ACRES



OTTAWA N.F. IRON RIVER RANGER DISTRICT

T45N, R37W COMPARTMENT 39

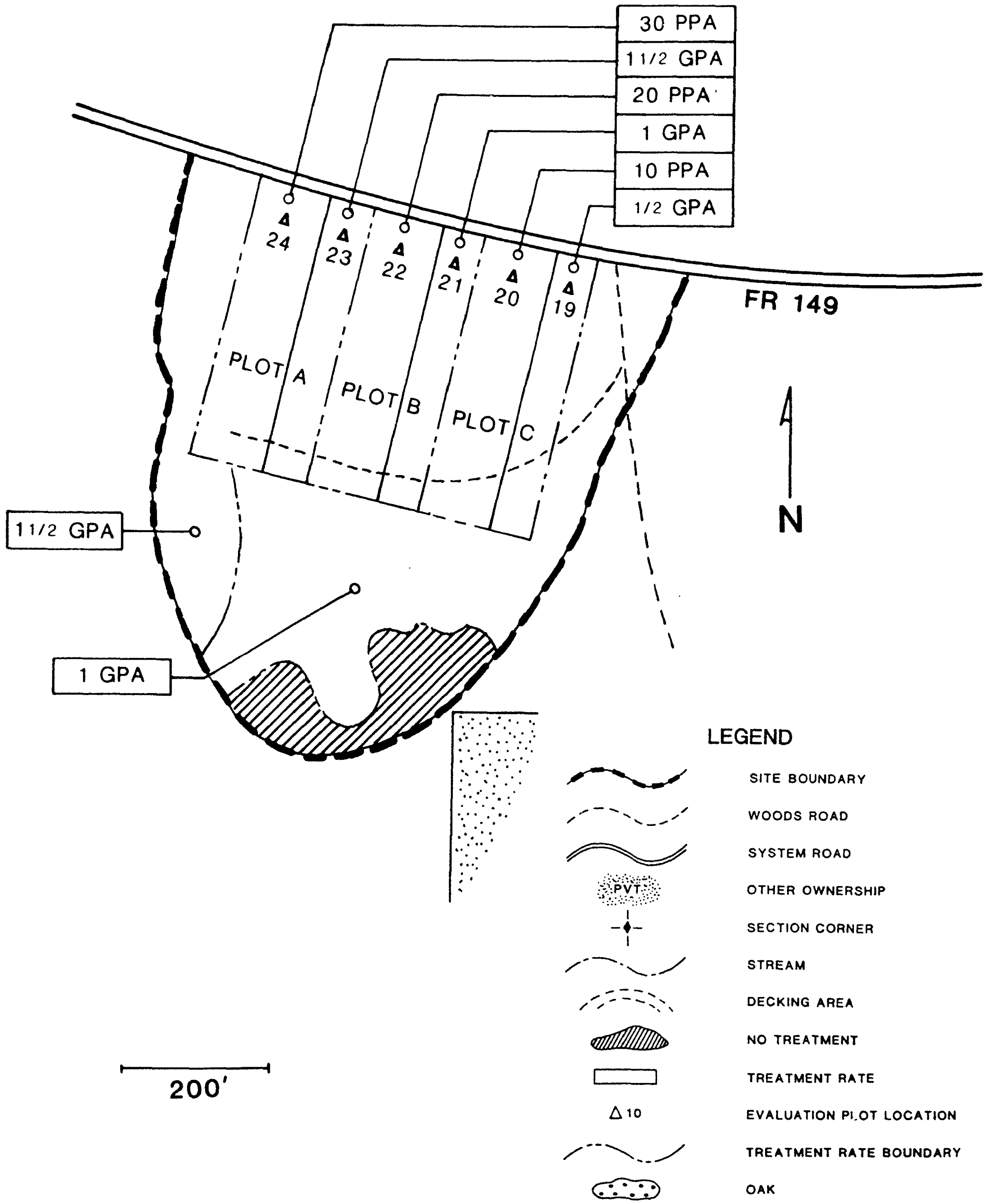
SECTION 20 BEAR PAW 20 ACRES

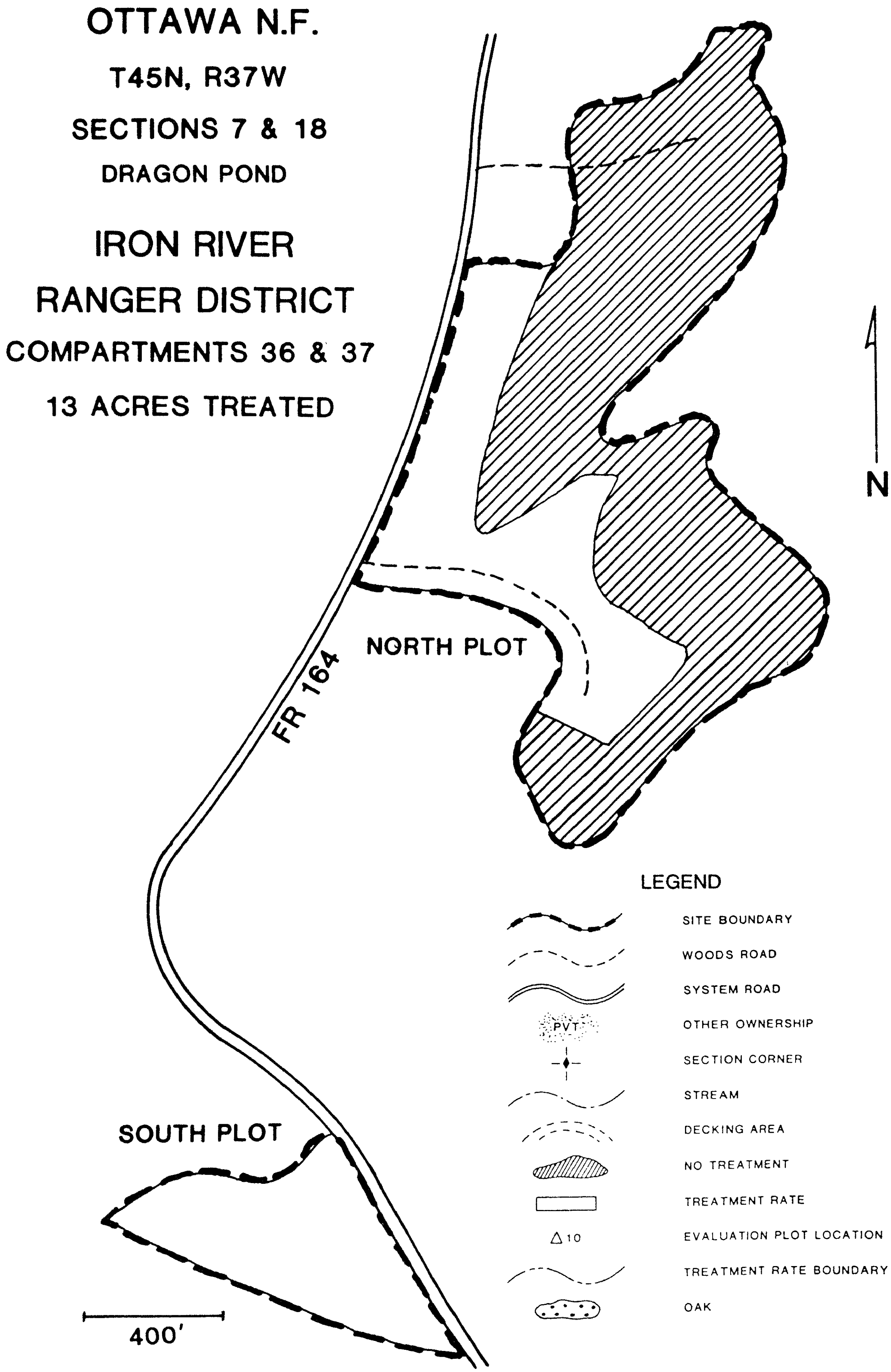


OTTAWA N.F. IRON RIVER RANGER DISTRICT

T45N, R36W COMPARTMENT 51

SECTION 26 SIMON SALE 10 ACRES

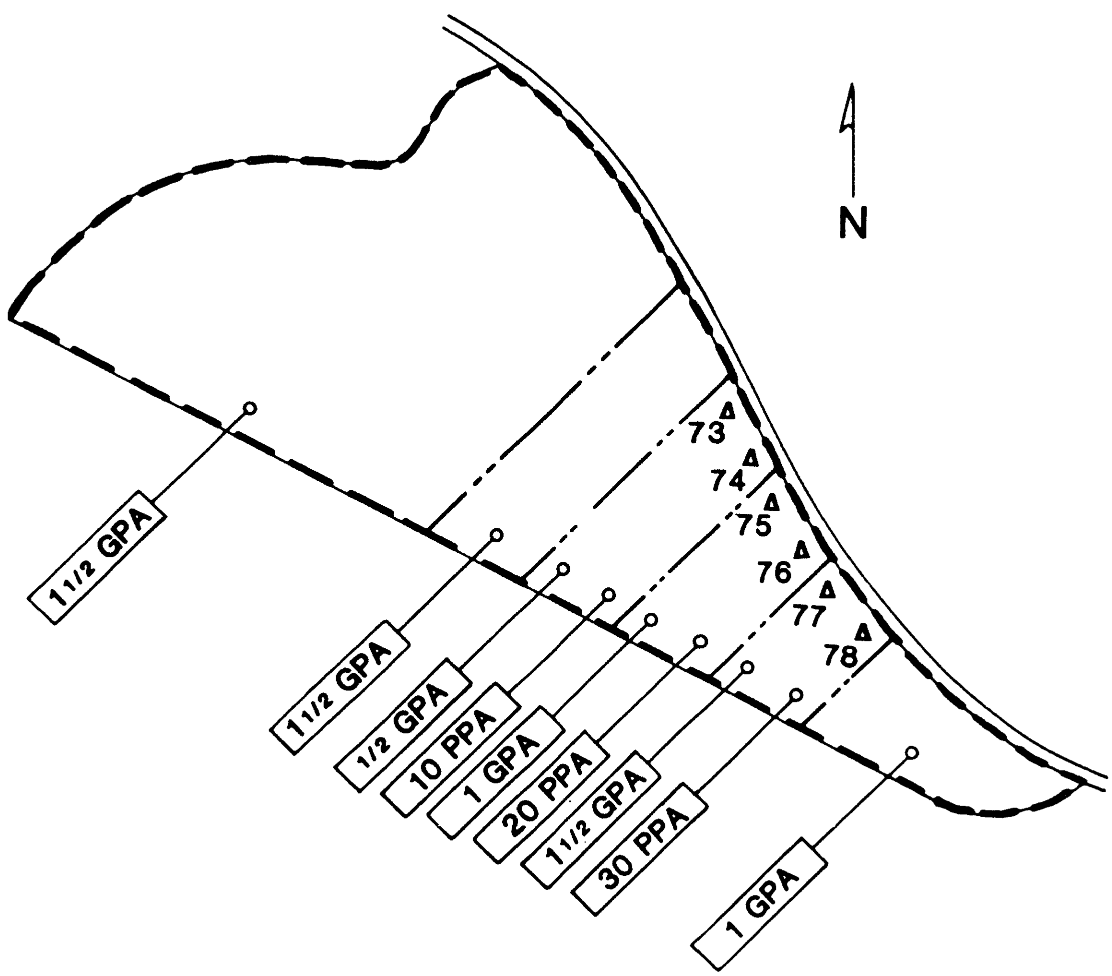




OTTAWA N.F.
T45N, R37W
SECTIONS 7 & 18
DRAGON POND
IRON RIVER
RANGER DISTRICT
COMPARTMENTS 36 & 37
13 ACRES TREATED
N
NORTH PLOT
FR 164
SOUTH PLOT
400'
LEGEND
SITE BOUNDARY
WOODS ROAD
SYSTEM ROAD
PVT
OTHER OWNERSHIP
SECTION CORNER
STREAM
DECKING AREA
NO TREATMENT
TREATMENT RATE
10
EVALUATION PLOT LOCATION
TREATMENT RATE BOUNDARY
OAK

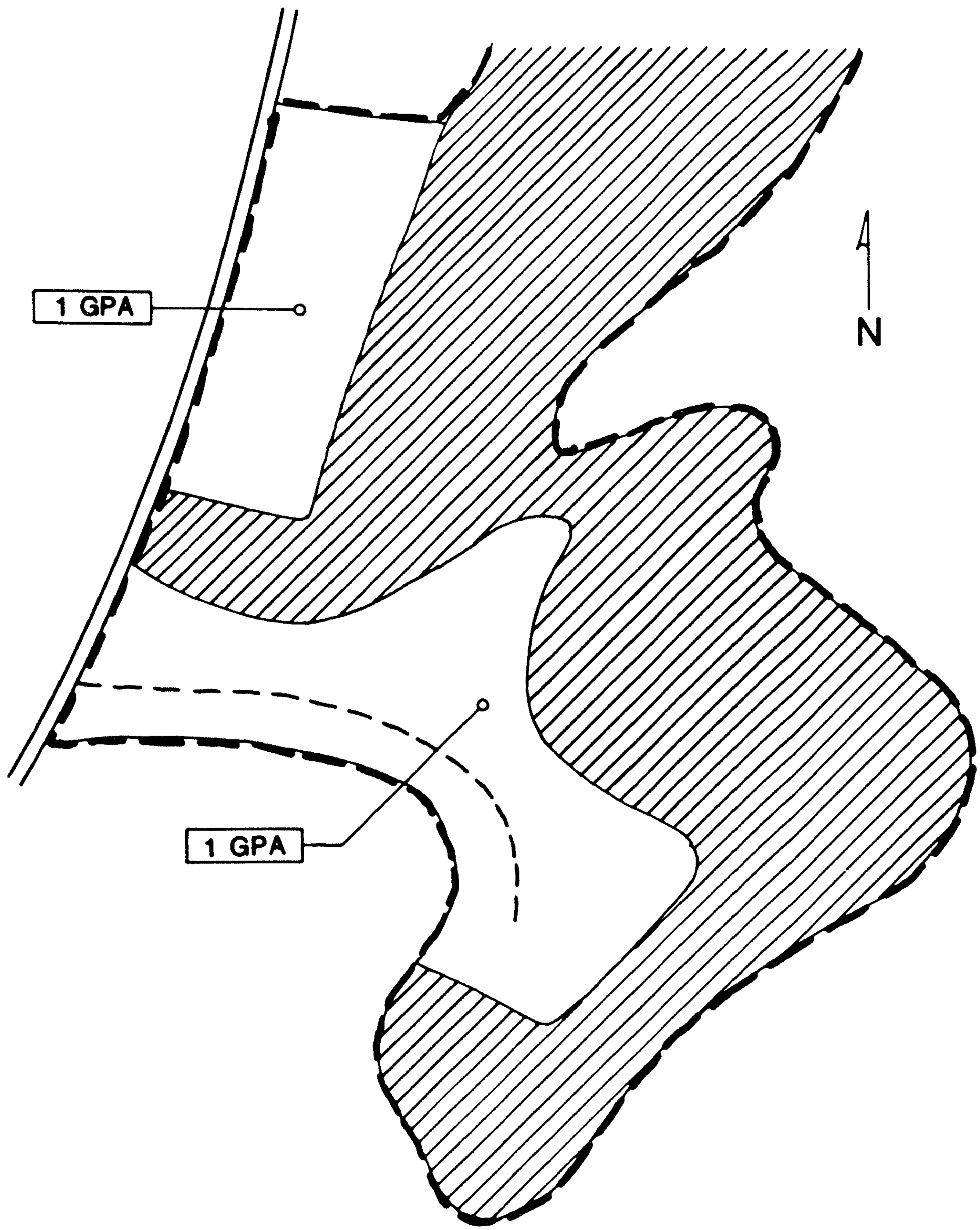
SOUTH PLOT

DRAGON POND



NORTH PLOT

DRAGON POND



APPENDIX C

Time Study Machine Rate Calculations

Actual 1984 System

Forwarder

Liquid Application System

Heavy-Duty, 1-Ton Pickup

MACHINE RATE CALCULATIONS
(Off-Road Equipment)

Description

Machine (make, model, type) Medium forwarder
Engine (hp, type) 100 hp diesel Accessories or Modifications
Initial Investment (P) - F.O.B Delivered Cost = $ 83,000
Economic Life (n) 4 years
Salvage Value (S) 20 % of P = $ 16,600
Scheduled Hours (SH) per Year 2,000 hours
Machine Utilization (U) 65 %
Productive Hours (PH) per Year 1,300 hours

Average Annual Investment (AAI) = [(P-S)(n+1)/2n] + S = $ 58,100 /yr

Ownership Costs

Depreciation (D) - Straight Line Method = (P-S)/n = $ 16,600 /yr
Interest 12 %
Insurance 7 %
Taxes 3 %
Overhead 8 %
Total 30 % x AAI $ 58,100 /yr = $ 17,430 /yr

Total Ownership Cost per Year = $ 34,030 /yr

Total Ownership Cost per Scheduled Hour = $ 17.02 /SH

Operating Costs

Repair/Service (% of D) 100 % x (D) $ 16,600 /yr/(1,300 PH/yr) = $ 12.77 /PH
Fuel ___ hp x ___ gal/hp-hr x $___ /gal = $ 2.75 /PH
Oil/Lubrication ___ % of fuel cost = $ 1.02 /PH
Tires [(n x PH/yr) - 1] [(1.15 x # tires x $/tire)/(n x PH/yr)] = $ 0.44 /PH

Total Operating Cost per Productive Hour = $ 16.98 /PH

Labor Costs

Hourly Wage = $ 10.00 /SH
Wage Taxes = 25 % of hourly wage = $ 2.50 /SH
Fringe Benefits = 25 % of hourly wage = $ 2.50 /SH

Total Labor Cost per Scheduled Hour = $ 15.00 /SH

Machine Rate

Total Cost per SH = ownership + operating x U + labor = **$ 43.06 /SH**

MACHINE RATE CALCULATIONS
(Off-Road Equipment)

Description

Machine (make, model, type) Liquid herbicide application system (skid mount)
Engine (hp, type) 8 hp gas   Accessories or Modifications ____

Initial Investment (P) - F.O.B Delivered Cost =		$ 3,000
Economic Life (n)	3 years	
Salvage Value (S)	0 % of P =	$ ____
Scheduled Hours (SH) per Year	100 hours	
Machine Utilization (U)	65 %	
Productive Hours (PH) per Year	65 hours	

Average Annual Investment (AAI) = [(P-S)(n+1)/2n] + S = $ 2,000 /yr

Ownership Costs

Depreciation (D) - Straight Line Method = (P-S)/n =		$ 1,000 /yr
Interest	12 %	
Insurance	7 %	
Taxes	3 %	
Overhead	8 %	
Total	30 % x AAI $ 2,000 /yr =	$ 600 /yr
Total Ownership Cost per Year =		$ 1,600 /yr
Total Ownership Cost per Scheduled Hour =		**$ 16.00 /SH**

Operating Costs

Repair/Service (% of D) 100 % x (D) $ 1,000 /yr/(65 PH/yr) =	$ 15.38 /PH
Fuel ____ hp x ____ gal/hp-hr x $ ____ /gal =	$ ____ /PH
Oil/Lubrication ____ % of fuel cost =	$ ____ /PH
Tires [(n x PH/yr) - 1] [(1.15 x # tires x $/tire)/(n x PH/yr)] =	$ ____ /PH
Total Operating Cost per Productive Hour =	**$ 15.38 /PH**

Labor Costs

Hourly Wage =	$ ____ /SH
Wage Taxes = ____ % of hourly wage =	$ ____ /SH
Fringe Benefits = ____ % of hourly wage =	$ ____ /SH
Total Labor Cost per Scheduled Hour =	**$ ____ /SH**

Machine Rate

Total Cost per SH = ownership + operating x U + labor = **$ 26.00 /SH**

MACHINE RATE CALCULATIONS
(On-Road Equipment)

Description

Machine (make, model, type) Heavy-duty, 1-ton 4x4 pickup truck
Engine (hp, type) Gas Accessories or Modifications w/75 Fire-fighting equipment
Initial Investment (P) - F.O.B Delivered Cost = $ 25,000
Economic Life (n) 5 years
Salvage Value (S) 20 % of P = $ 5,000
Scheduled Hours (SH) per Year 2,000 hours
Operating Miles per Year 25,000 miles
Operating Miles per SH 12.5 mi/SH

Average Annual Investment (AAI) = [(P-S)(n+1)/2n] + S = $ 17,000 /yr

Ownership Costs

Depreciation (D) - Straight Line Method = (P-S)/n = $ 4,000 /yr
Interest 12 %
Insurance 7 %
Taxes 3 %
Overhead 8 %
Total 30 % x AAI $ 17,000 /yr = $ 5,100 /yr

Total Ownership Cost per Year = $ 9,100 /yr

Total Ownership Cost per Scheduled Hour = $ 4.55 /SH

Operating Costs

Repair/Service (% of D) 50 % x (D) $ 4,000 /yr/(25,000 mi/yr) = $ 0.08 /mi
Fuel 0.10 gal/mi x $ 1.10 /gal = $ 0.11 /mi
Oil/Lubrication 37 % of fuel cost = $ 0.04 /mi
Tires [(n x PH/yr) - 1] [(1.15 x # tires x $/tire)/(n x PH/yr)] = $ 0.01 /mi

Total Operating Cost per Mile = $ 0.24 /mi

Labor Costs

Hourly Wage = $ 10.00 /SH
Wage Taxes = 25 % of hourly wage = $ 2.50 /SH
Fringe Benefits = 25 % of hourly wage = $ 2.50 /SH

Total Labor Cost per Scheduled Hour = $ 15.00 /SH

Machine Rate

Total Cost per SH = ownership + operating x U + labor = $ 22.55 /SH

Pesticide Precautionary Statement

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

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Wehr, Michael A.; Mattson, James A.; Bofinger, Roger W.; Sajdak, Robert L. 1992. **Ground-application trial of hexazinone on the Ottawa National Forest**. Res. Pap. NC-308. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 34 p.

Discusses rate results and associated machine costs and effectiveness of a ground-based herbicide application system.

KEY WORDS: Herbicide, ground sprayer, release, site preparation, treatment.