Duck population responses to water development in north central montana
by Shoawn Roy Bayless

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
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Breeding pair populations and waterfowl broods were assessed on 3 areas differing in pond densities in South Phillips County, Montana during 1990 and 1991. Pond physical parameters were measured and related to waterfowl production.

Numbers of pairs, productivity, and numbers of young produced were positively correlated with pond density. Retention type ponds ranked highest in the above factors, due primarily to increased water area, shoreline length, and shoreline development indices associated with this pond type. Nest losses to predation were not significant. Other factors influencing waterfowl production included quality of riparian and upland vegetation around the ponds.

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APPROVAL

of a thesis submitted by

Shawn Roy Bayless

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Recent studies indicate waterfowl production per unit of water area on western rangelands exceeded that found on the Prairie Pothole Region. However, production per km^2 is far less on these western rangelands because of low pond numbers. This study was initiated to compare breeding populations and productivity between rangelands with relatively high and low numbers of stockponds.

Breeding pair populations and waterfowl broods were assessed on 3 areas differing in pond densities in South Phillips County, Montana during 1990 and 1991. Pond physical parameters were measured and related to waterfowl production.

Numbers of pairs, productivity, and numbers of young produced were positively correlated with pond density. Retention type ponds ranked highest in the above factors, due primarily to increased water area, shoreline length, and shoreline development indices associated with this pond type. Nest losses to predation were not significant. Other factors influencing waterfowl production included quality of riparian and upland vegetation around the ponds.

These results suggest a higher density of ponds than those reported in this study and a heterogenous mixture of pond types, sizes, and ages on western rangelands will contribute most to increased waterfowl production.

INTRODUCTION

The value of wetlands to the environment, as well as to the future of waterfowl has been well documented (USFWS 1956, Eng et al. 1979, USFWS 1986, Fredrickson and Reid 1988, Bridges et al. 1989, Dahl 1990, WMI 1990, Walter 1990). Also well documented is the relationship between wetland drainage, upland nesting habitat degradation, and resultant declines in the continental waterfowl populations, especially in the Prairie Pothole Region (PPR) (Burwell and Sugden 1964, Tiner 1984, Higgins and Woodward 1986, Little et al. 1989). Stromstad and Donovan (1989), citing Tiner (1984), Herbst (1978), and Wittmeir (1985), indicated that agricultural development accounts for 99% of the 20,000 acres (8,090 ha) of wetlands lost in North Dakota annually. In that state, an estimated 60% of the total wetland base had been lost by 1989.

These losses to the PPR, combined with the degredation and fragmentation of upland nesting habitat and consequent increase in hen and nest predators has resulted in extremely low recruitment in this area. Studies in the central and eastern portions of the PPR report the highest incidence of predation, and the resultant lowest rates of recruitment. Cowardin, et al. (1985) reported heaviest densities of nests were found in roadside rights-of-way, the only nesting habitat available due to conversion of the native range to clean, small-grains farming. Nest success in that study was estimated at 8%, while hen success (which accounts for renesting activity) was estimated at 15%. He concluded these estimates were significantly lower than the minimum required for population maintenance (15 and 31% for nest and hen success, respectively).

In contrast, problems associated with the PPR are not realized in western rangelands where most of the waterfowl breeding occurs on various types of stock dams, which were constructed primarily to influence cattle distribution. Higher productivity recorded in these areas may be due in part to differences in predator populations (Sargeant and Arnold 1984). Krapu et al. (1983) reported higher nest success as pond numbers decreased, a phenomenon also reported by Ball and Eng (1989). These authors attributed overall high nest success to one or a combination of factors, including wide spacing of the ponds and better nesting habitat in the absence of clean, small grains farming, so prevalent in the eastern portions of the Northern Plains area. Ball et al. (1988) reported waterfowl production per hectare (ha) water in this area exceeded similar estimates from the more easterly prairie pothole region three- or four-fold. However, when overall population densities and production estimates are considered (per km^2 of breeding habitat), breeding pair and production estimates from prime breeding areas in Canada and South Dakota exceeded those estimates of Ball et al. (1988) by nearly 600%. This difference suggests that the limiting factor to waterfowl production on western rangelands may be the amount of water areas, whereas in the eastern Prairie Pothole Region secure nesting habitat is limited.

Annual construction of stock ponds in Montana and other rangelands where water areas are relatively scarce has varied from year to year. Bue et al. (1964) estimated there were 230,000 retention and pit-retention impoundments, as well as 225,000 dugouts within the prairie provinces of Canada, North and South Dakota, Minnesota, and Montana. Jones (1970) estimated 8,000 impoundments had been constructed in eastern Montana, with an annual increase of 240 impoundments per year. Many authors have advocated the benefits of these stockponds to waterfowl (Dzubin 1955, Bue et al. 1964, Jones 1970, Mundinger 1975, Eng et al. 1979, Hudson 1983, Ball et al. 1988). Others have indicated a positive relationship between waterfowl production and increased pond densities. Miller (1980) reported a negative correlation between numbers of broods per 100 meters (m) of shoreline and distance to nearest pond in his study in Valley County, Montana. Mack et al. (1980) concluded that density of wetlands surrounding brood waters was the most influential variable in determining brood use of stockponds. Lack of ponds may result in decreased nesting attempts. Krapu et al. (1983) found a unimodal pattern of nesting activity as pond numbers decreased, indicating a lack of renesting attempts.

While many studies have reported benefits of stockponds to waterfowl, few have indicated how the numbers of ponds and their position relative to other ponds affects productivity. Objectives of this study were to investigate the influences of pond density, juxtaposition, and pond physical parameters on the productivity of waterfowl, and thus guide future pond developments in this, and other areas where water surface acreage is the limiting factor to waterfowl production.

DESCRIPTION OF THE STUDY AREAS

The 3 study areas were located in southern Phillips County in north-central Montana, an area which has been described by Gieseker (1926) as a 'rolling plain dissected by rather deeply entrenched streams and coulees. Most of the stream borders and the more feebly glaciated areas are sites of rough, broken land, often approaching a badland situation'. The Milk River Valley, elevation 689 m, divides Phillips County in half. The climate is dry, with comparatively long, cold winters, hot summers, and a large proportion of sunny days (Atwater 1959). Weather data from 1906 to 1989 were characterized by a wider range of average monthly temperature extremes (-32 to 34 C), and more annual precipitation (32.9 cm) than all 3 years of the study (NOAA 1990). During this study (1990-1992), winter/spring precipitation was lowest during 1990-1991, as reflected in the number of dry ponds during early May. However, severe thunderstorms during late June of 1991 effectively filled ponds on 2 of 3 study areas, thus any inferred relation between the previous fall/winter precipitation accumulation and the condition of ponds based on water levels may be invalid. This phenomenon was noted by Rundquist (1973) who suggested over half the annual precipitation falls in the form of rain between April and July.

Several factors were considered in the selection of the 3 study units (Doll, Hould, and Veseth Study Areas (SA)): 1) all 3 were close enough to one another to enable comparisons of waterfowl productivity to be based primarily on pond densities, rather than other environmental variables (weather differences, differential migrational corridors, and habitat types), 2) areas were far enough apart that ingress or egress of breeding birds between areas does not bias the results, 3) study areas were similar in size (25.9 km^2), and on mostly private lands, 4) each study area had different pond densities, and 5) the lower density areas

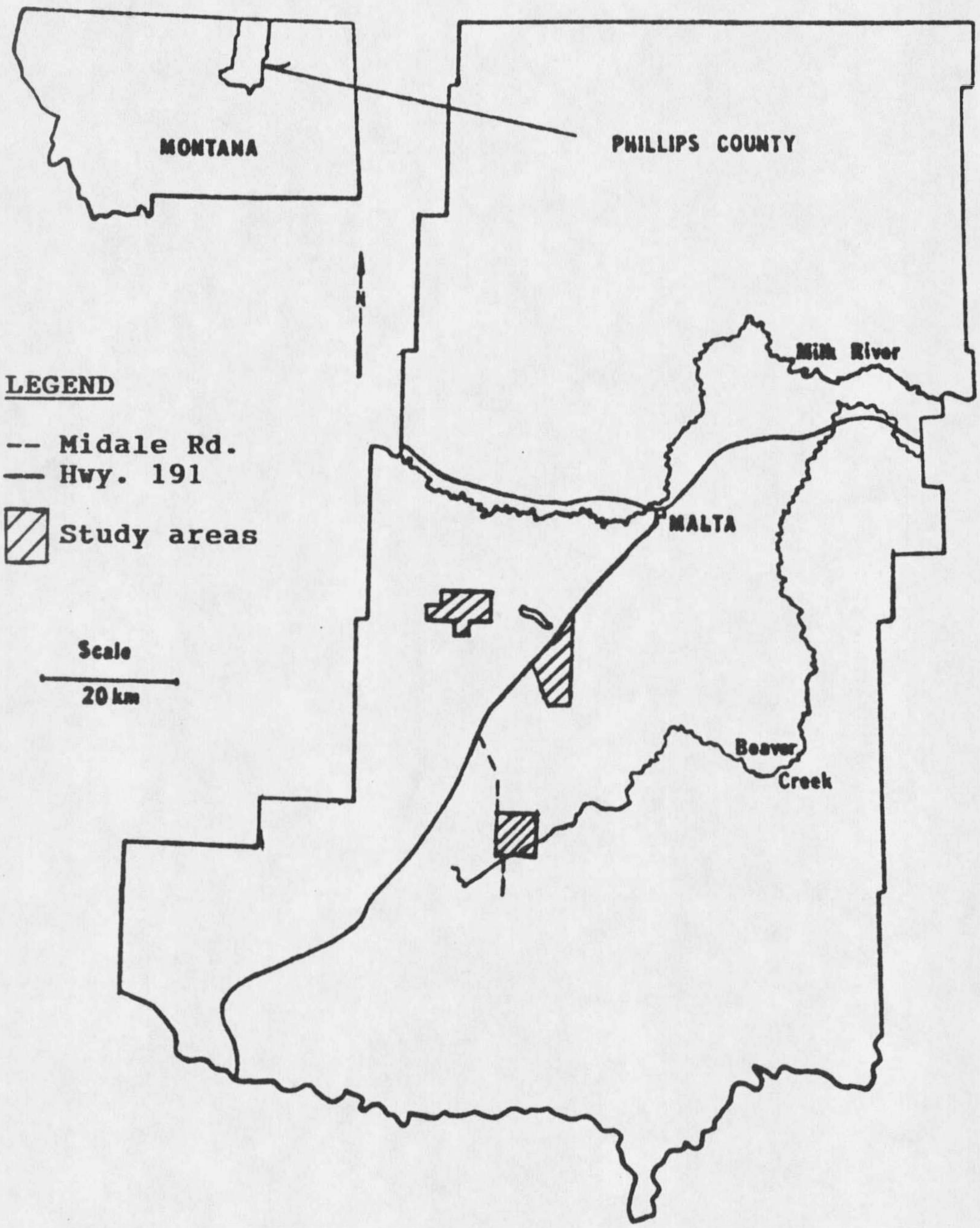

Figure 1. Map of Phillips County, Montana, showing location of study areas.

had a high potential for further pond development based on topography and geology. Furthermore, any area with ponds on or near the boundary was excluded. Ball et al. (1988) discouraged selection study areas due with boundary ponds due to the probable inflation of pair and brood counts from inclusion of these boundary ponds. The only study area to fail this requirement was the Doll SA, which had 2 ponds on or near the boundary. Effects of this were believed to be minimized due to the large number of ponds on the study area.

The Doll and Hould SA's were selected during spring, 1990, and the Veseth SA was selected the following spring to augment the Hould SA. The latter areas had a paucity of wetlands relative to the Doll SA and were of similar land area. All 3 had similar upland vegetation and land uses, and were dominated by a grassland habitat type. Land uses were primarily cow-calf grazing operations, with small grains farming bordering each area, and some haying operations on the wetter creek bottom sites of the Doll and Veseth SA's.

The Doll and Hould SA's were located on the east and west sides, respectively, of Highway 191, approximately 32 km southwest of Malta. The Veseth SA was located on the east side of the Midale Road, approximately 21 km south of the Doll and Hould SA's (see Figure 1 and Appendix Table 14 for general location and legal descriptions of each pond on the study areas).

Pond densities on the Doll, Hould, and Veseth SA's were 8.5, 3.1, and 1.6 per km^2. Creeks on the study areas (W. Alkali on the Doll SA and Beaver Creek on the Veseth SA) were ephemeral throughout the field seasons and were not used for production estimates due to broods using these water areas as egress corridors. However, some of these creeks have been shown to be highly productive and probably contribute significantly to total waterfowl production in some areas.

Most ponds on all 3 study areas were Type 3 or Type 4 (Cowardin et al. 1979) based on water permanence and presence of submerged aquatic vegetation. During the field season in 1990 all ponds contained water. In contrast, 1991 was a year of near normal precipitation, yet

21%, 9%, and 16% of the ponds on the Doll, Hould, and Veseth study areas, respectively, were dry at the beginning of the field season. This disparity was perhaps due to the smaller winter/spring precipitation accumulation during 1990/91 compared to winter/spring of 1989/90. The winter of 1990/1991 had 22% less precipitation between October and May than the previous year, and 11% less than the 1906-1989 average (NOAA 1990).

Four types of ponds were present on the study areas: retention (R), pit-retention (PR), pit (P), and slough (SL). Retention ponds are characterized by having a dam across a natural drainage coulee, and are the least permanent type. The pit-retention is similar to the retention in that the dam is constructed across a natural drainage, but differs by the addition of a pit located near the dam, commonly used as a borrow area for the dam material. Water permanence of this type is moderate in relation to the others. Pit type ponds are the smallest in surface area and most permanent due to higher depth:surface area ratio, and are commonly constructed in existing natural basins, maximizing use as livestock watering areas. The slough type areas were found only on the Doll and Veseth SA's. Water presence in these streams fluctuated frequently throughout the field season in response to irrigation, but these areas are often dry.

Proportions of the 3 pond types studied varied among the study areas. The Hould and Veseth SA's had 137 and 123% more retention ponds, respectively, than the Doll SA. The Doll SA had 67 and 100% more pit-retention types than either of the other areas. The pit pond was the least common on 2 areas, and was absent on the Veseth SA.

Fourteen soil types belonging to 5 families were present on the 3 areas (R. Bandy, Soil Cons. Serv., 1990, unpubl. data). The 5 families and associated types are presented in Appendix Table 17. Slopes of the upland sites ranged from 0-45 degrees to 35-75 degrees, but more commonly 0-8 degrees on most soil associations.

Vegetation commonly noted in and around the ponds was distributed in 4 distinct zones: dry upland, riparian, emergent and submerged aquatic. Each of these zones can be further separated into species specific zones influenced by the permanence and/or depth of the water. Vegetation specific to the dry upland zone consisted primarily of perennial grasses including western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), needle-and-thread (*Stipa comata*), and prairie junegrass (*Koelaria christata)*. Perennial forbs included fringed sagebrush (*Artemisia frigida*), plains prickly pear (*Opuntia polycantha*), and scarlet globemallow (*Spharalcia coccinia*). Woolly plantain (*Plantago patagonica*) was a common forb, and shrubs included silver sagebrush (*Artemisia cana)* and big sagebrush (*Artemisia tridentata*). Spikemoss selaginella (*Selaginella densa*) comprised the fern species common to the area. Relative proportions of these species were determined primarily by land use, which is discussed in greater detail in later sections.

The riparian zone typically consisted of an upper sub-zone of foxtail barley (*Hordeum jubatum*), middle sub-zones of either yellow sweetclover (*Melilotus officianalis*), western wheatgrass, or marsh knotweed (*Polygonum coccineum*), and the water's edge sub-zone of either longspike spikerush (*Eleocharis macrostachya*) or more commonly needle spikerush (*Eleocharis acicularis)*. The emergent zone consisted of fewer species, with longspike spikerush , softstem bulrush (*Scirpus validus*), and common cattail (*Typha latifolia*) being among the more prominent species. The submerged aquatic zone was usually very sparse, but several species noted were spiked watermilfoil (*Myriophyllum exalbescens*), fennelleaf pondweed (*Potamogeton pectinatus*), Richardson pondweed (*Potamogeton richardsonii*), and Canadian waterweed (*Elodea canadensis*). Woody species were relatively uncommon, but a few plains cottonwoods (*Populus sargentii*) and *Salix* species persist on dams of some larger ponds.

METHODS

Pair Counts Nesting, and Brood Data

Waterfowl surveys were conducted during spring and summer months of each field season. Each pond was sampled for breeding pairs and/or broods at approximately 3 day intervals, depending on pond accessibility. Breeding pair population surveys were not conducted during the 1990 field season, eliminating productivity estimates (broods/pairs). Thus, only production per unit area is reported for that year. Breeding pair surveys were initiated in late March, 1991, following procedures developed by Dzubin (1969).

Brood counts began in late June 1990, and late May, 1991. These counts continued through August of each year. Each pond was approached by foot, preferably from behind the dam, and broods observed with a 10 X 25 binocular or 15-60X spotting scope. Species, number of young, and age class of the brood as determined by Bellrose (1980) were recorded. Broody hens (those reluctant to leave the pond upon my arrival, or acting aggressive) were assigned 4 young (Anderson and Robinson, 1990), and Canada goose broods were counted, but are not presented in this report.

When alarmed, the broods invariably fled to the nearest cover. If I remained motionless, the birds reappeared after 10-15 minutes. On many occasions, unseen broods which had fled upon hearing the vehicle reappeared from hiding after the same amount of time. Thus, when possible, a minimum of 10 minutes were spent at each pond, especially when heavy emergent cover was present. Mallard and pintail hens usually led broods away from the pond when alarmed at my presence. If this behavior was detected, I immediately departed the area after counting and aging the young, in order to minimize observer induced predation.

Daily brood mortality estimates for each study area were determined by averaging the percentage of young lost per brood and dividing by the number of days the brood was observed. This value was multiplied by the approximate number of days remaining until fledging (based on age-class of brood and considering 42 days are required for fledging), providing an estimate of survival for that age-class. With this value, an estimated number of fledged young was determined for each brood. This method is similar to Mayfield's (1961) estimate of nest success which considers egg exposure days to predation. Other factors noted during each pond visit included degree of livestock use and presence of avian or mammalian predators.

An extensive nest search of several of the more productive ponds on each study area was conducted during June, 1991. A cable chain device similar to that described by Klett et al. (1986) was dragged concentrically around each pond until radial distance from the pond was approximately 200-300 m. Flushed birds were identified to species, the nest located and number of eggs recorded, and vertical obstruction at the Robel pole recorded, which was placed adjacent to the north side of the nest bowl. Species composition and maximum height of the vegetation within 30.5 cm (12 in.) of the pole were also recorded. The nest location was marked with an orange surveyor's flag placed 5 steps north of the nest bowl. Nests found incidental to other field activities were similarly recorded and marked.

Pond Physical Characteristics

Pond ages were determined from BLM archives and landowner questionnaires. Physical parameters measured include shoreline length, pond surface area, pond complex area (includes all riparian vegetation), shoreline development (a comparative figure relating shoreline length to the circumference of a circle with the same area as the pond), shoreline width, shoreline slope, width of riparian vegetation, percentage of the pond with depth less than 61 cm, and turbidity. The first 4 parameters were obtained from aerial photographs. Low altitude infra-red and Ektachrome photographs were taken of the Doll and Hould study areas in July 1990, whereas only Ektachrome was used to photograph the ponds on the Veseth SA. A Linear Measuring Set and digital planimeter were employed for these measurements.

The remainder of the parameters, except turbidity and percentage of pond less than 61 cm, were measured twice on opposite sides of the retention and pit-retention ponds during June, 1991. Shoreline width included the width of bare mud from the water's edge to the first incidence of riparian vegetation. The slope of this area was determined by placing a carpenter's level on the shore perpendicular to the water edge. The lower end of the instrument was lifted until the bubble indicated levelness. The height required to raise the level was divided by the length of the level, giving an estimate of slope. The width of riparian vegetation was obtained while conducting species compositon studies of this vegetal zone.

The percentage of each pond less than 61 cm in depth was obtained by dividing the number of readings less than 61 cm by the total number of readings. These measurements were conducted concurrently with submerged aquatic vegetation sampling, explained in the next section. Turbidity of each pond was determined by lowering a modified Secchi disk, an 18.4 cm (7.25") circular saw blade painted in alternating black and white quarter sections from a canoe. The average depth at which the device disappeared and reappeared was considered the turbidity reading.

Pond Vegetation

Riparian vegetation (those upland species influenced by the presence of the pond) measurements include species composition, canopy coverage, maximum height, and vertical obstruction readings. Two transects were established on both sides of each pond approximately halfway between the dam and tail. A surveyor's stake was emplaced at the water's edge, another at the interface between the riparian and dry, upland zones. Canopy coverage estimation (Daubenmire 1959), maximum height of the vegetation, and vertical obstruction within each plot were determined at 10 sites along the transect. Species composition was determined using a step-frequency method (Seigler 1941).

Transects for sampling emergent vegetation extended from the water's edge stake used in sampling riparian vegetation to the deepest extent of emergent vegetation. Sampling interval was determined by dividing transect length by 5. Methods developed by Low (1945) and used by Smith (1953) were modified for sampling. A 2 X 5 dm frame constructed of 1.3 cm (0.5") PVC pipe was used to determine species composition and density of emergent egetation. At each interval along the transect, the frame was dropped to the water from eye level. If the vegetation was thick enough to support the frame above the water, the culms were pulled through such that the frame floated freely on the water. Species, number of culms/m^2, and maximum heights of vegetation were recorded for each plot. On many occasions, the only emergent vegetation present was a dense stand of short *Eleocharis* sp. To save time, only those culms within one-eighth of the frame were measured, clipped, and counted. Density per m^2 was extrapolated from this value. The percentage of the pond covered by emergent vegetation was visually estimated. This same value was estimated from aerial photographs when possible.

I sampled submerged aquatic vegetation using a size 8/0 treble hook attached to a 7.6 m (25 ft) line. The line was marked every 0.3 m (1 ft) and every 1.5 m (5 ft) with colored marks, facilitating depth determinations. A lead fishing sinker was attached to the bottom of the hook to facilitate sinking. A transect running the length of the pond was divided into 10 equal sections. At each section, the hook was lowered from a canoe, dragged along the bottom for approximately 1 m, the depth noted, and retrieved to the boat. Any vegetation attached was recorded by species and cleaned from the hook. Species composition and frequency of occurrence for each pond was determined.

Upland vegetation was sampled on the Doll and Hould SA's in August 1990, and on all study areas in July 1991. Procedures were similar to those described by Daubenmire (1959), with only 10 plots per transect used. Two transects per pond, located approximately 250 m from, and running perpendicular to the pond shoreline, were used for upland vegetation sampling. Canopy coverage, maximum height, frequency, and vertical obstruction were determined for each plot. Common names of all plant species were obtained from Scott and Wasser (1980).

Other habitat characteristics noted include grazing schedules and weather data. The former were obtained from personal records of landowners, the latter from daily records kept at the Bowdoin NWR weather station. Long term weather data were obtained from the National Oceanic and Atmospheric Administration (1990).

Common and scientific names of vertebrates referred to in the text are presented in Appendix Table 12.

Non-parametric statistical evaluations were accomplished with programs developed by Dr. Dan Gustafson (Department of Biology, MSU, 1991). Parametric comparisons were accomplished with the MSUSTAT statistical package developed by Dr. Richard Lund (Agric. Exper. Sta., MSU, 1991). All significance levels are 95% unless otherwise specified.

RESULTS

Breeding Pair Populations

Total numbers of visits to ponds were 230 and 1,055 for 1990 and 1991, respectively. The lower number of visits in 1990 was due to a later start of field work that year, as well as having 2 study areas compared to 3 in 1991. There were 105, 80, and 48 pairs assigned to the Doll, Hould, and Veseth study areas, respectively in 1991. Species composition of breeding pairs is illustrated in Figure 2.

Phenology of species arrival is presented in Appendix Figures 4 and 5 for all 3 study areas combined. The earliest species to arrive on the Doll SA in decreasing order of peak arrival dates were mallard, gadwall, and pintail. Influxes of wigeon, shoveler, and blue-winged teal occurred approximately 2-3 weeks later. On the Hould SA, mallard, gadwall, and pintail were the earliest species noted. American wigeon, shoveler, and blue-winged teal peak arrivals occurred 2-3 weeks later. The Veseth SA differed from the others in that the peak arrival of gadwalls occurred concurrently with the later arriving species. Mallard and shoveler arrivals were earliest, followed by pintail and wigeon peak influxes, and finally gadwall and blue-winged teal. Redhead arrivals on the Hould and Veseth SA's occurred shortly after the early species, and were not observed on the Doll SA. Lesser scaup arrivals on all 3 areas peaked concurrently with redhead arrivals.

Species composition of breeding pairs differed among the 3 areas (Figure 2 and Table 1). On the Doll SA, gadwall, mallard and A. wigeon were the 3 most abundant breeding pairs (58.7% of total). Northern pintail and green-winged teal pairs were least represented (11.6% of total). Intermediate numbers of lesser scaup, northern shoveler, and blue-winged teal accounted for the remaining breeding pair population (29.8% of total).

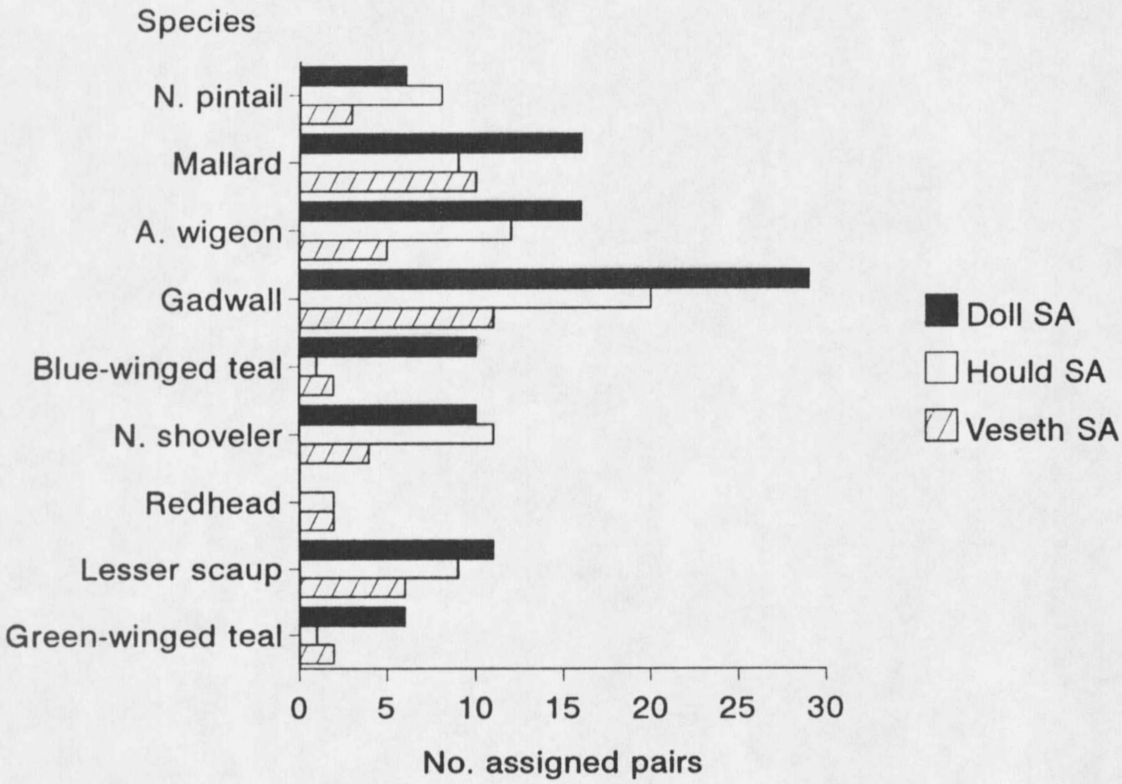

Figure 2. Species composition of breeding waterfowl on the Doll, Hould, and Veseth study areas, 1991.

On the Hould SA, the 3 most numerous species were gadwall, A. wigeon, and northern shoveler (60% of the breeding pair population). Blue-winged teal and redhead were the rarest (4%), mallard, lesser scaup, and northern pintail were intermediate in abundance (36%).

Gadwall, mallard, and lesser scaup comprised 60% of the pairs observed on the Veseth SA. The rarest species were similar to the Hould SA, with lesser scaup, northern shoveler, and northern pintail being intermediate in abundance.

Pair use per pond was most different between the Doll and Veseth SA's (3.5 and 8.0 pairs/pond, p=0.07), with the Hould SA intermediate (6.2 pairs/pond). Within each study area, significant differences of pair use were noted among the 3 pond types. The retention ponds had significantly more use than both the pit ponds ($p=0.04$) and the pit-retention ponds ($p < 0.0001$). Differences between the pit and pit-retention ponds were slight ($p=0.544$).

Table 1. Density and species composition of assigned breeding pairs, Spring 1991.

	Doll SA	Hould SA	Veseth SA
Species	*No. of assigned pairs/% of total		
N. pintail	6/5.8	9/11.1	4/8.3
Mallard	16/15.4	10/12.5	10/20.8
American wigeon	17/15.4	13/16.7	6/12.5
Gadwall	29/27.9	21/27.8	11/22.9
Blue-winged teal	10/9.6	1/1.4	2/4.2
N. shoveler	10/9.6	11/15.3	4/8.3
Redhead	0/0	2/2.8	2/4.2
Lesser scaup	11/10.6	9/12.5	6/12.5
Green-wing teal	6/5.8	0/0	0/0
Cinnamon teal	0/0	0/0	1/2.1
Eared grebe	0/0	4/5.3	2/4.2
Total	105	80	48

*Pairs observed, but not assigned: Common merganser Ringneck duck, Ruddy duck, Bufflehead, and Common Goldeneye.

Habitat parameters significantly related to pair use of each pond among all 3 study areas (Spearman rank correlations and multiple regressions) were: shoreline development index, shoreline length, and water surface area ($p < 0.001$) in order of decreasing significance (Appendix Table 9). Other factors contributing significantly to pair use were grazing intensity and percentage of the pond less than 61 cm deep. Non-contributing factors included slope of shoreline, emergent and submerged aquatic vegetation, quality of riparian vegetation, and water clarity.

Waterfowl Production

Total numbers of broods and fledged young differed between years and among study areas, but numbers per pond remained similar each year. In 1991, there were 62% and 58% fewer broods and fledged young, respectively, observed on the Doll and Hould SA's than in 1990. Average brood size remained the same. Tables 2 and 3, and Appendix Tables 10 and 11 report all brood, young, and production data.

In 1990, there were 104% more broods and 153% more fledged young on the Doll SA than on the Hould SA. Average brood sizes for the 2 areas were 4.7 and 3.9, respectively. Numbers of ducklings produced/pond were similar between the 2 areas. However, the numbers/100 m of shoreline and hectare of water were different. There were approximately 210% more young produced/hectare of water and 109% more young produced/100 m of shoreline on the Doll SA than on the Hould SA (productivity was not estimated in 1990 due to lack of pair data).

Table 2. Waterfowl production on the Doll and Hould study areas, 1990.

Number	Doll SA	Hould SA
Ponds surveyed	30	10
Broods[b]	45	22
Fledged young[a]	211	83.3
Broods/pond	1.5	2.2
Broods/100m shoreline	0.5	0.3
Broods/ha water	4.90	1.94
Fledged young/pond	7.1	8.3
Fledged young/100m shoreline	2.3	1.1
Fledged young/ha water	23.0	7.4

[a]Estimated from daily mortality.
[b]Includes broody hens.

In 1991, the Doll SA produced 125% more broods and 134% more young than the Hould SA, and 260 and 812% more broods and young, respectively than the Veseth SA. Average fledged brood sizes were larger on the Doll and Hould SA's than the Veseth SA (Appendix Table 11). Numbers of young/pond were similar for the Doll and Hould SA's, but less for the Veseth SA. Numbers of young/ 100 m shoreline and surface hectare of water on the Doll SA were 132 and 237%, respectively, more than the Hould SA, and 200 and 376% more than the Veseth SA. Productivity on the Doll SA exceeded that on both the Hould and Veseth SA's.

Table 3. Waterfowl productivity on the Doll, Hould, and Veseth study areas, 1991.

Number	Doll SA	Hould SA	Veseth SA
Ponds surveyed	30	13	6
Assigned pairs	105	80	48
Broods	18	8	5
Fledged young[a]	86.6	37	9.5
Productivity[b]	0.171	0.100	0.104
Broods/pond	0.60	0.62	0.83
Broods/100m shoreline	0.19	0.09	0.17
Broods/ha water	1.96	0.61	1.04
Fledged young/pond	2.90	2.90	1.58
Fledged young/100m shoreline	0.93	0.40	0.31
Fledged young/ha water	9.43	2.80	1.98

[a]Estimated from daily mortality, includes young associated with broody hens.
[b]Ratio of No. broods:No. breeding pairs.

Brood use among pond types differed significantly in 1990, but not in 1991. In 1990, more young were observed on retention ponds than either pit (p=0.04) or pit-retention ponds (p=0.03). Differences between pit and pit-retention ponds were not significant. Similar differences were noted in 1991, but the differences were not significant.

Spearman rank correlations (Appendix Table 9) indicated that duckling use in 1990 was associated with shoreline length, shoreline development, and water area. Other habitat parameters significant at $p < 0.10$ were percent of pond less than 61 cm deep and width of the riparian zone. Factors not contributing to duckling use in 1990 included percent of pond with submerged aquatic vegetation, width of bare shoreline, and density of riparian vegetation.

The same tests for 1991 data, a relatively atypical water year, indicated riparian and total pond complex areas, shoreline length, and water area contributed significantly to duckling use (Appendix Table 9). Additionally, Spearman-rank correlations were significant between duckling use and vertical obstruction ($p=0.008$) and maximum height of upland vegetation ($p=0.003$). At $p < 0.10$, riparian zone width and shoreline development index were significant. Non-contributing factors in 1991 were similar to those in 1990.

Species composition of duck broods differed between years and among study areas. (Appendix Tables 10 and 11). In 1990, the most common species on the Doll SA were blue-winged teal and gadwall. Species not observed included mallard, redhead, lesser scaup, and green-winged teal. On the Hould SA during the same year, the most common species were gadwall, blue-winged teal, and A. wigeon. Species not observed were similar to the Doll SA, except 9% of brood composition included mallard broods, and no canvasback broods were observed. Additionally, more broods of the Podicipedidae family were observed on the Doll SA.

In 1991, the most common species of broods on the Doll and Hould SA's were gadwall and A. wigeon. A. wigeon were most common on the Veseth SA, while gadwall broods were not observed. Mallard and northern pintail broods were next in abundance on the Doll SA. Mallard broods were not observed on the Hould and northern pintail broods were not observed on the Veseth SA. Northern shoveler broods were noted on the Doll and Hould SA's, but not on the Veseth SA. Lesser scaup broods were observed only on the Doll SA. Species with broods observed in 1990, but not in 1991 included green-winged teal, canvasback, the 2

Podicipedidae species (eared and pied-billed grebe), and coot.

Nesting, Predation, and Brood Mortality

The organized nest search conducted on all study areas in June, 1991 yielded only 1 nest, an anticipated outcome due to the relatively low density of nests with respect to land area. Incidental nest discoveries yielded 7 nests during the field season of 1991, only 3 of which were waterfowl. Three others were members of the Scolopacidae family (2 willet and 1 godwit), and 1 sagegrouse nest. Nest successes between areas were 50, 67, and 100% for the Doll, Hould, and Veseth SA's, respectively. However, these estimates were based on low sample sizes.

Numbers and species of predators observed differed among study areas during both field seasons. Avian predators observed included Swainson's hawks, ferruginous hawks, northern harriers, golden eagles, magpies, ringbilled and California gulls, and crows. Four species of mammalian predators were observed: red fox, coyote, badgers, and Richardson's ground squirrels. In 1990, 3 red fox adults were observed regularly on the Doll SA. In 1991, 3 adult red foxes with litters (total 7 pups) and 2 adult coyotes were observed on the Doll SA. No canid predators were observed on the Hould SA. One adult red fox with a litter (2 pups) was regularly seen on the Veseth SA.

Densities of raccoons were estimated (via trapping success) to have increased on the Doll SA during the last several years (W. Doll, pers. commun.), although I did not observe any during the 2 field seasons. This may be due to the nocturnal nature of raccoons and their preferred habitation of buildings and farmyard areas.

Average daily brood mortality (quotient of average brood loss and days between samples) for the Doll and Hould SA's in 1990 was estimated to be 2.0 and 2.5%, respectively. In 1991, these estimates, as well as the estimate for the Veseth SA were 1.1, 1.3, and 2.2%, respectively. Total brood loss from hatching to fledging, based on an average 42 days required for fledging, can thus be estimated as 46, 55, and 92% for the Doll, Hould, and Veseth SA's, respectively.

Pond Physical Characteristics

A complete list of pond physical data are presented in Appendix Tables 13 and 14. Kruskall-Wallis rankings were used to test differences, and are listed in Appendix Table 15. Means and standard deviations for each parameter are reported in Appendix Table 16.

Ages for all ponds were obtained for the Doll and Hould SA's, but complete age data for the Veseth SA were not available. The average age of ponds on the Hould SA (34.4 yr) exceeded the average for the Doll SA (22.8 yr, $p=0.05$).

Shoreline lengths were different among areas and pond types. The average shoreline length on the Hould SA (714 m) was longer than the average on the Doll SA (309 m, $p=0.006$), but only slightly longer than the Veseth SA average (505 m). Differences between the Doll and Veseth SA were not significant. Retention ponds on all 3 areas had longer shorelines than both pit and pit-retention ponds ($p < 0.0001$). Shoreline lengths between the latter 2 types were similar, due primarily to low water levels.

Shoreline development indices were similar among areas but significantly different among pond types. Retention ponds had higher indices, indicating a more irregular shoreline, than the pit or pit-retention ponds ($p=0.002$, and 0.0001, respectively). Differences between the latter 2 types were not significant ($p=0.865$), again due to low water levels. Shoreline widths and slopes were different among areas, but only slope was different between pond types. The average shoreline width was significantly greater on the Veseth SA than on either of the others, probably a function of the overall lower water levels on that area during 1991. Shoreline slopes were steeper on the Doll SA than on the Hould SA ($p=0.0001$), and steeper on the Veseth SA than on the Hould SA ($p=0.009$). Differences between the Doll and Veseth SA were non-significant. Slope was also steeper in the pit ponds than in the retention ponds (p=0.022) or the pit-retention ponds (p=0.082).

Pond size (water surface area) differed between the study areas and pond types. The average size on the Hould SA (1.02 ha) was larger than the average on the Doll SA (0.306 ha, p=0.001) and the Veseth SA (0.798 ha, p=0.064). Additionally, the retention ponds were larger than the pit or pit-retention ponds (p=0.0001), the latter 2 were not significantly different in size.

Pond depth, specifically the percent of the pond less than 61 cm deep, were similar among study areas but different among pond types. The pit-retention ponds had significantly more area less than 61 cm than either the retention or pit-retention ponds (p=0.009 and 0.007, respectively).

Water clarity differed significantly among the study areas but not among the pond types. Secchi disk readings were greater in ponds on the Doll SA than those on both the Hould SA (p=0.003) and the Veseth SA (p=0.008). Water clarity was similar between the Hould and Veseth SA's. Spearman-rank correlations between this variable and percentage of pond with submerged aquatic and emergent vegetation yielded significant relationships for both (p=0.03 and 0.002, respectively).

Width of the riparian zone (the shoreline vegetation directly influenced by the pond's presence) was different among study areas but not among pond types. The widths on the Veseth SA were larger than the Doll and Hould SA's (p=0.036 and 0.013, respectively), probably due to differences in water levels in 1991, and length of time for water fluctuations to occur. Long periods of low water levels, as experienced on the Veseth SA, resulted in establishment of riparian vegetation on previously inundated areas around the pond.

Differences in soil families among areas and pond types were not significant. All 14 types and families are listed in Appendix Table 17. Spearman-rank correlations between soil family and water clarity, submerged aquatic vegetation, and emergent vegetation yielded significant relationships for water clarity and emergent vegetation (p=0.04 and 0.03, respectively). Ponds located on soils belonging to the Borollic Natrargids/Paleargids family tended to have slightly clearer water than ponds located on soils of the Ustic Torriorthents/Torrifluvents family. Ponds with higher percentages of emergent vegetation were associated with the Borollic Natrargids/Paleargids and the Typic Albaqualf soil family.

Aquatic and Riparian Vegetation

Submerged aquatic vegetation within the ponds did not differ among study areas. Appendix Table 18 lists species and percentage of submerged aquatic vegetation within the ponds. Percentages on each pond ranged from 0-90%, but more commonly values were between 0-10%. The most common species on all 3 study areas were filamentous green algae and Canadian waterweed. Spiked watermilfoil, fennelleaf pondweed , and Richardson pondweed were also common. Depths at which the vegetation was sampled varied between ponds and species. In general, those species found at greater depths included common hornwort (*Ceratophyllum demersum*), spiked watermilfoil, and Canadian waterweed. Average depths at which these species were sampled were 3.5, 2.3, and 2.1 m, respectively. The species inhabiting shallower areas included Richardson pondweed and filamentous green algae.

Correlations between percentage of pond with submerged aquatic vegetation and percent of pond less than 61 cm was not significant (p=0.534), nor was the correlation between submerged aquatics and pond age. This may be a reflection of the age structure of the ponds, as all ponds were older than the age reported to affect aquatic vegetation changes (Hudson, 1983).

Visual estimation of emergent vegetation on each pond ranged from 0-80%. This variable differed among pond types and study areas. The Veseth SA had less emergent vegetation than the Doll or Hould SA (p=0.001 and 0.012, respectively), and differences between the latter 2 areas were not significant. Pit-retention ponds on all 3 areas had more emergent vegetation than the pit (p=0.007) or retention ponds (p=0.009). Furthermore, pit and retention ponds did not significantly differ. Spearman-rank correlation between emergent vegetation and percent of pond less than 61 cm was not significant.

Species composition of the emergent vegetation, along with abundances of each species, is listed in Appendix Table 18. The most common species observed on the Doll and Hould SA's were longspike spikerush and floating knotweed (*Polygonum natans*). The Veseth SA had relatively few emergent species, and low growth of those present. The only 2 species observed on this study area were narrowleaf waterplantain (*Alisma gramineum*) and northern arrowhead (*Sagittaria cuneata*), the former being the more abundant.

Table 4. Species composition and average frequency of emergent vegetation on the Doll, Hould, and Veseth study areas, July, 1991.

	Frequency (%)		
	Study area		
Species	Doll	Hould	Veseth
Poa sp.	4.0	1.8	-
Cruciferae sp.	2.9	-	-
Rumex sp.	3.2	1.1	-
Alisma gramineum	-	-	4.0
Beckmannia syzigachne	2.0	4.7	-
Eleocharis macrostachya	81.5	65.5	-
Grindelia squarrosa	T	-	-
Polygonum natans	6.1	6.5	-
Sagittaria cuneata	T	-	2.0
Scirpus validus	3.3	-	-
Typha latifolia	3.9	-	-

a-See Appendix Table 11 for listing of common names.
T-trace; less than 1.0%.

Maximum height and vertical obstruction readings of the riparian vegetation differed between study areas but not among pond types. Both the Veseth and Doll SA's had greater maximum height and vertical obstruction values than the Hould SA. Differences between the Doll and Veseth SA were not significant for either variable.

The 4 most common species of riparian vegetation differed slightly between the Doll and Veseth SA's. Foxtail barley and longspike spikerush were common on both areas, but needle spikerush and western wheatgrass were more common on the Doll SA. In contrast, marsh knotweed and yellow sweetclover were more common on the Veseth SA. Species composition was not sampled on the Hould SA due to travel restrictions. See Appendix Table 19 for complete listing of species composition and percentage of the vegetation common to each pond.

Upland vegetation comparisons, species composition, maximum height, and vertical obstruction readings are reported in Table 5 and Appendix Tables 20-22. Analyses of variances among the 3 areas showed significant differences among areas for maximum height and vertical obstruction. The Hould SA had lower mean values for both variables than both the Doll and Veseth SA's ($p=0.002$ and 0.05, respectively). The Doll and Veseth SA's did not differ for these 2 variables. Additionally, significant differences between the Doll and Hould SA's for life forms and bare ground were calculated. The Hould SA had more spikemoss selaginella and less bare ground than the Doll SA. Of the species present on the Doll and Veseth SA's, the following were not observed in any plots on the Hould SA: Louisiana sagewort (*Artemisia ludoviciana*), dotted grayfeather (*Liatris punctata*), alfalfa (*Medicago sativa*), prairie coneflower (*Ratibida columnifera*), inland saltgrass (*Distichlis stricta*), and big sage.

Table 5. Statistical analysis of upland vegetation collected August, 1990, Doll and Hould study areas.

Life form[a]	Mean[c] Doll S.A.	Mean[c] Hould S.A.	SE[d]	p[b]
Perennial grasses	4.19	6.11	1.09	0.35
Annual forbs	0.40	0.60	0.13	0.37
Perennial forbs	1.60	1.50	0.70	0.47
Shrubs	0.44	0.20	0.05	0.22
Ferns	8.20	20.40	1.25	<0.001
Litter	15.60	11.90	1.51	0.14
Bare grnd.	20.80	15.30	1.28	0.04
Max. ht.	10.5"	8.4"	0.37	0.01

[a]See Appendix Table 23 for complete species list.
[b]If $p < 0.05$, reject null hypothesis.
[c]Average canopy coverage for each area.
[d]Standard deviation of the mean.

Analyses of the effects of range renovation (chisel plowing) on the Doll SA showed significant differences between areas treated with this practice within 6 years and untreated areas (Hould and Veseth SA's). Maximum height and vertical obstruction values were greater on treated areas less than 6 years old than the Hould SA ($p < 0.001$), but not different from the Veseth SA (Appendix Figure 3). As the age of treatment increased beyond 6 years, the differences between treated areas and the other study areas decreased. At 15 years, the treated areas resembled untreated areas. Analysis of variance among different ages of renovation indicated greater maximum height and vertical obstruction values on treated areas less than 6 years old than treated areas greater than 15 years old ($p=0.003$). The correlation for these variables and age increased, peaked at 6 years ($r^2=0.71$), and decreased thereafter. See Tables 6 and 7 for complete listing of comparisons.

Table 6. Comparison of upland canopy coverage and frequency between ages of mechanical renovation, Doll study area, June, 1991.

Species	0-2 yrs %cov/freq	3-6 yrs %cov/freq	8-21 yr %cov/freq	Control %cov/freq
Agropyron smithii	6.6/50.0	11.3/58.0	6.6/43.3	7.8/51.0
Selaginella densa	17.3/67.5	3.2/20.0	11.3/54.4	20.4/74.0
Opuntia polycantha	3.1/15.0	0.2/3.3	0.9/5.6	1.0/5.0
Stipa comata	3.9/27.5	5.4/37.8	4.6/33.3	3.6/27.0
Bouteloua gracilis	25.5/87.5	11.1/62.2	15.8/63.3	26.8/90.0
Bare ground	14.6	23.2	20.2	15.3

Table 7. Analyses of variances between control and mechanical renovation, and within various age groups of renovation for canopy coverage and frequency of occurrence of upland vegetation, Doll study area, June, 1991.

Species	Control area vs. 3-6 yr. chisel		3-6 yr. vs. 8 yr + chisel	
	%cov.	%freq.	%cov.	%freq.
Agropyron smithii	p=0.09	>0.10	p=0.06	0.20
Selaginella densa	p=0.00002	0.00002	p=0.006	0.009
Opuntia polycantha	p=0.07	>0.10	p=0.20	>0.10
Stipa comata	p=0.21	0.20	p>0.10	>0.10
Bouteloua gracilis	p=0.00005	0.009	p>0.10	>0.10
Bare ground	p=0.03		p>0.10	

Other Habitat Variables

Grazing intensities varied among the study areas. Known stockage rates were obtained for the Doll and Hould SA's, intensities for the Veseth SA were estimated from daily observations. Cattle on the Doll SA were wintered on one pasture within the study area (approximately 968 AUM), and turned onto the other pastures in mid-June. The entire study area consisted of 10 pastures (complete grazing scheme consists of 15 pastures). Cattle use ranged from 0 AUM on 4 non-use pastures to 780 AUM, but most pastures experienced intensities of approximately 720 AUM. Additionally, 215 yearlings were grazed on 1 pasture (172 AUM) from late April to early July.

The grazing scheme on the Hould SA was based on a 6 pasture system divided into an east and west unit. Only 4 of the 6 pastures were on the study area. Cattle were turned on the first pasture in the west unit in early May (809 AUM), moved to the second pasture on 10 July (461 AUM), and moved to the third pasture on 10 August (799 AUM). The fourth pasture of the study unit was the third pasture of the east unit, receiving 764 AUM on 06 August. Cattle were assumed to winter on each of the final pastures.

Grazing intensity and timing of grazing on the Veseth SA was determined primarily by availability of water in the stock ponds. Consequently, there was little grazing on this area during the 2 years of the study, except around the larger reservoirs (V7 and V3), as spring runoff had not occurred during the study period on this area. This was reflected in the increased quantity and quality of the upland vegetation.

DISCUSSION

There are several drawbacks to the pair and brood survey method of estimating waterfowl production. These include broods hatched or ducklings lost after the final survey, assumption of 100% sightability, and the high variability in waterfowl production (Anderson and Robinson, 1990). However, it has been suggested that this is the only feasible method for estimating production in areas of low nest densities and relatively low waterfowl breeding populations (Kirby 1980, Ball and Eng 1989).

Past studies have indicated a need for the observer to walk the perimeter of each pond while conducting brood counts in an attempt to flush any broods hidden among shoreline vegetation (Smith 1953, Berg 1956, Duebbert 1966, Ball and Eng 1989). For this study, brood counts did not require this method, as most broods were observed on relatively small ponds. Additionally, shoreline and riparian vegetation was usually sparse, therefore any broods which attempted to hide were usually seen before they reached cover.

Breeding Pair Populations

Retention ponds had the highest pair use during this study. Shoreline development, a factor which increases visual isolation, shoreline length, and water area were the primary variables responsible for determining pair use. Retention ponds had more shoreline and water area, and thus higher development indices than either pit-retention or pit ponds. Mundinger (1975), in a study of waterfowl production on a portion of the Hould SA, also reported higher pair use of retention ponds except during years of high water. During wet years, the upland surrounding pit-retention ponds becomes flooded, creating a very attractive combination of factors to breeding waterfowl. He also reported very light use of the pit ponds during all years.

The numbers of pairs per pond on each study area reflected both differences in pond numbers and average pond sizes among areas. The Doll SA, with 8.5 ponds/km^2 and average pond size of less than 0.5 ha, had the lowest numbers of pairs/pond. In contrast, the Hould and Veseth SA's had larger average pond sizes, fewer ponds/hectare, and resultant higher pairs/pond (Appendix Table 16). Furthermore, the numbers of pairs/hectare water increased as the pond size decreased on all study areas. Other authors reporting higher pair numbers on the larger ponds, but higher densities on the smaller ponds include Smith (1953), Evans and Black (1956), and Lokemoen (1973).

Several studies have shown pond density influences pair use of an area. Lokemoen (1973) reported twice as many pairs on a study area with twice as many ponds as the control area. However, he did not assess productivity rates between the 2 areas. Krapu et al. (1983) found the density of mallard pairs to be positively correlated with pond numbers. As pond numbers decreased, the total breeding population and nesting activity decreased.

Although differences in total numbers of pairs among study areas was not proportional to differences in pond numbers, the differences in total assigned pairs was large. This non-proportionality may be a factor of relative composition of pond types and available water area. Whereas the Veseth SA had no pit ponds and had the highest percentage of retention ponds, the Doll SA had the most pits, and fewest retention ponds of the 3 areas. Thus, maximum pair use of ponds may be realized when retention ponds comprise the majority of the pond types.

Numbers of pairs per hectare of water were slightly higher during this study than earlier studies conducted in the same area (Gjersing 1970, Mundinger 1975, Hudson 1983, Ball et al. 1988). Additionally, these values are extremely high in relation to values reported in the PPR (Ball and Eng 1989).

In addition to pond size and type and shoreline length influencing pair use, grazing intensity and degree of shallowness of the ponds were also shown to be negatively and positively correlated, respectively, with pair use of the ponds. Salyer (1962) and Kirsch (1969) similarly found higher pair populations on or near ponds with ungrazed upland cover, and Mundinger (1975) reported a positive response by waterfowl to rested or non-grazed pastures.

Production

Although production per pond was similar among areas, the Doll SA had higher production per hectare of water and 100 m of shoreline, and higher overall productivity than either of the other study areas. The linear relationship for productivity between the 3 areas based on pond density alone stresses the importance of this factor to waterfowl production. In addition to increasing the complex of pond types, higher pond densities probably reduce the degree of predation upon transient broods as they move between ponds in response to water conditions, and or changing physiological requirements (food types, cover, grazing pressure, etc.). Keith (1961) and Cowardin (1985) reported longer brood movements as pond densities decreased which probably resulted in higher predation from mammalian or avian predators. Talent et al.(1982), from radio tracking marked broods, concluded that the cumulative home range of a brood (the total area of wetland habitat used by a brood) decreases as pond densities and complexes increase. Furthermore, most authors agree that the highest rate of brood mortality occurs within the first 1-2 weeks. This is the period of time when upland nesting broods make an initial nest-to-water journey, as well as additional treks soon thereafter to larger, more secure ponds.

Estimated daily mortality rates further suggest that instead of providing a 'predator sink', high pond densities act as a larger patch size. Rundquist (1973) and Ball et al. (1988) speculated that the distance between ponds, and thus overall low nest density, deters nest predators. Conversely, Clark and Nudds (1991) suggested that increased patch size and habitat heterogeneity of nesting habitats reduces foraging efficiency of predators. Thus, increased pond densities up to a certain level, and a mixture of pond types and sizes should provide increased patch size and heterogeneity, increased nest success and lower brood mortality. However, predator efficiency may increase at a threshold of prey availability (saturation of nesting populations due to extremely high pond densities, similar to that seen in the PPR where pond densities may approach 390/km^2). Further studies to determine this threshold would be very beneficial. Past studies indicate pond arrangement is critical to waterfowl production. Evans and Black suggested building many smaller ponds around larger ponds, maximizing the potential of an area to serve as brood habitat. Eng et al. (1979) suggest planning pond developments to include a cluster of ponds of variable sizes, rather than an equal distribution of ponds per unit area which tends to isolate the ponds. Mundinger (1975) reported higher pair populations and species diversity of the breeding pair population following maturation of existing younger ponds, and construction of new ponds. Duebbert and Frank (1984) and Talent et al. (1982) also suggested maintaining a heterogenous wetland complex to maximize both production and species diversity.

In addition to supporting higher pair populations, the retention ponds had higher brood use than either of the other pond types. This is probably due to a combination of factors, but the correlations calculated for the various pond parameters suggest pond size, and other factors related to size (shoreline length and development), are characteristics seemingly attractive to broods. These size related factors are especially common to retention ponds, especially in 1991 when pit and pit-retention ponds were morphologically similar due to low water levels. Other authors who have suggested pond size is the main contributor to brood use include Berg (1956), Evans and Black (1956), and Lokemoen (1973).

Data from both years of this study suggest that the gadwall is a very prominent breeder in northcentral Montana. In contrast, Hudson (1983) reported northern pintail and A. wigeon broods as the most numerous. Similarly, Mundinger (1975) reported highest percentages of northern pintails, mallard, and A. wigeons. Gadwalls those years were proportionately less represented. The relative paucity of northern pintails during the current study supports recent population estimates and forecasts for this species. Northern pintail breeding populations in 1988 were estimated to be 54% below the long term average (Ducks Unlimited, 1990).

Management Implications

In light of the increasing concern over nationwide waterfowl population declines, these data support the theory that waterfowl production may be increased by increasing pond construction on western rangelands. In order to maximize the cost:benefit relationship of pond construction, several factors should be considered before construction is begun. Size, shoreline length, shoreline development, degree of shallowness, and aquatic vegetation are functions of the pond's location due to the geomorphology and soil characteristics of the site. Additionally, as mentioned, a heterogenous arrangement of pond types and sizes may best serve the production of waterfowl by increasing nest success, species diversity, and overall attractiveness of the area to waterfowl and other vertebrate species which benefit from, or are obligate to wetlands.

Hudson (1983), investigating waterfowl response to different age classes of stock ponds on the current study area suggested choosing drainages in which the maximum pond size is 0.5 ha, with irregular shorelines, and with at least 40% of the pond less than 61 cm deep. These characteristics exclude most pit and pit-retention ponds during most years. However, a high percentage of potential waterfowl producing rangeland exists on private land, and the landowner's desires must also be satisfied. He is concerned primarily with water for cattle, and pit ponds serve this need most efficiently due to their greater permanence during dry years. Thus, a compromise between the 2 interests will probably be required.

Range management has also been shown to affect waterfowl production (Kantrud 1986, this study). The increased vegetation on the Doll SA from mechanical renovation will probably benefit waterfowl, as evidenced by the increased quantity and quality of the upland vegetation and supported by correlations with higher brood use. However, altered grazing management schemes may preclude the need for future renovations on this area. Gjersing (1975) concluded that rest rotation grazing management was beneficial to waterfowl production.

On a cost:benefit relationship, the various management techniques available to increase waterfowl production may vary in efficiency on a regional basis. Lokemoen (1984), examining economic efficiency of the various habitat improvement procedures, concluded that predator management was probably the most cost effective means of improving production in the Prairie Pothole Region of North and South Dakota and western Minnesota. However, when considering the limitations to production on western rangelands where nest success remains fairly high, the most effective method of improving waterfowl may come from well planned construction of stockponds, as proposed in the current study.

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APPENDICES

Appendix A

Tables

Table 8. Summary weather data for long term (1906-1989), 1989, 1990, and 1991 from weather station Malta 7E.

Period	Annual snowfall (inches)	Annual precip. (inches)	Snowfall between previous Oct.-May	Precip. between previous Oct.-May
1906-1989	28.76	12.95	24.94	5.93
1989	43.25	11.95	-	-
1990	30.95	10.55	28.70	6.89
1991	20.75	11.82	31.40	5.35

Period	Avg.annual temp (°C)	Avg.annual min.temp (°C)	Avg.annual max.temp (°C)	Lowest monthly min.temp (°C)	Highest monthly max.temp (°C)
1906-1989	6.1	-1.7	13.9	-32.2	34.4
1989	5.6	-2.8	13.9	-20.0	32.2
1990	7.8	-0.6	15.6	-19.8	30.9
1991	7.2	-1.1	15.6	-19.9	32.1

Table 9. Spearman rank correlations (Rs) and associated p-values (p) between waterfowl production and various habitat parameters, 1990 and 1991.

	Pairs 1991		Young 1991		Young 1990	
Variable	Rs	P	Rs	P	Rs	P
Pond size	.584	.000	.344	.015	.502	.001
Shoreline length	.620	.000	.360	.011	.569	.000
Shoreline development	.558	.000	.234	.106	.537	.000
No. broods, 1990	.399	.008	.313	.041	.991	.000
No. young, 1990	.414	.006	---	---	---	---
Size of riparian zone	.365	.011	.567	.000	.317	.041
Grazing intensity	.397	.008	-.028	.860	.248	.109
% pond < 61 cm	-.326	.025	-.119	.424	-.248	.078
No. broods, 1991	.285	.047	.970	.000	.291	.059
No. young, 1991	.270	.061	---	---	---	---
% pond w/submergents	.242	.101	.080	.591	.017	.914
Pond age	.235	.130	.204	.189	.224	.153
Shoreline slope	-.222	.129	-.052	.726	-.301	.052
% pond w/emergents	-.204	.169	-.048	.749	-.063	.694
Width of bare shore	.195	.253	-.027	.874	-.001	.996
Pond type	-.149	.308	.044	.764	-.126	.421
Soil type	.171	.239	-.130	.373	-.074	.637
Vert.obstr. of ripar.	.135	.462	.055	.978	.006	.976
Secchi depth	-.128	.390	.240	.105	.154	.337
Max.ht.riparian veg.	.123	.502	.042	.819	.077	.703
Width of ripar. zone	.143	.412	.290	.091	.339	.067

Table 10. Numbers of broods, fledged young, and average brood sizes, 1990.

	Doll Study Area	Hould Study Area
Species	Nos. broods/fledged young/avg. size	
N. Pintail	3/13.9/4.6	1/4.9/4.9
Mallard	0	2/8.8/4.4
American wigeon	3/17.1/5.7	7/25.7/3.7
Gadwall	9/29.5/3.3	5/15/3
Blue-winged teal	19/96.2/5.1	5/21.5/4.3
Northern shoveler	3/13.9/4.6	1/4.1/4.1
Redhead	0	0
Lesser scaup	0	0
Green-winged teal	0	0
Canvasback	1/1.8/1.8	0
Eared grebe	0	1/3.3/3.3
Pied-billed grebe	4/19/4.8	0
American coot	6/18/3.0	0
Canada Goose	6/37/6.2	6/34/5.7
Total	45/211/4.7	22/83.3/3.9

Table 11. Numbers of broods, fledged young, and average brood sizes, 1991.

	Doll SA	Hould SA	Veseth SA
Species	No. of broods/fledged young/avg. size		
N. Pintail	3/18.2/6.1	2/6.73.4	0
Mallard	3/9.3/3.1	0	1/2.7/2.7
A. wigeon	3/10.1/3.4	2/5.5/2.8	3/3.7/1.2
Gadwall	4/27.4/6.9	2/15.9/8.0	0
Blue-winged teal	2/10.5/5.5	1/4.9/4.9	1/3.1/3.1
N. Shoveler	2/8.6/4.3	1/4.0/4.0	0
Redhead	0	0	0
Lesser scaup	1/6.2/6.2	0	0
Green-winged teal	0	0	0
Canvasback	0	0	0
Eared grebe	0	0	0
Pied-billed grebe	0	0	0
A. Coot	0	0	0
Canada goose	3/12/4	2/9/4.5	1/2/2
Total	18/86.6/4.8	8/37/4.6	5/9.5/1.9

Table 12. Common and scientific names of avian and mammalian species referred to in text, 1990 and 1991.

Common name	Scientific name
Avian species	
Mallard	*Anas platyrhynchos*
Gadwall	*Anas strepera*
Northern pintail	*Anas acuta*
American wigeon	*Anas americana*
Northern shoveler	*Anas clypeata*
Blue-winged teal	*Anas discors*
Green-winged teal	*Anas crecca*
Lesser scaup	*Aythya affinis*
Redhead	*Aythya americana*
Canvasback	*Aythya valisineria*
Canada goose	*Branta canadensis*
Eared grebe	*Podiceps nigricollis*
Pied-billed grebe	*Podilymbus podiceps*
American coot	*Fulica americana*
Willet	*Catoptrophorous semipalmatus*
Marbled godwit	*Limosa fedoa*
Sage grouse	*Centrocercus urophasianus*
Swainson's hawk	*Buteo swainsoni*
Ferruginous hawk	*Buteo regalis*
Northern harrier	*Circus cyaneus*
Golden eagle	*Aquila chrysaetos*
Black-billed magpie	*Pica pica*
American crow	*Corvus brachyrhyncus*
Mammalian species	
Red fox	*Vulpes vulpes*
Coyote	*Canis latrans*

Table 12. (cont.)

Badger	*Taxidea taxa*
Richardson's ground squirrel	*Spermophilus richardsonii*
Raccoon	*Procyon lotor*

Table 13. Pond physical parameters on the Doll, Veseth, and Hould study areas, June, 1991.

P O N D	Secchi (ft.)	% of depth obs. <2.0 ft.	Width of bare shore (ft)	Shore slope	Area of ripar. zone.[a]	Visual est. of % of pond w/ emergent	Width of ripar. zone (ft)
D1	4.0	10	2.5	0.15	0.91	20	49
D2	3.5	10	0.5	0.12	1.43	15	41
D4	4.5	20	0.8	0.32	1.90	5	N/A
D5	2.0	20	1.5	0.48	0.23	10	N/A
D6	4.0	20	0	0.08	1.08	60	45
D7	3.0	20	0	0.09	1.26	70	12
D8	4.0	0	0	0.29	0.60	15	39
D9	5.0	40	0	0.09	1.07	70	25
D10	4.0	10	0	0.15	0.41	10	N/A
D11	6.0	50	0	0.23	0.47	5	N/A
D12	4.0	90	4.5	0.29	6.23	80	N/A
D13	4.0	50	N/A	N/A	0.36	55	N/A
D14	3.5	10	10.5	0.17	0.46	10	88
D15	4.0	30	5.3	0.09	5.79	5	87
D16	3.5	30	0	0.08	1.57	23	105
D17	5.0	40	0	0.07	0.61	70	265
D18	4.0	40	0.3	0.15	4.09	55	148
D20	4.0	50	0	0.14	1.58	10	69
D21	2.2	70	2	0.41	0.88	55	N/A
D22	3.0	30	9	0.28	0.26	10	101
D23	4.0	10	13.0	0.29	0.71	5	64
D24	4.0	20	4.0	0.17	2.57	5	42
D26	4.0	10	1.0	0.16	0.94	5	76

Table 13. (cont.)

D27	4.0	20	4.0	0.13	0.17	5	N/A
D28	N/A	N/A	0	0.18	0.33	N/A	N/A
D29	3.1	20	3.8	0.14	1.11	5	80
D30	2.2	40	0	0.08	0.25	40	33
D31	N/A	N/A	0	0.17	1.25	0	N/A
D32	2.0	20	2.3	0.18	0.06	5	N/A
D33	1.5	60	8	0.15	0.19	0	N/A
H1	3.0	10	N/A	N/A	0.47	5	40
H2	2.5	30	N/A	N/A	0.63	0	145
H3	0.2	20	N/A	N/A	0.47	10	18
H4	3.5	0	N/A	N/A	0.99	20	78
H5	3.5	60	N/A	N/A	0.42	35	33
H6	0.5	60	N/A	N/A	0.21	20	40
H7	4.0	0	N/A	N/A	3.96	5	70
H8	3.5	35	0	0.08	0.70	70	N/A
H10	0.5	30	N/A	N/A	0.30	5	45
H11	0.5	N/A	0	0.04	0.39	10	5
H12	5.0	25	N/A	N/A	0.67	20	114
V1	1.0	100	2.0	0.15	0.48	0	N/A
V3	2.0	40	2.8	0.18	14.74	0	350
V4	1.0	30	2.3	0.16	0.37	5	78
V5	1.5	30	4.5	0.14	1.31	0	67
V6	0.5	20	12	0.08	2.02	5	111
V7	7.0	10	9.0	0.08	16.55	0	140

[a]Calculated from digitized aerial photos

Table 14. Pond physical parameters on the Doll, Hould, and Veseth study areas, July-August, 1990.

Pond	Location	Type	Age	Area (ha)	Shore length (m)	Shore dev.[a]
D1	T28N R29E NW4 NE4 SEC.6	R	4	0.55	501.7	1.90
D2	T28N R29E NE4 NE4 SEC.6	R	40	1.52	1151.9	2.63
D3	T28N R29E SW4 NE4 SEC.6	SL	33	0.16	855.1	6.07
D4	T28N R29E SE4 NE4 SEC.18	P	21	0.03	71.9	1.21
D5	T28N R29E SW4 SE4 SEC.18	PR	21	0.06	98.2	1.16
D6	T28N R29E SW4 SE4 SEC.18	PR	32	0.18	184.4	1.22
D7	T28N R29E SE4 SW4 SEC.18	R	43	0.11	256.6	2.15
D8	T28N R29E SE4 NE4 SEC.19	R	44	0.81	694.6	2.18
D9	T28N R29E SE4 NW4 SEC.19	PR	20	0.11	147.2	1.23
D10	T28N R29E SE4 SE4 SEC.19	R	51	0.09	135.3	1.25
D11	T28N R29E NE4 SW4 SEC.20	PR	9	0.03	76.7	1.20
D12	T28N R29E NW4 NE4 SEC.30	PR	9	0.02	61.0	1.21
D13	T28N R29E SE4 SW4 SEC.19	PR	21	0.09	127.5	1.18
D14	T28N R29E SE4 SW4 SEC.30	R	23	0.85	615.8	1.88
D15	T28N R28E SW4 NE4 SEC.25	R	21	0.19	934.5	2.42
D16	T28N R28E NE4 SW4 SEC.24	PR	10	0.20	382.7	2.40
D17	T28N R28E SW4 NW4 SEC.24	PR	10	0.69	726.2	2.47
D18	T28N R28E SE4 NE4 SEC.24	PR	21	0.02	64.8	1.17
D19	T28N R29E SE4 SW4 SEC.6	SL	35	0.16	555.5	3.89
D20	T28N R28E NW4 NW4 SEC.23	PR	20	0.16	178.6	1.27
D21	T28N R28E SE4 NW4 SEC.14	PR	20	0.04	86.9	1.16
D22	T28N R28E SE4 SW4 SEC.12	PR	17	0.04	93.0	1.38
D23	T28N R28E SW4 NE4 SEC.12	P	17	0.08	128.1	1.27
D24	T28N R29E NW4 SW4 SEC.7	R	23	0.07	116.2	1.25

Table 14. (cont.)

D25	T28N R29E SW4 SW4 SEC.5	SL	35	0.14	335	2.55
D26	T28N R29E NE4 NW4 SEC.18	R	43	0.90	852.0	2.54
D27	T28N R28E NE4 NE4 SEC.13	P	10	0.04	93.0	1.30
D28	T28N R28E NE4 SE4 SEC.23	PR	20	0.06	99.2	1.18
D29	T28N R28E NW4 SE4 SEC.13	R	51	0.89	861.2	2.58
D30	T28N R28E SE4 SE4 SEC.14	PR	20	0.03	77.4	1.21
D31	T28N R28E SE4 NE4 SEC.14	PR	20	0.09	128.5	1.19
D32	T28N R28E SE4 NW4 SEC.13	P	22	0.04	87.9	1.23
D33	T28N R29E SW4 NW4 SEC.7	PR	0	0.12	152.0	1.51
H1	T28N R27E NE4 NE4 SEC.13	R	55	0.47	582.4	2.40
H2	T28N R27E SE4 NW4 SEC.13	P	21	0.12	152.3	1.23
H3	T28N R27E NW4 SW4 SEC.2	R	22	0.81	535.4	1.68
H4	T28N R27E NE4 SW4 SEC.12	R	29	0.95	765.1	2.21
H5	T28N R28E NE4 SW4 SEC.7	PR		0.38	460.1	2.12
H6	T28N R28E NW4 NE4 SEC.8	PR	55	0.56	499	1.88
H7	T28N R28E SE4 NE4 SEC.5	R	44	1.44	857.5	2.02
H8	T28N R27E SW4 NE4 SEC.13	R	55	0.51	412.0	1.63
H9	T28N R27E SE4 NE4 SEC.1	R	0	0.30	569.0	2.93
H10	T28N R28E SW4 SE4 SEC.6	R	55	0.82	621.6	1.93
H11	T28N R27E SE4 NE4 SEC.2	R	22	5.64	3179.7	3.78
H12	T28N R27E NE4 SE4 SEC.10	PR	55	0.19	218.5	1.40
V1	T26N R28E SE4 NW4 SEC.27	R	--	0.02	66.0	1.35
V2	T26N R28E NE4 SE4 SEC.26	R	41	dry	--	--
V3	T26N R29E SW4 NW4 SEC.30	R	--	1.63	1064.0	2.35
V4	T26N R28E SW4 SE4 SEC.25	PR	10	0.02	65.0	1.22
V5	T26N R28E SW4 NW4 SEC.34	PR	--	0.18	207.0	1.38
V6	T26N R28E SW4 NE4 SEC.35	R	--	0.25	323.0	1.84
V7	T25N R28E NE4 NE4 SEC.1	R	--	3.69	1305.0	1.91

[a]Comparative value between area and shoreline; high value indicates more developed shoreline.

Table 15. Kruskall-wallis statistics, corresponding p-values, and pair-wise comparisons for testing various habitat parameter differences among study areas.

Variable	Doll SA Mean rank	Hould SA Mean rank	Veseth SA Mean rank	P-value, pr.wise p-values
Grazing intensity	16.57	34.54	-------	.001
Shoreline slope	30.43	9.58	24.67	.001 1x2=.001 1x3=.246 2x3=.009
Vert. obstruction of riparian zone	18.50	8.06	24.50	.003 1x2=.002 1x3=.131 2x3=.001
Secchi depth	29.38	16.85	14.42	.004 1x2=.003 1x3=.008 2x3=.684
Percent of pond with emergent vegetation	27.82	23.31	7.67	.004 1x2=.273 1x3=.001 2x3=.012
Max. ht. of riparian vegetation	18.42	8.72	23.60	.007 1x2=.006 1x3=.211 2x3=.002
Avg. pond size	20.82	35.46	23.25	.008 1x2=.001 1x3=.678 2x3=.064
Avg. shoreline length	21.08	34.00	25.08	.025 1x2=.006 1x3=.508 2x3=.185
Avg. width of riparian zone	17.42	14.2	27.90	.047 1x2=.390 1x3=.036 2x3=.013
Avg. shoreline development index	21.57	32.12	26.75	.080

Table 16. Means and standard deviations of various habitat variables on all study areas.

	Study Area					
	Doll		Hould		Veseth	
Habitat Parameter	Avg	STD	Avg	STD	Avg	STD
Pond age (yr)	22.8	13.1	34.4	20.6	----	----
Pond area (ha)	0.31	0.40	1.01	1.38	0.80	1.31
Ripar.zone area (ha)	1.32	1.53	0.87	1.00	5.91	6.92
Shoreline length (m)	309	314	714	735	505	493
Shoreline dev.index	1.60	0.53	2.03	0.68	1.68	0.40
Ripar.vert.obstr.	1.7	0.6	0.9	0.3	2.8	1.5
Ripar.max.ht.(in)	9.9	4.2	6.8	2.0	11.3	2.5
Width of shoreline(ft)	2.5	3.5	----	----	5.4	3.8
Shoreline slope (%)	19.0	10.0	6.5	3.7	13.2	3.8
Secchi depth (ft)	3.64	0.98	2.30	1.54	2.2	2.2
% of pond w/subm. aquat. veg.	12.3	19.7	15.5	30.5	26.5	36.9
% of pond < 61cm deep	30	20.5	30	24.3	38	28.8
% of pond w/emergent veg.	25	26.3	15	18.8	1	1.4

Table 17. Soil families, types, and ponds associated with each soil type.

Soil Family	Soil type	Ponds
Borollic Natrargids/ Paleargids	Phillips-Absher	D24,D26,D30,D4, D5,D7,D16,D17, D18,D20,D29,D32, H5,H8,H10,H12, V7
	Elloam-Phillips Absher	D1,D6,D13
Borollic Natrargids	Thoeny-Absher	D2,H1,H4
	Thoeny-Elloam	D27
	Phillips-Elloam	D11,D14,D15,D21, D22,D23,D28,D31, V2
	Weingart-Vaeda-Bascovy	H11
	Phillips-Elloam-Thoeny	D8,D9,D10
Ustic Torriorthents Torrifluvents	Nobe-Toston	H9
	Harlem-Havre Saline	V1,V5,V6
	Neldore-Bascovy	D33
	Harlem	D3,D19,D25
Typic Albaqualfs	Nishon	D12
	McKenzie	H3
Argiboroll	Scobey	H3,V3,V4

Table 18. Submerged and emergent vegetation data, Doll, Hould, and Veseth study areas, July, 1991.

Pond	Submergent sp.	PERC	Emergent sp.	PERC	No. of culms/ m^2	Max. ht of emerg. veg.(in.)
D1	MYEX	30%	TYLA	70%	2.5	25
	BARE	70%	SCVA	10%	T	32
			BESY	10%	T	13
			ELMA	40%	96	6
D2	MYEX	10%	SCVA	90%	7	32
	BARE	90%	TYLA	40%	T	34
D4	ALGAE	40%	ELMA	83%	40	6
	BARE	60%	Poa sp.	33%	27	10
D5	BARE	100%	ELMA	75%	119	9.5
			PONA	75%	4	9.5
			Cruciferae sp.	20%	1	13
D6	BARE	100%	ELMA	100%	726	11.6
D7	BARE	100%	ELMA	100%	386	12
			PONA	10%	T	8
			SCVA	20%	5	36
D8	BARE	100%	ELMA	100%	224	6.7
			Poa sp.	12%	10	9
			PONA	12%	T	10
D9	ALGAE	10%	ELMA	100%	728	12.2
	BARE	90%				
D10	ALGAE	10%	ELMA	100%	267	6.6
	BARE	90%	Poa sp.	25%	1	11
D11	BARE	100%	GRSQ	0%	T	13
			ELMA	60%	70	5
			Cruciferae sp.	60%	9	10
D12	BARE	100%	Poa sp.	13%	15	17
			ELMA	63%	38	7.8
			PONA	13%	T	3
			GRSQ	13%	1	5
D13	BARE	100%	ELMA	100%	350	11.4
			PONA	10%	2	6
			Poa sp.	10%	1	9

Table 18. (cont.)

D14	ALGAE	10%	ELMA	100%	151	8.6
	BARE	90%	PONA	10%	T	3
D15	BARE	100%	ELMA	100%	226	8.8
D16	ALGAE	20%	ELMA	100%	260	6.4
	POPE	10%	Rumex sp.	20%	7	8.5
	CEDE	20%				
	ELCA	10%				
	BARE	40%				
D17	BARE	100%	ELMA	100%	302	6.7
			Rumex sp.	30%	2	8
D18	ALGAE	30%	ELMA	90%	103	7
	CEDE	10%				
	BARE	60%				
D20	ALGAE	60%	ELMA	90%	156	4
	BARE	40%	Rumex sp.	10%	T	7
D21	ALGAE	20%	ELMA	100%	127	6.4
	BARE	80%	Rumex sp.	30%	1	5
D22	BARE	100%	ELMA	80%	45	5
D23	BARE	100%	BESY	20%	3	9
			ELMA	50%	66	8
			PONA	40%	2	5
D24	BARE	100%	ELMA	100%	122	6
D26	BARE	100%	ELMA	100%	448	8.7
			Poa sp.	10%	2	14
D27	BARE	100%	ELMA	100%	71	7.1
			Poa sp.	10%	3	12
D29	BARE	100%	ELMA	100%	258	6.6
D30	POPE	55%	ELMA	100%	433	10
	BARE	45%	SACU	30%	10	4.5
			BESY	10%	T	10
D32	BARE	100%	ELMA	100%	273	8.6
			BESY	16%	T	12
D33	BARE	100%	-	-	-	-
H1	MYEX	20%	Rumex sp.	12%	T	4
	BARE	80%	ELMA	100%	111	6.6
			PONA	12%	T	4
			BESY	12%	T	8

Table 18. (cont.)

H2	POPE	10%	-	-	-	-
	BARE	90%				
H3	BARE	100%	PONA	20%	19	9
			ELMA	40%	32	7
H4	ELCA	53%	ELMA	90%	193	5.9
	MYEX	13%	PONA	20%	T	6
	PORI	13%				
H5	POPE	30%	ELMA	100%	332	11
	PORI	10%	BESY	40%	6	4
	ELCA	30%				
	ALGAE	30%				
	BARE	30%				
H6	BARE	100%	ELMA	100%	306	509
H7	BARE	100%	ELMA	10%	T	*
H8	BARE	100%	ELMA	100%	181	5.2
			PONA	20%	T	4
H10	BARE	100%	ELMA	100%	93	4.4
			Poa sp.	20%	T	12
H11	BARE	10%	**	-	-	-
H12	BARE	100%	ELMA	80%	184	6.3
V1	BARE	100%	-	-	-	-
V4	POPE	50%	SACU	10%	T	0
	BARE	50%	ALGR	10%	T	0
V5	BARE	100%	-	-	-	-
V6	PORI	10%	ALGR	10%	T	-
	BARE	90%				
V7	ELCA	90%	-	-	-	-
	POZO	10%				

*-All individual plants on this and most other Hould Study Area ponds prostrate due to heavy rainstorms and consequent flooding.
**-*Salix* spp. are only emergent vegetation present.
***-Other aquatic species incidentally observed: tule bulrush (*Scirpus acutus*), water hyssop (*Bacopa rotundifolia*), American waterplantain (*Alisma triviale*), pepperwort (*Marsilea vestita*), and common wigeongrass (*Ruppia maritima*).

Table 18. (cont.)

Abbreviation key:

	Common name	Scientific equivalent
ALGAE	Filamentous green algae	Unknown
ALGR	Narrowleaf waterplantain	*Alisma gramineum*
BARE	No submerged veg. sampled	-
BESY	American sloughgrass	*Beckmannia syzigachne*
CEDE	Common hornwort	*Ceratophyllum demersum*
ELCA	Canadian waterweed	*Elodea canadensis*
ELMA	Longspike spikerush	*Eleocharis macrostachya*
GRSQ	Curlycup gumweed	*Grindelia squarrosa*
MYEX	Spiked watermilfoil	*Myrriophyllum exalbescens*
PONA	Floating knotweed	*Potamogeton natans*
POPE	Fennelleaf pondweed	*Potamogeton pectinatus*
PORI	Richardson pondweed	*Potamogeton richardsonii*
POZO	Flatstem pondweed	*Potamogeton zosteriformis*
SACU	Northern arrowhead	*Sagittaria cuneata*
SCVA	Softstem bulrush	*Scirpus validus*
TYLA	Common cattail	*Typha latifolia*

Table 19. Riparian vegetation most commonly sampled on the Doll and Veseth study areas, June, 1991.

Pond	4 most commonly occurring riparian spp/frequency of occurence
D1	ELAC(22.5), AGSM(20), TYLA(10), POCO(10)
D2	SCVA(45), Carex sp(32.5), TYLA(5), AGSM(2.5)
D4	MEOF(30), AGSM(25), GRSQ(12.5), HOJU(5)
D5	HOJU(27.5), POCO(17.5), Cruciferae sp. (17.5), AGSM(5)
D6	HOJU(17.5), ELMA(15), AGSM(15), ELAC(10)
D7	AGSM(18), ELMA(14), Poa sp.(13), BRTE(10)
D8	HOJU(17), Potentilla sp.(17), PHPR(15), Carex sp.(12)
D9	AGSM(17.5), ELAC(15), HOJU(12.5), AGAL(12.5)
D10	HOJU(25), ELAC(22.5), AGSM(7.5), Potentilla sp (5)
D11	HOJU(67.5), Cruciferae sp. (10)
D12	HOJU(28), AGSM(28), GRSQ(8)
D14	HOJU(53), POCO(23), AGSM(5), ELAC(5)
D15	HOJU(27.5), Carex sp.(12.5), AGSM(10), Poa sp.(10)
D16	ELAC(25), ELMA(25), HOJU(25), Poa sp.(7.5)
D17	HOJU(31.8), ELMA(13.6), ELAC(18.2), PHPR(15.9)
D18	HOJU(52.6), AGSM(18.4), Poa sp. (8), POCO(8)
D20	ELMA(42.3), PHPR(21.4), HOJU(21.4), Poa sp.(5)
D21	HOJU(45), ELAC(17.5), POCO(15), MEOF(5)
D22	HOJU(17.5), AGSM(10), POCO(2.5)
D23	AGSM(17.5), HOJU(12.5), DAND(5)
D24	HOJU(27.5), AGSM(20), DAND(5)
D26	HOJU(14), ELAC(11), Poa sp.(11), PHPR(5)
D27	MEOF(22.5), BRTE(15), HOJU(12.5), Poa sp. (7.5)
D28	HOJU(36.4), ELMA(18.2), AGSM(11), BESY(9)
D29	ELAC(45), HOJU(15), Carex sp.(7.5), POCO(7.5)
D30	AGSM(27.5), ELMA(22.5), HOJU(20), Poa sp.(15)
D31	HOJU(27.5), ELAC(25), Poa sp.(12.5), DAND(10)

Table 19. (cont.)

D32	HOJU(30), ELAC(22.5), BRTE(15), POCO(5)
V1	HOJU(30), ELMA(17.5), DAND(17.5), PHPR(5)
V3	HOJU(25), POCO(11), SAIB(9), TYLA(5)
V4	AGSM(20), Carex sp.(12.5), AGAL(12.5), RULA(7.5)
V5	HOJU(28.5), MEOF(17), SCVA(7), BESY(7)
V6	POCO(27.5), HOJU(25), ELMA(17.5), Poa sp.(15)
V7	HOJU(47.5), MEOF(22.5),POCO(17.5), BRTE(7.5)

Legend:

	Common name	Scientific equivalent
AGSM	Western wheatgrass	*Agropyron smithii*
AGAL	Redtop bentgrass	*Agrostis alba*
BRTE	Cheatgrass brome	*Bromus tectorum*
BESY	American sloughgrass	*Beckmannia syzigachne*
DAND	Common dandelion	*Taraxicum officinale*
ELAC	Needle spikerush	*Eleocharis acicularis*
ELMA	Longspike spikerush	*Eleocharis macrostachya*
GRSQ	Curlycup gumweed	*Grindelia squarrosa*
HOJU	Foxtail barley	*Hordeum jubatum*
MEOF	Yellow sweetclover	*Melilotus officinalis*
PHPR	Common timothy	*Phleum pratense*
POCO	Marsh knotweed	*Polygonum coccineum*
RULA	Prairie coneflower	*Rudbeckia laciniata*
SAIB	Common russianthistle	*Salsola iberica*
SCVA	Softstem bulrush	*Scirpus validus*
TYLA	Common cattail	*Typha latifolia*

Table 20. Vertical obstruction (0.5 dm) and max. ht. readings (cm) for upland vegetation on the Veseth study area, June 1991.

POND	DATE	x	Sx	y	Sy	r	n	Ren. Age
V1	5-18	0.55	0.72	36.6	3.20	0.45	10	NA
V3	5-18	0.58	1.09	15.8	4.10	0.46	20	NA
V4	5-18	0.78	0.95	20.7	5.09	0.72	20	NA
V6	5-18	0.65	0.86	18.3	4.23	0.76	20	NA
V7	5-18	0.93	0.82	21.2	2.39	0.72	20	NA
AVG	-	0.70	0.07+	22.5	1.44+	0.62	-	-

Table 21. Vertical obstruction (0.5 dm) and max. ht. readings (cm) for upland vegetation on the Hould study area, June, 1991.

POND	DATE	x	Sx	y	Sy	r	n	Ren Age
H1	5-15	0.20	0.30	8.8	2.72	0.72	20	NA
H2	5-15	0.37	0.59	9.5	2.79	0.82	20	NA
H3	5-15	0.18	0.34	9.3	2.48	0.84	20	NA
H4	5-15	0.18	0.29	10.3	2.09	0.63	20	NA
H5	5-14	0.15	0.24	16.8	3.89	0.48	10	NA
H6	5-14	0.20	0.26	8.4	1.25	0.31	10	NA
H7	5-14	0.75	1.57	12.2	4.71	0.93	10	NA
H9	5-14	0.25	0.26	13.0	2.02	0.68	10	NA
H10	5-14	0.10	0.21	7.1	1.14	0.56	10	NA
H11	5-15	0.09	0.22	9.3	1.90	0.33	20	NA
H12	5-15	0.21	0.32	10.0	2.42	0.46	20	NA
AVG	-	0.24	0.13+	10.4	0.75+	0.62	-	-

[x]Vertical obstruction.
[y]Maximum height of vegetation.

Table 22. Vertical obstruction readings (0.5 dm) and max. ht. (cm) for upland vegetation on the Doll study area, June, 1991.

POND	DATE	x	Sx	y	Sy	r	n	Ren Age
D1@	5-16	0.35	0.65	12.5	2.25	0.58	20	12
D2@	5-16	0.65	0.69	13.2	2.98	0.65	20	12
D5	5-17	0.68	0.85	16.8	5.36	0.75	20	21
D6	5-17	0.75	1.13	14.1	4.17	0.75	20	21
D7	5-17	0.68	0.86	14.5	3.89	0.76	20	21
D8@	5-17	0.63	1.02	11.2	2.39	0.72	20	5
D9@	5-17	0.95	0.97	18.5	2.18	0.42	20	5
D11@	5-17	0.75	0.82	19.2	2.87	0.47	20	5
D12	5-16	0.83	0.75	17.7	3.53	0.55	20	8
D13@	5-17	0.60	0.64	14.0	3.07	0.76	20	5
D14	5-16	2.20	1.46	26.5	2.91	0.56	20	4
D15	5-17	0.60	0.72	15.0	2.90	0.46	20	4
D16	5-17	1.10	1.18	18.8	2.28	0.44	20	6
D17	5-17	0.85	0.78	18.2	4.39	0.45	20	6
D18	5-17	1.33	0.98	26.2	3.36	0.35	20	6
D20	5-16	0.35	0.54	9.8	1.93	0.38	20	1
D21	5-16	0.08	0.24	3.9	0.94	0.61	20	0
D23	5-16	1.53	1.86	20.1	2.97	0.88	20	5
D24@	5-16	0.45	0.50	13.2	2.74	0.17	10	7
D26	5-17	1.30	1.32	27.3	5.78	0.58	20	3
D27	5-17	1.38	1.01	30.9	4.31	0.43	20	3
D28	5-16	0.18	0.29	7.2	2.46	0.59	20	0
D29	5-17	0.10	1.24	14.7	6.62	0.77	20	20

Table 22. (cont.)

D30	5-16	0.08	0.24	3.9	0.94	0.61	20
D31	5-16	0.40	0.90	7.0	2.00	0.76	20
D32	5-17	0.28	0.57	11.1	3.10	0.57	20
AVG	-	0.73	0.17	15.4	0.62+	0.86	-

x=Average VOR reading
Sx=Standard deviation for x
y=Average max. ht.
Sy=Standard deviation for y
r=Correlation between x and y
n=Number observations per pond
@=Currently, or grazed previous fall/winter.
+ Standard deviation of the mean.

Table 23. Life form, species observed, canopy coverage, and frequency of each species on dry upland sites on the Doll and Hould study areas, 1990.

Veg. life form *Species*	Doll Study Area %Cov.	%Freq.	Hould Study Area %Cov.	%Freq.
Perennial grasses				
Koelaria christata	4.40	36.50	6.50	51.00
Stipa chomata	6.10	38.10	3.60	27.00
Bouteloua gracilis	14.80	67.40	26.80	90.00
Poa secunda	2.90	31.90	3.00	29.80
Distichlis stricta	0.40	1.60	0	0
Agropyron smithii	7.00	51.00	7.80	51.00
Carex filifolia	0.30	1.90	0.20	2.00
Agropyron christatum	1.80	6.50	1.00	4.00
Sorghum spp.	T	2.30	0	0
Annual forbs				
Plantago patagonica	1.00	13.20	1.80	34.00
Achillea millefolium	0.03	2.90	T	T
Perennial forbs				
Artemisia frigida	17.50	73.60	12.20	65.00
Atriplex nutallii	T	1.60	0.40	2.00
Opuntia polycantha	0.10	4.90	1.00	5.00
Phlox hoodii	T	1.90	1.60	10.00
Liatris punctata	T	0.70	0	0
Medicago sativa	T	0.70	0	0
Grindelia squarrosa	0.03	2.30	0.40	3.00
Rudbeckia luciniata	T	0.70	0	0
Spharalcia coccinea	0.02	3.60	0.30	3.00

Table 23. (cont.)

Thermopsis rhombifolia	T	0.70	0	0
Psoralea cuspidata	T	T	0	0
Shrubs				
Gutierrezia sarothrae	0.02	2.60	0.20	2.00
Artimesia tridentata	0.40	1.00	0	0
Artimesia cana	0.90	4.80	0.40	5.00
Ferns/Lichen				
Lichen	T	1.90	1.00	12.00
Selaginella densa	8.20	40.70	20.40	74.00
Litter	15.60	100.00	11:9	100.00
Bare ground	20.80	100.00	15.3	100.00

*T=trace;less than 0.01.

Other incidentally observed species:

Annual grasses-cheatgrass brome, six-weeks annual fescue (*Festuca octaflora*)
Perennial grasses-Japanese brome (*Bromus japonicus*), fowl bluegrass (*Poa palustris*), commontimothy (*Phleum pratense*), hairy grama (*Bouteloua hirsuta*)
Annual forbs-Clasping pepperweed (*Lepidium perfoliatum*), prairie dogweed (*Dyssodia papposa*), yellow starthistle (*Centaurea solstitialis*), prairie sunflower (*Helianthus petiolaris*)
Perennial forbs-American vetch (*Vicia americana*), narrowleaf poisonvetch (*Astragalus pectinatus*), wavyleaf thistle (*Cirsium undulatum*), Louisiana sagewort (*Artemisia ludoviciana*), arnica (*Arnica sororia*), blueflax (*Linum perenne*), white penstemmon (*Penstemmon albidus*), spreading fleabane (*Erigeron divergens*), tufted eveningprimrose (*Oenothera caespitosa*), sagebrush buttercup (*Ranunculus glaberrimus*), watercress (*Rorripa sinuate*), hymenoxys (*Hymenoxys richardsonii*), prairie onion (*Allium textile*), American licorice (*Glycyrrhiza lepidota*), field mint (*Mentha arvensis*), and wild buckwheat (*Eriogonum pauciflorum*).

Appendix B

Figures

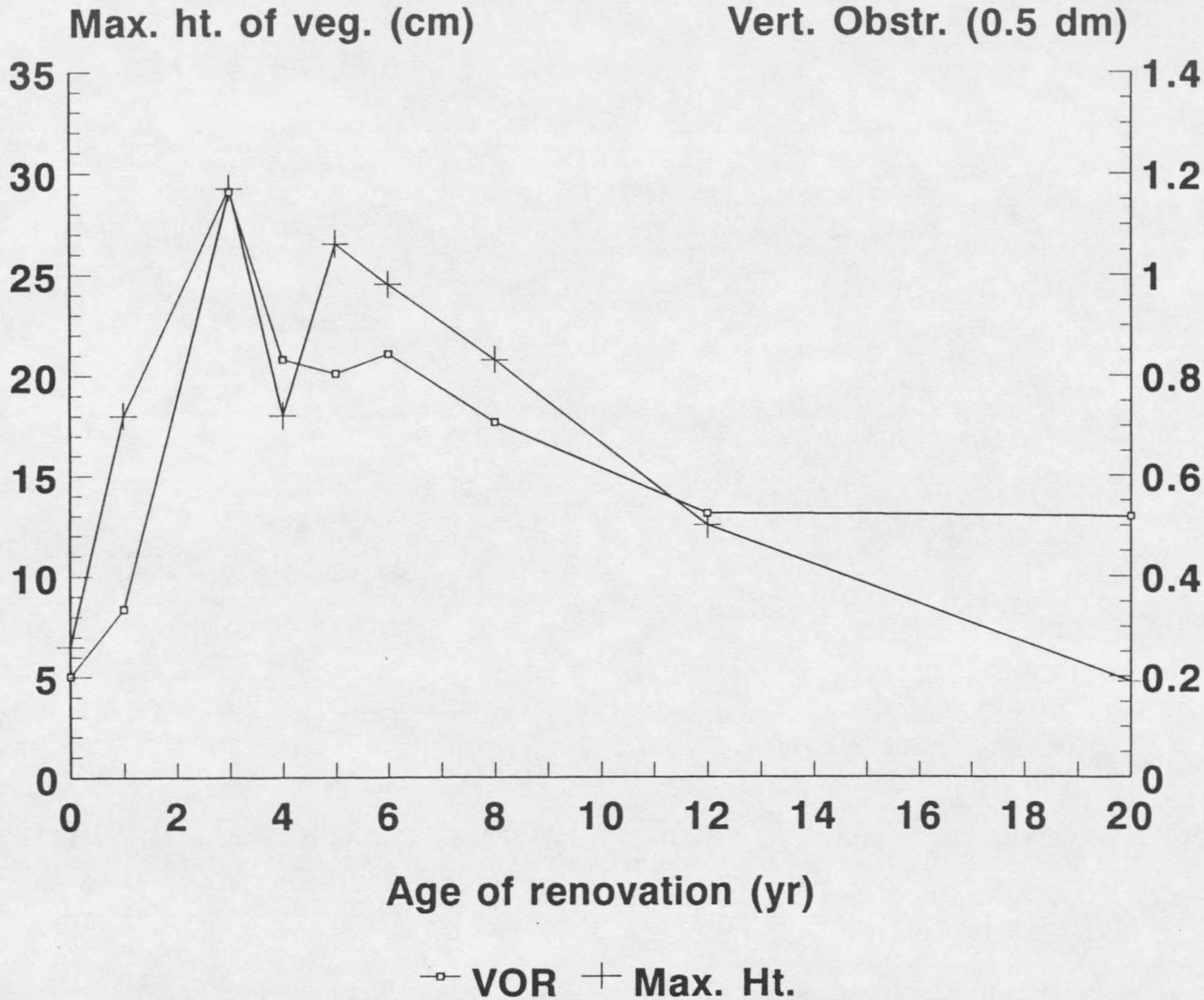

Figure 3. Effects of mechanical renovation on maximum height and vertical obstruction of upland vegetation on the Doll study area, 1991.

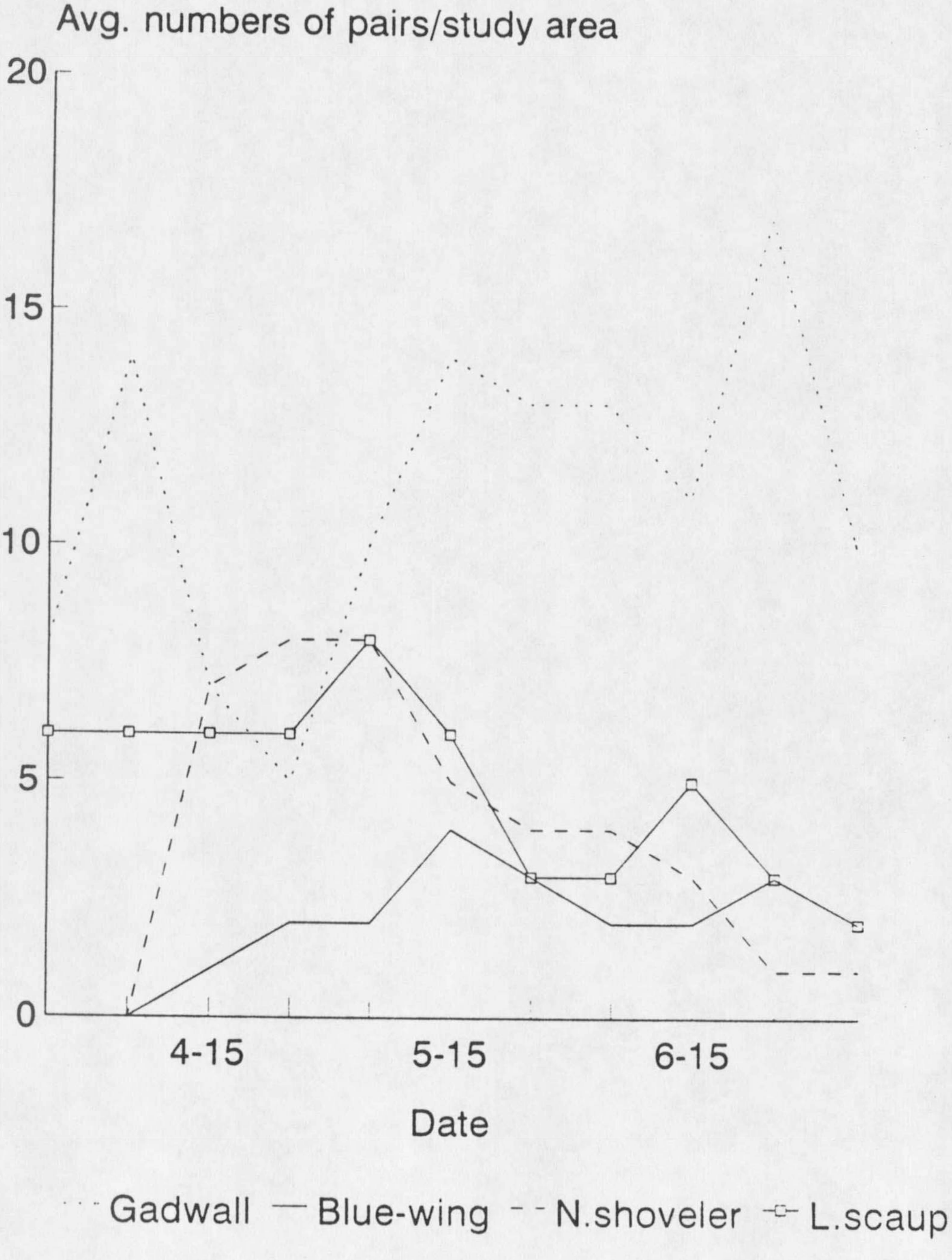

Figure 4. Chronology of pair arrival to South Phillips County, Montana, 1991.

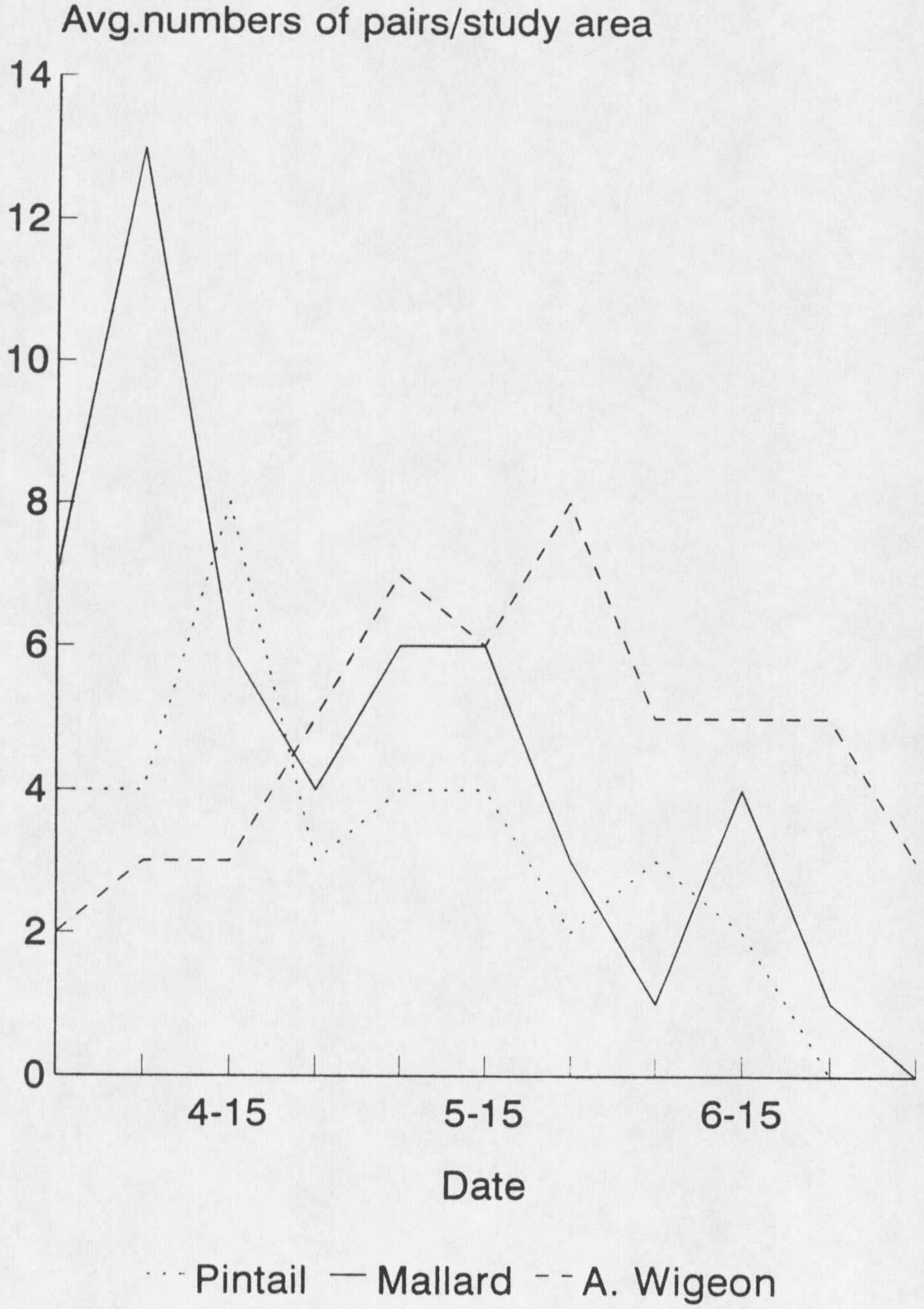

Figure 5. Chronology of pair arrival to South Phillips County, Montana, 1991.