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SIGNIFICANCE OF FOREST OPENINGS TO DEER IN NORTHERN WISCONSIN

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SIGNIFICANCE OF FOREST OPENINGS TO DEER IN NORTHERN WISCONSIN

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and

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Edited by Ruth L. Hine

ABSTRACT

The role of forest openings in summer deer range was studied in northern Wisconsin from 1959 to 1968 to determine the need, size, type and placement of openings for deer, determine relationships between deer population levels and forest cover types, and develop guidelines for maintaining summer range sufficient to support satisfactory deer population levels.

All areas studied showed consistently higher deer activity in aspen than in northern hardwoods. And in northern hardwoods with permanent grassy openings present, deer activity was significantly higher than in closed stands of northern hardwoods without forest openings. We concluded that permanent, grassy openings on loamy soils provide highly preferred summer habitat, and also function as a buffer to partially offset the effects of forest successional trends from aspen toward less favorable summer range types such as northern hardwoods.

Forests growing on sandy soils currently average some five times more open land than those on loams. But although deer populations are generally highest on the lighter sandy soils, we cannot as yet precisely define the importance of sandy soil openings. Unless major improvements in forest stocking are anticipated, we feel wildlife opening programs on the sands are not urgently needed.

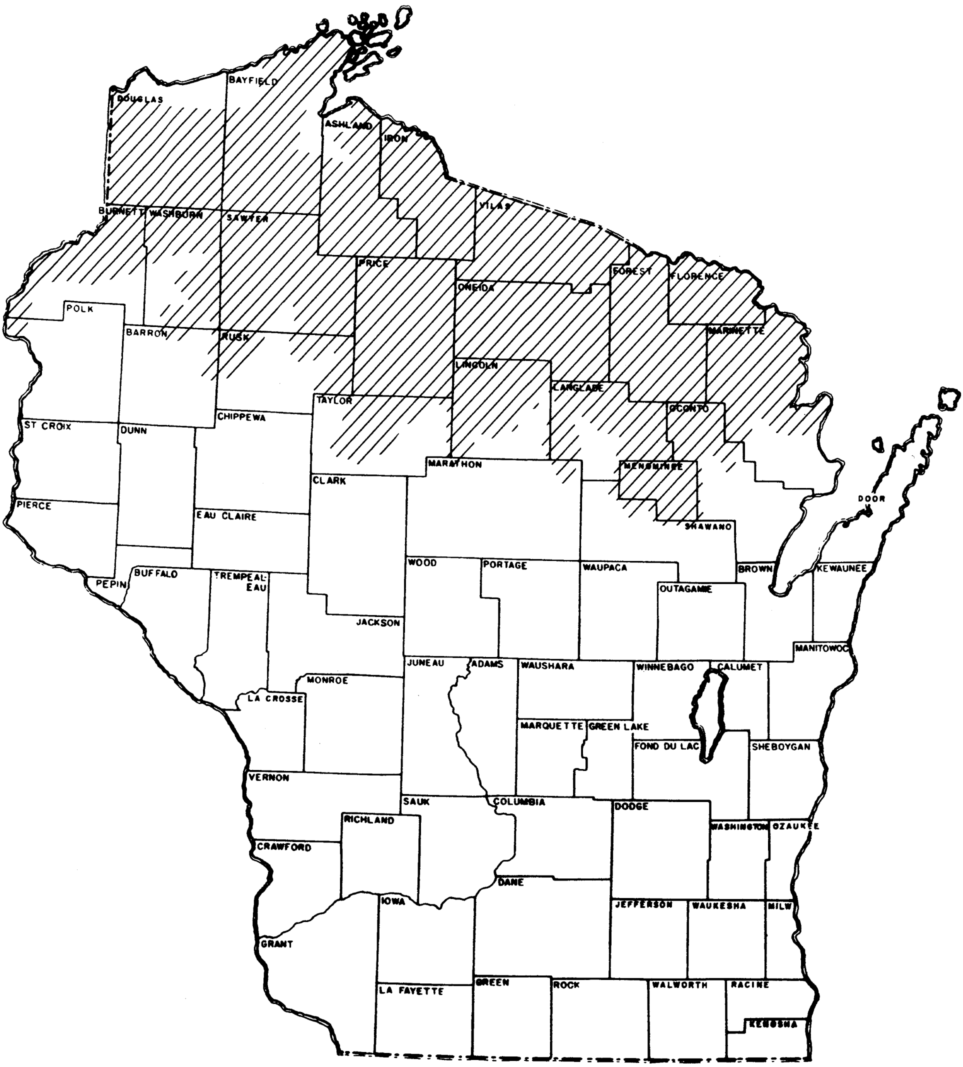
Most grassy openings in loamy soils have resulted from prolonged disturbance by man and his animals. They are presistent and resist easy reforestation. Permanent grassy openings are not being created through modern timber harvest operations.

Deer activity in forest openings is highest during spring and fall, and is strongly correlated with the frequency deer are seen on farm fields and northern roadsides. This appears to be related primarily to seasonal forage preferences, for most permanent openings on the heavier soils contain an abundance of forbs and exotic grasses.

Small openings, less than 5 acres or 5 chains in width, were used more intensively by deer than larger openings. However, in establishing openings management programs, esthetics and maintenance factors may override strictly biological considerations. Shallow topographic frostpockets, common in hilly moraine and naturally maintained, are used intensively by deer and offer good potential for incorporation into practical management programs.

In addition to their wildlife values, forest openings are esthetically pleasing, adding much to environmental quality for humans. Esthetic values should be considered in selecting openings for preservation.

Management recommendations for openings on loamy soils where hardwoods already prevail, or will eventually, include: Maintenance of 3 to 5 percent of the forest in permanent openings; preservation



Extensive forest of Northern Wisconsin. (Adapted from United States Series of Topographic Maps. Scale 1:250,000, prepared from photos dated 1953-55.)

from planting of all openings of less than 5 acres; selection of secure, sod-covered openings, preferably near high-value summer range forest types, when a choice exists; postponement of the creation of any new openings until existing openings are programmed for management.

Preservation of existing openings is critical. If openings are allowed to disappear, we will find it necessary to be content with fewer deer and a more monotonous environment.

CONTENTS

INTRODUCTION

This report summarizes summer deer range investigations conducted in northern Wisconsin from 1959 through 1968. Emphasis is directed toward the influence of forest openings on deer populations and distribution, since it is now clear that loss of permanent, grassy openings is a major cause of deteriorating summer range quality.

Until recently, summer range in northern Wisconsin has, by definition, included most of the forest landscape excluding winter yards. And heretofore, summer range quality has not been considered a serious factor limiting deer abundance. During the 1930's and 1940's when these concepts evolved, much of the North was, in fact, prime summer range. Most of the northern forest had been recently logged or repeatedly burned by wildfires. Vast expanses of grassland, brush, and sapling-size trees were common. Such areas were excellent summer range and as a result, deer populations rapidly increased to the point where the immediate consequence was a winter range bottleneck.

From its beginning in 1940 through 1958, Wisconsin's deer research program was focused on problems associated with maintenance of deer populations in balance with winter range capacity. This emphasis was stimulated by excessively high deer populations and subsequent browse shortages in winter yards. These investigations have been reported by Feeney (1942, 1943, and 1944), Swift (1946), Dahlberg and Guettinger (1956), Christensen (1954), Habeck (1960) and others.

The primary stimulus for our investigations came about from obviously declining deer populations in scattered northern areas where winter range capacity had ceased to be the overwhelming factor limiting deer abundance. Gross inspection showed such areas possessed some common characteristics: loamy soils, large blocks of pole-sized or larger northern hardwoods, and a scarcity of brush and forest openings. Conversely, as suggested by Habeck and Curtis (1959) it also became obvious that the highest deer densities were present on the lighter, sandy soils with aspen, scrub oak, and pine forest types predominating. Winter range remains the primary natural limiting factor on these light soils, but populations remain high despite sporadically heavy winter losses. Thus, we began to suspect that summer range quality and quantity must indeed have a significant impact on deer populations.

Several authors have commented on summer range limitations in the Lake States, but their remarks have been largely general in nature, and not based on quantitative investigation. Dahlberg and Guettinger (1956:138) wrote: "Ideal summer deer habitat contains a wide variety of cover types interspersed with openings and supplies of fresh water." Krefting (1962:41) indicated it is well known that deer thrive best in forests broken by openings. Habeck and Curtis (1959:49-50) stated that it is known that northern hardwoods provide poor summer range and that aspen and jack pine provide excellent summer range.

We began exploratory studies of summer range relationships as early as 1959, essentially to provide further perspective on the subject. Subsequently, in 1962, a revised Conservation Commission Policy on deer management was established, the basis for which was a report on "Deer-Forest Interrelationships in Forest Land Management" (Wisconsin Conservation Department, 1962). Representatives of all field divisions contributed to this revised policy, and one of their recommendations called for further study of forest openings . . . "the need where, when, how much and maintenance methods." Such information was deemed necessary to better implement a comprehensive deer management program.

Early in our study, we concluded that the most serious problems of summer range deterioration were occurring where northern hardwoods presently or will eventually occupy a large part of the forest landscape. Natural forest succession from aspen toward northern hardwoods and spruce-fir types and loss of forest openings is clearly most significant on loamy soils.

In this report we emphasize the role openings play in the summer range ecology of deer in areas where loamy soils predominate. Major sections deal with the influence forest types and openings have on deer distribution and density, characteristics and deer use of forest openings, and recommendations for designing and implementing openings management programs.

As we developed perspective on the summer range problems on loamy soils, we broadened our investigations to include the lighter, sandy soils occupied primarily by aspen, jack pine, and scrub oak forests. Though we found both deer and openings most abundant on these light soils, the interrelationships of openings and deer were more difficult to define than was true for loams. Unless forest stands change markedly in future rotations, we believe the sands will continue to produce high deer populations. However, these investigations are continuing, so our conclusions for sands must be considered preliminary.

Some resource managers have suggested that habitat management practices such as opening maintenance seem unjustified when the primary immediate need is closer regulation of deer harvests to insure better balance of range capacity and deer populations. In the short-term view this philosophy is sound, for certainly we cannot as yet point to optimum deer population control through hunting over much of the northern deer range. But this situation is changing with increased demand for deer, better public acceptance of herd control measures, and progressively improving road access. We cannot stress too strongly that, as we envision the future application of our findings, management of forest openings will not *increase* deer populations above recent levels. Rather such programs should be considered "preventive maintenance" directed to maintaining a remnant of a critical range type which is rapidly disappearing from the forest wildlife environment.

STUDY AREAS

Most of our research was done on 18 areas, 5 primary and 13 secondary, scattered over the northern one-third of Wisconsin. The primary study areas were Knight Township, Butternut, Argonne, Elton-Lily, and Northern Nicolet (Fig. 1). Two more important secondary study areas, Goodman and Anniversary Plantation, are also included in this section, while the remaining 11 secondary study areas are described later in the report.

The criteria used to select individual areas are summarized in Table 1. Most of the study areas were selected mainly because they contained a high proportion of northern hardwoods (S.A.F. 23-27) * and varying amounts of openings. A major reason for selecting the Anniversary Plantation, Butternut, and Argonne study areas was the high number of accessible openings. Road access was a major consideration in the selection of all study areas, and though adequate, was less than desirable on the Knight and Goodman areas. The wide range of conditions represented by these study areas is described in greater detail in the individual descriptions which follow.

TABLE 1

Characteristics Influencing Selection of Study Areas

Study Areas	Characteristics of Study Areas				
	High Amt. of N. Hardwood	High Amt. of Openings	Low Amt. of Openings	Good Access	History of Deer Population Trends*
Knight	x		x		x
Butternut		x		x	x
Argonne	x	x		x	
Elton-Lily	x		x	x	
N. Nicolet	x			x	x
Goodman	x		x		x
Anniversary Plantation		x		x	

*Recent deer population estimates for Deer Management Units discussed in this report are tabulated in Appendix C.

Knight Township

Located within Deer Management Unit 28 in southwestern Iron County (T43N, R1E), Knight Township was investigated because of its 20-year history of declining deer populations. The study area included 35 square miles. Most of the township was commercially clearcut during the late 1930's and early 1940's. Department personnel

*S.A.F. forest types are briefly described in Appendix A.
Taxonomic names are in Appendix B.

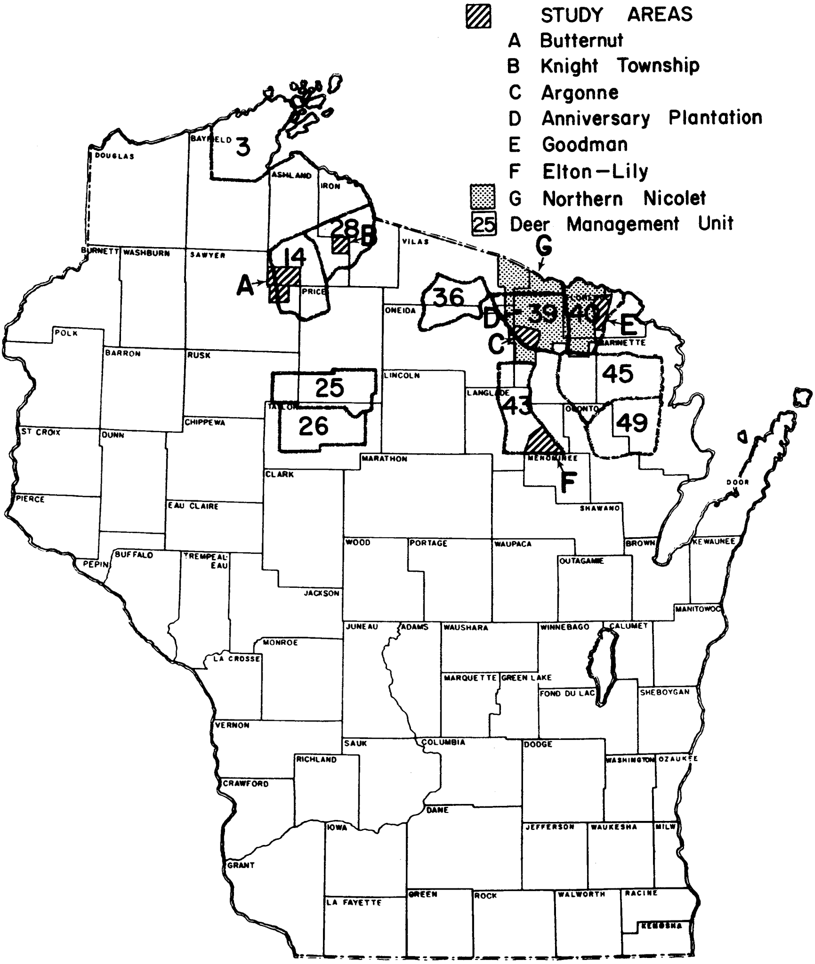


FIGURE 1. Areas and deer management units studied.

familiar with the tract reported deer were numerous during the late 1940's but had since undergone a progressive decline in numbers. Pellet count surveys in Unit 28 by the Department of Natural Resources resulted in an estimate of 19 ± 5 (mean with 95% confidence limits) deer per square mile in 1958. In 1961, only the Iron County portion of the Unit was surveyed; the resultant estimate was 12 ± 4 deer per square mile. Pellet surveys were later discontinued because of weaknesses in the original survey design caused by difficult access. Precise estimates of current deer populations on the study area were therefore unavailable, but our investigations suggested a fall density of less than 10 deer per square mile in 1963.

A forest type map prepared from 1951 aerial photos showed the major types were: upland hardwoods (S.A.F. 26, 27) mostly pole-sized, 31 percent; aspen (S.A.F. 16), 19 percent; and swamp conifers (S.A.F. 37), 25 percent. The remainder consisted of mixed types, much of it swamp hardwoods (S.A.F. 39) and lowland brush. Only 1.6 percent

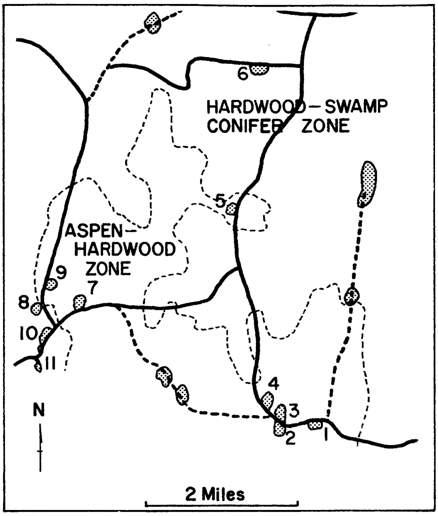


FIGURE 2. General forest types, access and openings on the Knight Township Study Area (T43N, R1E), Iron County.

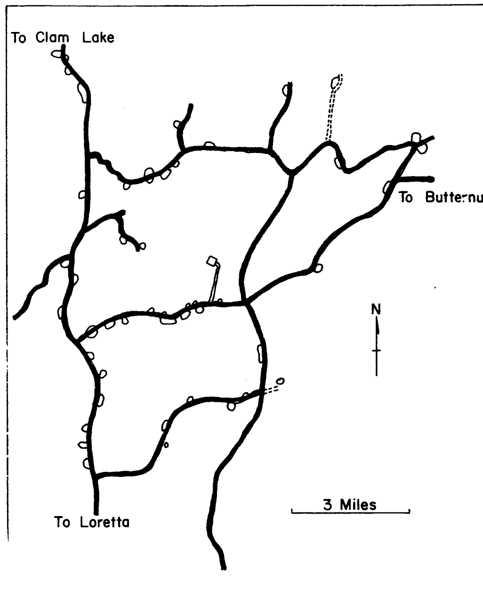


FIGURE 3. Butternut Study Area roads and accessible openings.

was typed as grass and upland brush (mainly hazel, willow, cherry). Many of the aspen stands were being rapidly replaced by northern hardwoods.

Soils are principally peats and heavy sandy loams of the Kennan and Cloquet series (Muckenhirn and Dahlstrand, 1946). Topography is moderately rolling.

About 22 miles of passable roads are present; we used 17½ miles of these for counting deer crossings and spotlighting accessible openings. The road network, openings studied, and major forest-type zones are shown in Figure 2.

Butternut

The 68-square-mile Butternut Study Area lies within the Glidden District of the Chequamegon National Forest in Ashland and Sawyer Counties (T40-41N, R3-4W). Good access, a high number of accessible openings, proximity to the Knight Township Study Area, and a moderately high deer density were factors leading to its selection.

Most of the study area falls within Deer Management Unit 14, a unit with a long history of deer pellet and range surveys by the Department of Natural Resources and U.S. Forest Service. Annual pellet counts since 1956 have produced average overwinter estimates ranging from 12 ± 2 to 31 ± 6 deer per square mile. Since 1960, mean winter densities have ranged from 17 to 26. Because of its remoteness from human population centers, deer harvests have been relatively low, and deer population levels have been regulated primarily by poor winter range

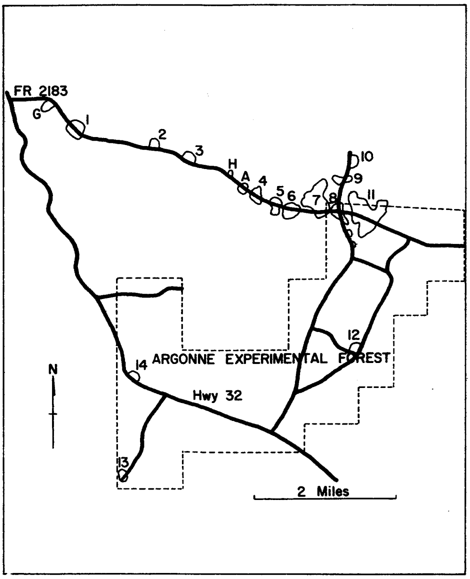


FIGURE 4. Shining route and openings on the Argonne Study Area.

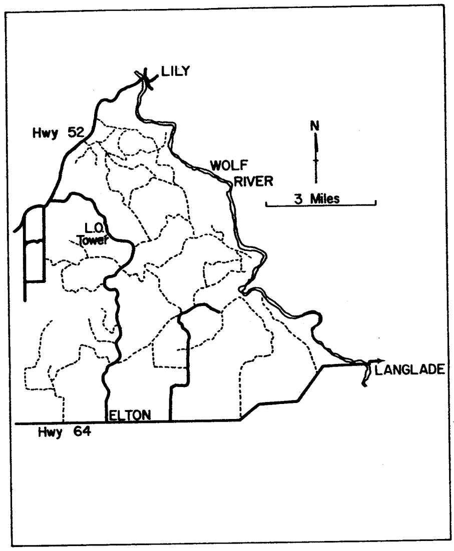


FIGURE 5. Elton-Lily Study Area and access.

conditions and erratic fawn production. Summer-fall populations on the study area probably exceeded 25 deer per square mile in 1963-64.

Upland soils are principally sandy loams and silt loams (Whitson et al., 1918). Topography is gently rolling.

Forest cover is a fairly diversified mixture of aspen, northern hardwoods (S.A.F. 26), pines and lowland conifers. Summer range quality was considered reasonably good at the time of our investigations, but reforestation, type-conversion projects, and replacement of aspen by balsam fir (S.A.F. 36) and northern hardwoods are rapidly reducing the acreage of important summer range types.

The route used for spotlighting deer in adjacent openings is shown in Figure 3.

Argonne

This 26-square-mile area is located in the Three Lakes District of the Nicolet National Forest (mainly T38N, R12E) and includes the Argonne Experimental Forest. Chosen partly because of its proximity to the Rhinelander headquarters, it also was convenient for cooperative work with the U.S. Forest Service. The area straddles an abrupt transition zone between medium-textured soils and heavy soils. Hence, the western portion is dominated by pine, birch, aspen and balsam fir upland types (S.A.F. 15, 16, 18, 21, 22, 36), whereas the eastern portion is forested mainly with experimentally managed northern hardwoods (S.A.F. 26, 27).

Summer deer densities, extrapolated from pellet surveys in Unit 39, track counts on the study area and general field impressions varied from approximately 30 deer per square mile in the western portion to less than 10 in the eastern portion. The area had more than 20 readily accessible openings, most of them surrounded by northern hardwoods. Most of these openings were regularly spotlighted in 1964 and 1965. About 79 acres of opening could be spotlighted. The spotlighting route and arrangement of openings on the area is shown in Figure 4.

Elton-Lily

The Elton-Lily Study Area includes 42 square miles in eastern Langlade County (mainly T32N, R13E). It was chosen because of its obviously poor summer range and unique accessibility. Geologically, the area is high moraine and very hilly. Soils are mainly Kennan silt loams (Hole et al., 1947). Most of the area was cut over during the early 1940's. A type map prepared during the early 1950's showed less than 3 percent openings, 5 percent upland brush, about 15 percent aspen, and about 70 percent second-growth, pole-sized, northern hardwoods S.A.F. 25, 26). Most of the openings are deep frostpockets, and most of the area formerly typed as upland brush is now occupied by sapling-sized rock elm. Aspen stands on the area are structurally similar to second-growth northern hardwoods in that understory vegetation is extremely sparse.

Though the southern half of the area is decidely better game range than the northern half, none of it is really good. A pellet survey in 1965 on 31 square miles of the area produced an overwinter use estimate of 9.6 $\pm$ 0.5 deer per square mile. This density estimate is higher than our track counts would suggest; we believe it may have been inflated due to the presence of a major winter yard abutting the east edge of the area. Thus deer not indigenous to the study area in summer may have been winter residents.

The area and access is shown in Figure 5.

Northern Nicolet

This area is located mainly in northern Forest and western Florence Counties, including most of the Eagle River, Florence, and Three Lakes Districts of the Nicolet National Forest. The area was chosen for three reasons: (1) mainly publicly owned, (2) located primarily on heavy soils — Iron River and Stambaugh silt loams (Wertz, 1966), and (3) long history of annual deer population surveys.

Pellet group surveys in Unit 39, which includes most of the study area, have been conducted annually since 1955. Overwinter use estimates (deer per square mile) rose from 24 $\pm$ 5 in 1955 to 31 $\pm$ 8 in 1957. Heavy harvests and poor production caused a decline to 14 $\pm$ 4 in 1960. Following a series of unusually favorable winters and restrictive harvests, the population rose to an estimated 35 $\pm$ 11 in 1965. Heavy winter mortality and reduced productivity in spring, 1965, again resulted in a herd reduction, with overwinter estimates dropping to 22 $\pm$ 5 in 1966, and 23 $\pm$ 4 in 1967.

This area includes the Argonne Study Area and Anniversary Planta-

The Elton-Lily Study Area is characterized by hilly moraine and an extensive forest of pole-sized second-growth northern hardwood. The summer deer density is undoubtedly less than 10 deer per square mile.

The Goodman Study Area is a large area of mature uneven-aged northern hardwood. Present management and forest condition on the area is similar to the future situation for much of northern Wisconsin's hardwood country. Despite a dynamic timber harvest program, summer deer densities were likely less than 10 deer per square mile.

The Anniversary Plantation is 400 acres of 35-year old red pine and contains about 40 acres of small grassy openings. Deer use on this area in summer was some of the highest found during the study. Winter use on the area is negligible.

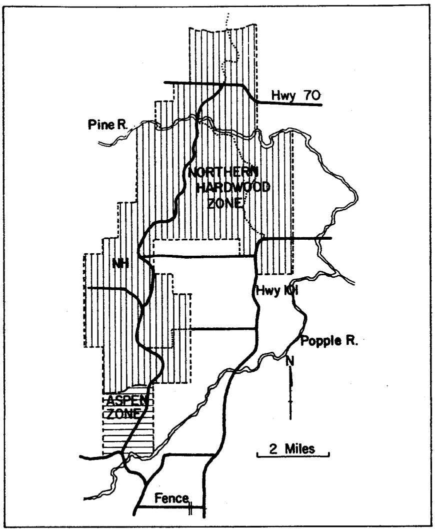


FIGURE 6. Goodman Study Area, its primary access and generalized forest cover types.

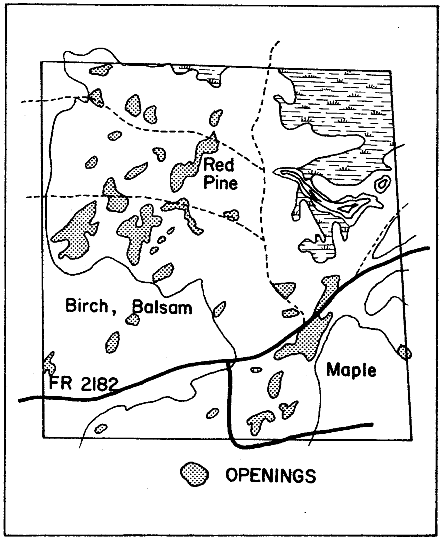


FIGURE 7. Anniversary Plantation (Sec. 31, T39N, R12E), its openings and adjacent forest types.

tion, and also adjoins the Goodman Study Area. The major upland forest types on federal lands are northern hardwoods (S.A.F. 23-27), 33 percent; aspen-birch, 15 percent; spruce-fir, 11 percent; pine, 10 percent; and upland brush and openings, 4 percent (U.S. Forest Service, 1966a, App. A).

Goodman

The Goodman Study Area is located in western Florence County (T38-40N, R16-17E) and includes about 41 square miles. Owned by the Goodman Division, Calumet and Hecla Group, it is one of the largest tracts of intensively managed northern hardwoods (S.A.F. 23, 26, 27) in northern Wisconsin.

Approximately 10 percent is typical white cedar — mixed conifer deer yard. Winter deer concentrations also spread out into the upland old-growth hemlock-hardwood stands in response to short-cycle selective logging.

Annual pellet surveys were conducted by the Department of Natural Resources from 1958 to 1964. Overwinter deer-use estimates during this period ranged from 17 to 30 deer per square mile, showing approximately the same fluctuations previously described for Unit 39. Except for 1958-60, deer harvests have been relatively light, and population mechanisms have been regulated primarily by natural mortality.

Upland soils are almost all Stambaugh and Goodman silt loams (Hole et al., 1962), a primary factor in the development of climax northern hardwood forests. Topography is rolling to hilly.

Openings are extremely scarce, so our investigation was limited to track counting on 11 miles of road bisecting the area from north to south. The study area boundaries, track count transect, and timber type zones adjoining the transect are shown in Figure 6.

Anniversary Plantation

This is a 400-acre, 30-year-old, red pine plantation in the Three Lakes District, Nicolet National Forest (Section 31, T39N, R12E). The site was primarily a burned-over, heavily sodded grassland at the time the plantation was established. About 40 acres of openings, ranging in size from ¼ to 5 acres, are scattered through the plantation. Origin of the openings is obscure; some were obviously never planted, perhaps because of anticipated frost problems. Others were evidently due to frost-caused seedling mortality.

Soils are principally light sandy loams of the Pence series. Topography is moderately rolling.

We became interested in this area in 1965 when field examination showed very heavy deer use in the openings and high numbers of deer tracks crossing the interior access roads. The distribution of openings and adjacent forest types is shown in Figure 7.

STUDY METHODS

Few investigations have been conducted on summer range relationships of white-tailed deer.Hence, there are few tried and proven techniques for evaluating their summer ecology. We began this study using only direct observation and track counting techniques. However, as the study progressed we developed a modification of pellet group counting which greatly expedited evaluating deer use of openings. Later we designed a systematic procedure for counting deer trails that permitted quantitative measurements of summer deer distribution. These and other techniques described below provided the quantitative data necessary for evaluating the biological importance of forest openings.

While some background data were gathered on the value of other forest types as summer range, most of the investigation was directed toward openings. With few exceptions, all openings taken under study contained less than 10 percent stocking of trees and less than 30 percent stocking of upland brush. These openings are distinct features on the forest landscape and their perimeters are usually well defined.

Deer Population and Use Measurements

The following techniques were used to determine when, why, where, and how much deer used openings, and also what kinds of openings deer preferred.

Spotlighting and daytime observations provided insight into the daily and seasonal behavior of deer. They also provided a measure of opening use by deer and a basis for interpreting results of other measurements of deer activity.

Spotlighting

Most spotlighting was accomplished from a slow-moving vehicle with a hand-held spotlight and 7x50 binoculars. Openings were approached carefully creating as little disturbance as possible. The light was quickly swept over the opening to obtain a total count of deer that might be fleeing. Deer that remained in the opening were carefully examined with binoculars. Deer observations were recorded according to opening number, odometer reading, activity when first observed, sex, and age (fawn or adult). The technique was used primarily to document daily and seasonal deer use of openings and to record deer distribution relative to other forest types.

Track Counts

Deer track counts were conducted on roads one day after dragging or heavy rains had obliterated the older tracks. Dragging was possible on sandy roads, but rains were necessary on clay and gravel roads to soften the surface so that imprints could be recorded. Counting was done from the hood of a slow-moving truck or by walking when there was a possibility that some tracks could be missed. Tracks were counted as they entered the transect and were tallied at half-mile intervals to facilitate correlation with adjacent forest types. Counts were conducted two to seven times on each of five areas, but sampling distribution was restricted by the limited numbers of suitable roads.

We used track counts primarily to document deer activity relative to openings and other forest types. However, we have cautiously interpreted these results as indicators of approximate densities. Brunett and Lambou (1962) refuted the validity of this procedure, but their study was limited to small numbers of penned deer. In the West, counts of tracks across migration routes have been used as an index to mule deer populations for many years (Hazzard, 1958:53). Furthermore, in Michigan and Wisconsin, track counts have been used successfully to estimate actual deer densities (Howe, 1954:26 and Pratt, 1967:19). Creed (Unpubl. data) found a highly significant correlation between tracks and deer population size on a 406-square-mile study area in Central Wisconsin.

Preparing track count transects on sandy roads was accomplished with a drag. Rain was necessary to prepare transects for recording imprints in areas of heavy soil or gravelled roads. Track counting was used extensively for documenting summer deer distribution.

Pellet Counts

Spring pellet group counts (Olson et al., 1955 and Eberhardt and Van Etten, 1956) were used to estimate the deer density on one study area, and results of surveys on larger areas surrounding study areas were used as an indication of approximate deer densities on the other study areas.

The technique has had only limited application for measuring summer range use (Quillen, 1959). We marked summer pellet groups in openings with numbered steel pins and recorded their rate of deterioration. Persistence varied with microclimate and weather, but most lasted for at least two months, with some lasting more than a year. By studying pellet groups on 160 permanent plots in eight openings we found we could estimate the age of pellets quite reliably. The seasonal nature of opening use by deer simplified this task. Groups deposited during September and October could be easily distinguished from

Adaptation of the pellet group survey technique for use in openings greatly expedited measuring seasonal use and evaluating deer use in relation to opening size and type. Sampling was usually done in late fall and required about 1½ man-hours per opening.

groups dropped earlier. By late fall, spring pellets were noticeably deteriorated by midsummer sun, mold, and moisture. Pellets dropped in midsummer that were not noticeably crumbled or moldy were so infrequent that the effect on fall counts was minimal. The freshness and shape of pellets deposited in autumn simplified separation from groups dropped earlier. Most counts were conducted in late autumn because the extra effort required to find pellet groups in dense summer vegetation precluded extensive use of the technique. Most midsummer counts were made in permanently marked plots which were voided prior to each deposition period.

Randomization of plot locations within openings was achieved using a ricocheting transect with random distances between plots. The starting point of the transect was the point on the opening edge nearest the observer as he first approached the opening. Initial direction was along one of the eight cardinal compass directions heading toward the nearest opposite edge. The investigator then placed a predetermined randomly selected distance along the transect to locate the first plot, and located additional plots by proceeding along the transect. Upon reaching the opposite edge, the observer turned back toward the opening 135° right or left, depending upon the angle of incidence with the edge. He then continued taking plots and "bouncing" alternately right and left upon reaching the opening edge until all plots were taken. Twenty plots were located in each opening sampled. A circular .01-acre plot size was used because this size proved more efficient in dense vegetation than larger plots.

Random distances between plots were drawn from pools of values that varied in relation to the size class of the opening sampled. Opening size classes were ½-1, 1-2, 2-4, 4-8 and 8-16 acres, and no opening sampled was less than 1 chain in width. The maximum distance allowed between plots for these size classes were 11, 22, 33, 44 and 55 paces, respectively. The minimum distance used was 4 paces (c. 24 feet) which prevented overlapping by consecutive plots. The fieldman carried a plot-spacing card with him (Fig. 8). Sampling was done in late October or early November and required only 1¼ to 1¾ man hours per opening, depending on the height of vegetation.

RANDOM DISTANCES (PACES) BETWEEN PLOTS

	Opening Acreage				
Plot No.	½-1	1-2	2-4	4-8	8-16
1	8	17	8	40	16
2	6	19	32	24	35
3	11	13	26	9	22
4	7	9	10	8	48
5	6	16	5	29	36
6	8	13	16	10	40
7	8	22	12	6	24
8	10	8	18	7	47
9	5	11	26	42	9
10	8	15	32	24	8
11	5	7	32	39	29
12	9	21	25	36	46
13	4	7	14	6	10
14	7	12	8	27	6
15	5	14	27	43	7
16	8	12	28	4	42
17	7	10	5	39	24
18	9	9	14	31	39
19	6	15	13	7	36
20	10	9	21	4	6

NOTE: Each pace = 2 steps.

FIGURE 8. Plot card of random distances used by observers while conducting pellet counts in openings. Acreage of individual openings was estimated prior to sampling by pacing the average length and width of the opening.

Trail Counts

The abundance of deer trails in an area can be assumed to be reasonably proportional to the deer population of the area. It has been suggested that the presence of trails in a forest type indicates that the type is used by deer mainly to get from one place to another (White, 1960:123). However, our experiments refute this, for we found that areas without numerous trails were usually timber types little used by deer. Conversely, preferred timber types had high numbers of trails.

We designed a systematic method for counting deer trails in the forest which employed a ¼-mile transect. Transects were walked from random starting points in a predetermined cardinal direction. Deer trails encountered were tallied at 4-chain intervals. Only trails that were undoubtedly created or maintained by deer were tallied. Defining trails in the field was not difficult. Dominant forest types were also tallied at 4-chain intervals.

Trail surveys were conducted in spring and fall. We excluded designated winter yarding range from sampling, and believe most trails tallied were the result of nonwinter use. The formation of trails on summer range in winter is greatly restricted by frozen ground, snow and deer behavior (yarding).

The mean number of trails per transect was used for comparing deer use among areas or forest types. Results are a reflection of relatively long-term use and do not accurately reflect short-term population changes. The main value of the survey is for measuring long-term deer distribution and use intensity.

The tally card and instructions are shown in Figure 9.

Habitat Measurements

The following techniques were used to determine the amount and kinds of openings present in the forest, the rate at which they were being created or lost, and the potential for economically maintaining them.

Photogrammetric Measurements

Most of the public forest land in northern Wisconsin has been aerially photographed three or more times since the 1930's. Study areas used in this investigation were flown in the late 1930's, late 1940's and early 1960's. Photos from the earliest flight have a scale of 1:20,000. Subsequent forest inventory photos have a scale of 1:15,840. The first flight was panchromatic, whereas the latter two were infra-red.

The availability of these photos greatly facilitated locating, measuring, and otherwise studying openings. The older photos were examined primarily for historical information such as cause of openings and longevity. The newer photos were used to determine changes, adjacent types, and access. Photo interpretation was done stereoscopically, primarily on randomly selected sample sections.

Opening longevity studies on the loamy soils centered in the northern half of the Nicolet National Forest. A sample of 25 sections was randomly chosen. All openings occurring in these sections, which had less than 10 percent stocking of trees and less than 30 percent stocking of upland brush, were traced stereoscopically from aerial photos dated 1938, 1948, and 1963. All openings occurring on the 1938 photos were numbered and the same openings were correspondingly numbered on acetate tracings from 1948 and 1963 photos. Openings were tallied according to their adjacent forest cover type as determined from U.S. Forest Service type maps, and their individual acreages were measured

DEER TRAIL TALLY

Unit No. ____________

Date ____________

Course No. ____________

Observer ____________

		Trails		
Ch	Type	Hvy	Mod	Total
4				
8				
12				
16				
20				
	TOTALS			

RG Flushed ____________ Buck Rubs Seen ____________

Comments

FRONT

DIRECTIONS

Unit No.: Deer Management Unit

Course No.: Assigned number or "40" description, e.g. NWSW 3-39-14.

Ch: Chains (4 Ch equals about 50 paces, 100 steps)

Trails: Hvy: Conspicuous trails, easily followed, often bare soil.
Mod: Undoubtedly a deer trail.

RG Flushed: Count only grouse flushed on the course, not returning.

Buck Rubs: No. of trees or shrubs where deer rubbed their antlers.

Types: Major forest type in the 4 Ch segment.
Use standard type symbols or:

W — White Pine
R — Red Pine
J — Jack Pine
F — Balsam Fir
A — Aspen
B — Birch
G — Grass, Open
S — Spruce

NH — Northern Hardwood
SH — Swamp Hardwood
O — Oak
UB — Upland Brush
LB — Lowland Brush
K — Marsh, muskeg

Size Classes:
b — Saplings
c — Poles
d — Sm. Timber

Stocking:
' — Poor 10-33%
'' — Medium 33-70%
''' — Good 70% plus

Example: Rc" — Red pine poles, med. stocking.

BACK

FIGURE 9. Tally card used for deer trail survey.

by grid counting. Ground reconnaissance was made of those openings near access and notes were made on invading species, adjacent types, and ground flora. Data were analyzed to determine the changes that had occurred during the past 25 to 30 years and to project future changes.

A similar effort to determine longevity on sand soils was conducted on eight sections on the Oneida County Forest (T37N, R7E). Difficulty was encountered in accurately delineating openings on the 1939 photos because much of the area had recently been cut over and burned. Therefore only 1951 and 1961 photos were used. This is too short a period to make long-range predictions, but it did provide a measure of opening loss during the decade.

Type Map Measurements

Most public forest land has been typed at least twice from the latter two flight photos mentioned above. Most type maps are reproduced with a scale of 1:15,840. The forest type compositions of some study areas were determined by dot-counting individual timber types. Type maps were also used for correlating forest types with results from spotlighting deer and track counts. Though type maps do not provide an exact ecological picture, they are one of the most important available tools for planning extensive forest habitat management.

Vegetation Measurements

Detailed sampling of vegetation was done only in the Anniversary Plantation openings. This area was sampled to determine if a unique plant composition was the reason for the concentrated deer use found in the openings. We used a random sample of 25 stands (.01-acre plots) in 17 openings. The sampling was stratified to permit heavier sampling in the larger openings. Frequency of herbaceous species was estimated using 30 random ¼-square foot quadrats in each stand. Species were then tabulated by frequency and presence. These measurements provided a basis for comparing these openings with others described by Curtis (1959), Vogl (1964), and Levy (1965).

Ground cover was also noted on each plot during pellet counting in openings; however, no significant correlations with deer use could be shown at our level of sampling.

Weather Observations

To determine the effect of daily weather on deer behavior and our observations, we recorded notes on weather for all days and nights that track counting or spotlighting was conducted. Notes were kept on approximate temperature, percent cloud cover, precipitation, wind direction and velocity, and moon phase.

Several recording hygrothermographs were maintained on the Argonne Experimental Forest by Dr. Forest W. Stearns, North Central Forest Experiment Station. Hygrothermographs were located in various sized openings as well as under the forest canopy. These measurements facilitated correlations between deer behavior and meteorological influences.

INFLUENCE OF FOREST TYPES ON SUMMER RANGE AND DEER DISTRIBUTION

Deer, like most living things, are irregularly distributed within their environment. Clearly, the forest types present and their distribution have an important bearing on how many deer any area will support. Important as openings may be in a deer's daily or seasonal routine, they represent only a portion of the normal home range. To assign values of openings in a given situation, it is necessary to determine first how specific forest types influence deer density and distribution.

We found measuring summer deer distribution a difficult problem, primarily because sound, easily used techniques were not available. Eventually we settled on track and trail surveys as our primary methods. Though not completely satisfactory for the task at hand, they offered the best possibilities for providing quantitative information.

Deer Distribution Among Forest Types

A summary of track surveys on four study areas where loamy soils predominated is shown in Table 2. Tracks were tallied by ½-mile segments along each route, and then related to adjacent forest types. Though some type intergradation was common, we were able to broadly

TABLE 2

Results of Deer Track Counts on Roads Through Northern Hardwoods and Aspen Types

		Miles in Type		Avg. No. Tracks/Half Mile		
Area	Date	Aspen	N. Hdw.	Aspen	N. Hdwd.	*t*
Knight Twp.	9 May 63	8.0	9.5	6.8	11.6	2.98 ***
	12 Jun 63	8.0	9.5	14.4	9.8	2.29 **
	1 Aug 63	8.0	9.5	7.8	3.9	2.89 ***
	13 Aug 63	8.0	9.5	8.9	4.9	2.84 ***
	19 Sep 63	8.0	9.5	6.2	5.6	— N.S.
	13 May 64	8.0	9.5	9.1	9.7	— N.S.
Butternut	26 Jun 63	2.5	2.0	35.2	10.2	2.80 **
	2 Aug 63	2.5	2.0	7.8	0.2	2.25 *
	20 Aug 64	2.5	2.0	15.0	5.0	2.54 **
	14 Sep 64	2.5	2.0	9.4	4.0	3.46 **
Elton-Lily	4 Sep 64	7.0	3.0	3.6	0.8	2.25 **
	5 Nov 64	7.0	3.0	9.1	3.3	3.42 ***
	8 Dec 64	7.0	3.0	2.1	0.0	1.72 N.S.
Goodman	5 Nov 64	2.0	9.0	19.5	4.0	9.01 ***
	9 Aug 65	2.0	9.0	15.0	4.3	3.95 ***
	Average			11.3	5.2	

Significance:
***$P < .01$
**$P < .05$
*$P < .10$
N.S. Not Significant ($P > .10$)

classify each segment by two primary types, aspen and northern hardwoods. A t test of significance (Steel and Torrie, 1960:73) was used in analyses.

With few exceptions, the counts showed significantly higher numbers of track crossings (and presumably more deer) in aspen than in northern hardwood types. The only counts deviating from this pattern were those conducted in May of both 1963 and 1964 on the Knight area. Deer activity along this route was undoubtedly influenced by recent road construction, more-than-average type interspersion, and at one point, a man-made salt lick.

Despite these biasing factors, the average number of tracks for all counts in the aspen segments were somewhat higher than in the northern hardwoods. On the other three areas, aspen segments produced consistently higher average counts than segments dominated by northern hardwoods.

Analyses of seven track counts on the Argonne study area permitted comparisons among three major types or type combinations (Table 3). Included in the 7.5-mile transect were 1.5 miles of pole-sized red pine mixed with grassy openings, 3.0 miles of northern hardwoods mixed with grassy openings and swamp conifers, and 3.0 miles of well-stocked, managed hardwoods with no grassy openings present.

There was a highly significant difference between track counts in pine and hardwood segments ($t = 5.00$, 12 d.f.) and a significant difference between track counts in the hardwoods with openings and the well-stocked hardwoods segments ($t = 2.97$, 12 d.f.).

Deer trail surveys were conducted in six northern deer management units, plus the Elton-Lily study area (part of Unit 43). Four units (25, 36, 45, and 49) had moderate to high fall deer densities ranging from 25 to 35 deer per square mile (Appendix C). Results from these units are presented in Table 4. The remaining three units (3, 26, and 43) had relatively low deer densities of 10 to 18 deer per square mile. Results from these latter lower-density units are summarized in Table 5. Fifty transects were run in each management unit, but some tran-

TABLE 3

Track Counts on the Argonne Study Area

Date	Avg. No. Deer Crossings/Half Mile		
	Pine & Openings	N. Hdwd. & Openings	Closed Hdwd.
10 Sep 65	20.7	9.8	2.6
14 Sep 65	17.3	4.5	1.8
5 Jun 66	15.6	9.3	5.0
28 Jul 66	18.3	3.0	0.8
2 Aug 66	17.6	3.5	2.2
24 Aug 66	27.6	15.8	4.0
4 Oct 66	19.3	10.3	1.8
Average	19.5	8.0	2.6

TABLE 4

Deer Trail Counts in Units with High Deer Densities

Deer Mgt. Unit	Deer Trails per Quarter-Mile Transect by Forest Type						
	Oak-Aspen-Jack Pine	Scrub Oak	Jack Pine	Aspen	Red & White Pine	N. Hdwd.-Aspen Mixtures	N. Hdwd.
25	—	—	—	10.2(20)	—	4.4(9)	3.2(15)
36	10.5(2)*	—	8.0(1)	7.7(20)	8.8(5)	4.1(10)	3.4(5)
45	9.4(5)	10.4(7)	—	6.7(3)	7.0(1)	5.1(9)	2.9(16)
49	8.1(16)	6.9(8)	8.1(8)	6.0(4)	5.0(3)	4.4(8)	—
Avg.	9.3	8.6	8.1	7.6	6.9	4.5	3.2

*Sample size in ( )

sects were not included in the tables because they could not be readily classified into any of the forest types listed. The number of transects run within a given type can be assumed to be reasonably consistent with the proportion of that type present within the summer range in each unit.

The results shown in Table 4 indicate highest deer activity (and by inference, deer densities) in oak (S.A.F. 14), aspen, and pine types. Lowest activity was found in northern hardwoods.

Forest types typically found on sand soils (aspen, oak, and pine) averaged consistently more trails per transect than forest types typically found on loamy soils (northern hardwoods and mixed types containing northern hardwoods). Forests on sandy soils provide more uniformly good summer range than most forests on heavier soils. This is likely the reason for consistently high deer populations on sandy soils as indicated by pellet surveys and buck harvests (Appendix C).

Reasons for lower deer numbers on some loamy soil areas become

TABLE 5

Deer Trail Counts in Units with Low Deer Densities

Deer Mgt. Unit	Deer Trails per Quarter-Mile Transect by Forest Type						
	Aspen	N. Hdwd.-Aspen Mixtures	N. Hdwd.	Red & White Pine	Oak-Aspen-Jack Pine	Scrub Oak	Jack Pine
3	3.9(12)*	1.9(8)	0.5(6)	4.0(1)	3.0(8)	2.7(3)	2.3(7)
26	3.6(11)	4.1(12)	1.8(18)	—	—	—	—
43	3.5(6)	3.5(17)	3.1(24)	—	—	—	—
Avg.	3.7	3.2	1.8				

*Sample size in ( )

Northern hardwoods are not preferred summer deer range. Following the extensive hardwood clearcutting in the early 1940s, deer populations soared. However, after hardwood reached pole size, the deer densities dwindled. The amount of pole-sized northern hardwood acreage in northern Wisconsin doubled between 1936 and 1956. Our results from hardwood areas indicate most support fewer than 10 deer per square mile in summer.

clearer when the data for types typically found on heavier soils (aspen and northern hardwoods) are considered separately. Northern hardwood acreages apparently subtract from the productive capability of the summer range in a unit.

Summer Range Trends on Loams

The outlook for maintaining good summer range is poorest on loamy soils where northern hardwoods and spruce-fir are replacing aspen. Stone and Thorne (1961:5) reported the acreage of northern hardwood pole timber in Wisconsin more than doubled from 1936 to 1956, while aspen acreage decreased by 18 percent. Heinselman (1954:738) predicted that natural conversion of aspen would greatly accelerate from 1965 to 1980.

Re-inventory of the Nicolet National Forest in 1966 showed northern hardwood acreages had increased 21 percent while aspen-birch had decreased 42 percent since 1953 (USFS, 1955:6; USFS, 1966a:App. A). A similar re-inventory of the Chequamegon National Forest showed northern hardwoods increased 20 percent while aspen-birch decreased 26 percent (USFS, 1957:16; USFS, 1967:4).

Although some of these type changes were due to modifications in typing standards from one inventory to the next, the successional trend is clearly evident.

Good summer deer range forest types are common on sandy soils. Aspen, oak, jack pine, brush, and openings consistently produce the highest deer densities in northern Wisconsin. Poorly drained soils forested mainly by aspen in north-central Wisconsin are also important deer producers.

Summer Range Trends on Sands

In contrast to the generally declining quality of summer range on loamy soils, the future on lighter soils appears a good deal brighter. Oaks, jack pine and aspens predominate on sands, and because of their fire histories, stocking is highly variable. Openings, upland brush, and under-stocked stands are relatively abundant.

The major sandy soil forest types commonly provide substantial levels of high quality deer food, particularly ground layer species, during their entire rotations. Aspen and jack pine are clearcut at short rotation ages, and for a period of up to 10 years following cutting, they produce large quantities of both summer forage and winter browse. It has been our impression that summer forage production in many stands will remain good in subsequent rotations, because stocking will likely remain highly irregular. Much of this irregularity in stocking levels is due to soil and moisture variations on the light soils. This contrasts rather sharply with the more uniform stocking levels and denser crown canopies common in northern hardwoods managed on an uneven-aged system.

Oaks, particularly scrub oaks, occur in either pure stands or mixed with jack pine and aspen on light soils. At least sporadically they contribute large quantities of acorns. By following semi-tame deer and observing their feeding preferences, Watts (1964:10) found that oaks (leaves, twigs, and mast) were the most important source of year-round food in the mixed-oak stands of central Pennsylvania.

On public and industrial forest lands particularly, further conversion of oaks, upland brush, and openings to red pine plantations can be anticipated. But at this time, the future magnitude of these programs and their ultimate effects on deer numbers are difficult to predict. Gysel (1966:472) reported that deer densities in an extensive red pine plantation in Michigan declined from about 20 to 7 deer per square mile over a 25-year period. But we believe that where plantations are managed for pulpwood through short-rotation clearcuts, or where they are well-mixed with other types, such drastic declines in deer numbers will be rather infrequent.

The foregoing discussion points up clearly that soil and forest types have an important bearing on deer density and distribution. The aspen, jack pine, and scrub oak stands and poorly stocked areas common to light soils generally provide good summer range. On the loamy soils, aspens and openings are critical summer range types. In the sections which follow, the characteristics of forest openings and their role in summer deer range will be examined in detail.

OPENING CHARACTERISTICS

Openings have likely been a component of the forest landscape since glaciation. Christensen (1959:231) indicated that while most of northern Wisconsin was forested by mature timber with little undergrowth, vast areas of barrens and burns were common. Curtis (1959:172) reported that historically savanna-like shrub lands and pine barrens were widespread in the northern forests. And Vogl (1964:70) described open areas in Florence County that apparently have never been forested.

However, except for remnants of former barrens, most of the openings within the scope of this study were quite different from those mentioned above. Most are less than 10 acres in size and most resulted from other than natural causes, particularly those on loamy soils. This section discusses the origin of these openings, their abundance, vegetative characteristics, and longevity.

Causes

Bracken grasslands and most openings on sandy soils are the result of timber cutting followed by wild fires (Curtis 1959:317, 342). On heavier soils, some openings are also the result of fires, but most small openings appear to have originated through prolonged disturbance by man and his animals. Many openings are remnants of old logging camps, CCC camps, or wilderness farms. Horses and sometimes cattle and oxen were kept at camps, and their browsing and grazing along with human disturbance led to the establishment of dense sod cover.

The abandonment of submarginal "wilderness" farms left numerous openings in the forest. However, few on public land remain unplanted. This 16-acre homestead opening is located in northern Forest County. Most sodded openings on loamy soils are the result of historic long-term disturbance by man. New ones are not being created by modern timber harvest operations.

Old camp openings are very secure unless planted. They often contain remains of early logging days. Note cable in foreground and log structure in background.

The great variety of exotic plants found in some openings is at least in part the result of hay transported into the woods to feed animals at the camps. Seeds from plants that established themselves in camp openings have since spread to other openings.

Openings were also created at log landings and yarding points. Some openings resulted when hemlock and pine were cut and then failed to regenerate. And still others resulted from frostpockets when cold air drainages were formed or enlarged with the removal of trees by logging.

Openings from other causes can be found, but they comprise a minor percentage of all grassy, forest openings.

Present Amount

Forest type statistics often mask the actual amount of open ground in a forest. Type definitions vary between land-managing agencies and often change between successive inventories. However, openings larger than 5 acres are almost always shown, and usually openings as small as 2 acres appear on type maps. But small openings occurring in poorly stocked stands or mixed with upland brush are frequently included as part of the larger type. Therefore, inventory statistics generally provide a minimum estimate of the amount of openings present.

We compared type statistics from county forests occurring principally on either sands or loams (Table 6). Soil-type judgments were made following a generalized map prepared by Muckenhirn and Dahlstrand (1946). Forest statistics were provided by the Forest Inventory Section, Department of Natural Resources (C. Rieck, pers. comm., March 2, 1968). Results indicated an average of more than five times as much open ground on sandy soils as on loams.

The resulting percentages are minimums, but are comparable because they were obtained during one survey which used the same type definitions throughout the inventory.

Additional data on the current amount and size-classes of openings present on sandy soils were obtained from a 12,468-acre sample of forest compartment type maps of county land in Burnett and Marinette Counties dated from 1961 to 1964. Use of maps rather than aerial photos expedited the comparison, but provided only minimum figures on opening numbers and acreage.

The map sample indicated almost 6 percent was typed as grass. This agrees closely with a forest-wide estimate of 6.3 percent for the Marinette County Forest (Wisconsin Conservation Department, 1964). In addition to the grass acreage, another 26 percent of the sandy units on the Marinette County Forest was typed as upland brush and poorly stocked timber. Similar current forest-wide statistics are not yet available for the Burnett County Forest. However, the sample data and field reconnaissance indicated a similarly "ragged" condition prevails in most forests on sandy soils.

The size-class distribution of openings within the sample is illustrated in Figure 10. No doubt many openings smaller than an acre in size

TABLE 6

Upland Grass Acreage on County Forests (c. 1955)

Sandy Soils			Loamy Soils		
County	Total Acres	Open	County	Total Acres	Open
Bayfield	163,544	8,254	Ashland	32,223	541
Burnett	100,308	3,685	Forest	10,807	205
Florence	35,626	3,699	Iron	171,438	1,357
Marinette	223,045	6,790	Price	87,854	195
Polk	7,335	525	Rusk	83,887	1,278
Vilas	32,442	3,212	Sawyer	112,268	1,005
			Washburn	142,098	972
Total	562,300	26,065		640,575	5,553
Percent		4.6			0.9

were omitted from many of the maps. The difference in distribution profiles illustrated in Figure 10 and 15 suggests this to be true. Proportionately far more small openings (< 1 acre) were found in the sample taken directly from photos.

Also indicated by the distribution curve is that about half of the openings (more than one-third of the acreage) were between 1 and 8 acres. In this size range they are too small to plant economically, but large enough to maintain for wildlife purposes.

Air photos of a systematic sample of 25 sections on the northern three districts of the Nicolet National Forest were stereoscopically examined. Photos taken in 1948 showed 422 acres of openings on the 16,000-acre sample, or 2.6 percent open. This compares with an in-

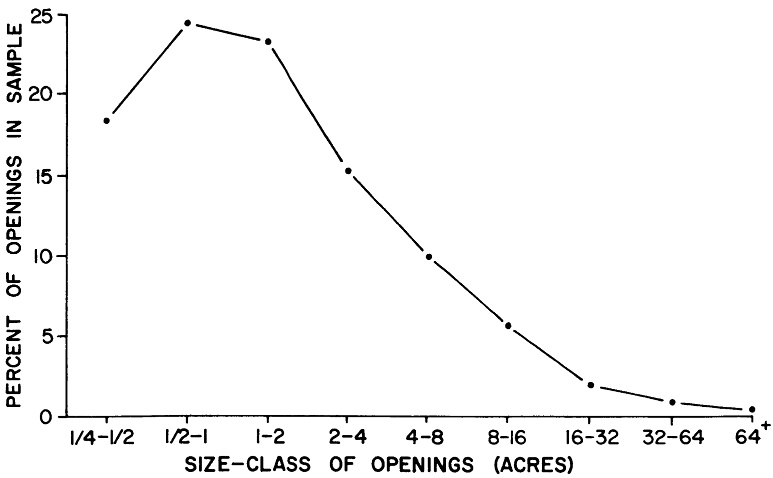


FIGURE 10. Distribution of opening size-classes on sandy soils in Marinette and Burnett Counties as shown on timber type maps.

ventory type map statistic of 1.0 percent (USFS 1955:Table 27). This comparison suggests that type definitions used by the U.S. Forest Service masked more than half of the actual open acreage in the inventory completed in 1953. Examination of 1963 photos for the same sample area revealed only 1.5 percent remained open. Soils on the sample sections were principally loams.

Parrish Township, Langlade County (T34N, R9E), was also inventoried using 1961 photos. Only 1.9 percent of the 17,000 acres of public land remained open. Each section of public land was then broadly classified by primary soil type to determine differences in the amount of openings by soil type (Table 7). Soil determinations were made using a map prepared by Hole et al. (1947).

The table shows that openings were least common on heavy soils and progressively more common on the lighter soils.

Approximately 5,100 acres were examined for openings on the Oneida County Forest (T37N, R7E). The area is located primarily on Vilas sands (Hole and Schmude, 1959). A dot-count of seven sections of forest indicated that 4.7 percent was open in 1961. An additional section in the study area had formerly been about ⅓ open but was subsequently planted. At least 10 percent of this planted area will remain open because of seedling mortality and unplanted pockets. If the latter assumption is correct, about 5 percent of the total study area is presently open.

Vegetation

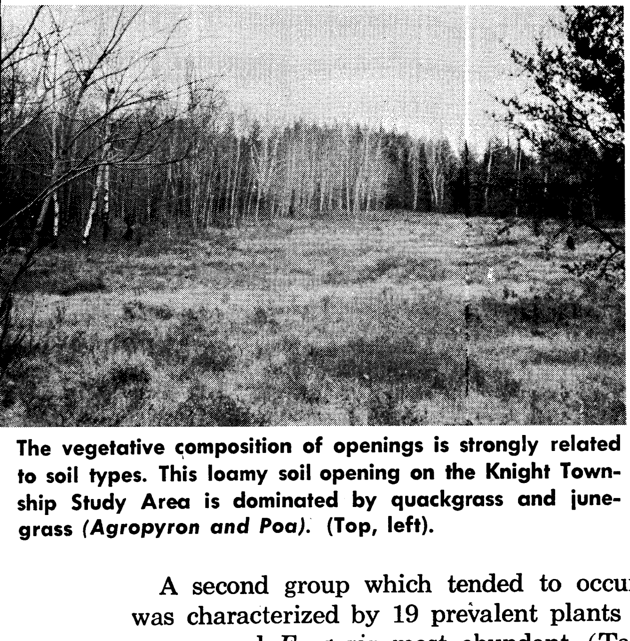
Two major studies of vegetation in openings have been conducted in northern Wisconsin. Levy (1965) studied 69 selected stands within 58 openings on a variety of soils. Vogl (1961) worked mainly on selected stands in bracken grasslands and restored brush prairie. His areas were primarily large openings (25 acres +) which were being managed for sharp-tailed grouse.

Through ordination techniques, Levy (1965) classified openings according to three groups. Group 1 openings typically occurred on heavier soils (loams and silt loams), and this group he called the *Agropyron-Poa* community. He listed 23 prevalent plants as characteristic of this community, among which *Agropyron, Poa, Cirsium, Rubus,* and *Achillea* were most common (Table 12, Appendix D).

TABLE 7

Amount of Openings in Relation to Soil Types on Parrish Township

	Peats	Loams	Loams and Sandy Loams	Sandy Loams	Total
Acres in Public Ownership	2,160	7,420	2,800	5,320	17,700
Acres Open	12	109	58	161	340
Percent Open	0.6	1.5	2.1	3.0	1.9



The vegetative composition of openings is strongly related to soil types. This loamy soil opening on the Knight Township Study Area is dominated by quackgrass and junegrass *(Agropyron and Poa)*. (Top, left).

Openings on sand typically contain an abundance of sweetfern, blackberry, and blueberry. This opening is heavily used by deer. Note the stability of the opening edge. No aspen suckers can be seen encroaching into the opening. (Left).

Forests on sandy soils average five times more openings than forests on loams according to county forest statistics. Sandy openings in northwestern Wisconsin contain a high frequency of prairie plants. Here bluestems, prairie gayfeather, lead plant, and dusty miller are shown with sumac in a jack pine opening. (Above).

A second group which tended to occur on medium-textured soils was characterized by 19 prevalent plants with *Poa, Hieracium, Agropyron,* and *Fragaria* most abundant (Table 13, Appendix D). We also studied 25 randomly located stands in 17 openings in Anniversary Plantation, a red pine plantation on light sandy loam, and found the composition similar to that of Levy (Table 14, Appendix D). Our most common species were also *Hieracium, Poa, Agropyron,* and *Fragaria.* In addition to those found by Levy, our openings showed a high frequency of *Carex pensylvanicum,* but lacked *Phleum pratense.*

Levy identified a third group having 28 prevalent species with *Hieracium, Myrica, Vaccinium,* and *Poa* being the most common genera. This group occurred almost exclusively on light soils (Table 15, Appendix D).

Vogl's (1964) study of selected stands in bracken grasslands resulted in a list of prevalent plants similar to those found by Levy in openings on light soil. He derived a list of 21 prevalent plants with *Pteridium, Myrica, Vaccinium, Carex,* and *Gaultheria* topping the list (Table 16, Appendix D).

Another group of openings that is quite different from those studied by Levy are the openings that occur on finer sands along the old prairie border and pine barrens. A reconnaissance of openings on sandy soils in northwestern Wisconsin during September of 1967 led to the obvious conclusion that prairie plants were far more common there than in openings studied on heavier soils. Notable were *Andropogon, Liatris, Amorpha* and *Artemesia.* Vogl (1961) studied restored brush prairie near Grantsburg and found 41 prevalent species with *Andropogon, Poa, Carex, Aster,* and *Koeleria* leading the list (Table 17, Appendix D). Many of these prairie plants are represented in openings on other sandy areas in the North, particularly on pine barrens.

The studies of Levy and Vogl were restricted to selected homogeneous stands in a relatively small number of openings, but they provided a reasonably good description of northern forest openings. Few openings are known to the authors that could not be described by one of the five types discussed in this section. Though considerable intergradation occurs, it is possible to categorize most openings by gross physiognomy and soil type into one of the five types.

A more complete treatment of vegetative characteristics is given by Levy (1965).

Longevity

Knowledge of the natural ability of forest openings to persist is basic to determining the economic feasibility of their maintenance. Some individual openings are known to have persisted well over 50 years, but little documentation of opening longevity is available.

Smith (1942) conducted an on-the-ground survey of opening longevity in Michigan. He related canopy closure in openings along road transects. Though several soil types were studied, most of the area was sandy and 80 percent had been burned. Among his findings were the following:

1. Fourteen percent of the burned area remained open after 20 years, and 11 percent remained after 30 years.
2. Aspen and cherry encroachment into openings by suckering was at the rate of only 2 to 3 feet per year.
3. Sodded areas on loamy sands and sandy loams closed extremely slowly.
4. Areas that had remained open for 20 to 30 years were not likely to close for at least another 20 to 30 years.

Our study was similar to Smith's except that we were interested in both longevity and new openings, used aerial photos combined with ground reconnaissance, and worked mainly in small openings on loamy soils in a cutover hardwood area. Supplementary data were subsequently gathered on the longevity of openings on sandy soils.

Opening longevity studies on loamy soils centered on the northern half of the Nicolet National Forest. Similar studies on sandy soils were conducted in western Oneida County.

Heavy Soils

The change in total acreage of openings determined from the Nicolet aerial photos for 1938, 1948, 1963 reflects acreage lost to all causes (Fig. 11). It does not depict year-to-year changes, but does permit a rough forecast. A simple projection of the curve suggests an impending loss of an additional 25 percent of remaining grassland acreage by 1975. The figure also illustrates the sample area planted during the same periods.

Although large acreages of the northern Nicolet National Forest were devoid of trees in 1938, only 6½ percent of the sample appeared to be sodded. Opening acreages of 1,037, 422, and 245 were tallied for the respective years. Greatest loss during the first decade was to tree planting. Of the 1,037 acres of open grassland in 1938, 426 acres were planted in 1948. Planting temporarily decelerated after 1948 with only an additional 63 acres planted on the sampled sections from 1948 to 1963.

Many of the openings in the larger size classes disappeared in the first decade when most open ground was planted (Fig. 12). The apparent increase in the proportion of smaller size classes is partly the result of fragmentation of larger openings through planting and succession. Time, tree planting, and natural succession are reducing both the number and size of openings.

Our investigations showed similar loss rates of acreage to natural succession in the larger size classes of openings. Surprisingly, the smallest size class (0.4 — 1.0 acre) had by far the lowest rate of attrition. Apart from no planting, the reason for this is obscure but may

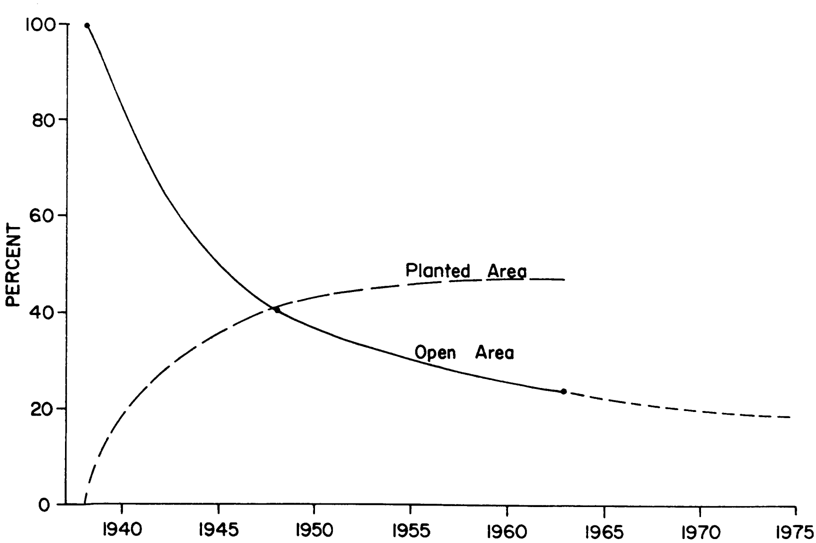


FIGURE 11. Open area remaining as a percentage of what existed on the northern half of the Nicolet National Forest in 1938.

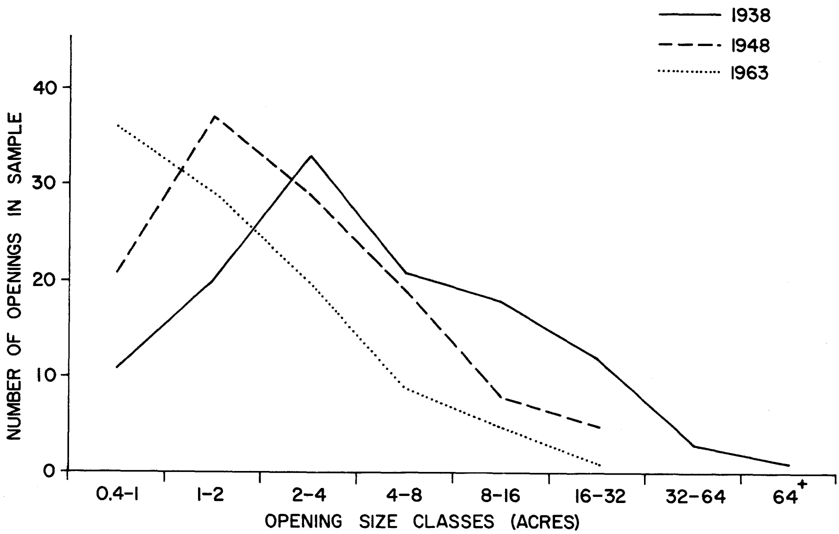


FIGURE 12. Size class distributions of openings for the years 1938, 1948 and 1963 on the northern half of the Nicolet National Forest.

be because more of these were historically the result of topographic and edaphic factors rather than man-caused factors.

The loss of open acreage by adjacent forest type is shown in Figure 13. The figure excludes planted openings so that acreage lost primarily to natural succession could be determined. These curves suggest similar rates of loss for both northern hardwood and aspen on the heavier soils. However, other observations indicate that hardwood openings are more stable, and Smith (1942:11) also reported that openings in hardwood are more stable because fewer pioneer species are found in northern hardwoods. Perhaps one reason the curves in the figure appear as they do is because aspen cutting is just beginning on this area. As more cutting is done in aspen types, loss of openings through disturbance and suckering will accelerate.

Invading types were determined partly through the use of type maps and aerial photos, but were spot checked by ground reconnaissance. In aspen openings, aspen was found to be the most aggressive invader, followed by balsam, cherry, willow and hazel. In hardwood areas, hardwood species were closing openings primarily through canopy spread as trees matured. Hardwood "invasion" was followed in importance by cherry, balsam, and willow.

One of the most significant findings of this survey was that only nine small openings found on the 1948 and 1963 photos were not identified with the 129 found on 1938 photos. These could possibly have been new openings created during the interim, but more likely are the result of better resolution on the later photographs. Whether new or not, they accounted for an addition of only 7.2 acres in 1948 and 3.0 acres in 1963. These data indicate that permanent openings of the type and quality required for optimum deer range are not being created through present forest management practices on hardwood soils.

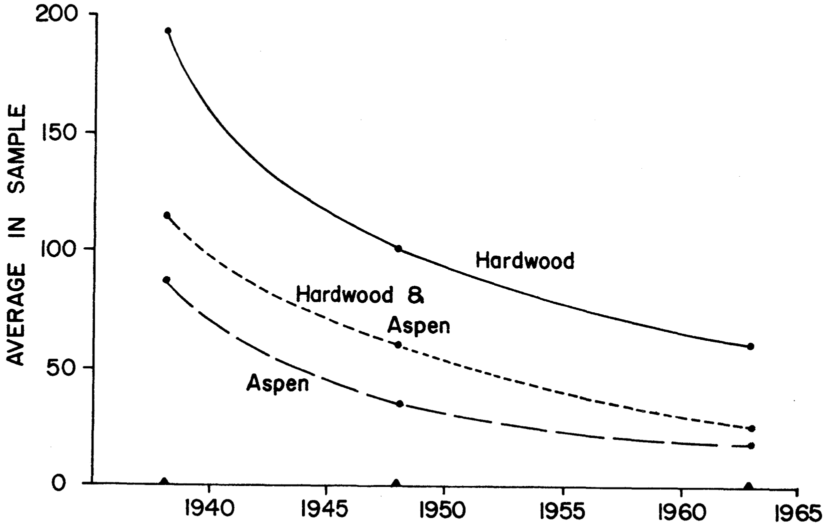


FIGURE 13. Rate of open acreage loss according to adjacent forest cover type as found on the northern half of the Nicolet National Forest. (Excludes planted acreage.)

Sandy Soils

A total of 72 openings on the Oneida County Forest (T37N, R7E) were used to estimate longevity of openings on Vilas series sand soils. Results showed the upland area decreased from 122.6 acres in 1951 to 98.1 acres in 1961, or a loss due to natural causes of 20 percent. The planted area during the same interim amounted to 189.0 acres in 12 openings. One planted opening was larger than 100 acres.

That 20 percent of the open area was lost during only 10 years may merely reflect forest growth from established regeneration around openings rather than rapid successional invasion. Gysel (1966:470) reported a loss of about 50 percent of the open acreage in a red pine plantation after 25 years, but much of the loss occurred when openings less than ½-acre closed. We suspect the rate of natural succession on Oneida County forests has slowed and will continue to decelerate during the present aspen rotation. However, cutting in the near future may result in closing (through suckering) of the smaller openings that are only lightly sodded and are not topographic frostpockets.

The numbers of openings by size class on the sample area at the times of the two photo flights, and the numbers planted during the ten-year period are shown in Figure 14. Though the total number of openings is about the same, the decrease in size of larger openings from natural causes is readily apparent. The openings planted are not included among the 1951 and 1961 openings in the figure. During the 10-year period one new opening (0.4 acre) appeared on the photographs while three disappeared. Nine openings were recorded as having increased in size, but the gains were small (0.2 to 0.4 acre) and could have resulted from photo interpretation error.

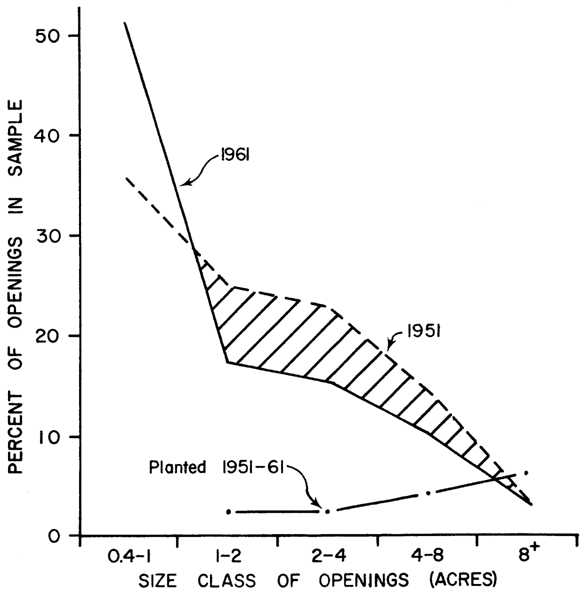


FIGURE 14. Change in distribution of opening size-classes in Cassian Township, Oneida County, after a 10-year period.

These results suggest that openings on the Vilas series sand soils are sufficiently stable to be economically maintained if the need for maintenance is justified.

Natural Maintenance Factors

Physical, chemical, climatic, and biological factors combine to maintain openings. Grass sod is perhaps the most important single factor governing opening tenure. Sod physically impedes seeds from reaching mineral soil (Chapman, 1940:178, Schreiner, 1945:426, and Hutnick, 1954:494). Smith (1942:11), Vogl (1964:79), and Levy (1965:77) also cite sod as a very significant factor in the maintenance of openings.

In addition to the physical impediment of grass, many grasses and forbs produce, or are suspected of producing, antibiotics (Curtis, 1959:318). These toxins may be very important in deterring invasion by other species.

Microclimatic frost (as in "frostpockets") also plays an important role in reducing successful invasion of woody shrubs and trees. Freezing occurs in many openings in Wisconsin on any calm clear night irrespective of season. Danckelman (1898) indicated that topographic kettles as well as openings that are wider than 3 chains are subject to heavy frost damage. Stearns (Unpubl. data), studying forest opening microclimates near Hiles, Wisconsin, recorded temperatures in a large flat opening during the period 1964-67. The summer with the most cold nights was in 1967, when freezing temperatures were reached four times in June, five times in July, seven times in August, and 13 times in September. Examples of some of the coldest summer nights during the recording period are listed in Table 8. Also poor air drainange in small openings results in very humid conditions which favor *Cytospora* cankor, which in turn effectively kills invading aspen suckers (Graham et al., 1963:209).

Adjacent timber types have an important bearing on woody invasion into openings. The ability of northern hardwood species to pioneer in open areas is much less than that of white birch, aspen, and associated species. Presumably with more intolerant pioneer species there is a greater threat of opening invasion.

Least well documented, but obviously important, is the influence mammals exert on the maintenance of openings. Small mammals (particularly mice) abound in grassy openings and commonly girdle tree seedlings. Other rodents including ground squirrels, porcupines and beaver also contribute to retarding tree growth in some openings. Bears in their quest for fruit and insects will pull down and knock down trees. Most openings contain cherry trees that have been damaged by bears.

Perhaps the most influential creature is the white-tailed deer. Quite by accident, deer contribute much to their own welfare in maintaining openings. Where deer densities are high, browsing pressure alone is sufficient to kill invading woody species. Unpalatable species and saplings often become targets for belligerent bucks in the fall. Rare is the opening that doesn't exhibit trees and shrubs scarred or killed by "buck rubs." Openings concentrate deer in fall, and obviously much of the rutting activity is also concentrated there.

Frostpockets typically contain a wide variety of herbaceous vegetation. If preserved from planting and protected from the disturbance caused by effects of timber harvest operations, they will persist for decades without specialized management.

TABLE 8

Low Temperatures Recorded in an Opening Near Hiles, Wisconsin, 1964-67

June		July		August		September	
14 Jun 64	16°	19 Jul 65	29°	9 Aug 64	25°	12 Sep 64	16°
10 Jun 65	20°	20 Jul 66	27°	19 Aug 66	31°	11 Sep 65	20°
1 Jun 67	23°	5 Jul 67	23°	11 Aug 67	23°	25 Sep 66	16°
24 Jun 67	27°	10 Jul 68	25°	22 Aug 67	20°	10 Sep 67	13°

From unpublished data of N.C. Forest Experiment Station, courtesy of Dr. F. W. Stearns.

Without the influence of natural factors, few openings would remain today. Only because of the past and present impact of these natural influences is the contemplated maintenance of openings economically feasible.

Conclusions

1. County forest statistics show forests on sandy soils average five times more openings than forests on loams.
2. Permanent sodded openings of the type found on loamy soils are rare on sandy soils. Most openings on sands contain an abundance of low shrubs and are more nearly like temporary openings resulting from clearcut timber harvest operations in forests on sandy soil.
3. Most forest openings can be generally categorized by soil and the five vegetative types described by Vogl (1961) and Levy (1965).
4. Permanent sodded openings on loamy soils are not being created through modern timber harvest techniques. Most are the result of historic long-term disturbance by man and his animals.
5. Most remaining openings are sufficiently persistent to be economically maintained. If preserved from planting and protected from the effects of timber harvest operations, they will persist for decades without specialized management.

DEER USE OF FOREST OPENINGS ON LOAMY SOILS

Our investigation of forest openings and other components of summer range have emphasized problems on heavy soils (Fig. 15). Our objectives were to determine when, where, and how much deer used openings. Most of our data on deer behavior were obtained through direct observations, although seasonal and annual use relationships in openings were supplemented by pellet surveys. Data on deer preferences for openings were obtained primarily by pellet surveys. This section reports results of these studies in relation to deer use patterns, intensity, and preferences.

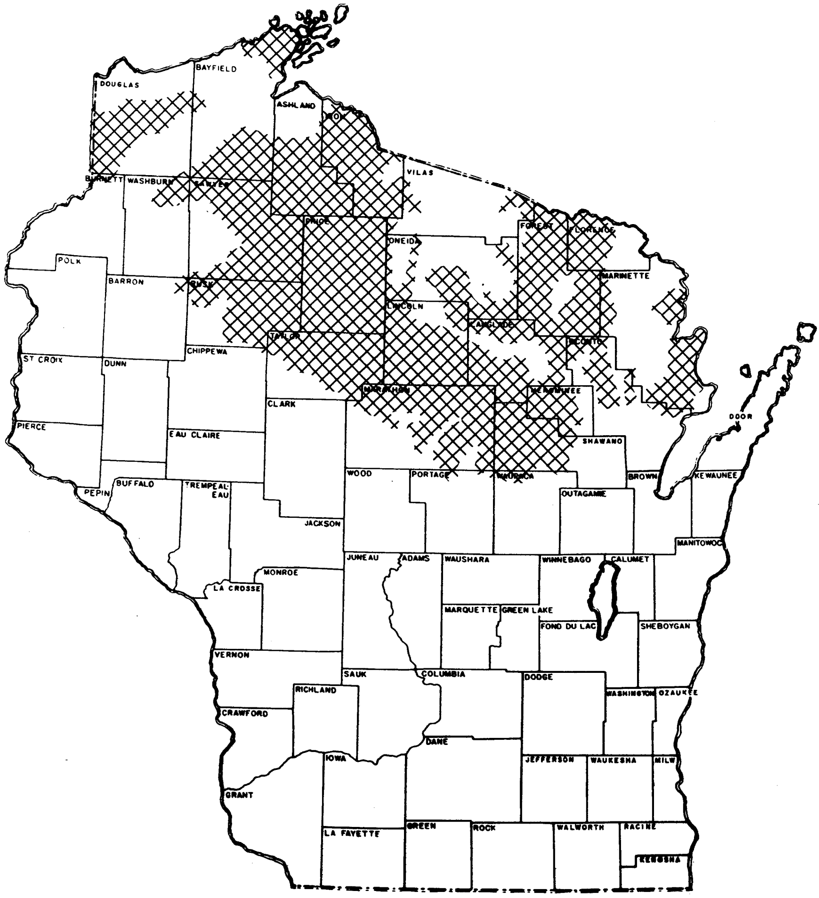


FIGURE 15. Area of podzolized loam soils where aspen types are converting to more tolerant types and where openings programs are urgently needed in the large blocks of forested land. (Adapted from Wilde et al., 1949:10)

Patterns of Use

The intensity of deer activity in forest openings was found to vary daily, seasonally, and annually. Some of the factors regulating activity rhythms of deer have been documented by other investigators. Though none of these latter studies were directed specifically to deer use of openings, we have related their findings to our results where applicable.

Daily Use

Direct observations of deer from April to November, 1963, were obtained by driving a 42-mile transect at varying times of the day. The transect, located on the Butternut Study Area, intersected 38 openings ranging in size from 1/4 acre to 17 acres. A total of 400 deer were observed during 132 hours of observation. The hourly frequency that deer were seen is illustrated in Figure 16. The frequency that

Deer use openings very heavily during spring and fall. The intensity of use may exceed three to five times the average intensity of use on all range types. This seasonal pattern of deer activity is similar to the frequency deer use roadsides and farm fields and suggests the prime stimulus is green forage.

Small openings, less than 5 acres, were found to be used most intensively. Here two deer retreat when their feeding was interrupted in a 1-acre opening.

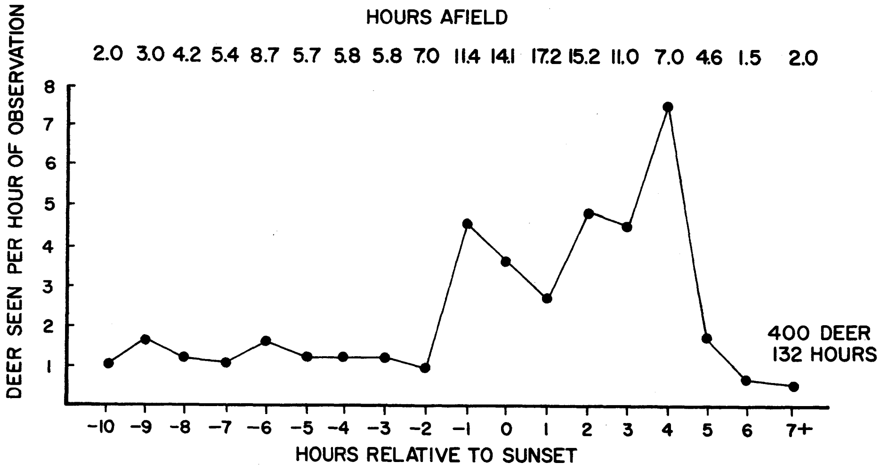


FIGURE 16. *Daily activity relative to sunset on the Butternut Study Area (May-November).*

deer were seen *in openings* is illustrated in Figure 17. This latter graph shows the average number of deer seen per acre because the acreage visited each hour varied considerably. The observation of most deer in openings during the first 4 hours after sunset corroborates findings of Anderson (1959) and Progulske and Duerre (1964:32).

Analysis of daily use for different seasons resulted in similar curves but with varying amplitude. All had troughs at 1 and 3 hours after sunset, with peak activity occurring 4 hours after sunset. The peak at the fourth hour is biased upward somewhat by the fact that most shining during that hour was done during fall when all deer activity in openings is highest. However, the fourth hour was also the best according to Progulske and Duerre (1964:32).

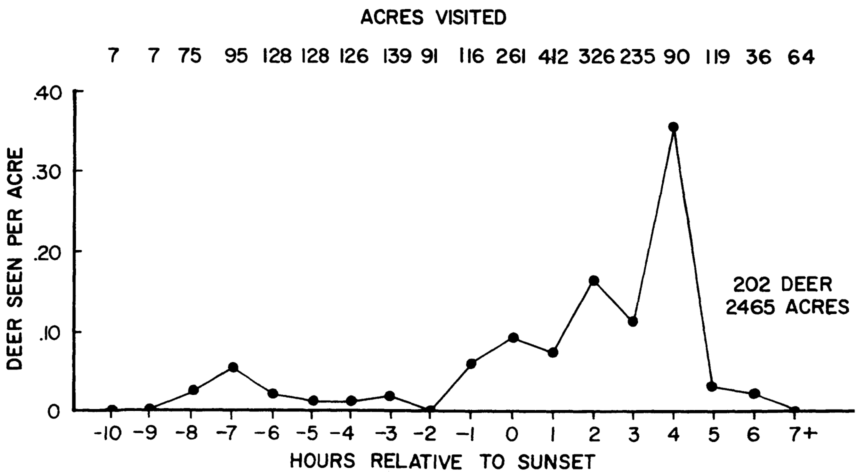


FIGURE 17. Deer seen per acre of forest opening on Butternut Study Area (May-November).

The trough or dip in activity that occurred the third hour after sunset may have been caused by deer bedding. Anderson (1959) and Dealy (1966:4) found that deer bedded during this period. The drop in activity after the fourth hour was also experienced by Progulske and Duerre (1964:32) with 79 percent of their observations recorded during the 4-hour period beginning 1 hour after sunset.

The direct observations and documentation of daily use provided a basis for designing more systematic procedures for measuring seasonal deer use and interpreting data obtained by other techniques.

Seasonal Use

More intensive and systematic shining than that conducted on the Butternut Study Area was subsequently conducted on the Argonne Study Area. On this area we employed a 23-mile transect intersecting 19 openings. The transect was traversed by vehicle about twice per week beginning one hour after sunset. The seasonal use pattern observed during 1964 and 1965 based on 511 deer observations is illustrated in Figure 18. Deer were seen in openings at a much greater frequency during spring and fall than during midsummer. This familiar pattern corresponds with the frequency with which deer are commonly observed along roadsides and in farm fields.

Figure 18 is similar to the curves of Behrend (1966:Fig. 9) and Progulske and Duerre (1964:33). Behrend, shining daily from mid-May until late August, found peak numbers during May and June with a gradual decline to a low in August. Progulske and Duerre began shining in July and found activity doubled from a low in July and August to a high in September.

Further documentation of seasonal trends in opening use was obtained through pellet group counts. Twenty permanent .01-acre plots were randomly located in each of eight openings on the Argonne Study Area. Openings ranged in size from 1 to 12½ acres. Plots were voided upon establishment and subsequently counted and voided periodically during the following two years. Results corroborated the pattern of seasonal use obtained by direct observations. High numbers of pellet groups were found during counts after the spring and fall deposition periods, but only a few groups were found during midsummer (Fig. 19).

Deer activity in openings was light after snow began to accumulate. During most of the winter, deer were oriented toward swamp conifers and traditional yarding areas. One opening near a yard was heavily utilized, mainly for hazel (*Corylus cornuta*) browse. Wood fern (*Dryopteris* sp.) and some sedges and grasses (mainly *Carex intumescens* and *Schizachne purpurascens*) were also heavily used wherever exposed. Tracks and beds indicated that deer had used the north edge of the opening intensively for sunning themselves.

Annual Use

In addition to the daily and seasonal differences in opening use by deer, differences were also observed between years. In 1963 and 1964,

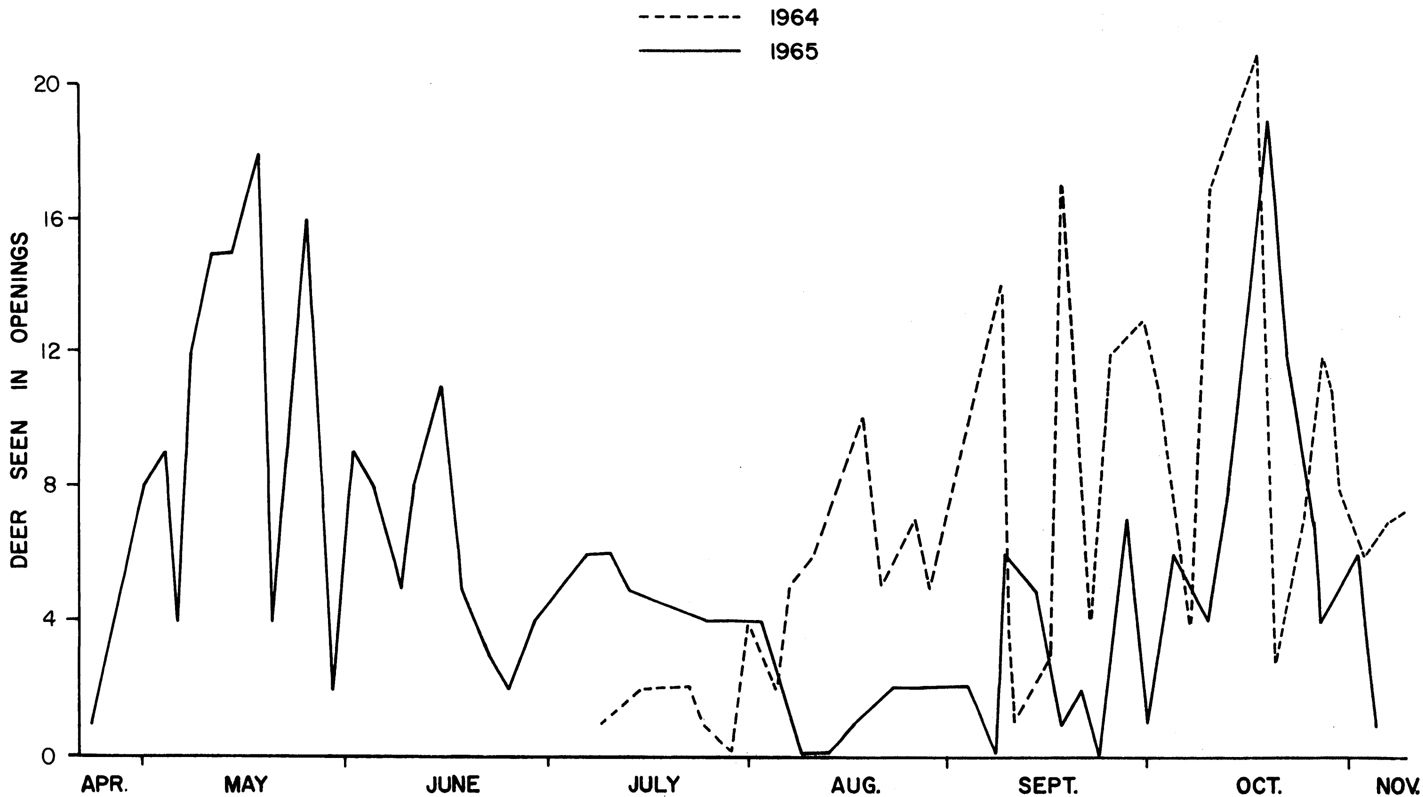


FIGURE 18. Seasonal use of forest openings on Argonne Study Area observed by spotlighting.

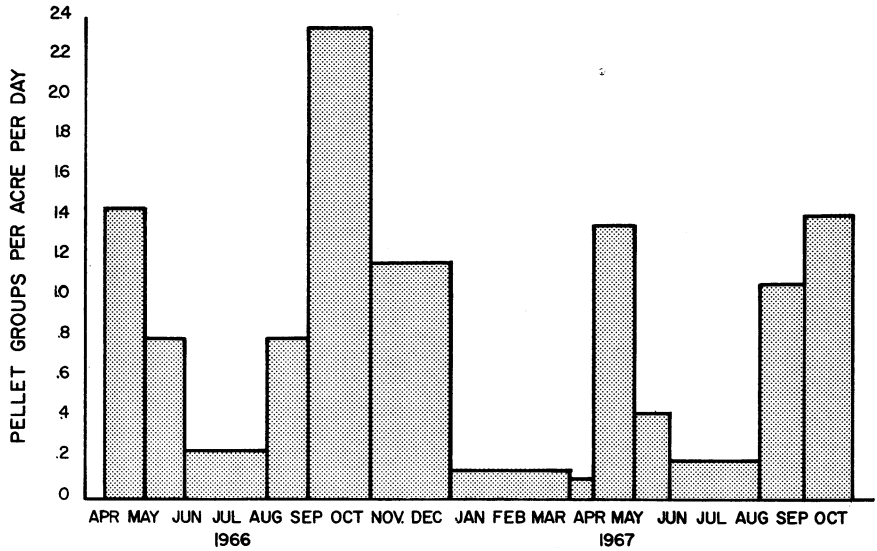


FIGURE 19. Seasonal deer use of eight forest openings on the Argonne Study Area as determined by pellet group counts on permanent plots. (Bar width indicates deposition period)

spotlighting observations revealed a relatively short period of intensive use during the spring whereas the fall activity for those years was high and sustained. However, in 1965 the pattern was reversed with high sustained use occurring in spring, with only a short period of high use occurring late in the fall. To further substantiate these differences, we plotted the frequency of reported highway-killed deer in several northeastern Wisconsin counties (Fig. 20). The results showed more deer killed in the fall of 1964 than 1965, and also more deer killed during the spring of 1965 than 1964, thereby corroborating our observational data.

The number of deer seen on roadsides on the Argonne Study Area and alongside of the highway while returning from spotlighting trips had previously in the study been correlated with the number of deer seen using forest openings on the transect. The resulting correlation coefficient (r = + 0.61, 42 d.f.) indicated a highly significant relationship between deer seen in openings and deer seen on roadsides. The correlation was improved (r = + 0.72, 30 d.f.) by excluding 12 observations during a period in spring when deer were observed using roadside salt (Fig. 21).

Intensity of Use

Deer activity measured by spotlighting and pellet counts provided estimates of the relative intensity of opening use by deer.

The Argonne Study Area had a deer density of approximately 25 deer per square mile. If deer were randomly distributed and all range types were sampled, one would expect to record an average of one

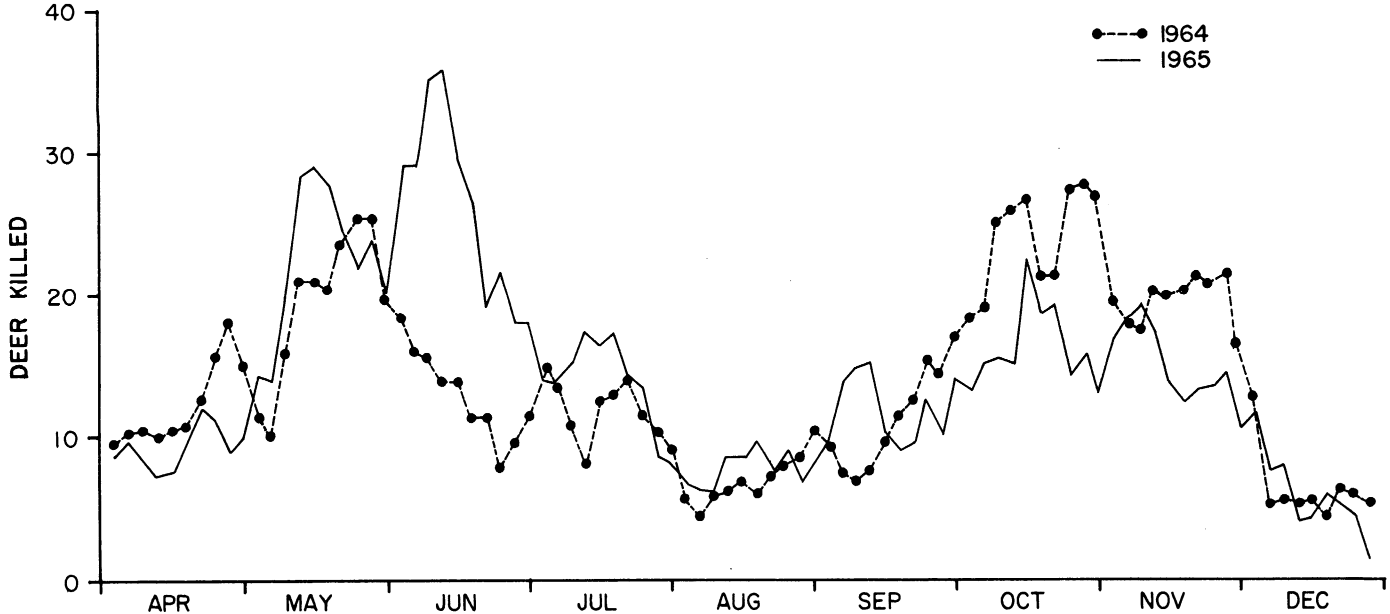


FIGURE 20. Seasonal pattern of reported car-killed deer in Northeast Area of Wisconsin. (Three-point running averages)

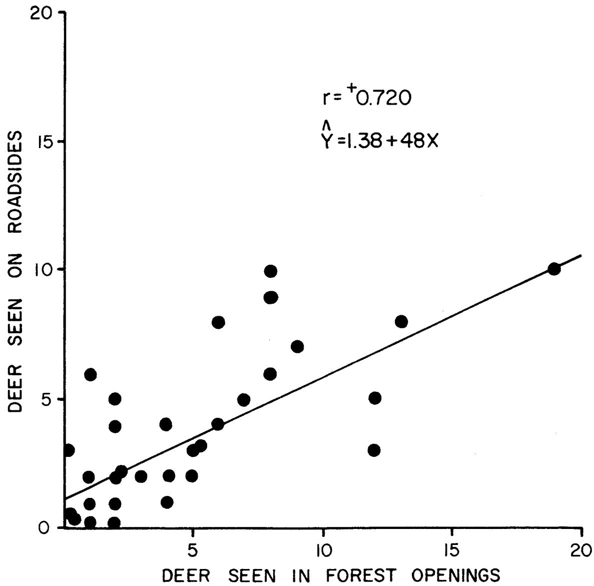


FIGURE 21. Relation between deer seen on roadsides and deer seen in openings on the Argonne Study Area.

deer per 25.6 acres or 25 deer per square mile. In 19 openings totalling 79 acres, deer observations averaged three to five times higher than would be expected if they were randomly distributed. Some counts on individual nights exceeded five times the "expected" rate of three deer (Fig. 18).

Pellet counts on permanent plots in openings on the Argonne Study Area also indicated high deer use. We assumed the daily fecal deposition rate to be a constant 12.7 pellet groups per deer (Eberhardt and Van Etten, 1956). Applying this factor to our data (Fig. 19) we calculated the use-level to be equivalent to 65 to 120 deer per square mile of opening during spring and fall. This again approximates three to five times as much activity as would be expected with a randomly distributed deer herd.

The highest intensity of opening use that we found occurred in a sample of seven openings in the Anniversary Plantation. Here 241 pellet groups were found on 140 .01-acre plots after a deposition period of about 60 days. This is equivalent to the use of about 145 deer per square mile.

These calculated use intensities are not clear expressions of need, but they do suggest that openings are a very important and preferred component of summer deer habitat.

Factors Affecting Use

Food

Our observations of deer in openings suggested that feeding was their primary reason for being there.

The seasonal nature of opening use by deer is likely related to both

The highest intensity of opening use found during the study was found through annual surveys on seven openings in the Anniversary Plantation. Woody browse is scarce in these openings, but green herbaceous forage is abundant.

plant phenology and deer physiology. Openings green-up early in spring and again in fall, offering a lush source of forage. Deer physiological requirements are especially high at these periods following winter stress and coinciding with the activity of the rut. Although we did not study food habits specifically, we believe the importance of grass and forb forage classes to deer in Wisconsin has been underestimated.

The importance of grasses and forbs to deer has long been debated. Townsend and Smith (1933:205) reported deer eating some grass during spring but they concluded grass was an unimportant food item. Food habits studies in a Pennsylvania oak forest showed grass and forbs comprised only a minor portion of food eaten (Watts, 1964).

However, Stiteler and Shaw (1966:209) stated that with the exception of the far North, browse probably comprises less than 10 percent of the food eaten by deer during the entire year and that more attention should be given to grasses and herbs. DeGarmo and Gill (1958:21) found deer feeding heavily in openings in spring prior to green-up in the forest. High seasonal use of grasses and forbs has also been reported for deer in Missouri (Korschgen, 1954), Montana (Allen, 1965; Martinka, 1968), Pennsylvania (Healy and Lindzey, 1968), and South Dakota (Schneeweis, 1968).

In Texas, Chamrad and Box (1968:158) found that deer were primarily grazers during the winter and spring. Grasses comprised 22 percent of the diet, and forbs contributed 68 percent. On the heavier

The importance of forbs and grasses in the diet of northern Wisconsin deer has likely been underestimated. Openings, fields, and roadsides concentrate deer activity in spring and fall. In autumn, archers can often profit from hunting along deer trails leading to, and interconnecting openings.

soils in Texas, Drawe (1968:164) found 8 percent grasses and 70 percent forbs in the midsummer diet. In fall, winter and spring, grass alone comprised 27, 37, and 34 percent of the forage preference by deer (Drawe and Box, 1968:226). Forbs were the most important forage class in these Texas studies while browse was least important.

Young grasses are high in protein content (Stoddard and Smith, 1955:268 and Ullrey et al., 1967:684). Ullrey et al. found higher protein values for grasses and certain forbs than for woody browse, while Young et al. (1967:811) found that protein yields were significantly greater in openings than in shade. The early availability of this nourishing food in openings corresponds with a period of high physiological need. In spring, deer require body-building nutrition following the austerities of winter. They must recover rapidly to produce a successful fawn crop. Verme (1962) reported a high plane of nutrition in spring could do much to compensate for low nutrition during the winter. Pregnant does on a low nutritional diet in both winter and spring lost 92.9 percent of their fawns, whereas those receiving good nutrition in spring lost only 35.1 percent of their fawns (Verme, 1962: 25, 27). We think grass may contribute greatly to the spring recovery of malnourished deer.

As grass matures, its phosphorus and crude protein content decreases; fiber, cellulose, lignin and other carbohydrates increase, while the leaf:stem ratio declines (Stoddard and Smith, 1955:268). Klein's (1962:156) study of summer forage quality revealed high protein content on good quality range and high fiber content on poor quality range. The decline in grass palatability and forage value accompanied by an increase of more succulent forage within the forest is undoubtedly a major reason for the low use of openings during midsummer.

In autumn deer again use openings intensively. Skovlin (1967:17) found that grasslands responded to fall rains with regrowth (tillering), whereas plants common within the forest did not respond similarly. Deer react rapidly to changes in food availability. New growth on tillering grasses in the fall again provides a highly nutritious green forage which contrasts with the maturing and drying of vegetation within the forest.

Weather

Some early observers including Leopold (1933:127) suggested one reason deer used openings was to obtain relief from mid-day heat. While deer may occasionally use openings for this purpose, our findings suggest this stimulus is of minimum importance. Fewest deer were seen in openings during midsummer when temperatures were highest.

The rather erratic day-to-day fluctuation in observed numbers of deer shown in Figure 18 was also reported by Behrend (1966:Fig. 9) and Progulske and Duerre (1964:33). Progulske and Duerre reported that daily variations in numbers of deer seen could be traced to daily weather. They found a correlation between daily activity and weather and between numbers of deer seen while spotlighting and temperature. Deer observations were highest on warm nights. Hahn (1949:11) reported seeing more deer on days of low humidity.

Ehrenreich and Bjugstad (1966) reported cattle grazing time decreased with increasing temperature and humidity values. We applied their Temperature-Humidity Index ($THI = 0.4 (T_w + T_d) + 15$, where T_w = wet-bulb temperature and T_d = dry-bulb temperature) to our spotlighting observations on the Argonne Study Area. We detected a similar decline in deer seen as THI values rose above 60, but our correlation is questionable because few observations were recorded on nights with high THI values.

Behrend (1966:40) failed to report any significant weather-related influences in his study. Hart (1960:5) suspected that spotlighting was less successful on nights when temperatures were below 44°F than when temperatures were warmer. We also believe that warm and overcast nights were best for observing deer, but our data are too variable to show significance.

Insects and Bedding

Leopold (1933:127) suggested that deer bedded in openings to seek relief from insects. However, we observed few deer making mid-day use of openings when biting flies were most bothersome. Deer seen in midsummer were often noticeably bothered by flies, but they did not appear to be oriented toward openings during periods of fly activity.

While a large proportion of deer observed in openings at night were lying down, we don't believe they selected openings for that purpose. Bedding appeared to follow feeding. Montgomery (1964:425) observed that the proportion of deer bedded increased to 70 percent by the eighth hour after sunset during summer and to 60 percent by the fifth hour in fall. We observed a high number of deer bedded but could not determine to what degree this behavior affected the total number observed.

Human Disturbance

Some early investigators believed the daily activity rhythm of deer was regulated largely by human disturbance (Townsend and Smith, 1933:275). However, our data suggested that deer are primarily crepuscular and late evening animals rather than clearly diurnal or nocturnal. However, for a short period in spring deer appeared in openings in large numbers irrespective of time of day. Apparently the attractive forage in openings in May motivates them to temporarily depart from their more secretive routine.

Interference by man on the Butternut Study Area was minimal. Only occasional tourists, woods workers, or conservation personnel travel the area during most of the summer. Seldom were more than five vehicles encountered while traversing the 42-mile transect, and after dark it was rare to encounter more than two vehicles. Throughout most of the year, deer activity could not have been noticeably affected by human activity. Daytime observations of deer did drop to a very low level during fall about the time bow hunting and ruffed grouse hunting seasons began. However, hunting pressure was light and it seems doubtful that hunting had any significant effect on observations. Therefore, the activity patterns illustrated in Figures 16 and 17 should be representative of the daily activity of wild deer.

Behavioral Observations

Sex and Age Ratios and Family Groups

A total of 850 deer was observed by spotlighting on the Argonne Study Area in 1964 and 1965. There were 636 deer observed in openings, and 462 of these were classified by sex and age. Only 381 are used in our analysis because 81 identified deer were seen in combination with unidentified deer. Including these latter observations would tend to bias sex and age ratios in favor of the more easily identified deer.

Observed sex and age ratios changed considerably during the months of observation (Table 9), but only August and September deviated greatly from expected ratios. Prior to October, bucks are secretive and fawns are still in hiding. By October the onset of the rut reduces the wariness of bucks, and also by this time fawns are feeding with does more consistently.

TABLE 9

Sex and Age Composition of Deer Seen in Openings on the Argonne Study Area, 1964-65

Month	Bucks	Does	Fawns	Yearlings	Total
April*	3 Adults			2	5
May*	35 Adults			18	53
June*	26 Adults		1	Adults 6/1	27
July	8	15	1	↓	24
August	5	24	3	↓	32
September	7	37	9	↓	53
October	30	73	43	↓	146
November	8	17	10	↓	35
December		3	3	↓	6

*1965 only

No individual deer were marked on the study area; however, groups of deer having the same age composition were repeatedly seen in some openings. We believe that we were likely seeing the same family groups from time to time.

In two adjacent openings a group of one doe and two fawns was seen three different times, accounting for 9 of 17 observations in these openings. In three other adjacent openings, a group of one doe and two fawns was seen five times, and a group of one doe and one fawn was seen on 12 occasions. These two groups accounted for 39 of 102 deer seen in these three openings. In an isolated opening where 28 deer were seen during shining in 1964, a group consisting of one doe and two fawns were seen five times. In this same opening during 1965, one group of deer accounted for 34 out of a total of 52 deer observed. On many nights unidentified deer were seen that could very well have also been deer belonging to one of the above groups.

To assume that precisely the same deer were seen regularly would be speculative. But the probability that they were the same deer most of the time is great. Home ranges during the summer are typically small; thus the relative intensity of deer use in openings may be influenced greatly by local deer densities, which also vary from year to year. Very likely these highly variable local differences account for much of the variation within our measurements.

Signs of Deer Activity

Other manifestations of deer activity in openings, though often conspicuous, were only qualitatively recorded. Among these "signs" are buck rubs and scrapes, beds, trails to and connecting with openings, tracks in grass, and browsed vegetation. These "signs" and the presence of droppings have long been used by hunters as indicators of game abundance and have occasionally served as indices in scientific investigations.

Buck rubs, where deer have rubbed their antlers on saplings and shrubs, and scrapes, where bucks have pawed bare spots on the ground, are common in and around forest openings. In November, openings without rubs or scrapes are rare despite local variations in deer density around openings. Perhaps the presence of does in the openings during fall is a bigger attraction for bucks than the available forage. Nevertheless, bucks come to the openings, display for courtship, and vent their frustration by attacking shrubs and saplings.

Deer beds can be found in openings at almost any time. Three counts in a 4.2-acre opening on the Knight Township Study Area on July 1, August 6, and October 22, 1964, resulted in finding 13, 19 and 34 beds, respectively. Abundance of beds was directly related to the seasonal frequency that deer were observed by spotlighting. Two other openings were surveyed on October 21, 1964. A 3.7-acre opening had 33 beds and a 3.5-acre opening had 36 beds. The technique was not continued because of the considerable time required to examine each opening and because beds often were not easily distinguished from small areas of matted grass caused by other disturbances. However, the abundance of beds offers further evidence of high deer use of openings.

Deer trails entering openings and interconnecting nearby openings are often worn to bare soil by mid-November. Bowhunters are quick to employ blinds overlooking these trails. These trails, plus the tracks which are readily apparent in the lodged grasses, are mute testimony to the use of openings by deer.

Browsed woody plants are common in almost all openings, but evidence of deer use of herbs and grasses is much less conspicuous. Whitetails are very selective grazers. Missing leaves on forbs and patches of "nuzzled" grass indicate where deer have been feeding. Forage utilization was much more easily found in openings on sandy soil where much of the vegetation is woody.

Though these various types of signs were not used extensively as quantitative expressions of deer use, they are mentioned here because they include some of the most obvious indicators of deer activity. These signs are sufficiently conspicuous that they attract the interest of nature enthusiasts as well as hunters. Likewise, they are useful evidence in the field to convince skeptics of the wildlife value of openings.

Use Preferences

Efficient management requires knowledge of types of openings preferred by deer. The determination of optimum size, type, and placement of openings were important considerations in our studies.

Opening Size

Spotlighting in two consecutive years on two different study areas indicated that smaller openings were used more intensively than larger openings. Results were grouped into six size classes (½-1, 1-2, 2-4, 4-8, 8-16 and 16-32 acres) and analyzed by linear regression. The correlation coefficient was significant at $P < .05$ (Fig. 22). This suggested an important relationship potentially useful for planning land use.

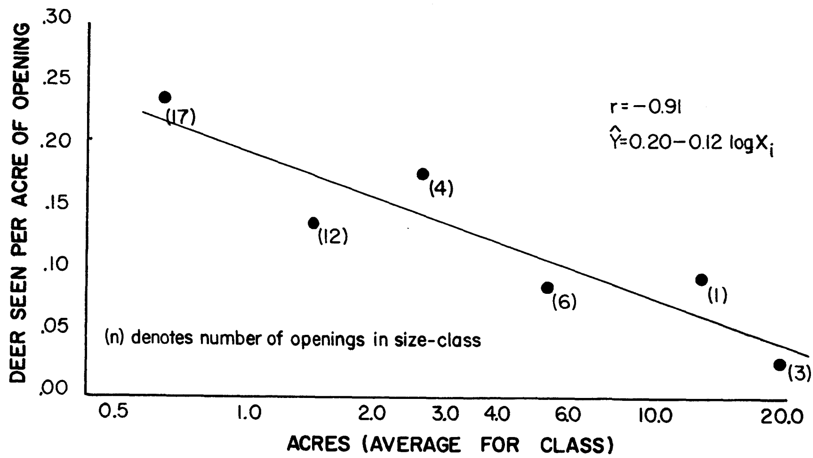


FIGURE 22. Relation between size of forest openings and deer use indicated by spotlighting on the Butternut and Argonne Study Areas.

During 1965, 50 openings were selected in the northern half of the Nicolet National Forest for pellet-group sampling to further test this relationship. Ten openings were selected in each of five size classes: ½-1, 1-2, 2-4, 4-8, and 8-16 acres. Acreages were estimated by pacing the approximate length and width of the openings. Precision of this measurement was sufficient to place openings into the proper size classes. Five openings in each size class were selected in aspen forest types and 5 openings per size class in northern hardwood types. Openings were sampled using 20 randomly located .01-acre plots. Sampling was done in late October after a fall of only moderate deer use in openings (Fig. 18). Surveying took 8 days and counts were adjusted to a common date by using results obtained from recounted openings. We used results from 43 openings in the final analysis. Six were excluded from the survey because they were "topographic frostpockets" which deviated from the type of openings intended to be surveyed, and one, a 1-acre hardwood opening sample containing 60 pellet groups, was so different from all others that it too was excluded.

The means for each size class were analyzed by linear regression. The mean numbers of pellet groups found on the 20-plot samples for the five size classes were plotted over the mean acreage of the openings in each size class (Fig. 23). The resulting regression coefficient was highly significant ($P < .01$). The results indicate a higher deer use intensity in smaller openings and corroborates the relationship suggested by spotlighting. A test of the difference between the mean for openings larger than 5 acres and the mean for smaller openings was significant only at $P < .10$.

Mean frequencies (average number of plots having pellet groups per 20-plot sample) for each size class were plotted in Figure 24. The regression coefficient was significant at $P < .05$, indicating a greater proportionate use of smaller openings.

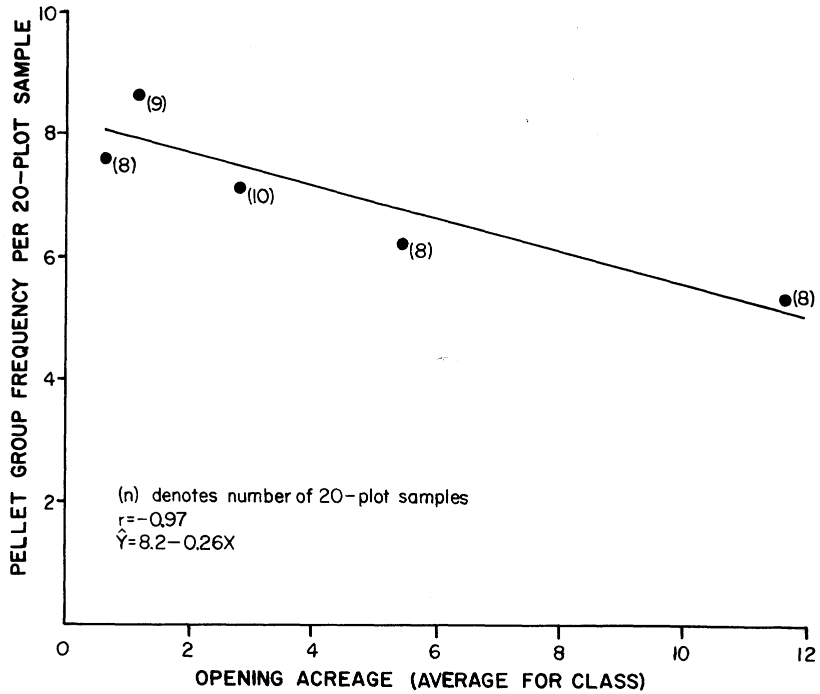


FIGURE 23. Number of pellet groups found in relation to opening area.

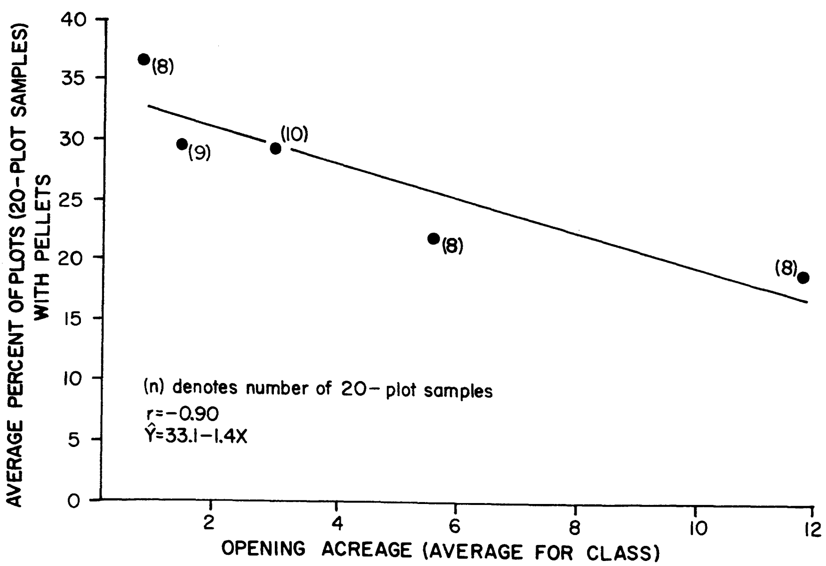


FIGURE 24. Plots containing pellet groups in relation to opening size.

Separate regressions for openings in aspen and openings in northern hardwood showed no significant difference between forest types at this level of sampling. However, the average number of pellet groups in aspen averaged somewhat higher than in northern hardwood openings.

Data were subsequently regrouped into 7 width classes: 2½ - 3½, 3½ - 4½, 4½ - 5½, 5½ - 7½, 7½ - 9½, and 9½ - 12½ chains. Means for these categories are plotted over the average "minimum widths" (short diameters) for the classes in Figure 25. The resulting coefficients were significant at $P < .05$.

A t test of the difference between the mean number of pellet groups found in openings less than 5 chains in width and the number found on wider openings was significant at $P < .05$. Most openings conformed roughly to an oval shape, so width (or short diameter) and area were closely related. However, 12 elongated openings with long axes at least twice their short axes averaged half again as many pellet groups as were found in all other openings in the same size classes. A test of these means showed a difference at $P < .10$. It appears that these long openings (one was 4 x 16 chains) are available to more deer than shorter openings of the same acreage. This suggests narrow openings are biologically more efficient acre for acre than larger openings. However, maintenance considerations may often override strictly biological considerations.

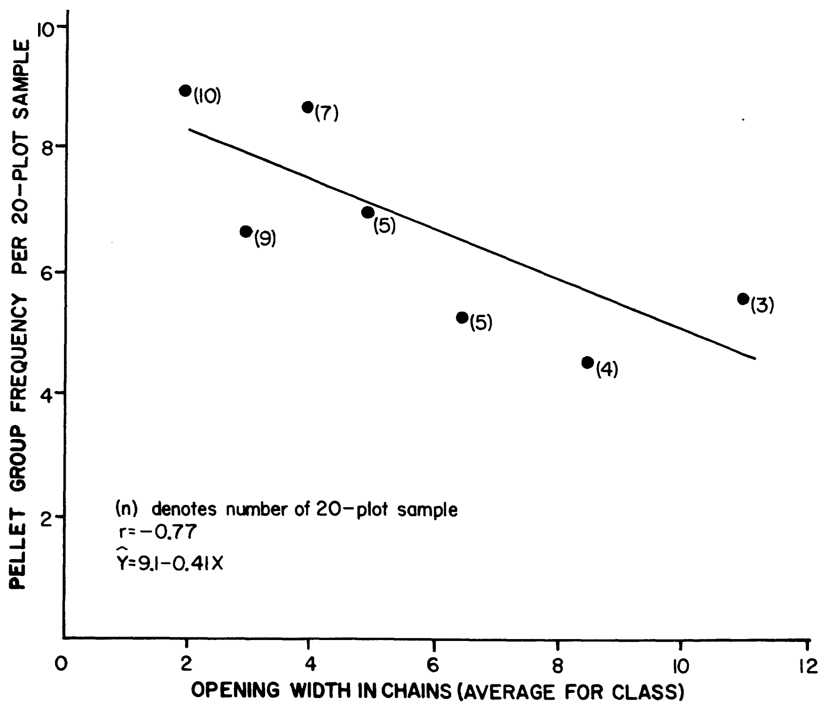


FIGURE 25. Number of pellet groups in relation to opening width class.

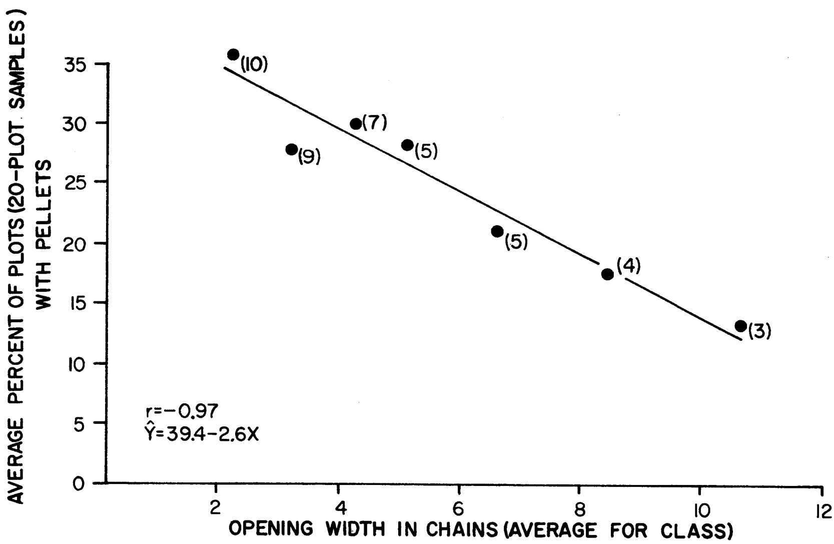


FIGURE 26. Plots containing pellet groups in relation to opening width.

The average frequency of pellet group occurrence in each class is plotted over the average width of the classes in Figure 26. This regression is significant at $P < .01$.

Though the data in Figures 23 and 24 were analyzed by linear regression, the line should not be projected beyond (below) 0.5 acres, as at very low acreages this line must abruptly drop to the range-wide use level. Similarly, it should not be projected to the larger (over 12 acres) openings as the line would asymptotically approach the X-axis. We believe that large areas tend to dilute the use of a more or less "fixed" number of deer. Taber and Dasmann (1958:43) indicated that mule deer are so sedentary on their home ranges that they will not leave, even for an attractive new source of food. Perhaps whitetails don't move far to feed in openings, either.

As anticipated, from experience with previous pellet counts, high variation was found between counts for individual openings within size classes. Much of this variation can be attributed to local differences in deer density, although many other factors may have been operating. The mean pellet counts for each size class are shown in Table 10.

Large Openings and "Edge"

We studied deer activity in relation to opening edge by intensively sampling three large openings. The openings, one in hardwoods (21 acres) and two in aspen (16 and 26 acres), were sampled with 78, 63, and 98 plots respectively with a grid layout.

Only 16.7 pellet groups per acre were found in the hardwood opening, which likely reflects the relatively low deer density in the surrounding hardwood types. In the aspen openings, 84.1 pellet groups

TABLE 10

Statistical Summary of Pellet Counts in Forest Openings by Size and Width Classes

Size Classes	Frequency of Pellet Groups in Plots (Percent)	No. Plots Sampled	Pellet Groups Per Plot	
			Mean	Standard Error
Acres				
½ - 1	36.2	160	.413	.047
1 - 2	29.5	180	.444	.061
2 - 4	29.0	200	.400	.051
4 - 8	21.8	160	.331	.061
8 - 16	18.8	160	.269	.054
Chains				
1½ - 2½	35.5	200	.475	.053
2½ - 3½	27.8	180	.320	.046
3½ - 4½	30.0	140	.450	.071
4½ - 5½	28.0	100	.380	.074
5½ - 7½	21.0	100	.280	.070
7½ - 9½	17.5	80	.238	.065
9½ - 12½	13.3	60	.250	.106

per acre were found in the 16-acre opening and 49.0 per acre in the 26-acre opening.

The plot locations were systematically located with about half the plots located within 1.5 chains of the opening edge. Comparison of the pellet group densities in the two strata showed no significant differences at this intensity of sampling. Reynolds (1962:2) reported mule deer ranged at least 1,100 feet from cover, but spent most of their time within 700 feet. If whitetails behave similarly in forest areas, we would not readily detect a significant edge effect in wild openings much smaller than 40 acres. Openings remaining in Wisconsin forests are rarely as large as those found in western mule deer ranges.

Previously we had found a significant correlation between the number of deer seen in openings and the perimeters of openings. Perimeters were estimated for 19 openings repeatedly spotlighted on the Argonne Study Area. Openings varied in size from ¼-acre to 23 acres. Correlation of deer seen with length of perimeter produced a highly significant coefficient of + 0.65 (P .01, 17 d.f. = .575). This suggested that edge might be a factor governing intensity of deer use. However, our inability to detect a measureable orientation of deer activity toward opening edges with pellet counts suggests that the above correlation is just another expression of the linear relationship between opening dimension and deer activity as shown in Figure 26.

Frostpockets

Frostpockets are common in moraines and pitted outwash areas, often outnumbering other openings. Since they are not generally suit-

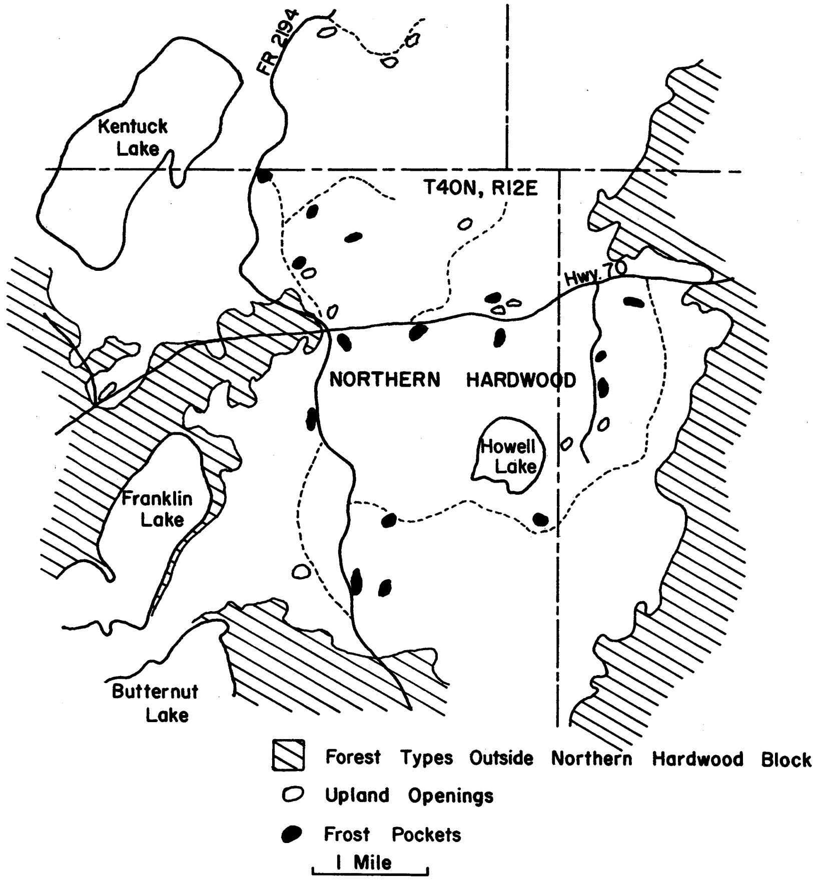


FIGURE 27. Juxtaposition of openings in frostpocket study.

able for tree planting and conceivably could be substituted for openings with better tree-planting potential, we attempted to identify their value to deer in relation to other openings.

During the summer of 1966, 36 openings were selected to test for a difference in intensity of deer use between "upland" openings and "frostpockets." Frostpockets used in this test were upland openings in the sense that they did not contain water or marsh, but were distinguished from "upland" openings by the presence of a distinct topographic influence.

In the frostpocket test we attempted to "pair" frostpockets with nearby upland openings. By pairing openings we hoped to minimize variation caused by differing opening sizes, local deer populations, and adjacent forest types. A large block of monotypic northern hardwoods located near Howell Lake (mainly T40N, R12E) was selected as the primary study area. Because of the lack of openings, virtually all openings in this block had to be included in the test despite deviations from optimum pairing. Figure 27 shows the location of 28 openings sampled. Additional pairs of openings in adjacent areas were also sampled. All openings were surveyed in late October.

Deer density in the Howell Lake hardwood block is very low, hence our opening pellet counts ran correspondingly low; too low, perhaps to show great differences in use intensity.

Samples from frostpockets averaged slightly more pellet groups per acre than samples from upland openings. A *t* test of means showed no significant differences at $P < .05$. A Chi-square test of the number of frostpocket samples exceeding values found in upland openings also failed to show a significant difference. Any manipulation to make the data seemingly more comparable, such as adjusting sample values on the basis of opening size, resulted in higher use values for frostpockets.

It appears that shallow frostpockets in northern hardwood areas are used as intensively by deer as are other upland openings. This is a particularly significant finding. Frostpockets presently have a low priority for reforestation, and also are naturally maintained, thus requiring little special management by man.

Conclusions

1. Daytime use of openings by deer is light, but the intensity increases in evening to the fourth hour after sunset. This behavioral pattern suggests that biting flies and mid-day heat are of minor importance in motivating deer to use openings.

2. Deer use openings most intensively in spring and fall. This periodicity corresponds closely with observations of deer feeding in farm fields and on roadsides, and suggests deer use openings primarily as a source of forage. The intensity of deer use in openings during spring and fall was found to be at least three to five times as great as would be expected if deer were randomly distributed in the forest.

3. Annual observed differences in the intensity of opening use by deer suggest that rainfall and severity of winters may significantly affect the intensity of opening use.

4. The importance of forbs and grasses in the diet of deer in northern Wisconsin has likely been underestimated. Food habits studies in other states report heavy use of forbs and grasses during the snow-free seasons. Our observations tend to corroborate these studies. Major activities observed were feeding and incidental bedding.

5. Fawns and adult bucks were not seen using openings in expected ratios with does during late summer (August and September). Reasons for this are speculative.

6. Deer beds, trails, tracks, browsed vegetation, buck rubs and scrapes are abundant and conspicuous in openings during fall (October and November). These are useful evidence for convincing skeptics of the value of openings to deer.

7. Deer use in smaller openings (½ to 5 acres) was more intense than in larger openings. This indicates that openings need not be large to meet the requirements of deer.

Midsummer use of openings is only about as intense as would be expected if deer were randomly distributed. The relatively lower use during the warmest season suggests that deer use openings for reasons other than to escape midday heat and insects.

8. Pellet counts in three large openings (16 to 26 acres) failed to show a significant orientation of deer activity toward the edges of the openings. This suggests that the nearness of cover does not appreciably affect deer use in openings of the size we sampled.
9. Comparisons of deer use in shallow frostpockets and other upland openings failed to show any significant differences in deer preference. Both types were used at similar intensities. Therefore, frostpockets can and should be included in permanent wildlife opening planning.

DEER USE OF OPENINGS ON SANDS

Although this study has emphasized deer-opening relationships on loamy soils, there are also some 5,600 square miles of gray acid sands (Fig. 28) in northern Wisconsin (Muckenhirn and Dahlstrand, 1946). Since many of these sandy areas occur on public forest lands, average five times as much open land as loamy areas, and also support some of northern Wisconsin's highest deer densities, we endeavored to determine the relationship between openings and deer populations on sand.

These preliminary investigations provided more insight on methodology than on deer-opening relationships. We immediately found that some techniques we had successfully applied on loamy soils did not work as well on sands. Fall pellet surveys in most cases proved impractical because abundance of low shrubs prevented accurate counts. Track counts, too, were only partially successful because large blocks of well-stocked timber needed for controls were difficult to find.

Track Counts

To determine what effect openings may have on deer distribution on light sands, we tried to locate extensive areas without openings, but having roads suitable for track counting. Considerable difficulty was experienced in meeting these conditions. By compromising the ideal somewhat, three track count routes were located, two in Marinette County and one in Bayfield County.

Marinette

The Marinette County areas were located in the town of Silver Cliff (T34N, R18E) and the town of Stephenson (T32N, R18E). Similar

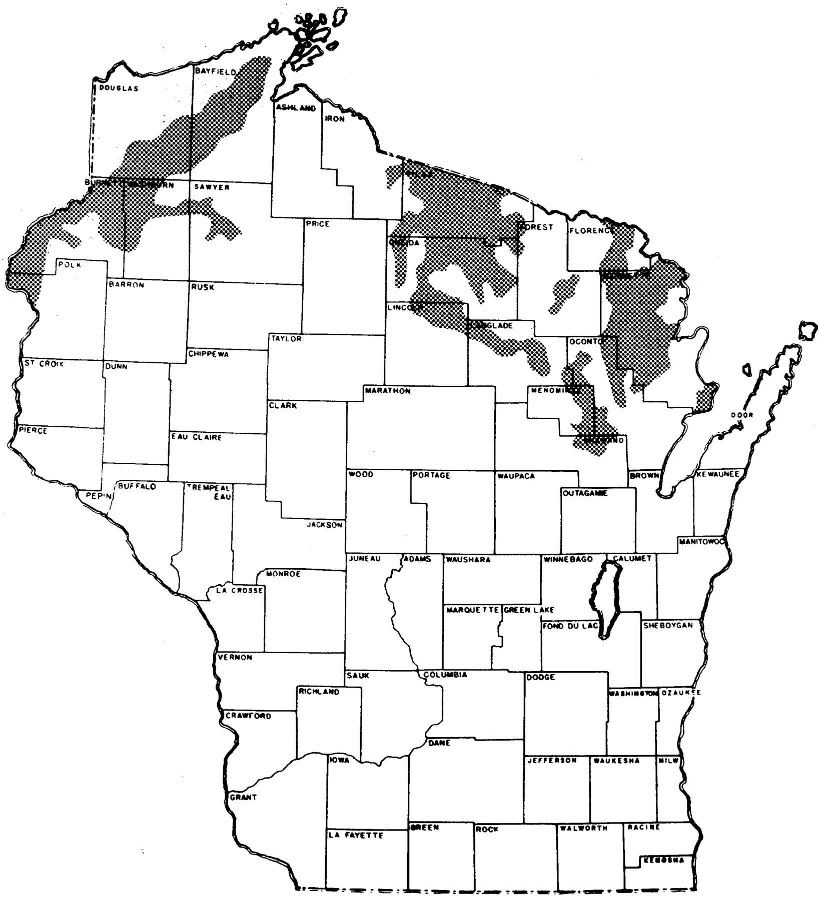


FIGURE 28. Area of melanized sands where northern deer summer range appears most secure. (Adapted from Wilde et al., 1949:10)

upland types were common to both areas, but the Stephenson block had more lowland types in the southern portion. Primary upland types on both areas were oak, aspen and jack pine. Stand sizes and type arrangement varied; stand sizes on the Silver Cliff area were larger and the openings were less well distributed than on the Stephenson area. The Silver Cliff area was 6.8 percent open with an additional 0.2 percent in upland brush. The Stephenson area had 7.2 percent in openings supplemented with 1.7 percent fields and 3.1 percent upland brush.

Track counts were conducted on August 25 and September 26, 1967. Upland segments on the Stephenson area averaged 30.6 tracks per mile in August and 44.0 in September, while the Silver Cliff counts averaged 38.7 and 46.4, respectively. The number of tracks in the lowland portion of the Stephenson area averaged only 6.3 and 12.3 tracks per mile.

When plotted on type maps, no relationship between tracks and types was conspicuous, other than the apparent avoidance of lowland types by deer on the Stephenson area. Despite the difference in the amount of open land on the two areas, track counts showed no significant difference in deer activity. This suggests that well-defined openings may have little influence on late summer deer distribution in these light-soil forest types.

During October when deer usually show a high preference for openings, newly fallen oak leaves and heavy traffic by grouse and deer hunters precluded fall track surveys. Early spring counts may produce results different from the above.

Bayfield

Two days of track counting were completed in Bayfield County. The longest transect was 11½ miles and was located in the town of Hughes (T45-46N, R9W). Six miles of this transect were in pine types and 5½ miles were in oak, aspen and pine mixtures. Five other transects ranging from 2 to 5 miles in length were located nearby in jack pine plantations owned by the Mosinee Paper Company. Counts were conducted on October 5, 1967, and October 22, 1968.

Tracks on all roads averaged 26.8 per mile and were most numerous in jack pine of highly variable stocking. Twenty-nine miles in jack pine averaged 29.7 tracks per mile, while 7 miles in oak, aspen and pine mixtures averaged only 14.9 tracks per mile.

No specific orientation to openings could be detected, perhaps due to the open nature of the adjacent types. Sharp-tailed grouse were flushed on several occasions in the jack pine area, reflecting the open nature of the stands.

Our track counts on sands have suggested little tendency for deer to concentrate around well-defined openings. However, the presence of many very small openings throughout these stands could easily have influenced deer distribution, and hence the track patterns.

Pellet Counts

Fall pellet counts were tested in 14 Vilas County openings in 1965. Ranging in size from 0.5 to 2.2 acres, they were selected to include only those with sparse, shrubby vegetation. Newly fallen leaves prevented accurate counts in openings with dense shrub cover.

Despite careful selection of openings, sweet fern, wintergreen, and false strawberry leaves often hid pellet groups, causing highly variable results. The fourteen 20-plot samples (0.01-acre plots) varied from 0 to 0.75 pellet groups per plot, averaging 0.27. Based on an estimated 60-day deposition period, average fall use for this period was calculated at approximately 23 deer per square mile of opening, or less than the 30 + deer per square mile density estimated for the general area (Unit 36) where the openings were located.

These rather sketchy results are presented only to illustrate the type of quantitative data which may be obtained, and also some of the problems encountered with the method. We have not adequately tested the technique on sands, and it is possible that pellet counts could be made more accurately 40 to 60 days after snow melt in spring and before green-up is too far advanced.

Other Observations

Although we did not attempt to employ spotlighting or other systematic direct observations, we did observe many deer using sandy soil openings. Well-used trails leading to openings and high utilization of browse plants within them were common. Browsing on oak grubs, willow, sweet fern, and blackberry was almost everywhere.

Deer apparently prefer "light-loving" plants. Texas studies by Halls and Alcaniz (1968:15) showed seven primary browse plants produced seven times as much browse in openings as beneath the adjacent forest canopy. Further, these plants produced 32 times as much fruit in the openings as in the forest. Lay (1964:3) in another Texas study, indicated fleshy fruits were avidly sought by deer.

By following semi-tame deer and observing their feeding habits, Healy and Lindzey (1968:12) found blackberry was the most important plant consumed by deer in all seasons in the Allegheny National Forest, Pennsylvania.

Existing forest conditions on sandy soils promote high numbers of deer. Results from all sandy areas studied indicated high densities of deer except in Unit 3 which has an obvious winter range bottleneck. Trail count results in Units 36, 45, and 49 showed high numbers of deer trails (Table 4). Track count results in both Bayfield and Marinette Counties indicated a high amount of deer activity. Population estimates based on spring pellet surveys and buck harvests also show consistently high deer densities on sandy soil areas (Appendix C). Unless forest stands change markedly in subsequent rotations, these areas will continue to produce high deer populations.

Conclusions

1. Our preliminary surveys on sandy soils suggest well-defined openings may have little influence on summer deer distribution, perhaps because small, poorly defined openings occur frequently in forests growing on these light soils.

2. High forage production (principally low-growing herbs and shrubs) and conspicuous deer browsing suggest sandy soil openings are important to deer. But our surveys to date have been inadequate to determine seasonal-use relationships, or whether forest management practices are significantly reducing availability of preferred forage species.

3. Existing forest conditions on sand support high densities of deer. The future for deer populations on these areas will become clearer as forests mature and new rotations become established.

OTHER USES

"In the long run, a rich and varied landscape is the healthiest landscape for all forms of wildlife — and for people as well." (Hamerstrom et al. 1952:34).

Forest opening values can perhaps best be classified as those primarily benefiting humans and those benefiting wildlife, although in many instances such values accrue to both. But certainly the values are great, and when all are considered they clearly offer formidable competition to full and exclusive production of wood products.

Human Values

Those of us who have grown up with a love for trees sometimes find the vast expanses of the prairies lonesome, monotonous, or even foreboding. A forest without openings can create the same feelings. Except for occasional open views across lakes, rivers, and bogs, much of the north country is rapidly acquiring this closed-in, monotonous character. Sight distance is an important factor governing esthetic value (Lindsay, 1969:34). Esthetic values should rate high in justifying the preservation of those few open areas remaining today.

Fall "colorama" tours and celebrations have become major attractions in northern Wisconsin, as in other parts of the country. Special routes have been designated for tourists and widely publicized. Scenic tour routes necessarily must include open vistas of some sort for maximum opportunity to view the fall spectacular. Fully stocked forests growing right up to the roadside offer little chance to see fall colors, nor do they produce as much color.

Roadside openings attract wildlife, particularly deer, so that they in turn can be seen by people. Deer rate high as an esthetic resource in northern Wisconsin; indeed, maintenance of enough deer for easy

Openings add much to environmental quality. They provide scenic overlooks, panoramas of seasonally changing colors, and opportunities to stretch one's legs as well as his imagination. This deep frostpocket is located on pitted outwash sands. ▶

In spring, various fruit-bearing shrubs flower, providing a refreshing aura of vernal anticipation. Openings on sandy soil contain abundant browse as well as green forage. This opening contains hazel, sweetfern, cherry and juneberry.

observation by tourists continues to be an issue in most summer resort areas. Limited efforts have been made by conservation agencies to manage openings along some backwoods roads to attract deer for this purpose.

Berry picking, particularly blueberry and blackberry picking, must be included in the list of human uses of some forest openings. Curtis (1959:317), referring to the common practice of driving through bracken grasslands to view deer, commented, "This use, combined with daytime blueberry picking, has served to give the northern grassland a wide popular knowledge that is not matched by a current scientific understanding."

Some wild flowers give forest openings a special esthetic flavor. Orange hawkweed, blazing in early summer, is particularly spectacular. Seasonally changing colors in openings add much to visual variety and hence to environmental quality for the human animal.

Hunters, by preference, appear to concentrate where openings are common. Whether they do this because deer "sign" is also more abundant in such places, or whether some other motivation is involved, we can't be sure. Larson (1967) pointed out that bowhunters especially are dependent on sod clearings for their sport. It is well known that many hunters choose stands in or near openings simply to gain a better view for sighting deer. Openings unquestionably serve as landmarks for hunters; they also help define areas for making deer drives. All things considered, openings help make the deer woods more "huntable."

Openings offer excitement to the woodland hiker, particularly the individual interested in reconstructing man's historical past. Old logging camps are fairly common, some dating back to the turn of the century or before. A camp's dining hall may be detected by the presence of old tin plates and rusty "silverware" lying on the ground. Other foundations may have been bunk houses, stables, or woodsheds. Sometimes one can find the root celler — that underground cooler which served so well in pioneer times.

Added to the natural beauty that can be found in openings are artifacts of bygone eras. Old homesteads often contain remnants of buildings; underground rootcellars are common finds in old camps; and steel from donkey engines and railroad logging can be found along most old grades and landings..

Old railroad grades often intersect the camp clearings. Pieces of rail, rail spikes, broken parts of engines and cars . . . can't you almost hear the squeal of the "donkey" engine coming down the track? Grab your canthooks, boys, we've got work to do! Those sweet-talkin' Hurley gals will be waitin' come break-up! Yahoo!

Old homestead clearings, too, can still occasionally be found. One can't help wondering who lived there. What happened to them and their families? Were their lives happy? And oh, how they must have struggled to conquer the forest to grow enough food for their cattle and families! So it is with nostalgia that for a moment we relive the lives of the pioneers.

These relics of the past are too often lost to the bulldozer, the tree planter, and to other functions of "civilization" — and their passing is so often termed "progress"!

Wildlife Values (Other Than Deer)

The principal value of openings to all forms of forest wildlife lies in the variety of vegetation they provide. These values are inadequately known in a quantitative sense, but some are at least qualitatively recognized.

Ruffed grouse, the major game bird of northern forests, have a liking for particular types of forest openings, especially those with favorable ground vegetation and some shrubby overhead protection from avian predators. Temporary openings, created by forest cutting, are more important to grouse than sodded openings (Moulton, 1968). The centers of grassy, sodded openings are evidently little used by ruffed grouse, but the edges provide vegetational variety not generally found in the adjacent forest. Particularly common to opening edges are hazel, cherries, juneberries, and other light-loving species.

Woodcock were frequently heard and seen in openings, particularly on the Butternut and Knight Township study areas. More than half of the openings on the Knight Township Area were known to be spring "singing" grounds. No specific attempt was made to document woodcock use, and most singing birds recorded in field notes were

During summer, openings are ablaze with orange hawkweed.

heard over the sound of an idling truck while spotlighting deer. Certainly more birds would have been heard in more openings had we deliberately listened for them. Woodcock are also known to use openings during summer, and usually fly to openings shortly after sunset. However, the role of sodded openings in influencing woodcock populations and distribution is not well documented.

Though we did not record observations of bear quantitatively, evidence of their activity in forest openings was common. This was especially true in midsummer when deer activity was low and bear "signs", therefore, were more readily discerned. Bears evidently used openings for loafing, playing, and feeding on vegetation and insects. Rare is the old log or stump that is not annually rolled over or torn apart by bears in their search for insect grubs. Although use is light, the role openings may play in bear welfare is unclear. They may have no significant impact on bear distribution or population mechanics.

Openings required to sustain sharp-tailed grouse are necessarily much larger (hundreds to thousands of acres) than we have examined in this study. While sharptail management and forest management are basically incompatible on the same lands, we should not fail to consider the warnings offered by Hamerstrom et al. (1952:28) in commenting on the recent reforestation of the Namekagon Barrens in Douglas County:

> "Where and when, and at what cost and effort, will a new sharptail area be created to replace the Namekagon Barrens? That question can no longer be evaded. Unless a replacement is created for *every* present sharptail area that is reforested out of existence, the loss of sharptail range obviously will continue. The corollary is equally clear: it would be simpler (and surer) to save what we now have than to create replacements."

Here it is, only 16 years later, and we are now concerned about preserving a small remnant of the myriads of small openings which were a short time ago so common. Except for a few intensively managed areas, the sharptail openings are gone. When lessons are so clear, it seems inexcusable that we repeat the failures of the past, species by species. Must we continue to be but casual observers on the scene?

MANAGING OPENINGS

Where

An immediate effort to save openings is not required throughout all of northern Wisconsin. At this point in our understanding, only on the heavier soils can we demonstrate a distinct requirement. Studies are continuing in forests on very sandy soils. Forested areas on sands contain many small openings, and usually the floral composition in these openings is not markedly different from vegetation found within the adjacent forest stands. This is in contrast to openings on heavier soils where introduced grasses constitute a significant portion of the floral composition.

Our recommendations presently apply to the general area shown in Figure 29. Precise opening requirements for specific locales within this area vary considerably and must be determined by the local resource manager. Prime factors to be considered in determining the requirements for openings and the justification for a program are: (1) distribution of farm clearings; (2) present and future forest types and timber harvest prospects; and (3) potential for adequately harvesting surplus deer, now and in the future.

Most large unbroken forested tracts are either public or industrial forests (Fig. 30). Small private holdings are usually well interspersed with clearings or active farms. The requirement for deer openings on private forests is therefore minimal. But, the resource manager should not overlook the other values of preserving openings if public land is located adjacent to farm lands.

That most unbroken tracts are in public ownership is advantageous. Here programs may be implemented with the greatest freedom. Important is the immediate identification of those public forests where maintenance programs for openings are needed. Only by implementing programs on these lands can an example be set for other forest owners. Without action programs on county, state, and federal lands, it is unreasonable to criticize inaction on other forest properties.

How Much

What portion of the forest landscape should be maintained in openings? Most authorities recommend percentages ranging from 5 to 12 percent for optimum forest game range (Leopold, 1933; Giles, 1961; Allison, 1966; and Shaw, 1967). The 12 percent value is impractical for areas devoted primarily to timber production, and we do not believe this much is necessary or justified in extensive game management programs. For the most part, there are few public forests on heavy soils which presently contain more than 5 percent open ground; hence, it becomes academic to talk of preserving more.

The precise openings requirement is a function of forest composition, intensity of forest management, and the deer density desired. Our studies have shown that scattered openings comprising 10 percent

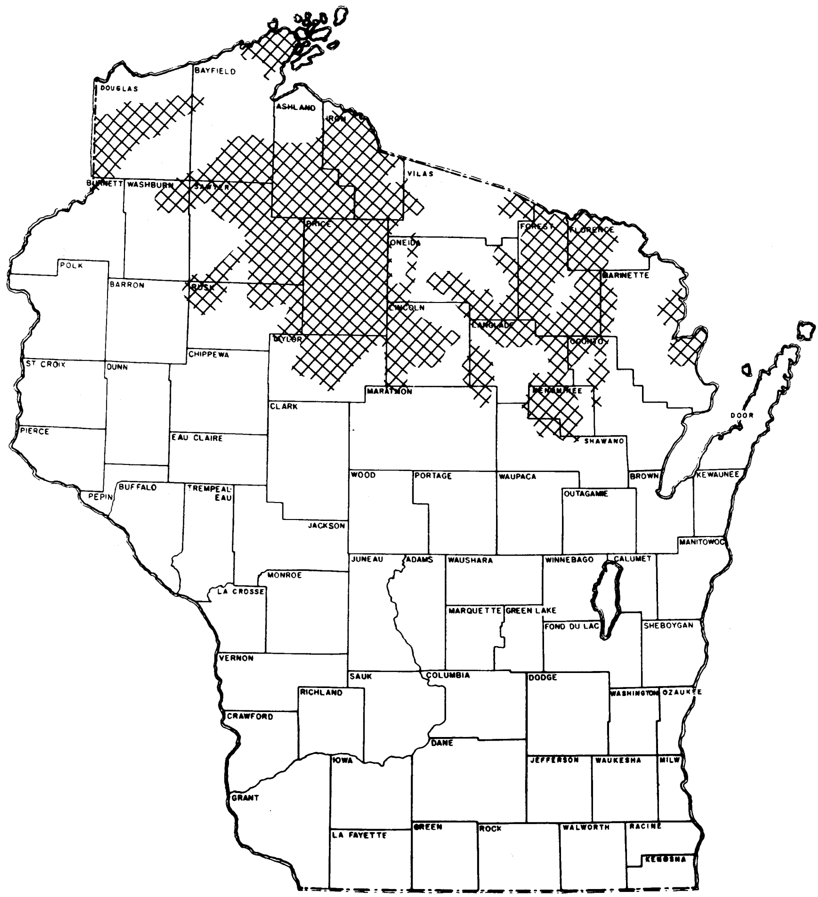


FIGURE 29. Area of loamy soils within the extensive northern forest where programs for opening maintenance should rate high priority, and where our management recommendations are most applicable. (Adapted from Frontespiece and Fig. 15)

is ample grassland in a 400-acre red pine plantation, (Anniversary Plantation), but that 1 percent is inadequate in areas dominated by hardwoods (Knight, Goodman, and portions of the Elton-Lily and Northern Nicolet study areas).

One secondary study area of township size (Parrish Township, Langlade County) has maintained a substantial deer population (20-25 deer per square mile) with only 2 percent of the area in wild openings. However, this small proportion in wild openings is supplemented by an additional 4.2 percent in farm fields on one side of the township. For a rule-of-thumb, we believe 5 percent will be adequate for most areas. If openings are very well distributed relative to the productive summer range forest types (aspen, oak, pine, upland brush), 3 percent may be sufficient (Fig. 31).

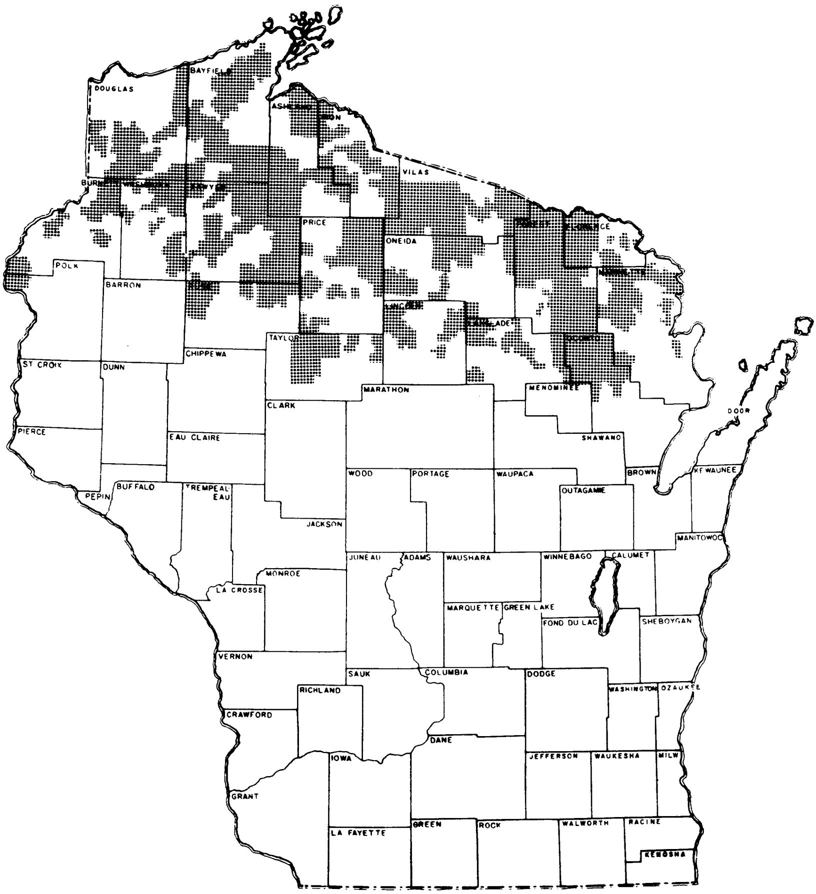
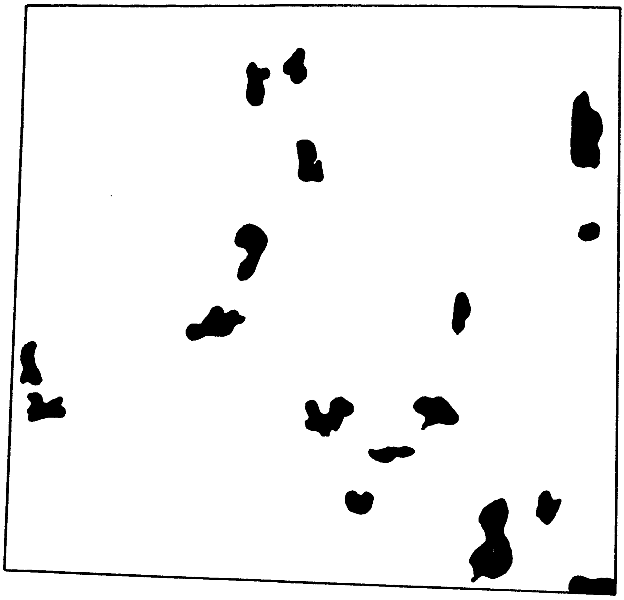


FIGURE 30. Publicly owned forests within the extensive forest region.

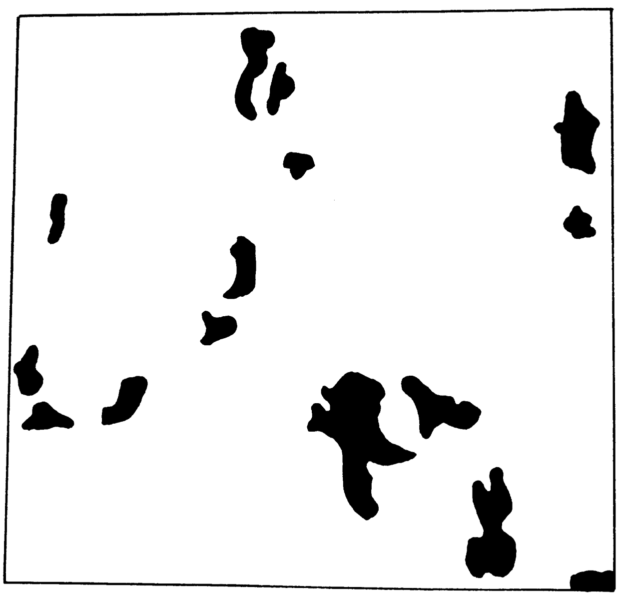
Opening size is also an important consideration. From the biological standpoint, openings need not be especially large to fulfill the requirements of deer. Our research has indicated that openings of ½ to 5 acres receive the highest intensity of use. However, larger openings will require less frequent maintenance, and have the highest "people value". Therefore, if some larger openings are available for nonforestry uses, they should be incorporated into the plan.

We do not recommend extensive creation of openings, but we do strongly recommend that existing openings be meaningfully designated for management. Once they are identified as wildlife openings, whether or not a maintenance program is initiated immediately, their existence is at least assured for many years.

Extensive creation of openings is too costly to be justified in relation

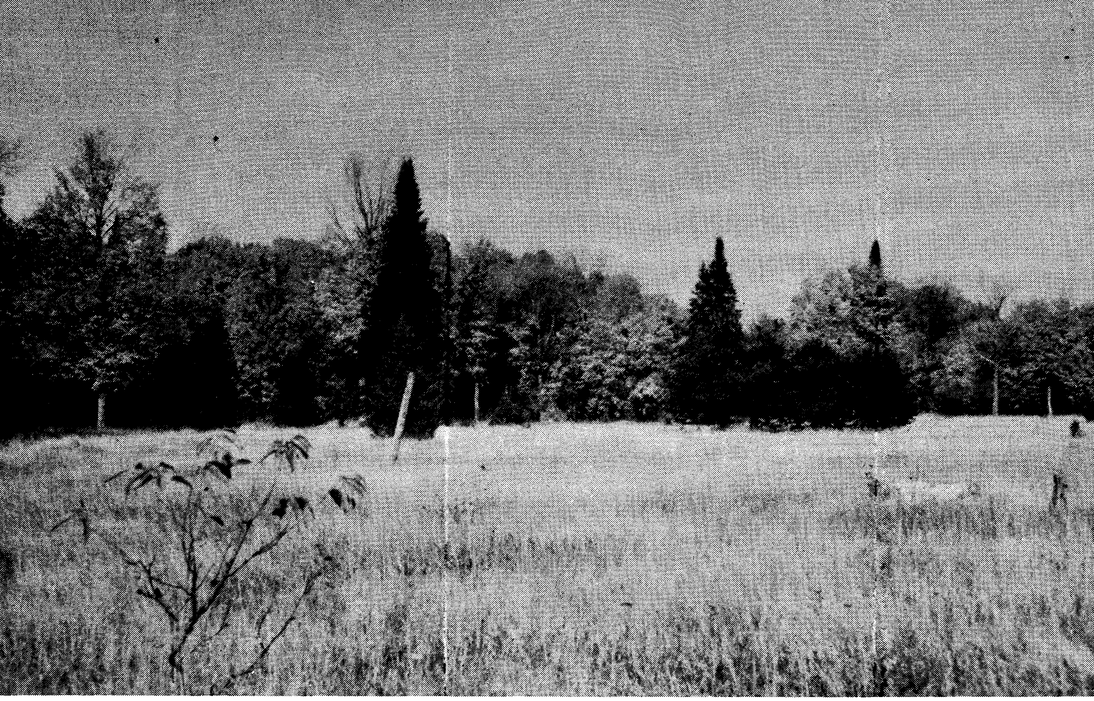


3 PERCENT OPENINGS



5 PERCENT OPENINGS

FIGURE 31. Appearance of 3 and 5 percent openings on one square mile as traced from aerial photos.



Where a choice exists, stable sod-bound openings should be selected for a permanent wildlife openings program. Selecting transitional types or newly cut-over areas for permanent openings invites maintenance problems.

to the present supply and demand for deer hunting alone. Furthermore, such clearings can be made at any time. On the other hand, maintenance can only be done while there are natural openings remaining to maintain.

Detailed procedures for inventorying openings and planning openings programs are shown in Appendix E.

Maintenance Methods

Permanent wildlife openings should have less than 10 percent stocking of trees and less than 30 percent stocking of upland brush. Greater stocking of trees or brush will require early maintenance.

Opening maintenance in northern Wisconsin primarily involves controlling aspen, balsam fir, cherry, willow and hazel invasion. Of these, the most difficult to control are aspen and willow. These species sucker prolifically when sprayed with most herbicides or cut.

One of the best herbicides for openings maintenance appears to be TORDON* (4-amino-3,5,6-trichloropicolinic acid). Applied as a leaf-stem spray, TORDON produces a slow top kill and a high degree of root kill. It is a systemic compound, effective on most broad-leaved plants and some conifers. Experiments in Michigan indicated a mixture of ½-1 pound (acid equivalent/100 gallons) gave satisfactory control of cherry, willow, maple, aspen and balsam (Watson and Wiltse, 1963:11).

*Dow Chemical trade name.

If a shrub sere is desired to promote ruffed grouse use, management should be directed toward manipulating the wood's edge of the opening, not the opening *per se*.

The chemical can be applied by using vehicle-mounted spray units or by back-pack sprayer depending on access and area to be treated. A pelleted form (TORDON 10K) is also available, costing about $1.00 per pound. They appear to be a convenient medium for selective control of shrubs in small openings. Pellets evenly spread by hand over root systems of unwanted woody vegetation during the active growing season will give excellent control, especially if followed by light to moderate rainfall (Wiltse, 1964:4). Complete control is not always necessary. In small openings, aspen suckers are usually eliminated by competition, shading, insects, fungi and deer browsing (Graham et al., 1963:210).

A very helpful booklet on herbicides has been prepared by the U. S. Forest Service (1966b) for use in northeastern United States. This booklet discusses various herbicides and techniques of chemical management of vegetation. Another publication on herbicide characteristics and use has been prepared by the University of Wisconsin (Stamm, 1964). Even experienced herbicide workers will find these references useful.

Burning has been suggested as a method for maintaining forest openings. However, to preclude exorbitant control costs on such small acreages, burning would have to be conducted early in spring while snow remained under the forest canopy. This early burning would often have limited effect on woody vegetation except to encourage sprouting. It may temporarily improve forage quality and palatability; however, it may also open the sod and herb cover to seedling establishment, thus increasing the maintenance problem.

Any major disturbance of the sod cover is likely to increase maintenance problems. For this reason, any effort to promote a brushy edge (hazel, willow or tree sprouts) to favor ruffed grouse should be done by manipulating the wood's edge of small openings, rather than the opening itself.

The establishment of 1-chain "no-cut" zones around openings in aspen types will help preserve openings from the invasion of suckers when aspen is harvested. The no-cut zone may revert to brush as the aspen deteriorates, thereby adding to the attractiveness of the opening to wildlife.

Costs

The U. S. Forest Service has explored maintenance on some of the 6,000 designated wildlife openings on the Nicolet National Forest. These openings range in size from ½ to 5 acres and average about 2½ acres. To date, only 20 openings have been improved with an average cost of $28.50 per opening (Edwin Wilder, U. S. Forest Service, pers. comm., November 8, 1968). Unwanted trees were cut and herbicide was sprayed on other woody vegetation. The cost includes 20 percent for overhead administration.

Maintenance of 32 openings on the Oneida County Forest by Department of Natural Resources personnel cost an average of $28.13

Prescriptions for "no-cut" zones should be adopted around openings in aspen types to prevent any disturbance in or adjacent to openings that may shorten the opening's longevity or damage its esthetic value.

per opening. These openings ranged in size from $1/8$ to 5 acres and averaged about 1 acre. The treatment included cutting and removing trees, back-pack spraying of herbicide, and retreatment of 13 openings where the first herbicide treatment failed. The total cost of the job was $900, including about $100 for chemicals and $70 for transportation. About 230 man-hours were expended, of which approximately 20 percent was travel time. Salaries made up the remaining $730 of cost (Arlyn Loomans, pers. comm., October 10, 1968).

Costs incurred by both of these agencies are somewhat higher than would be expected on the average. Three reasons are offered for this. First, salaried personnel were used by both agencies; second, the openings treated in both cases were brushier and more transitional in nature than should be selected in the first place; third, the personnel doing the work had only limited experience with opening maintenance. They have subsequently developed some shortcuts.

Shortages of funds should not delay program planning. Inventorying and designating openings for preservation costs little, but goes a long way toward saving them for the future. Once set aside they will exist for many years without specific maintenance.

Ideally, management programs should begin when enough openings still remain so that some choice exists as to which ones will be maintained. Proper selection of sod-bound openings where there is a choice will minimize an expensive initial maintenance effort. Costs can also be minimized by using less expensive manpower. Maximum advantage should be taken of public work programs. Public work crews can accomplish most openings maintenance with a minimum of supervision. If such programs can be anticipated, maintenance should be postponed to coincide with availability of low-cost labor.

Economical maintenance may be achieved by the use of aerial spraying with a helicopter. Although costs may approach $300 per hour, perhaps 80 or more acres could be treated per hour. Much would depend on the size of the machine and the experience of the pilot. Openings are rather distinct physiographic features, so premarking on the ground may not be necessary. While this technique has not been tried here, it offers possibilities. However, before such blanket spraying is attempted, investigations should be completed of potential deleterious effects that it may have on desirable vegetation. Many broad-leaved herbaceous plants which are valuable as deer forage would be particularly vulnerable to aerially applied herbicide without the protection of an overhead canopy.

Openings Creation

We do not recommend opening creation as an extensive habitat management technique.

If permanent openings could be created for only $60 per acre, the cost of creating 5 percent openings in just one township would be $69,120! Opening creation at present is too expensive to be considered practical in extensive forest habitat management. However, on intensively managed hunting areas, some creation may be desirable.

On sandy soils, creating openings similar to naturally existing openings may not be too difficult, if future research indicates they are needed. By controlling overstory vegetation, ground plants will increase and dominate the site as they do in existing openings. Vogl (1961:44, 46), studying restored brush prairie in northwestern Wisconsin found that 31 of 41 brush prairie prevalent species were also among 39 prevalent species found within the unburned forest.

Creating openings on hardwood sites is far more difficult and expensive unless the chosen site was formerly open. The vegetational composition of naturally existing openings is difficult to simulate and would likely require seeding and other cultural treatments in addition to controlling overstory vegetation. Deteriorating white birch stands on some sites lend themselves as potential openings.

Any permanent openings created should be at least 3 chains in width to enlist frost as an agent for natural maintenance.

The problems and costs involved in creating openings emphasizes the importance and value of saving those still existing. Twenty years from now it would indeed be embarrassing to find it necessary to create openings in areas where openings are still present today.

Management Recommendations

The following statements summarize our management recommendations applicable to the area of extensive forest on loamy soils shown in Figure 29.

1. Three to 5 percent of the commercial forest land should be maintained in permanent sod openings, because they are very important to the welfare of deer and other wildlife as well as to our own environmental quality.
   a. Sod openings should be saved because they meet a very specific seasonal need of deer not met elsewhere in the forest.
   b. Sod openings are economically maintained and therefore easily incorporated into an extensive wildlife management program.
   c. Preserving sod openings is especially important because they are no longer being created by modern timber harvest operations.
2. The first step in starting an openings program is to halt reforestation of nonstocked areas in an effort to buy time to secure a program. Inventorying and designating openings for preservation costs little, but once designated they will exist for many years without specific maintenance.
3. All openings less than 5 acres should be preserved from planting, whether specifically designated for maintenance or not. Most public forestry agencies already have policies which specify that openings less than 10 acres should not be planted. However, these policies are not strictly followed. Strict compliance with them does not preclude the need for specifically designating openings. If not designated many small openings will be lost as part of larger type conversion projects.
4. Openings should be selected ecologically rather than mechanically. Mechanical selection places too much restriction on the choice

Esthetics should rate a high priority in all land management. Here an interesting "monument" of the past will soon be obscured by trees for tomorrow. Many openings are worth saving for scenic values alone.

of openings. Secure, sod-covered openings should be selected, preferably near high-value summer range types, when a choice exists.

5. Openings with esthetic value or access should be given a high priority for preservation. Access will simplify maintenance and guarantee public use. Many openings are worth saving for their scenic values alone.

6. Uncut strips should be left around openings in aspen stands to deter suckering into the openings when trees are cut. This no-cut zone may revert to brush as aspen deteriorates, thereby adding to the attractiveness of the opening to wildlife. However, any major disturbance of sod cover is likely to aggrevate the maintenance problem.

7. Management to encourage a shrub sere around openings should not be performed within small openings. Creation of brushy edges (hazel, willow, or tree sprouts) to favor ruffed grouse should be accomplished by manipulating the wood's edge of small openings, rather than the opening itself.

8. Creation of openings should be postponed until all needed existing openings are programmed for preservation.

Present existing forest conditions on sandy soils generally produce high deer densities. We feel certain that openings play an important role in this productivity. However, because of the uneven stocking of most forests on sands, we were unable to quantitatively document their importance. Unless major improvements in forest stocking are anticipated we feel wildlife openings programs on sandy soil are not urgently needed.

RESEARCH NEEDS

Although our investigation has emphasized deer-opening relationships, we have also gained some perspective on the role major forest types play in regulating summer deer density and distribution. But the minimum amounts of key types required to maintain prescribed deer population levels on management units are yet largely unknown. Forest and game management programs to perpetuate the aspen type are being expanded, and concern has been expressed for preserving selected oak stands in major pineries. Improved guidelines for coordinating these management efforts are urgently needed.

We must know more about year-around deer ecology on sandy soils, where some of Wisconsin's highest deer densities presently occur. Since the light soils also offer the best opportunities for conversion of oak and aspen types to pine, a potential conflict exists between wildlife and forestry interests. Though we firmly believe the foreseeable outlook for deer range on sands is favorable, development of more economical stand conversion practices could easily change the picture. Where objectives conflict, guidelines will have to be worked out to provide for wildlife needs. Close monitoring of forest management objectives and their potential effects on wildlife populations seems essential.

Except through deduction and inferences drawn from research in other states, we have not determined a physiological need for grassland openings. True, we have documented a significant relationship of openings to deer distribution on loamy soils, with a concomitant effect on range-wide deer density, and these alone provide ample justification for maintaining openings. But the specific relationships of openings to deer physiology remains unclear.

Studies of rumen contents of deer collected from spring through fall would clarify forage preferences during these seasons. On sands, where vegetation in openings is so different from that found on loams, precise information on the major species consumed would help determine whether openings management programs are necessary on the lighter soils.

Remote sensing techniques, such as described by Croon et al. (1968) offer the most exciting possibilities for obtaining better quantitative information on daily and season deer distribution. More precise measurements of seasonal deer densities among forest types would go far in defining habitat management priorities. High costs and limited effectiveness in detecting deer under heavy forest canopies are problems presently limiting the use of remote sensing techniques, but further development of equipment will eventually lead to more efficient, economical application.

Evaluation of the costs and benefits of creating a large number of openings where none presently exist would add to our understanding. A sound experiment would ideally encompass several thousand acres where deer populations and behavior could be monitored for several years before, during, and following opening development. Forest influences, including logging, would necessarily have to be tightly controlled during this period. Other factors influencing the deer population, such as hunting removals and winter losses, would also need close watching.

Existing openings to be managed should ideally be selected to permit cheap and easy maintenance. Nevertheless, more information is needed on maintenance methods and costs. On-the-ground treatment with herbicides presently offers the best possibilities, but aerial application by helicopter also offers some promise. Where enough openings requiring maintenance are concentrated in a given locale, helicopter application may be reasonably economical despite high per-hour costs. But before such blanket spraying is attempted, investigations should be made to determine whether this will have serious effects on desirable vegetation. Without the protection provided by an overhead forest canopy, many broad-leaved herbaceous plants valuable to wildlife would be particularly vulnerable to aerially applied herbicides.

The impact of deer browsing as a natural control of woody vegetation, particularly following opening maintenance work, merits further study. We have been impressed by the control deer exert on woody plants in some openings. Totally effective control through herbicides is not necessary, or perhaps even desirable, if deer browsing is sufficient to retard sprouting and prevent establishment of tree seedlings.

Most public agencies have policies indicating that no openings less than 10 acres should be artificially regenerated. However, these policies are not strictly followed. Strict compliance with these policies would not preclude the need for specifically designating openings for preservation. If not designated, many small openings would still be lost in larger type-conversion projects.

APPENDIX A

FOREST TYPES ADAPTED FROM DESCRIPTIONS BY THE SOCIETY OF AMERICAN FORESTERS (1964).

Type 14 Northern pin oak, often with red oak and jack pine. Scrub oak.

Type 15 Red pine, often with white pine, jack pine, oaks, paper birch and aspen.

Type 16 Aspen, usually combinations of quaking and large-tooth aspen, and often with paper birch and balsam fir.

Type 18 Paper birch, often with quaking and large-tooth aspen, balsam fir, red maple and sugar maple.

Type 21 White pine, occasionally with red pine, quaking and large-tooth aspens, red maple and oaks.

Type 22 White pine — hemlock, usually with sugar maple, basswood, and yellow birch.

Type 23 Hemlock, usually with sugar maple, yellow birch, basswood, balsam fir, and white pine.

Type 24 Hemlock — yellow birch, often with red maple, sugar maple, and basswood.

Type 25 Sugar maple — (beech) — yellow birch, usually with basswood, red maple, hemlock, white ash, balsam fir, and paper birch.

Type 26 Sugar maple — basswood, often with elm, yellow birch, and northern red oak.

Type 27 Sugar maple, often with yellow birch and white ash.

Type 36 White spruce — balsam fir — paper birch, often with quaking and large-tooth aspens.

Type 37 Northern white cedar, usually with greater amounts of black spruce, balsam fir, tamarack, and black ash.

Type 39 Black ash — American elm — red maple, often with an understory of alder.

APPENDIX B

SCIENTIFIC NAMES OF PLANTS AND ANIMALS CITED IN TEXT*

Plants

Alder	*Alnus rugosa*
Ash	
Black	*Fraxinus nigra*
White	*Fraxinus americana*
Aspen	
Large-tooth	*Populus grandidentata*
Quaking (trembling)	*Populus tremuloides*
Basswood	*Tilia americana*
Beech	*Fagus grandifolia*
Birch	
Paper	*Betula papyrifera*
Yellow	*Betula alleghaniensis*
Blackberry	*Rubus* spp.
Blueberry	*Vaccinium myrtilloides*
Cedar, northern white	*Thuja occidentalis*
Cherry	*Prunus* spp. *(virginiana)*
Elm	
American	*Ulmus americana*
Rock	*Ulmus Thomasii*
False-strawberry	*Waldsteinia fragarioides*
Fir, balsam	*Abies balsamea*
Grass	*Graminae*
Hazel	*Corylus cornuta* and *C. americana*
Hemlock	*Tsuga canadensis*
Juneberries	*Amelanchier* spp.
Oak	
Northern pin (Scrub oak)	*Quercus ellipsoidalis*
Red	*Quercus rubra*
Maple	
Red	*Acer rubrum*
Sugar	*Acer saccharum*
Orange hawkweed	*Hieracium aurantiacum*
Pine	
Jack	*Pinus banksiana*
Red	*Pinus resinosa*
White	*Pinus strobus*

*Plant nomenclature from Gleason (1958).

Spruce	
Black	*Picea mariana*
White	*Picea glauca*
Sweet fern	*Myrica asplenifolia*
Tamarack	*Larix laricina*
Willow	*Salix* spp.
Wintergreen	*Gaultheria procumbens*

Animals

Bear	*Ursus americanus*
Beaver	*Castor canadensis*
Deer, white-tailed	*Odocoileus virginanus*
Ground squirrel	*Citellus tridecemlineatus*
Mule Deer	*Odocoileus hemionus*
Porcupine	*Erethizon dorsatum*
Ruffed grouse	*Bonasa umbellus*
Sharp-tailed grouse	*Pedioecetes phasianellus*
Woodcock	*Philohela minor*

APPENDIX C

TABLE 11

Recent Deer Population and Harvests: Management Units Discussed in this Bulletin

Deer Mgt. Unit	Year	Deer/Sq. Mi. of Deer Range: Spring Pellet Survey[1]	Deer/Sq. Mi. of Deer Range: Fall Density Based on Sex-Age-Kill Analyses[2]	Gun Season Kill/Sq. Mi.[3]: Regular	Gun Season Kill/Sq. Mi.[3]: Party	Major Soils[4] and Upland Range Types
3	1963	12 ± 3	15-19	1.3	—	Sands and heavy sandy loam
	1964	—	16-20	1.6	0.5	
	1965	—	11-13	1.0	0.8	Oak, jack pine, aspen
	1966	16 ± 6	9-12	0.9	0.7	
	1967	—	9-12	0.9	0.6	
14	1963	25 ± 5	—	1.3	0.6	Mostly loams
	1964	17 ± 3	—	1.7	1.4	Northern hardwood, aspen
	1965	26 ± 7	—	1.1	1.1	
	1966	—	—	0.9	0.8	
	1967	—	—	0.8	0.8	
25	1963	33 ± 8	—	1.9	—	Poorly drained silt loams
	1964	—	—	3.1	1.4	
	1965	—	24-30	2.2	1.8	Aspen, hardwood
	1966	—	27-34	2.5	2.0	
	1967	—	25-31	2.3	2.0	
26	1963	13 ± 3	—	1.3	—	Northern hardwood, aspen
	1964	—	—	1.8	—	
	1965	—	—	1.7	1.0	
	1966	18 ± 3	—	1.6	1.1	
	1967	—	—	1.7	1.3	
28	1963	—	—	0.7	—	Heavy sandy loams
	1964	—	—	0.7	—	Northern hardwood, aspen
	1965	—	—	0.5	—	
	1966	—	—	0.8	0.4	
	1967	—	—	0.7	0.8	
36	1963	30 ± 7	28-35	3.7	—	Sands
	1964	40 ± 6	36-44	4.5	1.2	Aspen-birch, oak, pine
	1965	48 ± 8	30-37	4.1	3.7	
	1966	37 ± 6	22-28	3.1	3.5	
	1967	32 ± 6	26-33	3.6	1.9	
39	1963	25 ± 5	—	1.2	—	Mostly silt loams
	1964	30 ± 6	16-20	1.7	0.6	Northern hardwood,
	1965	35 ± 11	13-16	1.4	1.1	aspen, pine
	1966	22 ± 5	11-13	1.1	0.9	
	1967	23 ± 4	13-16	1.4	1.1	
40	1963	21 ± 5	—	1.1	—	Loams
	1964	26 ± 6	—	1.7	0.7	Northern hardwood,
	1965	—	—	1.9	1.1	aspen
	1966	—	—	1.1	0.9	
	1967	16 ± 4	—	1.6	1.1	

TABLE 11 (Cont.)

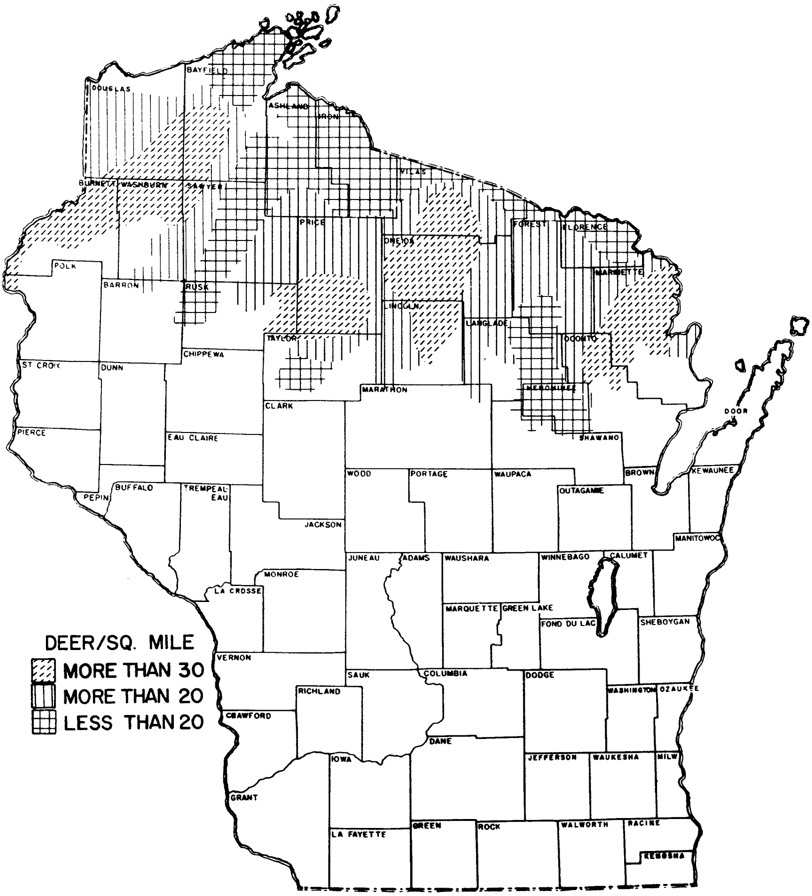
Deer Mgt. Unit	Year	Deer/Sq. Mi. of Deer Range: Spring Pellet Survey[1]	Fall Density Based on Sex-Age-Kill Analyses[2]	Gun Season Kill/Sq. Mi.[3]: Regular	Party	Major Soils[4] and Upland Range Types
43	1963	—	—	0.9	—	Silt loams
	1964	9 ± 3	—	1.3	—	Northern hardwood,
	1965	—	—	1.2	—	aspen
	1966	—	—	1.2	0.6	
	1967	—	—	1.6	1.1	
45	1963	8 ± 1	14-17	1.7	—	Sands and silt loams
	1964	15 ± 3	19-24	2.2	—	Oak, aspen, jack pine
	1965	—	23-28	2.8	1.5	Northern hardwood
	1966	—	19-24	2.4	1.4	
	1967	—	22-28	2.7	1.5	
49	1963	—	20-25	2.5	—	Sands
	1964	25 ± 8	26-33	3.1	—	Oak, aspen, jack pine
	1965	—	31-39	4.0	2.5	
	1966	28 ± 6	30-37	3.9	2.2	
	1967	—	30-38	3.9	2.2	

[1]From: Thompson (1968). Deer per square mile estimates are expressed with 95 percent confidence limits.

[2]From: Creed (1968). Deer per square mile estimates expressed as a range of values; these are not statistical confidence limits.

[3]"Regular" kill includes adult bucks (3-inch spike or better) shot on regular licenses. "Party" includes deer of any age or sex, shot on party permits which allow a group of 4 hunters to take one extra deer. Most of these are does or fawns, although small numbers of antlered bucks are included.

[4]Soils from Whitson et al. (1918).



Generalized deer distribution in extensive northern forest. Fall, 1967.

APPENDIX D

PLANT SPECIES LISTS

TABLE 12

Prevalent Species in Group 1 Openings (Levy, 1965:41)*

Species	Percent Present[1]	Average Frequency[2]
Agropyron repens	100	71.6
Poa pratensis	100	75.2
Cirsium arvense	93	42.4
Rubus strigosus	82	21.1
Achillea millefolium	78	15.2
Hieracium aurantiacum	74	13.8
Phleum pratense	74	8.5
Fragaria virginiana	70	11.9
Carex pensylvanica	67	13.5
Solidago canadensis	67	11.1
Solidago graminifolia	63	7.4
Geum aleppicum	59	4.8
Lactuca canadensis	59	4.3
Oryzopsis asperifolia	59	5.4
Pteridium aquilinum	59	11.9
Aster macrophyllus	56	9.5
Fragaria vesca	52	3.1
Bromus ciliatus	48	6.1
Potentilla norvegica	48	2.6
Aster ciliolatus	44	6.8
Cornus canadensis	37	1.1
Carex arctata	37	2.8
Rumex acetosella	37	2.9

*These openings typically occur on heavier soils.
[1]Percent of sampled stands containing the species.
[2]Percent of all sample quadrats containing the species.

TABLE 13

Prevalent Species in Group 2 Openings (Levy, 1965:42)*

Species	Percent Present[1]	Average Frequency[2]
Agropyron repens	100	44.0
Fragaria virginiana	100	36.0
Hieracium aurantiacum	100	64.0
Poa pratensis	100	66.0
Phleum pratense	94	28.0
Trifolium repens	94	31.0
Achillea millefolium	88	17.0
Rubus strigosus	81	22.0
Rumex acetosella	81	14.0
Agrostis alba	69	6.0
Cirsium arvense	63	6.0
Taraxicum officinale	56	5.0
Aster ciliolatus	44	4.0
Convolvulus spithamaeus	44	3.0
Danthonia spicata	44	9.0
Oryzopsis asperifolia	44	3.0
Pteridium aquilinum	44	13.0
Schizachne purpurascens	44	2.0
Trifolium hybridum	44	10.0

*This type of opening generally occurs on more moderate (sandy loam) soils than Group 1 openings.

[1]Percent of sampled stands containing the species.

[2]Percent of all sample quadrats containing the species.

TABLE 14

Prevalent Species in Openings on Sandy Loam (Anniversary Plantation: Sec. 31, T39N, R12E.)

Species	Percent Present	Average Frequency
Hieracium aurantiacum	100	87.3
Poa pratensis	96	77.0
Agropyron repens	92	34.4
Fragaria virginiana	76	29.5
Carex pensylvanica	80	25.3
Polytricum juniperinum	72	24.1
Trifolium spp. *(repens)*	76	20.4
Achillea millefolium	88	18.3
Aster spp.	60	10.5
Rumex acetosella	64	9.1
Phleum pratense	56	6.5
Convolvulus spithamaeus	48	5.7
Potentilla norvegica	20	4.3
Danthonia spicata	8	3.9
Rubus spp.	64	3.5

TABLE 15

Prevalent Species in Group 3 Openings (Levy 1965:43)*

Species	Percent Present[1]	Average Frequency[2]
Hieracium aurantiacum	100	29.8
Myrica asplenifolia	100	27.0
Vaccinium angustifolium	95	34.1
Danthonia spicata	95	15.1
Oryzopsis asperifolia	95	16.7
Vaccinium myrtilloides	95	10.2
Poa spp. *(Poa compressa)*	89	30.0
Pteridium aquilinum	89	22.4
Aster ciliolatus	84	14.0
Carex pensylvanica	84	24.5
Rumex acetosella	84	9.1
Viola adunca	79	10.2
Waldsteinia fragarioides	79	17.5
Fragaria virginiana	74	11.9
Gaultheria procumbens	74	11.2
Panicum depauperatum	74	4.4
Schizachne purpurascens	74	9.9
Campanula rotundifolia	68	5.7
Convolvulus spithamaeus	68	11.8
Polygala paucifolia	68	6.8
Solidago nemoralis	68	2.5
Bromus ciliatus	63	5.8
Bromus kalmii	63	5.0
Epigaea repens	58	2.7
Cladonia spp.	53	9.6
Anemone quinquefolia	47	2.0
Antennaria neglecta	47	5.1
Trifolium repens	47	3.7

*These openings occur almost exclusively on light soils.
[1]Percent of sampled stands containing the species.
[2]Percent of all sample quadrats containing the species.

TABLE 16

Prevalent Species on Undisturbed Bracken-Grasslands (Vogl 1964:73)

Species	Frequency	Species	Frequency
Pteridium aquilinum	52.9	*Convolvulus spithamaeus*	29.2
Myrica asplenifolia	51.7	*Aster macrophyllus*	23.3
Vaccinium angustifolium	49.6	*Bromus kalmii*	22.9
Carex spp.	42.5	*Apocynum androsaemifolium*	20.8
Gaultheria procumbens	42.1	*Agropyron trachycaulum*	19.6
Waldsteinia fragarioides	37.1	*Aster sagittifolius*	17.9
Poa pratensis	36.7	*Fragaria virginiana*	17.1
Rubus (black)	36.3	*Diervilla lonicera*	16.7
Oryzopsis asperifolia	32.9	*Muhlenbergia racemosa*	14.2
Schizachne purpurascens	31.2	*Amelanchier* spp.	13.3
Solidago missouriensis	31.2		

TABLE 17

Most Common Species on Restored Brush Prairie (Vogl. 1961:46)

Species	Frequency	Species	Frequency
Andropogon gerardi	71.3	*Helianthus occidentalis*	20.6
Poa pratensis	51.0	*Amorpha canescens*	20.4
Carex spp.	46.5	*Rosa* spp.	17.9
Andropogon scoparius	45.6	*Vaccinium angustifolium*	17.3
Aster azureus	41.2	*Galium boreale*	15.0
Koeleria cristata	37.5	*Ceanothus ovatus*	14.1
Helianthus rigidus	30.7	*Salix discolor*	13.9
Lathyrus venosus	30.1	*Corylus americana*	13.8
Artemisia ludoviciana	28.9	*Viola pedatifida*	13.3
Helianthemum canadense	21.0	*Solidago missouriensis*	12.9
Phlox pilosa	20.8	*Asclepias ovalifolia*	11.0
		Prunus pumila	10.9

APPENDIX E

PROCEDURES FOR ESTABLISHING OPENINGS PROGRAMS*

The following procedures were developed while planning an openings program for a portion of the Langlade County Forest. Actual implementation of the management program has been delayed, and many of the latter steps listed here have not been applied. Therefore we anticipate that there will be changes and shortcuts discovered through use.

I. INVENTORY

A. Materials

1. Recent forest-cover-type township maps
2. Recent aerial photography and index
3. Stereoscope
4. Acetates (6″ x 6″)
5. No. 0 Rapidograph pen or No. 3 pencil
6. Color coding pencils: red, blue, green and yellow
7. County highway maps

B. Procedures

1. Outline ownership to be worked on county highway map. Prepare to work one township or unit at a time.
2. Using index, select flight folder containing photos of outer sections of township or unit.
3. Center acetate on desired section. Most forest management photos have section corners marked; if not, use physical features on type map for reference.
4. Basic information required on each acetate includes the following (See Fig. 32):
   a) Section, Township and Range
   b) Section corners
   c) Access in red
   d) Water in blue
   e) Agricultural fields in yellow, if desired
5. Using stereoscope, delineate all forest openings larger than ½ acre noting where maintenance is necessary: i.e., "20% UB," "10% Trees," etc.
6. Check type map for openings not on your acetate and recheck photo.
7. Color section on highway map to indicate it has been completed, thereby preventing omission of sections or duplication of effort.
8. Proceed with consecutive sections *in the flight* (up, down, or across). Following sections in numerical order will result in unnecessary shuffling of flight folders.

(Adapted From McCaffery, 1968)

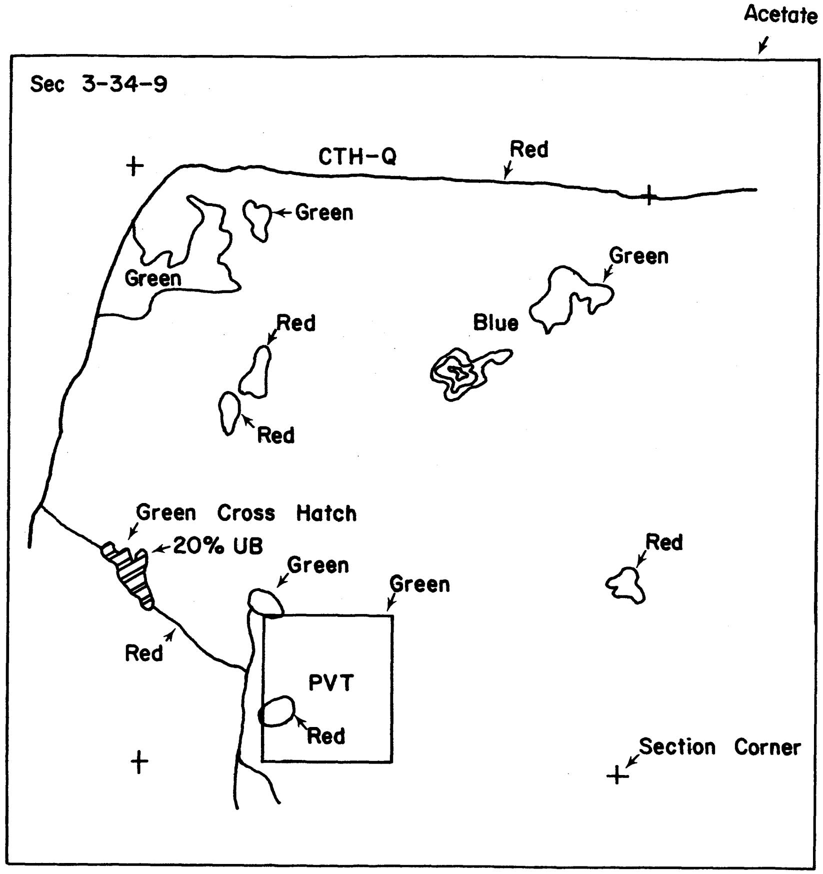


FIGURE 32. Example of acetate tracing from aerial photo with color coding and necessary identification.

C. Selection

1. Check acetate tracings with type map for errors such as muskeg and open marshes.
2. Trace private ownership boundaries from type map onto acetate in green.
3. Color coding (See Fig. 32):
   a) Color green all old camps, log landings, and other openings known to be well sodded and/or without major maintenance requirements, and to which there is easy access.
   b) Crosshatch with green other openings with easy access where immediate maintenance (within 5 years) is needed.
   c) Color red other inaccessible openings that have potential including forest openings on private land.

d) Openings remaining uncolored because of unfamiliarity should be reconnoitered. Consultation with other resource workers who are familiar with the area will minimize field effort.

4. Carefully eliminate unneeded openings. More than 10 percent in a square mile or more than 5 percent in an intensively managed forest may be considered excessive. When choosing or excluding openings, consider:
   a) Esthetics (especially important along roads)
   b) Ease of maintenance (access and stability)
   c) Vegetative quality (Junegrass and quack-grass *vs.* bracken, poverty grass, and hawkweed)
   d) Ecological position (nearness to other components of range, stability of adjacent types)
   e) Size (maintenance *vs.* distribution)
   f) Other uses (forestry)
5. Check acreage and distribution. If acreage is lacking or distribution poor, try to supplement through ground reconnaissance and salvaging "1948 openings" (openings that appear on the 1948 type maps but not on the 1963 photos). Intimate knowledge of an area plus ground reconnaissance will often double the number of openings as seen on air photos.
6. If a major effort (approaching creation) is needed to supply necessary openings, select areas formerly open or areas with Junegrass or quack-grass present as major components of the ground flora. These areas are usually associated with rock elm, cherry, balsam, etc.

II. RECORDS

A. Map

1. Using a 30″ x 30″ sheet of vellum and the township type map, trace section corners, compartment boundaries and access onto vellum.
2. Slide acetate tracing from photo between vellum and map, positioning acetate using known landmarks (water, access, section corners, etc.) and transfer openings for management and property boundaries to vellum.
3. Color code openings on vellum as under I.C.3.
4. Grid count openings by color and ownership (if private land contains important openings) on form as shown in Figure 33. Make pencil entries in the event of future changes.
5. Incorporate completed map in District Forester's county forest map book in front of his planting and cultural treatment map for the township.

B. Compartment Examination Records (Fig. 34)

1. On line 1, assign a separate stand number or sub-lettered number to wildlife openings, such as, 7 for grass and 7A for wildlife openings.

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCES
Box 450
Madison, Wisconsin 53701

Fi-278

PARRISH TOWNSHIP (34-9E) OPENINGS

Compartment	Semi-Permanent		Need Maint.		Inaccessible		TOTAL		Other Private	
	Number	Acreage	Number	Acreage	Number	Acreage	Number	Acreage	Number	Acreage

FIGURE 33. Example of tally used for summarizing opening acreages from township maps.

Oneida
(County or Forest)

Comp. Acreage 405

Comp. No. 86 Sec. ____ T 36 R 4 Date 6-22-60 By ________

1. Stand No.	1	2	3	4	5	6
2. Timber Type	LB	AO-5'	AO-5"	A5-11'	G	WO
3. Acres	10	45	25	5	15	3/5
4. Year of Origin	32	29	31	32		
5. Total Height	51	38	46	56		
6. Average DBH & Main Range Diameters	8" 6-10	5" 4-6	5" 4-7	6" 4-8		
7. Growth	9	10	9	9		
8. Site Index	65	55	60	70		
9. Stocking	35-40	35-40	40-45	45-50		
10. Volume Cords	2-3 cd	1 cd	2 cd	4-5 cd		
" Bd. Ft.						
11. Mgt. Objective						
12. Mgt. Prescription						
13. TST Needs						
14. Regeneration Conditions						
15. Plantation Needs						
16. Site Preparation						
17. Logging Chance						
18. Operability						
19. Recreational Potential						8
20. Soil						
21. Year of Harvest	1960-65	1960-65	RE-EX 1965	1960-65		RE-EX 1970
22. Year of Treatment						
23. Remarks	A 5-11' Hvy. Hypox. Many dead and dying	A 5-11' stand v. poor Hypox.	A 5-11' cut as possible	Rot in bored trees, Hvy Hypox.	Some T. A. coming in sw. Hvy. sod cover. Furrow and plant sw 2-1 or 3-0	Heavy sod. Remove scattered Elm. Maintain as wildlife opening.

2-63

FIGURE 34. Compartment examination record.

2. On line 2, indicate usual type symbol "G" or "WO".
3. On line 3, enter number of openings and acreage from Tally Form (Fig. 33) as shown in Figure 34.

4. On line 19, code "8", "Potential for other", with remark "Maintain as wildlife openings."
5. Other lines may be completed as desired.
6. For future reconnaissance purposes, compartment file maps should also show wildlife openings.

C. Comprehensive County Forest Land Use Plan
After all townships or units to be programmed in a county are completed, publish Figure 33 with explanatory narrative. Narrative should be prepared jointly with District Forester. Distribute Figure 33 and explanation for inclusion with land use plans.

III. RECONNAISSANCE

A. Regular reconnaissance will be achieved during compartment examinations.

B. Supplementary reconnaissance can be done incidentally to other field work.

IV. MAINTENANCE

A. Methods

1. No aspen cutting should be permitted within 1 chain of an opening edge unless special treatment is to follow, such as herbicides or mechanical control in the opening.
2. Sod disturbance in openings should be minimized to discourage pioneering woody plants.
3. Shade trees should be removed from openings to permit direct sunlight, except where esthetics will be damaged.
4. Paint stumps of trees with herbicide to reduce sprouting.
5. Use basal spray of 2,4-D and 2,4,5-T on aspen suckers in late May. TORDON* (101 mixture) foliage spray or TORDON 10K pellets if available are very effective for spot treatments in openings.
6. Brush (hazel, willow and tree sprouts) may be encouraged around openings to promote ruffed grouse use, but should be done by manipulating the woods edge in small openings, not the opening itself. Disturbance within openings reduces natural resistance to succession, and results in costly maintenance.
7. To minimize cost, treat several openings in an area at a time.

B. Records

1. As access is gained to formerly inaccessible openings, color code on map should be changed from red to green or green crosshatch if maintenance is needed.
2. Green crosshatched openings (those requiring maintenance work) should be colored all green after maintenance work is completed and opening is stabilized.

---

*Dow Chemical trade name

LITERATURE CITED

ALLEN, E. O.
1965. Food and range use habits of whitetail deer on Missouri River bottoms in northcentral Montana. M.S. Thesis, Mont. State Univ., Missoula. vii + 41. p. (mimeo).

ALLISON, D. G.
1966. Improving your land for ruffed grouse. N. H. Fish and Game Dept., Concord. 17 p.

ANDERSON, C. F., JR.
1959. Nocturnal activities of the Columbian black-tailed deer, *Odocoileus hemionus columbianus* Richardson, affecting spotlight census results in the Oregon Coast range. M.S. Thesis, Oregon State Coll., Corvallis. 86 p.

BEHREND, D. F.
1966. Behavior of white-tailed deer in an Adirondack forest. N.Y. Conserv. Dept., Final Rep. P-R Proj. W-105-R-7, Job V-A. 78 p. + App. (litho).

BRUNETT, L. E. AND V. W. LAMBOU
1962. A test of track counts as a measurement of deer population size. Presented at 16th Ann. Conf. S.E. Assoc. Game and Fish Comm. 7 p. (litho).

CHAMRAD, A. D. AND T. W. BOX
1968. Food habits of white-tailed deer in South Texas. J. Range Mgmt. 21(3):158-164.

CHAPMAN, A. G.
1940. Problems in forestation research. J. For. 38(2):176-182.

CHRISTENSEN, E. M.
1954. A phytosociological study of the winter range of deer of northern Wisconsin. PhD. Thesis, Univ. of Wis., Madison. 173 p.
1959. A historical view of the ranges of the white-tailed deer in northern Wisconsin forests. Amer. Midland Naturalist 61(1):230-238.

CREED, WILLIAM A.
1968. Statewide deer inventory. Wis. Dept. Natural Resources, P-R Proj. W-141-R-3, Job IV-B (mimeo).

CROON, G. W., D. R. MCCULLOUGH, C. E. OLSON, JR., AND L. M. QUEAL
1968. Infrared scanning techniques for big game censusing. J. Wildl. Mgmt. 32(4):751-759.

CURTIS, J. P.
1959. The vegetation of Wisconsin, Univ. of Wis. Press, Madison. 657 p.

DAHLBERG, B. L. AND R. C. GUETTINGER
1956. The white-tailed deer in Wisconsin. Wis. Conserv. Dept. Tech. Bull. No. 14. 282 p.

DANCKELMAN, B.
1898. Spatfrostbeschadigungen im Markischen Wald. Z. f. F. u. Jagdw. 30:389-411. *In* Geiger, R. 1965.

DEALY, J. E.
1966. Spotlighting deer; potentials for management in western Oregon. U. S. For. Serv., Pacific N.W. For. and Range Exp. Sta., Res. Note 32. 8 p.

DEGARMO, W. R. AND JOHN GILL
1958. West Virginia whitetails. Cons. Comm. of W. Va., Bull. No. 4. 87 p.

DRAWE, D. L.
1968. Mid-summer diet of deer on the Welder Wildlife Refuge. J. Range Mgmt. 21(3):164-166.

DRAWE, D. L. AND T. W. BOX
1968. Forage ratings for deer and cattle on the Welder Wildlife Refuge. J. Range Mgmt. 21(4):225-235.

EBERHARDT, L. AND R. C. VAN ETTEN
1956. Evaluation of the pellet group count as a deer census method. J. Wildl. Mgmt. 20(1):70-74.

EHRENREICH, J. H. AND A. J. BJUGSTAD
1966. Cattle grazing time is related to temperature and humidity. J. Range Mgmt. 19(3):141-142.

FEENEY, W. S.
1942. Famine stalks the deer. Wis. Conserv. Bull. 7(8):8-10.
1943. Wisconsin deer today and tomorrow. Wis. Conserv. Bull. 8(8):11-19.
1944. The present status of Wisconsin's deer herd and deer range. Wis. Conserv. Bull. 9(6):4-5.

GEIGER, R.
1965. The climate near the ground. Harvard Univ. Press, Cambridge, Mass. 611 p.

GILES, ROBERT H., JR.
1961. Overlay mapping as a technique for improved management of upland game. Ohio Coop. Wildl. Res. Unit, Release No. 212. 6 p.

GLEASON, H. A.
1958. The new Britton and Brown illustrated flora of the northeastern United States and adjacent Canada. N.Y. Bot. Garden, New York City. 3 vols.

GRAHAM, S. A., R. P. HARRISON, JR., AND C. E. WESTELL, JR.
1963. Aspens; Phoenix trees of the Great Lakes region. Univ. Mich. Press, Ann Arbor. xiii + 272 p.

GYSEL, L. W.
1966. Ecology of a red pine *(Pinus resinosa)* plantation in Michigan. Ecol. 47(3):465-472.

HABECK, J. R.
1960. Winter deer activity in the white cedar swamps of northern Wisconsin. Ecol. 41(2):327-333.

HABECK, J. R. AND J. T. CURTIS
1959. Forest cover and deer population densities in early northern Wisconsin. Wis. Acad. Sci., Arts, and Letters 48:49-56.

HAHN, HENRY C., JR.
1949. A method of censusing deer and its application in the Edwards Plateau of Texas. Tex. Game, Fish, and Oyster Comm., P-R Proj. 25-R:1-24.

HALLS, L. K. AND R. ALCANIZ
1968. Browse plants yield best in forest openings. J. Wildl. Mgmt. 32(1)185-186.

HAMERSTROM, FREDERICK, FRANCES HAMERSTROM, AND OSWALD E. MATTSON
1952. Sharptails into the shadows? Wis. Conserv. Dept., Wis. Wildl. No. 1. 35 p.

HART, R. D.
1960. Evaluation of summer spotlighting counts of deer, 1960. S.D. Dept. Game, Fish and Parks, Job Compl. Rept. P-R Proj. W-75-R-3, Job D-22-A-3. 11 p. (mimeo).

HAZZARD, L. K.
1958. A review of literature on big game census methods. Colo. Game and Fish Dept., Job Compl. Rept. P-R Proj. W-38-R-11, Job No. 4A. 178 p. (litho).

HEALY, W. M., AND J. S. LINDZEY
1968. Forage preferences of captive deer while free ranging in the Allegheny National Forest. *In* Research Briefs, Pa. State Univ., Univ. Park. 20 p. (mimeo).

HEINSELMAN, M. L.
1954. The extent of natural conversion to other species in the Lake States aspen-birch type. J. For. 52(10):737-738.

HOLE, F. D., N. P. DAHLSTRAND, AND R. J. MUCKENHIRN
1947. Soils of Langlade County, Wisconsin. Wis. Geol. and Nat. Hist. Survey Bull. No. 74, 61 p.

HOLE, F. D. AND K. O. SCHMUDE
1959. Soil survey of Oneida County, Wisconsin. Wis. Geol. and Nat. Hist. Survey Bull. No. 82, 59 p.

HOLE, F. D., G. W. OLSON, K. O. SCHMUDE, AND C. J. MILFRED
1962. Soil survey of Florence County, Wisconsin. Wis. Geol. and Nat. Hist. Survey Bull. No. 84, 140 p.

HOWE, D. L.
1954. A comparison of deer census methods in the Rifle River Area. Mich. Dept. Conserv., Game Div., Rep. No. 2020. 33 p. (ditto).

HUTNICK, R. J.
1954. Effect of seed bed condition on paper birch reproduction. J. For. 52(7):493-495.

KLEIN, D. R.
1962. Rumen contents analysis as an index to range quality. Trans. N. Amer. Wildl. Conf. 27:150-164.

KORSCHGEN, LEROY J.
1954. A study of the food habits of Missouri deer. Mo. Conserv. Comm. 43 p.

KREFTING, L. W.
1962. Use of silvicultural techniques for improving deer habitat in the Lake States. J. For. 60(1):40-42.

LARSON, J. S.
1967. Forests, wildlife, and habitat management; a critical examination of practice and need. U. S. For. Serv., S.E. For. Exp. Sta., Paper No. 30. 28 p.

LAY, D. W.
1964. The importance of variety to southern deer. Proc. 18th Ann. Conf. S.E. Assoc. Game and Fish Comm. 6 p.

LEOPOLD, ALDO
1933. Game management. Chas. Scribners Sons, New York. 481 p.

LEVY, G. F.
1965. The phytosociology of northern Wisconsin upland openings. PhD. Thesis, Univ. of Wis., Madison. 96 p.

LINDSAY, J. J.
1969. Locating potential outdoor recreation areas from aerial photographs. J. For. 67(1):33-34.

MACKIE, R. J.
1965. Deer, elk, and cattle food habits and range relationships in the Missouri River breaks. Mont. Fish and Game Dept., Final Rep. P-R Proj. W-98-R-4&5. 228 p.

MARTINKA, C. J.
1968. Habitat relationships of white-tailed and mule deer in northern Montana. J. Wildl. Mgmt. 32(3):558-565.

MCCAFFERY, K. R.
1968. Establishing openings programs on loamy soils in northern Wisconsin. Wis. Dept. of Nat. Resources, Res. Rep. No. 32. 17 p. (mimeo).

MONTGOMERY, G. G.
1963. Nocturnal movements and activity rhythms of white-tailed deer. J. Wildl. Mgmt. 27(3):422-427.

MOULTON, J. C.
1968. Ruffed grouse habitat requirements and management opportunities. Wis. Dept. Nat. Resources, Res. Rep. No. 36. 32 p.

MUCKENHIRN, R. J. AND N. P. DAHLSTRAND
1946. Soils of Wisconsin. Univ. Wis. Agr. Exp. Sta. Leaflet.

OLSON, H. F., J. M. KEENER AND D. R. THOMPSON
1955. Evaluation of deer pellet group count as a census method. Wis. Conserv. Dept. 12 p. (mimeo).

PRATT, R. E.
1967. Tracks in the sand. Wis. Conserv. Bull. 32(5):19.

PROGULSKE, DONALD R. AND DONALD C. DUERRE
1964. Factors influencing spotlighting counts of deer. J. Wildl. Mgmt. 28(1):27-34.

QUILLEN, J. H.
1959. The effect of forestry practices and wildlife management on abundance and distribution of deer. Va. Acad. Sci., Charlottesville, Va.

REYNOLDS, HUDSON G.
1962. Use of natural openings in a ponderosa pine forest of Arizona by deer, elk, and cattle. U. S. For. Serv., Rocky Mt. For. and Range Exp. Sta., Res. Note No. 78. 4 p.

SCHREINER, E. J.
1945. How sod affects establishment of hybrid poplar plantations. J. For. 43(6):412-427.

SCHNEEWEIS, J. C.
1968. A food habits study of whitetail deer *(Odocoileus virginianus)* in the northern Black Hills of South Dakota, 1967. Prog. Rep. P-R Proj. W-75-R-9. 16 p.

SEGELQUIST, C. A. AND W. E. GREEN
1968. Deer food yields in four Ozark forest types. J. Wildl. Mgmt. 32(2):330-337.

SHAW, S. P.
1967. Private woodlands in the northeast — are we neglecting their wildlife potential? Le Naturaliste Canadien 94:347-357.

SKOVLIN, J. M.
1967. Fluctuations in forage quality on summer range in the Blue Mountains. U. S. For. Serv., Pacific N.W. For. and Range Exp. Sta., Paper No. 44. 20 p.

SMITH, NORMAN F.
1942. Forest openings; shall we help or hinder their closing? Mich. Conserv. 11(6):4-5, 11.

SOCIETY OF AMERICAN FORESTERS
1964. Forest cover types of North America (exclusive of Mexico). S.A.F. Washington, D. C. 67 p.

STAMM, KEITH
1964. Use of herbicides in forestry and game management. Univ. Wis. Dept. Forestry. 123 p. (mimeo).

STEEL, R. G. D. AND J. H. TORRIE
1960. Principles and procedures of statistics. McGraw-Hill Book Co., New York. 481 p.

STITELER, W. M., JR., AND S. P. SHAW
1966. Use of woody browse by whitetail deer in heavily forested areas of northeastern United States. Trans. N. Amer. Wildl. Conf. 31:205-212.

STODDARD, L. A. AND A. D. SMITH
1955. Range management. McGraw-Hill, Inc., New York. 433 p.

STONE, R. N. AND H. W. THORNE
1961. Wisconsin's forest resources. U. S. For. Serv., Lake States For. Exp. Sta., Paper No. 90. 52 p.

SWIFT, E.
1946. A history of Wisconsin deer. Wis. Conserv. Dept., Publ. No. 323. 96 p.

TABER, R. D. AND R. F. DASMANN
1958. The black-tailed deer of the chaparral. Calif. Dept. Fish and Game, Bull. No. 8. 163 p.

THOMPSON, DONALD R.
1968. 1968 deer management unit pellet group surveys. Wis. Dept. Natural Resources Survey Rep. (mimeo).

TOWNSEND, M. T. AND M. W. SMITH
1933. The white-tailed deer of the Adirondacks. Bull. N. Y. State Coll. Forestry, Syracuse Univ. 6(1):153-385. (Roosevelt Wild Life Bull. 6(2).

ULLREY, D. E., W. G. YOUATT, H. E. JOHNSON, L. D. FAY AND B. L. BRADLEY
1967. Protein requirements of white-tailed deer fawns. J. Wildl. Mgmt. 31(4):679-685.

U. S. FOREST SERVICE
1955. Nicolet National Forest timber management plan. U. S. For. Serv., Dept. Agri., Milwaukee, Wis. 59 p. (mimeo).
1957. Chequamegon National Forest timber management plan. U. S. For. Serv., Dept. Agri., Milwaukee, Wis. 33 p. + App. (mimeo).
1966a. Timber management plan; Nicolet National Forest. U. S. For. Serv., Dept. Agri., Milwaukee, Wis. 36 p. + App. (mimeo).
1966b. Vegetation management for rights-of-way. U. S. For. Serv., Dept. Agri., Milwaukee, Wis. 38 p. (mimeo).
1967. Timber management plan, Chequamegon working circle. U. S. For. Serv., Dept. Agri., Milwaukee, Wis. 25 p. + App. (mimeo).

VERME, L. J.
1962. Mortality of white-tailed deer fawns in relation to nutrition. Proc. Nat. Deer Disease Symp., Univ. of Ga., Athens 1:15-58.
1965. Reproduction studies on penned white-tailed deer. J. Wildl. Mgmt. 29(1):74-79.

VOGL, R. J.
1961. The effects of fire on some upland vegetation types. PhD. Thesis, Univ. of Wis., Madison. 154 p.
1964. The effects of fire on the vegetational composition of bracken-grasslands. Wis. Acad. Sci., Arts and Letters 53:67-82.

WATSON, A. J. AND M. G. WILTSE
1963. Tordon for brush control on utility rights-of-way in the eastern United States. Down to Earth 19(1):11-14.

WATTS, C. R.
1964. Forage preferences of captive deer while free ranging in a mixed oak forest. Pa. Coop. Wildl. Res. Unit, Paper No. 112. 16 p. (mimeo).

WERTZ, W. A.
1966. Interpretation of soil surveys for wildlife management. Amer. Midland Naturalist 75(1):221-231.

WHITE, K. L.
1960. Differential range use by mule deer in the spruce-fir zone. Northwest Sci. 34(4):118-126.

WHITSON, A. R., C. THOMPSON AND T. J. DUNNEWALD
1918. General map of the soils of northern Wisconsin. Wis. Geol. and Nat. Hist. Survey, Madison.

WILDE, S. A., F. G. WILSON AND D. P. WHITE
1949. Soils in Wisconsin in relation to silviculture. Wis. Conserv. Dept., Publ. No. 525-49. 171 p.

WILTSE, M. G.
1964. Tordon herbicide as a soil treatment for brush control. Down to Earth 19(4):3-6.

WISCONSIN CONSERVATION DEPARTMENT
1962. Deer-Forest interrelationships in forest land management. Madison, Wis. 62 p. (mimeo).

WISCONSIN CONSERVATION DEPARTMENT
1964. Marinette County forest statistics. 11 p. (litho).

YOUNG, J. A., D. W. HEDRICK AND R. F. KENISTON
1967. Forest cover and logging. J. For. 65(11):807-813.

TECHNICAL BULLETINS

Currently Available From The Department of Natural Resources

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Cyril Kabat, R. K. Meyer, Kenneth G. Flakas and Ruth L. Hine

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Stanton J. Kleinert, Paul E. Degurse, and Thomas L. Wirth

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