Evaluation of waterfowl production areas in Wisconsin. No. 135 1982

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EVALUATION OF WATERFOWL PRODUCTION AREAS IN WISCONSIN

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ABSTRACT

The Waterfowl Production Area (WPA) acquisition pilot program, a cooperative effort of the U.S. Fish and Wildlife Service and the Wisconsin Department of Natural Resources, resulted in the acquisition of 29 parcels or 1,365 ha (3,372 acres) of waterfowl habitat at a cost of over $1.5 million. The pilot program objective was to identify and acquire WPAs in the Waterfowl Production Unit (WPU) complexes. During 1977-79, a study was undertaken to evaluate WPAs within the WPU complexes at 2 major study areas. The Southern Study Area (SSA) consisted of 11 separate WPUs totalling 142.6 km^2 (55 $mile^2$) in Columbia, Dane, Dodge, and Jefferson counties, and the Northwest Study Area (NSA), a 362.6-km^2 (140 $mile^2$) block in St. Croix and Polk counties. This study was designed to provide the base data necessary for an evaluation of the WPA acquisition program under Wisconsin conditions, and to provide guidelines for waterfowl management schemes under the WPA concept.

Wetland vegetation comprised 17.2 ha/km^2 (110.1 acres/$mile^2$) on the SSA, and 7.7 ha/km^2 (49.3 acres/$mile^2$) on the NSA. May surface water averaged 5.8 ha/km^2 (37.1 acres/$mile^2$) and 7.0 ha/km^2 (44.8 acres/$mile^2$) for the SSA and NSA, respectively. WPU wetland vegetation on the SSA consisted mostly of Type II wetlands (56%), whereas most of the surface water was found in wetland Types IV (33%) and V (18%). The NSA encompassed more permanent wetlands; Type V wetlands were the major component of the WPU wetland vegetation (36%) and May surface water (70%). Wetland losses in east central Wisconsin have accelerated from 0.8% per year in 1958-73 to a 1.6% annual loss in 1973-77. Three-quarters of all wetland losses were attributed to ditch drainage.

Nearly a quarter of the SSA and 29% of the NSA contained vegetative cover that potentially could serve as nesting habitat for ducks. In the SSA, 86% of the potential nesting cover was on private lands which comprised 96% of the study area. Comparable figures for the NSA were 93% and 95%, respectively. Domestic hay represented half of all nesting cover in the SSA, and 3/4 in the NSA. Because of favorable weather and efforts to control outbreaks of alfalfa weevils, the harvest chronology of hayfields was earlier than normal during this study. The most secure nesting cover available was in retired cropland and pasture (17% of total in the SSA, 18% in the NSA), with the majority found on WPAs (41%) and Waterbank lands (24%) in the SSA. Monotypic stands of switchgrass appeared to provide cover superior to other vegetation types examined.

Breeding duck density averaged 7 pairs/km^2 (or 1.4 pairs/ha surface water; 18 pairs/$mile^2$, 16.5 pairs/100 acres water) on the SSA, and 6 pairs/km^2 (or 0.9 pairs/ha water; 15.5 pairs/$mile^2$, 31.7 pairs/100 acres of water) on the NSA. Wetland Types III and IV, along with ditches and streams held the greater densities. Breeding density on WPAs was higher (about 14 pairs/km^2; 36 pairs/$mile^2$ for both study areas) than on lands within 0.4 km (0.25 mile) (9 pairs/km^2; 23 pairs/$mile^2$) or 0.8 km (0.5 mile) (6 pairs/km^2; 15.5 pairs/$mile^2$) of WPAs. Blue-winged teal represented 60% of the SSA breeding population, and 44% of the NSA population. Mallards comprised 25% of the SSA and 30% of the NSA breeding populations.

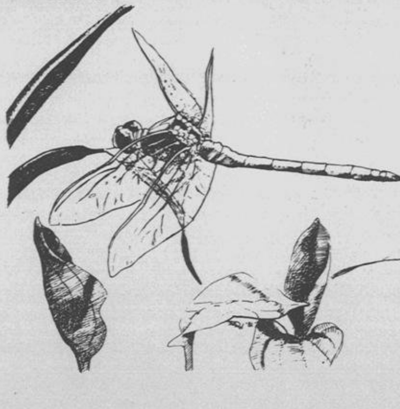
Based on limited data, nest densities apparently declined 25-50% between 1977 and 1978 in mowed hayfields and WPAs, primarily due to a lower breeding density in 1978. Brood water in WPAs is currently adequate for the available breeding duck populations. Some WPAs, particularly on the SSA, lack sufficient brood habitat during dry years. The minimum 1977 production on WPUs in the SSA was 1.2 broods/km^2; (3.1 broods/$mile^2$) or 0.43 broods/ha (0.17 broods/acre) of June surface water. Comparable figures for the NSA were 1.3 broods/km^2 (3.4 broods/$mile^2$) or 0.21 broods/ha (0.09 broods/acre) of surface water. The higher brood densities noted on WPAs were attributed primarily to the higher breeding pair density on these areas, rather than better reproductive success. In 1977, higher brood densities were found in WPA wetlands than were found on wetlands 0.4-0.8 km (0.25-0.50 mile) away from WPAs. However, the number of broods seen on WPAs indicated a pair success of only 8% compared to an estimated pair success of 17% for WPUs.

Breeding densities of pheasants within 0.4 km (0.25 mile) of the WPAs in the SSA were 1.1 cocks and 3.6 hens/km^2 (3.1 cocks, 9.3 hens/$mile^2$); comparable figures for the NSA were 2.3 cocks and 4.5 hens/km^2 (6.0 cocks, 11.7 hens/$mile^2$). Nineteen species of summer resident marsh birds, including 12 nesting species, were observed on the SSA. Thirty-six species were observed on the NSA of which 18 nested on WPAs. From 1977 to 1978, yellow-headed blackbirds declined 75% on sampled NSA wetlands. Sixteen species of songbirds associated with grasslands were found in 13 WPAs in the NSA. Five additional species of upland game birds were observed on WPAs. Winter track counts indicated a wide variety of bird and mammal use on WPAs.

Interviewed duck hunters bagged 0.5 ducks/hunter and hunted an average of 3.4 hours/trip on NSA WPAs in 1977-78. Twenty-six cocks were harvested on 6 WPAs in 1978. Extensive trapping, contrasted to light nonharvest use, was observed on WPAs.

Suggested management goals for nesting waterfowl on WPAs are a minimum of 70% nesting success and a nest density of 2.5 nests/ha (1 nest/acre) in managed upland cover. Dense nesting cover should be planted in blocks of at least 16 ha (40 acres) to maximize its predator-resistant qualities. At least 40 breeding pairs of dabblers should be present within 0.8 km (0.5 mile) of a proposed WPA to obtain the nest density goal for managed cover.

WPA acquisition decisions should be based on biological justifications. If minimum production goals are attained, the WPA program in Wisconsin can provide secure nesting cover for a minimum of 17% of the state's current breeding populations of mallards and blue-winged teal. Brood habitat should be present in a ratio of 1:4 with upland nesting cover, or a minimum of 4 ha (10 acres) of secure brood water within 0.8 km of any WPA. Monotypic stands of switchgrass are recommended for dense nesting cover establishment on upland sites, while organic soils should be left to revert to successional changes such as aster-goldenrod complexes. Strong efforts need to be made to halt invasion of woody vegetation in upland nesting fields. Water development may be warranted when brood habitat is insufficient; however, emphasis should be placed on the acquisition of existing brood water.



EVALUATION OF WATERFOWL PRODUCTION AREAS IN WISCONSIN

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INTRODUCTION

Wetlands have long been recognized for their vital role in the maintenance of wildlife populations. Throughout the cultivated area of North America, agricultural interests have competed directly with wildlife interests for the use and control of wetlands. On an economic basis, wetland wildlife values have not been able to mount a substantial challenge to agricultural values, and as a consequence, the loss of wetlands due to drainage has remained a critical problem (Hedlin 1969, Lodge 1969).

In Wisconsin, acquisition has been a primary tool for wetland preservation. The Wisconsin Department of Natural Resources (DNR) projected an acquisition goal of 221,970 ha (J. Wetzel DNR pers. comm. 1980) with 167,431 ha (approximately 2/3 wetlands) purchased through June 1979. Approximately 647,500 ha of wetlands remain in private ownership; 197,000 ha lie in the more fertile and more wildlife productive southeastern Wisconsin (Kabat 1972). Continued drainage, however, will have a dramatic effect on wetland wildlife in Wisconsin, particularly breeding waterfowl populations.

Wetland preservation and waterfowl management are intrinsically related. While it is recognized that at least 45% of Wisconsin's ducks breed on private, small, scattered wetlands (Wheeler and March 1979), wetland preservation by fee title acquisition represents an imminent phase of the duck management program in Wisconsin. The U.S. Fish and Wildlife Service (FWS) has acquired waterfowl habitat throughout the country as part of the National Wildlife Refuge System as either major refuges or as Waterfowl Production Areas (WPAs). The Migratory Bird Conservation Act was amended in 1961 by the federal congress as a response to continued wetland drainage. The amended act provided an additional source of funding to allow the FWS to accelerate their wetland acquisition program.

Wisconsin was selected in 1974 to participate in a pilot program that for the first time used federal migratory bird hunting and conservation stamp (duck stamp) monies to acquire WPAs outside the prairie states. In a cooperative effort, the FWS identified and purchased 1,365 ha of land at a cost of over $1.5 million. When funding again became available in 1978-81, an additional 1,489 ha of WPA habitat were purchased for $3.27 million. The FWS identified and prioritized 33 regional waterfowl habitat categories; categories 1 through 15 received major funding emphasis after concept plans and detailed descriptions of the categories were prepared.

The Category 11 Concept Plan estimated the WPA acquisition goal in Wisconsin at 8,100 to 16,200 ha (FWS 1979). WPA goals for Wisconsin were based on the needs of existing waterfowl populations and the quality of habitat available. The WPA program called for the acquisition and management of waterfowl production habitat within Wisconsin for the expressed purpose of maintaining and increasing the production of wild waterfowl. The Concept Plan provided the justification and rationale behind extending the FWS Small Wetland Acquisition Program into the eleventh priority waterfowl breeding habitat in the Upper Mississippi Flyway. WPA acquisition in Wisconsin is projected to include 26 counties. At current land values, it is estimated this additional area would cost over $34 million.

Authority for federal WPA acquisition is found in s. 1.036 Wis. Stat. In general, the program calls for assistance by the state for acquisition in federal fee title. Management of the lands is by the state resource agency under a written cooperative agreement and approved management plans. In 1978, funds from the sale of the Wisconsin Waterfowl Stamp became available, a portion of which provided for the management of WPAs. The Wisconsin Waterfowl Stamp is expected to provide approximately $220,000 annually, and approximately 30% is expected to be used on WPAs (J. Wetzel DNR pers. comm. 1980).

WPAs are generally small, key areas (< 125 ha) of duck production habitat identified and purchased within larger units of land and water that contain one or more wetland complexes. These units are called Waterfowl Production Units (WPUs) and are almost entirely private holdings. An objective in the pilot program was to identify and acquire the waterfowl production habitat (WPAs) required to conserve and develop a number of Waterfowl Production Units (WPUs). Selection of individual WPAs was based on existing wetland quality and distribution, plus waterfowl production potential.

This 1977-79 study was designed to provide the data necessary for an evaluation of the WPA acquisition program in Wisconsin and to provide guidelines for waterfowl management schemes under the WPA concept. If the primary goal of the WPA program is to produce ducks, can an effective WPA program be developed in Wisconsin at a reasonable cost? It was necessary to evaluate Wisconsin's success with preliminary WPA acquisitions to justify continued efforts. It was known that continued wetland drainage has steadily deteriorated the habitat base for ducks in Wisconsin. However, it was necessary to document the magnitude of these losses and other detrimental wetland modifications to justify accelerated acquisition of duck habitat. A WPA evaluation should also involve management guidelines, including: (1) establishment of WPA duck production goals; (2) the size, type, and location of upland nest cover development; (3) future WPA acquisition needs and priorities; and (4) the use of specific management techniques (e.g., water development, cover manipulation, and indirect predator management).

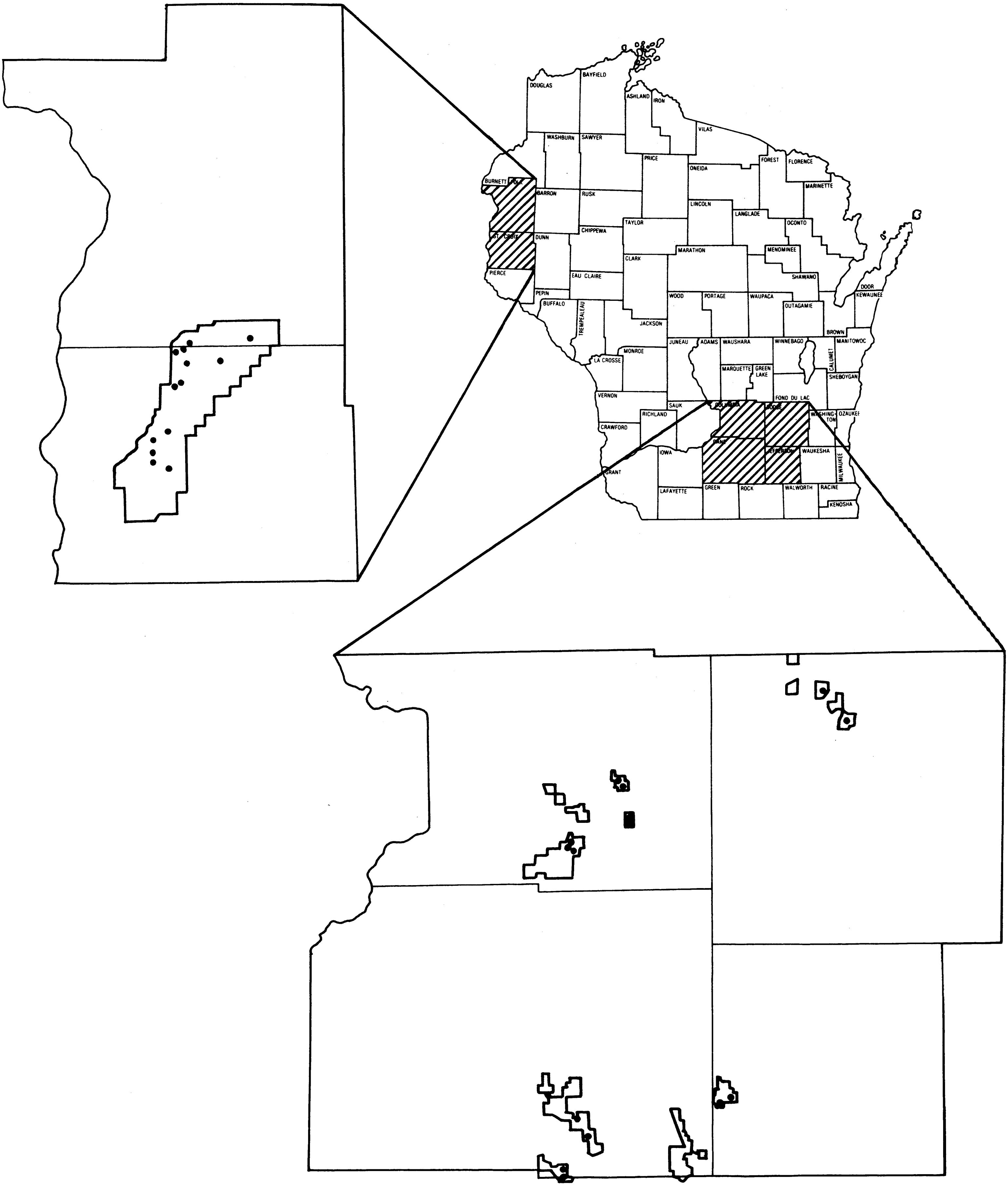


FIGURE 1. *Location of Waterfowl Production Units (WPUs) (outlined) and Waterfowl Production Areas (WPAs) (dots) under study, 1977-79.*

STUDY AREA

The study areas were located in portions of Columbia, Dane, Dodge, and Jefferson counties in south central Wisconsin (referred to as the Southern Study Area or SSA), and in parts of St. Croix and Polk counties in northwestern Wisconsin (the Northwest Study Area or NSA) (Fig. 1). The SSA was 142.6 km^2 and consisted of 11 separate WPUs, ranging in size from 3.9 to 42.2 km^2. Lying within the WPUs were 16 WPAs or 552 ha of purchased waterfowl habitat. The NSA represented a number of wetland complexes enclosed by one WPU measuring 362.6 km^2. The NSA contained 13 WPAs, totalling 854 ha.

The SSA is generally an area of low relief (usually less that 30 m elevation), a result of glacial deposition, with uneven glacial deposits accounting for most of the surface irregularity. Soils are developed from a discontinuous loess covering, glacial till and outwash, lacustrine deposits, and peat and muck of bogs (Beatty et al. 1964). Hole (1976:61) noted the large extent of the wetlands, the variability of soil depth and the high level of natural soil productivity. Approximately 15% of the landscape is occupied by wet mineral soil in numerous lowlands and nearly 10% of the region is in peat and muck soils.

Presettlement vegetation consisted of oak-hickory forests and oak savannas, interspersed with extensive tracts of prairie vegetation (Beatty et al. 1964). Native vegetation has been drastically altered. Today, land use is predominantly dairy farming with a typical alfalfa-corn-oats cropping rotation, with some drained lowland sites devoted to mint and sod production.

The landscape of the NSA is gently undulating with slope gradients rarely exceeding 20%. This area occupies the flat-topped highland regions between the St. Croix and Chippewa rivers. All of the area has been glaciated and the relief has been decreased by glacial deposition (Martin 1965:46). The major soil region of the NSA is one of grayish and sandy loams, derived mostly from local bedrock formation by glaciation (Beatty et al. 1964). Presettlement vegetation consisted of southern hardwood forests, oak savanna, and prairie communities (Curtis 1959:59-62), none of which occupy significant areas today.

Wisconsin's climate is classified as continental, characterized by long, cold winters and short, warm summers (Burley 1964). The growing season is 160 and 130 days in the SSA and NSA, respectively. Mean annual precipitation is about 78 cm in the SSA and 74 cm in the NSA. Late September rains are characteristic, with June being the wettest month and December the driest. Rainfall during July and August occurs mainly as thunderstorms which tend to be erratic and poorly distributed (Burley 1964).

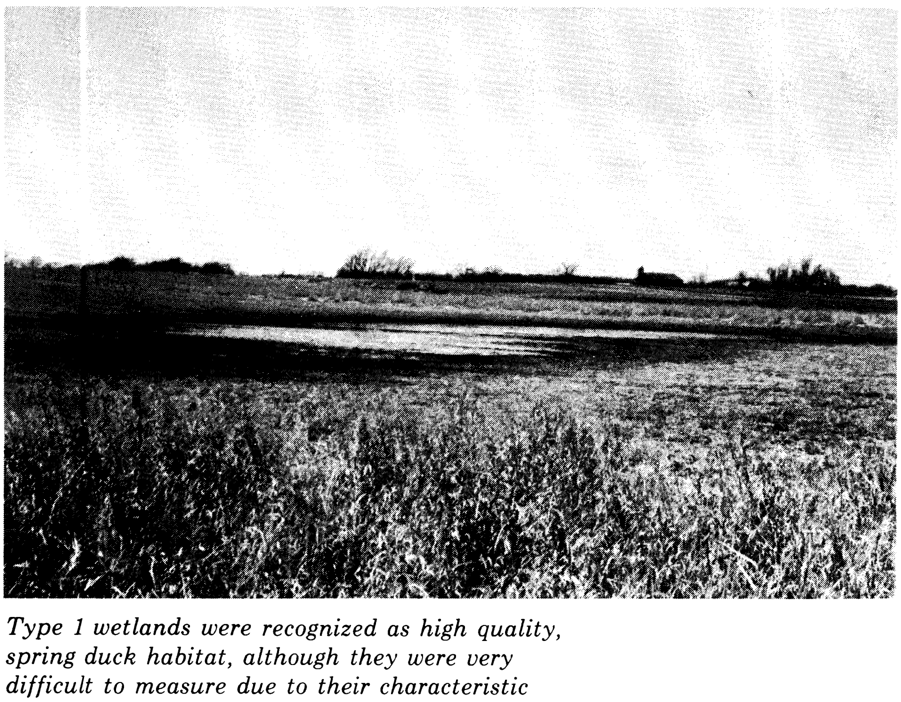
METHODS

HABITAT ANALYSIS

Planning Techniques. Aerial photographs and USGS topographic maps (15′ quadrangles) initially were used to examine the proposed study areas. Due to its large size, the entire NSA could not be examined. Therefore, wetlands were stratified by type (Martin et al. 1953, Shaw and Fredine 1956 as modified for Wisconsin conditions by March et al. 1973, Wheeler and March 1979) and a 10% sample of each type was surveyed for water conditions and wildlife use. Land use was approximated for the NSA by cover mapping a 10% random sample of 65-ha plots.

Aerial photographs were used as field maps to locate and delineate spring water, for recording breeding waterfowl and other observed wildlife, and for cover mapping.

Spring Water Conditions. Surface water, as estimated by the investigators during the spring surveys, was



Type 1 wetlands were recognized as high quality, spring duck habitat, although they were very difficult to measure due to their characteristic ephemeral nature.

recorded on aerial photos and later measured by polar planimeter and grid-dot overlays. Wetland area, as determined by the presence of hydrophytes, also was measured on photos.

Initially, WPU water conditions were monitored monthly during April, May, and June. April water conditions were measured to appraise habitat conditions for early breeding waterfowl and to determine high water marks for individual wetlands. May surface water indicated habitat status for late nesting and renesting ducks, while brood surveys and brood water availability were obtained during the June survey. In 1978, these surveys were modified due to manpower constraints and the inability of the April and June surveys to produce reliable data. The April water survey was confined to WPAs and wetlands within 0.4 km of WPAs.

Wetland Losses. We estimated wetland losses over the past 20 years within the better waterfowl production regions of Wisconsin from two primary sources: (1) wetlands present on 202 randomly selected 16-ha plots from a 1,305-km^2 area in parts of Dodge, Fond du Lac, Green Lake, and Columbia counties (A reexamination of the Scattered Wetlands Study Area (SWSA) of Wheeler and March [1979] that overlapped the SSA); and (2) wetlands on WPUs in south central and northwestern Wisconsin. Losses were categorized by wetland types as defined by Martin et al. (1953), Shaw and Fredine (1956), and Stewart and Kantrud (1971) (Append. III). Type I wetlands (seasonally flooded basins usually cropped and without presence of sedges) were not considered in our analysis as they normally do not hold water long enough for the establishment of moist soil vegetation. Random plots were examined by comparing land use surveys from the late 1950's and 1973 (from W. Wheeler DNR, unpubl. data 1978) with a reexamination of land uses in 1977. Data for the southern WPUs were obtained by comparing wetland surveys from the late 1950's (Wis. Conserv. Dep. 1960, 1961*a*, 1961*b*, 1961*c*) with 1977 conditions determined during this study. Data for the northwest WPU were taken from interpretations of 1958 and 1973 aerial photos, and 1977 field checks.

Cover Mapping. Land uses in both study areas were mapped in 1978. There was little evidence to suggest that cropping patterns underwent substantial annual changes; therefore, cover mapping results from 1978 were used to represent the study period.

Vegetated areas offering potential value as nesting cover were of particular concern, because a lack of nesting cover was a potential limiting factor to waterfowl productivity. A 1.0-km strip of highway right-of-way was estimated to contain 1.0 ha of nesting cover, and a railroad right-of-way was estimated at 1.3 ha of cover/km. Fencelines and ditch banks were not considered to offer potential nesting cover due to their overall poor quality although some were undoubtedly used by nesting ducks. Visual obstruction measurements were made of the residual vegetation available in early April in different types of cover on WPAs using the Robel et al. (1970) method as modified by L. Kirsch (USFWS pers. comm. 1974). The WPA cover types were systematically sampled (stratified random system, approximately 1 sampling station/0.4 ha), measuring height of 100% coverage, maximum height of vegetation, and litter depth. The resulting data allow a quantitative comparison of cover types, and analysis of the developmental stages of dense nesting cover.

Upland managed cover and wetlands protected by the Federal Waterbank Program were identified. The Waterbank Program is administered by the Agricultural Stabilization and Conservation Service (ASCS) and is designed to preserve, restore, and improve wetlands for waterfowl production (Harris and Sauey 1980). Annual payments are provided to enrolled landowners over the 10-year contract period to protect wetlands from uses incompatible with wildlife uses, with additional cost sharing available to develop adjacent upland nesting habitat.

Gross changes in vegetative cover during the study were monitored by using established photo-points. Although uplands subject to management were of primary concern, lowland areas were also sampled.

Hay Harvest Chronology. Domestic hay, primarily alfalfa, harvest chronology was determined by driving selected roadways through and adjacent to WPUs. Hayfields abutting roadways were recorded as either standing or mowed. Partially mowed fields were recorded according to the estimated percentage cut. Transects were run periodically from mid-May until approximately 80% of the selected fields were cut (about the third week in June). The four transects for the SSA (mean length of 49 km) were averaged to provide a mean value for south central Wisconsin. A single transect (45 km) was run in the NSA.

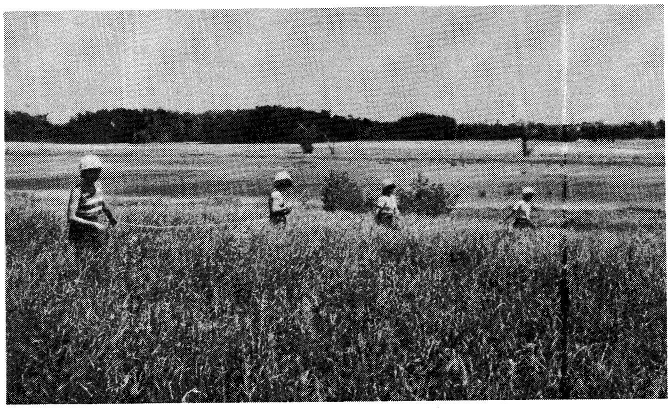
WILDLIFE POPULATION INDEXES

Waterfowl Breeding Pairs. Waterfowl breeding populations were estimated by ground counts. Two breeding pair counts were initially made, one during 15 April through 12 May for early nesting mallards and wood ducks, and the second during 11 May through 3 June for later nesting blue-winged teal and other species. Exact timing of pair counts was dependent on local conditions. An evaluation of data from the 1977 breeding season suggested that consistently higher counts of early nesting ducks were recorded during the later (May-June) pair count. Consequently, the early pair count was discontinued after 1977, and a single mid-May to June breeding pair survey was used. Several NSA marshes used by breeding ringnecks and lesser scaup were resurveyed after the mid-May survey. In 1978, counts were made between 9-25 May and in 1979, from 14 May through 12 June. Pairs, lone drakes, and groups of 5 or less drakes were tallied as breeding pairs (Dzubin 1969). Only waterfowl species known to breed on the two study areas were counted.

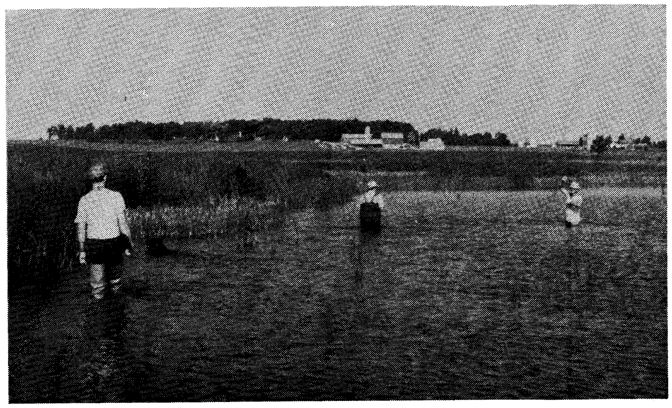
A complete search was made of all SSA wetlands during pair counts. However, on the NSA, breeding pairs were counted only on a 10% random sample of wetland types, due to the large number of study area wetlands, and on all WPAs and wetlands within 0.4 km of WPA boundaries. The 10% sample was expanded to estimate breeding populations on the entire NSA.

The annual Wisconsin Breeding Duck Population survey (March et al. 1973, Hunt et al. 1979), which utilizes both aerial and ground transects, was used to estimate regional waterfowl breeding populations and habitat conditions for the Southeast-Central and Northern High geographic regions (which correspond to the Southern and Northwest study areas, respectively).

Waterfowl Nests and Broods. Nest searches were confined to dense nesting cover and suitable grass-forb cover on WPAs and a nonrandom sampling of harvested hayfields on private lands. WPA nesting cover was searched by 2 observers pulling 15-m rope drags with attached rock-filled cans and by groups of observers walking 2 m apart probing the vegetation with sticks. The latter technique allowed location of nests without the female present (including destroyed, hatched, or abandoned nests), although it was a relatively slow, time-consuming procedure. Searches of hayfields involved walking between windrows of freshly cut and raked hay looking for nest remains. To maximize searching efforts, only mowed hayfields within 0.4 km of surface water were examined. Unmowed WPA cover was searched regardless of the



Upland nesting cover was searched for duck nests using rope drags. Only WPA cover within close proximity of surface water was examined to maximize efforts.



Flush censuses for duck broods were used along with observation counts to estimate duck productivity. Dogs proved to be quite valuable in locating and flushing duck broods from heavy cover.

distance to water. Nest searches on unmowed WPAs and privately owned hayfields were conducted from 27 May to 28 June 1977 and 8-15 June 1978.

In 1977, 2 brood surveys were made during late June through early August. We located broods in the SSA by searching all available WPU water, frequently accompanied by dogs (Keith 1961), and by early morning-late evening vigils overlooking select wetlands (modified after Bennett 1967). NSA brood surveys were conducted on the stratified sample of WPU wetlands and on wetlands within 0.4 km of all WPA boundaries. Brood surveys were supplemented by brood observations obtained incidental to other duties. No attempt was made to band ducklings on the SSA, but banding was conducted on the NSA. An index to duckling production was obtained from the total broods observed, corrected for possible repeat observations. An index to productivity rates was determined by dividing the number of observed broods by the maximum number of breeding pairs counted.

Spring and Summer Pheasant Populations. Pheasant population indexes were obtained from (1) crowing cock tallies within 0.4 km of WPAs during May; (2) pheasant nests and broods observed during waterfowl nest searches; and (3) 5 roadside pheasant brood transects (mean length of 49 km) run during late July through mid-August.

Grassland Breeding Songbirds. Thirteen WPAs in the NSA were examined in 1977-78 for grassland songbirds. Upland fields examined were mainly switchgrass, retired cropland, or pasture. Dominant grass species found were quackgrass, timothy, bluegrass, and switchgrass. Alfalfa, goldenrod, and aster were the common forbs. Songbird populations were estimated using Emlen's (1971) line-transect methods. A 0.42-km transect was established on each WPA, starting 30 m from adjacent fencelines to eliminate edge bias. All birds found within 30 m on either side of the transect line (approximately 2.4 ha) were recorded. Transects were run from one-half hour before sunrise through 8:00 a.m., during 23 June-8 July 1977 and 26 June-15 July 1978.

Marsh Birds. The presence of other summer resident marsh birds was recorded during waterfowl surveys on the SSA and NSA. In addition, breeding black terns and yellow-headed blackbirds were censused on selected wetlands in the NSA. Wetlands were examined up to 7 times during the breeding season, and the highest breeding pair count was used as the estimated breeding population.

Other Wildlife. Observations or signs of many other wildlife species were recorded incidentally to other surveys. These included: predator nests or dens, muskrat use of wetlands, jackrabbits, ruffed grouse, sharp-tailed grouse, bobwhite quail, and gray partridge.

Winter Wildlife Observations. Winter tract transects were run on the WPAs to document winter wildlife use. Transects were walked diagonally across each WPA and number of tracks intercepted were recorded by species and cover types. Transects were walked 24 to 48 hours after a fresh snowfall. On the SSA, 15 transects were run an average of 3.6 times/WPA from 1977-79. In the winter of 1977-78, 11 WPA transects were each conducted in early and late winter. Track counts on the NSA were run only once on each WPA in the winter of 1977-78.

Public Use. Efforts were made to document the type and intensity of public use of WPAs, such as hunting, fishing, hiking, bird watching, and photography. Some use was documented during our wildlife surveys, field checks, and special hunter checks. Individual WPAs were assessed for potential recreational opportunities available.

RESULTS AND DISCUSSION

HABITAT CONDITIONS

Land Use Summary

Land use patterns in 1978 indicated WPUs on both study areas are extensively cultivated, with corn as the predominant crop (Table 1). Hay, usually alfalfa, was the second most abundant crop, and was only slightly less important than corn on the NSA. The amount of corn, in relation to hay and oats, suggests some use of corn as a cash crop especially on the SSA. Cash-crop farming often replaces dairy operations, especially on smaller, marginal farms. Wetlands occupied 17% of the SSA and 8% of the NSA.

A summary of WPA land use indicates that proportionately they contained about twice the percentage of wetlands (Table 2) as found in the surrounding WPUs. On WPAs within the SSA, retired cropland comprised the major land use (40%); 6% of the WPA cropland still produced corn. On the NSA, comparable figures are 11% retired cropland and 2% corn land, with new seeding (primarily switchgrass) the major land use (53%). Cornfields usually were planted and harvested by local farmers as part of share-cropping efforts to establish nesting cover or represented a negotiated agreement from the original transaction.

Annual Wetland Status

May surface water averaged 5.8 ha/km^2 on the SSA and 7.0 ha/km^2 on the NSA. An average of 34% of the SSA wetlands and 91% of the NSA wetlands were covered by surface water in May 1977-79 (exact dates same time as waterfowl breeding surveys). Seven percent of the NSA land area annually held surface water in May compared to 6% surface water on the SSA. Other wetland investigations suggest that the amount of surface water tends to vary considerably among regions. Wheeler and March (1979) reported wetlands covered 11% of the SWSA, and Benson (1964:108) calculated a similar percentage (12%) for Pope County, Minnesota. An appreciably lower percentage of wetlands was found in the Alberta parklands (7%, Smith 1971:16).

Rainfall has a direct effect on the amount of May surface water present; however, this relationship is not always linear. Factors including evapotranspiration, ground water seepage, wetland physiognomy, rainfall rate and timing, and the amount of snowfall can all modify the amount of May surface water. May water was low in 1977 when the September 1976 through March 1977 precipitation was 42% (-14.0/33.0) below normal on the SSA, while abundant water prevailed in May 1979, when rainfall was 28% (9.1/33.0) above normal (Table 3). A similar trend was observed in the NSA.

TABLE 1. *Summary of WPU land use on the southern and northern study areas, 1978.*

	Southern Study Area		Northwest Study Area*	
Land Use Types	ha	%	ha	%
Cultivated lands				
Corn	5,997	42	835	23
Hay	1,728	12	782	22
Oats	434	3	374	10
Winter wheat	133	1	—	—
Other crops**	706	5	29	1
Subtotal	8,998	63	2,020	56
Pasture	497	4	410	11
Woodlots	943	7	481	13
Undisturbed cover[1]	599	4	177	5
Strip cover	174	1	51	1
Miscellaneous[2]	578	4	204	6
Wetlands	2,472	17	284	8
Total	14,261	100	3,627	100

*Represents a 10% sample of the 363 km^2 NSA in 16-ha blocks.
**Includes peas, tobacco, soybeans, and garden crops.
[1]Includes retired cropland and retired pasture.
[2]Includes farmsteads, road pavements, and railroad grades.

TABLE 2. *Summary of land use on WPAs, 1978.*

	Southern Area		Northwest Area	
Land Use Types	ha	%	ha	%
Retired cropland	219	40	93	11
Corn*	33	6	21	2
New seeding	48	9	453	53
Retired pasture**	27	5	31	4
Strip cover**	5	1	7	1
Miscellaneous	9	2	22	3
Woodlots	44	8	55	6
Wetlands	167	30	172	20
Total	552	101	854	100

*Share-cropping efforts.
**Primarily Kentucky bluegrass.

TABLE 3. *Summary of rainfall on southern and northern study areas, 1976-79.*

Study Area and Year	Departures From Normal Precipitation* June-May	September-March	April-June
Southern Study Area**			
1976-77	-32.6	-14.0	- 6.8
1977-78	3.0	- 8.8	17.8
1978-79	19.3	9.1	- 6.9
Normal	76.8	33.0	26.4
Northwest Study Area[1]			
1976-77	-25.6	-19.2	0.6
1977-78	10.5	- 2.7	11.2
1978-79	27.4	4.1	0.2
Normal	77.3	29.1	29.1

*Rainfall in centimeters.
**Data from NOAA, Madison.
[1]Data from NOAA, River Falls.

An examination of surface water by wetland type identified differences between the 2 study areas (Table 4). In May, 70% of the surface water on the NSA was found on Type V wetlands (4.8 ha/km^2), compared to only 18% in Type V's on the SSA (1.1 ha/km^2). Surface water in Type III and IV wetlands combined averaged 22% (1.5 ha/km^2) of the NSA, and 50% (3.0 ha/km^2) of the SSA, respectively. The higher proportion of wetlands that contain surface water on the NSA reflect its higher proportion of permanent wetland types relative to the SSA. The apparent discrepancy in NSA Type V wetlands area (3.0 ha/km^2) compared to surface water found on Type V (4.8 ha/km^2) was believed due to different sampling procedures (Table 4).

Type V basins and areas are not spread out as homogenously as other wetland types throughout the NSA. When a 10% sample of random 16-ha plots was chosen, by chance a disproportionately smaller area of Type V resulted. The Type V wetland area samples were stratified by type and political boundary to supply a more accurate figure.

Wetland parameters for the SSA could not be compared directly to wetland data from the 1,305-km^2 SWSA of Wheeler and March (1979). They did not determine the actual amount of surface water, but instead calculated the total area of wetland basins containing surface water in May; basins with only a fraction of surface water were included as total area. Wetland parameters estimated for the SWSA were, therefore, not based solely on surface water, but instead included some wetland vegetation that was not flooded. However, these dry areas were believed to be minimal (W. Wheeler DNR pers. comm. 1980). Also the proportions of the SWSA wetland types differed when compared to the SSA. For example, the SWSA contained a lower proportion of Types II (34% of SWSA wetland area, 56% of the SSA), IV (5.6% SWSA, 14% SSA), and V (27% SWSA, 6% SSA). The SWSA reflected wetland conditions over a wide geographic region (1,305 km^2), while the SSA represented selected wetland complexes of high waterfowl value within or adjacent to the same region.

April through June changes in surface water were documented only during 1977, a "dry" year. Water losses over the 3-month period were less than expected, 26.7% and 21.0% decreases in the surface waters of the SSA and NSA, respectively. However, the April 1977 surface waters (SSA: 3.8 ha/km^2; NSA: 6.9 ha/km^2) were already below the average levels, and most of the available water was more permanent. April through May water losses accounted for most of the overall reduction (decreasing 16.6% on the SSA, and 19.4% on the NSA). By May 1977, virtually all ephemeral, temporary, and seasonal water had disappeared. Surface water present in June 1977 could be considered the "minimum" amount of available brood water that might be anticipated on our study areas (SSA: 2.8 ha/km^2; NSA: 5.4 ha/km^2).

WPAs in southern Wisconsin averaged 6.8 ha of surface water/km^2 during 1977-79 (a 17% greater water area

TABLE 4. *WPU May surface water and wetland vegetation by year and wetland type, 1977-79.*

Year	Total Surface Water* Total	(yearly mean)	Total Wetland Area*,** Total	(mean)	I	II	III	IV	V	VI	VII	VIII	Dugouts	Ditches	Streams
					Wetland Type in Surface Water and Wetland Vegetation (ha/km^2)										
Southern Area[1]															
1977	494.1	(3.5)			t	t	0.2	1.8	1.1	t		0.1	0.1	0.1	0.1
1978	942.4	(6.6)			0.3	1.4	1.2	2.1	1.1	t	t	0.1	0.1	0.2	0.1
1979	1,053.4	(7.4)			0.1	1.7	1.5	2.2	1.1	0.2	0.2	0.2	0.1	0.2	0.1
1977-79	830.0	(5.8)			0.1	1.1	1.0	2.0	1.1	0.1	0.1	0.1	0.1	0.2	0.1
1978			2,452.7	(17.2)		9.7	1.9	2.4	1.1	0.6	0.3	0.8	0.1	0.3	0.1
Northwest Area[2]															
1977	208.2	(5.8)				t	t	0.9	4.7	0.2					t
1978	260.2	(7.3)				0.1	0.3	1.3	4.7	2.8					t
1979	277.8	(7.8)				0.3	0.4	1.6	5.0	0.5					t
1977-79	248.7	(7.0)				0.1	0.2	1.3	4.8	0.5					t
1978[3]			2,795.1	(7.7)		0.6	1.1	1.7	3.0	1.0		tr	tr	0.4	

*t=< 0.1 ha/km^2; total = total amount of surface water or wetland area; yearly means = amounts in ha/km^2.
**Wetland vegetation calculated for 1978 only.
[1]Examined all wetlands on the 142.6 km^2 study area.
[2]Based on a 10% stratified sample of wetlands.
[3]Based on a 10% sample of random 16-ha plots.

than WPUs); on the May 1978 survey, the same areas had 30.1 ha of wetland vegetation/km^2 (75% more than WPUs) (Table 5). Only 23% of the wetlands in SSA WPAs contained surface water during our May inventories compared to 34% with water on WPUs. In comparison, the NSA WPAs averaged 15.3 ha of surface water/km^2 and 18.5 ha wetland vegetation/km^2. Eighty-three percent of the northern WPA wetlands contained surface water in May, primarily because the NSA consists mainly of the permanent wetland types. Most of the smaller, more temporary wetlands in the NSA have been drained (Table 6).

Wetland density is considered to play an important role in defining an area's carrying capacity for breeding waterfowl (Bellrose et al. 1961, Lynch et al. 1963, Gollop 1963, Crissey 1963, 1969, Pospahala et al. 1974). Bellrose et al. (1961) observed a general relationship between higher wetland numbers and higher breeding pair populations. Stoudt (1952) believed wetland density was more important than the total area of water. However, Dzubin (1969:139) noted a wide variation in breeding pairs per pond from various studies and emphasized such relationships must be tempered by the consideration of pond size, configuration and quality.

Wetland density was not well defined on our study areas as individual wetlands were often quite difficult to delineate (e.g., large and contiguous river floodplain wetlands). Wetland basins containing several discrete areas of surface water in dry years

TABLE 5. *Comparison of WPU to WPA mean May surface water and 1978 wetland vegetation.*

	Percent of Total Surface Water or Wetland Vegetation by Type										
Study Area	II	III	IV	V	VI	VII	VIII	Dugout	Ditch	Creek	Total (ha/km^2)
Southern Area											
Surface water											
WPA	25	26	29	0	7	2	0	8	6	0	6.8
WPU	18	17	33	18	2	2	2	2	3	2	5.8
Wetland vegetation											
WPA	66	12	7	0	8	4	0	1	2	0	30.1
WPU	56	11	14	6	4	2	5	1	2	1	17.2
Northwest Area											
Surface water											
WPA	0	9	37	50	5	0	0	0	0	0	15.3
WPU	1	3	19	70	7	0	0	0	0	tr	7.0
Wetland vegetation											
WPA	2	12	34	42	8	0	0	0	0	0	18.5
WPU	8	14	22	36	14	0	0	tr	tr	5	7.7

TABLE 6. *Recent changes in wetlands by types for a 1,305 km^2 in east central Wisconsin**

	Wetlands			Wetland Losses (ha)							
		Area (ha)									
Years Compared	Type	Total	Net Change	Ditch drain.	Tile drain.	House Const.	Pond Const.	Misc. Losses	Conversion to Other Wetland Types	Total Gains in Wetland Area by Type[1]	Percentage Annual Wetland Change
1958-73**	II	994 to 805	−189	116.5	44.2	2.6	0.5	5.2	41.2	21.4	− 1.3
	III	240 to 216	− 24	19.7					4.7		− 0.7
	IV	2 to 2	0								0.0
	V	448 to 452	+ 3							3.0	+ 0.1
	VI	304 to 231	− 73	36.0	23.0			9.7	42.3	38.1	− 1.6
	VII	16 to 45	+ 29		1.6			2.0		32.2	+12.1
	All	2,004 to 1,750	−254	172.2	68.8	2.6	0.5	16.9	88.2	94.7	− 0.8
1973-77	II	805 to 691	−114	101.3	11.5			6.5		5.5	− 3.5
	III	216 to 186	− 30	21.4				3.3	5.5		0.0
	IV	2 to 2	0								0.0
	V	452 to 452	0								0.0
	VI	231 to 231	0					0.3			0.0
	VII	45 to 45	0								0.0
	All	1,750 to 1,606	−144	122.7	11.5			10.1	5.5	5.5	− 2.1

*Based on a 10% sample of 16-ha plots; a re-examination of the SWSA of Wheeler and March (1979).
**From W. Wheeler DNR, unpubl. data 1977.
[1]Gains in wetland area due to hydrosere succession or man-made changes.

often merged into a single unit when rainfall was above normal. Therefore, we found that wetland density per se could be misleading. For example, in an average year wetlands occupied 11% of the SWSA (Wheeler and March 1979) which was similar to the proportion of wetlands (8-12.5%) found on 3 study areas in Saskatchewan's prairie-parkland region (Millar 1969:73). However, a mean density of 1.9 wetlands/km^2 contained surface water on the SWSA (this is believed to closely approximate the wetland density on our study areas), while Millar (1969:73) found 31.4 to 36.4 wetlands/km^2 in Saskatchewan. Although wetland density may be a key index to duck abundance on Canadian prairie-parkland regions, this more simplistic approach is not directly applicable to wetland-waterfowl relationships in Wisconsin.

Regional Water Conditions

Study area water conditions generally reflected regional trends determined from the May statewide survey of waterfowl breeding habitat. A comparison of 1977-79 water trends in the Southeast-Central and Northern High regions also indicated that 1977 was an abnormally "dry" year, that conditions were slightly above average in 1978, and that 1979 was the wettest of the 3 years (Hunt et al. 1979).

Wetland Losses

SWSA surveys confirm an accelerated rate of drainage in recent years, with an average net loss of 0.8%/year during 1958-73 (W. Wheeler DNR unpubl. data 1977), compared to a 2.1% average net annual loss in 1973-77 (Table 6). Losses of Types II and III accounted for a majority of the decline. The small increase of Type V wetland area (3 ha) is attributed to the construction of dugouts, often used as a drainage technique for Type II and III wetlands. A net increase in the amount of Type VII wetlands (29 ha overall) was due to hydrosere succession of Type VI wetlands, normally maintained by fire in natural communities (Curtis 1959:374-76). From 1958 to 1977, a 13% (254/2,004) overall net loss of wetland area was recorded within the SWSA plots. Ditch length increased 8.7 km from 1973 to 1977. Average annual ditching length increased 4.3%. Over 74% of observed wetland losses were attributed to ditching.

On WPUs in the SSA, an 11.7% net wetland area loss occurred from the late 1950's through 1977, or a 0.6% annual net loss (Table 7). Again, wetland Types II and III suffered most, representing 81% of all losses. Although a similar loss rate was noted for Type IV wetlands (3.6% overall, or 0.2% annually), these losses were especially important due to the value of Type IV's as brood water. Because only 2.6 ha of Type IV wetland/km^2 exists at present and it is important to duck

TABLE 7. *Changes in WPU wetland area by study area in Wisconsin, 1955-77.*

Area and Year	Area of Wetland Types (ha) II	III	IV	V	VI	VII	VIII	Total
Southern Area								
1955*-60	1,040.0	650.8	379.0	61.4	94.4	10.8	38.6	2,275.0
1977	809.6	612.3	365.2	82.0	89.6	10.8	38.6	2,008.1
Percent diff.	−22.2	−5.9	−3.6	+33.5	−5.1	0	0	−11.7
Northwest Area**								
1958[1]	5.9	14.5	59.1	139.6	34.5	26.9		280.5
1977	4.7	10.5	55.4	141.0	34.5	26.9		273.0
Percent diff.	−20.3	−27.6	−6.2	+1.0	0	0		−2.7

*From Wisconsin Conservation Department (1955-60).
**A 10% sample for St. Croix County.
[1]Interpreted from ASCS aerial photographs.

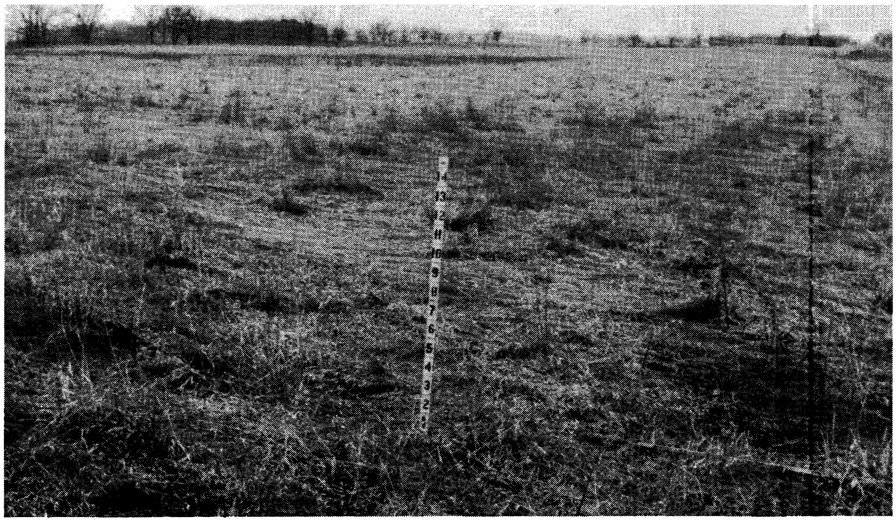
TABLE 8. *Potential waterfowl nesting cover recorded in May, 1978.*

Study Area & Cover Type	Potential Nest Cover (total ha) Found On: Private Lands*	Waterbank	WPA	Total Potential Nest Cover: Area (ha)	Percent of Nest Cover	Percent of Total Area
Southern Area**,[1]						
Retired cropland	100	40	219	359	10	3
Retired pasture	109	104	27	240	7	2
Rights-of-way[2]	168	0	6	174	5	1
Type II wetlands[3]	865	0	97	962	28	7
Domestic hay	1,728	0	0	1,728	50	12
Subtotal	2,970	144	349	3,463	100	24
Northwest Area **, [1]						
Retired cropland	807	56	540	1,403	14	4
Retired pasture	301	60	30	391	4	1
Rights-of-way[2]	507	-	7	514	5	1
Type II wetlands[3]	204	-	1	205	2	1
Domestic hay	7,819	-	-	7,819	76	22
Subtotal	9,638	116	578	10,332	100	29

*Does not include Waterbank.
**Area in ha, percent of total lands examined.
[1]Extrapolated from 10% random sample of the 362.6-km^2 NSA.
[2]Includes strip cover along highway and railroad rights-of-way.
[3]Average amount of Type II wetlands that were dry and produced vegetation sufficient for nesting.

production (Jahn and Hunt 1964, Gates 1965), any additional losses will have substantial impact on brood-rearing over a relatively large area. A 34% net increase in Type V wetlands reflected the greater number of dugouts.

Further wetland deterioration is evident in St. Croix County in the NSA. Although the net wetland loss was only 2.7% from 1958 to 1977, severe losses were recorded for wetland Types II, III, and IV (Table 7). Large areas of Types V, VI, and VII, which were not readily drainable, provided the stability to offset the other wetland losses. Fourteen percent of the individual wetlands disappeared from 1958 to 1977 (17 of 119 wetlands), or 1.0% annually. Wetlands 0.4 ha or less were the most vulnerable to destruction.



Unlike switchgrass, smooth brome did not always provide quality residual nesting cover. After a heavy snow, residual vegetation in this smooth brome field existed in small, isolated clumps.

Availability of Nesting Cover

Twenty-four percent of the SSA land was considered as potential nesting cover; however, half of the potential cover was high risk domestic hay (Table 8). On the NSA, 29% of the total area was potential nesting cover, with 76% of this in hay. In contrast, Wheeler and March's (1979) SWSA contained 19% potential nesting cover, of which 60% was domestic hay.

Dry Type II wetlands when measured in May also made a substantial contribution to available nesting cover on the SSA (7% of the total SSA; 28% of all SSA nesting cover). However, April to May losses of surface water in 1977 (17% on the SSA) suggested that 1/6 of the Type II nesting cover available in May was flooded and unavailable to early nesting ducks in April. Type II cover also constituted a risk to nesting ducks since a majority of Type II wetlands lay in floodplains subject to flooding following heavy spring or summer rains.

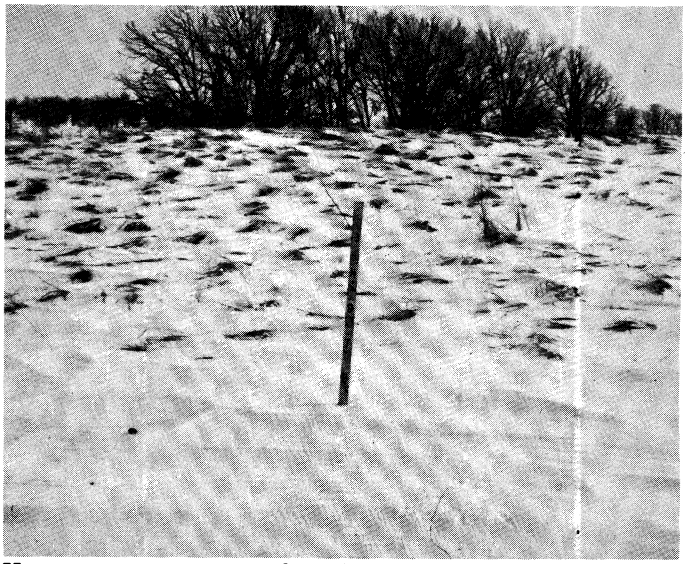
After the mild winter of 1979-80, the same smooth brome field provided excellent residual nesting cover. All the cool-season grasses examined were susceptible to flattening damage by even normal snow cover, thus constituting a management risk as nesting cover on WPAs.

Strip nesting cover along highways and railroad rights-of-way are searched easily by mammalian predators and it offers relatively little secure cover. For example, Wisconsin pheasants had only 26% nesting success for strip cover (Gates and Hale 1975:34).

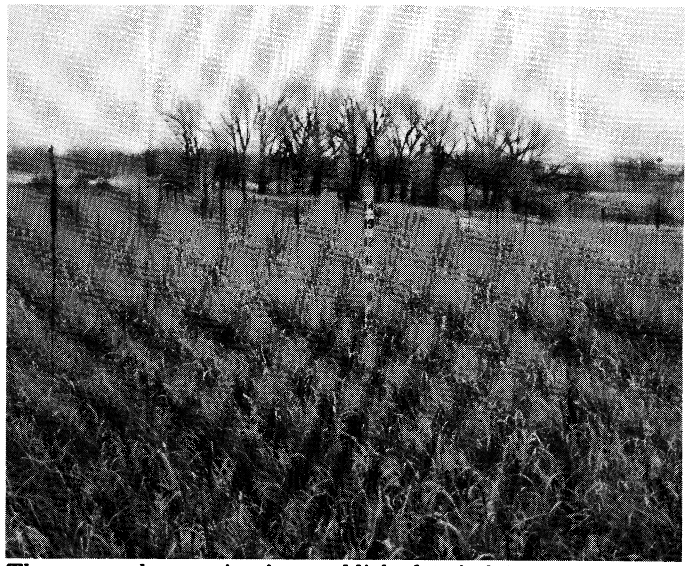
Subjectively, the best (most secure) available potential nest cover appeared to be the retired croplands and pastures, 5% (599 ha) of the SSA and 17% of the potential nesting cover; NSA: 5% (1,794 ha) and 18%, respectively (Table 8). Forty-one percent (246/599) of the best SSA cover was found on WPAs, and 24% (144/599) was located on Waterbank lands. Respective NSA figures were 32% (570/1,794) on WPAs, 7% (116/1,794) on Waterbank lands. Since WPAs are generally scattered across the landscape, they, along with Waterbank parcels are believed to effectively function as the only higher quality nesting cover. Waterfowl habitat that does not benefit from WPA acquisition must depend heavily on Waterbank parcels to provide quality nesting cover. Retired croplands and pastures on private lands (non-Waterbank) were frequently smaller parcels (< 0.4 ha), of low quality cover (open and short vegetation), and in poor juxtaposition with wetlands. Waterfowl nesting activities apparently are influenced by only small portions of the study areas. Under these conditions, a management priority for establishing adequate nesting cover can be identified easily.

Quality of Available Nesting Cover

Residual cover from established switchgrass stands, with a mean obstruction measurement of 3.4 dm, ranked higher than any other vegetative type (Table 9). Switchgrass usually needs several years (3-5) to establish (Woehler 1979), especially when planted with a nurse crop as were those



Heavy snow cover severely reduces the height-density of all residual nesting cover except for switchgrass dense nesting cover. A photo-point in an established switchgrass field shows snow cover at 4 dm in January 1978.



The same photo-point in established switchgrass dense nesting cover taken in April 1978 showing recovery of the residual cover after the heavy snow cover. The height-density of residual switchgrass at this photo-point exceed 7 dm.

TABLE 9. *Growth form parameters of WPA residual nesting cover, 1977-79.*

Areas and Cover Types	Fields Sampled	Height of 100% Density (dm) Mean	Height of 100% Density (dm) Range	Mean Litter Depth (cm)	Mean Maximum Height (dm)
Southern Area					
Established switchgrass	15	3.4	0-11.0	12.3	8.1
Alfalfa-quack	2	1.6	0.5- 4.0	11.6	3.1
Brome	4	1.4	0- 4.5	6.3	5.4
Aster-goldenrod	3	1.3	0- 6.0	5.3	5.1
Warm-season grasses	3	1.2	0- 4.0	8.4	8.6
Canary grass	3	1.1	0.5- 2.0	9.9	2.4
New switchgrass	5	0.9	0.5- 7.0	4.7	4.0
Intermediate wheatgrass	1	0.8	0.5- 3.0	7.8	1.5
Sweet clover	1	0.7	0.5- 2.0	7.5	3.8
Alfalfa-bluegrass	2	0.7	0.5- 1.5	6.8	1.9
Alfalfa	4	0.6	0.5- 1.0	6.0	0.9
Brome-alfalfa	2	0.6	0- 1.5	4.7	1.1
Bluegrass	6	0.6	0- 1.0	4.8	0.8
Northern Area					
Established switchgrass	2	2.1	0- 6.5	4.2	10.4
Quack-annual weeds	2	0.6	0- 1.5	2.3	5.3
Canary grass	6	0.5	0- 2.5	1.9	5.7
Switchgrass plantings**	20	0.5	0- 8.0	1.6	6.0
Timothy	6	0.4	0- 1.5	1.8	3.8
Bluegrass	6	0.4	0- 2.0	2.3	3.7
Bluegrass-quack	44	0.4	0- 6.0	2.2	4.7
Bluegrass-annual weeds	24	0.3	0- 3.5	1.7	4.8
Intermediate wheatgrass	10	0.3	0- 2.0	1.5	4.8
New switchgrass	6	0.3	0- 2.0	0.8	6.0

*Measurements after Robel et al. (1970).
**Older plantings poorly established.

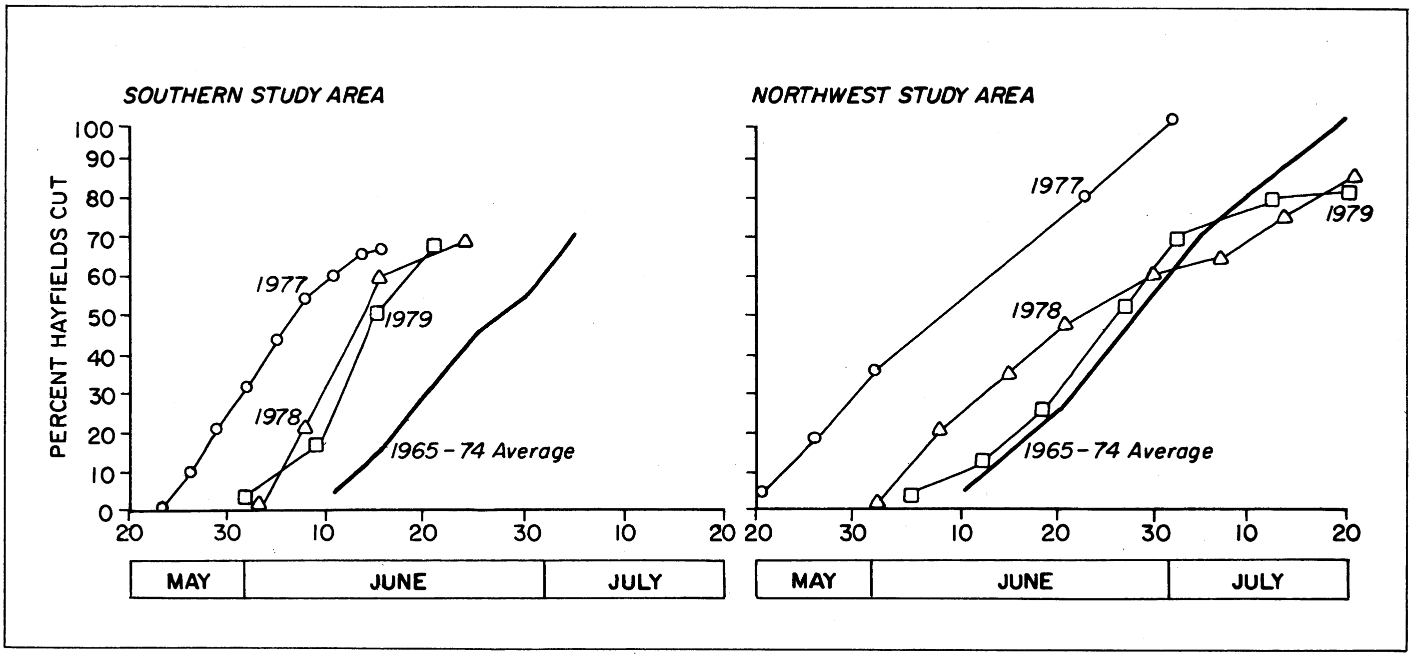


FIGURE 2. *First crop hay harvest chronology, 1977-79.*

stands in the NSA. "New fields" (1-2 years) and "switchgrass plantings" in Table 9 either had not yet developed into quality dense nesting cover or they represented planting failures.

Snow cover affects residual cover height-density in the subsequent spring; heavier snows flatten the cover more severely. The winter of 1978-79 was unusually mild and with little persistent snow cover, consequently several SSA vegetative types provided good residual nesting the following spring. In 1977 and 1978, established switchgrass was the only residual cover type to have mean obstruction values over 1.0 dm.

Our judgments for the quality of waterfowl nesting cover were determined by collating data from studies elsewhere, and our subjective observations on various vegetative characteristics associated with high duck nest density and success. Higher nest density and success in native prairies were associated with excellent range condition (a high proportion of climax vegetation), residual vegetation in a matted mulch condition, and vegetative cover height-density greater than 2.5 dm (Kaiser et al. 1975). No native upland vegetation was sampled in Wisconsin; however, a mixture of seeded warm-season grasses failed to produce obstruction indexes above 1.2 dm. Our sample of vegetation examined was based on availability and is not intended to represent a comprehensive evaluation of waterfowl nesting cover in Wisconsin.

Tall, dense, rank cover has generally been found to support greater densities of duck nests and hatched nests than adjacent cover types (Duebbert 1969, Duebbert and Kantrud 1974, Duebbert and Lokemoen 1976, 1980). High waterfowl production in dense nesting cover may reflect the ability of vegetative characteristics to reduce predation. The dense nesting cover may impede the foraging efficiency of mammalian predators by interfering with olfactory and visual clues, and by presenting a physical barrier to their movements.

In North Dakota, mallards and blue-winged teal preferred fields with the tallest, most dense vegetation (U.S. Fish and Wildlife Service 1978); 100% visual obstruction averages at nest sites were 3.8 dm for mallards (similar to our values for switchgrass), and 2.0 dm for blue-winged teal. Obstruction measurements taken at the nest site, however, would be inflated by vegetative growth occurring since the nest site was selected. Ducks may select a dense, well concealed nest site in an otherwise poor field.

Hay Harvest Chronology

From 282 to 303 and 66 to 72 hayfields were examined annually for hay harvest chronology on the SSA and NSA, respectively. Cutting dates of the first crops varied by year and were affected by weather conditions and insect pests (Fig. 2). Annual harvest chronology appeared to be consistently earlier than previously reported for Wisconsin (Walters et al. 1976). In addition, the reported harvest chronologies for our study areas were minimal as some fields never were cut but were still included in the overall sample. The hay harvest in 1977 was approximately 20 days earlier on both study areas, primarily due to mild weather conditions. During 1978 and 1979, the SSA hay harvest was affected by alfalfa weevil infestations, resulting in 50% harvest levels much earlier than on the uninfested NSA (12-15 June, compared to 26-28 June on the NSA). The primary method of controlling weevil damage was early cutting combined with insecticides.

A recent analysis of first cutting rates over time in southern Wisconsin indicated that by 18 June, percentage completion had ranged from 7 to 35% (J. R. Davies USDA pers. comm. 1980). The most serious implication to hayfield nesting species is that greater proportions of hayfields are being cut earlier than in past years. For example, Davies reported the cutting rate on 18 June is increasing by approximately 1.3% per year. As more hay is cut by 18 June, more hayfield nesting birds will have their nests destroyed or themselves be killed (Gates 1965). This change in land use will have severe negative impacts upon many wildlife species.

BREEDING WATERFOWL NUMBERS

Pair Densities

May breeding pair densities for the study areas were similar per unit of WPU area (SSA: 6.9 pairs/km^2; NSA: 5.9 pairs/km^2), although variation about the NSA mean is large ($\pm$3.9

pairs/km^2 at 95% CL; Table 10). Breeding pair density per unit of May surface water, however, indicated that the SSA (135.4 pairs/100 ha of surface water) was carrying more pairs than the NSA (85.5 pairs/100 ha of water). The higher proportion of Type V wetlands on the NSA (42% of total wetland vegetation as compared to 6% on the SSA) had a major influence on the differences between study area breeding densities in pairs/ha water. An inverse linear relationship was observed between the hectares of May surface water on Type V wetlands and total pairs of breeding ducks by counties in the SSA (Y=64.2 - 0.33, r=0.71). Similar comparisons with other wetland types all proved to be positively related. This suggests that a wetland complex consisting of a few, large Type V's will have less potential to attract ducks per ha of water than a complex consisting of numerous small Types III and IV wetlands. The reduced capacity of Type V wetlands may be related to a higher proportion of deeper, open water, and less interspersed emergents and food resources (Kaminsky and Prince 1981).

WPU breeding pair density varied by wetland type (Table 11). Breeding densities on wetland Types III and IV were relatively high, while Types II and V wetlands held lower densities. The amounts of water examined for wetland Types I, VI, VII, and VIII on the SSA were quite small (< 52 ha surface water in 3 years); densities calculated for these types have a low precision and should be viewed with caution.

Breeding density on WPAs in the SSA, on the other hand, was 1.9 pairs/ha of water, 39% higher than the WPU density. Respective figures on NSA WPAs were 1.0 pairs/ha water, 11% higher than that on the WPU. The major differences in the SSA were due to higher densities on wetland Types II and IV associated with WPAs. However, comparison of duck densities by wetland type or study area must be done with caution. On the SSA, estimates of breeding pairs and water areas approximated total counts, while NSA estimates are based on subsampling wetland types. Study areas also were delineated differently with the NSA encompassing areas with few or no wetlands.

Breeding duck densities are known to vary partially in relation to the amount and type of surface water, but other factors obviously play a role (e.g., habitat quality and population levels). Wheeler and March (1979) suggested a direct relationship between total wetlands and occupancy rate with 2 factors possibly responsible for occupancy rates decreasing disproportionately to the available wetlands: (1) wetlands became less attractive to pairs; and/or (2) ducks declined to a point where fewer of the remaining wetlands were required for their needs. The average breeding density on the SWSA was 3.4 pairs/km^2 (Wheeler and March 1979). The higher densities found on WPUs and WPAs probably reflect our selection of better quality waterfowl habitat as study areas.

TABLE 10. *May waterfowl breeding pair estimates on WPU, 1977-79.*

Species and Study Area	Population Estimates (Pairs/km^2) 1977	1978	1979	Mean (±95% C.L.)
Mallards				
SSA	2.3	1.3	1.7	1.8
NSA	2.3	1.4	1.6	1.8 (±1.2)
Blue-winged teal				
SSA	5.1	3.2	3.9	4.1
NSA	2.9	1.9	2.9	2.5 (±1.5)
All species				
SSA	8.5	5.2	6.9	6.9
NSA	7.6	4.6	5.5	5.9 (±3.9)
	Population Estimates (Pairs/100 ha of Surface Water)*			
Mallards				
SSA	63.8	16.8	21.5	34.1
NSA	37.1	18.5	20.3	25.2 (±25.5)
Blue-winged teal				
SSA	148.3	45.7	49.4	81.0
NSA	49.2	24.2	37.3	36.8 (±31.1)
All species				
SSA	244.6	72.9	88.5	135.4
NSA	127.7	60.3	68.7	85.5 (±91.4)

*NSA population estimates extrapolated from a 10% sample of wetland types; SSA figures represent complete area counts.

Wheeler and March (1979) found that almost all wetland Types III (only those with open water) and IV were occupied (contained at least 1 breeding pair of ducks), and that apparently wetland fertility and food resources were not limiting occupancy rates. The occupancy of an individual wetland by 1 or 2 breeding duck pairs is different from the carrying or holding capacity of that same wetland for additional breeding pairs. There was some evidence that wetlands on our study area could have held or supported greater breeding densities. For example, numbers of mallard pairs found on Schoeneberg's Marsh, a 45-ha Type IV wetland, varied from 4 to 52 pairs during the study, even though the May surface water area remained quite stable (from 42 to 47 ha). Although a single annual breeding survey cannot be expected to provide an accurate estimate of all breeding ducks using a particular wetland, our data strongly suggest that annual mallard densities for Schoeneberg's Marsh changed considerably without any apparent corresponding changes in wetland conditions.

Habitat capacity for breeding waterfowl has been related to 3 factors: (1) pair intolerance; (2) availability of adequate water space (Hochbaum 1944, Stoudt 1952); and (3) food resources (Moyle 1961, Schroeder 1973). Dzubin (1955) believed his study area near Minnedosa (Manitoba) contained more suitable mallard habitat than was utilized. Hand-reared mallards released in mass near Minnedosa increased mallard breeding density to 25.5 pairs/km^2 while control sites remained at 4.6 pairs/km^2 (Sellers 1973). McHenry (1971) was able to increase blue-winged teal breeding densities at Minnedosa from 14 to 21 pairs/km^2 by seeding yearling breeders. This increase of breeding density of blue-winged teal had no effect on the size of home ranges, suggesting the

TABLE 11. *Comparison of average breeding densities on various wetland types of WPUs.*

Area	I	II	III	IV	V	VI	VII	VIII	Dugout	Ditch**	Stream[1]
Southern Area											
Water summary	51.8	436.8	410.0	862.4	469.0	27.9	6.9	49.8	49.5	76.3	51.0
Pairs/ha water	1.4	0.8	1.6	1.2	0.5	0.4	0.5	1.7	3.3	1.7	2.8
Northeast Area											
Water summary*		17.7	26.6	137.8	512.4	49.7	-	-	-	-	0.6
Pairs/ha water		1.6	3.2	1.7	0.4	0.8	-	-	-	-	-

*A 3-year total for the entire study area.
**A 3-year total for 10% sample of wetland types.
[1]Area calculated for ditches/streams based on 6.1 m width.

TABLE 12. *Mean numbers of breeding duck pairs/km^2 associated with WPAs and surrounding areas.*

		Mean Breeding Pairs/km^2								
	WPA Area	Counted on WPAs			Counted Within 0.4 km of WPA			Counted Within 0.8 km of a WPA*		
Area	(km^2)	Mallard	BWT	All	Mallard	BWT	All	Mallard	BWT	All
Southern Area	5.34	2.5	9.3	13.5	2.0	5.4	8.8	1.5	3.6	6.1
Northwest Area	7.95	4.8	5.8	14.4	2.8	4.0	8.8	-	-	-

*Data not obtained for the NSA.

seeded pairs were readily able to occupy vacant breeding niches.

Stewart and Titman (1980) determined discrete, well-defined blue-winged teal breeding territories of 0.7 ha, including the nest site and ponds closest to the nest. Overall, the SSA had 1.2 ha of water/pair of blue-winged teal and the NSA had 2.7 ha of water/pair. These densities suggest that additional teal could be accommodated with the WPUs except for Type III wetlands. However, on the SSA, WPAs had only 0.7 ha of water/breeding pair of blue-winged teal. The higher breeding density of blue-winged teal on SSA WPAs may be attributed to a lack of Type V wetlands (e.g., less productive open water areas), possibly different levels of predatory influence, or better quality waterfowl habitat available.

While such comparisons must be used with caution, the data on average territorial size suggest that some Wisconsin wetlands may still be underutilized by breeding waterfowl. Densities, however, may be related directly to some aspect of habitat quality that may be in a dynamic annual flux rather than to quantity. Adequately defining underutilized waterfowl habitat and determining how to increase use offers a management challenge of considerable magnitude. There is not enough supportive data on the ecological aspects of individual wetlands over time to make a valid determination of the upper limits of breeding pairs that wetlands can support. Some factor totally unrelated to water area (e.g., availability of secure nesting cover) may be influencing the distribution of breeding pairs.

WPA parcels were purchased because they were assumed to represent some of the better waterfowl habitat. An overall view indicates WPAs do provide valuable waterfowl habitat. Breeding densities on WPAs were twice those found on WPUs (SSA: 13.5 pairs/km^2 for WPAs, 6.9 pairs/km^2 for WPUs; NSA: 14.4 pairs/km^2 for WPAs, 5.9 pairs/km^2 for WPUs) (Tables 11, 12). Annual breeding densities of mallards (2.5-4.8 pairs/km^2) and blue-winged teal (5.8-9.3 pairs/km^2) are comparable with densities found in North Dakota by Stewart and Kantrud (1974). WPAs only represented 4% of the WPU area in the SSA. However, within the SSA WPUs, 40% of the ducks were found on or within 0.8 km of WPAs. Breeding densities on land surrounding WPAs were inversely associated with the distances from WPAs. Pair densities within a 0.4-km radius of WPAs were 35-39% less than densities found on WPAs (both study areas). At 0.8 km, SSA duck densities declined another 31%, or 66% less than densities found on WPAs. These results are not surprising, however, since WPAs had twice as much wetland area (30%) as WPUs (17%) (Tables 1, 2). Also nearly half of the better quality nesting cover was on WPAs.

Species composition of breeding populations varied between years and study areas (Tables 13, 14). The proportion of blue-winged teal remained relatively stable on the SSA (range 57-62%), but increased on the NSA during the study (range 38-53%). While the proportion of teal in relation to total populations on NSA increased, the number of blue-winged teal pairs counted remained the same (104-105 pairs). The changes in the species composition on the NSA primarily reflect decreases in ruddies and other diving ducks in response to changing

TABLE 13. *Percent composition of breeding waterfowl on WPUs, 1977-79.*

Species	Southern Area 1977	Southern Area 1978	Southern Area 1979	Northwest Area 1977	Northwest Area 1978	Northwest Area 1979
Blue-winged teal	60	62	57	38	41	53
Mallards	27	24	25	30	30	29
All other species	13	14	18	32	29	18
Wood duck	3	2	10	9	4	11
Ruddy duck	1	1	2	14	11	1
Pintail	3	1	1	1		
Scaup				2	3	
GW teal	1	1	2	tr		
Ringneck				3	7	1
Gadwall	1	2	1	tr		
Shoveler	1	3	tr		1	1
Widgeon	2	1	tr	tr		1
Redhead	tr*	1	tr			
Black duck	tr		tr			
Canada goose	tr	1	1	2	3	2

*tr = < 0.5%.

TABLE 14. *Comparison of mean WPU and WPA breeding waterfowl species composition,* 1977-79.*

Species	Southern Area WPU	Southern Area WPA	Northwest Area WPU	Northwest Area WPA
Blue-winged teal	60	69	44	40
Mallards	25	19	30	33
Wood ducks	5	8	8	2
Ruddy ducks	1	0	9	11
All other species	9	4	9	13

*In percent composition.

TABLE 15. *Regional breeding duck population estimates from Wisconsin, 1976-79.**

Regions and Years	Mallard	% Comp.	Blue-winged Teal	% Comp.	Other Species	Total	Percent Change Between Years
Southeast-Central							
1976	49,500	28%	115,500	66%	9,500	174,500	
1977	25,700	27%	56,200	60%	12,500	94,400	−46%
1978	30,000	26%	62,300	54%	22,900	115,200	+22%
1979	52,800	32%	96,500	59%	13,300	162,600	+41%
Northern High							
1976	13,300	24%	29,600	53%	12,700	55,600	
1977	18,200	20%	49,000	53%	25,400	92,600	+67%
1978	28,300	36%	20,300	26%	30,700	79,300	−14%
1979	30,000	50%	21,800	36%	8,200	60,000	−24%

*Data from Hunt et al. 1979.

TABLE 16. *Waterfowl nest search summary, 1977-78.*

Cover Type and Area	Area Searched (ha) 1977	Area Searched (ha) 1978	Nests Found/100 ha (n): Mallard 1977	Mallard 1978	Blue-winged teal 1977	Blue-winged teal 1978	All 1977	All 1978
Mowed alfalfa*	37.6	25.6	18.5 (7)	4.0 (1)	58.1 (22)	35.1 (9)	77.1 (29)	43.0 (11)
Unmowed WPA vegetation**	112.9	83.0	0	0	9.6 (11)	5.9 (5)	9.6 (11)	7.2 (6)
SSA subtotal	150.5	108.6	4.7 (7)	0.9 (1)	21.9 (33)	12.9 (14)	26.6 (40)	15.7 (17)
Mowed alfalfa*	49.8	42.8	0	4.7 (2)	0	9.4 (4)	28.2 (14)	14.1 (6)
Unmowed WPA vegetation**	0	54.6	0	1.7 (1)	0	0	0	1.7 (1)
NSA subtotal	49.8	97.4	0	3.1 (3)	0	4.1 (4)	28.2 (14)	7.2 (7)
Total	200.3	206.0	3.5 (7)	1.9 (4)	16.5 (33)	8.7 (18)	27.0 (54)	11.7 (24)

*June surveys; all examined fields within 0.4 km from water; 155.8 ha in total searched.
**Only WPA vegetation examined; 250.5 ha in total searched.

water conditions. The proportions of mallards remained essentially stable on both study areas during 1977-79. Percentages of wood ducks (annual range: 2-10%) and ruddies (1-2%) also increased in the SSA in 1979.

Blue-winged teal pairs accounted for greater proportions of the average breeding population on WPAs than found overall for WPUs on the SSA (Table 14). Conversely, mallards and all other species combined accounted for larger proportions of the average WPU population. Mallards accounted for a greater proportion of the WPU population even though the mean mallard density was 33% higher on WPAs. This greater mallard density on WPAs was completely obscured by the larger number of blue-winged teal also present on these areas (a 122% higher mean density than found for WPUs). Larger home ranges, and possibly different habitat needs, could limit the number of mallard pairs using individual WPAs. Dzubin and Gollop (1972) noted that breeding mallards in habitat containing ponds larger than 1.4 ha showed a more flexible social structure, and had a greater tolerance to neighboring pairs. Stoudt (1969) and Drewien and Springer (1969) observed an inverse relationship between breeding density and pothole size. WPAs tend to have smaller wetlands. Difference in availability of wetland types on WPAs and WPUs also may be involved with ducks showing a preference for different wetland types. On the SSA, wetland Types II and III made up only 35% of the WPU water area, but provided 51% of the WPA water area. Interestingly, SSA waterfowl trends are weaker and opposite those of the NSA (Table 14), yet the Type II and III wetlands are also more abundant on WPAs than WPUs.

Species composition of the SWSA breeding population (Wheeler and March 1979) was similar to that found on SSA WPUs. Wheeler and March (1979) found no changes over 3 years in mallard or blue-winged teal proportions even though mean densities changed numerically by as much as 37%. The SSA breeding densities, representing estimates from all study area wetlands, also showed variable mallard (range: 1.3-2.3 pairs/km^2) and blue-winged teal densities (3.4-5.1 pairs/km^2).

Regional Trends

The 1977-79 regional breeding duck population estimates (Hunt et al. 1979) showed somewhat different trends than our data (Table 15). March et al. (1973) indicated that the regional aerial waterfowl surveys should be able to detect a 20% change between years; therefore, regional changes less than 20% are unreliable. However, some general trends can be examined. On the SSA both mallard and blue-winged teal densities declined between 1977 and 1978, then increased slightly in 1979 (Table 10). Southeast-Central regional mallard and teal populations increased annually between 1977 and 1979. On the NSA, population densities tend to agree with regional trends for bluewings in all 3 years, but mallard trends differed between 1977 and 1978 (Tables 10, 15).

When regional trends are expressed on the basis of percent composition, there were smaller proportions of mallards and blue-winged teal in both the Southeast-Central region and the SSA (Tables 13, 15). However, the species composition of the NSA differs considerably from the regional composition (Tables 14, 16). The regional survey covered a much larger geographic area of northern Wisconsin and our relatively small NSA study area apparently did not parallel regional trends.

WATERFOWL NESTING SUCCESS AND PRODUCTION

Limitations of Survey Techniques

Waterfowl production surveys were intended to provide relative indexes to differences between managed WPAs and unmanaged WPUs. However, statistically reliable estimates could not be attained because of manpower constraints and low waterfowl breeding densities. The lateness of nest searches limited sample sizes and biased findings, especially for mallards. On the SSA, 196 ha of unmowed WPAs were searched without locating any nesting mallards; 16 of the 17 nests found were from blue-winged teal.

The searching of selected wetlands ("beat outs") did not provide a satisfactory index to annual brood production. During the relatively dry summer of 1977, broods were highly visible on the few remaining wetlands. However, the situation changed drastically in 1978-79. The low water level in 1977 promoted a heavy growth of emergent vegetation on both permanent and temporary wetlands, and broods were not readily observed. In the early morning or late evening, observations of open brood water helped locate some broods in 1978 and 1979. However, sample sizes were small and are not believed to provide a representative index to actual brood production for all wetlands. Overall, duck nesting and production surveys did not fully achieve the desired objectives, and must be interpreted with caution.

Nest Densities and Preferred Cover Types

For both study areas in both years, 406.3 ha of cover (155.8 ha of mowed alfalfa and 250.5 ha of unmowed WPA vegetation) was searched for nests (Table 16). Nest densities in mowed alfalfa declined by almost half from 1977 to 1978 on both study areas. Although the samples were smaller, the decline appeared to be less in extent for nests in the unmowed vegetation. The decline in nests generally agrees with decreases in study area breeding duck populations in 1978.

Duck nest densities were higher on the SSA than on the NSA, even though the mallard nest densities in mowed alfalfa were similar for both study areas. The difference in total nest densities between study areas follows the higher density of blue-winged teal on the SSA. Our early searching procedures favored an increased probability of locating blue-winged teal nests. Several nesting hens, killed during hay cutting operations, also were found during our searches. Hens were killed on 10% (3 of 31 nests) of the blue-winged teal hayfield nests found on the SSA. We found no evidence of mallard hens being killed, although discussions with local farmers indicated their vulnerability also.

Duck nest density ranged from 7.2 to 9.6/100 ha on WPAs in the SSA, and 1.7 nests/100 ha were found on WPAs in the NSA. WPA nest densities for all duck species in the SSA decreased 25% between 1977 and 1978, again agreeing with the lower number of breeding ducks counted in 1978. Nest densities in mowed alfalfa cannot be compared to WPAs because of the different searching techniques involved. We anticipate greater nest densities (and breeding pair use) on the WPAs over time as the overall quality of the nesting cover improves (taller and more dense). Quality nesting cover should lead to greater hen success; successful hens, their offspring, and unsuccessful hens from other cover types all should make more use of the better quality, managed vegetation.

Hatching chronologies are based only on the 1977 brood observations (Figs. 3 and 4). In 1978 and 1979, sample sizes of broods were too small (less than 12/year) to develop adequate hatching curves. The mallard hatching

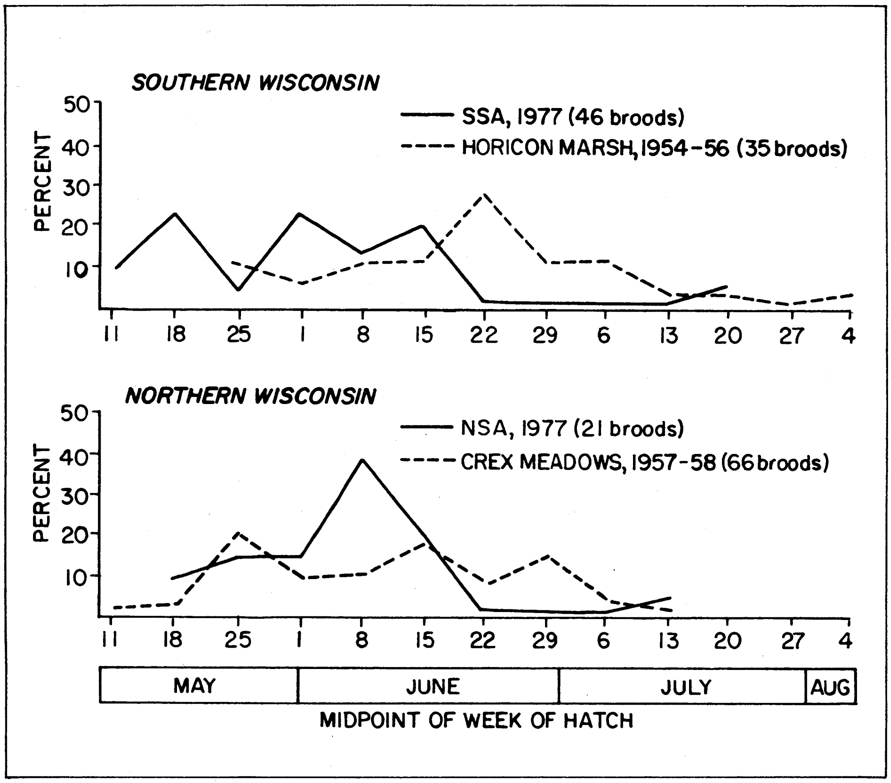


FIGURE 3. *Mallard hatching chronology on Wisconsin WPUs, 1977.*

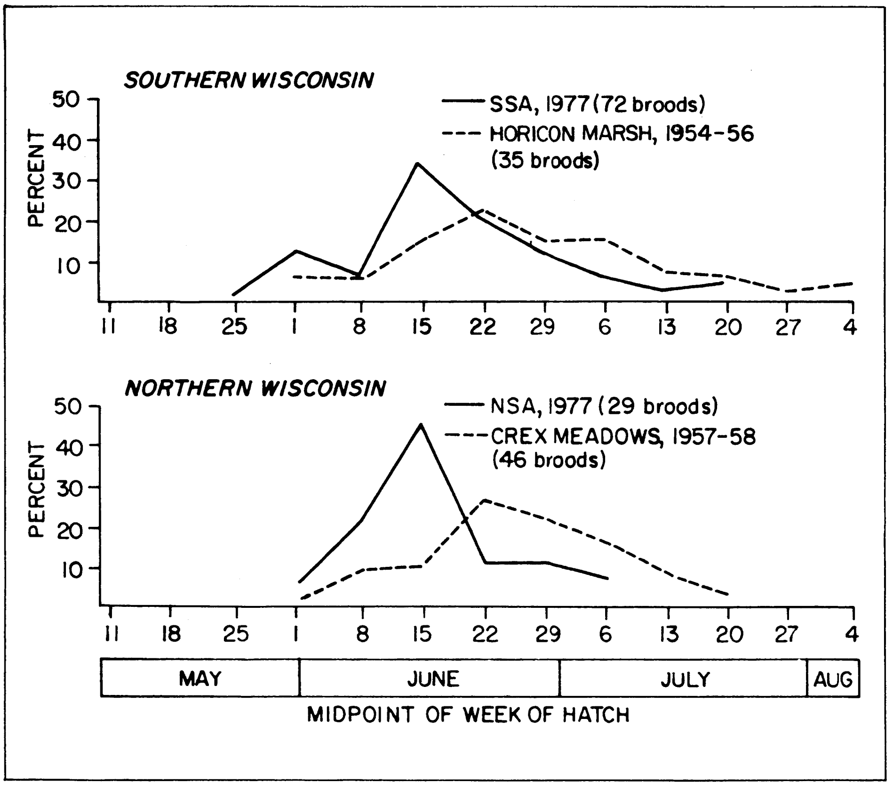


FIGURE 4. *Blue-winged teal hatching chronology on Wisconsin WPUs, 1977.*

curve for the SSA was multi-modal in 1977 (peaks on 18 May and 1, 15 June) and generally earlier than the Horicon hatching curve for 1954-56 (Jahn and Hunt 1964) (Fig. 3). Wheeler and March (1979) also found a bimodal hatching curve, however, the 1973-75 peaks occurred later than on the SSA in 1977. The small proportion of broods hatching about 25 May 1977 may have been due to nest destruction caused by wide-scale plowing of Type II wetlands on the SSA. The mallard hatch peaked on the NSA at 8 June 1977, which was about 2 weeks later than the first peak for mallards recorded at Crex Meadows Wildlife Area in 1957-58 (Jahn and Hunt 1964).

Blue-winged teal hatching curves for both the SSA and the NSA peaked on 15 June 1977 (Fig. 4). On the SSA, this was a week earlier than the average peak obtained in 1954-56 at Horicon (Jahn and Hunt 1964) or in 1973 and 1975 on the SWSA by Wheeler and March (1979). The 1974 blue-winged teal hatch peaked much later—between July 3-9 (Wheeler and March 1979). Since hatching curves are based only on successful nests, their usefulness is somewhat limited. Peaks in nest initiation, based on all nesting attempts, would provide more useful data for cover management, and collating these peaks to the growth of nesting cover would offer better insight to nest site preferences.

Reproductive Success

A minimum of 18% and 16% of the breeding mallards and blue-winged teal pairs, respectively, hatched broods. Wheeler and March (1979) reported a 3-year average reproductive success (generally nondrought years) of 30% for mallards, 31% for blue-winged teal, and 29% for all duck species. The dry spring of 1977 had a major influence on the poorer reproductive performance recorded on our study areas. The excellent June-July water conditions and heavy vegetation growths in 1978-79 should have resulted in good to excellent brood survival during those years, although an adequate sample of broods was not made. 1978-79 breeding pair success at rearing broods was probably greater than the 17% recorded in 1977. A 17% reproductive success indicates unstable breeding populations even assuming a high rate of homing by both adults and juveniles. Pioneering was assumed to play an important role in maintaining breeding populations on the SWSA (Wheeler and March 1979), and it appears that a similar situation may exist on our study areas as well.

TABLE 17. *Potential brood water on WPUs, 1978.*

Area and Wetland Type	Potential WPU Brood Water (ha)			
	Private Lands	Waterbank	WPA**	Total
Southern Area				
Type III	217 (29)	32 (4)	19 (3)	268 (36)
Type IV	291 (39)	27 (4)	17 (3)	335 (45)
Type V	131 (18)	13 (2)	0	144 (19)
Subtotal	639 (85)	72 (10)	37 (5)	747 (100)
Northwest Area				
Type III	325 (17)[2]	0.4 (t)	18 (1)	343 (18)
Type IV	471 (24)	15 (1)	54 (3)	540 (28)
Type V	961 (50)	30 (2)	62 (3)	1,053 (54)
Subtotal	1,757 (91)	46 (2)	133 (7)	1,936 (100)

*Does not include Waterbank area.
**1978-81 WPA acquisition efforts on the SSA have produced the following changes: Type III:43 (6), Type IV:50 (7); Type V:3 (1). NSA changes: Type III:24 (1), Type IV:96 (5), Type V:114 (6).
[1]Percent
[2]Estimated from a 10% random sample of 16-ha blocks, less Waterbank and WPA estimates.

TABLE 18. *Potential brood water associated with WPAs and surrounding areas, 1978.*

Area and Wetland Types	Potential Brood Water (ha)	
	WPA	Within 0.8 km of WPA
Southern Area		
Type III	19	104
Type IV	17	136
Type V	0	10
Subtotal	37	250
Northwest		
Type III	18	46
Type IV	54	184
Type V	62	329
Dugout	0	tr
Streams	0	7*
Subtotal	133	559

*Stream measured in km.

The 1977 brood production on WPUs in the SSA averaged 1.2 broods/km^2 and 0.43 broods/ha of June surface water. Comparable figures for the NSA were 1.3 broods/km^2 and 0.21 broods/ha of surface water. Brood production on WPAs was 61% higher than on WPUs in the SSA, and 28% higher in the NSA. Higher brood densities on WPAs are probably related to the greater availability of water. Brood density on the SWSA during a "dry" year (1975) was 0.6 broods/km^2, compared to a 1973-75 mean value of 1.0 brood/km^2 (Wheeler and March 1979). The higher hen success on the SWSA is probably related to better habitat conditions overall in 1973-75.

Abundance and Availability of Brood Water

A previous study of duck production in Wisconsin farmlands suggested that a deficiency of brood habitat limits brood survival and production (Gates 1965). Approximately 70% of the SSA, and 90% of the NSA wetland area could function as brood (May-August) water if rainfall is abundant (Tables 4, 17). Realistically, permanent brood water would consist mainly of wetland Types IV and V, which represent 57% of the water available in May on the SSA, and 87% of the NSA May surface water. Surface water was calculated during May, and while some May through June water losses are anticipated, such losses would be minimal for the more permanent wetland types. Wheeler and March (1979) reported that all available wetland types were utilized by broods; however, lakes and Type IV wetlands were clearly the more heavily used areas, with approximately one-third of the Type III wetlands also attracting broods. Brood utilization was believed to be determined by the presence or absence of surface water, rather than wetland fertility and associated food resources (Wheeler and March 1979). Approximately 3% of the SSA, and 6% of the NSA represents permanent brood habitat. Although no criteria have been developed to determine how much brood water is necessary for optimum productivity, WPU brood water currently appears adequate for the existing breeding duck populations. The average WPU breeding density on the SSA is 6.9 pairs/km^2, about 0.5 ha of brood water/breeding pair. Conditions on the NSA appear even more favorable, with about 1.0 ha of brood water/breeding pair.

Proper juxtaposition of brood habitat may be a problem on the Wisconsin WPUs. Permanent water tends to be found in fairly large tracts (> 10 ha), with many breeding pair wetlands 0.8 km or more from secure brood habitat. This problem became evident during dry 1977. From April through June, water area declined 21-26%; wetland Types II and III were almost completely dry, and many Type IV wetlands had exposed mud flats. Only relatively isolated lakes and large Type IV wetlands (> 25 ha) remained relatively functional as brood habitat.

SSA WPAs may lack sufficient brood habitat, especially in dry years (Table 18). In 1977, we observed higher brood densities on SSA WPA wetlands than on wetlands 0.4-0.8 km away. However, these observations indicated a pair success of only 8% compared to an estimated pair success of 17% for SSA WPUs overall. Eighty-five percent of SSA brood water is on private lands (Table 18) with 10% in Waterbank lands and only 5% in WPAs. While privately owned Type V wetlands are in less danger of being altered, two-thirds of all potential brood habitat is in privately owned Type III and IV wetlands. The loss or modification of Type III and IV wetlands remains a potential limitation to maximizing waterfowl production on and around SSA WPAs.

NSA WPAs do not appear to lack brood habitat. Large expanses of more drainage-resistant Type V's surround them (Table 18) and many of the Type IV wetlands within 0.8 km are owned in part, precluding drainage. However, still drainage-vulnerable Type III and IV wetlands and rapidly proliferating nondrainage wetland alterations (Table 8) may limit potential waterfowl production.

Preliminary Wisconsin DNR guidelines for waterfowl habitat acquisition recommend that brood habitat should be acquired in a 1:4 ratio with managed nesting cover (J. Wetzel DNR pers. comm. 1980). If a reasonable objective for managed cover would be at least 2.5 nests/ha, and there was a minimum of 70% nesting success, a 1:4 ratio of brood water to upland nest cover would provide 0.12 ha of surface water/brood on WPAs. Only 0.12 ha of brood habitat/brood would not seem adequate if maximum production and duckling survival is to be achieved. Gates (1965) judged the 0.24 ha brood habitat/brood inadequate and a major factor in limiting duck production in east central Wisconsin farmland.

ASSOCIATED WILDLIFE

Ring-necked Pheasant

Crowing cocks were associated with every WPA on both study areas. On the SSA, WPAs averaged 2.7 cocks/km^2 (ranging from 1.9 to 3.2/km^2). Within 0.4 km of WPAs, there were an average of 1.1 cocks/km^2 of land. NSA counts were conducted in 1978 and 1979. On the northern WPA, 0.8-1.8 cocks/km^2 cocks were heard, and 2.3 cocks/km^2 were heard within 0.4 km of WPAs. The Waterloo Wildlife Area (Jefferson and Dodge counties) averaged 1.2 crowing cocks/km^2 from 1963-74 (E. Woehler DNR pers. comm. 1980), although these data were obtained when statewide pheasant population levels were higher.

The relative number of pheasant hens present annually was determined by multiplying the number of cocks heard on the crowing counts by the combined winter sex ratio for the counties containing WPAs. Mean winter sex ratios for the SSA were 3.1 females/cock in 1977-79 (A. Rusch DNR pers. comm. 1980). Total hen estimates for SSA WPAs ranged from 6.7 to 13.8 hens/km^2. Within 0.4 km of the WPAs there was an estimated average of 3.5 hens/km^2. On the NSA WPA, the mean winter sex ratio was 1.8 hens/cock, indicating a hen population of between 4.2 to 4.8 hens/km^2 within 0.4 km of the WPAs.

On the SSA, 12 pheasant nests were found destroyed (19 nests/100 ha) in 63 ha of mowed hayfields. Eight hens were killed by hay mowers, plus an additional hen and her 1-2 day old brood. Gates and Hale (1975) found 49 pheasant nests/100 ha of mowed hayfields in east central Wisconsin. On the NSA, 2.2 nests/100 ha were found in 93 ha of mowed hayfields. No hen mortality was observed.

Our rope-can drag searches only located 5 active nests (2.5 nests/100 ha nesting cover) and 12 broods (5.9/100 ha) in 203 ha of nest cover during 1977-78. The rope-can drags underestimated pheasant nests because some nests hatched prior to searching, and some nests could be missed if the hen did not flush. No pheasants were found on the 55-ha nesting cover searched in the NSA.

An average of 3.1 pheasant broods/100 km (range: 1.9-3.6) was recorded during roadside pheasant brood transects in the SSA. Observed brood densities varied by county, ranging from 1.0 to 7.1 broods/100 km. The NSA brood transect averaged 2.8 broods/100 km in 1978 and 1.0 broods/100 km in 1979. Brood surveys conducted in southern Wisconsin study areas during 1971 found 10.7 broods/100 km (Petersen 1972).

Although Wisconsin's pheasants have generally decreased during the late 1970's (Kabat 1978, D. Thompson DNR pers. comm. 1980), local populations appear to be responding to the improved nesting and winter cover developed and maintained on WPAs. WPA nesting cover seems to function as "bait cover" by attracting breeding pheasants away from insecure hayfields early in the season. WPAs provided 41% of the secure nesting cover available on our SSA, and 32% on the NSA. These nesting areas represented "islands" of permanent herbaceous vegetation scattered across intensively cultivated croplands. Pheasants also were observed using dense switchgrass nesting cover as winter cover when snowcover was generally less than 10 cm. As cover conditions improve on WPAs, increased pheasant nest density and survival can be anticipated. The overall outlook for pheasants on WPAs looks quite promising.

Marsh Birds

Nineteen summer resident marsh bird species were recorded on the SSA (Table 19) of which 12 were thought to have nested on WPAs. Wilson's phalaropes, rare summer residents (Gromme 1963), were found on 2 WPAs. During the study period, no sandhill crane nests were found on WPAs but at least 1 breeding pair was consistently found immediately adjacent to a Columbia County WPA. In 1980, a nest was located on a WPA in Columbia County.

Thirty-six summer resident marsh bird species were found in the NSA. At least 18 of the 35 species seen on the WPAs used them for nesting and brood rearing. Nearly all the shorebird species listed were seen migrating through the NSA each year, but decreased in occurrence as summer residents from 1977 through 1979 as the extensive mud flats exposed in the 1976-77 drought were reflooded.

Many fish- or amphibian-eating species used NSA WPAs because of the greater abundance of Type V wetlands.

The invisibility of some species may have biased their status designation. The American or least bitterns, for example, may be more common than listed but were not seen because of their secretive behaviors and excellent camouflages.

In 1977, 401 territorial male yellow-headed blackbirds were found on 23 of 25 wetlands counted in the NSA, averaging 17 males/occupied wetland (range of 1 to 107 males/occupied wetland). In 1978, only 112 males (-72%) were located on 12 of the 25 wetlands for an average of 9 males/wetland (range of 1 to 22 males/occupied wetland).

Because changes in numbers of territorial males reflect sampled wetlands only, they cannot be extrapolated to the entire NSA. Lederer et al. (1975) suggested that the number of available nesting sites is influenced by water depth, weather, and habitat size which can vary from year to year. Also, the degree of previous breeding success may influence the number of adults returning.

During the dry conditions in 1977, yellowheads were concentrated into fewer areas of suitable habitat and for the most part only wetlands containing yellowheads were sampled. The increased water levels in 1978 encouraged yellowheads to expand their breeding activities into other suitable habitat. Overall, yellow-headed blackbirds were found throughout the NSA, and are a common part of its wetland avifauna.

Grassland Songbirds

On the NSA, 16 species of songbirds associated with grasslands were found on 13 WPAs (Table 20). The species most frequently observed were bobolinks, red-winged blackbirds, and grasshopper sparrows. Eight species were found on at least half of the WPAs. Each grassland species has different requirements for litter depth, height and density of the vegetation, degree of wetness, and the extent of bare ground. These differences could account for the variation in use of WPAs by individual species. Overall, 648 songbirds were found/100 ha of grassland.

The 1966-75 Wisconsin breeding bird surveys showed a marked decrease for several species found on the NSA surveys including dickcissels, grasshopper, vesper, and field sparrows (Robbins 1977). Declining numbers of these species have resulted in their inclusion on the "watch" list for Wisconsin birds (Les 1979). The Le Conte's sparrow, a rare summer resident in Wisconsin (Gromme 1963), was also found. Species such as sedge wrens and Le Conte's sparrows are not strictly oriented to grasslands, but are more commonly found in wetter habitats (Green and Janssen 1975). It is expected that as the grassland WPA areas increase, associated species will respond in a similar manner.

Other Upland Game Birds

On the SSA, gray partridge were found on 4 of 15 WPAs. One 34-ha WPA in Dane County was used by at least 3 pairs of gray partridge during spring 1979. Bobwhite quail, locally common in the SSA, were found within 0.4 km of only 1 Columbia County WPA.

Ruffed grouse were heard drumming on 2 WPAs of the NSA and 3 other WPAs had grouse within 0.4 km of their boundaries. On the SSA, ruffed grouse were observed on 1 WPA, and within 0.4 km of 2 other WPAs. Woodcock were flushed on 5 of the 15 WPAs in the SSA and probably nested on them. A sharp-tailed grouse was flushed from 2 NSA WPAs.

Winter Wildlife Observations

Based on SSA winter track counts, there was little difference in wildlife use between early and late winter in 1977-78 (Table 21). Red fox and striped skunk use increased due to increased movements during the breeding season. Cottontail rabbits, gray and fox squirrels, ring-necked pheasants, red fox, mink, and weasels were found on over two-thirds of the WPAs. Deer wintered on 8 of the 15 WPAs. Songbirds also made heavy use of some WPAs. With increased snow depths in 1977-78, large flocks of snow buntings were observed on both study areas feeding in switchgrass fields where seedheads were at snow level.

Cottontail rabbits, gray and fox squirrels, ring-necked pheasants, red fox, mink, weasels, and striped skunks were found on NSA winter track counts. White-tailed jackrabbits, rare in much of Wisconsin, were found on 5 of 13 WPAs.

Winter track counts could not always be carried out as planned due to a lack of snow cover or poor tracking

TABLE 19. *Occurrence of summer resident marsh birds on WPU wetlands, 1977-79.*

	Southern Area			Northeast Area		
Species Observed	Status[1]	No. Wetlands	Total Sightings	Status	No. Wetlands	Total Sightings
Common loon**				u	4	4
Pied-billed grebe *,**	c	23	23	c	31	46
Red-necked grebe**				u	5	6
Double crested cormorant**				r	2	2
Great egret**	u	8	13	c	16	22
Great blue heron**	u	13	15	c	50	72
Green heron*,**	c	55	67	c	63	101
B-C night heron**	r	2	2	u	8	9
American bittern*,**	u	14	17	u	11	11
Least bittern**	u	9	9	r	1	1
Sandhill crane*	u	11	13			
Virginia rail*,**	u	8	8	u	12	13
Sora rail*,**	c	64	72	c	48	75
Common gallinule	r	2	2			
American coot*,**	c	35	47	c	30	47
Killdeer*,**	c	99	119	c	56	68
Spotted sandpiper**	u	14	14	u	13	13
Pectoral sandpiper**				u	9	9
Semipalmated sandpiper**				u	7	8
Wilson's phalarope*,**	u	10	14	r	1	1
Common snipe*,**	c	45	51	c	23	27
Forster's tern*,**	u	8	10	u	7	8
Black tern*,**	c	38	56	c	29	50
Belted kingfisher**				u	14	16
Yellow-headed blackbird*,**	u	10	18	c	19	20

*Found on SSA WPAs.
**Found on NSA WPAs.
[1]Status ranking: common (c) >15 wetlands where birds were seen; uncommon (u)=3-14 wetlands; rare (r) < 2 wetlands.
[2]Number of different wetlands where sightings occurred.
[3]Number of sightings over the 3-year study period; counting only 1 sighting/wetland/year.

TABLE 20. *Occurrence and mean density of grassland birds on NSA WPAs, 1977-78.**

Bird species observed	Percent Occurrence	Birds/ 100 ha	Estimated Breeding Pop. Found on 13 WPAs
Horned lark	8	1	6
Sedge wren	39	26	143
Bobolink	100	113	620
Eastern meadowlark	8	1	6
Western meadowlark	92	46	253
Red-winged blackbird	92	113	620
Dickcissel	62	58	319
American goldfinch	15	5	28
Savannah sparrow	85	45	247
Grasshopper sparrow	93	112	615
Le Conte's sparrow	8	10	55
Henslow's sparrow	15	7	38
Vesper sparrow	23	11	60
Clay-colored sparrow	62	49	269
Field sparrow	23	3	17
Song sparrow	77	48	264

*Grassland habitat on WPA: 549 ha.

TABLE 21. *Summary of WPA winter track counts.*

Study Area and Wildlife Species	Number of WPAs Found to Have: Heavy Use* Early	Heavy Use* Late	Medium Use* Early	Medium Use* Late	Low Use* Early	Low Use* Late
Southern Study Area**						
Cottontail rabbits	2	3	3	3	2	1
Small mammals	3	3	5	5	2	1
Dogs				1	3	2
Red fox		3	3	2	3	2
Mink			1	1	3	1
Gray-fox squirrels			2	3	2	3
Songbirds	2	1			3	1
Ring-necked pheasants			1		2	3
Weasels			1	1	3	1
White-tailed deer			3			2
Raccoon						
Striped skunk		1				1
Cats						1
Ruffed grouse						
Opossum						
Northwest Study Area**						
Small mammals		2		5		5
Songbirds		10				1
Cottontail rabbits		2		2		5
Weasels				6		3
Dogs				1		5
Ring-necked pheasants		1				4
Jackrabbits				2		3
Red fox				1		3
Gray-fox squirrels				1		2
Mink						3
Cats						3
Striped skunk						2

*Intensity of use defined: heavy use: >10 tracks/1000 m, medium use: 3-9.9 tracks/100 m; low use: 0.1-2.9/1000 m.

**Comparison of SSA early and late winter survey only possible for 11 WPAs; surveys conducted only during 1977-78 winter. Overall SSA use combines early and late use for 15 WPAs. Only 1 late survey conducted on the NSA in February 1978 on 13 WPAs.

conditions. Herbaceous vegetation became buried under heavy snow cover forcing many species to abandon the open fields for more protective stands of woods and shrub-carr. The lack of suitable cover on some WPAs forced pheasants and songbirds in particular to leave these areas almost entirely. However, the results generally indicate a wide variety of winter wildlife use on WPAs. The frequent occurrence of dog tracks on WPAs may also warrant concern—repeated use by dogs may limit WPA values as winter cover for wildlife, particularly pheasants (Pils and Martin 1978).

PUBLIC USE BENEFITS

According to Wisconsin Wetland Management Guidelines (U.S. Fish and Wildlife Service 1975) for WPAs, "the mission of the program is to manage the land and water resources to provide as many benefits as possible. . ." Public use benefits include wildlife-oriented recreation such as hunting, fishing, hiking, bird watching, nature photography, and a host of others that are derived from the land and water resources of the system.

Public use was difficult to quantify with our limited manpower. Much occurred on weekends. Some use was documented during our wildlife surveys, field checks, and special hunter bag checks. Table 22 lists potential recreational opportunities available on individual WPAs.

NSA. Waterfowl hunting was permitted on all WPAs except for 81 ha of the Oak Ridge WPA, a designated waterfowl refuge. Migrating fall waterfowl peaked at about 10,000 birds with mallards and ringnecks being most abundant. Up to 2,000 widgeons used the refuge in early fall.

WPA car counts were conducted during the waterfowl season (10 weekend days and 5 weekdays) in 1977; 339 cars were counted, with 44% on opening day. In 1978, 191 cars were counted with 56% present on opening day (7 weekend counts and 2 weekdays).

In the 2 years, 259 hunters were checked on the WPAs. Hunters averaged 0.5 ducks bagged and 3.4 hours hunted. Ten species of waterfowl were bagged; mallards (52%), wood ducks (20%), and blue-winged teal (9%) accounted for 81% of the bag.

Pheasant hunting pressure increased each year on WPAs and opening day car counts in 1977 and 1978 equalled 57% of the counts recorded on the opening day of the waterfowl season. Few bag checks were conducted for pheasants, but one hunter claimed to have harvested 40 to 45 cocks each year on WPAs.

TABLE 22. *Potential public use opportunities available on WPAs.*

			Hunting Potential				Trapping Potential	
Name of Areas	Size (ha)	Spring Birding	Waterfowl	Pheasants	Deer	Rabbits-Squirrels	Mink-Muskrat	Fox-Raccoon
Southern Area								
Aalsma	49		X	X	X	X	X	X
Carr	35		X	X				X
Dyerson	19		X	X				X
Haupt	41	X	X	X			X	X
Johnson	13			X				X
Johnson	16			X	X	X		X
Laun	16	X	X	X	X	X	X	X
Ludwig	14		X	X		X	X	X
Lund	45		X	X	X	X	X	X
Mauthey	45		X	X	X	X	X	X
Pieper	33		X	X			X	X
Severson	101		X	X	X	X	X	X
Sime	33		X	X	X	X	X	X
Vangen	33		X	X	X	X	X	X
Northwest Area								
Deer Park	78		X	X	X	X	X	X
Erickson	65		X	X			X	X
Fish Lake	88		X	X			X	X
Johnson	49		X	X				X
Kerber	64	X	X	X			X	X
Kobernick	32		X	X		X	X	X
Kniizenga	77		X	X			X	X
Lundy Pond	16		X	X				X
Oak Ridge	210	X	X	X	X	X	X	X
Star Prairie	16		X	X			X	X
Ten Mile Cr.	81		X	X		X	X	X
Three Lakes	63		X	X			X	X
Weiss	15		X	X			X	X

WPAs also provided opportunities for fox, raccoon, mink, and muskrat trapping. Most areas were intensively trapped, especially for muskrats.

Other uses of these WPAs were for leech and minnow trapping, berry picking, cross country skiing, and bird watching. Two WPAs (Kerber and Oak Ridge) were excellent places to observe waterfowl and shore birds, and both were heavily used by the public.

SSA. Twelve of the 14 WPAs provided waterfowl hunting. On the SSA, WPAs are generally smaller than those on the NSA, and some only accommodated 1 party of hunters or were used primarily for jump shooting. On the opening days of the waterfowl seasons in 1977 and 1978, 15-20 cars were counted each year. Because of this low use and the geographic distribution of WPAs across 4 counties, very few hunters were checked.

All WPAs provided hunting opportunities for pheasants and were heavily hunted. At least 26 cocks were shot on 6 WPAs in 1 year. The 8 WPAs used by deer were hunted intensively during both the bow and gun seasons.

Furbearers occurred on all WPAs and while no trapper-use surveys were conducted, trapping was observed on many of the areas.

Other public uses were hiking and birdwatching. Up to 23 species of waterfowl could be found on 2 of the WPAs during the spring migration. Because of their excellent visibility from adjacent roads, these areas attracted many birdwatchers.

MANAGEMENT IMPLICATIONS

GOALS FOR MANAGED LANDS

Nelson and Duebbert (1974) suggested that minimum goals for managed waterfowl nesting cover are: (1) 70% nesting success (percent of nests hatching); and (2) 2.5 nests/ha of cover. While these goals were essentially established for the prairie pothole region based on findings in the Dakotas, there is some evidence to indicate that they can realistically be adopted in Wisconsin. Wetland complexes and associated WPAs in Wisconsin do attract breeding pairs of mallards and blue-winged teal in densities similar to those found in North Dakota by Stewart and Kantrud (1974). Duck nest density on an upland site at the Horicon Marsh Wildlife Area exceeded the proposed goals during 1 year when nest success reached 79% with a density of 10 nests/ha of cover on the 4-ha field (Gatti et al. 1981). Until additional research better defines brood water guidelines for Wisconsin, the 1:4 ratio of water to managed nesting cover can be considered as a minimum value. Every 16 ha of managed nesting cover would, therefore, require at least 4 ha of brood habitat within a radius of 0.8 km. If production goals for managed cover can be achieved, a 1:4 ratio of water to nesting cover may be inadequate judging from the work of Gates (1965). There is sufficient brood water to meet current production estimates of 2.5 nests/ha and 37% nest success (Petersen 1981).

The block size of managed nesting cover is also important when considering the goals of habitat quality in relation to waterfowl production. Nelson and Duebbert (1974) recommended establishment of 32-40 ha cover blocks whenever possible, and discouraged blocks less that 16 ha in size. Long, narrow strips should be avoided; rather, a square-like shape is preferred. Nelson and Duebbert (1974) also indicated that nests in small blocks of cover were subject to much higher predation and other disturbances. Small, narrow bands of nesting cover around the periphery of wetlands, for example, often function as "death traps" for nesting ducks. We have observed that small blocks of nesting cover are also very susceptible to damage by upland game hunters. That is, hunters seek out and search blocks of quality cover that may hold pheasants or other upland game. Heavy use creates numerous access trails throughout the block, negating the potential value of the cover as predator-resistant vegetation. Blocks of dense nesting cover > 16 ha are much more resistant to hunter damage simply due to their larger size.

Justification for establishing a 16-ha block of quality cover should be based on the potential for the proposed parcel to reach suggested goals for managed cover. Unless there are sufficient pairs within 0.8 km of the proposed tract, there is little likelihood the goals can be reached in a 10-year period. A ratio of 2.5 pairs of dabblers (within 0.8 km) for every ha of upland nesting cover appears adequate to warrant the cost of development of > 16-ha blocks (> 40 pairs/16-ha block).

ACQUISITION PRIORITIES AND NEEDS

Management efforts to maximize duck production on WPAs must begin with a sound plan. A realistic approach to WPA acquisition is the priority consideration in an effective, overall WPA program. The Category 11 Concept Plan established a maximum WPA acquisition goal of 16,200 ha for Wisconsin. Approximately 60% of the 1978 WPA land offered potential for upland cover development. If minimum production goals can be attained, the WPA program in Wisconsin upon completion has the capability of providing secure nesting cover for a minimum of 24,000 breeding pairs of ducks. Blue-winged teal and mallards represent 75-90% of the estimated WPU breeding populations. Hunt et al. (1979) estimated the average 1973-79 breeding population to be 42,350 pairs of mallards and 82,200 pairs of blue-winged teal. The Wisconsin WPA program, therefore, has the baseline potential to affect 17% of our breeding populations of mallards and blue-winged teal. In addition, if the evidence suggesting the ability to "stack up" breeding pairs of dabbler ducks in high quality habitat (Nelson and Duebbert 1974) applies in Wisconsin, then the 17% represents a minimum level.

Ideally, the decision to purchase a specific parcel as a WPA should be based on biological justification especially when funds must be spent on the basis of priority. Estimates of breeding pairs that can be affected by the acquisition (pair density within 0.8 km of the proposed tract), and juxtaposition of available brood water in relation to upland sites with management potential are the major concerns. A form was developed (Fig. 4) to assist the wildlife manager in a feasibility evaluation of a proposed tract. Acquisition criteria are: (1) the presence of >16 ha of uplands capable of dense nesting cover; (2) at least 40 pairs of dabbling ducks within 0.8 km of the tract for an approximate ratio of 2.5 pairs/ha of nesting cover; (3) available brood habitat within 0.8 km of the tract; and (4) a minimum ratio of 1:4 brood water to upland nesting cover, or at least 4 ha of secure brood habitat within 0.8 km of the proposed tract.

Ecological patterning is an acquisition approach developed by Hamerstrom et al. (1957) for prairie chickens and later used by Gates (1970) for sustaining pheasant populations. The basic premise of ecological patterning is to preserve critical habitat components in the minimum amount necessary to perpetuate the existing wildlife species population of concern. Total lands needed to be purchased usually amount to only 5% of the total area. The feasibility evaluation suggested here is a variation of the ecological patterning concept. WPAs should be purchased only where a biological potential is demonstrated, with acquisition efforts oriented to entire wetland complexes (purchase of a variety of wetland types within both large and small WPUs).

Future acquisition on the SSA was projected using the biological criteria suggested above. During the study, 3.8% of the SSA was in WPAs. Continuing WPA acquisition increased this to 5.6% by late 1980. We selected an additional 3.9 km^2 of high quality parcels with the best potential for future acquisition, giving a suggested total of 11.5 km^2 in WPAs, or 8.1% of the SSA. This level of acquisition as we defined it should potentially affect 80% of the ducks within the SSA (approximately 70 pairs of ducks/km^2 of WPA). On the NSA, qualitative as well as quantitative biological factors, threat of drainage or alteration and management potential all played a part in tract delineation. During this study, 854 ha (2.4% of the NSA) were purchased as WPAs. By the end of 1980, 1,430 ha (4.0%) were in WPAs; some of this area will be used for potential trades. Total acquisition in the NSA is currently planned to be about 3,240 ha (9.1% of the NSA).

The current approach used in WPA acquisition involves obtaining negotiation approval for prospective tracts from FWS (frequently the Enhancement Biologist for Wisconsin). Prospective tracts are usually nominated by DNR wildlife management personnel. Once approved, negotiations with the landowner can begin and if a willingness to sell is indicated, appraisals are initiated, culminating in a signed option if both parties agree on a purchase price. Approval of the signed option and, therefore, actual purchase of the tract by FWS personnel is essentially made on a "first come, first served" basis until the annual WPA acquisition allotment for Wisconsin is depleted. There has been no systematic effort to evaluate the relative priorities of all prospective WPAs prior to acquisition of individual parcels. As available funds (both state and federal) become in shorter supply, some system of priority is needed to guide acquisition of parcels.

A central clearing house, perhaps the Duck Strategic Planning Committee in DNR, can provide a more organized and effective WPA acquisition program. Some person or persons must make the oftentime difficult decisions on which proposed tracts to purchase as the number of available parcels invariably exceeds the amount of acquisition funds allocated. Use of the WPA feasibility form submitted by wildlife managers would aid in identifying tracts with lower biological potential — a good beginning point. The primary acquisition criteria should include cost-benefit comparisons, with judgments made using hard biological evidence, and the proposed tracts weighted on relative merits in comparison to one another. Also, because land values vary across Wisconsin, it may become necessary to acquire a less expensive tract than one that has a similar biological value, but is more expensive. A "first come, first served" WPA acquisition program is not in the best interests of Wisconsin's waterfowl resource it hopes to benefit.

Trading of land parcels is another acquisition tactic that offers some potential for obtaining key parcels. Trading entire units, or parts thereof, from existing WPAs or future acquisitions can often achieve results where other acquisition efforts have failed. Surplus cropland is often obtained when entire farms are purchased in order to acquire wetlands on a portion of the holdings. Adjacent or nearby landowners who often resist selling parts of their farms, may be willing to improve the economic solvency of their farming operation by trading wetland for productive cropland.

We have already conducted feasibility evaluations of all WPAs in the SSA using our proposed form, and have identified several potential trading parcels. We are now in a position to judge which tracts offer minimal biological value, but which may be useful as trading stock. Land trading has already become an effective part of the WPA acquisition program in the NSA.

Long-term or perpetual easements have been suggested as an alternative to fee title acquisition. Easements have not generally been used in Wisconsin because: (1) habitat management is usually not possible on easement lands; (2) lands covered by easements must be frequently checked for term violations; and (3) the cost of a comprehensive easement approaches that of fee title acquisition, especially on a long-term basis. However, limited wetland easements (preventing filling, draining, or burning) may have potential for preserving breeding pair ponds within close proximity of WPAs.

WPA MANAGEMENT NEEDS

WPA management approaches are outlined in the FWS Wisconsin Wetland Management Guidelines. Management objectives stress all wildlife and ecological values and their application to human benefits (U.S. Fish and Wildlife Service 1975), whereas in the Memorandum of Understanding, the State of Wisconsin and the U.S. Department of the Interior mutually agreed to acquire and manage WPAs for the "express purpose of maintaining and increasing the production of wild waterfowl". Waterfowl management needs are apparently the priority consideration, and associated wildlife species are of secondary concern. Management activities directed at secondary species should be considered only when they do not adversely impact the production of waterfowl. Unless a change in WPA management policies occurs at the federal level, we will assume that management needs reflect waterfowl production needs. Waterfowl management includes nesting cover development, water level manipulation, woody vegetation control, and negative predator management.

Efforts directed at managing nesting cover should maintain vigorous stands of vegetation with "the tallest, most dense cover that is possible under prevailing soil and climatic conditions" (Duebbert et al. 1981). Density obstruction indexes of residual vegetation strongly indicate that monotypic stands of switchgrass surpass any yet established cover type examined in Wisconsin. While switchgrass fields may not always be highly preferred nesting cover, management efforts need to encourage ducks to nest in this predator-secure cover regardless of preference. However, supportive data are lacking to determine the predator-resistent qualities of switchgrass. Work at Horicon suggests switchgrass is as good as other cover types examined, but no better (Gatti et al. 1981). We recommend WPA upland sites of > 16 ha be seeded to switchgrass. Periodic rejuvenation of switchgrass by prescribed burning or herbicide application may be necessary if weed species, woody vegetation, or litter accumulation begin to adversely affect height-density factors. Research efforts are continuing to clarify the time constraints with which switchgrass stands may need to be rejuvenated. Obstruction indexes taken every 2 years may prove to be a relatively simple, yet effective indicator.

Other grass-legume mixtures may provide residual cover comparable with switchgrass. However, we measured no other cover type that even approached switchgrass residual qualities. A recent trend in Wisconsin towards planting a warm-season grass mixture (including switchgrass) for nesting cover produces poorer visual obstruction indexes and should be considered only with caution. Dense nesting cover development on lowland sites (organic soils) also needs additional research before specific recommendations can be made. Until guidelines can be developed, allowing successional wild cover to remain undisturbed would appear the most logical course of action on organic soils.

Development of additional water areas on WPAs can be justified. Drained wetlands often can be restored by simply blocking drainage ditches or drain tile systems. Water control structures on drainage ditches increase wetland management capabilities, but do require additional maintenance costs. The removal of 15-60 cm of soil from a wetland basin can produce a more secure (better water retention) wetland. The scraping of a Type II wetland can, for example, develop it into a Type III wetland. WPAs short of brood water or breeding pair ponds should benefit by water development.

Old brush or stone piles are ideal haunts for skunks and other mammalian predators. Such predator haunts on WPAs should be eliminated whenever possible.

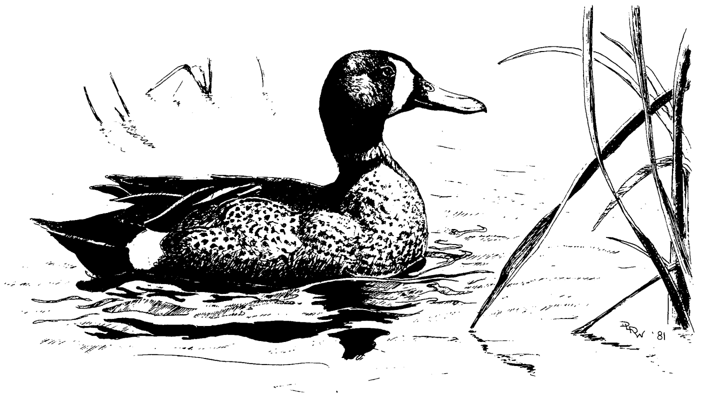
Nesting cover should be seeded in blocks 16 ha or more in size, and immediately adjacent to secure brood water if possible. Any intervening woody vegetation, old foundations, and wood or rock piles are predator havens and should be removed before nesting cover is seeded.

Native warm-season grasses and forbs may be viewed as potential duck nesting cover, although current efforts have failed to produce residual vegetation with height-density measurements any better than successional vegetation or cool-season grasses.

Care must be taken not to remove too much bottom soil; this can result in inadvertent draining by breaking the wetland seal. Soil test cores must be taken to determine the depth to which bottom soil can be removed safely.

The presence of trees and shrubs along fencerows and lanes, in seeded nesting cover, or in abandoned pastures, may warrant removal. Upland pastures offering potential waterfowl nesting habitat should not be seeded until trees have been removed. It is neither feasible nor desirable to remove entire woodlots; however, clumps of trees and shrubs lying between existing cover and brood habitat offer predator havens and impede the movement of ducklings to water. The germination of tree seedlings in seeded nesting cover should not be tolerated under any circumstances. The removal of seed sources can be effective in controlling the spread of box elder and other weedy tree species.

Negative predator management is often overlooked on waterfowl production areas. Rock or wood piles, denning trees, raptor hunting perches, old foundations, hedgerows, and fencelines provide predator havens or access. Any site that encourages use by predators should be eliminated promptly. Trapping to remove mammalian predators should be encouraged during the open seasons. Traditional fox dens are quite difficult to eliminate; even bulldozing is often ineffective. Dens in gullies can be discouraged by filling the gully; hilltop dens in open sites can be seeded with dense stands of switchgrass to discourage continued use. Selective removal of trees used as raptor hunting perches can reduce duck predation by great horned owls and red-tailed hawks (Petersen 1979). Periodic inspection of WPAs will alert the manager to predator use, allowing prompt and, therefore, effective predator management. Additional methods of negative predator management are currently the subject of ongoing research (e.g., electric fence barriers, selective removal) or should be investigated in the future (e.g., aversive conditioning, additional habitat manipulation).



CONCLUDING STATEMENTS

Our evaluation of the Waterfowl Production Area acquisition program was somewhat tempered by the fact that the FWS already committed themselves to an active WPA acquisition program in Wisconsin. The Category 11 Concept Plan outlines the maximum acquisition goal (16,200 ha) for waterfowl habitat in Wisconsin. By October 1981, approximately 2,854 ha of waterfowl habitat had been purchased (18% of the maximum allotment). Fiscal restraints at the federal level may limit acquisition in the immediate future, but the long-range outlook is promising.

The WPA acquisition program in Wisconsin has resulted in the purchase of some excellent waterfowl habitat. Breeding densities of mallards (2.5-4.8 pairs/km^2) and blue-winged teal (5.8-9.2/km^2) are comparable with densities found in North Dakota by Stewart and Kantrud (1974). Increasing nest success on WPAs appears dependent on development of the tallest, most dense nesting vegetation possible under existing climatic and soil conditions. Monotypic stands of switchgrass are far superior in relative density to any other upland vegetative type examined and are recommended as nesting cover. Hen success and brood survival currently may be handicapped on some WPAs by a noticeable lack of secure brood water. Additional research is needed to clarify brood habitat requirements in Wisconsin. Acquisition and management priorities need to place greater emphasis on securing adequate brood habitat.

Our suggested WPA management goals essentially parallel FWS standards and are to: (1) produce a nest density of at least 2.5 nests/ha of upland managed nesting cover; (2) achieve a minimum of 70% nest success; (3) establish dense nesting cover plots no less than 16 ha in size; and (4) secure brood habitat at a 1:4 ratio with established dense nesting cover. If minimum nest densities and successes are to be obtained, acquisition is not feasible for dense nesting cover plots substantially less than 16 ha, and/or if at least 40 breeding pairs of puddle ducks are not within 0.8 km of a proposed tract. A more systematic DNR approach to WPA acquisition is needed to ensure that the highest priority tracts are purchased. The current approach of "first come, first served" for available acquisition funding is not necessarily cost effective. The WPA program currently has the potential to affect a minimum of 17% of Wisconsin's breeding population of mallards and blue-winged teal.

WPAs also provide additional benefits besides waterfowl habitat. A host of other wildlife species appear to respond to the acquisition and management of WPAs. Pheasants, the most sought after upland game bird in southern Wisconsin, have been positively affected. WPAs essentially represent islands of secure nesting cover in areas of intensively cultivated lands. Pheasants, grassland songbirds, and small mammals all orient to WPAs. Winter use by associated wildlife is dependent upon snow cover and existing cover types. Heavy snow cover appears to discourage use by pheasants and songbirds. The presence of woody vegetation will encourage winter use by rabbits, squirrels, and white-tailed deer.

Current policies regarding the acquisition and management of WPAs stress waterfowl production. Spinoff benefits for other wildlife species can be anticipated, although management efforts directed toward associated wildlife at the expense of the primary goal would seem inappropriate. The WPA program in Wisconsin has the potential to substantially impact our mallard and blue-winged teal breeding populations. Refinement of acquisition priorities and goals will assure this impact can be realized as long as funding remains available.

APPENDIXES

I. Yearly Summary of May Surface Water for the SSA, 1977-79.

County and Year	May Surface Water (ha/km^2) by Wetland Type*										
	I	II	III	IV	V	VI	VII	VIII	Dugout	Ditch	Creek
Columbia											
1977	tr	tr	0.3	2.0	0.8	-	-	-	tr	tr	tr
1978	0.7	0.6	0.7	2.5	0.8	0.1	tr	-	tr	0.1	tr
1979	0.1	1.7	0.8	2.6	0.8	0.2	0.1	-	tr	0.1	tr
Dane											
1977	-	tr	0.1	1.2	0.8	-	-	0.2	0.1	0.2	0.2
1978	tr	1.0	0.8	1.4	0.8	tr	-	0.2	0.2	0.2	0.2
1979	tr	0.8	0.9	1.6	0.8	tr	-	0.3	0.2	0.2	0.2
Dodge											
1977	-	-	tr	-	-	-	-	-	tr	0.1	0.1
1978	0.3	4.5	3.6	0.4	-	0.2	tr	-	0.1	0.4	0.2
1979	0.5	4.3	3.4	0.3	-	0.2	tr	-	0.1	0.4	0.2
Jefferson											
1977	-	tr	0.5	10.0	7.3	tr	-	tr	0.3	0.1	-
1978	-	0.1	0.5	10.0	7.3	-	-	tr	0.3	0.1	-
1979	tr	1.9	4.4	10.3	7.7	0.6	0.4	0.3	0.5	0.1	-

*Trace = < 0.1 ha/km^2.

II. Scientific Names of Plants and Animals Cited.

Plants*

Alfalfa (*Medicago sativa*)
Alder (*Alnus* ssp.)
Aster (*Aster* spp.)
Birch (*Betula* spp.)
Black spruce (*Picea mariana*)
Boxelder maple (*Acer negundo*)
Bulrush (*Scirpus* spp.)
Canary grass (*Phalaris arundinacea*)
Cattail (*Typha* spp.)
Cedar (*Thuja* spp.)
Corn (*Zea mays*)
Cranberry (*Vaccinum oxycoccus*)
Dogwood (*Cornus* spp.)
Goldenrod (*Solidago* spp.)
Hickory (*Carya* spp.)
Intermediate wheat grass (*Agropyron intermedium*)
Labrador tea (*Ledum groenlandicum*)
Leatherleaf (*Chamaedaphne* spp.)
Kentucky bluegrass (*Poa pratensis*)
Maple (*Acer* spp.)
Mint (*Mentha* spp.)
Oak (*Quercus* spp.)
Oats (*Avena sativa*)
Peas (*Pisum sativum*)
Quackgrass (*Agropyron repens*)
Sedges (*Carex* spp.)
Sphagnum (*Sphagnum* spp.)
Smooth brome (*Bromus inermis*)
Soybean (*Glycine max*)
Switchgrass (*Panicum virgatum*)
Tamarack (*Larix laricina*)
Timothy (*Phleum pratense*)
Tobacco (*Nicotiana* spp.)
Wheat (*Triticum aestiuum*)
White clover (*Trifolium repens*)
Willow (*Salix* spp.)

*Plant reference: Scott and Wasser (1980).

Birds**

Common loon (*Gavia immer*)
Pied-billed grebe (*Podilymbus podiceps*)
Red-necked grebe (*Podiceps grisegena*)
Double-crested cormorant (*Phalacrocorax auritus*)
Great egret (*Casmerodius albus*)
Great blue heron (*Ardea herodias*)
Green heron (*Butorides virescens*)
Black-crowned night heron (*Nycticorax nycticorax*)
American bittern (*Botaurus lentiginosus*)
Least bittern (*Ixobrychus exilis*)
Canada goose (*Branta canadensis*)
Mallard (*Anas platyrhynchos*)
Black duck (*Anas rubripes*)
Gadwall (*Anas strepera*)
Pintail (*Anas acuta*)
Green-winged teal (*Anas crecca*)

Blue-winged teal (*Anas discors*)
American widgeon (*Anas americana*)
Northern shoveler (*Anas clypeata*)
Wood duck (*Aix sponsa*)
Red-head (*Aytha americana*)
Ring-necked duck (*Aytha collaris*)
Lesser scaup (*Aytha affinis*)
Ruddy duck (*Oxyura jamaicensis*)
Red-tailed hawk (*Buteo jamaicensis*)
Marsh hawk (*Circus cyancus*)
Ruffed grouse (*Bonasa umbellus*)
Greater prairie chicken (*Tympanuchus cupido*)
Sharp-tailed grouse (*Pedioeceles phasianellus*)
Bobwhite quail (*Colinus virginianus*)
Ring-necked pheasant (*Phasianus colchicus*)
Gray partridge (*Perdix perdix*)
Sandhill crane (*Grus canadensis*)
Virginia rail (*Rallus limicola*)
Sora (*Porzana carolina*)
Common gallinule (*Porphyrula chloropus*)
American coot (*Fulica americana*)
Killdeer (*Charadrius vociferus*)
Spotted sand piper (*Actitis macularia*)
Pectoral sandpiper (*Erolia melanotos*)
Semipalmated sandpiper (*Ereunetes pusillus*)
Wilson's phalarope (*Steganopus tricolor*)
American woodcock (*Philohela minor*)
Common snipe (*Capella gallinago*)
Common tern (*Sterna hirundo*)
Forster's tern (*Sterna forsteri*)
Black tern (*Childonias niger*)
Great horned owl (*Bubo virginianus*)
Short-eared owl (*Asio flammeus*)
Belted kingfisher (*Magaceryle alegon*)
Horned lark (*Eremophilia alpestris*)
Short-billed marsh wren (*Cistothorus plantensis*)
Bobolink (*Dolichonyx oryzivorus*)
Eastern meadowlark (*Sturnella magna*)
Western meadowlark (*Sturnella neglecta*)
Yellow-headed blackbird (*Xanthocephalus xanthocephalus*)
Red-winged blackbird (*Agelaius phoeniceus*)
Dickcissel (*Spiza americana*)
American goldfinch (*Spinus tristis*)
Savannah sparrow (*Passerculus sandwichensis*)
Grasshopper sparrow (*Ammodramus savannarum*)
Henslow's sparrow (*Ammodramus henslowii*)
Le Conte's sparrow (*Ammospiza leconteii*)
Vesper sparrow (*Pooecetes gramineus*)
Clay-colored sparrow (*Spizella pallida*)
Field sparrow (*Spizella pusilla*)
Song sparrow (*Melospiza melodia*)
Snow bunting (*Plectrophenax nivalis*)

**Bird reference: American Ornithologist's Union (1957).

Mammals[1]

Virginia opossum (*Didelphis marsupialis*)
White-tailed jackrabbit (*Lepus townsendii*)
Eastern cottontail (*Sylvilagus floridanus*)
Minnesota gray squirrel (*Sciurus carolinensis*)
Western fox squirrel (*Sciurus niger*)
Common muskrat (*Ondatra zibethicus*)
Dog (*Canis domestica*)
Red fox (*Vulpes fulva*)
Raccoon (*Procyon lotor*)
Weasels (*Mustela* spp.)
Mink (*Mustela vison*)
Striped skunk (*Mephitis memphitis*)
Cat (*Felis domestica*)
White-tailed deer (*Odocoileus virginianus*)

[1]Mammal reference: Jackson (1964).

III. Criteria Used in Classifying Wetlands (from March et al. 1973).

TYPE I AREAS - Seasonally flooded depressions in agricultural fields or in pastures (if not associated with sedges).

TYPE II AREAS - Seasonally flooded sedge meadows or brush patches (sedge and willow and/or dogwood).

TYPE III AREAS - Water areas expected to dry out by July 15. Usually associated with cattails and occasionally with bulrush. Included alder bottoms in northern Wisconsin, willow/dogwood areas in southern Wisconsin if these areas appeared to be deep, and flooded creek bottoms if cattail and/or alder were present.

TYPE IV AREAS - Cattail- and bulrush-rimmed marshes and potholes that appeared to have permanent water. Contained clumps of emergents dispersed throughout basin.

TYPE V AREAS - Open, fresh water areas, including most lakes, artificial ponds and blasted potholes with permanent surface water and vegetation restricted to shoreline.

TYPE VI AREAS - Shrub swamps which were included with Type II and Type III areas.

TYPE VII AREAS - Wooded swamps which in the north, included flooded black spruce, tamarack, birch, maple, or cedar, and in the south, included flooded maple, tamarack, birch, willow, or oak.

TYPE VIII AREAS - Bogs, consisting of temporarily flooded leatherleaf, labrador tea, cranberry, sphagnum, occasional sedge, black spruce or tamarack.

DITCHES - All drainage ways, including channelized streams, which contain surface water and which may be either seasonally flooded or permanent waters.

STREAMS - All creeks and rivers, including those flowing water areas which were created by runoff which did not follow a ditch channel.

APPENDIX IV. Sample Feasibility Evaluation Form for Acquisition Consideration of a Proposed WPA.

WILDLIFE FORM XXX: Waterfowl Production Area Feasibility Evaluation.

Instructions: Fill in all requested data, compute equations and compare results with standards.

Proposed WPA

Location: County:__________; Township:__________; Twn:__________N;

Range:________ E/W; Sections:________; Hectares:________ ha

Landowner (Name and Address): ______________________________

____

Cover Type Area on Proposed Tract

Cropland _____ ha; Upland pasture: _____ ; Woodland:_____ ha;

Misc: _____ ha; Wetlands: _____ ha (as measured by outer growth of hydrophytes)

Wetland Type Area:

Wetland Type II: _____ ha; Type III: _____ ha; Type IV: _____ ha;

Type V: _____ ha; Type VI: _____ ha; Type VII: _____ ha;

Dugouts: _____ ha; Ditches: _____ ha; Streams: _____ ha.

Estimated Numbers of Breeding Puddle Ducks Associated (on or w/i 0.8 km of tract) with the Proposed WPA

Complete one of the following methods (do not include wood ducks):

Method #1: May Breeding Duck Pair Count

Species	*Number of Pairs**
Mallard __________	__________
Blue-winged teal __________	__________
Pintail __________	__________
Shoveler __________	__________
Green-winged teal __________	__________
Other __________	__________
Total Puddle Ducks	__________

*Use simple tally to record observed pairs; consider pairs, lone males, and groups of 5 males or less to equal breeding pairs.

Method #2: Wetland Type Area X Standardized Breeding Densities*

(Wetland Type Area)	*(Breeding density)*	= *Estimated Pairs*
Type II: __________	ha x (0.8)	= __________
Type III: __________	ha x (1.6)	= __________
Type IV: __________	ha x (1.2)	= __________
Type V: __________	ha x (0.5)	= __________
Type VI: __________	ha x (0.4)	= __________
Type VII: __________	ha x (1.5)	= __________
Dugouts: __________	ha x (1.7)	= __________
Ditches: __________	ha x (3.3)	= __________
Streams: __________	ha x (1.7)	= __________
	Total Pairs Estimated	= __________

*Based on average values from Petersen *et al.* (1982).

Relationship of breeding duck densities with potential nesting cover and brood water

A. Total hectares of cropland and upland pasture on the proposed tract: _____ ha (include any DNC from existing WPAs within 0.8 km).

B. Total number of breeding puddle duck pairs within 0.8 km of proposed tract: _____ pairs.

C. Ratio of potential upland nesting cover (A)/breeding duck pairs (B) = _____ : _____ .

D. Potential brood water within 0.8 km of proposed tract:

________ ha wetland Type III

________ ha wetland Type IV

________ ha wetland Type V

________ ha total brood water

Standards for Acquisition

A. Potential upland nesting cover on proposed tract should be at least 16 ha (contiguous block preferred).

B. Ratio of potential nesting cover on proposed tract to breeding duck pairs within 0.8 km of proposed tract should be approximate to 1:2.5 (necessary to obtain management goals of 2.5 nests/ha and a minimum of 70% nesting succees).

C. Ratio of potential brood water within 0.8 km of proposed tract to potential upland nesting cover on proposed tract should approach 1:4. (Approximately 4 ha of brood habitat necessary for the 16-ha nesting block).

Wetland Classification

Type II Wetlands - Seasonally flooded sedge meadows or brush patches (sedge and willow and/or dogwood).

Type III Wetlands - Water areas expected to dry out by July 15. Usually associated with cattails and occasionally with bulrush.

Type IV Wetlands - Cattail- and bulrush-rimmed marshes and potholes that appeared to have permanent water. Contains clumps of emergents dispersed throughout basin.

Type V Wetlands - Open, fresh water areas, including most lakes, artificial ponds and blasted potholes with permanent surface water and vegetation restricted to shoreline.

Type VI Wetlands - Shrub swamps which were included with Types II and III areas.

Type VII Wetlands - Wooded swamps, included flooded maple, tamarack, birch, willow, or oak.

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ENGLISH-METRIC CONVERSIONS

LENGTHS

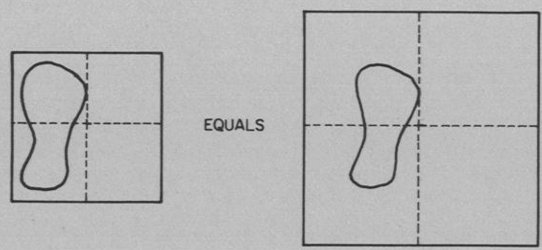
1 centimeter (cm)	= 0.3937 inch	
1 decimeter (dm)	= 10 centimeters	= 3.937 inches
1 meter (m)	= 10 decimeters	= 39.37 inches
1 kilometer (km)	= 1,000 meters	= 0.621 miles

AREAS

1 hectare (ha)	= 2.471 acres	
1 square kilometer (km^2)	= 100 hectares	= 247.1 acres = 0.386 square miles ($miles^2$)

SAMPLE CONVERSIONS

1 duck pair/km^2	= 2.59 pairs/$mile^2$
1 ha water/km^2	= 2.471 acres/ 247.1 acre area = 0.01 acres/ $mile^2$
16-ha plot	= 40 acres



A 17.4-ha marsh within 1 km^2

A 43-acre marsh within 1 $mile^2$

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