Forest opening construction and impacts in northern Wisconsin. No. 120 1981

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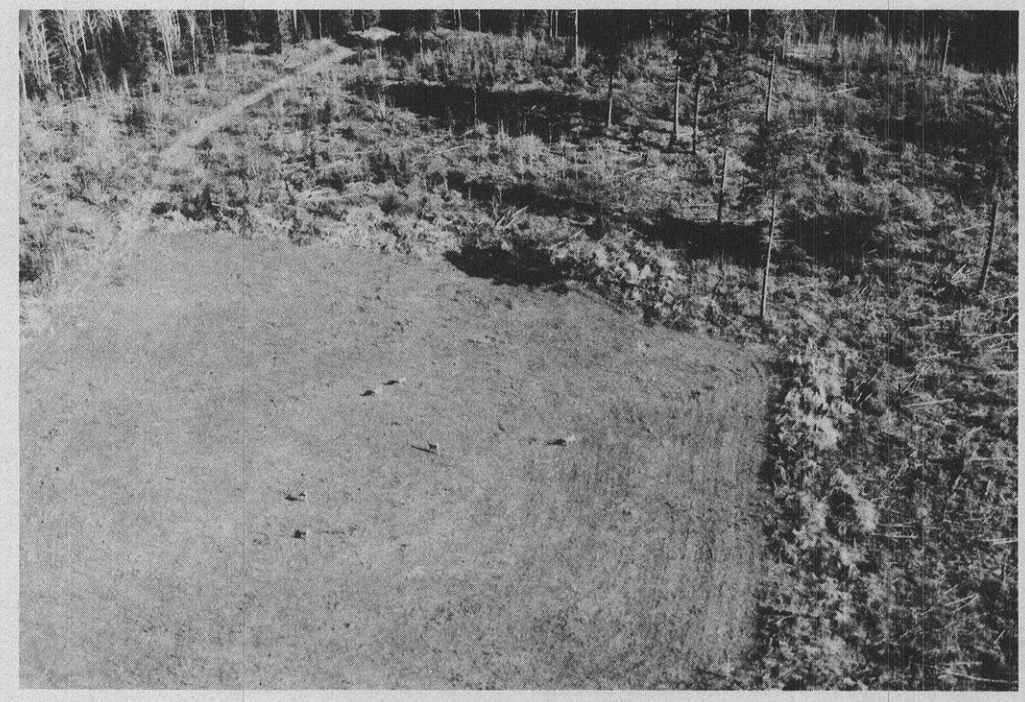
FOREST OPENING CONSTRUCTION AND IMPACTS IN NORTHERN WISCONSIN



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Cover Photo: *Six deer in a constructed opening during early spring. Opening was constructed previous fall in recently logged aspen stand (WDNR photo by Ron G. Eckstein).*

ABSTRACT

The Wisconsin Department of Natural Resources began a management program of maintaining relict forest openings in 1968. As this phase of openings management approached completion, plans were formulated to supplement existing relict openings with constructed openings. The latter phase involved higher cost and greater environmental impact. The research covered in this report began concurrent with the beginning of the construction phase in 1974. The research objective was to evaluate costs and impacts and develop guidelines for constructing openings.

Vegetation measurements and other observations indicated that the construction methods used since 1974 successfully established "permanent" herbaceous openings. Rockraking and leveling with a heavy construction disc reduced aspen suckering, thereby reducing the need for early maintenance followup after construction. The 1979 cost of constructing openings exceeded $800/ha compared to $94/ha to maintain relict openings in 1979.

Most constructed openings had the aspect of a cultivated field during the 1st year, but within 3 years those on loamy soils had reverted to a grass and weed community similar to the vegetative composition of relict-type openings.

Deer use of constructed openings was extremely heavy (up to 40 times expected rangewide use) during the 1st fall, but use declined in subsequent years as opening vegetation reverted from a clover food patch to a relict-type herbaceous opening. The intensity of fall deer use of openings remained high, but appeared to vary directly with the presence of clover in openings and inversely with the availability of acorns in the forest, particularly in areas with sandy loam soils. The growth of clover in openings during the first few years after seeding was directly affected by droughty conditions in 1976. This was followed by wetter conditions in 1977 and 1978 to which the dormant clover seed responded with excellent growth. Concommitantly, deer use of openings increased.

Scent baits and trapping were used to provide general information on the number of wildlife species using openings. At least 12 species of mammals were known to have visited scent stations within constructed openings. Among these, deer, skunks, coyotes, and snowshoe hares were the most frequent visitors. Seven species of smaller mammals were snap-trapped within constructed openings. Opening construction favored meadow voles, and potentially favored those predators that feed on voles. The greatest number and diversity of small mammals were caught in the 5-m-wide edge between the clearings and the forest.

Forty-nine species of birds were seen or heard from or in openings. Songbird numbers and diversity observed from openings were somewhat greater than observed from control points in woodland. Mourning warblers, indigo buntings, robins, and American goldfinches appeared to be favored by opening construction.

Three amphibian and 3 reptile species were also seen in openings. Of these, the smooth green snake was most likely favored by opening construction because it is a species of open habitats.

Hunting was the principal public use of the Enterprise Area based on a questionnaire survey conducted on that area. Awareness and support of opening construction was high, and about 1/3 of the respondents indicated use of the openings. Archers, grouse hunters, and berry pickers were the groups most favored by opening construction. Public uses of the other study areas were not surveyed.

Guidelines were prepared which emphasize the importance of maintaining existing relict openings and also recommend that no more than 1% of the forest be *constructed* into openings. This amount of construction appears adequate for present densities of deer. While the cost of constructing openings precludes establishing any more than are necessary to maintain present deer densities, measurements of other uses (wildlife and various human activities) indicate a potentially broad spectrum of other values. These need more detailed study for use in cost/benefit development. The data gathered in this study provide a starting point for this effort.

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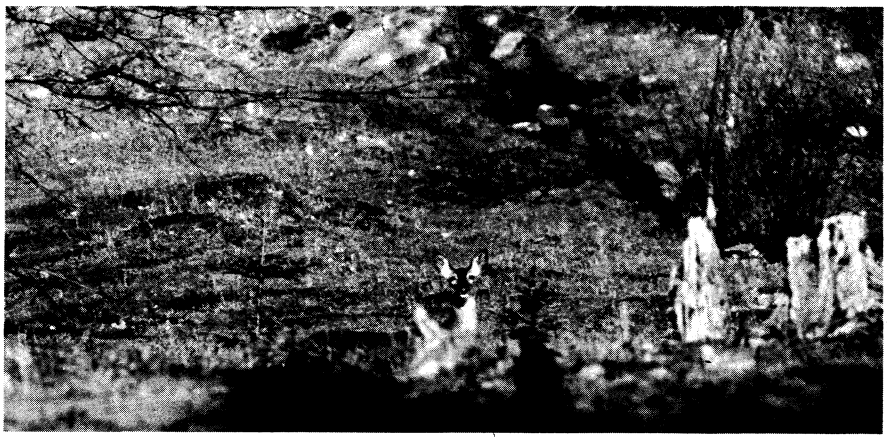
INTRODUCTION

Openings have been determined to be critical components of forested deer range. Most relict openings are the result of historic logging, settlement, and fires. They are less than 10% stocked with trees and dominated by perennial grasses and forbs. Such openings are not being created through modern forest harvest operations.

Upland herbaceous openings are heavily used by deer in spring and fall and appear to cause deer to be better distributed among all habitat types where openings are present (McCaffery and Creed 1969, McCaffery 1980). They provide cool-season grasses and certain forbs which appear to be very important transition foods during spring and fall (McCaffery et al. 1974, Kalmbacher and Washko 1977). Nutritious forage at these times may both reduce winter deer losses and improve survival of new fawns in spring (Verme 1962, Mautz 1978). Seasonal use of openings by bears, woodcock, and other species has been reported by other investigators. Based primarily on the apparent benefits to deer and other inferred values, the Wisconsin Department of Natural Resources (DNR) adopted a recommendation to maintain 3-5% of public forests in relict openings (McCaffery and Creed 1969:79). No more than 10% of the area of these upland openings was to be stocked with trees and no more than 30%, stocked with shrubs. Most openings were 0.2-4 ha in size. The herbaceous composition of these openings was described by Levy (1970).

Guidelines were prepared for inventorying openings (McCaffery and Creed 1969:93-98). Inventory, designation, and maintenance programs were intiated on most public forests with first-round treatments being completed on some properties by 1974 (Ron Eckstein, Wis. Dep. Nat. Resour., pers. comm. 1974). Initial maintenance involved spot-treatment of woody vegetation with a pelleted herbicide (10% picloram*) as described by McCaffery et al. (1974); retreatments in about 10 years were anticipated for some openings. As these phases of the openings program approached completion, it became apparent that many areas contained less than 1% open area suitable for long-term maintenance (Ron Eckstein, pers. comm. 1977). Plans evolved to bring the opening component up to 3-5% by mechanically constructing openings. During 1974, 250 sites were designated and developed as wildlife openings in the DNR North Central District. Since this phase of the openings program was obviously to be more costly than previous phases, specific guidelines were sought to direct development. The number of openings that should be constructed, opening location, appropriate construction methods, etc. needed to be more specifically defined. Previous phases of the openings program had minimal physical impact on the forest communities. However, the construction of new openings involved changing habitat form. Documentation of potential impacts was desirable. Furthermore, better measures of total benefits were needed to support this higher level of expenditure.

Openings construction had been earlier considered too expensive to be applied as an extensive management practice in Wisconsin (McCaffery and Creed 1969:78). However, food plots and forage clearings have been used in



Deer use relict and constructed openings most heavily during spring and fall. Primary use appears to be for feeding.

Many relict openings are the result of prolonged disturbance by man: old fields, log landings, and camps. The formation of a dense sod has deterred encroachment by woody plants. Similar openings are not a natural by-product of modern forest management.

*4-amino-3, 5, 6-trichloropicolinic acid in pellets marketed by the Dow Chemical Company as TORDON 10K.

forests of eastern states for many years, with most programs beginning prior to 1955 (Krusac and Michael 1979). Based on measurements of forage quality and quantity removed from openings, Kalmbacher and Washko (1977) recommended managing high-protein forages (cool-season grasses) in Pennsylvania as a food supplement for deer between winter and spring.

Larson (1967:17,26) conducted an appraisal of openings management practices in the eastern states and concluded that openings were a necessary part of habitat and should be constructed where absent. However, he warned managers to "exercise extreme caution regarding commitment to an expensive program of agricultural clearings".

Segelquist (1974:144) working in a poor habitat in Arkansas found that clearings increased deer carrying capacity, especially in years of mast failure. He recommended intensively managing openings in such habitats on the basis that alternative habitat improvements might be more costly.

The openings program in Arkansas and those in eastern states have employed regularly farmed food patches. In contrast, the objective in Wisconsin was to construct stable herbaceous openings similar to relict openings that would not require frequent maintenance or renovation treatments. Previous efforts to evaluate openings development have not been conducted in the upper Lakes States.

The objective of this evaluation was to develop guidelines for opening construction based on a study of costs, development designs, and forage produced, and to assess the impact of opening construction on mammals, birds, and people. This report summarizes information gathered from 1974 to 1980.

Many relict openings have persisted 30-50 or more years. Frequent frosts are an important factor in natural maintenance, especially in topographically depressed openings (frostpockets).

STUDY AREAS

Most measurements were made on 6 study areas, 3 primary and 3 secondary, in northeastern Wisconsin (Fig. 1). The choice of study areas was limited by the scope of the openings construction program which began in the North Central District. Initially, 2 factors were paramount in selecting study areas: soil type and layout of openings. Later, the opportunity for pretreatment deer-use measurements in nearby relict openings resulted in adding a 3rd primary study area. Primary study areas included Enterprise, Arbor Vitae, and Vandercook areas. Secondary areas included Parrish, Northern Highland, and Boulder Junction areas. The Arbor Vitae and Vandercook areas included a relatively large buffer area around the compartments where openings were constructed in order that local deer densities could be estimated by deer trail surveys.

ENTERPRISE STUDY AREA

The Enterprise Area comprises about 2,400 ha (ca. 2,100 ha are county owned) in the northwest quarter of Enterprise Township (Sections 4-9, 16-20, T35N, R9E) on Oneida County Forest land (Fig. 2). Upland soils are principally Goodman-Iron River silt loams on rolling topography (Hole and Schmude 1959). About 40% of the area is lowland peat. Forest types are dominated by aspen (26%), northern hardwoods (22%), conifers (mainly lowland, 28%), and noncommercial lowland types (23%). Floristic characteristics and biomass production of upland hardwood stands near the study area were described by Zavitkovski (1974, 1976). Relict openings made up only 1% of the study area and 2/3 of the open area was on private land. The area is without permanent human residents. Deer densities in the vicinity were estimated to be about 5-8/km^2.

ARBOR VITAE STUDY AREA

The Arbor Vitae Area includes about 2,800 ha of state (1,750 ha) and privately owned (1,050 ha) lands, and is divided into two subareas, Madeline (1,000 ha) and Mishonagon (1,800 ha), both in Vilas County. The smaller area (Fig. 3) circumscribes a forest compartment in Section 32, T40N, R7E where openings were constructed. The larger area (Fig. 4) circumscribes Section 15, T40N, R6E. Upland soils are mainly Pence sandy loam and Pa-

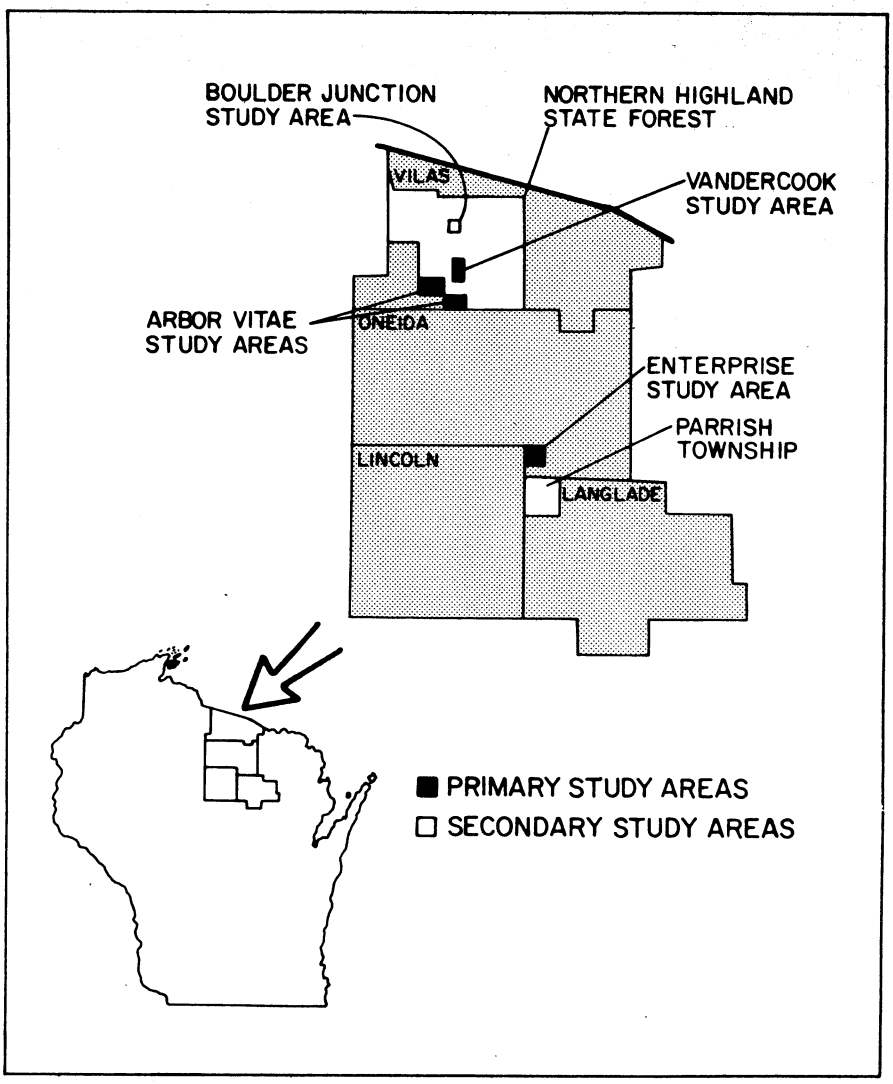


FIGURE 1. *Location of the 3 primary and 3 secondary study areas.*

Most sites selected for opening construction were located in recently logged areas. Some, as on the Enterprise Study Area, were located in poorly stocked areas within uncut timber.

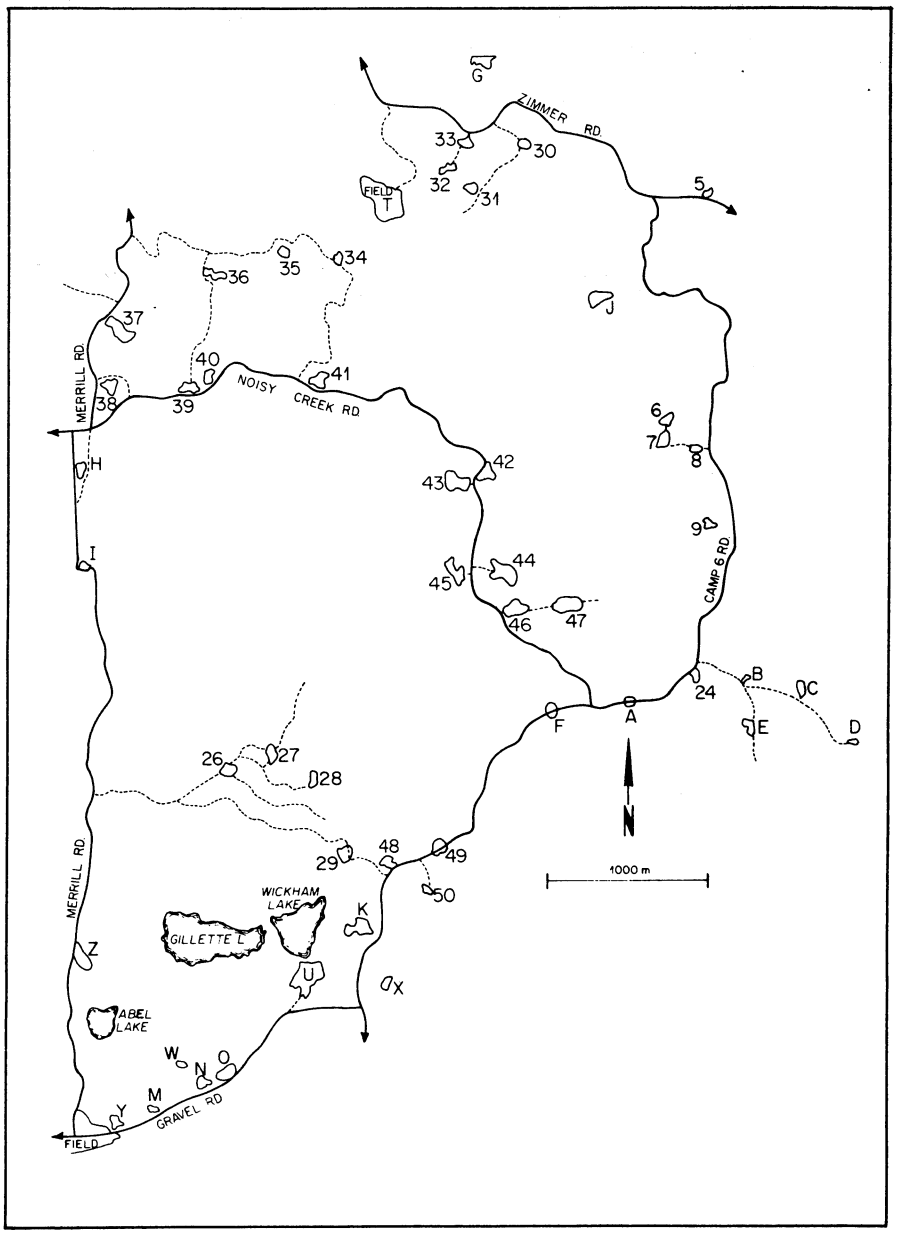


FIGURE 2. *Constructed (numbered) and relict openings (lettered) on the Enterprise Study Area.*

dus-Pence sandy loam (U.S.D.A. Soil Conservation Service 1978) on rolling topography. Forests on the publicly owned land are dominated by aspen (58%), northern hardwoods (10%), lowland types (mainly black spruce, 21%), pines (6%), and openings (4%). Most measurements were made in openings constructed in 3 publicly owned compartments containing 280 ha of young aspen (cut in 1970-74). The privately owned lands, though mostly wooded, are heavily developed for rural residences. The level of development probably interferes with deer activity and results in a somewhat lower density of deer than less developed areas nearby. The deer density was estimated to be about 8/km^2.

VANDERCOOK STUDY AREA

The Vandercook Area comprises about 1,500 ha of state-owned land around Sections 6 and 7, T40N, R7E, in Vilas County (Fig. 5). This areas is an annex to the Arbor Vitae Area, but was given separate status because it was added later in the study. The presence of relict openings in this area in close proximity to planned opening construction and the timing of opening construction permitted pretreatment measurements of deer activity. These events were somewhat fortuitous and permitted an attempt to replicate measurements of deer use in both relict and constructed openings as done on the Enterprise Study Area. Relict openings occurred in steep topographic depressions. Soils were mainly Padus sandy loam and Padus-Pence sandy loam (U.S.D.A. Soil Conservation Service 1978) on rolling topography. Forest types were northern hardwoods

containing northern red oak (50%), aspen (35%), pines (4%), lowlands (mainly muskeg, 8%), and openings (2%). Most openings studied, including all constructed openings, were located in young (cut in 1972) aspen stands. Human development was limited to lakeshores just outside the study area and was not a factor affecting deer activity. Deer densities in this area were estimated to exceed 8/km^2.

OTHER AREAS STUDIED

One-time pretreatment measurements of vegetation and site conditions were conducted on 3 other properties. These measurements were made to document operability and floral characteristics of sites chosen for openings development. Ten sites were examined in Parrish Township (T34N, R9E), Langlade County, and 30 sites were measured on 11 forest compartments scattered throughout the Northern Highland State Forest (NHSF). Three of these compartments became the nucleus of the Arbor Vitae Study Area and a 4th compartment became the Boulder Junction Study Area. The latter area is located in Sections 25, T42N, R6E, and 30, T42N, R7E, Vilas County, and was chosen for systematic followup observations to determine vegetation response to openings development on very sandy soil.

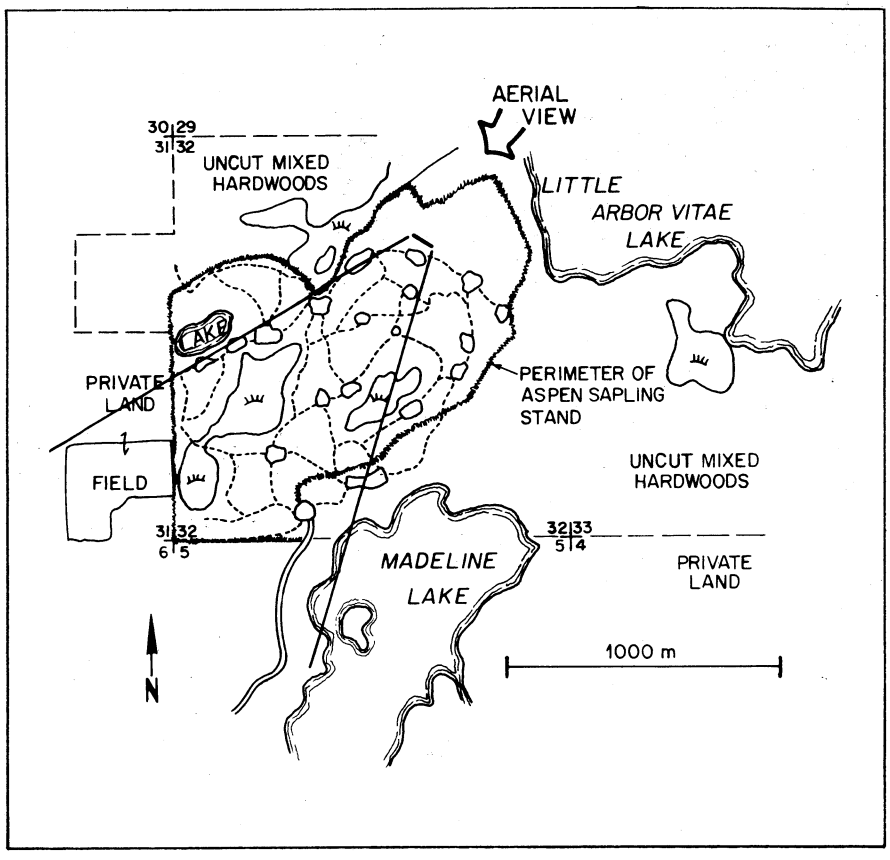


FIGURE 3. *Constructed openings and other features in the Madeline Unit of the Arbor Vitae Study Area. (An aerial view of this Unit appears on page 20.)*

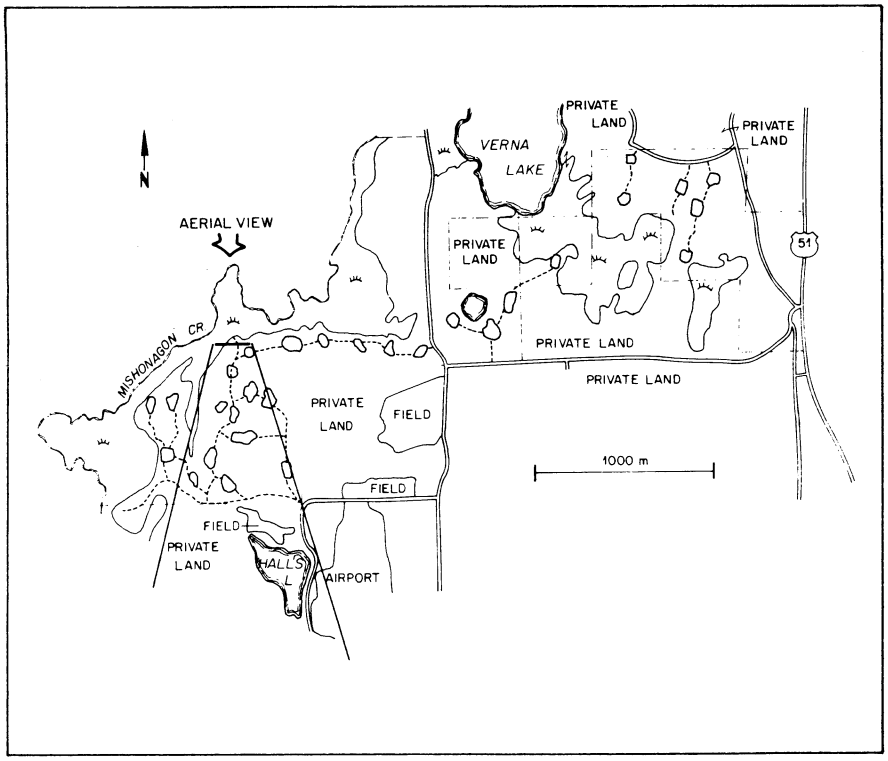


FIGURE 4. *Constructed openings and other features in the Mishonagon Unit of the Arbor Vitae Study Area. (An aerial view of this Unit appears on page 20.)*

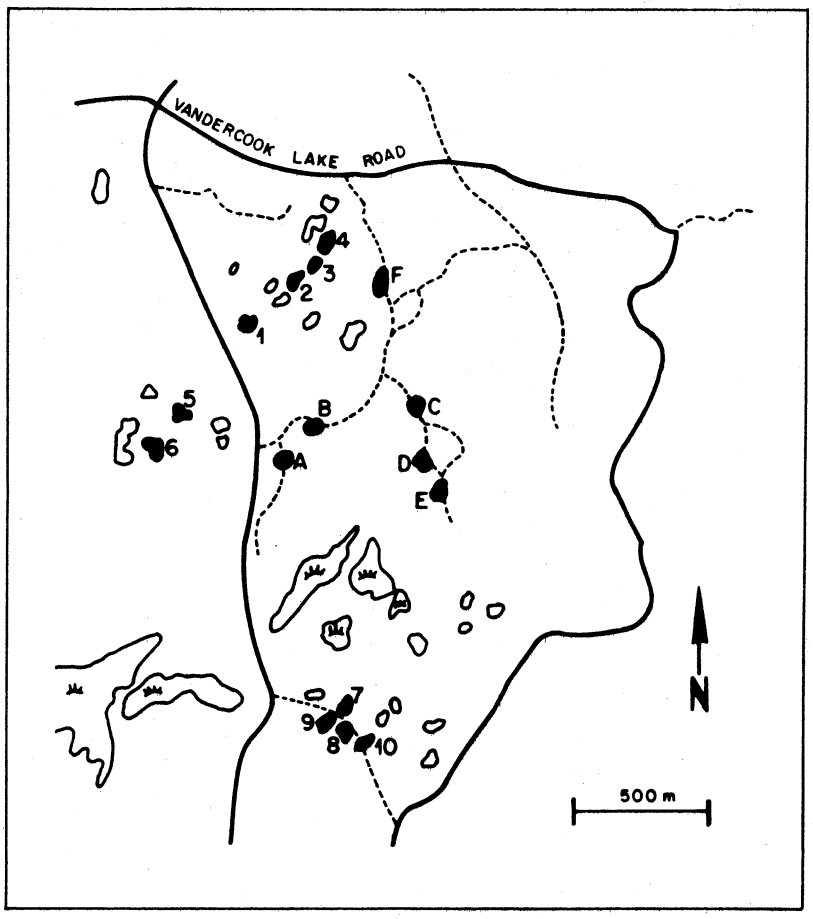


FIGURE 5. *Openings and marshes of the Vandercook Study Area. Numbered openings are pre-existing frostpockets used in the study. Unmarked openings are also frostpockets. Lettered openings are constructed openings.*

METHODS

We were fully aware of the difficulties in getting precise information on opening use by mammals, birds, and other wildlife, but believed it was necessary to document the spectrum of wildlife species using forest openings as a starting point for more precise research when needed. Methods chosen were practical approaches to achieve this end.

Although evaluations of vegetative response and deer use were made on several study areas, many of the more intensive evaluations (e.g., small mammal trapping, breeding bird censuses, public use sampling, etc.) were focused on the Enterprise Study Area. The reason for this was the close proximity of this area to our field station.

OPENING CONSTRUCTION

Sites for each opening to be constructed were selected and marked by DNR field personnel. Most site selection and opening construction followed timber sale completion on the site. Usually 10-50 sites were set up in an area as a unit for bidding by private contractors.

Specifications (Appendix A) called for grubbing each site with a rockrake and crawler tractor so that at least 90% of the resulting opening had exposed topsoil. No rocks or debris were to protrude more than 10 cm above the soil surface. Debris was to be windrowed or feathered-out on the perimeter of the opening. Sites were to be disced in preparation for seeding and fertilizing. Premixed seed composed of 9 kg/ha clover and 7 kg/ha bluegrass was provided by DNR. Oats were added at 50 kg/ha as a cover crop. A 16-8-8 fertilizer was provided and applied at a rate of 220 kg/ha. After 1975, some contracts required clearing and grubbing only, with the Department completing the discing, seeding, and fertilizing. Contractors were invited to tour the proposed sites and sealed bids were solicited on a per-acre (0.4 ha) basis. Completed work was evaluated by DNR personnel.

Openings were roughed-in by using a medium-sized dozer and a landclearing blade. This phase of construction was usually completed by private contractors.

After leveling with a small dozer with blade and heavy disc, openings were fertilized and seeded using a wheeled tractor.

Area wildlife managers provided project plans, schedules, and records of development costs for this study. Plans were reviewed for site distribution and amount relative to pre-existing relict openings, and tentative guidelines were recommended.

VEGETATION MEASUREMENTS

Fifty sites scheduled for opening construction were selected for evaluation by a randomized method, with 10 sites selected from 50 on each of 5 bidding units: Parrish Township, Enterprise Study Area, and 3 bid units on the NHSF in Vilas County. Pretreatment measurements were made of vegetation and other site factors. Forest type, volume, and stocking; soil type, drainage, and stoniness; time since cut, stumpiness, and amount of slash; and vegetative composition of the ground cover were recorded. Basal area of residual trees was determined using a 10-factor angle gauge. Shrub coverage and composition were visually estimated, as was ground cover. Stump density was counted on 40-m^2 plots. Notes were also recorded on soil type, apparent stoniness, and topography.

Deer use of openings was measured by counting droppings on 20 random 40-m^2 plots per opening.

A scent station was prepared in 25 openings. Animals visiting the stink-bait left their tracks in the raked soil.

For analysis, the samples from the 20 sites in Parrish Township and nearby Enterprise Study Area were combined to typify sites on loamy soils. The 30 samples on the NHSF tracts were combined to typify pretreatment site conditions on sandier soils.

Post-treatment vegetation in openings was measured 4 growing seasons after construction in 10 randomly selected new openings on the Enterprise Area and 10 on the Arbor Vitae Area. Twenty circular 40-m^2 plots were randomly located within each opening using procedures described by McCaffery and Creed (1969:18-19). Tree seedlings more than 60 cm tall were counted at each location. Tree seedlings less than 60 cm tall and shrubs more than 60 cm tall were tallied by species on a center 4-m^2 plot. Two or 3 (depending on opening size) of the plot centers within each opening were randomly selected before the clearing was sampled. At each of these, thirty 930-cm^2 quadrats were randomly located within a 160-m^2 plot and herbaceous species frequency and coverage were recorded for each quadrat (Appendix B). Presence was also noted of herb species within the 160-m^2 plot that were not in quadrats. Vegetative composition of constructed openings was also monitored annually by inspection to detect major changes in species composition that might affect deer use or vegetative stability of the openings. Color slides were also taken annually of opening vegetation to provide a photographic record of vegetation change.

Herbaceous coverage and composition of 10 relict frostpocket openings on the Vandercook Area were sampled using 20 randomly located 930-cm^2 quadrats in each opening. Plot randomization was achieved as described by McCaffery and Creed (1969:18-19).

Forest type composition of the study areas was obtained from forest inventory data maintained by state and county foresters. Forest type definitions are listed in Appendix C. Scientific names of plants found are given in Appendix D; taxonomy follows Gleason (1958).

ANIMAL USE ESTIMATES

Estimates of relative fall deer densities on primary study areas were obtained by deer trail counts (McCaffery 1976*a*). Twenty randomized transects were distributed throughout each area (16 on the Vandercook Area) to estimate deer trail abundance. Counts were transformed to deer density estimates by multiplying the mean count by 2 (McCaffery 1979:3).

Deer use within openings was measured by pellet group counts as described by McCaffery and Creed (1969:17-19). Pellet groups consisted of about 50 separate small pellets or 1-3 larger consolidated masses. The deposition period was estimated to be 15 August to the date of count in the following early May. Pellets were tallied as summer droppings (15 August to 15 September), fall droppings (15 September to 30 November), winter droppings (30 November to 15 April), and spring droppings (15 April to survey). Seasonal classifications were based on dropping shape and condition as found in early May. Droppings from the previous summer were typically badly weathered, discolored, and partially eaten by insects. Fall droppings were dark colored throughout, and occurred as masses or as pellets that were usually flat or dented on one end and pointed on the other. Winter pellets had rounded ends and were composed mostly of brown or tan woody fibers. Spring droppings were shiny black or dusty olive with a bright green or yellowish interior. Pellets from a previous fall occasionally persisted when on exposed mineral soil, but were crumbly and charcoal-like in general appearance.

Indices to the use of openings by both predatorial and other mammalian species on the Enterprise Area were obtained by the use of scent stations and baits similar to methods described by Linhart and Knowlton (1975). One baited station was located in each of 25 constructed openings. Another 25 stations were located along the roads throughout the study area. Baited stations were read for 4 days in August and 3 days in October 1975, and 3 days in May 1976. Visits to a station by more than 1 animal of the same species were recorded as 1 visit, but multiple visits were recorded when more than 1 species visited a station.

Small mammal species composition and abundance was sampled in openings, on opening edges, and in adjacent forest on the Enterprise Study Area. Fifty traps (40 mouse and 10 rat) were used for each transect. Within openings, traps were placed systematically at 7.5- to 10-m intervals, depending on opening size. On the opening edge, 25 stations with 2 traps each were equally spaced around the entire perimeter of the openings. The first trap was placed about 1 m into the edge or berm around the opening. The second trap

was placed about 3 m into the edge or berm. Traps on the forest transects were spaced about 7.5 m apart in a U-shaped pattern. Every 5th trap was a rat trap on all transects. Traps were baited with unhomogenized peanut butter. Traps were visited daily and bait replaced as necessary. Mammals captured were tentatively identified, tagged, and frozen for later verification. Three transects (opening, edge, and forest) were employed at each of 3 constructed openings, and 1 opening transect was used within each of 2 relict openings. Transects were operated for 6-11 days each during September of 1976 and 1977.

Scientific names of mammals or mammal sign collected or observed are given in Appendix D; taxonomy follows Jackson (1961).

BIRD USE ESTIMATES

Ten constructed clearings were selected for bird use estimates, and a control point was located 150 m from the edge of each opening (Conner and Adkisson 1975). At these 20 sites, species variety and relative abundance of songbirds were determined by singing male counts (Emlen 1971). Songs and calls heard from the center of each opening and control area were identified by species and number of individuals. Censuses were carried out from 6:40 a.m. to 8:30 a.m. during June 1976 and 1977. Observers listened for 5 min at each of the 20 points.

Woodcock peenting surveys were conducted in 54 and 57 constructed openings during 1975 and 1976, respectively, using techniques described by Mendall and Aldous (1973). Surveys were carried out during dusk periods between 29 April and 31 May. In addition, searches to locate woodcock broods and ruffed grouse drumming logs were carried out adjacent to constructed clearings. A pointing dog was used to search a 20-m width, although Gregg and Hale (1977) had reported that most use by young woodcock broods outside openings would be within 10 m of the edge. Perimeters of 35 clearings were searched in 1975, and of 22 in 1976.

Avian observations in clearings were also documented incidental to other field surveys in the area. Birds flying overhead were generally not counted. However, swallows (Hirundinidae), swifts (Apodidae), and raptors (Cathartidae, Accipitridae, and Falconidae) were recorded since they normally feed or hunt on the wing and would, therefore, be using the clearing from the air. All avian species observed using the clearings were added to a presence list. Scientific names of birds documented are given in Appendix D; taxonomy follows the American Ornithologists' Union (1957, 1973, 1976).

HUMAN USE ESTIMATES

Human activities were also sampled on the Enterprise Study Area. Questionnaires were mailed to owners of vehicles seen during 1975 and 1976 (Appendix E). Names and addresses were obtained from a law enforcement check of vehicle license numbers. Questionnaires and postpaid return envelopes were mailed to vehicle owners in January. Questions pertained to user activities during the previous year. Data were then analyzed to determine the influence of clearings upon human activities, and the degree of public awareness and support for clearings construction. Types of activities, number of days of use, and selected characteristics of users were also evaluated. Traffic counters were used to determine the seasonal distribution of vehicular use. A counter was placed on each of 3 main roads into the study area and counters were checked at least twice a week from 24 April to 29 November. Counts were expressed as cumulative number of counts per traffic-counter day. Relative use was then compared among spring, summer, fall, and among various hunting seasons.

More detailed information was obtained during the deer hunting seasons. The number of vehicles seen parked per mile of road within the study area was determined at dusk during each of the first 9 days of bowhunting. After the opening weekend of gun hunting, snow-covered clearings were searched to help evaluate the amount and types of human use.

RESULTS AND DISCUSSION

OPENING CONSTRUCTION AND COSTS

Pretreatment Site Conditions

The physical and biological condition of sites chosen in 1974 for opening construction were examined prior to development to provide a basis for evaluating physical and biological impacts and costs of construction. Fifty sites were examined on 5 separate tracts scheduled for bidding by private contractors. Factors that were expected to affect development costs were of primary interest.

Trees and Stumps. Timber on 13 of 20 sites examined on loamy soils in Parrish Township and the Enterprise Study Area had not been cut within the last 10 years. Standing tree volumes on these uncut sites averaged 46 m^3/ha (7.1 cords/acre) as estimated by point sampling (Hovind and Rieck 1970). This volume estimate is somewhat inflated because some trees were tallied that were outside the final clearing perimeter. The volume consisted of 48% aspen-birch, 42% northern hardwoods, and 10% balsam fir. Sites cutover within the last 10 years on loamy soils had a residual volume of 15 m^3/ha (2.3 cords/acre). All 30 sites examined on sandy soils in the NHSF had been recently cutover and had a residual volume of less than 6 m^3/ha (1 cord/acre).

Stump densities were estimated on 25 cutover sites on sandy soils and on 10 sites on loams. Densities were similar with 20.9/400 m^2 on sands and 17.8/400 m^2 on loams (Table 1). Approximately 2/3 of the stumps on each area were aspen. On loamy sites, 21% were balsam fir, 8% sugar maple, and 5% white birch. On sandy sites, 13% were white birch. 12% red maple, 9% red oak, and 3% pines. Sixty-one percent of the stumps on sandy sites were more than 20 cm in diameter, while 38% were 20 cm or larger on loamy sites. Oaks, maple, and pines contributed to the number of large stumps on the sandy sites.

Topography and Visible Stoniness. Most sites examined were on level (21 sites) to rolling topography (27 sites). Only 2 sites were categorized as steep. Drainage appeared to be good to excessive on all but 1 of the 50 sites. Some of the sandy sites in the NHSF appeared to be excessively well drained. Only 1 of 30 sites on sandy soils was visibly stony, i.e., with 10% or more of the surface showing stones larger than 25 cm in diameter. Four of 20 sites on loamy soils appeared stony.

Shrubs and Herbaceous Cover. Estimates of shrub densities were somewhat higher on loamy sites, averaging 56% coverage compared with 31% on sandy sites. Species composition on both soils was dominated by hazel, brambles, and cherries.

An ocular estimate of the composition of dominant herb species was made on each site. Pretreatment herbaceous composition was dominated on both soils by bracken fern, grasses, asters, and sedges (Table 2). Barren strawberry was also a dominant herb on sandy sites.

Development Costs

Bids were solicited from contractors in 1974 for the cost of clearing, discing, seeding, and fertilizing, with the seed and fertilizer furnished by the Department. The planned 250 clearings were advertised as 6 units with 11 to 52 clearings each. Six contractors bid, with 3 bidding on all 6 units and 5 bidding on units occurring on both loamy and sandy soils. Bids ranged from $428 to $2,400/ha ($173-$970/acre) depending on the contractor (Arlyn Loomans, Wis. Dep. Nat. Resour., in litt. 8 May 1974). Bids of individual contractors for units on sandy soils were not different from bids for units on loamy soils. Apparently, contractors felt the difficulty of operating on the damper and stonier loamy sites was offset by the increased number and

TABLE 1. *Stump density and size class distribution (percent) on cutover sites selected for clearing construction.*

Soil condition	Stumps/ 400m^2	Size class (cm) of stumps			
		< 13	13-20	20-30	> 30
Sands (25 sites)	20.9 ± 2.3*	14	25	46	15
Loams (10 sites)	17.8 ± 2.5	15	47	27	11

* ± 1 SE.

TABLE 2. *Pretreatment herbaceous composition on sites selected for opening development based on ocular estimates of coverage (percent).*

Herbaceous ground cover	Taxa	30 sites on sands	20 sites on loams
Bracken fern	*Pteridium*	44	25
Grasses	Poaceae*	28	18
Asters	*Aster***	26	9
Barren strawberry	*Waldsteinia*	26	–
Sedges	Cyperaceae****	10	32
Strawberry	*Fragaria*	9	7
Blueberry	*Vaccinium*	7	2
Sweetfern	*Myrica*	4	–
Blackberry	*Rubus*	3	–
Hawkweed	*Hieracium*	3	9
Wintergreen	*Gaultheria*	2	–
Lousewort	*Pedicularis*	2	–
Bunchberry	*Cornus*	–	4
Goldenrod	*Solidago*	–	2

*Mainly *Oryzopsis, Poa, Schizachne.*
**Mainly *Aster macrophyllus, A. ciliolatus.*
***Mainly *Carex pensylvanica.*

TABLE 3. *Cost of opening construction in 1977 for the 2 northern districts.*

Activity	Cost/0.4 ha NCD	NWD[d]
Search and site marking	$24.13[c]	?
Bid inspection and contract supervision	13.33[b]	?
Contract bid (roughing-in)	175.00[a]	$175.00[e]
Finishing (including measurements)		
Salaries	41.51[c]	77.24
Equipment	12.61[c]	24.12
Seed and fertilizer	30.28[c]	48.00
Administrative overhead	?	?
Maintenance and reseeding (within 2 years)	?	?
Total Cost (rounded)	$300	$320

[a]Arlyn Loomans (Wis. Dep. Nat. Resour. 2 August 1977), actual bid.
[b]Carl McIlquham (Wis. Dep. Nat. Resour. 3 August 1977), approximate.
[c]Carl McIlquham (Wis. Dep. Nat. Resour. in litt. 9 December 1977), PR report.
[d]Sam Moore (Wis. Dep. Nat. Resour. in litt. 1 August 1977).
[e]John Olson (Wis. Dep. Nat. Resour. 2 May 1978) indicated actual bids for 1978 were $250 to $300/0.4 ha.

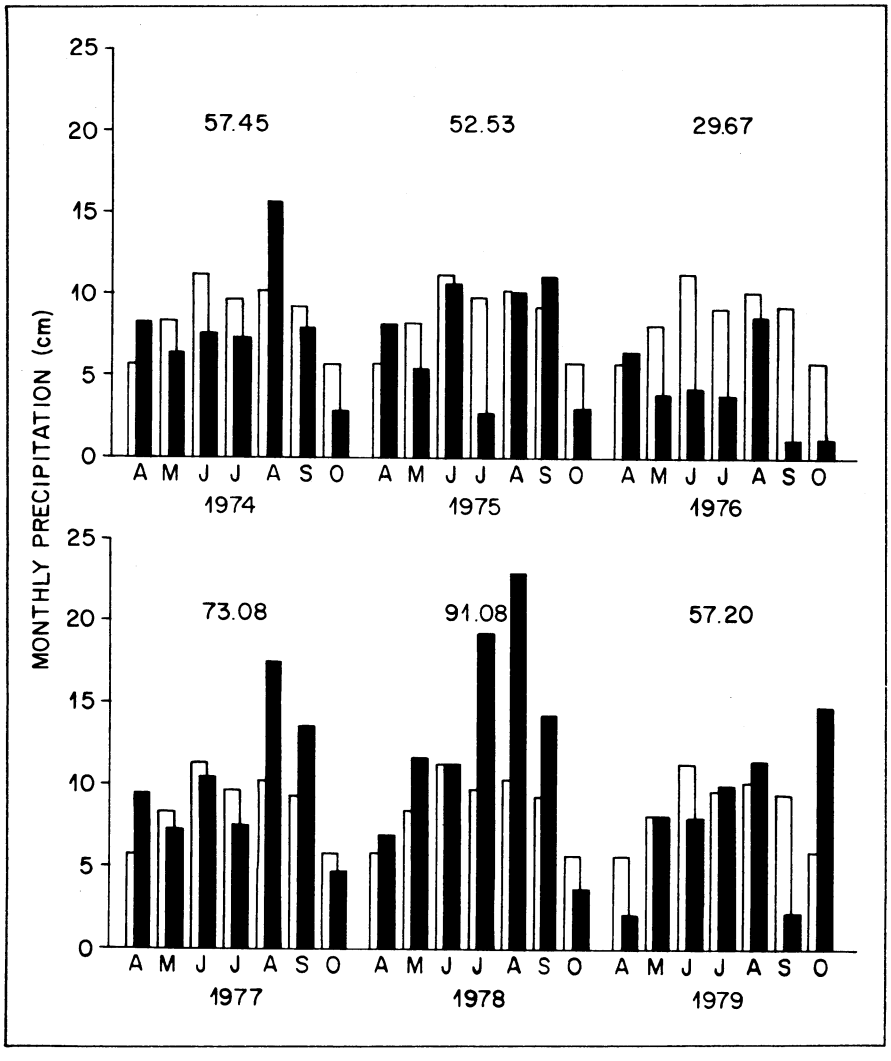


FIGURE 6. *Monthly precipitation for April through October recorded at Rhinelander (solid bars) in relation to 72-year means (open bars). Seven-month total rainfall is shown above the bars. The 72-year 7-month mean is 61.34 cm.*

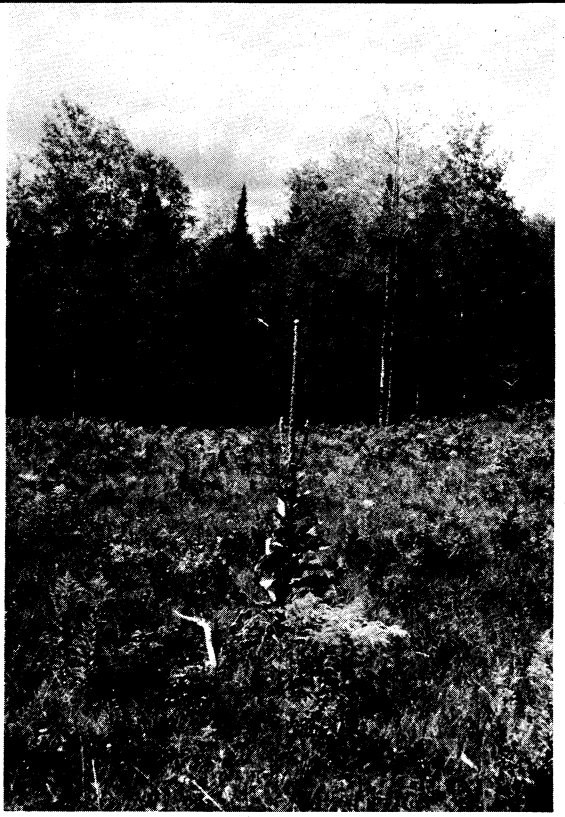
Clover and oats dominated constructed openings during late-summer and fall the 1st year.

size of stumps on the sandy sites, the presence of logging slash, and the greater distance from the contractor's home to the sandy sites. The contract, including all units for 1974, was awarded to the lowest bidder at $428/ha.

Total cost of the 237 openings completed in 1974 probably approached $620/ha ($250/acre) when costs of seed, fertilizer, and supervision were added. Contract costs increased after 1974. To economize, all phases of construction except clearing and grubbing were undertaken by the DNR in the North Central District in 1977. Total costs in 1977 were estimated at about $740/ha in the North Central District (Table 3) and likely exceeded $800/ha in 1979. Somewhat higher costs were experienced in the Northwest District. These costs compare to a construction cost of about $740-$1,100/ha in northern Michigan (James Hammill, Mich. Dept. Nat. Resour., in litt. 20 August 1980) and a mean cost of $1,150/ha in northeastern states (Krusac and Michael 1979). Costs of *maintaining* relict openings averaged $33/ha in 1973 on the Nicolet National Forest (McCaffery et al. 1974) and $94/ha on North Central District lands in 1979-80 (Arlyn Loomans, pers. comm. 3 September 1980).

As in 1974, subsequent (through 1979) land clearing bids by contractors have not seemed to be greatly influenced by soil type and other site factors. However, none of the tracts developed to date in the North Central

During the 2nd growing season after construction, the openings took on a weedy aspect as vegetation reverted from a farm food patch appearance to that of a relict opening.



Three years after construction, clearings on heavy soils had vegetative composition similar to that in relict openings.

TABLE 4. *Frequency, presence, and number of woody plants found in Enterprise clearings 3 years after construction.*

Species	Frequency (percent)	Presence (percent)	Number on plots	Number per 0.4 ha
TALL SHRUBS (>60 cm tall)				
Rubus allegheniensis	9.0	70	54	270
Rubus idaeus	6.0	30	37	185
Prunus virginiana	2.5	30	23	115
Salix spp.	2.0	40	9	45
Corylus cornuta	1.0	20	4	20
Spiraea alba	1.5	20	3	15
Amelanchier spp.	0.5	10	1	5
Rhus typhina	0.5	10	1	5
Total ± 1 SE				660 ± 237
TREE SEEDLINGS (<60 cm tall)				
Populus tremuloides	9.5	80	34	170
Acer rubrum	4.0	40	24	120
Betula papyrifera	2.5	30	12	60
Prunus serotina	2.5	30	5	25
Populus grandidentata	1.0	10	2	10
Total ± 1 SE				385 ± 127
ESTABLISHED TREE SEEDLINGS (>60 cm tall)				
Populus tremuloides	25.5	80	167	84
Prunus serotina	12.0	70	42	21
Quercus rubra	1.5	20	3	2
Populus grandidentata	1.0	20	2	1
Acer rubrum	0.5	10	1	1
Betula papyrifera	0.5	10	1	1
Total ± 1 SE				110 ± 40

TABLE 5. *Frequency, presence, and number of woody plants found in Arbor Vitae clearings 3 years after completion.*

Species	Frequency (percent)	Presence (percent)	Number on plots	Number per 0.4 ha
TALL SHRUBS (>60 cm tall)				
Amelanchier spp.	1.0	20	12	60
Rubus allegheniensis	2.0	40	4	20
Prunus virginiana	1.0	20	2	10
Total ± 1 SE				90 ± 46
TREE SEEDLINGS (<60 cm tall)				
Populus tremuloides	10.5	60	41	205
Populus grandidentata	3.5	30	17	85
Prunus serotina	1.0	20	2	10
Total ± 1 SE				300 ± 98
ESTABLISHED TREE SEEDLINGS (>60 cm tall)				
Populus tremuloides	21.0	70	130	65
Populus grandidentata	9.0	30	87	44
Prunus serotina	2.5	50	9	4
Acer rubrum	0.5	10	1	1
Betula papyrifera	0.5	10	1	1
Total ± 1 SE				115 ± 53

District have been excessively rocky.

Typical development involved 4 phases: (1) clearing and grubbing with a medium-sized crawler tractor with a rockrake-type landclearing blade, (2) leveling and discing with a small crawler tractor with a straight blade and heavy farm or construction disc, (3) handpicking stones and roots, and (4) seeding and fertilizing with a wheeled farm tractor and cyclone seeder.

VEGETATION IN CONSTRUCTED OPENINGS

Composition and growth of vegetation in the studied openings was affected by extremes in seasonal precipitation between 1974 and 1979 (Fig. 6). Rainfall was less than half of normal in 1976, but half again as great as normal in 1978. The effects of these extremes were expecially noticeable on clover survival.

TABLE 6. *Woody stems (>60 cm tall) counted in the Enterprise clearings 6 growing seasons after construction.**

Species	No. on plots	SE (percent of mean)	No./0.4 ha
SHRUBS			
Rubus idaeus	513	52	2,565
Rubus allegheniensis	392	35	1,960
Prunus virginiana	28	64	140
Salix spp.	11	55	55
Corylus cornuta	7	37	35
Viburnum sp.	4	100	20
Rosa sp.	1	100	5
Total ± 1 SE			4,800 ± 1,400
TREE SEEDLINGS			
Prunus serotina	15	67	75
Populus tremuloides	13	68	65
Betula papyrifera	3	71	15
Larix laricina	1	100	5
Ostrya virginiana	1	100	5
Total ± 1 SE			165 ± 65

*20 4-m^2 plots were taken in each of 10 clearings.

Initial Succession

By early autumn (1974) following construction, clearings on the Enterprise and Arbor Vitae areas had the outward appearance of cultivated fields. Oats and clover dominated the clearings with lesser amounts of original vegetation present, most notably, bracken fern. Bluegrass was scarce. One year later, oats were absent and clover had lost dominance to bluegrass. Most clearings lost their agricultural aspect and took on a weedy appearance. Bull thistles and aster occurred in varying abundance in all clearings. In individual clearings, blackberries, bromegrass, and bracken fern contributed in varying proportions to the weedy aspect. Aspen suckers were evident in some clearings, but they did not appear to pose a problem.

Some openings were mowed to improve their appearance and to increase their attractiveness to game. Mowed

Aspen suckers became a problem in some openings. Thorough discing during opening construction seemed to minimize the need for early maintenance.

Horseweed, brambles, and pearly everlasting dominate this photo. Vegetative succession in the openings constructed on the Vandercook Study Area was unlike that on the Arbor Vitae and Enterprise areas. The difference may have been caused by the sequence of wet and dry growing seasons.

TABLE 7. *Cover, frequency, presence, and commonness of prevalent ground layer plants found in Enterprise clearings 3 years after construction.*

Species	Cover (percent)	Frequency (percent)	Presence (percent)	Commonness ($F \times P$)
*Poa pratensis**	28.1	82.3	100	8,230
*Aster ciliolatus**	2.2	20.3	92	1,868
*Carex pensylvanica**	2.5	18.0	96	1,728
*Rubus idaeus**	2.2	14.5	80	1,160
*Pteridium aquilinum**	5.0	15.5	64	992
Trifolium repens	3.9	15.5	64	992
Rubus allegheniensis	3.6	11.2	88	986
*Hieracium aurantiacum**	1.4	11.4	64	730
*Agropyron repens**	0.7	8.4	60	504
Carex spp.*	0.6	6.5	76	494
Muhlenbergia spp.	0.5	8.0	60	480
*Aster macrophyllus**	0.4	6.8	68	462
Solidago spp.*	0.4	5.6	68	381
Trifolium hibridum	1.1	8.0	36	288
Agrostis perennans	0.5	10.5	24	252
Bromus spp.*	0.2	3.6	52	187
*Fragaria virginiana**	2.7	2.1	84	176
Lactuca spp.*	0.1	2.9	52	151
Hieracium florentinum	0.3	3.3	36	119
Cirsium spp.*	0.4	4.7	24	113
Chrysanthemum leucanthemum	0.3	3.3	28	92
Populus tremuloides	0.3	1.9	36	68
*Oryzopsis asperifolia**	0.2	2.1	32	67
Schizachne purpurascens	0.4	3.3	20	66
*Achillea millefolium**	0.1	2.7	24	65
Potentilla spp.*	0.1	1.5	36	54

*Species listed as prevalents in openings characterized as Group 1 by Levy (1970:224).

clearings on the Arbor Vitae Area retained their neat cultivated appearance in 1975. However, the vegetative composition appeared to have undergone changes similar to those in the unmowed clearings. Three growing seasons after seeding, most clearings in the Enterprise Area were dominated by bluegrass. Some of the weedy aspect of the previous year was lost because fewer thistles were evident in 1976. Clearings on the Arbor Vitae Study Area were well sodded with bluegrass. Very little clover remained, despite mowing during the 2nd summer. Extreme drought in 1976 contributed to "burning off" the clover. A change in dominance from clover to grass was expected as reported by Webb and Patric (1961), but the near absence of clover in 1977 was not expected.

TABLE 8. *Cover, frequency, presence, and commonness for prevalent ground layer plants found in Arbor Vitae clearings 3 years after construction.*

Species	Cover (percent)	Frequency (percent)	Presence (percent)	Commonness ($F \times P$)
*Poa pratensis**	44.7	99.2	100	9,920
Rubus allegheniensis	2.7	8.5	80	680
*Pteridium aquilinum**	2.0	6.5	76	494
Aster macrophyllus	0.6	6.5	76	494
*Carex pensylvanica**	0.6	5.3	68	360
*Aster ciliolatus**	0.4	3.6	48	173
*Oryzopsis asperifolia**	0.1	1.7	48	82
*Fragaria virginiana**	0.3	1.9	32	61
Conyza canadensis	0.4	1.9	28	53
Hieracium florentinum	0.2	1.7	24	41
Agrostis perennans	0.4	2.3	16	37
Populus tremuloides	0.2	0.9	32	29
Potentilla spp.	0.1	1.2	20	24
Carex spp.	0.2	1.1	20	22
Lychnis alba	0.1	1.5	12	18
Rubus idaeus	0.2	1.2	12	14
*Danthonia spicata**	0.1	0.8	16	13

*Species listed as prevalents in openings characterized as Group 3 by Levy (1970:225).

Plot Measurements

Four growing seasons after construction (1977), vegetation in the openings was quantitatively sampled on the Enterprise and Arbor Vitae areas to determine the success of establishing a stable herbaceous community and to detect relative differences on heavy and light soils.

Shrubs and Seedlings. Tall woody shrubs were significantly more abundant in constructed openings on the heavier soils (Enterprise) than on the lighter soils (Arbor Vitae) but still totalled fewer than 2,500 stems/ha (Tables 4 and 5). This shrub density is less than 1/10 as dense as in the typical aspen stand (McCaffery 1976*b*). Tree seedlings were about equally abundant in openings on the areas. Overall, woody growth was not posing a threat to the openings. However, estimates in 2 openings (1 on each study area) exceeded 1,000 established (taller than 60 cm) tree seedlings/ha. A fully stocked conifer plantation contains 2,000-2,500 evenly spaced seedlings/ha. The latter 2 openings will require a maintenance treatment within the next few years. More openings may require maintenance if small seedlings (less than 60 cm tall) survive, although recounts of tall woody stems in the Enterprise openings 6 growing seasons after construction did not show an important increase in tree density (Tables 4 and 6). However, shrubs (mainly *Rubus*) increased about tenfold.

Poor success was achieved when attempting to construct openings on very sandy soils. Often the vegetation removed during construction was of greater forage value than was realized in the resulting opening.

Aspen, blackberry, and raspberry growth appeared to pose a maintenance requirement in about 1/4 of all openings studied by the end of the 5th growing season. Aspen regeneration was most vigorous in openings that were not thoroughly rockraked or disced during construction. Root disturbance reduces the regenerative vigor of aspen (Perala 1977:4). In the Northwest District, clearings were inspected 2 years after construction and surviving aspen was treated with a light application of picloram pellets (2-8 kg of product/ha, 10% acid equivalent) with excellent results (Jeff Wilson and John Olson, Wis. Dep. Nat. Resour., pers. comm. 16 April 1980).

Herbs. Herbaceous ground layer composition in openings was much more diverse on the heavier soils of the Enterprise Study Area than on the lighter soils in the Arbor Vitae Area (Tables 7 and 8). Almost 50% more prevalents (Curtis 1959:79-80) were

TABLE 9. *Deer population estimates on the Enterprise, Arbor Vitae, and Vandercook Study Areas as determined by trail surveys from 1974 through 1979.*

	Enterprise		Arbor Vitae		Vandercook	
Fall	Trails/0.4 km	Deer/km^2	Trails/0.4 km	Deer/km^2	Trails/0.4 km	Deer/km^2
1974	3.15 ± 0.57*	6.3	4.25 ± 1.27	8.5	–	–
1975	3.55 ± 1.02	7.1	5.25 ± 0.85	10.5	–	–
1976	3.15 ± 0.76	6.3	3.50 ± 1.09	7.0	–	–
1977	4.25 ± 0.92	8.5	4.15 ± 0.95	8.3	3.81 ± 1.36	7.6
1978	4.64 ± 0.99	9.3	4.35 ± 0.98	8.7	3.38 ± 1.00	6.7
1979	–	–	–	–	5.38 ± 1.22	10.8

*95% confidence limits.

TABLE 10. *Deer use of constructed openings on the Enterprise Study Area based on counts in 10 openings during 1975-79.*

	Deer pellet groups/800-m^2 sample			
Date sampled	Summer	Fall ± 1 SE	Winter	Spring
8 May 1975	23	240 ± 44	1	20
11 Nov 1975	4	48 ± 10	–	–
19 Apr 1977	1	24 ± 5	+	2
7 Apr 1978	1	51 ± 13	0	0
24 Apr 1979	1	43 ± 6	0	+

+ Rounds to zero.

found in the Enterprise openings as in the Arbor Vitae openings. Ten species contributed 1% or more of the cover on Enterprise sites as contrasted with only 3 species on Arbor Vitae openings. Three years after construction, Enterprise openings had taken on the character and vegetative composition of relict openings. Seventeen of 23 prevalents found by Levy (1970:224) in "Group 1" openings were among the prevalents found in Enterprise openings, as were 9 of his 11 indicator species. His Group 1 openings occurred on moderate- to heavy-textured soils.

The herbaceous composition of the Arbor Vitae openings did not conform well to species lists from any group of previously studied openings (McCaffery and Creed 1969:89-92). The Arbor Vitae openings contained only 7 of 28 prevalent species found by Levy (1970:224-25) in openings on sandy soils and only 7 of 23 found on heavier soils. Except for thistles and mullein, these openings have appeared to be relatively weed-free since construction. Drought conditions may have precluded survival of a higher proportion of species that were present before site disturbance. Notably absent from the prevalents were *Waldsteinia, Vaccinium, Myrica,* and *Trifolium.* Pretreatment observations (before clearing construction) indicated that *Waldsteinia* made up about 26% of the herbaceous coverage (Table 2). Perhaps additional herbs will become established in the future.

The predominance of *Poa pratensis* insures natural maintenance of these clearings on the Enterprise and Arbor Vitae areas for the foreseeable future.

Clover Responses

The 5th growing season (1978) was exceptionally rainy and, as a result, more clover was found in some openings. The most dramatic increase occurred in the Arbor Vitae openings. Many openings and trails had the appearance of having been reseeded with clover. Clover had been nearly absent when quantitatively sampled the previous year. The clover component in 1978 varied between openings from almost none to over 30% coverage. Vegetation in the Enterprise openings in 1978 did not appear to be different from that measured in 1977.

Openings on the Vandercook Area were constructed during the 1976 drought. As a result, clover and bluegrass were poorly represented in the 1st year cover. More nearly normal rainfall during early 1977 resulted in good germination and establishment of clover (about 80% coverage). In 1978, the aspect of most openings was clearly dominated by horseweed and blackberry. Clover appeared to cover an average of about 25% of the clearings and bluegrass covered less than 30%. Observations in June 1979 indicated that clover and bluegrass composition was similar to that noted in 1978. Many leaves from suckers of large-toothed aspen and from stems of brambles had been removed by foraging deer. These openings were mowed during late summer 1979, to improve their appearance and reduce vigor of invading woody plants. Vegetative succession on these openings has not been similar to that on the Arbor Vitae openings. The difference may have been caused mainly by the sequence of wet and dry growing seasons following opening construction.

Openings on the Boulder Junction Area were constructed on very sandy soil and seeded in 1975. Oats grew in the 1st season, but planted species were very poorly represented thereafter. Mullein was very abundant after the 1st year. Bluegrass was patchy and no clover was seen. Large areas of bare sand were present. Sweet fern, poverty-grass, hawkweed, and aspen suckers were among the dominant species. This condition was still evident in 1979. Future opening construction should not be attempted on dry sands.

Implications

All openings except those on the sandiest sites appeared to have satisfactory herbaceous coverage and stability after 5 years. Only a small amount of fertilizer was used to accomplish our vegetation goal. Kalmbacher et al. (1978) also indicated that only a small amount of lime and fertilizer was necessary to establish forage clearings in Pennsylvania. Wildlife openings need not be vegetated completely with high palatability foods. Though yield and utilization measurements were not made during this study, availability of

plants most commonly used by deer clearly exceeded utilization (with the possible exception of the 1976 drought year). Heavier fertilization may have increased forage utilization by deer (Thomas et al. 1963). However, utilization measurements in Pennsylvania openings indicated that only about 14% of available forage was removed by deer (Kalmbacher and Washko 1977). Segelquist (1975:22-25) in Missouri found up to 17% of the forage was removed from his clearings during a winter following a poor crop of acorns.

Deer use of openings was documented primarily by pellet group counts conducted during early May. Deer use was very heavy during the 1st year following construction.

DEER DENSITIES AND USE

Densities on Study Areas

Deer populations have generally increased throughout northeastern Wisconsin from 1972 to 1978 with only a temporary setback following the severe winter in 1975-76. A 2nd severe winter occurred in 1978-79 (Creed et al. 1979). Deer densities on the 3 primary study areas as estimated by trail counts have ranged from 6.3 to 10.5 deer/km^2 and averaged about 8 during the study period (Table 9).

The counts on the Arbor Vitae Area are considered minimal because of high numbers of man-made trails in the vicinity; many of these trails may have been used by deer but were not counted. Similarly, counts on the Vandercook Area are probably conservative because of the difficulty of distinguishing deer trails on cutover portions of the area. As a result of these counting difficulties, estimates on these 2 areas may have been conservatively low by as much as 2 deer/km^2.

Use of Constructed Openings

Deer use of clearings was very heavy the 1st fall after construction when fertilized new clover was especially attractive. Use during subsequent falls generally declined as herbaceous composition reverted from that of an agricultural-type field to that found in relict openings. Deer use appeared to increase with clover availability but was depressed when forage supplies were influenced by drought conditions or an abundance of acorns. Deer use of clearings in winter was negligible as indicated by tracks and pellet counts.

Enterprise Openings. Deer activity was spectacular in constructed openings during fall 1974. Deer were often seen in openings even during mid-day. By late September, the effect of grazing was already conspicuous on clover. Deer pellet accumulations by May 1975 averaged 284/800-m^2 sample (Table 10). By assuming a defecation rate of 12.7 groups/day, the average use on these new clearings from 15 August to 9 May was equivalent to 100 deer/km^2. If pellets were accurately ascribed to the proper season, the intensity of use during the first fall (240/sample) was about 300 deer/km^2. This intensity of use was about 40 times the average expected use over the adjacent range, and greatly exceeded the highest levels of use previously measured in relict openings (McCaffery and Creed 1969:48).

Deer use declined dramatically during the 2nd fall when less clover was available, and declined further the 3rd fall (1976). The 1976 drought reduced clover coverage to only 5%.

Deer use in nearby relict openings was negligible during 1974, but increased in subsequent falls (Table 11). Although no pretreatment counts were made on these relict openings, the highly attractive new clearings appeared to have had the effect of attracting deer away from the relict openings the 1st year (Fig. 7). Thereafter, deer appeared to begin returning to relict openings as clover gave way to weeds and grass in the new openings. By the 3rd year (1976) after construction, deer use of the new openings was similar to use of relict openings.

Fall deer use during 1977 was much higher than during 1976 in all openings. Average pellet counts in relict openings increased from 18 to 42/sample and from 24 to 51 in constructed openings. Reasons for this surge in use are unclear, but were likely a combination of a higher deer population, increased rainfall in 1977 resulting in a surge of herbaceous growth, and a reduced acorn crop. Future deer use trends in new and relict openings would probably continue to be similar to those from 1976 to 1978 if future counts were made.

The practical significance of these use patterns is unclear. However, one might speculate that a relatively small number of annually "farmed" clearings might substitute for a larger number of relict-type openings (where absent) in meeting needs of deer. The results of counts in nearby relict openings lend some support to this thesis. More use should have been evident in the relict openings in 1974 if deer requirements were greater than provided by the new clearings. This is not to say that farmed openings should be *substituted* for relict openings, but that where relict openings are absent, a small number of farmed openings may be adequate to meet deer forage requirements on loamy soils.

Arbor Vitae Openings. Deer use of these constructed openings was also heaviest during the first fall (Table 12). Use was only about 1/2 that measured in the Enterprise clearings, but was still about 20 times the expected average use of adjacent range. Use may have been lower relative to the Enterprise clearings in part because of the close spacing of the Arbor Vitae clearings (Figs. 3 and 4). These clusters of clearings may have had the effect of diluting use by a relatively finite number of deer. If so, it suggests that fewer openings of this quality would have been sufficient to meet the needs of deer.

As at Enterprise, deer use declined after the 1st year. Proportionally, the

TABLE 11. *Deer use of relict openings on the Enterprise Study Area based on counts in 10 openings during 1975-79.*

Date sampled	Deer pellet groups/800-m^2 sample			
	Summer	Fall ± 1 SE	Winter	Spring
13 May 1975	0	1 ± 0.4	+	1
10 Nov 1975	2	11 ± 3	–	–
20 Apr 1977	1	18 ± 5	0	+
8 Apr 1978	1	42 ± 9	+	+
23 Apr 1979	+	34 ± 8	+	1

+ Rounds to zero.

TABLE 12. *Deer use of constructed openings on the Arbor Vitae Study Area based on counts in 10 openings during 1975-79.*

Date sampled	Deer pellet groups/800-m^2 sample			
	Summer	Fall ± 1 SE	Winter	Spring
9 May 1975	4	121 ± 27	2	5
18 Nov 1975*	1	55 ± 11	(1)	(5)
27 Apr 1977	1	4 ± 2	+	0
17 Apr 1978	+	8 ± 2	+	0
26 Apr 1979	+	42 ± 18	0	0

* 5 openings were not counted until 20 May 1976.
+ Rounds to zero.

TABLE 13. *Deer use of relict openings on the Vandercook Study Area based on counts in 10 openings during 1976-80.*

Date sampled	Deer pellet groups/800-m^2 sample			
	Summer	Fall ± 1 SE	Winter	Spring
19 Apr 1976	5	68 ± 9	1	1
25 Apr 1977	4	16 ± 5	0	+
4 May 1978	4	85 ± 14	4	3
10 May 1979	5	114 ± 14	4	6
6 May 1980	2	14 ± 3	+	3

+ Rounds to zero.

TABLE 14. *Deer use of constructed openings on the Vandercook Study Area based on counts in 6 openings during 1977-80.*

Date sampled	Deer pellet groups/800-m^2 sample			
	Summer	Fall ± 1 SE	Winter	Spring
4 May 1977	+	90 ± 10	+	2
27 Apr 1978	23	302 ± 23	51	18
26 Apr 1979	6	40 ± 8	16	17
5 May 1980	2	18 ± 5	+	6

+ Rounds to zero.

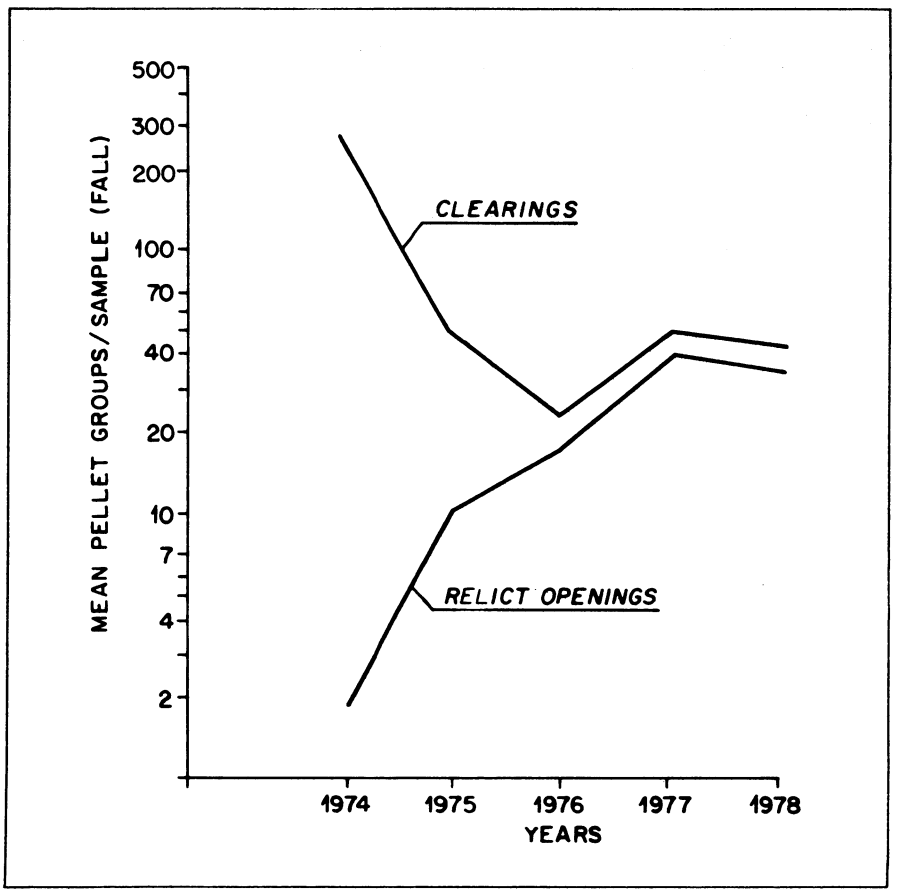


FIGURE 7. *Changes in fall deer activity on constructed clearings and pre-existing openings as determined by pellet group counts on the Enterprise Study Area.*

decrease was less than occurred on the Enterprise clearings. However, by the following year, deer use in Arbor Vitae clearings declined to almost 0 and remained very low through fall 1977 (Fig. 8). The lowest count corresponded with the 1976 drought, a virtual extirpation of clover, and an abundant acorn crop.

The importance of clover in this habitat seemed to be underscored in fall 1978. Clover had rebounded as a result of wetter growing seasons, and average fall pellet counts increased from 8 to 42 groups/sample. Counts ranged from 0 to 178/sample and appeared to be closely related to the amount of clover in each opening. Seven clearings estimated to have up to 10% coverage of clover averaged 12 pellet groups/sample. Three clearings were estimated to have more than 15% clover and averaged 111 groups/sample.

The vegetation during 1976 and 1977 in these openings on sandy loam soils had reverted to a nearly pure bluegrass community. The associated near-absence of deer use seemed to indicate that grass forage was not in short supply in adjacent forested habitat or that more preferred foods were available. However, the resurgence of deer use in 1978, corresponding to the clover recovery and absence of acorns, showed that these openings can be seasonally important if broad-

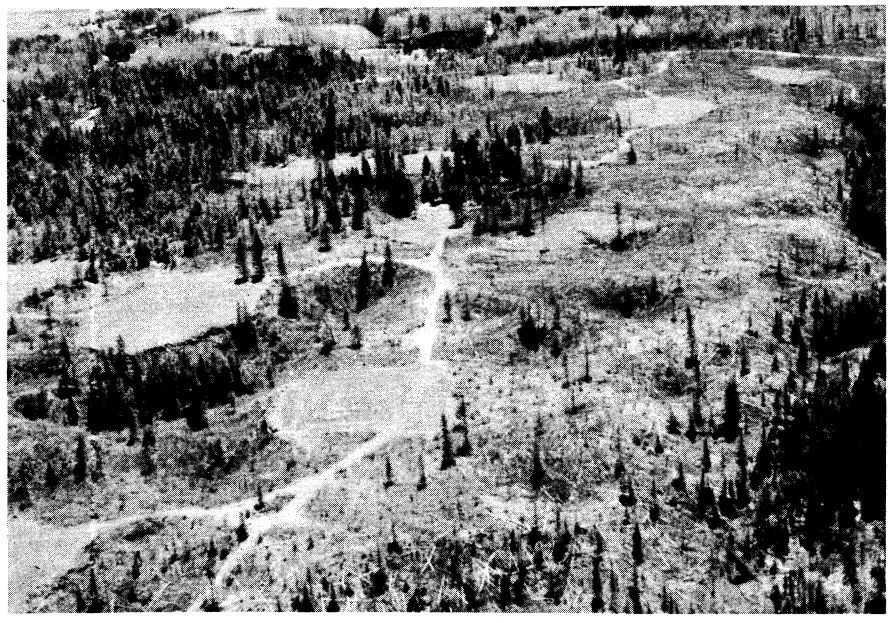
leaved forage is provided in spring and fall.

Vandercook Openings. The addition of this study area was primarily to replicate deer use measurements as conducted on the Enterprise Area. Deer-use measurements in relict openings began 1 year prior to the construction of clearings. Pretreatment (1975) fall deer use of relict frostpockets was high, averaging 68 pellet groups/sample (Table 13). Deer appeared to shift to the newly constructed clearings in fall 1976 to take advantage of oats, rutabagas, and some clover (Fig. 9). However, deer use in both relict and new openings was likely depressed by the droughty 1976 conditions, a poor catch of clover in the new openings, and an ample acorn supply in adjacent timber.

Record high fall use was found in constructed openings in 1977 (Table 14). Clover germination and growth appeared to have been delayed by dry conditions in 1976 and the main flush did not take place until 1977. This record use (302 pellet groups/sample) did not appear to detract from deer activity in the nearby relict frostpockets which also had higher use than in previous falls. Decreased mast availability, a higher deer population, and the highly attractive clover in clearings appeared to concentrate deer use in this compartment and the relict openings.

Clover coverage in clearings decreased from an average estimated coverage of 80% in 1977 to about 25% in 1978. This was matched by a dramatic decline in deer use from an average of 302 to 40 pellet groups/sample. Conversely, deer use increased to record levels in relict openings (114 pellet groups/sample). The mast failure coupled with the reversion of man-made opening vegetation from a community dominated by clover to one dominated by horseweed and brambles appeared to result in concentrated deer use of the frostpockets.

Clover abundance in clearings during 1979 appeared to be about the same as in 1978. However, deer use continued to decline to only 18 pellet groups/sample (Table 14). This low use was similar to the 14 pellet groups/sample found in the nearby frostpockets. These counts closely matched the 16 pellet groups/sample counted in frostpockets for the previously high acorn year of 1976. Segelquist



Oblique aerial view of openings constructed on the Mishonagon unit of the Arbor Vitae Study Area where 5% of the cutover portion was designated for openings. Photo was taken 1st spring following timber sale and openings construction. Direction of this view is marked on Figure 4. (WDNR photo by Ron Eckstein.)

Oblique aerial view of Madeline Unit of Arbor Vitae Study Area 5 years after opening construction. Direction of this view is marked on Figure 3. (WDNR photo by Ron Eckstein.)

Relict frostpockets on the Vandercook Study Area were dominated by a lush growth of barren strawberry which was heavily used by deer, especially when acorns were scarce in the forest.

Coyote tracks at a scent station in a constructed opening. The 4 most frequent visitors in order were deer, skunks, coyotes, and snowshoe hares. Of these, deer and coyotes appeared to be most favored by opening construction.

(1974:143, 1975:62) also noted that his forage clearings in Arkansas were used less in high mast years. Openings appear to be especially important as a food source during periods of forage shortage elsewhere in the habitat.

With the exception of the "acorn" years of 1976 and 1979, deer use in these frostpockets was high (Fig. 9). The principal attraction appeared to be barren strawberry. Vegetation sampling found 22 prevalent green plants in mid-October 1978 (Table 15) with *Waldsteinia* clearly dominant. *Oryzopsis, Hieracium,* and *Poa* contributed much of the additional green herbaceous cover.

Deer use of forest openings on sandy soils appeared to depend on the herbaceous composition of the openings. Grassy openings seemed relatively unimportant as noted on the Arbor Vitae clearings in 1976 and 1977. Vandercook clearings were expected to revert to grass within 3 years so that this observation could be confirmed by a replicate measurement. However, vegetative succession in the latter clearings did not follow the expected pattern due, in part, to higher rainfall. If grassy openings are relatively unimportant on sandy soils, it is presumably

TABLE 15. *Summary of prevalent plants found in 10 frostpocket openings on the Vandercook Study Area during mid-October, 1978.**

Species	Coverage (percent)	Frequency (percent)	Presence (percent)	Commonness ($F \times P$)
Waldsteinia fragarioides	47.1	91.5	100	9,150
Hieracium aurantiacum	11.7	57.5	100	5,750
Poa spp.	7.1	49.5	100	4,950
Oryzopsis asperifolia	15.9	44.0	100	4,400
Carex pensylvanica	4.0	36.5	90	3,285
Vaccinium angustifolium	5.6	32.0	90	2,880
Fragaria virginiana	3.4	26.5	100	2,650
Schizachne purpurascens	4.3	26.0	100	2,600
Polytrichum spp.	2.4	19.0	100	1,900
Aster ciliolatus	1.4	19.0	80	1,520
Danthonia spicata	1.5	10.0	90	900
Viola spp.	0.7	12.5	60	750
Polygala paucifolia	0.5	7.5	90	675
Panicum spp.	0.7	8.5	60	510
Muhlenbergia spp.	0.3	5.0	80	400
Trifolium repens	0.5	3.5	60	210
Gaultheria procumbens	0.8	4.0	50	200
Bromus spp.	0.2	1.5	80	120
Hieracium florentinum	0.4	3.5	30	105
Myrica asplenifolia	1.2	2.0	50	100
Phleum pratense	0.2	2.0	40	80
Solidago spp.	0.4	2.5	30	75

*Fifty-two species were tallied on 10 openings and averaged 22 species per opening. Only live plants were included.

because adequate grass or alternative forage is available to deer in clearcut timber stands and elsewhere. Clover and barren strawberry openings appear to be highly preferred, especially in the years with few acorns. The paradox here is that both grasses and barren strawberry are readily available in adjacent timber stands and recently cutover areas on most sandy soils. Perhaps the sheer quantity of barren strawberry in openings, accompanied by direct sunlight, increases its attractiveness to deer. Where not in openings, barren strawberry is quickly shaded by new tree growth, bracken fern, and other tall herbs even in clearcut areas.

OTHER ANIMAL USE OF CONSTRUCTED OPENINGS

The purpose of this section is to provide additional perspective on the spectrum of wildlife species using forest openings. Methods used to gather this information were not designed to provide meaningful data on populations or the significance of forest openings to natality and survival of these species.

Large and Medium-sized Mammals

Scent stations were used on the Enterprise Area to obtain an index to the species of animals visiting clearings in relation to species known to be present in the vicinity. Deer, skunks, coyotes, and snowshoe hares were the most frequent visitors to scent stations on constructed openings during the late summer and fall (Table 16). A higher frequency of visitation by deer and coyotes occurred in clearings than on road transects. Based on Niemi et al. (1979), coyotes appear to be modal species in open habitats and should be favored by clearing construction.

Meaningful measurements of relative use are difficult to obtain from scent stations because controls are difficult to define. Many animals tend to bias their activity toward roads and trails which they use as travel lanes. Two scent transects run along roads during 1974-75 in northwestern Wisconsin also had skunks, coyotes, deer, and snowshoe hares, respectively, as the 4 most frequent visitors (Orrin Rongstad, Univ. Wis.-Madison, Dep. Wildl. Ecol., in litt. 17 September 1975).

Most mammals including deer, were attracted to the scent bait. Frequencies

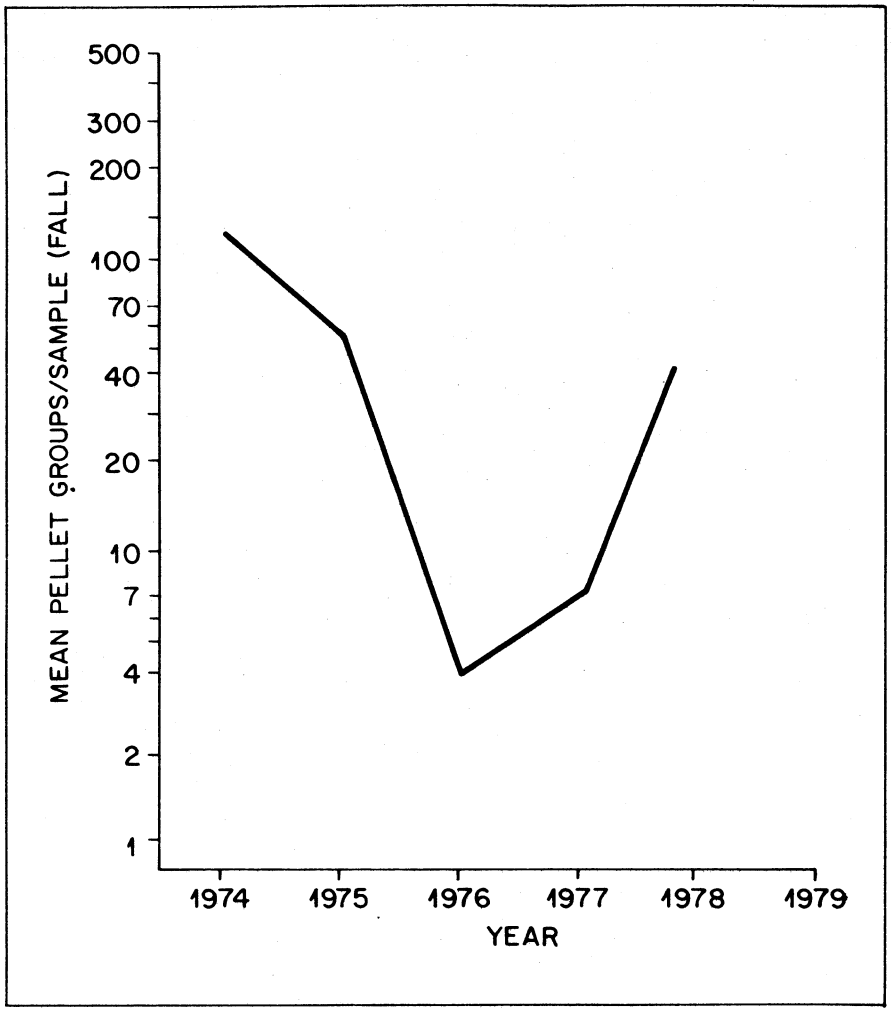


FIGURE 8. *Changes in deer activity in constructed openings on the Arbor Vitae Study Area as determined by pellet group counts.*

TABLE 16. *Animal visits* to scent stations on the Enterprise Study Area during late 1975 and spring 1976.*

	Road transects			Constructed openings		
Animal	Aug	Oct	May	Aug	Oct	May
Deer	93	133	107	270	293	133
Skunk	198	27	13	34	40	13
Coyote	35	27	27	67	67	0
Snowshoe hare	47	53	27	45	40	13
Songbird	23	13	40	22	13	0
Raccoon	12	27	40	22	13	0
Small mammal	23	0	13	11	13	0
Cottontail rabbit	0	0	27	0	27	0
Fox	12	0	0	11	0	13
Dog	0	0	13	0	0	27
Bear	23	0	0	0	0	0
American woodcock	0	0	13	0	0	13
Bobcat	0	0	0	0	0	13
Ruffed grouse	12	0	0	0	0	0
Common crow	12	0	0	0	0	0
Common raven	0	0	0	11	0	0
Chipmunk	0	0	0	11	0	0
Red Squirrel	0	0	0	11	0	0

*Index = visits/station nights × 1,000.

Black bears are known to make considerable use of forest openings for eating grasses, fruits, and insects. (WDNR photo by Bruce Kohn.)

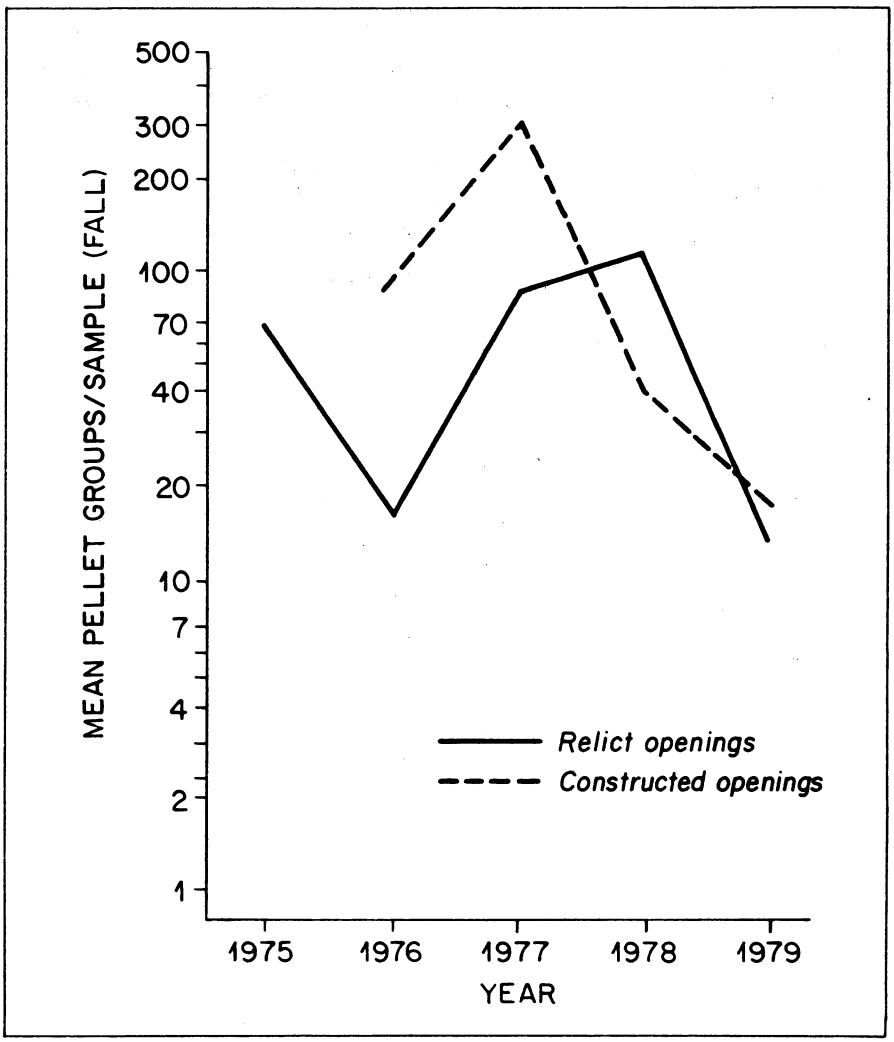


FIGURE 9. *Changes in deer activity on constructed openings and relict openings as determined by pellet group counts on the Vandercook Study Area.*

of deer tracks in unbaited stations were less than 1/2 those in baited stations. Scent stations were again baited in May 1976. Combined visitation rates by all animals were lower than during the fall, especially in openings (Table 16). Seasonally lower populations and hot dry weather may have been contributing factors.

Bear and bobcat visitation rates were lower than would likely be expected in more remote habitat. Populations of both species on the Enterprise Area are kept at an artificially low level by high hunting and trapping exploitation. Bears are known to make considerable use of the openings for insects and fruit (McCaffery and Creed 1969:70) and grasses (Bruce Kohn, Wis. Dep. Nat. Resour., pers. comm.). Kohn also found openings to be one of the most productive trapping sites during his study.

One common species expected but not seen in openings or on edges was the woodchuck.

Small Mammals

In total, small mammals were more numerous on the Enterprise Area during September 1977 than in September 1976 (Table 17). Captures in 1977 averaged 88.9/1,000 trapnights compared to 47.7 in 1976. Species composition was also dramatically different with greater numbers of voles and fewer shrews. Species diversity and total captures were greatest along the edges of clearings. This suggests that woodland and clearing populations are somewhat additive in this ecotone.

TABLE 17. *Small mammals captured in 4 habitats during September 1976 and 1977 on the Enterprise Study Area.*

Species	Percent by year 1976	Percent by year 1977	Numbers captured by habitat: Relict opening	Constructed clearing	Clearing edge	Adjacent woodland	Total captures
Sorex cinereus	71.0	15.7	21	36	83	91	231
Microtus pennsylvanicus	4.4	34.8	12	67	53	1	133
Clethrionomys gapperi	1.6	25.3	2	2	44	45	93
Peromyscus spp.	8.1	16.2	5	0	40	32	77
Blarina brevicauda	9.3	3.4	0	5	16	14	35
Eutamias minimus	1.2	2.3	0	0	7	4	11
Zapus hudsonius	2.0	0	1	1	3	0	5
Tamias striatus	0.8	0.6	0	0	1	3	4
Sorex arcticus	1.6	0	0	2	2	0	4
Tamiasciurus hudsonicus	0	0.9	0	0	1	2	3
Citellus tridecemlineatus	0	0.6	1	1	0	0	2
Lepus americanus	0	0.3	0	0	0	1	1
Captures	248	351	42	114	250	193	599
Trapnights	5,200	3,950	1,850	2,450	2,450	2,400	9,150
Captures/1,000 trapnights	47.7	88.9	22.7	46.5	102.0	80.4	65.5

Physical and vegetative characteristics of the edge and woodland transects are described in Table 18. Adjacent forest overstory of 2 clearings trapped was dominated by aspen poles while the 3rd clearing was located in 6-year-old aspen suckers.

Fewest species (6) and fewest individuals (23/1,000 trapnights) were caught within relict openings. The capture rate was 1/2 that for constructed clearings. No explanation for this difference was readily apparent. Seale et al. (1976), trapping on the Chequamegon National Forest, had similar capture rates in a relict opening and in aspen woodland (27 and 25 captures/1,000 trapnights). Mammal species composition in their opening and aspen transects was roughly similar to the composition of captures in this study.

A striped ground squirrel was seen and not captured during our trapping.

Voles were not at the peak of their population cycle during either the Chequamegon or Enterprise trapping. Our observations and those of Hamerstrom (1979) indicate that 1974 was a cyclic peak vole population year.

Among our captures, *Microtus* and *Zapus* are considered specific to open habitats by Niemi et al. (1979). *Sorex* appeared to be least habitat specific of the mammals captured and was least affected by clearing construction. Beuch (1974*b*:123-35) indicated that the most abundant small mammals on his study area from 1970 to 1972 were *Peromyscus, Microtus, Blarina, Clethrionomys,* and *Tamias,* each averaging about 5/ha at their maximum density during the period. He did not sample *Sorex* spp., but stated

TABLE 18. *Principal plants and features* at small mammal trap sites on edges of constructed openings and on forest transects, on the Enterprise Study Area.*

Plant or feature	Percent	Plant or feature	Percent
OPENING EDGES		FOREST TRANSECTS	
Berm**	35	*Pteridium*	41
Rubus	23	*Corylus*	25
Carex	21	*Carex*	24
Corylus	21	*Brachyelytrum*	19
Pteridium	18	*Aster*	19
Aster	13	*Schizachne*	15
Bromus	12	*Rubus*	10
Populus	12	*Oryzopsis*	8
Schizachne	10	*Bromus*	5
Logs	9	*Calamagrostis*	5
Sticks	6	*Diervilla*	3
Viburnum	5	*Aralia*	2
Oryzopsis	4	Sticks	2
Prunus	4	Logs	2
Brachyelytrum	3	*Acer*	2
Apocynum	3	*Prunus*	2
Convolvulus	3	*Salix*	2
Diervilla	2	*Spiraea*	2
Agrostis	2	*Ostrya*	1
Aralia	2	*Scirpus*	1
Agropyron	2	Stump	1
Iris	2	*Viburnum*	1
Stumps	1	*Abies*	1
Acer	1	*Agropyron*	1
Calamagrostis	1	*Lycopodium*	1
Poa	1	*Osmunda*	1
Salix	1		
Picea	1		
Smilax	1		

*Includes items immediately under, over, or adjacent to traps. The list does not include plants or features occurring at less than 1% of trap sites.

**Berm includes undifferentiated debris (soil, rocks, and wood) rockraked from the clearing.

that *Sorex cinereus* was about 3 times as abundant as *S. arcticus* (Beuch 1974*a*:120).

Our 2 September samples indicate that clearing construction favors establishment of a *Microtus* population at the expense of *Clethrionomys* and *Peromyscus*. The importance of this new population to raptors and mammalian predators could be very significant. The loss to the *Clethrionomys* and *Peromyscus* populations would be inconsequential in view of the vast acreage of woodland habitat.

Other Animal Observations

While we were counting deer pellet groups, all other animal sign found within the 40-m^2 plots was systematically recorded (Table 19). Though these measurements may not reflect population abundance, they do provide an additional indication of types of animals visiting openings.

Other than deer pellets, snowshoe hare pellets were the most frequent sign found in constructed openings. Snowshoe hare populations were high throughout the study years. Frequency of hare pellets on 80-m^2 plots during deer management surveys in spring throughout northern Wisconsin progressively increased from 36% in 1974 to 59% in 1978 (Thompson 1978). Frequencies on 40-m^2 plots in openings ranged from 84%on the Vandercook clearings in 1978 to none in relict openings on the same area in 1977. Frequencies were generally highest in newly constructed openings (Table 19) and declined in subsequent years as clover abundance diminished. Hare use was also strongly related to adjacent habitat. Clearings in aspen saplings (Arbor Vitae and Vandercook) had greater use than those in uncut stands found on Enterprise. Relict openings had consistently low use with a maximum of 7% frequency of pellets on Enterprise in 1978 and 1979. Most relict openings were in pole-sized timber and contained a relatively small amount of clover.

Nests of meadow voles were most common in openings after the 1974-75 winter, averaging 22/ha. Nests declined to fewer than 2/ha by the 1975-76 counts. The number increased to 5.7/ha after the 1977-78 winter and was 3.7/ha after 1978-79. Numbers of nests found in constructed clearings did not appear to be greatly different from numbers found in the Enterprise relict openings. Few nests were found in the Vandercook frostpockets. This was probably due to the predominance of barren strawberry and relatively small amount of grasses and other cover.

Tufts of deer hair were found on a high number of plots in constructed

Nests and evidence of winter feeding by small mammals. Opening construction had the effect of adding a population of meadow voles in a forest habitat dominated by white-footed mice, shrews, and red-backed voles.

TABLE 19. *Other animal sign recorded on 40-m^2 survey plots during spring by study area and type of opening. Entries show 4-year average and highest annual result.*

	Enterprise		Vandercook		Arbor Vitae
Sign*	Relict	New	Relict	New	New
Hare pellet frequency**	4.7(6.7)	14.0(24.8)	1.9(4.2)	35.3(84.3)	25.5(42.4)
Mouse nests/ha	7.8(19.5)	10.1(30.0)	0.7(1.7)	5.3(15.0)	2.7(9.5)
Grouse roosts/ha	0.7(1.4)	1.7(2.6)	5.6(11.4)	3.7(12.9)	0
Deer hair frequency	0.7(2.1)	2.0(7.1)	0.7(1.4)	4.3(9.6)	2.6(11.4)
Coyote scats/ha	0.7(1.2)	1.0(1.2)	1.7(3.2)	2.9(6.5)	2.3(5.2)
Snakes/ha	3.7(6.5)	2.0(3.2)	3.0(5.2)	0	0.3(1.3)
Dens/ha	3.7(10.4)	0.7(1.3)	0.7(1.7)	0.5(2.1)	0.7(1.6)
Frogs/ha	0	1.0(4.8)	0	0	1.3(6.3)
Skunk scats/ha	0	0.7(2.6)	0	0.6(2.1)	1.0(2.5)
Grouse dropping frequency	0	0.1(0.5)	0.8(2.1)	0	0
Owl pellets/ha	0.3(1.3)	1.7(8.0)	0	0	0

*Horse manure was also found on 1 plot and 2 bear scats were found on separate Enterprise plots.

**Frequency = percent occurrence on all plots.

openings. The frequency of hair corresponded with the abundance of deer pellets. The tufts probably were the result of activities related to the rut. This abundance of deer hair on plots has not been noted in any of our previous opening studies.

Scats or droppings of ruffed grouse, coyotes, skunks, bears, owls and a horse were also found. Of these grouse roosts (nightly accumulation of droppings) were most common, averaging 2/ha overall, and were clearly most abundant in openings on the Vandercook Area where adjacent habitat was most favorable. No grouse sign was found while sampling the Arbor Vitae openings, although some grouse were flushed from openings and drumming was heard. Scattered grouse droppings were also found during counts in the Vandercook frostpockets indicating that the birds used these openings for feeding when snow was absent as well as for snow burrowing in winter.

Coyote scats averaged 1.5/ha for all openings and were about twice as common in constructed clearings as in relict openings. Skunk sign was not abundant, but droppings and/or diggings were found in both clearings and relict openings. Two bear droppings were found on separate plots. Six owl pellets were found on the Enterprise openings in spring 1975, 5 of them in constructed clearings. Pellets included remains of grasshoppers, but were apparently composed primarily of *Microtus* remains.

Mammal dens averaged 1/ha and were found on all study areas in both relict and constructed openings. Entrance diameters ranged in size from 2.5 to 13 cm, but most appeared to be burrows of striped ground squirrels.

In addition to the signs discussed above, we found a number of snakes and frogs on the plots. The numbers seen were highly variable because the time of year and the daily weather prevailing during counts affected their activity. Frogs were encountered only during the spring 1975 counts. Seven wood frogs and 1 eastern American toad were found on plots. Northern leopard frogs were also seen in openings, but not on plots. All frogs were seen in constructed clearings.

Thirteen eastern garter snakes, 9 smooth green snakes, and 7 northern red-bellied snakes were seen. Twenty of the 29 snakes were in relict openings, including all of the smooth green snakes. All 3 snakes are listed as "watch species" in Wisconsin (Les 1979). Smooth green snakes are listed as specific to open habitats by Niemi et al. (1979).

In addition to the measurements discussed in previous sections of this report, these incidental observations suggest that openings are used by ruffed grouse for winter roosting and

TABLE 20. *Numbers of individual birds seen or heard in 10 constructed clearings and 10 controls on the Enterprise Study Area, June 1976 and 1977.*

	Clearings		Controls	
Species	1976	1977	1976	1977
Ovenbird	11	20	9	14
Red-eyed vireo	12	10	10	13
Blue jay	8	11	9	15
Chestnut-sided warbler*	5	10	5	8
White-throated sparrow	8	2	7	5
Indigo bunting*	8	5	2	0
American robin	4	7	2	2
Mourning warbler	6	4	1	2
Brown-headed cowbird	3	2	4	3
Song sparrow	4	3	2	2
Common crow	0	6	0	5
Veery	3	2	3	2
Black-throated green warbler	0	2	4	4
Nashville warbler*	5	0	4	0
Hermit thrush	3	4	1	1
Great crested flycatcher*	1	2	5	1
Warbler (unidentified)	0	4	0	5
Rose-breasted grosbeak	2	1	2	3
Woodpecker (unidentified)	2	3	0	3
Least flycatcher*	1	4	2	1
Black-and-white warbler	1	1	2	3
Yellowthroat	1	1	1	3
Black-capped chickadee	1	4	0	0
Common flicker	1	3	0	1
Connecticut warbler*	4	0	0	0
Eastern wood pewee*	1	1	1	1
Great blue heron	0	2	0	2
Scarlet tanager*	2	1	0	0
Golden-winged warbler*	2	0	1	0
Winter wren*	0	1	2	0
Boreal chickadee*	0	1	0	2
Chipping sparrow*	1	0	0	1
Hairy woodpecker	0	1	0	0
Chimney swift	0	0	0	2
Gray jay	0	6	0	5
American bittern	0	1	0	1
White-breasted nuthatch	0	1	0	1
Broad-winged hawk	0	1	0	1
Olive-sided flycatcher*	0	2	0	0
Swamp sparrow*	1	0	0	0
Northern parula warbler	1	0	0	0
Ruby-crowned kinglet*	1	0	0	0
Northern waterthrush*	1	0	0	0
Blackburnian warbler	0	0	1	0
Canada warbler	0	0	1	1
Yellow-rumped warbler	0	0	1	0
American goldfinch*	0	0	1	0
Red-winged blackbird	0	0	1	0
Pileated woodpecker	0	1	0	0
Ruffed grouse	0	1	0	1
Total species	30	36	28	31
Total individuals	104	126	85	109

*Birds not listed by Beuch (1974a:121).

TABLE 21. *Percent occupancy of constructed clearings by peenting woodcock during 1975, 1976, and 1977.*

	Number of	Number occupied (percent)		
Area	clearings censused	1975	1976	1977
Enterprise Study Area	22	3(14)	9(41)	6(27)
Arbor Vitae Study Area				
Madeline Unit	19	2(11)	1(5)	1(5)
Mishonagon Unit	16	No data	0(0)	2(12)
Mean		5(12)	10(17)	9(9)

Ruffed grouse made use of openings for feeding in fall and snow roosting in winter. The presence of clover made some openings especially attractive to grouse in fall. (WDNR photo by John Kubisiak.)

Two-thirds of the human uses of constructed openings reported by questionnaire respondants involved hunting and other "gathering" activities such as berry-picking, mushroom picking, and firewood cutting.

TABLE 22. *Densities of peenting woodcock in habitat types on the Madeline Unit, 1975, 1976, and 1977.*

		Number of woodcock				
Habitat	Ha	1975	1976	1977	Total	Ha/bird
Forest roads	3.5	2	3	0	5	2.1
Clearings	6.3	2	1	1	4	4.7
Cutover aspen	110.0	3	3	3	9	36.7

TABLE 23. *Seasonal distribution of vehicle traffic in the Enterprise Study Area, 1975 and 1976.*

	Combined number of traffic counts/day	
Season	1975	1976
Spring (breakup to Memorial Day weekend)	29	15
Summer (Memorial Day weekend through Labor Day weekend)	17	13
Fall (Labor Day weekend to winter snow cover)	32	23

TABLE 24. *Distribution of vehicle traffic by hunting season in the Enterprise Study Area, 1975 and 1976.*

		Combined no. traffic counts per day	
Hunting season	Date	1975	1976
Bear	2nd Sat. in Sept	27	19
Deer bow	3rd Sat. in Sept	33	23
Woodcock	3rd Sat. in Sept		
Other small game	1st Sat. in Oct	37	26
Deer gun	3rd Sat. in Nov	66	50

by owls that were not otherwise seen. Opening construction may also favor the smooth green snake.

BIRD USE OF CONSTRUCTED OPENINGS

Nongame Birds

Total numbers of individuals and species of nongame birds heard and seen from sample points within constructed openings in the Enterprise Study Area were slightly greater than from control points within nearby forest (Table 20). The 2-year sample averaged 8.4 species and 11.5 individuals/opening and 7.8 species and 9.7 individuals/forested plot. These results may be biased somewhat by the greater radius of audibility and visibility in clearings, but Balda (1975:63) reported that greatest bird variety and numbers occur in multiple storied habitats such as may be provided by edges of openings. Lay (1938) working in Texas also found a higher number of species and individuals on clearing margins than within adjacent forests.

The most common species recorded during morning surveys were ovenbirds, red-eyed vireos, blue jays, chestnut-sided warblers, and white-throated sparrows. These species were about equally abundant on openings and control plots. Constructed openings were found to favor indigo buntings, robins, and mourning warblers while discriminating against arboreal species such as black-throated green warblers and great crested flycatchers. Later in the year, indigo buntings and flocks of

American goldfinches were seen feeding on bull thistle flower heads in the openings. Raptors seen in or near openings incidental to other work during summer 1975 included 6 red-tailed hawks, 2 broad-winged hawks, 1 goshawk, and 1 great horned owl.

All birds seen or heard in the Enterprise openings, including those noticed incidental to other field work, are listed in Appendix D. Listed are several species not seen or heard at the sample or control points noted in Table 20; these are the goshawk, red-tailed hawk, American woodcock, common snipe, great horned owl, whip-poor-will, and common raven. During our surveys on the Enterprise Study Area, we saw or heard 20 species not recorded by Beuch (1974*a*) in his survey of vertebrates of the Enterprise Forest. Of these species, 17 are identifed by asterisk in Table 20; the other 3 include the goshawk, common snipe, and whip-poor-will.

However, Beuch's list includes 15 additional summer residents we did not find. Among the birds seen or heard by us in openings, only the American goldfinch is specific to openings and open habitat according to Niemi et al. (1979). Our observations, supported by information in the literature, suggest that diversity and richness of forest birds may be enhanced by opening construction as turf and shrub birds are favored in an otherwise primarily arboreal habitat.

Game Birds

Based on spring singing ground surveys, an average of about 15% of the constructed openings sampled were occupied by woodcock (Table 21). Occupancy rate was highest on the Enterprise Area presumably because of higher woodcock populations on the heavier soils. These openings did not appear to be especially important to singing woodcock. Complete audio coverage on the Madeline Unit of the Arbor Vitae Area indicated that forest roads were the most heavily used of 3 habitat types on the area (Table 22). Very small "holes" in the young aspen also served as singing grounds. However, as the 4- to 5-m tall aspen suckers continue to grow, the managed openings may become more important as singing grounds. A high percentage of relict openings in pole-sized forests on heavy soils were used as singing grounds in a previous study (McCaffery and Creed 1969:69).

Searches for grouse drumming sites and broods and woodcock broods adjacent to constructed openings with a pointing dog found nothing and were discontinued after searching borders of 35 clearings in 1975 and 22 clearings in 1976. Gregg and Hale (1977) reported that the edges of small openings (roadsides, relict openings, etc.) were the most productive habitats for woodcock nest and brood searches. However, our limited searches were unproductive, probably due mostly to inexperience in conducting such a survey.

Some game birds were seen incidental to other work. A common snipe was flushed from a constructed opening during a woodcock survey. Later in the year, a brood of grouse was flushed from an opening. Numerous ruffed grouse were flushed from constructed openings during the fall. Grouse appeared to be attracted to clearings in the fall by the presence of clover. Reports from grouse hunters and the presence of spent shotshells in many openings indicated frequent hunter/grouse contacts in openings, especially when clover was present.

HUMAN USES OF CONSTRUCTED OPENINGS

Human use was reported as one of the principal benefits of wildlife openings programs in forests of eastern U.S. (Larson 1967:17). His questionnaire data indicated that human benefits were primarily in the form of improved hunter access and bowhunting opportunity.

Vehicle Traffic

Mechanical counters on the Enterprise Area recorded greater traffic volumes during spring and fall than during summer (Table 23). This seasonal traffic pattern was due mainly to spring trout fishing and fall hunting activities. Fall traffic progressively increased as the various hunting seasons opened and culminated with the highest volume of traffic occurring during the deer gun season (Table 24).

Human Activities

Questionnaires were mailed to 184 persons whose vehicles were seen on the Enterprise Area during 1975 and 1976, and 100 responses were received. Individuals were asked to indicate the activities that they had pursued on the area. About 1/3 of the respondents

TABLE 25. *Activities pursued in the Enterprise Study Area during 1975 and 1976 based on questionnaires.*

Activity	No. respondents pursuing activity*
Deer gun hunting	67
Ruffed grouse hunting	62
Sightseeing	44
Berry picking	40
Fishing	40
Deer bow hunting	34
Hiking	26
Seeking solitude	23
Working (timber harvest, mineral exploration)	21
Snowmobiling	21
Bird watching	10
Trapping	8
Photography	7
Picnicking	7
Woodcock hunting	7
Skiing	6
Mushroom picking	6
Predator hunting	5
Firewood gathering	5
Trailbike riding	4
Rabbit hunting	4
Waterfowl hunting	2
Horseback riding	1
Bicycle riding	1
Camping	1
Minnow trapping	1
Jogging	1

*100 respondents provided 454 responses.

made some use of the openings. Hunting dominated as the principal activity by respondents (Table 25). About 40% of 454 notations were related to hunting and another 27% involved various other "gathering" activities (berries, mushrooms, firewood, etc.). About 28% of the notations were purely nonconsumptive, nature appreciation or sporting activities (sightseeing, hiking, picnicking, etc.). The remaining 6% involved mechanized recreational pursuits (snowmobiles, bikes). Persons most likely to benefit from constructed clearings were hunters and berry pickers.

Relative importance of individual activities in Table 25 may have been somewhat biased despite attempts to stratify sampling in 1976. License numbers were recorded whenever research personnel were in the study area during the summer and fall. License numbers were not recorded during winter when many people were known to use the area for snowmobiling, cross-country skiing, and snowshoe hare and predator hunting. In addition, license numbers were more likely to be recorded on parked than on moving vehicles. These biases may have overemphasized the importance of hunting and underemphasized the importance of sightseeing, for example.

Most of the respondents were local residents who made a number of trips and enjoyed thir use of the county forest in Enterprise. Eighty-one percent of the users lived in Oneida or Lincoln County. One percent of the users were from out of state. Numbers of trips/year to the area ranged from 1 to 300 and averaged 39 trips/respondent. Enjoyment of this portion of the county forest was rated as very good by 58% of the respondents and as good to very good by 91%.

User awareness and support of clearing construction appeared to be high. Eighty-one percent of the respondents noticed the constructed clearings, and 83% liked the idea of having them constructed. Eighty-one percent of the respondents agreed that openings would benefit the wildlife in this area. Of 84 respondents answering one question, 10 expressed an opinion that too many clearings had been constructed. Sixty-two percent of the users in 1975 and 36% in 1976 indicated that their use of the area had increased because of the clearings. The difference between these 2 years is due in part to bowhunters whose use of clearings declined as deer use decreased. Bowhunting pressure in 1975 averaged 1 parked vehicle/3.4 km of road during the 1st 9 days of the season. Passengers per vehicle averaged 1.2. Some crowding and competition among bowhunters was evident in clearings the 1st year.

Gun deer hunters used most of the clearings. Signs of hunter activity were noted in 23 of 25 clearings checked after the opening weekend in 1975 and 20 of 25 clearings in 1976. Hunter stands were found in 10 clearings each year. Clearings were also used as rendezvous locations, vehicle parking areas, and end points for deer drives. Deer tracks were also found in most openings.

The most enthusiastic users were bowhunters. However, their enthusiasm and that of sightseers appeared to diminish proportionately with decreased deer use and the loss of a cultivated aspect to the clearings after the 1st year.

RECOMMENDATIONS

MANAGEMENT

Forest opening development is an intensive and costly form of management and, therefore, careful planning and evaluation should precede actual construction. An inventory of existing relict openings is paramount to planning openings construction. Securing existing open area by maintenance treatments must also precede an openings development program.

Guidelines

Provisional guidelines for planning openings construction were developed in consultation with wildlife managers and foresters, and incorporated into a Departmental directive (Appendix F). The directive was designed to limit development rather than to mandate a specific construction goal. The directive limits construction to no more than 1% of any forest compartment (ca. 250 ha) and then only where relict openings in adjacent compartments (2,500 ha) comprise less than 1/2 of the recommended percentage. The recommended amount of opening ranges from 1 to 5% depending on the prescribed deer density goal (Appendix G). This 1% recommendation for construction is considerably less than the original opening maintenance goal of 3-5% (McCaffery and Creed 1969:79). The higher maintenance goal was necessary because relict openings are typically overdispersed (clumped) and of variable size and quality. A much smaller proportion of constructed openings is recommended in part because of cost, but mainly because size, quality, and distribution can be controlled. Furthermore, additional openings can be constructed in the future if more are needed. A maintenance goal preserves options at low cost, but conservatism is wise when recommending construction due to the high cost of overdevelopment.

The guidelines also restrict development to areas (2,500 ha) where habitat is composed of no less than 15% nor more than 55% intolerant (sun-loving) upland forest types. These constraints were recommended to avoid attempts to develop openings in habitats with only limited potential for wildlife or where populations are already high. Portions of some forests are so dominated by northern hardwoods and swamps that the mere addition of openings would do little to elevate habitat quality for deer. In contrast, areas dominated by intolerant forest types (usually on sandy soils) continue to produce high game populations even though they may be deficient in permanent herbaceous openings. The productivity of these areas may decrease in the future as new and better-stocked stands mature, in which case the role of openings on sandy soils may become more significant. Maintenance of relict openings should remain a high priority in all habitats.

Departures from these guidelines may be justified. For example, constructed openings may increase the huntability of areas with very low game populations by attracting game. Openings construction will also usually increase public use where additional recreational pressure is justified and, theoretically, relieve excessive public use elsewhere. These and other considerations may warrant openings construction even in submarginal habitats.

Procedures

To date, most opening construction has employed heavy equipment and methods described earlier in this report. Construction typically followed timber harvest operations. This practice facilitates access, eliminates waste of standing timber volume, and enables managers to choose from partially cleared sites (such as trail junctions and log landings) for development. Furthermore, some amount of open area often remains after clearcutting aspen (McCaffery 1975). North Central District personnel typically chose poorly stocked sites in cutover aspen for development. However, the Northwest District recommended choosing better-stocked sites to avoid wet, rocky, or otherwise poor soils. Each method has its advantages and disadvantages, but the latter method appeared to have higher development costs and required earlier maintenance.

Constructed clearings should be at least 0.3 ha and only rarely more than 0.8 ha, depending on the site. Shape and orientation of openings is relatively unimportant so long as the minimum dimension exceeds 60 m. Proximity to winter yards is not important. The amount of construction should not exceed the agency's projected capability for future maintenance.

Construction should be avoided when soils are wet. The least soil is removed by land clearing equipment when soils are dry and leaves have fallen from shrubs and saplings. Use of a straight-blade for clearing is not recommended. Too much soil is removed and too little root destruction occurs. As a result, aspen regenerates prolifically. The least aspen regeneration occurred after sites were cleared with a rockrake and were leveled using a heavy construction disc (Jeff Wilson and John Olson, Wis. Dep. Nat. Resour., pers. comm. 16 April 1980).

While roughing-in openings can best be done when soils are not excessively wet, the best clover germination and growth can be expected in moist soil. Droughtiness may delay clover germination for a year or more, affect bluegrass establishment, and increase competition from weeds and woody plants.

Woody regrowth, including aspen, may be controlled by double-cutting in June (cutting with the mower set high and recutting in 3 hours with the mower set lower) as suggested by Stoeckeler (1947:269). Though no additional studies of double-cutting have been published, interest in the technique is increasing as herbicide controversies escalate. A single mowing during late June or early July is less effective than double-cutting. Single mowing in August or September will improve fall green-up, but is least effective for controlling woody vegetation (D.A. Perala, U.S. For. Serv., pers. comm. 23 September 1980).

Various seed mixes and the elimination of soil amendments (fertilizers) have been recommended in Wisconsin and elsewhere (Webb and Patric 1961). However, present methods have been successful and cost-savings of these alternative recommendations appeared insignificant. Opening development by chemical means may have potential. But costs of chemicals, reluctance to employ herbicides, and delays in obtaining the desired vegetative community have discouraged extensive testing of this technique.

Openings construction should not be attempted on sites with infertile dry sandy sods. Abiding by the intolerant-type constraints in the guidelines should preclude development on excessively sandy sites.

RESEARCH

Additional ecological studies will be important to sustain effective management programs. Measures of deer use, alone, have provided essential information for evaluating the importance of forest openings. A previous study found that deer activity in northern hardwoods with openings was 3 times as great as in hardwoods without openings, and deer use in openings was 3-5 times as great as on overall ranges (McCaffery and Creed 1969:24,48). Deer dependence on relict openings in a red pine plantation appeared to increase as the pine matured (McCaffery 1980). However, more information would be desirable on the impact of openings on deer physiology and carrying capacity. Segelquist (1974:143) indicated that deer-carrying capacity of a 243-ha Arkansas enclosure may have been increased by 25% in years of mast failure by the addition of 4 intensively managed forage clearings making up 2.2% (5.45 ha) of the enclosure. The impact of openings is probably not as great in Wisconsin. But similar controlled experiments have not been conducted in forested habitats of the Lakes States. To replicate Segelquist's study under northern Wisconsin conditions would be difficult because of the effects of winter severity on deer populations and our desire to study the importance of relict-type openings.

The relative importance of *grassy* openings to deer on sandy loam soils is still unclear. Clover and barren strawberry openings were heavily used, especially in years of low acorn production. Additional monitoring of deer use and vegetation in the Arbor Vitae and Vandercook areas would strengthen our appriasal of grass importance, especially if vegetation in these openings returns or reverts to predominantly grass, thereby replicating conditions noted on the Arbor Vitae Area in 1977 and 1978.

This study provides general information on the broad spectrum of wildlife species using openings. It was not intended, however, to answer the question of the real significance of openings which still remains to be done. As with deer, presence within and use of openings alone does not necessarily indicate a quantified need for openings. Intensive studies of population densities in treatment areas and controls would be necessary to demonstrate dependence of small mammals and birds on openings.

The dollar costs of openings construction and maintenance are easily determined. However, the economic benefits of openings programs remain ill-defined. Krusac and Michael (1979:95) list a number of "return units" from openings such as population increases, use days, and public relations, but note that dollar values have not yet been assigned to these units. While Larson (1967), Krusac and Michael (1979), and this study have identified some types of return units, much remains to be done to complete the list and to quantify returns by unit, even before attempting economic quantification.

Further research to define lower-cost construction methods should be encouraged. Attempts have been made to construct openings by using chemicals, but insufficient time has elapsed to evaluate the results (John F. Olson, Wis. Dep. Nat. Resour., pers. comm. 1980). Followup observations should be made on these treatment areas and additional trials and exploration of construction methods should be pursued.

The actual economic and ecological value of openings remains obscure and may never be fully understood. However, the increased competition for land and the increased cost of restoring

openings will continue to press for information on the value of openings. Reduction in opening program costs through research on new methods of construction and maintenance will sustain the program for an interim period. But the more difficult priority will be to "factor out" the contribution of openings to increasing carrying capacity. If estimated just for deer, economists may be able to better assess the economic value of openings.

SUMMARY

The cost of constructing openings in northern Wisconsin in 1979 was about $650-$800/ha. Costs for heavy equipment contractors were relatively unaffected by pretreatment site conditions in the North Central District, although no sites studied were exceptionally stony. Subsequent maintenance costs can be minimized if initial site preparation includes thorough discing so as to fragment aspen root stocks. Surviving aspen suckers are less vigorous and are readily killed by treatment with pellets containing picloram or, perhaps, double-cutting with a mower 2-3 years after opening construction. The construction methods and seed mix used since 1974 have successfully established the herbaceous communities desired to supplement relict openings, except on the sandiest soils.

Newly constructed openings received extremely heavy use by deer and appeared to attract deer away from available relict openings. A relatively small amount of annually farmed clearings might substitute for the absence of a larger amount of relict-type openings in meeting needs of deer, but at a higher cost. As vegetation in new openings "reverted" from crops to a grass/forb community, deer use declined. Vegetation and deer use in constructed openings on loamy soils appeared to be similar to that in relict openings 3 years after construction. Deer use of openings on sandier soils appeared to be related directly to the availability of broad-leaved herbs (clover and barren strawberry) in openings and inversely to acorn availablity in the forest.

A variety of other wildlife was found using openings. Coyotes appeared to be attracted to openings and bears are known to frequent them in remoter habitats. A new population of meadow voles was established with clearing construction, and a concentration of diverse small mammals was found on opening edges. These populations have implied benefits to predators. Hare use of openings was heavy when clover was present and adjacent habitat was young aspen. Ruffed grouse, skunks, and owls were known to use the openings. Openings construction appeared to enhance songbird diversity by favoring turf and shrub bird species. Woodcock were found using some clearings for singing, but were also found in small unstocked areas within the adjacent young aspen. As the aspen matures, managed openings may become more important as singing grounds. Smooth green snakes were among the reptiles that may be favored by opening construction.

High public approval of openings construction was found when opinions were sampled on the Enterprise Area. Principal beneficiaries of the openings appeared to be hunters and berry pickers. Public enthusiasm for the program appeared to dampen somewhat with the realization that openings were not to be annually farmed food patches. However, the openings construction phase of Wisconsin's forest habitat program has gained considerable momentum since its inception in 1974. Within 6 years, 1,048 openings were constructed within 5 counties of the Woodruff and Antigo areas alone (Ron Eckstein, Wis. Dep. Nat. Resour., pers. comm. 1980). These openings clearly add diversity to the habitat and increase the variety of birds and animals using an area, and public support for openings construction is high. However, justification for constructing openings continues to be based primarily on deer and human uses and on the desirability of restoring a natural component to the environment that is being diminished by intensive forest protection and management.

Guidelines for openings construction were prepared which limit development to not more than 1% of the forest and then only where relict openings are deficient (less than 1/2 the desired goal). This level of construction appears to be adequate to meet the needs of deer at present densities. Less conservative guidelines may be adopted in the future, if total benefits become clearer or cheaper construction methods are found.

Additional ecological studies will be important to sustain effective openings management programs. This study provides perspective on the spectrum of species using openings and the potential values of openings. More detailed study is needed of the impact of openings on natality and survival of wildlife, as are studies directed toward cost/benefit development. The data gathered in this study provide a starting point for these efforts.

APPENDIXES

APPENDIX A: OPENINGS CONSTRUCTION CONTRACT USED BY NORTH CENTRAL DISTRICT DURING 1974 AND 1975

Agreement entered into between the Bureau of Game Management, Wisconsin Department of Natural Resources, hereinafter referred to as the "Department" and

_____ of _____ hereinafter called "Contractor."

Contractor may operate on the following described lands: _____

_____

_____

_____

The price at which contractor shall operate is _____ per _____ subject to the following terms and conditions:

1. Contractor will completely perform his obligations under this contract by the 1st day of December 1975. An extension of time may be granted, in writing, as an addendum to the contract, signed by both parties, providing unusual environmental conditions warrant an extension.
2. Contractor shall equip his machine with a rockrake or other land clearing equipment acceptable to the Department.
3. Initial clearing shall be done by removing debris (including stones, trees, brush, stumps, etc.) to the outside of the opening perimeter.
4. Debris is to be deposited at random no more than 5 ft above the ground level outside the periphery of the opening.
5. All resonable effort will be used to retain the topsoil. The Department will determine if excessive topsoil is being removed from the opening and constitutes a violation of this contract.
6. Following initial clearing, Contractor shall prepare a seed bed by exposing a minimum of 90% of the topsoil of the opening and by removing rock and other debris protruding 4 inches or higher above the ground level.
7. Contractor shall prepare a seed bed that is suitable for subsequent seeding, using a farm disc or other suitable equipment acceptable to the Department. Following discing, Contractor shall traverse site at least once using a spike tooth harrow or other equipment suitable to the Department.
8. Contractor shall be responsible for seeding and fertilizing the opening following seed bed preparation.
9. Seeding and fertilizing will be prohibited from 16 June through 31 August and shall be allowed during the remainder of the contract only on freshly worked soil within the opening.
10. The Department shall provide the seed and fertilizer to be used.
11. Contractor shall apply the premixed seed mixture at the rate of 14 lb/acre (8 lb of white dutch clover and 6 lb of Kentucky blue grass) and the fertilizer at the rate of 200 lb/acre (16-8-8) in a manner acceptable to the Department. Oats shall also be seeded at the rate of 1 bushel/acre on those openings designated by the Department.
12. Contractor shall be responsible for staying within the boundaries of the treatment area and shall be liable for all trespass committed by the Contractor outside of such boundaries.
13. Contractor agrees to assume all liability for any damage or injury to persons or property, real or personal, resulting from Contractor's operations under this contract and shall certify that he has liability insurance in the following amounts or more prior to beginning work: bodily injury—$10,000 each person, $20,000 each accident; and property damage—$5,000 each accident.
14. Contractor shall inform the Department of the date he will begin operations before starting such operations.
15. Completed tracts or units will be computed by the Department to determine exact acreage treated and this figure will be final.
16. Failure by the Contractor to comply with the conditions of this contract may result in the cancellation of this contract and 50% reduction in the prorated per unit bid for the portion of the contract area completed.
17. All modifications to this contract must be in writing signed by the parties hereto.

Dated this _____ day of _____, 19_____.

Signed: _____
(Contractor)

APPENDIX B: METHOD FOR SAMPLING HERBACEOUS VEGETATION

The method used for sampling herbaceous vegetation was taken from Cameron Wilson (Wis. Dep. Nat. Resour. pers. comm. 1968).

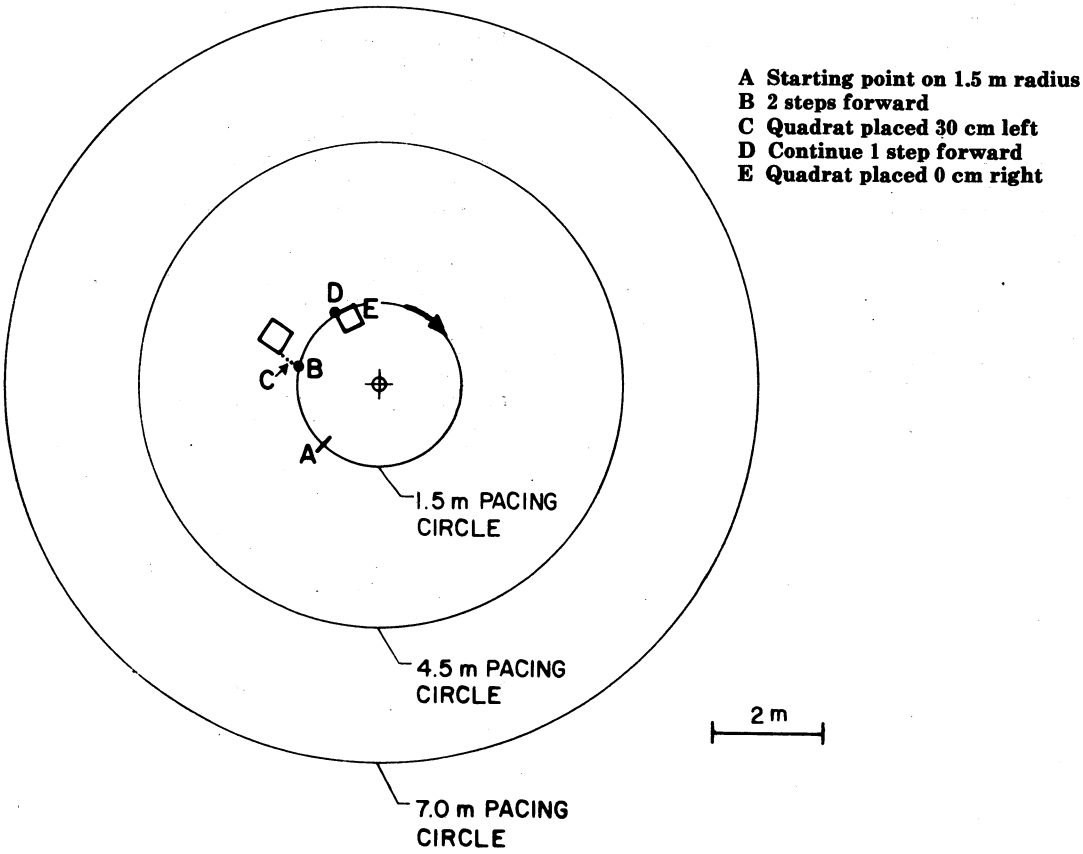
1. Of the 20 randomly located plots within each opening, 2 or 3 (depending on whether the opening was larger or smaller than 0.4 ha) were randomly chosen, and their centers located by pacing to the plot center as described by McCaffery and Creed (1969:19).

2. Thirty 930-cm^2 quadrats were randomly located (stratified random) along 3 concentric pace circles with radii of 1.5, 4.5, and 7.0 m. The numbers of quadrats per circle (e.g., 4, 13, 13) were allocated according to the area sampled from each circle.

3. Three sets of random numbers were used. The 1st set provided the number of steps forward on each pace circle. The 2nd set (odd or even) determined a right or left measurement. The 3rd set determined the amount of right or left measurement. The finished numbers would be as follows: 04 L 60 meaning 4 steps forward and left 60 cm.

4. The starting point on the 1st pace circle and the direction of pacing was arbitrarily fixed for each plot. A flexible tape was pivoted from the plot center to enable the observer to position quadrats.

5. Below is a diagram for 2 arbitrary quadrant locations: 02 L 30 and 01 R 00.



APPENDIX C: FOREST TYPES

Forest types mentioned in the text include the following species:

Aspen: Predominantly quaking aspen, but also large-toothed aspen with variable components of paper birch, balsam fir, red maple, and black cherry.

Conifers, lowland: Combination of species, but mostly black spruce, tamarack, white cedar, and balsam fir.

Openings (relict): Upland less than 10% stocked with trees and less than 30% stocked with brush. Dominant cover is herbaceous (Levy 1970).

Noncommercial lowland: Stunted black spruce, marsh, muskeg, and lowland brush.

Northern hardwoods: Predominantly sugar maple with variable components of basswood, white ash, red oak, paper birch, and balsam fir.

Pines: Combination of species—red pine, white pine, and jack pine.

APPENDIX D: TAXONOMY OF PLANTS AND ANIMALS

Taxonomy of plants cited (Gleason 1958):

Alsike clover - *Trifolium hybridum*
Aspens or poplars - *Populus* spp.
Aster - *Aster ciliolatus*
Asters - *Aster* spp.
Balsam fir - *Abies balsamea*
Barren strawberry - *Waldsteinia fragarioides*
Basswood - *Tilia americana*
Beaked Hazel - *Corylus cornuta*
Bent grasses - *Agrostis* spp.
Bindweeds - *Convolvulus* spp.
Birches - *Betula* spp.
Black cherry - *Prunus serotina*
Black spruce - *Picea mariana*
Blue grasses - *Poa* spp.
Blueberry - *Vaccinium angustifolium*
Bracken fern - *Pteridium aquilinum*
Brambles - *Rubus* spp.
Brome grass - *Bromus inermis*
Brome grasses - *Bromus* spp.
Bull thistle - *Cirsium vulgare*
Bulrushes - *Scirpus* spp.
Bunchberry - *Cornus canadensis*
Bush honeysuckles - *Diervilla* spp.
Carrion flowers or cat briars - *Smilax* spp.
Cedar - *Thuja* spp.
Cherries - *Prunus* spp.
Choke cherry - *Prunus virginiana*
Cinquefoils - *Potentilla* spp.
Club mosses - *Lycopodium* spp.
Common blackberry - *Rubus allegheniensis*
Dogbanes - *Apocynum* spp.
European raspberry - *Rubus idaeus*
False melic grass - *Schizachne purpurascens*
Firs - *Abies* spp.
Flowering ferns - *Osmunda* spp.
Flowering wintergreen - *Polygala paucifolia*
Goldenrods - *Solidago* spp.
Grasses - *Poaceae*
Hair cap mosses - *Polytrichum* spp.
Hawkweeds - *Hieracium* spp.
Hazels - *Corylus* spp.
Hemlocks - *Tsuga* spp.
Horseweed - *Conyza canadensis*
Irises - *Iris* spp.
Ironwood - *Ostrya virginiana*
Jack pine - *Pinus Banksiana*
Japanese honeysuckle - *Lonicera japonica*
Kentucky blue grass - *Poa pratensis*
King-devil - *Hieracium aurantiacum*
Ladino clover - *Trifolium repens* var. *latum*
Large-toothed aspen - *Populus grandidentata*
Large-leaved aster - *Aster macrophyllus*
Lettuces - *Lactuca* spp.
Long-awned wood grass - *Brachyelytrum erectum*
Louseworts - *Pedicularis* spp.
Maples - *Acer* spp.
Meadow-sweet - *Spiraea alba*
Mullein - *Verbascum thapsus*
Oats - *Avena sativa*
Ox-eye daisy - *Chrysanthemum leucanthemum*
Panic grasses - *Panicum* spp.
Paper birch - *Betula papyrifera*
Pearly everlasting - *Anaphalis margaritacea*
Poverty-grass - *Danthonia spicata*
Quack grass - *Agropyron repens*
Quaking aspen - *Populus tremuloides*
Red maple - *Acer rubrum*
Red oak - *Quercus rubra*
Red pine - *Pinus resinosa*
Reed grasses - *Calamagrostis* spp.
Rice grass - *Oryzopsis asperifolia*
Rice grasses - *Oryzopsis* spp.
Roses - *Rosa* spp.
Rutabagas - *Brassica Napobrassica*
Rye - *Secale cereale*
Sarsaparillas - *Aralia* spp.
Satin or Muhly grasses - *Muhlenbergia* spp.
Sedge - *Carex pensylvanica*
Sedges - *Carex* spp.
Service berries - *Amelanchier* spp.
Spruces - *Picea* spp.
Staghorn sumac - *Rhus typhina*
Strawberry - *Fragaria virginiana*
Sugar maple - *Acer saccharum*
Sweet fern - *Myrica asplenifolia*
Tamarack - *Larix laricina*
Thistles - *Cirsium* spp.
Timothy - *Phleum pratense*
Upland bent grass - *Agrostis perennans*
Viburnums - *Viburnum* spp.
Violets - *Viola* spp.
Wheatgrasses - *Agropyron* spp.
White ash - *Fraxinus americana*
White campion - *Lychnis alba*
White cedar - *Thuja occidentalis*
White clover - *Trifolium repens*
White pine - *Pinus Strobus*
White spruce - *Picea glauca*
Willows - *Salix* spp.
Wintergreen - *Gaultheria procumbens*
Yarrow - *Achillea millefolium*
Yellow devil's paintbrush - *Hieracium florentinum*

APPENDIX D. Continued.

Taxonomy of birds cited (AOU, 1957, 1973, 1976):

Great blue heron - *Ardea herodias*
American bittern - *Botaurus lentiginosus*
Goshawk - *Accipiter gentilis*
Red-tailed hawk - *Buteo jamaicensis*
Broad-winged hawk - *Buteo platypterus*
Ruffed grouse - *Bonasa umbellus*
American woodcock - *Philohela minor*
Common snipe - *Capella gallinago*
Great horned owl - *Bubo virginianus*
Whip-poor-will - *Caprimulgus vociferus*
Chimney swift - *Chaetura pelagica*
Common flicker - *Colaptes auratus*
Pileated woodpecker - *Dryocopus pileatus*
Hairy woodpecker - *Picoides villosus*
Great crested flycatcher - *Myiarchus crinitus*
Least flycatcher - *Empidonax minimus*
Eastern wood pewee - *Contopus virens*
Olive-sided flycatcher - *Nuttallornis borealis*
Gray jay - *Perisoreus canadensis*
Blue jay - *Cyanocitta cristata*
Common raven - *Corvus corax*
Common crow - *Corvus brachyrhynchos*
Black-capped chickadee - *Parus atricapillus*
Boreal chickadee - *Parus hudsonicus*
White-breasted nuthatch - *Sitta carolinensis*
Winter wren - *Troglodytes troglodytes*
American robin - *Turdus migratorius*
Hermit thrush - *Catharus guttatus*
Veery - *Catharus fuscescens*
Ruby-crowned kinglet - *Regulus calendula*
Red-eyed vireo - *Vireo olivaceus*
Black-and-white warbler - *Mniotilta varia*
Golden-winged warbler - *Vermivora chrysoptera*
Nashville warbler - *Vermivora ruficapilla*
Northern parula warbler - *Parula americana*
Yellow-rumped warbler - *Dendroica coronata*
Black-throated green warbler - *Dendroica virens*
Blackburnian warbler - *Dendroica fusca*
Chestnut-sided warbler - *Dendroica pensylvanica*
Ovenbird - *Seiurus aurocapillus*
Northern waterthrush - *Seiurus noveboracensis*
Connecticut warbler - *Oporornis agilis*
Mourning warbler - *Oporornis philadelphia*
Yellowthroat - *Geothylpis trichas*
Canada warbler - *Wilsonia canadensis*
Red-winged blackbird - *Agelaius phoeniceus*
Brown-headed cowbird - *Molothrus ater*
Scarlet tanager - *Piranga olivacea*
Rose-breasted grosbeak - *Pheucticus ludovicianus*
American goldfinch - *Carduelis tristis*
Indigo bunting - *Passerina cyanea*
Chipping sparrow - *Spizella passerina*
White-throated sparrow - *Zonotrichia albicollis*
Swamp sparrow - *Melospiza georgiana*
Song sparrow - *Melospiza melodia*

Taxonomy of mammals cited (Jackson 1961):

Cinereous shrew - *Sorex cinereus*
Saddle-backed shrew - *Sorex arcticus*
Giant mole shrew - *Blarina brevicauda*
Snowshoe hare - *Lepus americanus*
Cottontail rabbit - *Sylvilagus floridanus*
Woodchuck - *Marmota monax*
Striped ground squirrel - *Citellus tridecemlineatus*
Chipmunk - *Tamius striatus*
Least chipmunk - *Eutamias minimus*
Red squirrel - *Tamiasciurus hudsonicus*
White-footed mice - *Peromyscus* spp.
Red-backed vole - *Clethrionomys gapperi*
Meadow vole - *Microtus pennsylvanicus*
Meadow jumping mouse - *Zapus hudsonius*
Coyote - *Canis latrans*
Red fox - *Vulpes fulva*
Dog - *Canis familiaris*
Bear - *Ursus americanus*
Raccoon - *Procyon lotor*
Long-tailed weasel - *Mustela frenata*
Skunk - *Mephitis mephitis*
Bobcat - *Lynx rufus*
White-tailed deer - *Odocoileus virginianus*
Horse - *Equus caballus*

Taxonomy of reptiles and amphibians cited (Vogt 1981):

Eastern American toad - *Bufo americanus americanus*
Northern leopard frog - *Rana pipiens*
Wood frog - *Rana sylvatica*
Smooth green snake - *Opheodrys vernalis*
Eastern garter snake - *Thamnophis sirtalis sirtalis*
Northern red-bellied snake - *Storeria occipitomaculata occipitomaculata*

APPENDIX E: QUESTIONNAIRE USED TO SAMPLE HUMAN ACTIVITIES AND OPINIONS ON THE ENTERPRISE STUDY AREA

Entry No: _____

Date: _____

Observer: _____

We're interested in the kind of use being made of this Enterprise Area and how some of the land management being carried out here affects you.

Could you take the time to answer a few questions?

1. Is this your first trip to the Enterprise Area? ( ) Yes ( ) No
   a. If No, how many other trips did you make to the Enterprise Area this year? _____.
   b. How many previous years have you visited the Enterprise Area? _____.

2. What was the main purpose (s) of this trip? (Check all boxes that apply.)
   ( ) Hunting: ( ) Deer ( ) Grouse ( ) Woodcock ( ) Bear ( ) Ducks ( ) Other ( ) Sightseeing ( ) Gathering Berries
   ( ) Canoeing ( ) Picnic ( ) Fishing ( ) Watching Birds ( ) Camping ( ) Photography ( ) Trapping ( ) Gathering Mushrooms
   ( ) Hiking ( ) Solitude ( ) Other purpose (specify) _____

3. Have you noticed the sodded openings in this area? ( ) Yes ( ) No
   a. If Yes, are you in the Enterprise Area now because of these openings? ( ) Yes ( ) No
   b. If Yes, what area did you use before these openings were constructed? _____

4. Do you like the idea of having these openings constructed in the woods? ( ) Yes ( ) No
   a. For what reason? _____

5. Do you like the locations of them? ( ) Yes ( ) No
   a. ( ) Too close to road
   b. ( ) Too far from road
   c. ( ) Just right distance

6. Do you like the number of openings constructed in this area? ( ) Yes ( ) No
   a. ( ) Too few
   b. ( ) Too many
   c. ( ) Just right

7. Residence
   a. ( ) Oneida Co.
   b. ( ) Other Co. in Wisconsin
   c. ( ) Nonresident. State _____

8. Age (record number)
   a. ( ) Child
   b. ( ) Teen
   c. ( ) Young - Middle-aged
   d. ( ) Retired (65+)
   e. ( ) Total

9. Sex (record number)
   a. ( ) Male
   b. ( ) Female

10. Weather

a. Temperature	b. Precipitation	c. Wind	d. Sky Condition
( ) -20°F	( ) None	( ) Calm	( ) Clear
( ) -20-0	( ) Light rain	( ) Light (1-7mph)	( ) 1/4-1/2 Cloud cover
( ) 1-20	( ) Heavy rain	( ) Moderate (8-12)	( ) 1/2-Overcast
( ) 21-40	( ) Mist	( ) Strong (12+)	( ) Overcast
( ) 41-60	( ) Fog		
( ) 61-80	( ) Snow		
( ) 81+			

APPENDIX F: FOREST OPENING MAINTENANCE AND CONSTRUCTION

Manual Code 2112.1

State of Wisconsin
Department of Natural Resources

SUBJECT: Forest Opening Maintenance and Construction

REASON FOR CHANGE: Procedural

This directive provides revised goals for managing *natural* and *constructed* herbaceous forest openings for wildlife. Forest openings, especially on heavier soils, are classified as an important habitat type (see Manual Code 2112). It is important that herbaceous openings of 1/2 to 5 acres be set aside as permanent wildlife openings. The original goal of 3-5% natural openings was set recognizing that openings as seen on aerial photographs are of variable quality and poor distribution. Experience has shown that a smaller acreage of *managed* openings may be sufficient to meet requirements of deer. Furthermore, the acreage of *constructed* openings required is much less than for natural openings because quality, size, and distribution can be controlled. Therefore, this directive provides a new 2-pronged goal; 1 for natural openings and a 2nd for constructed wildlife openings.

The following guidelines apply to all DNR lands north of Wisconsin Highway 21 and county forests following acceptance by county forest committees and amendment of respective 10-year plan.

NATURAL OPENINGS

Definition: Pre-existing or maintained herbaceous openings that contain less than 10% stocking with trees and less than 30% stocking with brush; usually resulting from historic disturbances such as old camps, homesteads, log landings, frostpockets, etc., not mechanically constructed for wildlife objectives, but may have been reclaimed by herbicide treatment.

Objective: Seek to maintain up to 3% of the total land area in permanent herbaceous openings on each 1/4-township-sized habitat inventory unit (HIU) as recommended by Manual Code 2112.

Procedures: If forest reconnaissance type maps do not identify small openings, a special inventory will be required. Use procedures similar to those recommended in Appendix E, pp. 93-98 of DNR Technical Bulletin No. 44. Those openings identified, discussed with the land manager, and mapped as provided in Manual Code 2112 are to be set aside as permanent openings and are not to be diminished by any project activity.

CONSTRUCTED OPENINGS

Definition: Mechanically constructed wildlife openings planted with a seed mixture designed to establish permanent herbaceous openings similar to natural openings; not annually farmed food patches.

Objective: Design clearings to provide up to 1% of the land area in herbaceous openings where none exists, or to augment natural openings where they comprise less than 1/2 of the recommended HIU composition prescribed in Manual Code 2112.

Procedures: Inventory and maintenance of all natural openings is prerequisite to opening construction. Openings should be constructed on better soils, and priority should be given to areas where the forest composition in the HIU is not less than 15 nor more than 55% intolerant upland forest types. Constructed openings should be a minimum of 3/4 acre in size, but rarely larger than 2 acres depending on site. The minimum diameter should exceed 3 chains. Constructed clearings should not exceed 1% of the land area of a *compartment* nor exceed 2 acres on any 40-acre tract.

****

Departures from these guidelines are permissible only when additional values can be clearly demonstrated such as aesthetics, heavy human use, etc., or where these guidelines conflict with special use objectives such as wilderness areas, sensitive environmental corridors, etc., and exceptions identified in county forest 10-year plans.

SECRETARY'S DIRECTIVE ASE

Date: November 29, 1978

Distribution:

All Manual Holders
County Forest Administrators

Special Instructions:
Rescinds and replaces M.C. 2112.1 (4-8-70)

APPENDIX G: GUIDELINES FOR DEFINING FOREST WILDLIFE HABITAT MANAGEMENT PRIORITIES

Manual Code 2112

State of Wisconsin
Department of Natural Resources

SUBJECT: Guidelines for Defining Forest-Wildlife Habitat Management Priorities

The purpose of this directive is to provide a procedure for planning habitat work on all forest lands of the Department of Natural Resources north of Wisconsin Highway 21, and on all county forest lands with the approval of county forestry committees. Improved habitat is to be achieved by identifying critical types, locating critical stands, collating and coordinating management objectives, and designating specific forest stands which require protection or specialized treatment.

IMPORTANT HABITAT TYPES

"Important habitat types" are those forest types known to be important to wildlife or types without which a species would be significantly less abundant. Types important to deer include aspen, sodded openings, upland brush, scrub oak, jack pine and conifers used as deer yarding cover. Aspen, lowland brush-alder and upland brush are also important to ruffed grouse, woodcock, and showshoe hares. All of these types, except some yard types, are composed of shade-intolerant (sun-loving) species. Aspen should be maintained as a major component of a stand or as a major type wherever huntable populations of ruffed grouse are desired. Aspen interspersed with lowland brush-alder has especially high potential for both woodcock and grouse.

While abundance of intolerant tree species alone is a key factor in game production, diversity is also necessary for range quality, forage variety, community stability, and aesthetics. Habitat evaluation should proceed using a 1/4-township-sized area (about 6,000 acres) as a basic habitat inventory unit (HIU). This size area provides greater perspective and choice than individual compartments, and better insight into type arrangement than total property statistics. The HIU facilitates record keeping and aids in achieving a desirable distribution of important habitat types over the property. The HIU is also large enough to reasonably provide all seasonal requirements of deer and other major forest game species. Table 1 contains compositional guidelines for evaluating deer habitat quality and for defining forest-type management priorities in northern Wisconsin. A breakdown of intolerant types is provided in the table because each is *known* to provide a unique requirement of deer. All tolerant types and plantations are combined in the table because these types produce uniform shading of the understory which reduces forage variety and quality.

Table 1. Compositional Guidelines for Evaluating Forest Habitat Quality

Forest	Percent Required to Maintain Specified Fall Densities		
	10 Deer/Sq. Mi.	20 Deer/Sq. Mi.	30+ Deer/Sq. Mi.
Intolerant forest types	>25	>45	>65
Grass & Upland Brush	1	3-5	5
Oak & Scrub Oak	5	10	20
Aspen & Off-Site Aspen	20	25	30
Jack pine or Yarding Cover[1]	10	15	15
Tolerant types[2] & Plantations	<65	<45	<25

[1]Cedar, Hemlock, Swamp Conifers, White Spruce, Balsam Fir, and White Pine.
[2]Northern hardwoods, Mixed hardwoods (Maple-Red Oak-Aspen-Birch), and Balsam Fir.

These compositional guidelines should be applied to each HIU to determine local habitat needs and to insure interspersion of habitat components. No HIU is expected to have the exact composition as recommended, and not all HIUs were, are, or will ever be quality game range. These guidelines are to be used as an aid for identifying present and potential habitat deficiencies. Areas which are already deficient in one or more types should be prevented from becoming poorer habitat by maintaining remaining components of good habitat. On the other hand, some HIUs may greatly exceed the minimum guidelines for a specific type, yet still contain critical stands based on deficiencies in adjacent HIUs or the total property. The paramount concern is that the property meet or exceed the minimum intolerant composition necessary to achieve the desired deer population goal. When an important habitat type falls below the percentage listed, it becomes a "critical type" on the property. Specific stands of critical type required to maintain diversity or wildlife abundance become "critical stands." The management objective is to identify and seek to maintain all critical stands.

(more)

SECRETARY'S DIRECTIVE ASE

Date: October 20, 1976

Distribution:

All Manual Holders
All County Forest Administrators

Special Instructions:
Rescinds and replaces M.C. 2112 (4-8-70)

PROCEDURES FOR INVENTORYING AND MAINTAINING IMPORTANT HABITAT TYPES

The following procedures are to be implemented on DNR lands north of Wisconsin Highway 21 and all county forest lands following approval of county forestry committees.

Wildlife Manager

1. Establish survey units (HIUs) of about 1/4 township or 6,000 acres in size conforming to compartment boundaries where compartments are established.
2. Evaluate acreages of critical types by using compartment recon sheets, dot count summaries, or other available quantitative information where recon data have not yet been programmed. Forest openings must be inventoried separately from aerial photos (see Manual Code 2112.1) since forestry mapping standards do not provide the necessary information.
3. Analyze percentage of important habitat types (where compartment recon is complete and current) for each forest unit of the property as contained within Program 3 of Preliminary Recon Printout. Determine what types do not meet the minimum percentage desired within the unit. These become critical types on the property.
4. Construct current type map of each HIU by piecing together compartment BW type maps or use of township base maps. Evaluate these critical types (color-coding only critical types provides perspective) with reference to distribution within the unit, soil types in the area, and timber management objectives within the unit.
5. Designate critical stands that should be maintained.

Wildlife Manager and Property Manager

6. Examine the management objective of each critical stand as coded on Line 11 of the Compartment Examination Record (Form 2400-26). See Compartment Reconnaissance Handbook for coding.
   a. All stands coded *other than 0* should be reevaluated and discussed with the forester.
   b. If economics of maintaining a critical stand are submarginal for forestry (may be coded 1, 4, or 5) and the subsequent stand will not have decidedly higher multiple use values, wildlife management should schedule specialized treatment augmenting forestry monies by the amount necessary to maintain the stand.
   c. If a stand is clearly (economically and ecologically) a case for natural or forced conversion, remove it from the list of critical stands.
7. Differences in objectives under 6b and 6c should be resolved in accordance with recognized department goals. Changes should be noted on Lines 11 and 12 of the Compartment Examination Record and if significant, the property master plans or County Forest Comprehensive Plans amended accordingly.
8. Record locations of critical stands requiring specilized management on maps constructed for this purpose.
9. Coordinate habitat management projects for critical stands.
   a. Forester and Fish Manager will inform Wildlife Manager when cutting in types adjacent to openings or in stands identified as critical.
   b. Wildlife Manager will coordinate maintenance activity in these critical stands.
10. Include appropriate management prescriptions in the property management plan after openings and critical types have been identified.

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