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EXPERIMENTAL COTTONTAIL HABITAT MANAGEMENT ON THE BROOKLYN WILDLIFE AREA

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ABSTRACT

In 1975, an experimental habitat management plan for cottontail rabbits was designed for use on the Brooklyn Wildlife Area (BWA) in southern Wisconsin. Brush pile construction, planting of shrubs, and sowing of food patches were the primary practices implemented from 1976 through 1979 on the 20.2-ha Best Experimental Unit in an attempt to increase rabbit numbers. The 20.2-ha Hughes Unit, located 1.6 km southeast of the Best Unit, was established as a control area to monitor cottontail abundance. Local cottontail abundance trends were monitored by July roadside cottontail surveys. Rabbit numbers were estimated at Best and Hughes by fall and winter live trapping and winter track and trail counts. The Hughes cottontail population estimates were initially higher and remained higher than those for the Best Unit, although populations declined on both units during the study. Except in 1978, summer BWA cottontail populations also showed a downward trend. Greater vulnerability of Best Unit populations to hunting because of higher hunter pressure and less dense cover may explain why habitat management efforts did not result in a measurable population increase. Overall, the experimental habitat management may have helped prevent cottontail densities from diminishing as rapidly in the Best Unit as they did in the Hughes Unit following the severe winter of 1978-79. Future habitat management practices should include denser concentrations of brush piles and food patches, along with a more accurate assessment of mortality.

CONTENTS

INTRODUCTION

Although cottontails are an important small game animal in southern Wisconsin, quantitative evaluations of cottontail management are generally unavailable. During 1970-79 the annual statewide harvest, derived from Wisconsin Department of Natural Resources (DNR) game questionnaires, averaged an estimated 966,000 rabbits. In addition, recent predator studies at Waterloo (Pils and Martin 1978; Petersen 1979) indicated that cottontails serve as an important buffer species in relation to predation on pheasants. Although there is considerable demand for cottontails as a game species, only limited efforts have been made to develop habitat management guidelines for maximizing production. Habitat management guidelines for cottontails in Wisconsin (Wisconsin Conservation Department 1966) are of a general nature; their results have not been evaluated in terms of population response on managed versus unmanaged areas. Demonstration areas with intensively managed habitat are essentially nonexistent.

Specific cottontail habitat improvement techniques such as the establishment of "loose brush" (Bushong 1959), brush piles (Drahos and Dell 1951; Rowe 1951; Uhlig and Anderson 1959), winter food and cover (Hendrickson 1938), and rotational burning (Rose 1972) have been suggested. There is an important need to summarize the various management practices available and to test their effectiveness in promoting rabbit populations under Wisconsin conditions. The objective of this study was to design, implement, and evaluate a low-cost program of food and cover management intended to increase cottontail rabbit densities on a 20-ha state-owned segment of the Brooklyn Wildlife Area (BWA). Results of the study could then be applied to small-scale cottontail management on private and public lands.

The BWA was selected as the experimental management site for cottontails because it is typical of a southern Wisconsin wildlife area in which cottontails are a key game species. Vegetational components necessary for experimental management and control areas were present at Brooklyn, and access to these units was excellent. Also, Brooklyn is within easy travel distance (21 km) of the equipment and labor needed for implementing the necessary habitat management and for evaluating the results.

STUDY AREA

The Brooklyn Wildlife Area (BWA) consists of 701 ha owned and 729 ha leased by the DNR in a mosaic of parcels located in southern Dane and northern Green counties (Fig. 1). Agriculture has dominated the BWA for the past century, and only remnants of the oak savanna, mesic prairie, sedge meadow, and shrub-carr communities exist today (J. Bergquist, pers. comm.). Woodlots dominated by oaks and hickories with dogwood, American filbert, blackberry, and gooseberry understories are scattered throughout the BWA.

Current agricultural practices consist of dairy farming, corn growing, common soybean row cropping, and hay production. During the past 50 years, BWA wetland areas were ditched, drained, and converted to cropland and pasture (J. Bergquist, pers. comm.). Story Creek, a high quality trout stream, flows north and south through the middle of the BWA. Disturbance vegetation such as reed canary grass, stinging nettles, and giant ragweed exists on nearby drained wetlands recently purchased by the DNR. On some lowland sites shrubs and quaking aspen have become established (J. Bergquist, pers. comm.).

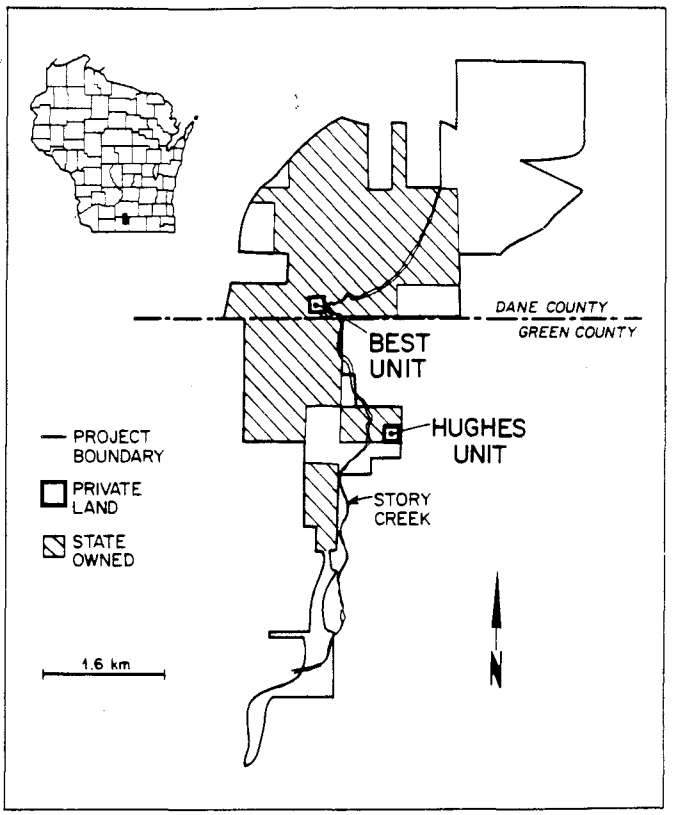

FIGURE 1. Location of the Best and Hughes Units on the Brooklyn Wildlife Area.

METHODS

Habitat Management Plan

A 5-year habitat management plan developed in 1975-76 required that the bulk of the management take place during April-July 1976, after the pre-management cottontail densities were estimated and other indexes of abundance were gathered (Pils 1976). Additional management was planned if rabbit abundance did not increase on the experimental management unit after the first year. All habitat management practices were minimized in order to achieve effective cottontail management at the lowest possible cost. This low level approach was employed in order to make the experimental cottontail management system more acceptable to the farmer or landowner.

A 20.2-ha experimental management unit (the Best Compartment, Fig. 2a) was the site selected for testing various cottontail management practices, and a 20.2-ha unit was the control (the Hughes Compartment, Fig. 2b). The Best Compartment was 1.6 km east of the Hughes Compartment; this distance minimized chances of interchange between units.

The 5.8 ha woods in the Best Experimental Unit.

Trapping lanes were bulldozed in the woodlot in the Best Unit and were maintained each year.

Habitat improvement was preceded by a sampling of vegetation (using the system described by a Ohman and Ream 1971) in the 5.8-ha woods in the Best Experimental Unit and the 4.5-ha woods in the Hughes Unit during August 1975 to document the amount of woody cover. Additional measurements were taken during February 1976 and March 1978. Cover maps were prepared for each unit, and the habitat management plan was completed by April 1976.

Management practices developed for implementation on the Best Unit included (Fig. 3):

1. Bulldozing trails in the woodlot to provide trapping lanes which incidentally created edge (1975); trapping lanes were also bulldozed at Hughes. Trails were cleared every year by various personnel, including a Youth Conservation Corps (YCC) work party.

2. Establishing 8 large brush piles (4.5 x 4.5 x 1.8 m) for loafing and escape cover (1976).

3. Clearcutting the northwest (0.2-ha) and southwest (0.2-ha) portions of the woodlot to encourage early successional growth and to construct loose brush piles (1976).

4. Drilling 0.3-m escape holes (13 cm in diameter) joined in the ground at a 45° angle at 90-m intervals along the bulldozed trails (1976).

5. Removing old wire fence and posts to form small junk piles as escape cover (1976).

6. Establishing food and nesting and escape cover plots through plowing and disking, planting, mowing, and controlled burning (1976-79) (Table 1). The primary work was done in 1976. In 1978, when cottontail densities in the experimental unit did not show a measurable increase as expected (Pils 1978), supplementary disking and plowing was done in C-2, C-4, and C-7 to promote growth of desirable annuals and perennials. Also, a 1,200-m^2 sorghum food

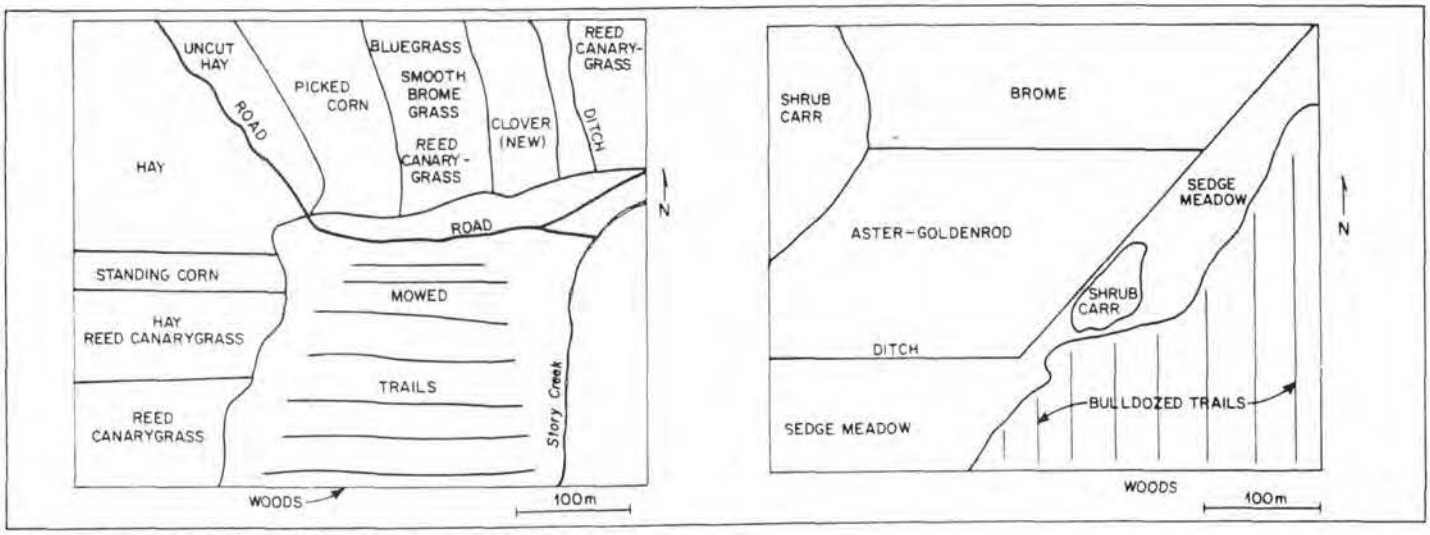

FIGURE 2. Best Experimental Unit (20 ha) (left) and Hughes Control Unit (20 ha) (right) in spring 1976 before treatment.

SOME OF THE MANAGEMENT PRACTICES USED IN THE BEST EXPERIMENTAL UNIT:

Construction of large brush piles

Placement of smaller, loose brush piles

Establishment of food patches

Piling of old wire fencing

Construction of artificial rabbit burrows

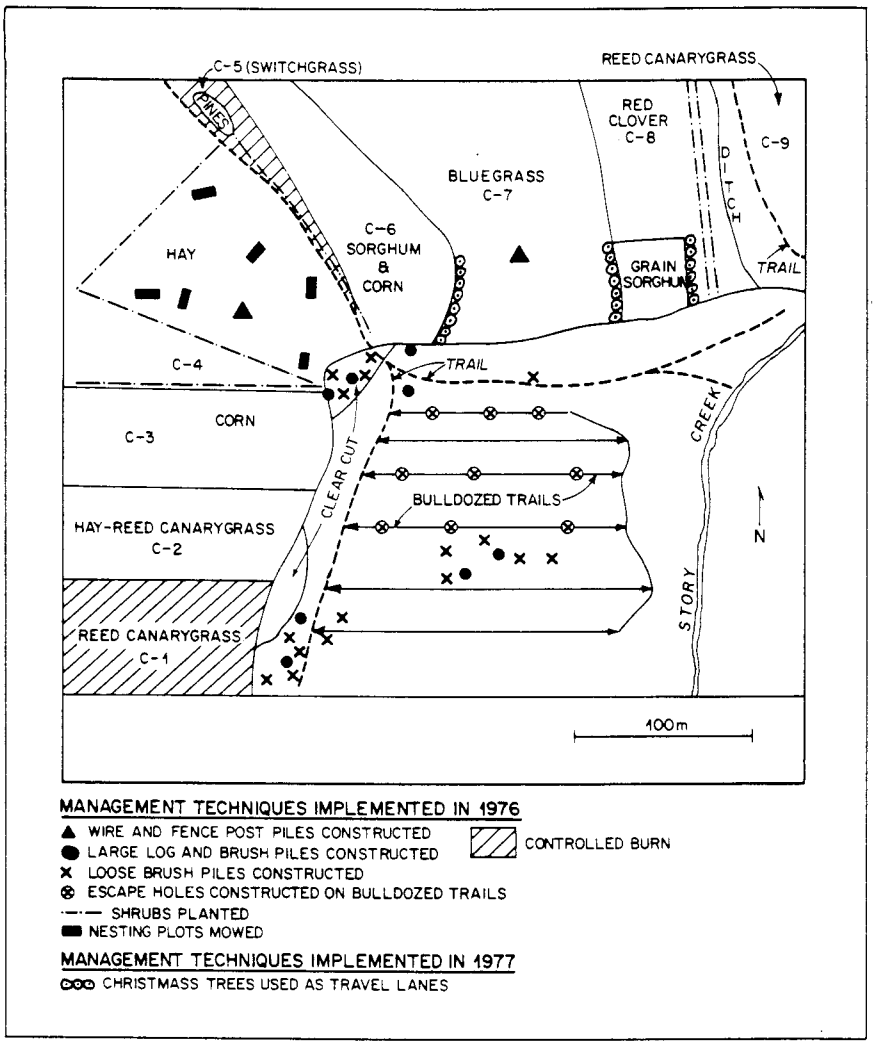

FIGURE 3. Planned experimental cottontail habitat management on the Best Unit from April through August 1976 to April 1977.

patch (Titan E Sorghum) was planted in the clearcut area on the south side of the Best woodlot. In April 1979, two food patches were replanted: C-3 (corn) and C-6 (black amber cane [Titan E] and corn).

7. Planting shrubs (1976-78). Shrubs were planted in fields along the old fencelines to provide travel lanes (Tables 1 and 4, Fig. 3). Princip herbicide was sprayed around the plantings to reduce grass and weed competition. Weeds were trimmed by a YCC work party in 1979.

8. Placing old Christmas trees (1977). A local high school biology class collected and transported 500 discarded Christmas trees to the wildlife area, and DNR personnel placed the trees adjacent to food patches as escape lanes for cottontails feeding at food patches during the winter.

9. Constructing and burying 16 artificial burrows (1978). This was undertaken when cottontail densities did not show the expected increase in the experimental unit. Modified after the basic plan of Haugen (1943), the burrows consisted of a PVC pipe 10 cm in diameter and 76 cm long, instead of a 137-cm inverted wooden trough. The bottom of the PCV pipe was coated with glue and sand to provide traction for cottontails.

A timetable for the management practices is presented in Table 5.

Scientific names of all birds, mammals, and plants cited in this report are listed in Appendix A.

Roadside Surveys

Local cottontail abundance was monitored by using summer roadside transects. A driver and an observer counted all rabbits observed from a vehicle driven at 40 km/hour along a 47-km road transect surrounding the BWA (Fig. 4). Four counts were made each July, starting 30 min after sunrise on clear, calm mornings with heavy ground dew. Results were expressed as cottontails observed/100 km.

Population Estimates

Cottontails were live trapped in both the Best and Hughes units using wooden box traps and collapsible wire traps following procedures described by Pils (1974). Traps were equally distributed throughout both units during the fall, whereas only the woodlots were trapped during the winter. Live trapping was conducted for 10-15 days during the fall (October-November) and winter (January-February) during 1975-79. The frequency of capture-linear regression method of Edwards and Eberhardt (1967)

TABLE 1. Food and cover plot establishment and shrub planting on the Best Unit, Brooklyn Wildlife Area, spring 1976.

Management Practice	Cover and Seed Rate	Compartment Number	Compartment Size(ha)	Date Completed	Purpose
Burn	Reed canary grass	C-1	1.3	By 10 April	Food and cover
Disk	Reed canary grass	C-1	0.3	Spring	Food and cover
Leave intact	Hay-reed canary grass	C-2	0.2	---	Escape cover
Disk	Corn*	C-3	0.8	Spring	Escape cover
Mow	Hay	C-4 (6 plots)	0.3	By 1 May	Food-nesting cover
Burn	Switchgrass	C-5	0.8	By 10 April	
Seed	Switchgrass 1.1 kg/ha	C-5	0.8	15 May-15 July	Shelter-nesting cover
Seed (grain drill)	Sorghum* 2.4 kg/ha	C-6	0.8	After 1 May	Food (strips of sorghum and corn)
Seed (planter)	Corn 2.4 kg/ha	C-6	0.8	After 1 May	
Leave intact	Bluegrass	C-7	2.0	---	Nesting cover
Seed	Red clover	C-8	0.4	1 May-15 June	North side-nesting cover
Seed	Sorghum 2.4 kg/ha mix with grain sorghum; 4.5 kg-forage with 2.3 kg of grain sorghum	C-8	0.4	1 May-15 June	South side-food patch
Leave intact	Reed canary grass	C-9	1.6	---	Escape cover
Plant - double rows 1.5 m apart except for C-8, where 3 rows were 1.5 m apart.	Shrubs (Table 4)	C-4,C-5, C-6,C-8	---	By 17 April	

*All corn and sorghum planted during the study had a maturity of 85 and 95 days, respectively.

was used to estimate cottontail abundance in both units. Since over 90% of all the rabbits were trapped in the woods during all trapping periods, cottontail densities were calculated on the basis of woodlot areas only.

Initially, boxes containing hunter-volunteer interview forms were set up at locations near the two units in an attempt to monitor numbers of cottontails shot. However, only a minimal response was received and the boxes were continually vandalized; this technique was abandoned after the 1975-76 hunting season.

Track and Trail Counts

Cottontail tracks and trails in the snow were also counted 24-48 hours after at least a 3-cm snowfall. Six transects totalling 0.981 km were run at the Best Unit (Fig. 5a), and 11 transects totalling 1.81 km were run at the Hughes Unit (Fig. 5b). Mean numbers of trails/km were used as indexes to cottontail abundance in the two units from December through March 1976-80. Each year t-tests were used to test the null hypothesis that there was no difference in mean numbers of trails/km between transects in the Best and Hughes units. F-tests comparing track abundance at both units were also performed with a small truncation of the first 2 segments to employ an ANOVA program which handled only 9 values/cell. Examination of the data showed that this modification had only a minimal effect on conclusions and did not alter the significance statements. Unless otherwise noted, $P < 0.05$ was used as the criterion of statistical significance.

Subjective estimates (ranging from "low" to "high") of cottontail use observed near brush piles and food patches were made after the track and trail counts.

RESULTS AND DISCUSSION

Vegetation Analysis

Inventories of vegetation in the woods made at both units indicated that avens, Virginia strawberry, and sweet cicely were the three primary ground cover species (based on Importance Values; Ohman and Ream 1971) at Hughes as compared to grass, Virginia strawberry, and pellitory at Best. Total shrub densities were higher at Best, because of an abundance of Allegheny blackberries (Table 2). However, potential concealment cover at Hughes was more dense than that at Best because of a greater sapling density in the control area woodlot (Table 3). Before the larger brush piles were created by felling mature trees, larger diameter (> 10 cm) trees were more common at Best.

Roadside Surveys

Twenty-two cottontail transects were run during the 5-year study. Although 2 transects were run in

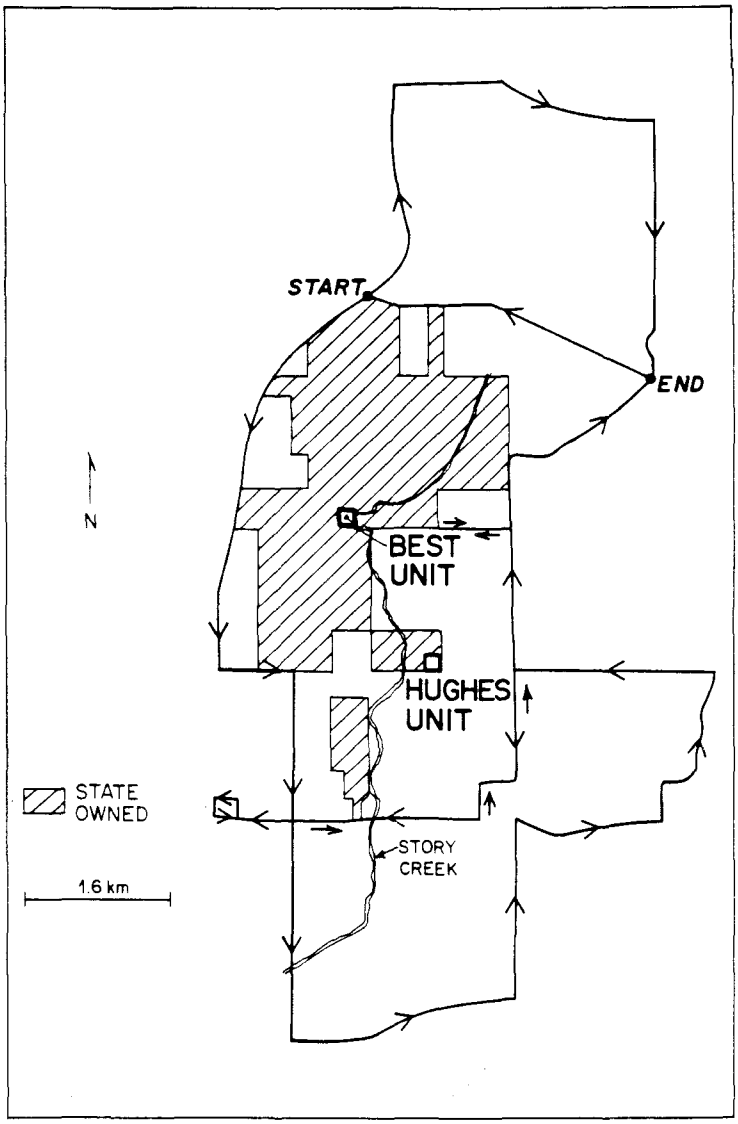

FIGURE 4. The 46-km cottontail roadside transect surrounding the Brooklyn Wildlife Area.

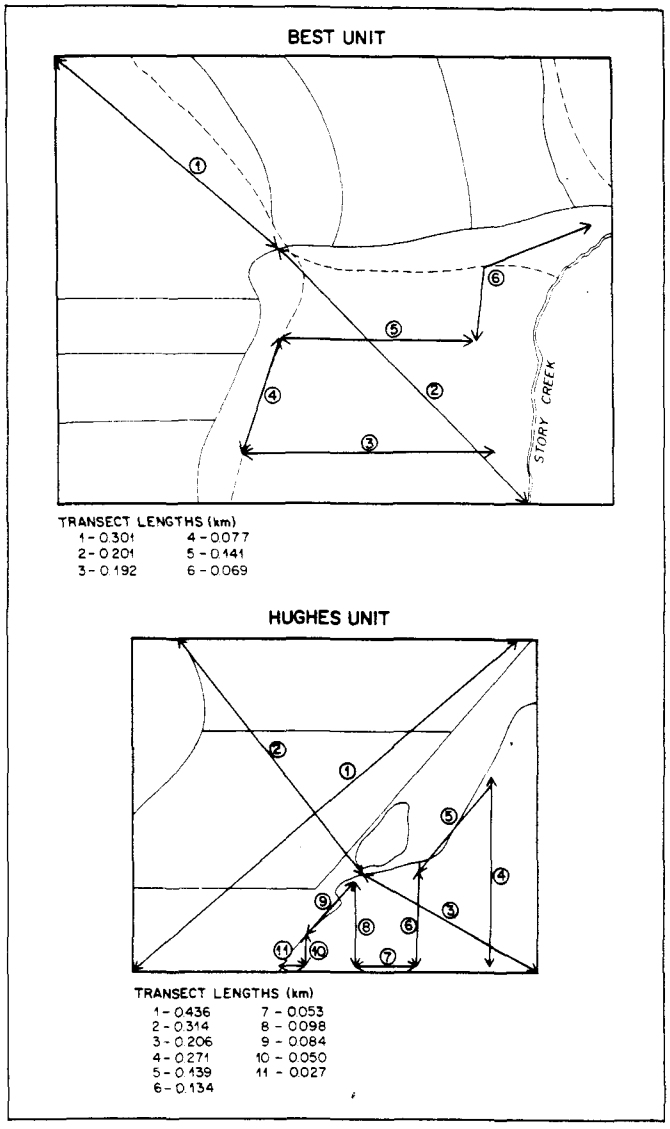

FIGURE 5. Winter trail count transects used on the Best and Hughes Units, Brooklyn Wildlife Area.

TABLE 2. Shrub densities measured in the Hughes and Best Units during October 1975.

Principal Species	No. Stems/ha Hughes	Best
American filbert	17,523	9,741
Allegheny blackberry	5,401	24,221
Gray dogwood	4,084	657
Red raspberry	3,953	1,052
American elder	2,635	1,052
Blackcap raspberry	2,502	1,578
Gooseberry	264	
Rose	131	131
American black currant		264
Roundleaf dogwood		788
Unknown	131	921
Totals	36,624	40,405

August, both during marginal weather conditions, only the data from 20 transects run in July were utilized to measure abundance. The numbers of rabbits observed during these surveys ranged from 9 to 33 cottontails/100 km. A decline in the mean numbers of cottontails seen in summer was noted from 1975 to 1977, followed by a peak in mean numbers observed during 1978 (Fig. 6). Another decline resulted in the lowest number of rabbits seen in 1979.

Population Estimates

From October 1975 through October 1979, 54 cottontails were trapped at the Best Unit and 78 rabbits were captured at the Hughes Unit (Append. B). No cottontails were trapped at Best during fall 1979. Heavy snow accumulation during January 1979 prevented the movement of traps into either unit. Results from the previous (1976-78) January-February periods indicated a low trapping success rate. Tracking data from December 1979 suggested that too few cottontails were available in both units to justify additional winter trapping in 1980. Numbers of cottontails trapped in both units

TABLE 3. Importance Values, stem densities, and basal areas of trees measured at the Hughes and Best Units during February 1976 and March 1978.

	Importance Values*					
	Trees >10 cm in Diameter			Samplings 3-10 cm in Diameter		
	1976		1978	1976		1978
Principal Species	Hughes	Best	Best	Hughes	Best	Best
Black oak	38	49	44	14	26	35
Quaking aspen	28	6	11	32	12	6
Bur oak	17	1	--	15	--	--
Black cherry	15	9	5	38	26	16
White oak	3	34	36	--	3	6
Slippery elm	--	2	3	--	34	31
No. stems/ha	320	202	104	424	74	77
Basal area (m^2/ha)	16	24	12	1	0	0

*Importance Value (Ohman and Ream 1971) is a summation of relative values of density, basal area, and frequency for species within a community type. This provides a means of comparing each species' contribution to the composition of the type.

declined from 1975 to 1979 (Fig. 7). Estimated densities of cottontails in both units also suggested a general decline between 1976 and 1978 fall populations (Table 6). Hughes Unit cottontail population estimates were initially higher than those for the Best Unit and remained higher throughout the study. No peak occurred in the 1978 trapping data as suggested by the BWA July roadside cottontail survey.

Track and Trail Count Abundance Estimates

Annual averages of track and trail counts ranged from 19 to 322 trails seen/km (Table 7). The highest number of cottontail trails was observed during the winter of 1977-78; counts declined sharply during the two subsequent winters, reaching a 4-year low during January-February 1980. Both units reflected similar fluctuations of relative abundance during the study (r = 0.951), although t-tests showed that the mean numbers of trails/km within a unit were not significantly different between each of the 4 years. When mean track abundance was compared between the Best and Hughes units for the 4 years (Table 7), no significant differences were noted (F = 2.39; 1,52 df). However, analysis of variance showed an overall significant difference in trail abundance between years (F = 8.22; $P < 0.01$; 3,52 df). Therefore, track and trail counts, which indicated no differences in abundance between the two units, differed from trapping density estimates suggesting higher population levels in the Hughes Unit. Red foxes, gray foxes, squirrels, and dogs were the principal species other than cottontails recorded during the trail counts (Append. C).

TABLE 4. List of 3,150 shrubs planted at the Best Experimental Unit from 1976 through 1978.

	No. Planted/Year		
Shrub	1976	1977	1978
American filbert	600		500
Autumn elaeagnus	100	125	
European cranberry viburnum	100		
Gray dogwood	100	200	
Red-osier dogwood	50	50	
Mixed crabapple	50		
Nannyberry viburnum	100		
Common ninebark	50	50	
Silky dogwood	100	100	500
American plum		375	
Total	1,250	900	1,000

Evaluation of Habitat Management Practices

Checks were made of the various management techniques used in order to assess use by cottontails. Number of tracks observed around the brush piles at the Best Unit decreased from "high" during the winter of 1976-77 to "low" during the winter of 1979-80. Throughout the study, few cottontail tracks were noted in the food patches during the winter. The Christmas tree travel lane, established as a sheltered route during January 1977 (Table 3), failed to encourage rabbits to feed upon corn and sorghum available in the food patches.

TABLE 5. Timetable for planned management activities at the Best Experimental Unit, 1976-79.

Year-Month	Activity	Person-Hours Worked	Percent of Total Management Time
1975	Bulldozing*	-	-
1976 Apr	Controlled burn	21	2.3
Apr	Plant shrubs	125	13.8
Apr	Plow, disk, and plant food patches	4	0.4
May-Aug	Clearcut and construct brush piles	446	49.3
Jun-Jul	Mow trapping trail	20	2.2
Jun-Jul	Mow and search nest plots	27	3.0
Jul-Aug	Dig escape tunnels	13	1.4
Totals		656	72.4
1977 Jan	Build Christmas tree travel lane	24	2.7
Apr	Plant shrubs	24	2.7
Aug	Mow trapping lanes	8	0.9
Totals		56	6.3
1978 Apr	Plant shrubs and apply herbicide to grass competition	22	2.4
Apr	Bury artificial burrows	15	1.7
Apr-May	Disk and plant food patches	12	1.3
Aug	Mow trapping lanes	4	0.4
Totals		53	5.8
1979 Jun	Plow, disk and plant food patches	32	3.5
Aug	Hand cut trapping lanes	54	6.0
Aug	Herbicide and hand cut shrub competition	54	6.0
Totals		140	15.5
Grand Total		950	100.0

*Done primarily to create trapping lanes, and not undertaken as a management measure.

TABLE 6. Estimates of cottontail densities determined by live trapping on the Brooklyn Wildlife Area, 1975-79.

	Estimated Cottontail Populations (no./ha)								
Unit	Fall 1975	Winter 1976	Fall 1976	Winter 1977	Fall 1977	Winter 1978	Fall 1978	Winter 1979	Fall 1979
Best	4.4	1.5	5.2	*	4.2	*	3.0	*	*
Hughes	9.6	5.2	6.6	3.0	7.3	*	4.1	*	*

*Number of cottontails trapped was too low to make reliable estimates.

TABLE 7. Combined results of 13 cottontail track and trail count transects on the Brooklyn Wildlife Area, 1976-80.

Year	Mean No. Trails/km Best Transect (0.981 km)	Hughes Transect (1.81 km)
1976-77	106	74
1977-78	206	322
1979	36	42
1980	19	24
$\bar{x} \pm$ S.E.	92 ± 49	116 ± 80
F.	2.39; n.s.	

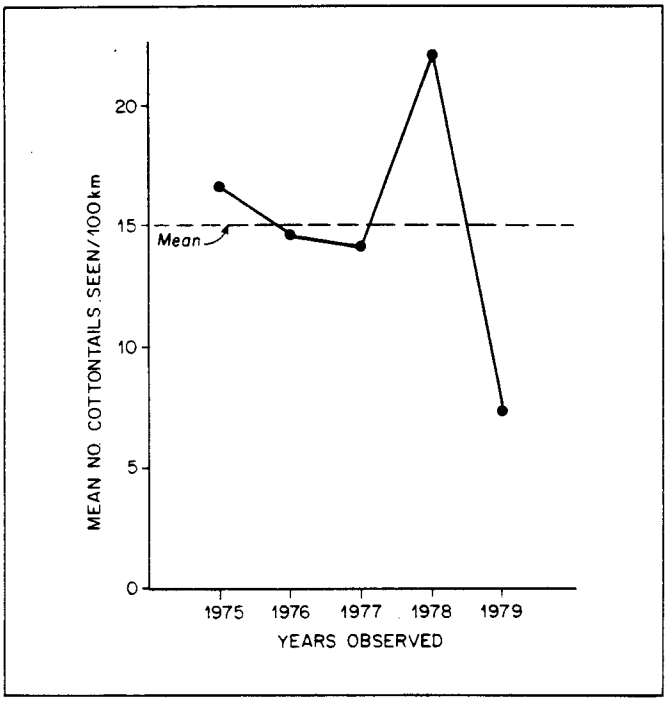

FIGURE 6. Results of 20 July counts in roadside cottontail transects surrounding the Brooklyn Wildlife Area, 1975-79.

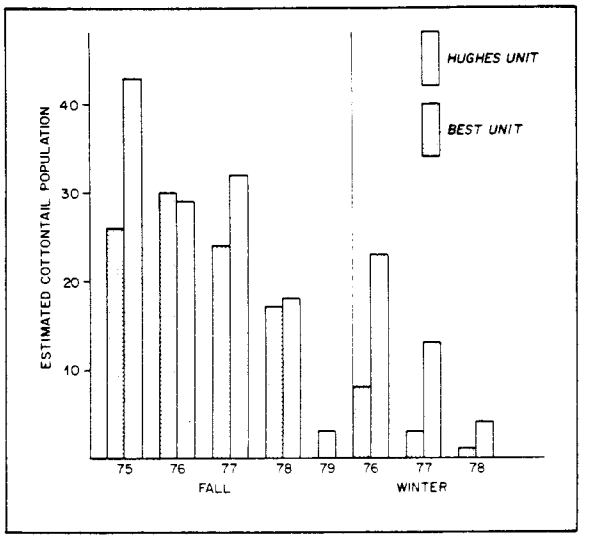

FIGURE 7. Cottontail population estimates derived from trapping results obtained at the Best and Hughes Units, 1975-79.

Although 10 escape tunnels were dug at the Best Unit during the summer of 1975, they soon collapsed because of sandy soil and were not redug. Bulldozing trapping lanes at Hughes may have had a positive impact on cottontail populations, but this effect could not be measured.

Haugen (1943:112) found that use of artificial burrows created as escape cover for Michigan cottontails prevented mortality. However, no evidence of cottontail use was noted in or near any of the 16 artificial burrows inspected at the Best Unit during October 1978 and January 1979.

Approximately 805 of the 2,150 shrubs planted during 1976 and 1977 died either as a result of plant competition or because of extremely low spring and summer rainfall. The 1,000 stems planted during 1978 had a better survival rate because of higher rainfall and the control of weedy competition with herbicides during 1978 and 1979. The shrubs planted on the Best Unit were intended primarily to benefit cottontails and other wildlife beyond the 5-year period of the current investigation and probably had not reached their maximum potential impact on wildlife when the study ended.

On 21 June 1976, an 11-person crew searched the alfalfa, clover, and smooth bromegrass cover plots in order to obtain some idea of cover preference. No cottontail forms were found during the 27 person-hours of searching. The lack of labor and time constraints prevented additional search efforts.

Comparisons of Abundance

Population estimates at both units, based on live trapping results, indicated that Hughes cottontail numbers were considerably higher than Best estimates during the prehabitat-management period (Table 6). Subsequent fall estimates of the Best Unit indicated either an increased or stable density through 1977, then showed a decline of approximately 1 cottontail/ha in 1978. At the same time, Hughes densities declined 3 rabbits/ha in 1976, increased about 1 animal/ha in 1977, and then declined 3 cottontails/ha in 1978. The estimated 1978 fall density in the control unit (Hughes) was less than half its initially estimated fall density. Conversely, estimated population density had declined only about 25% in the experimental unit (Best). Although the population estimates included sampling variability because of our method of estimating density (Edwards and Eberhardt 1967), the Hughes decline was apparently more precipitous than the decline in the Best Unit. It is not clear whether habitat management helped lessen the decline at the Best Unit as compared to the Hughes Unit, however. The results of our comparisons of unit abundance also conflicted with results of the summer roadside cottontail surveys. Neither unit seemed to follow the upward trend shown by roadside counts in 1978 (Fig. 6). However, since these counts are made in summer, they are not necessarily

comparable to fall trapping results because of summer-to-fall mortality.

Trends in winter track/trail counts agreed more closely with live trapping population estimates. Except for the winters of 1975-76 and 1976-77, track/trail counts also suggested a downward trend in both units. Rabbits may also have moved less distance and/or less often after 1977-78. During 1978-79 and 1979-80, the differences in average track/trail counts between winters appeared to be of the same general proportions in both units (Table 7).

CONCLUSIONS

Based on the available data, we conclude the following:

1. The Hughes Area contained a higher prehabitat-management cottontail population than the Best Area.

2. Both the Hughes and Best populations decreased or because less countable, in terms of trapping results, from 1977 to 1979. The severe winter of 1978-79 seemed to be the immediate cause of this decline.

3. Based on population estimates obtained from trapping, this decline may have been less severe within the Best unit. However, track/trail counts were inconclusive.

4. While habitat management did not produce a clearly measurable positive result, it may have reduced the effects of a population decline within the Best Unit. The cause of the decline in both units was the harsh winter of 1978-79, which negatively influenced cottontails locally and regionally (W. Edwards, pers. comm.). This weather critically disrupted our analysis of the impact of habitat management in the Best Unit.

5. An alternate hypothesis to explain the lack of a measurable response within the Best Unit (according to trapping results) is that cottontails were either less prone to trapping or were more vulnerable to hunting there than in the Hughes Unit. Improved habitat, principally in the form of the large brush piles, may have caused reduced movements and a subsequent poorer trap response. The Best Unit was also a highly visible management area and may have attracted more hunters than the Hughes Unit. Our inventory of vegetation taken at both units indicated that the potentially concealing cover at Hughes was denser than that at Best. Dogs and hunters may have been able to more effectively hunt this less dense cover of the Best Unit. Anderson and Pelton (1976) found that the tendency of cottontails to flush decreased as cover became harder for hunters and dogs to penetrate. However, when 3 cottontails were radio tagged and released in each of the units during the fall of 1976, rabbits in the Hughes Unit showed a greater tendency to flush and showed more random, wide-ranging, and long-duration escape runs when subjected to hunting dog pressure than the Best Unit cottontails, which had easy access to brush piles (T. Moser, pers. comm.). The apparent contradiction between the two studies may be explained by differences in vulnerability due to snow cover. Whereas Moser evaluated chase time during the fall, previous research (Pils and Martin 1978) has indicated that most rabbit-hunting in southern Wisconsin occurs during the winter when snow cover is present. Snowfall makes tracking possible and aids the hunter by making the rabbit more visible. Therefore we felt that although brush piles at Best afforded cottontails escape cover, the extent of hunting pressure at Brooklyn, during months of snow cover, together with the lesser stem density, could have negated the positive experimental habitat management benefits.

Overall, we felt that although our experimental habitat management in the Best Unit did not increase cottontail densities, it may have helped prevent populations from diminishing as rapidly as in the Hughes Unit following the severe winter of 1978-79.

MANAGEMENT RECOMMENDATIONS

The small sizes of the experimental and control units may have prevented an accurate assessment of cottontail habitat and changes in densities. Future cottontail habitat management experiments should be attempted on multiple, larger units, such as the five 65-ha areas studied by Haugen (1943) in southwestern Michigan. Potential cottontail habitat could be objectively evaluated by using the technique outlined by Baskett et al. (1980). The placement of habitat improvements relative to each other or to existing land features may be equally important. Because cover and food are the key components of cottontail survival (Haugen 1943), we suggest that future habitat management should employ higher densities of brush piles and food patches than used at the Best Unit. Cottontail abundance could be adequately monitored by using only summer roadside counts and winter track counts, thus eliminating the time and labor consuming live trapping (Edwards and Eberhardt 1967). A more costly alternative would be to implement a more extensive and continuous marking and trapping program within individual units. Wildlife students and/or DNR personnel could also check management areas, especially after snowfalls or during weekends, to obtain an estimate of hunting pressure.

The current literature on cottontail habitat management is listed in Appendix D to help to guide future management efforts.

LITERATURE CITED

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APPENDIX A. Scientific names of birds, mammals, and plants used in the text.

Asterisks denote mammals observed at the Best Experimental Unit from June through August, 1976. All birds were noted during this period.

Scientific names of birds from Gromme (1963); mammals, Jackson (1961); and plants, Scott and Wasser (1980).

BIRDS

American goldfinch, Spinus tristis
Barn swallow, Hirundo rustica
Belted kingfisher, Megaceryle alcyon
Black-capped chickadee, Parus atricapillus
Blue jay, Cyanocitta cristata
Bobolink, Dolichonyx oryzivorus
Bobwhite, Colinus virginianus
Brown thrasher, Toxostoma rufum
Cardinal, Cardinalis cardinalis
Catbird, Dumetella carolinensis
Cedar waxwing, Bombycilla cedrorum
Common flicker, Colaptes auratus
Crow, Corvus brachyrhynchos
Downy woodpecker, Dendrocopos pubescens
Eastern kingbird, Tyrannus tyrannus
Eastern meadowlark, Sturnella magna
Eastern wood pewee, Cantopus virens
Field sparrow, Spizella pusilla
Grackle, Quiscalus quiscula
Gray partridge, Perdix perdix
Great blue heron, Ardea herodias
Great horned owl, Bubo virginianus
Hairy woodpecker, Dendrocopos villosus
Harrier, Circus cyaneus
House sparrow, Passer domesticus
Kestrel, Falco sparverius
Killdeer, Charadrius vociferus
Long-billed marsh wren, Telmatodytes palustris
Mallard, Anas platyrhynchos
Mourning dove, Zenaidura macroura
Northern oriole, Icterus galbula
Purple finch, Carpodacus purpureus
Red-headed woodpecker, Melanerpes erythrocephalus
Red-tailed hawk, Buteo jamaicensis
Red-winged blackbird, Agelaius phoeniceus
Ring-necked pheasant, Phasianus colchicus
Robin, Turdus migratorius
Rose-breasted grosbeak, Pheucticus ludovicianus
Song sparrow, Melospiza melodia
Starling, Sturnus vulgaris
Vesper sparrow, Pooecetes gramineus
Woodcock, Philohela minor
Wood thrush, Hylocichla mustelina
Yellow-billed cuckoo, Coccyzus americanus
Yellowthroat, Geothlypis trichas

MAMMALS

*Chipmunk, Tamias striatus
*Cottontail rabbit, Sylvilagus floridanus
Domestic dog, Canis familiaris
*Fox squirrel, Sciurus niger
Gray fox, Urocyon cinereoargenteus
*Gray squirrel, Sciurus carolinensis
*Little brown bat, Myotis lucifugus
Mink, Mustela vision
*Prairie mole, Scalopus aquaticus
Red fox, Vulpes vulpes
Weasel, Mustela sp.
*White-tailed deer, Odocoileus virginianus
*Woodchuck, Marmota monax

PLANTS

Alfalfa, Medicago sativa
Allegheny blackberry, Rubus allegheniensis
American black currant, Ribes americanum
American elder, Sambucus canadensis
American filbert, Corylus americana
American plum, Prunus americana
Aster, Aster sp.
Autumn elaeagnus, Elaeagnus umbellata
Avens, Geum sp.
Blackberry, Rubus sp.
Blackcap raspberry, Rubus occidentalis
Black cherry, Prunus serotina
Black oak, Quercus velutina
Bluegrass, Poa sp.
Bur oak, Quercus macrocarpa
Clover, Trifolium sp.
Common ninebark, Physocarpus opulifolius
Common soybean, Glycine max
Corn, Zea mays
Crabapple, Malus sp.
Dogwood, Cornus sp.
European cranberry viburnum, Viburnum opulus
Giant ragweed, Ambrosia trifida
Goldenrod, Solidago sp.
Gooseberry, Ribes sp.
Grass, Poaceae
Gray dogwood, Cornus racemosa
Hickory, Carya sp.
Nannyberry viburnum, Viburnum lentago
Oak, Quercus sp.
Pellitory, Parietaria pensylvanica
Quaking aspen, Populus tremuloides
Red clover, Trifolium pratense
Red-osier dogwood, Cornus stolonifera
Red raspberry, Rubus idaeus
Reed canary grass, Phalaris arundinacea
Rose, Rosa sp.
Roundleaf dogwood, Cornus rugosa
Silky dogwood, Cornus amomum
Slippery elm, Ulmus rubra
Smooth bromegrass, Bromus inermis
Sorghum, Sorghum sp.
Stinging nettle, Urtica dioica
Sweet cicely, Osmorhiza sp.
Switchgrass panicum, Panicum virgatum
Virginia strawberry, Fragaria virginiana
White oak, Quercus alba

APPENDIX B. Summary of cottontail trapping at Brooklyn Wildlife Area, 1975-79.

Date Trapped	Best Unit Trap-Nights	Males	Females	Unk.	Total Recaptures	Hughes Unit Trap-Nights	Males	Females	Unk.	Total Recaptures
Oct 1975	1,162	7	4	0	17	1,308	4	3	0	0
Feb 1976	632	0	1	0	1	572	5	3	2	20
Oct 1976	1,245	6	12	0	16	1,437	11	9	2	30
Feb 1977	941	1	2	0	5	941	3	3	0	8
Oct 1977	693	8	2	1	7	819	11	4	1	5
Feb 1978	480	1	0	0	1	480	2	2	0	0
Oct-Nov 1978	955	6	3	0	11	955	4	6	0	11
Jan 1979	----------				N O T R A P P I N G	----------				
Oct 1979	600	0	0	0	0	544	1	2	0	2
Totals	6,708	29	24	1	58	7,056	41	32	5	76

APPENDIX C. Tracks (no./km) of species other than cottontails observed during the 13 cottontail trail count transects on the Brooklyn Wildlife Area, 1976-80.*

Tract-Year (No. Transects)	Red Fox and Gray Fox	Squirrel	Weasel	Deer	Mink	Dog	Quail	Pheasant
Best (0.981 km)								
1976-77(2)	34	49	1	2	3	5	5	0
1977-78(4)	54	63	5	4	3	6	4	0
1979(4)	39	36	7	0	0	19	0	0
1980(3)	30	62	0	6	0	54	0	0
Mean 1976-80	39	53	4	3	2	21	2	0
Hughes (1.812 km)								
1976-77(2)	18	7	0	7	1	10	4	9
1977-78(4)	41	13	5	82	5	1	0	15
1979(4)	28	93	15	0	7	0	11	0
1980(3)	41	10	0	1	0	23	68	8
Mean 1976-80	32	31	5	23	3	9	21	6

*Songbirds and small mammals not included.

APPENDIX D. Summary of cottontail literature related to habitat management.

Author(s)	Year	State	Key Words
Bowers, E. F.	1967	Georgia	Management
Klimstra, W. D. and E. L. Corder	1957	Illinois	Food habits by pellet analysis
Rose, G. B.	1972		Burning, food, cover, habitat manipulation
Bushong, C.	1959	Indiana	Brush piles, cover
Hendrickson, G. O.	1938 1940 1947	Iowa	Winter food and cover Nest cover selection Cover types, foods, management
Kurtt, R.	1978		Food patches and cover
Wunz, G. A.	1959	Kentucky	Farm game management
McDonough, J. J. and H. K. Maxfield	1959	Massachusetts	Pole-type forest management
Allen, D. L.	1939	Michigan	Winter foods
Friley, C. E.	1955		Food, cover preferences
Haugen, A. O.	1943		Experimental management
Hickie, P. F.	1940		Cover, food, propagation
Baskett et al.	1980	Missouri	Habitat evaluation
Rowe, K.	1951		Nesting, escape, shelter cover, restocking
Sadler, K. C.	1976		Food, cover
Sweetman, H. L.	1944	New England	Woody plants as winter food
Alkon, P. U.	1962 1963	New York	Brush pile evaluation Summer foods
Dell, J.	1958		Food, shelter, plantings
Drahos and Dell	1951		Brush piles, cover
Smith, R. H.	1950		Shelter, escape, food-producing, and nest cover
Smith, R. L.	1958		Conifers as habitat
Azenhofer, D. R. and D. L. Leedy	1947	Ohio	Transfer of cottontails and habitat improvement management
Dusi, J.	1951		Food habits by pellet analysis
Leedy, D. L. and G. E. Laycock	1946		Nesting cover, food patches
Urban, D.	1974		Burning frequency for rabbit management
Beule, J. D.	1940	Pennsylvania	Nesting cover
Bowers, G. L.	1954		Management practices

APPENDIX D. (Cont'd)

Forbes, S. E. and J. E. Harney	1952		Bulldozers as management tools
Gerstell, R.	1937		Management, propagation, food patches
Parlaman, R. D.	1955		Cut swath through briars
Sheffer, D. E.	1962		Food plot seeding rate, cover brush piles
Studholme, C. R.	1952		Experimental management techniques
Fortenberry, D. K.	1959	Virginia	Management procedures
Krug, A. S.	1960		Intensified management
Bennet, L.	1951	West Virginia	Rock-pile escape houses, foods, cover
Chambers, R. B.	1959		Management evaluation
Wisconsin Conservation Department	1966	Wisconsin	Food, cover, range

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