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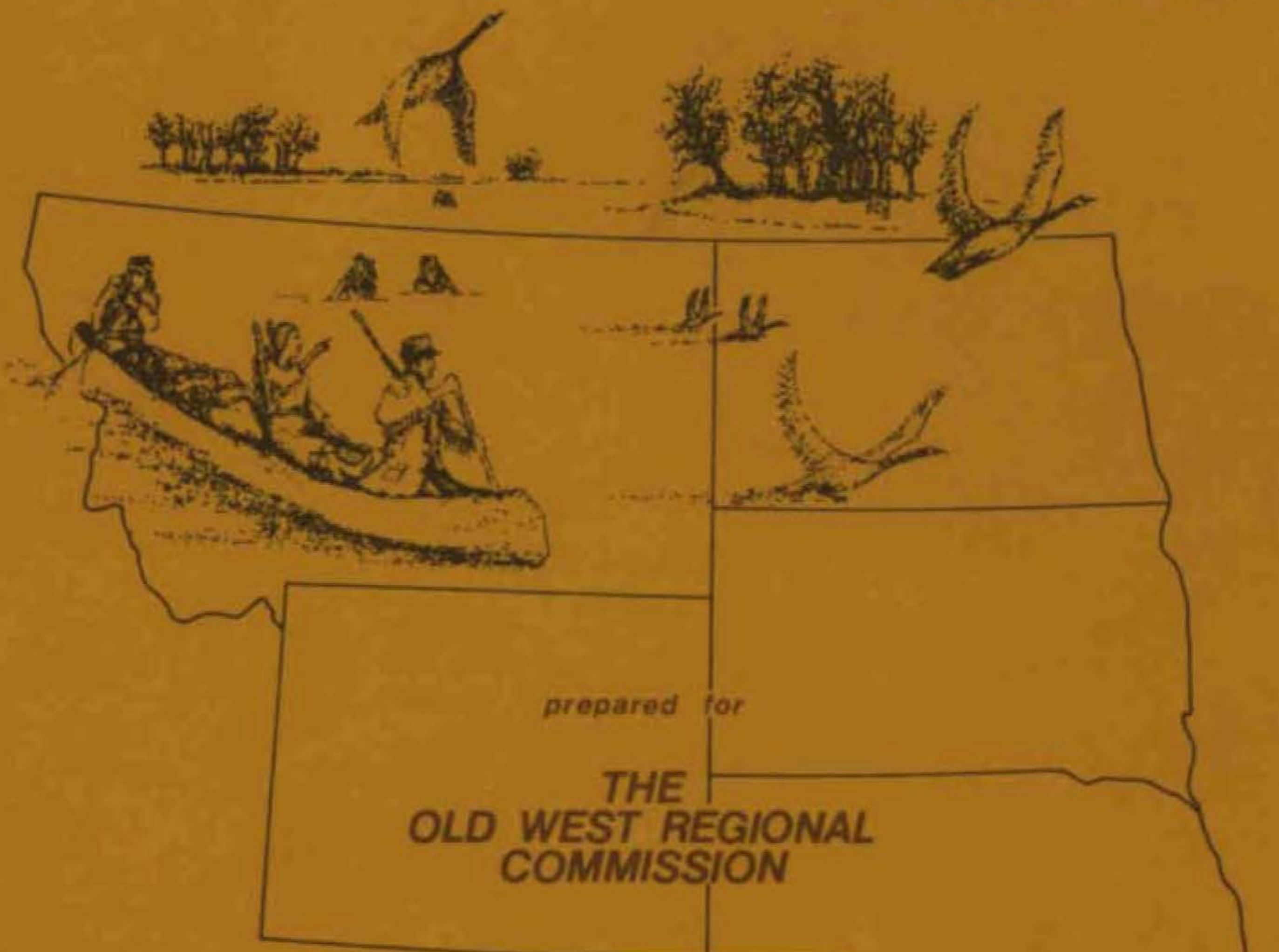
YELLOWSTONE IMPACT STUDY

TECHNICAL REPORT NO. 7



prepared for

THE OLD WEST REGIONAL COMMISSION

by

DNRC WATER RESOURCES DIVISION
MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION

JULY 1977

The effect of altered streamflow on migratory birds of the Yellowstone River Basin, Montana

by

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The Old West Regional Commission is a Federal-State partnership designed to solve regional economic problems and stimulate orderly economic growth in the states of Montana, Nebraska, North Dakota, South Dakota and Wyoming. Established in 1972 under the Public Works and Economic Development Act of 1965, it is one of seven identical commissions throughout the country engaged in formulating and carrying out coordinated action plans for regional economic development.

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FOREWORD

The Old West Regional Commission wishes to express its appreciation for this report to the Montana Department of Natural Resources and Conservation, and more specifically to those Department staff members who participated directly in the project and in preparation of various reports, to Dr. Kenneth A. Blackburn of the Commission staff who coordinated the project, and to the subcontractors who also participated. The Yellowstone Impact Study was one of the first major projects funded by the Commission that was directed at investigating the potential environmental impacts relating to energy development. The Commission is pleased to have been a part of this important research.

George D. McCarthy
Federal Cochairman

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Abbreviations used in this report

af	acre-feet
af/y	acre-feet per year
b/d	barrels per day
cfs	cubic feet per second
FAA	Federal Aviation Authority
ft	feet
ha	hectare
hm^3	cubic hectometer
hm^3/y	cubic hectometers per year
kg	kilogram
km	kilometer
lb	pound
m	meter
m^3/sec	cubic meters per second
M.C.R.	mean cover rating
mi	mile
mmaf	million acre-feet
mmcfd	million cubic feet per day
mmt/y	million tons per year
mw	megawatts
t/d	tons per day
tr	trace

Preface

THE RIVER

The Yellowstone River Basin of southeastern Montana, northern Wyoming, and western North Dakota encompasses approximately 180,000 km^2 (71,000 square miles), 92,200 (35,600) of them in Montana. Montana's portion of the basin comprises 24 percent of the state's land; where the river crosses the border into North Dakota, it carries about 8.8 million acre-feet of water per year, 21 percent of the state's average annual outflow. The mainstem of the Yellowstone rises in northwestern Wyoming and flows generally northeast to its confluence with the Missouri River just east of the Montana-North Dakota border; the river flows through Montana for about 550 of its 680 miles. The major tributaries, the Boulder, Stillwater, Clarks Fork, Bighorn, Tongue, and Powder rivers, all flow in a northerly direction. The western part of the basin is part of the middle Rocky Mountains physiographic province; the eastern section is located in the northern Great Plains (Rocky Mountain Association of Geologists 1972).

THE CONFLICT

Historically, agriculture has been Montana's most important industry. In 1975, over 40 percent of the primary employment in Montana was provided by agriculture (Montana Department of Community Affairs 1976). In 1973, a good year for agriculture, the earnings of labor and proprietors involved in agricultural production in the fourteen counties that approximate the Yellowstone Basin were over $141 million, as opposed to $13 million for mining and $55 million for manufacturing. Cash receipts for Montana's agricultural products more than doubled from 1968 to 1973. Since that year, receipts have declined because of unfavorable market conditions; some improvement may be in sight, however. In 1970, over 75 percent of the Yellowstone Basin's land was in agricultural use (State Conservation Needs Committee 1970). Irrigated agriculture is the basin's largest water use, consuming annually about 1.5 million acre-feet (af) of water (Montana DNRC 1977).

There is another industry in the Yellowstone Basin which, though it consumes little water now, may require more in the future, and that is the coal development industry. In 1971, the North Central Power Study (North Central Power Study Coordinating Committee 1971) identified 42 potential power plant sites in the five-state (Montana, North and South Dakota, Wyoming, and Colorado) northern Great Plains region, 21 of them in Montana. These plants, all to be fired by northern Great Plains coal, would generate 200,000 megawatts (mw) of electricity, consume 3.4 million acre-feet per year (mmaf/y) of water, and result in a large population increase. Administrative, economic, legal, and technological considerations have kept most of these conversion facilities, identified in the North Central Power Study as necessary for 1980, on the drawing board or in the courtroom. There is now no chance of their being completed by that date or even soon after, which will delay and diminish the economic benefits some basin residents had expected as a result of coal development. On the other hand, contracts have been signed for the mining of large amounts of Montana coal, and applications have been approved not only for new and expanded coal mines but also for Colstrip Units 3 and 4, twin 700-mw, coal-fired, electric generating plants.

In 1975, over 22 million tons of coal were mined in the state, up from 14 million in 1974, 11 million in 1973, and 1 million in 1969. By 1980, even if no new contracts are entered, Montana's annual coal production will exceed 40 million tons. Coal reserves, estimated at over 50 billion economically strippable tons (Montana Energy Advisory Council 1976), pose no serious constraint to the levels of development projected by this study, which range from 186.7 to 462.8 million tons stripped in the basin annually by the year 2000. Strip mining itself involves little use of water. How important the energy industry becomes as a water user in the basin will depend on: 1) how much of the coal mined in Montana is exported, and by what means, and 2) by what process and to what end product the remainder is converted within the state. If conversion follows the patterns projected in this study, the energy industry will use from 48,350 to 326,740 af of water annually by the year 2000.

A third consumptive use of water, municipal use, is also bound to increase as the basin population increases in response to increased employment opportunities in agriculture and the energy industry.

Can the Yellowstone River satisfy all of these demands for her water? Perhaps in the mainstem. But the tributary basins, especially the Bighorn, Tongue, and Powder, have much smaller flows, and it is in those basins that much of the increased agricultural and industrial water demand is expected.

Some impacts could occur even in the mainstem. What would happen to water quality after massive depletions? How would a change in water quality affect existing and future agricultural,industrial, and municipal users? What would happen to fish, furbearers, and migratory waterfowl that are dependent on a certain level of instream flow? Would the river be as attractive a place for recreation after dewatering?

One of the first manifestations of Montana's growing concern for water in the Yellowstone Basin and elsewhere in the state was the passage of significant legislation. The Water Use Act of 1973, which, among other things, mandates the adjudication of all existing water rights and makes possible the reservation of water for future beneficial use, was followed by the Water Moratorium Act of 1974, which delayed action on major applications for Yellowstone Basin water for three years. The moratorium, by any standard a bold action, was prompted by a steadily increasing rush of applications and filings for water (mostly for industrial use) which, in two tributary basins to the Yellowstone, exceeded supply. The DNRC's intention during the moratorium was to study the basin's water and related land resources, as well as existing and future need for the basin's water, so that the state would be able to proceed wisely with the allocation of that water. The study which resulted in this series of reports was one of the fruits of that intention. Several other Yellowstone water studies were undertaken during the moratorium at the state and federal levels. Early in 1977, the 45th Montana Legislature extended the moratorium to allow more time to consider reservations of water for future use in the basin.

THE STUDY

The Yellowstone Impact Study, conducted by the Water Resources Division of the Montana Department of Natural Resources and Conservation and financed by the Old West Regional Commission, was designed to evaluate the potential physical, biological, and water use impacts of water withdrawals and water development on the middle and lower reaches of the Yellowstone River Basin in Montana. The study's plan of operation was to project three possible levels of future agricultural, industrial, and muncipal development in the Yellowstone Basin and the streamflow depletions associated with that development. Impacts on river morphology and water quality were then assessed, and, finally, the impacts of altered streamflow, morphology, and water quality on such factors as migratory birds, furbearers, recreation, and existing water users were analyzed.

The study began in the fall of 1974. By its conclusion in December of 1976, the information generated by the study had already been used for a number of moratorium-related projects--the EIS on reservations of water in the Yellowstone Basin, for example (Montana DNRC 1976). The study resulted in a final report summarizing all aspects of the study and in eleven specialized technical reports:

Report No. 1	Future Development Projections and Hydrologic Modeling in the Yellowstone River Basin, Montana.
Report No. 2	The Effect of Altered Streamflow on the Hydrology and Geomorphology of the Yellowstone River Basin, Montana.
Report No. 3	The Effect of Altered Streamflow on the Water Quality of the Yellowstone River Basin, Montana.
Report No. 4	The Adequacy of Montana's Regulatory Framework for Water Quality Control
Report No. 5	Aquatic Invertebrates of the Yellowstone River Basin, Montana.
Report No. 6	The Effect of Altered Streamflow on Furbearing Mammals of the Yellowstone River Basin, Montana.
Report No. 7	The Effect of Altered Streamflow on Migratory Birds of the Yellowstone River Basin, Montana.

Report No. 8 The Effect of Altered Streamflow on Fish of the Yellowstone and Tongue Rivers, Montana.

Report No. 9 The Effect of Altered Streamflow on Existing Municipal and Agricultural Users of the Yellowstone River Basin, Montana.

Report No. 10 The Effect of Altered Streamflow on Water-Based Recreation in the Yellowstone River Basin, Montana.

Report No. 11 The Economics of Altered Streamflow in the Yellowstone River Basin, Montana.

ACKNOWLEDGMENTS

Tom Hinz was assisted in report preparation, goose banding and study direction by Bob Martinka, also of the Montana Department of Fish and Game. Other Fish and Game personnel assisted with goose banding and observation. Appreciation is also extended to Miles City Aero Service.

Shari Meats and Pam Tennis of the Department of Natural Resources and Conservation provided editorial assistance. Graphics were coordinated and prepared by Gary Wolf with the assistance of D. C. Howard, who also designed and executed the cover.

Introduction

PURPOSE

The purpose of the study was to determine the importance of the Yellowstone River to geese, ducks, bald eagles, great blue herons, and other migratory birds and assess the impact on those birds of altered streamflow. The structure and vegetation of the river, with particular attention to islands, were also to be studied.

SCOPE

Although all large migratory birds present in the study area were studied to some extent, more time was invested in observation of the most common species. Canada geese (*Branta canadensis)* were believed to be the only large migratory birds to breed, rear their young, summer, winter, and occur as fall and spring migrants on the lower Yellowstone River. Because of this year-round use of the river and of the species' economic and aesthetic value, goose studies were given the most time. Mallards (*Anas platyrhynchos)* were also believed to occur in the study area year-round, but nesting and brood-rearing on the river itself was thought to be limited. Great blue herons (*Ardea herodias)* were known to nest and rear their young on the river but were not believed to be present during the colder months of the year. Bald eagles (*Haliaeetus leucocephalus)* had been observed along the river during the colder months but were not believed to breed there. All other migratory birds were ranked below these in importance in the study.

In the analysis of river structure and vegetation (conducted from aerial photographs), the parameters studied were cover type, length of shoreline per cover type, island size, thalweg length, sinuosity, total water area, total shoreline length (wetted perimeter), and total gravel bar area.

STUDY AREA

To permit more intensive study of large migratory birds in areas where they were believed to be more numerous, the study area was limited to the Yellowstone River from Billings to the North Dakota border. The analysis of vegetation was also limited to that section of the river to allow comparison with the numbers of birds observed.

Other geographic limitations involved local variations in habitat use by particular species. Duck, goose, and bald eagle feeding areas, for instance, included the largest area. Most observations of the other birds were limited to the river banks, islands, and channels.

Methods

RIVER STUDY SECTIONS

To simplify organization of collected data and to facilitate presentation of findings, the portion of the river studied, beginning at Billings and ending at Fairview, was divided into 21 study sections, shown in figure 1. These study sections were helpful mainly in the Canada goose and dabbling duck studies.

MAJOR BIRD STUDIES

CANADA GEESE

Aerial Censuses

Canada goose populations along the lower Yellowstone River were counted at irregular intervals depending on the time of year, migrations, and weather. Flights were conducted with a Piper Super Cub (PA-18) from Miles City to Billings on one day and from Miles City to Fairview on the next that weather permitted. Because geese sometimes loafed away from the river at midday from late fall through the spring migration, censuses taken during that period sometimes required flying over parts of the valley away from the river.

Observations of field-feeding geese were recorded at all times of the year except during the flightless period. Records were kept of the type of field used, number of geese in each flock, field condition, and time of day. In addition, after neck bands had been applied to resident birds in 1975, field-feeding flocks were closely scrutinized to locate neck-banded individuals. All recorded observations of such birds were plotted on maps for calculation of the sizes of the birds' seasonal home ranges.

Nest Surveys

Surveys of nesting Canada geese were conducted through the springs of 1975 and 1976. Selection of study sections was based upon the availability of boat-launching sites at their downstream ends. In 1975, nesting surveys were conducted in the Bighorn-to-Hysham, Hathaway-to-Miles City, Miles City-to-Kinsey (upstream from the mouth of Sunday Creek only), and Fallon-to-Glendive sections of the river. The downstream ends of these areas were searched first; areas upstream were checked only as time allowed. Nest searches in 1975 were ended when eggs began to hatch. In 1976, they were ended when excessive desertion occurred between the weekly-to-biweekly nest checks; it was suspected that the disturbance associated with the nest checks may have caused the desertion. Nests believed to be late or renesting efforts were not surveyed because of the change in nest-site parameters by that late date. Because nest surveys were conducted primarily on warm days (see discussion of egg mortality on page 38), weather in 1976 permitted more field work to be conducted, and six areas of the river were surveyed: those sections used in 1975, the Sanders-to-Forsyth section, and the reach from Sunday Creek to Terry.

Island and bank nesting areas were searched for the presence of goose nests by one observer with the aid of a second observer and/or a dog. Only those islands small enough to be covered on foot were searched completely. Larger islands, main shorelines, and heavily-vegetated areas were searched only when the presence of a single goose or pair suggested that a nest was nearby. Most driftwood piles and drifted trees within the study areas were also searched for nests.

Both physical and biological factors associated with goose nests were measured. Biological data collected included caliper measurements of egg widths and lengths, clutch size and number of adult geese attending the nest. Distance from nests to water was measured with a 100-foot graduated nylon rope. Elevation of nests above water was estimated using a level and stadia rod. Substrate around the nests was recorded as composed of rocks, rocks and silt, silt, or soil. (Soil was distinguished from silt by the presence of litter, organic material, and/or vegetation; silt was considered to be bare and undeveloped.) Other physical factors noted were: 1) whether the nest was constructed by a drifted log or tree; 2) whether it was on an island, peninsula, or the main bank; and 3) whether it was on a cliff, by a tree, or at another identifiable site. Photographs were taken of each nest for a record of the vegetative growth stage during the early nesting season. These photographs also served as a general record of the structure of cover at each site.

Density of vegetative cover around each goose nest was estimated utilizing a cover board marked with numbers 1-6 (figure 2) similar to that devised by Wight (1938). Cover density was estimated from four positions 15.2 m (50 feet) from the nest, spaced at 90-degree angles around the nest. The first position was chosen as the most open side of the nest. The four values thus obtained were averaged, giving a mean cover rating (M.C.R.) for each nest as shown in the following example:

	Numbers Visible	Numbers Partially Visible	Numbers Obscured	Cover Rating
Open side	1, 2, 3	4	5, 6	8.0
90° Counterclockwise	1-6	None	None	21.0
180° Counterclockwise	None	1-6	None	10.5
270° Counterclockwise	1, 2, 3, 4	5	6	12.5

Yellowstone River Basin

Yellowstone River Study Sections

	Thalweg Length (km)
Billings to Huntley	16.6
Huntley to Worden	18.3
Worden to Pompeys Pillar	13.3
Pompeys Pillar to Custer	43.8
Custer to Bighorn	7.8
Bighorn to Hysham	31.6
Hysham to Sanders	19.9
Sanders to Forsyth	41.0
Forsyth to Rosebud	19.5
Rosebud to Hathaway	31.3
Hathaway to Miles City	32.3
Miles City to Kinsey	29.9
Kinsey to Zero	24.0
Zero to mouth of Powder River	5.5
Mouth of Powder River to Terry	21.0
Terry to Fallon	14.3
Fallon to Glendive	52.6
Glendive to Intake	32.4
Intake to Savage	30.9
Savage to Sidney	37.4
Sidney to Fairview	22.8

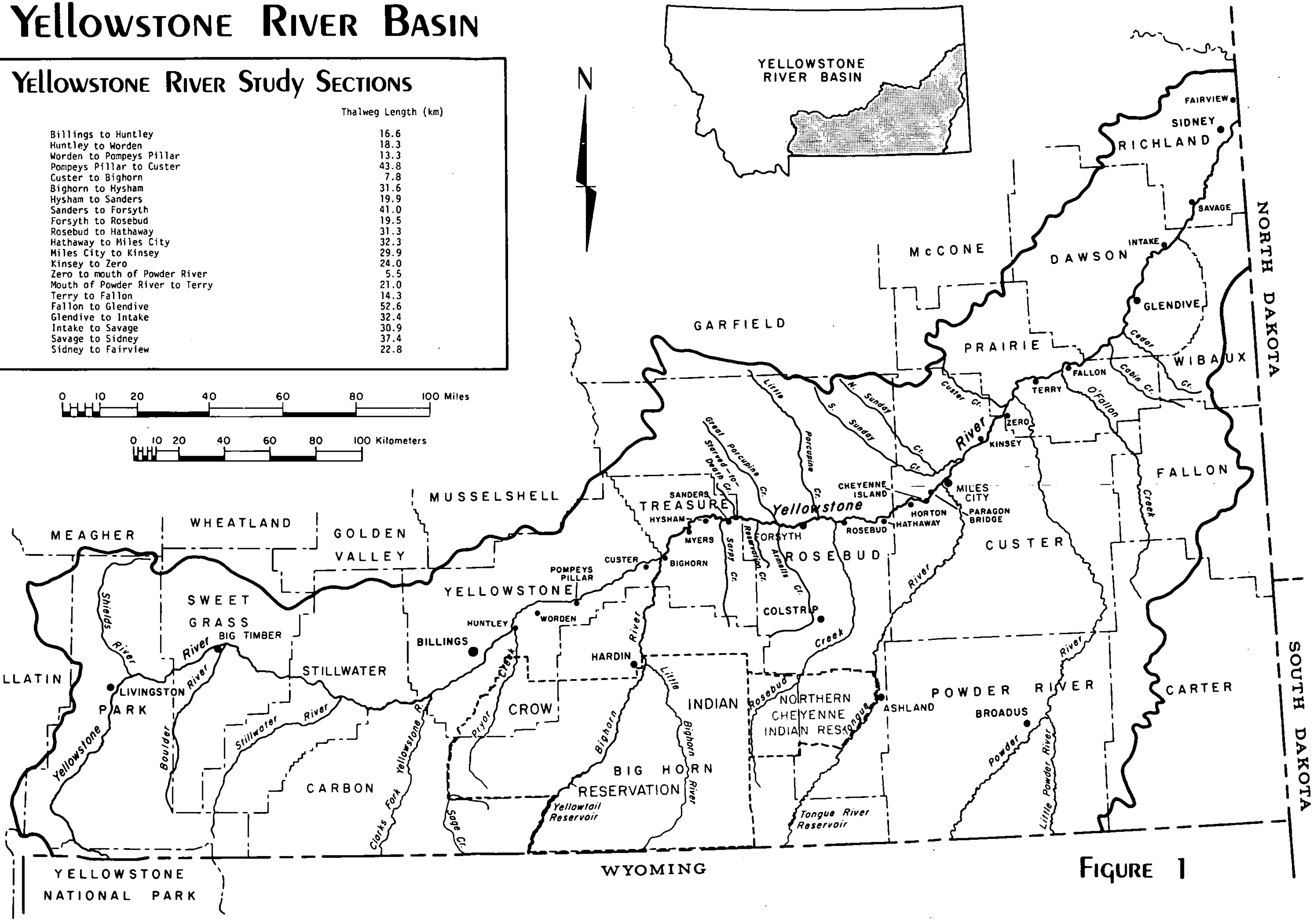

FIGURE 1

The cover rating per side is determined by this formula:

$$\text{cover rating} = X_n + \frac{Y_n}{2}$$

where: X_n = numbers visible to the observer

Y_n = numbers partially visible

The obscured numbers do not contribute to the cover rating. The M.C.R. is equal to the sum of cover ratings per side divided by 4.

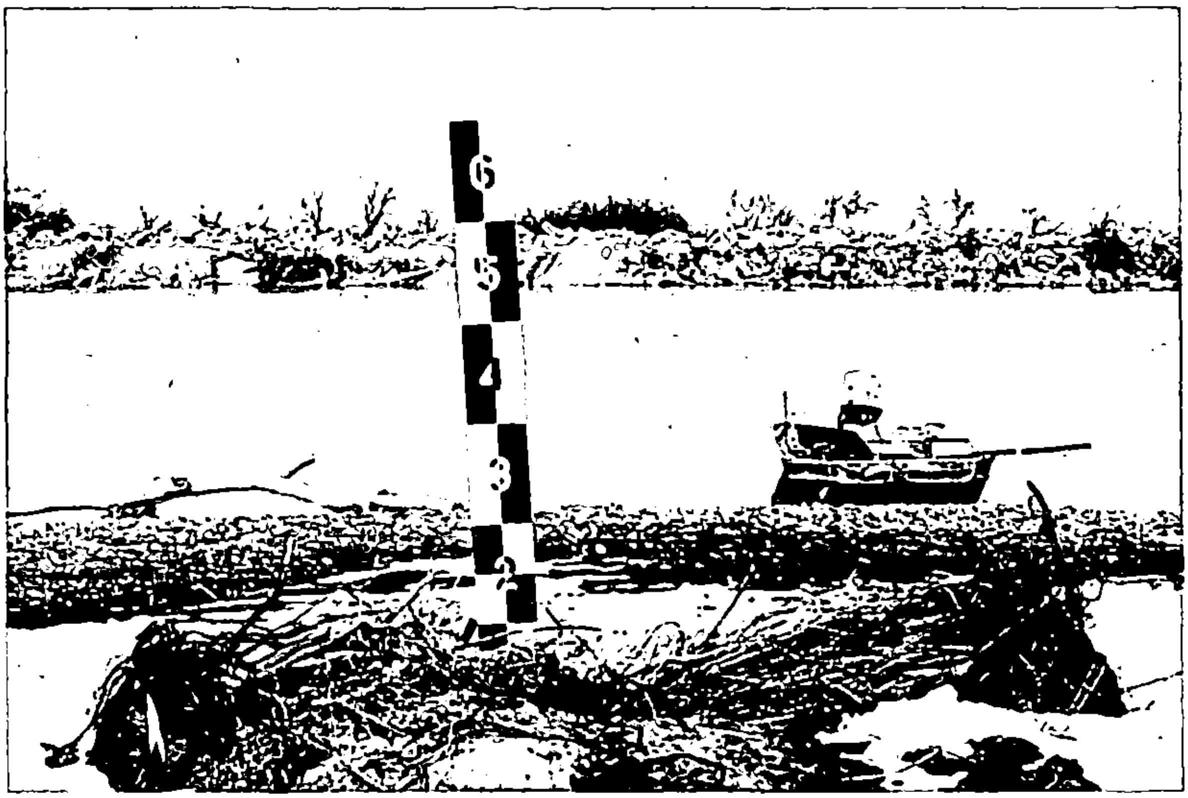

Figure 2. Cover board used to estimate density of vegetative cover surrounding goose nests.

Water levels at each nest site were monitored with the use of 6-foot steel fence posts driven into a firm substrate at the water's edge near the nest. Each post was numbered and identified by attaching a metal tag to the top. Water level (gage height) was determined by measuring the distance from the top of the post to the water surface.

Marking and Banding

Goslings hatched within the study areas were marked utilizing two techniques. In 1975, eggs from selected clutches were injected with colored dyes as described by Evans (1951) and McCabe (1975). In 1976, 37 young were marked with numbered web-tags as used by Forrest Lee (1975) at the Northern Prairie Wildlife Research Center. None of these web-tagged birds were recaptured later during the free-banding operations.

Canada geese were captured during the flightless period in 1975 and 1976 by the free-banding technique described by Hanson and Eberhardt (1971). Modifications of their technique included use of one or two boats, from three to seven banders, a dog, and a Piper Super Cub for aerial location of the geese. Contact between the air and boats was accomplished with the use of two-way radios. Goslings which appeared to be less than six weeks of age were marked with standard aluminum leg bands and released. Captured birds six weeks of age or older were marked with green-and-white neck bands and aluminum leg bands (figure 3). (The green bands with white letters and numerals are those assigned to Montana by the U.S. Fish and Wildlife Service for neck-banding waterfowl.)

Figure 3. Marking Canada Geese with plastic neck collars and standard aluminum leg bands.

DABBLING DUCKS

Observations

Ground observations of loafing dabbling ducks were recorded at the outset of the study but later omitted from records because of the unsystematic means by which they were obtained. Aerial censuses were the only reliable estimates of dabbling duck populations on the river. Ground observations were used only as a general indicator of species abundance and distribution.

Aerial censuses of dabbling ducks were conducted simultaneously with those of geese and other birds. These censuses provided some observations of individual species, but, because not all ducks could be identified by species from the air, total numbers of each species were not obtained. It was possible, however, to distinguish goldeneyes (*Bucephala sp.)* and common mergansers (*Mergus merganser)* from the other species. Observations of other diving ducks were included in the dabbling duck figures because they could not be consistently differentiated, although they were believed to be too few in number to appreciably alter the total census.

Field-feeding observations of dabbling ducks were recorded from late summer through spring. Observations recorded included species and number of ducks, location, and field type. Dabblers and Canada geese were sometimes observed field-feeding together, as the feeding areas of these species often overlapped.

Although incubating dabbling ducks were encountered during goose banding operations, no systematic attempts were made to survey dabbling duck nesting cover. It was believed that determination of goose nesting requirements would provide a better basis for correlating waterfowl nesting with river structure and vegetation because most geese nest on the river proper. Dabbling duck nesting was believed to occur along oxbows, sloughs, creeks, irrigation ditches, and fields away from the river.

Sex Ratios

Sex ratios of mallard flocks were determined within sections of the river where the loafing population size had been estimated during aerial censuses. Flocks were observed until a large number of individuals had been classified as to sex. The sample size was deemed adequate when it exceeded (Snedecor and Cochran 1967):

$$n = \frac{4pq}{L^2}$$

where: n = sample size needed to attain a given limit of error, L

p = proportion of drakes observed

q = proportion of hens observed

L = limit of error, in this case, 0.1

If the computed value of n was greater than 10 percent of N, the estimated population size, then a revised n' was calculated to account for the finiteness of the population:

$$n' = \frac{n}{1+\frac{n}{N}}$$

COMMON MERGANSERS AND COMMON GOLDENEYES

Common mergansers and common goldeneyes (*Bucephala clangula)* were counted from the air as described above. All goldeneyes observed were classified as common goldeneyes since no Barrow's goldeneyes (*Bucephala islandica)* were observed during ground surveys. Other studies performed included merganser food habits analyses and brood observations of mergansers and goldeneyes.

Food habits analyses were qualitatively performed. The stomachs of dead birds were opened and their contents identified. Where possible, the food items were counted by kind; where not, the kinds of items were noted. Mergansers, goldeneyes, white pelicans, and great blue herons were collected with shotguns from boats on the river under the authority of federal and state collecting permits. Appendix B shows the results of food habits analyses for these four species.

BALD EAGLES

Bald eagle (*Haliaeetus leucocephalu)* populations were also counted on the census flights. Individuals with predominantly white heads and tails were counted as adults (Southern 1967), and predominantly brown birds as juveniles. Food items utilized were noted during both aerial censuses and ground surveys.

Bald eagles frequenting large nests near the river were closely observed from the air to determine if the birds were nesting or simply roosting by the nests. Similar reconnaissance was made of areas where marked eagles had been reported. Attempts were made to relocate marked birds so that an accurate description of the colored tags could be reported to the banders.

GREAT BLUE HERONS

Great blue herons (*Ardea herodias)* in rookeries and along the banks of the river were counted on the census flights. The number of active nests and the stage of laying, incubating, or brooding in some of the nests were noted. Herons were observed in their feeding areas, and some were collected for analyses of food habits.

WHITE PELICANS

White pelican (*Pelecanus erythrorhynchos*) studies included aerial censuses and some food habits analyses. In addition, pelicans collected or found dead on the river were checked for federal leg bands. Bands thus obtained were sent to the Migratory Bird Populations Station in Patuxent, Maryland.

OTHER MIGRATORY BIRD STUDIES

Other large migratory birds, shorebirds, and piscivorous species were observed on occasion. Notes on their feeding habits, distribution, and time of year observed in the study area were recorded.

ISLAND AND VEGETATION ANALYSIS

Aerial photographs taken by the Montana Department of Highways were used in an analysis of selected aspects of the river vegetation and channel morphology. The photographs utilized were color prints approximately 9 X 9 inches in size, scaled to 1:24,000, with approximately 50 percent overlap. The photographs from Billings to Fairview, Montana, were divided into groups corresponding with the sections into which the flight data were divided.

All parameters to be studied were traced on plastic overlays; cover types along the shoreline (dense cottonwood, cottonwood-grassland, sagebrush-grassland, shrubs, cleared for grazing, agricultural, breaks, industrial and housing, and gravel bars) were coded by color. All island cover types were color coded according to the same scheme.

Areas of vegetation types, lengths of shoreline per vegetation type, island sizes, and thalweg lengths were measured with a digitized planimeter. Sinuosity was later calculated by dividing the thalweg length by the straightline distance between the midstream points at the upstream and downstream ends of each section (the down-valley distance). Other parameters measured were the total water area, total shoreline length (the wetter perimeter), and the total gravel-bar area. Results of this analysis are shown in appendix C.

Existing situation

MAJOR BIRD STUDIES

CANADA GEESE STUDIES

Investigations into the ecology of Canada geese on the lower Yellowstone River were divided into six periods: wintering, spring migration, breeding, brood-rearing and flightless, early fall resident, and fall migration. The wintering period began with the onset of extended periods of cold weather in late fall which induced geese in most sections of the river to depart on southern migrations, possibly because of extensive ice cover on the river. Wintering periods ended with the onset of warmer weather, the resultant ice melt, and arrival of migrants in early spring. Thus, the spring migration period begins as migrants stop in the study area on their way to northern breeding grounds and ends as most migrant flocks present in the study area dissipate. The early part of the breeding period overlaps with the end of the migration period, in that the establishment of territories by resident birds occurs while some spring migrants are present in the same areas. The breeding period ends and the brood-rearing and flightless period begins when the first clutches hatch. This period ends and the early fall resident period begins when the first flocks of geese gain flight. The early fall resident period extends through the fall until the first cold and snowy weather brings large numbers of migrant geese back into the area. The fall migration period continues until the onset of cold, wintry weather.

Wintering Period

Geese Present. Numbers of Canada geese observed in the study area during this period in 1975 and 1976 were among the lowest observed during the study (figure 4). Only during the brood-rearing and flightless period were the censuses as low, but during that time geese are secretive and difficult to observe from the air. During the wintering period, 83.8 percent of goose observations recorded during aerial censuses occurred between Bighorn and Hathaway (table 1). Study sections within that reach remain largely free of ice because of the entrance of warmer water from the Bighorn River into the Yellowstone and its influence on ice formation downstream. Below Miles City, the river was largely frozen during the winters of 1974-75 and 1975-76 and did not harbor a significant number of geese (table 1).

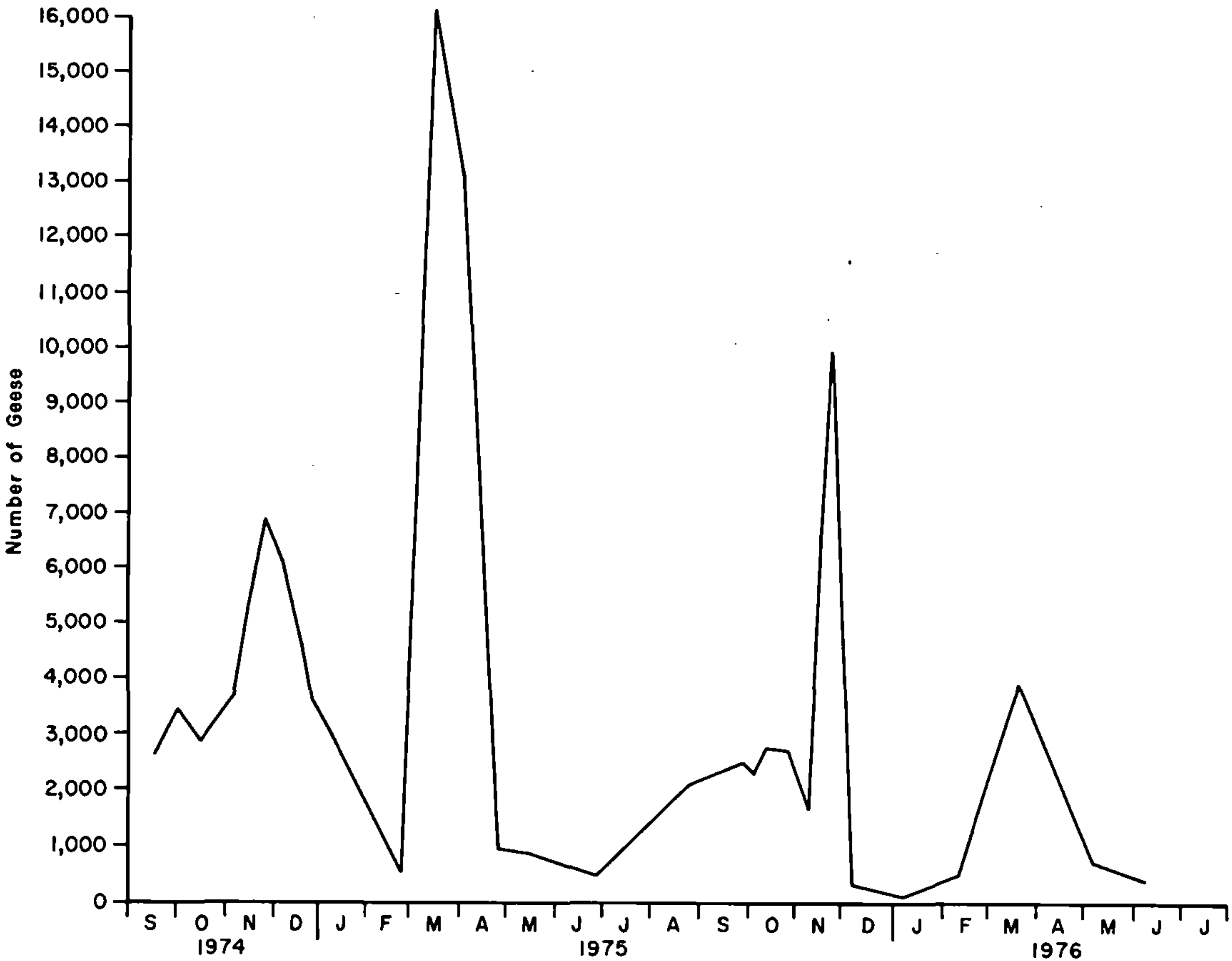

Figure 4. Goose censuses conducted along the lower Yellowstone River between Billings and Fairview, Montana, from September 1, 1974, to August 1, 1976.

TABLE 1. Numbers of Canada geese observed during aerial censuses in the Wintering Period

Section	Number of Geese[a]	Geese/km
Billings to Huntley	26	2
Huntley to Worden	178	10
Worden to Pompeys Pillar	0	0
Pompeys Pillar to Custer	300	7
Custer to Bighorn	2	tr[b]
Bighorn to Hysham	873	28
Hysham to Sanders	177	9
Sanders to Forsyth	1,185	29
Forsyth to Rosebud	917	47
Rosebud to Hathaway	554	18
Hathaway to Miles City	163	5
Miles City to Kinsey	24	1
Kinsey to Zero	9	tr[b]
Zero to Powder River	0	0
Powder River to Terry	0	0
Terry to Fallon	0	0
Fallon to Glendive	14	tr[b]
Glendive to Intake	0	0
Intake to Savage	0	0
Savage to Sidney	0	0
Sidney to Fairview	0	0

CONVERSIONS: 1 goose/km = 1.61 geese/mi

NOTE: Five flights from departure of fall migrants until arrival of spring migrants.

[a]All flights

[b]Tr = fewer than .5 geese

Geese present in the study area during the winter appeared to be giant Canada geese (*B. c. maxima)* or Great Basin Canada geese (*B. c. moffitti)*, the two largest subspecies (Hanson 1965). According to Lefebvre and Raveling (1967), the smaller subspecies cannot survive winters in such climates. It is possible that wintering geese were resident breeders, especially in the Bighorn-to-Hysham section of the river. Even on January 7, 1976, when the maximum temperature for the day at the FAA office at Miles City was -23° C (-9° F), an aerial census conducted in this section produced observations of 70 geese. One goose observed near Hysham in February 1976 (appendix D) had been banded in that area the previous summer, indicating that at least some of the geese wintering in that area may be resident birds.

Crops and Forage Utilized. Crop types utilized by geese in winter were, in decreasing order of use, corn cut for silage, barley stubble, seeded winter wheat, and alfalfa and hay (table 2). Most of these fields were located on the flood plain, reflecting the tendency of geese to feed in fields close to the river. Seeded winter wheat fields, most of which occur on the benches away from the river, were used only when snow cover was light.

TABLE 2. Canada goose utilization of selected field types over all study sections during four periods, 1975 and 1976.

Field Type	Spring Migration and Breeding Period[a]	Harvesting Period[bc]	Post-Harvest to Late Fall Period[cd]	Winter Period[e]	Overall Annual Utilization
Barley stubble	56.4(12,993)	42.1(1,467)	7.4(603)	23.5(5,493)	35.4(20,556)
Wheat stubble	9.7(2,243)	57.6(2,005)	8.5(688)	8.2(1,925)	11.8(6,861)
Seeded winter wheat	tr[f] (11)	-- --	3.6(295)	14.4(3,357)	6.3(3,663)
Corn cut for silage	22.5(5,189)	0.3 (10)	80.3(6,521)	27.6(6,449)	31.3(18,169)
Picked corn	5.2(1,196)	-- --	-- --	9.3(2,162)	5.8(3,358)
Alfalfa and hay	5.9(1.367)	-- --	-- --	14.1(3,282)	8.0(4,649)
Pastures and feed lots	0.3 (57)	-- --	-- --	2.6 (609)	1.2 (666)
Pinto beans	-- --	-- --	-- --	0.3 (60)	0.1 (60)
Sugar beets	-- --	-- --	0.2(15)	-- --	tr[f] (15)

NOTE: Entries are given first as percentage of observations per period and second, in parentheses, total number of observations in that field type that period.

[a]March 1 through May 31

[b]July 15 through corn harvest (date depending on the year)

[c]Because field feeding patterns and crop harvesting periods differ in duration from goose migration and life-history periods, the periods used in this table do not correspond exactly with those used in all other phases of this Canada goose study.

[d]Post-corn harvest through first cold weather and influx of northern migrants

[e]Northern migrant arrival through winter

[f]Tr = less than 0.1 percent

Movement. Geese loafing on the river during winter commonly rested on the ice shelf near the water's edge. When in the fields, where they rested as well as fed, they remained there much of the day. During periods of warmer weather, geese showed more movement, as was apparent in February 1976 when river ice was restricted largely to borders of islands and banks upstream from Miles City.

Spring Migration Period

Geese Present. One of the census flights made during the spring migration period of 1975 produced the highest number of geese counted during the study (figure 4). Seventy percent of the observations were recorded between Bighorn and Miles City (table 3). Similar numbers might have been observed in the spring of 1976 had the aerial census been conducted earlier in March, judging by ground observations of large field-feeding flocks of geese between Bighorn and Miles City in early March.

TABLE 3. Numbers of Canada geese observed during aerial censuses in the Spring Migration Period

Section	Number of Geese[a]	Geese/km
Billings to Huntley	70	4
Huntley to Worden	531	29
Worden to Pompeys Pillar	106	8
Pompeys Pillar to Custer	1,984	45
Custer to Bighorn	77	10
Bighorn to Hysham	2,775	88
Hysham to Sanders	2,792	140
Sanders to Forsyth	3,983	97
Forsyth to Rosebud	1,631	84
Rosebud to Hathaway	1,719	55
Hathaway to Miles City	1,299	40
Miles City to Kinsey	897	30
Kinsey to Zero	637	26
Zero to Powder River	535	98
Powder River to Terry	162	8
Terry to Fallon	11	1
Fallon to Glendive	525	10
Glendive to Intake	30	1
Intake to Savage	65	2
Savage to Sidney	126	3
Sidney to Fairview	243	11

CONVERSIONS: 1 goose/km = 1.61 geese/mi

NOTE: Two flights conducted in March during the period of greatest migrant influx into the study area.

[a]All flights.

This stopover of large numbers of geese occurred both during periods of snow and inclement weather (1975) and under fair skies and warm temperatures (1976), indicating a tendency of geese to home to particular migration stops in the spring. This spring stopover may be similar to annual fall migration stopovers which provide available food and loafing areas as suggested by Bellrose (1974).

Spring migrant flocks consisted of birds of several races as determined by their differences in size, coloration, bill shape, and voice. Small geese of the shortgrass prairie populations (*B.c. parvipes*) were common in some flocks, although the Great Basin and giant Canada geese were more numerous. Some flocks contained snow geese (*Chen caerulescens*) and white-fronted geese (*Anser albifrons frontalis*).

Field-feeding flocks of geese were observed closely to locate any marked individuals. In addition to neck-banded residents (appendix D), some birds neck-banded in other areas were also observed. In 1975, two geese neck-banded by Ducks Unlimited were observed near the mouth of Reservation Creek. Both were females banded at Dowling Lake, Alberta, in June 1973, one as a yearling and one as a juvenile. Thirty-one other geese wearing similar bands were observed on or near the river between Reservation Creek and Myers in 1976; all had been banded on their breeding grounds on lakes near Edmonton and Calgary, Alberta, in the summer of 1974 and 1975 (Leitch 1976). No such banded birds were observed in any other part of the study area, which suggests the presence of a migration corridor used by birds breeding in Alberta and migrating across southeastern Montana, as discussed by Bellrose (1968).

Resident birds (identified by neck bands), including adult females, were observed in the study area during the spring migration period (appendix D). These individuals utilized the same fields as migrant flocks. The territoriality of resident birds was evidenced by their reluctance to fly long distances from the river to feed. As the spring migration period continued and the breeding season progressed, the territorial pairs spent less time in the fields, remaining close to the river nesting sites.

Crops and Forage Utilized. Observations of field-feeding geese indicated that fields of barley stubble and corn cut for silage were the most preferred in the spring migration period, as they were year-round (table 2). As discussed previously the use of these crops reflects the tendency of geese to feed on the flood plain, often adjacent to the river. During this period, geese were observed flying back and forth over the banks from field to loafing area throughout the day, rather than just at morning and evening.

Movement. Loafing areas utilized by geese during this period were those used in fall, except where ice covered some loafing sites. Between Glendive and Sidney, where the river was largely frozen, geese loafed on the ice shelf next to pockets of open water.

Breeding Period

Geese Present. Breeding populations of geese in the study area during this period could not be accurately counted. Based on the total number of pairs and singles observed on aerial censuses (Hanson and Browning 1959), the breeding population was estimated to be 484 breeding pairs on the first 1975 census, 433 on the second 1975 census, and 404 on the 1976 census. However, many pairs observed from the air were found by ground observation to be nonbreeding birds only defending a territory. Breeding pair counts conducted in early May when hens were incubating were based on observations of territorial males defending territories in addition to some late-nesting and renesting pairs. The omission of some breeding pairs from the aerial censuses by overlooking some solitary males and the erroneous inclusion of some nonbreeding pairs probably negate each other to some degree. Therefore, a rough estimate of the size of the breeding population of geese in the study area at 400 to 450 pairs may reasonably be made.

Hanson (1965) reported the use of egg measurements in delineating possible breeding areas of giant Canada geese. He believed that the geese breeding along the Yellowstone River were giant Canada geese. Table 4 shows that, based on egg sizes, approximately 20 to 25 percent of the geese breeding in the study sections on the lower Yellowstone River are giant Canada geese. Other characteristics of giant Canada geese observed among some breeding birds included a white forehead spot, massive bill, large tarsal scutes, light color, and posterior extension of the cheek patches (Hanson 1965). The remaining 75 to 80 percent of the breeders are believed to be members of the Great Basin race or possibly a hybrid of Great Basin and giant Canada geese (Hinz 1974).

TABLE 4. Racial composition of Canada goose flocks nesting in study sections along the lower Yellowstone River based upon sizes of eggs in completed clutches.

Section	1975		1976	
	B.c. moffiti[a]	*B.c. maxima*[b]	*B.c. moffiti*[a]	*B.c. maxima*[b]
Bighorn to Hysham	57.1 (4)	42.9 (3)	79.2 (19)	20.8 (5)
Sanders to Forsyth	---	---	83.3 (10)	16.7 (2)
Hathaway to Miles City	75.0 (6)	25.0 (2)	75.0 (3)	25.0 (1)
Miles City to Sunday Creek	100.0 (13)	0.0 (0)	75.0 (3)	25.0 (1)
Sunday Creek to Terry	---	---	84.6 (11)	15.4 (2)
Fallon to Glendive	55.5 (5)	44.5 (4)	69.2 (9)	30.8 (4)
MEANS AND TOTALS	75.7 (28)	24.3 (9)	78.6 (55)	21.4 (15)

NOTE: All entries are expressed as percentages followed by, in parentheses, number of nests.

[a]Clutches with eggs whose lengths averaged 87.0 mm or over.

[b]Clutches with eggs whose lengths averaged under 87.0 mm.

Two hens neck-banded in 1975 were observed on their nests in the spring of 1976 in the vicinity of their capture (appendix D), demonstrating the tendency of breeding hens to return to the same areas to nest. Only five observations of juvenile birds returning with their parents to nesting areas were recorded. Migration to other breeding grounds, post-banding mortality, and neck-band loss are the factors believed to be responsible for the paucity of these observations.

Crops and Forage Utilized. Feeding by breeding geese during this period was largely limited to streamside fields and riparian vegetation.

Movement. During the period of nest initiation, the breeding segment of the population remained on the river most of the time, the females on or near the nest and the gander on a territorial defense site. The gander defended the territory from a small bar or island near the nest or from the main bank where he could also graze on green vegetation.

Nest Initiation. As shown in figure 5, nesting by Canada geese in the study area began in late March in 1975 and mid-March in 1976. FAA records from Miles City showed similar mid-March temperatures in both years. Both years there was a peak in the dates of nest initiation, around April 12, 1975, and April 1, 1976. The later peak in 1975 may have been the result of heavy snow and blizzard conditions in the study area during the first week of April. A renesting and/or late-nesting peak in 1976 is not apparent in figure 5 because these late nests were not surveyed. Late nesting followed high rates of predation and desertion of early nests in the upstream study sections (table 5).

Nesting Density. Goose nesting densities were low overall, but on certain islands (table 6) they approached or exceeded those found by other researchers (table 7). This tendency of high numbers of geese to nest on isolated islands may result from hens returning to nest on islands where they successfully nested in previous years; this pattern may be disrupted by predation as occurred on the most densely-nested island in the Miles City-to-Kinsey section. In 1975, there were 2.5 nests/ha (1.0 nest/acre) on that island, and, in 1976, similar numbers of hens began to nest there (table 6). One or more raccoons, possibly attracted to the island by the large number of nesting geese, preyed on all goose nests on the island shortly after these nests were initiated. Later, four pairs of geese, two of which were successful, renested or late nested on the island, a density of only .66 nests/ha (.27 nests/acre).

Nest Site Characteristics. In order to predict the effect of water withdrawals from the river on goose nesting and on numbers of breeding, summering, migrant, and wintering geese, these parameters were statistically compared with the number of islands, sinuosity, gravel bar area, and area of agricultural land, cottonwood-grassland, and dense cottonwoods in each section of river. No significant correlations were found. However, the goose nest sites themselves were believed to have certain other characteristics in common.

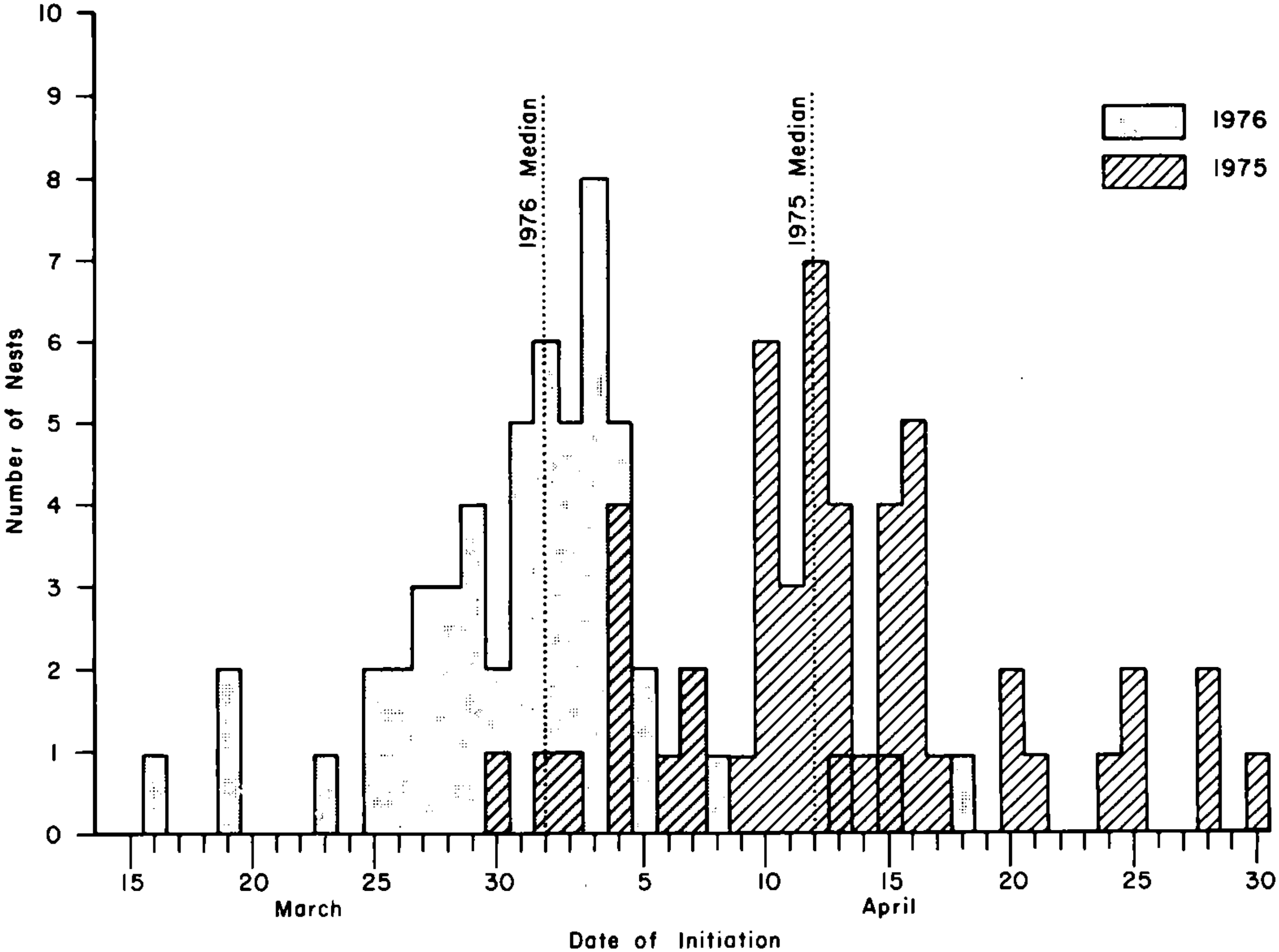

Figure 5. Dates of initiation of 51 Canada goose nests in 1975 and 58 nests in 1976 on the lower Yellowstone River, Montana.

TABLE 5. Summary of Canada goose nest fates from study sections on the lower Yellowstone River, 1975 and 1976

Study Section	Number of Nests	Successful	Flooded	Predated	Deserted
		1975			
Bighorn to Hysham	17	47 (8)	35 (6)	12 (2)	6 (1)
Hathaway to Miles City	5	40 (2)	60 (3)	0 (0)	0 (0)
Miles City to Sunday Creek	13	84 (11)	0 (0)	8 (1)	8 (1)
Fallon to Glendive	10	80 (8)	0 (0)	20 (2)	0 (0)
TOTALS AND MEANS	45	64 (29)	20 (9)	11 (5)	5 (2)
		1976			
Bighorn to Hysham	27	59 (16)	7 (2)	26 (7)	7 (2)
Sanders to Forsyth	21	33 (7)	5 (1)	38 (8)	24 (5)
Hathaway to Miles City	6	33 (2)	0 (0)	33 (2)	33 (2)
Miles City to Sunday Creek	14	36 (5)	0 (0)	57 (8)	7 (1)
Sunday Creek to Terry	14	71 (10)	7 (1)	7 (1)	14 (2)
Fallon to Glendive	14	64 (9)	0 (0)	7 (1)	29 (4)
TOTALS AND MEANS	96	51 (49)	4 (4)	28 (27)	17 (16)

NOTE: Nest fates are given first as percentages of study section nests, then (in parentheses) as number of nests. Nests in which eggs were injected with colored dyes were excluded (see page 38).

The average height of goose nests above water was between 1 and 3 m (table 8), similar to the height above water of goose nests on the upper Snake River as reported by Dimmick (1968). Flooding of goose nests was more pronounced in the upstream study areas in 1975. Figures 6 through 9 show the increase in gage height during the nesting season in 1975 and 1976. More nests in the Bighorn to Hysham and Hathaway to Miles City study sections were flooded than in downstream study sections because gage heights in the upstream sections increased more rapidly. The stage in 1975 substantially increased before the peak of hatching in the upstream sections (figures 6 and 7) and little in those downstream (figures 8 and 9). In 1976, no flooding occurred in any section prior to the hatching peaks.

The average distance of goose nests from water was variable between study areas (table 8) and indicative of the nature of the islands surveyed. Nest searches on islands with steep banks and high relief revealed nests close to the edge of the island and close to the water. The average distance from water of goose nests in all study areas in both years was 23.2 m (76.1); distances ranged from .3 to 126 m (1 to 413 ft). These figures are similar to those reported by Dimmick (1968) for geese nesting along the Snake River in Wyoming.

TABLE 6. Number of Canada goose nests per hectare on the most densely nested islands in each study section surveyed along the lower Yellowstone River in 1975 and 1976.

Section or Reach	Island Size (hectares)	1975		1976	
		Number Of Nests	Nests/ ha	Number of Nests	Nests/ ha
Bighorn to Hysham	5.58	11	1.8	3	0.5
Sanders to Forsyth	6.08	4	0.7	5	0.8
Miles City to Kinsey	6.03	15	2.5	12	2.0
Sunday Creek to Terry	8.16	--	--	10	1.2
Fallon to Glendive	8.47	9	1.1	5	0.6
MEANS AND TOTALS	34.32	39	6.1	35	5.1

CONVERSIONS: 1 ha = 2.47 acres
1 nest/ha = .405 nest/acre

TABLE 7. Density of Canada goose nests on islands from studies conducted in other areas.

Source	Water Type	Nests Per hectare
Bowhay (1972)	lotic	0.7-10.6
Culbertson et al. (1971)	lotic	0.3-1.7
Hanson and Browning (1959)	lotic	.01-9.9
Hanson and Eberhardt (1971)	lotic	.02-3.9
Hanson and Oliver (1951)	lotic	2.5-5.9
Kossack (1950)	lentic	25-30
Naylor (1953)	lentic	153
Vermeer (1969)	lentic	0.7-19.8
Williams et al. (1948)	--	133-163
Witt (1955)	lentic	52
Yocum et al. (1956)	lentic	1.7

CONVERSIONS: 1 nest/ha = .405 nest/acre

TABLE 8. Height above water and distance to water of Canada goose nest sites on the lower Yellowstone River, 1975 and 1976 (in meters)

Section	1975				
	Number of Nests Examined	Average Height Above Water	Range	Average Distance To Water	Range
Bighorn to Hysham	29	1.55	0.43-2.80	20.7	2.4-70.1
Sanders to Forsyth	3	2.77	1.80-3.51	29.3	17.1-36.3
Hathaway to Miles City	10	1.10	0.30-2.13	30.8	0.9-125.9
Miles City to Sunday Creek[a]	18	1.34	0.91-1.83	15.8	2.4-37.2
Sunday Creek to Terry[a]		--	-- --	--	-- --
Fallon to Glendive	10	1.37	0.91-1.58	15.2	2.4-31.7
MEANS	70	1.46	0.30-3.51	20.4	0.9-125.9

Section	1976				
	Number of Nests Examined	Average Height Above Water	Range	Average Distance To Water	Range
Bighorn to Hysham	25	1.34	0.18-2.96	19.8	0.3-91.7
Sanders to Forsyth	12	1.55	0.49-5.49	15.2	1.5-38.4
Hathaway to Miles City	4	1.13	0.61-2.13	30.5	9.1-64.3
Miles City to Sunday Creek[a]	5	1.62	1.28-2.16	25.3	14.0-43.3
Sunday Creek to Terry[a]	13	2.56	1.98-3.51	33.8	4.6-60.7
Fallon to Glendive	14	2.07	1.22-2.77	36.6	4.0-74.7
MEANS	73	1.74	0.18-5.49	25.9	0.3-91.7

CONVERSIONS: 1 m = 3.28 ft

[a]These two reaches differ from the original study sections identified in figure 1.

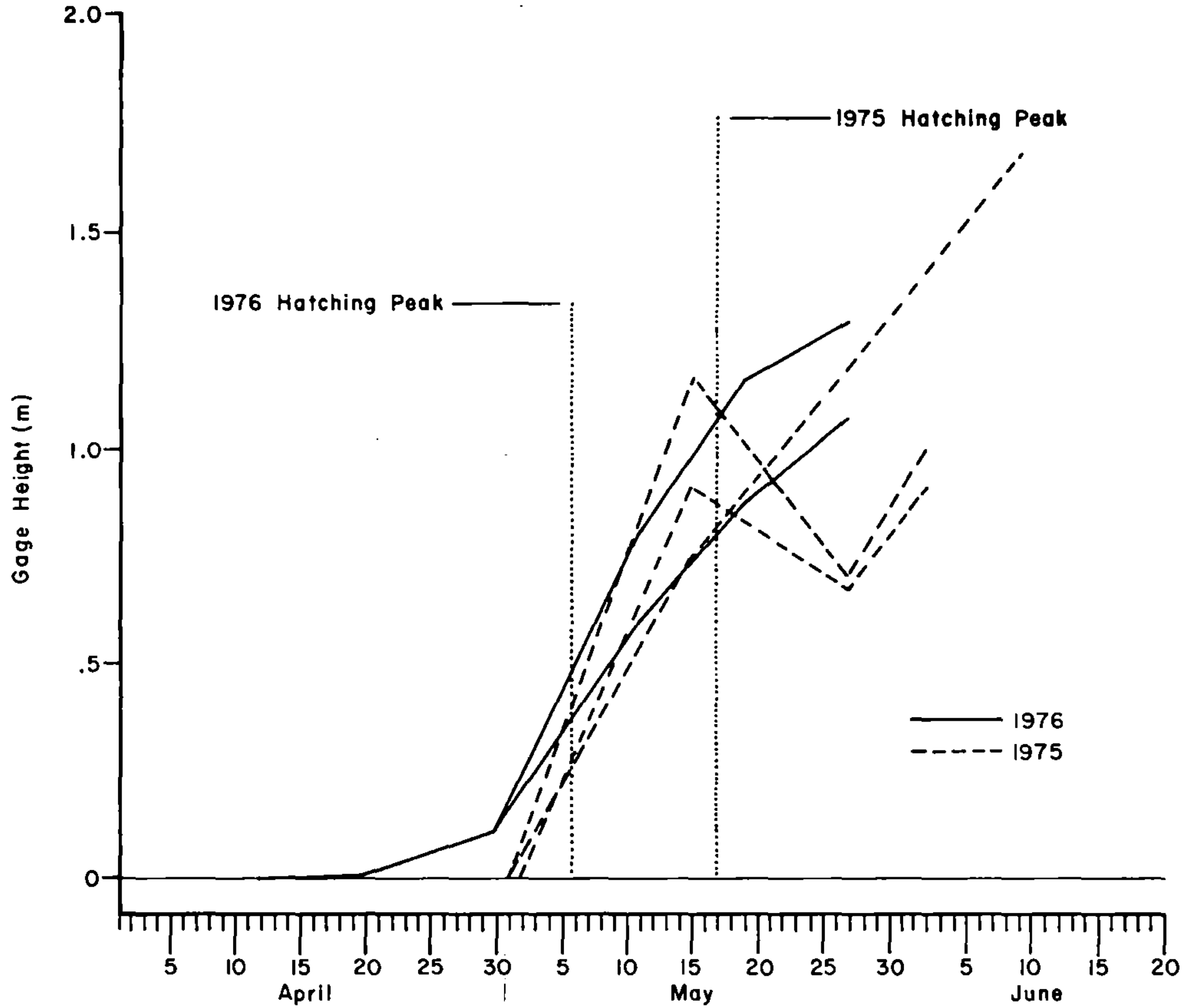

Figure 6. Gage heights from selected sites within the Bighorn-to-Hysham section of the lower Yellowstone River, 1975 and 1976.

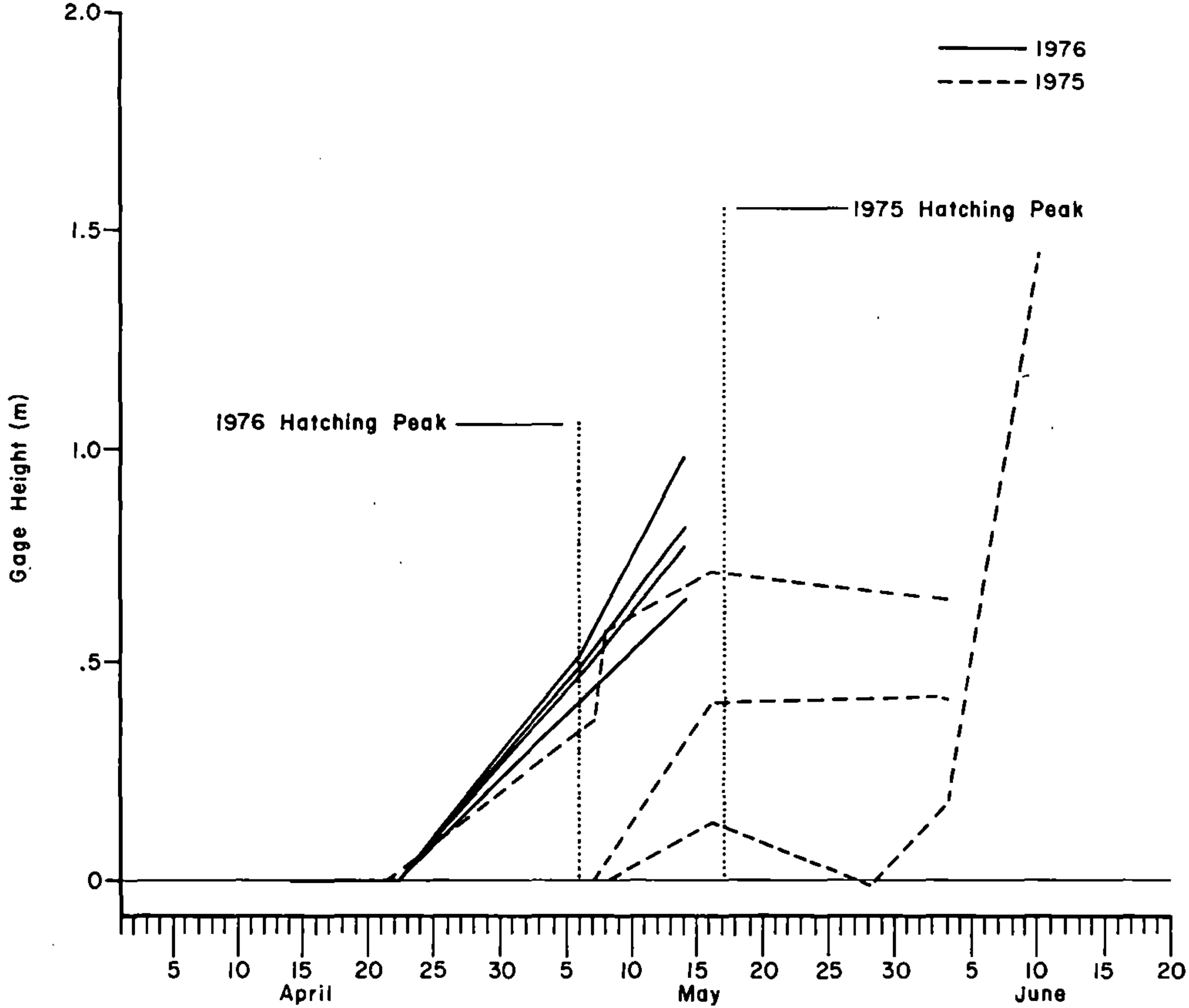

Figure 7. Gage heights from selected sites within the Hathaway-to-Miles City section of the lower Yellowstone River, 1975 to 1976.

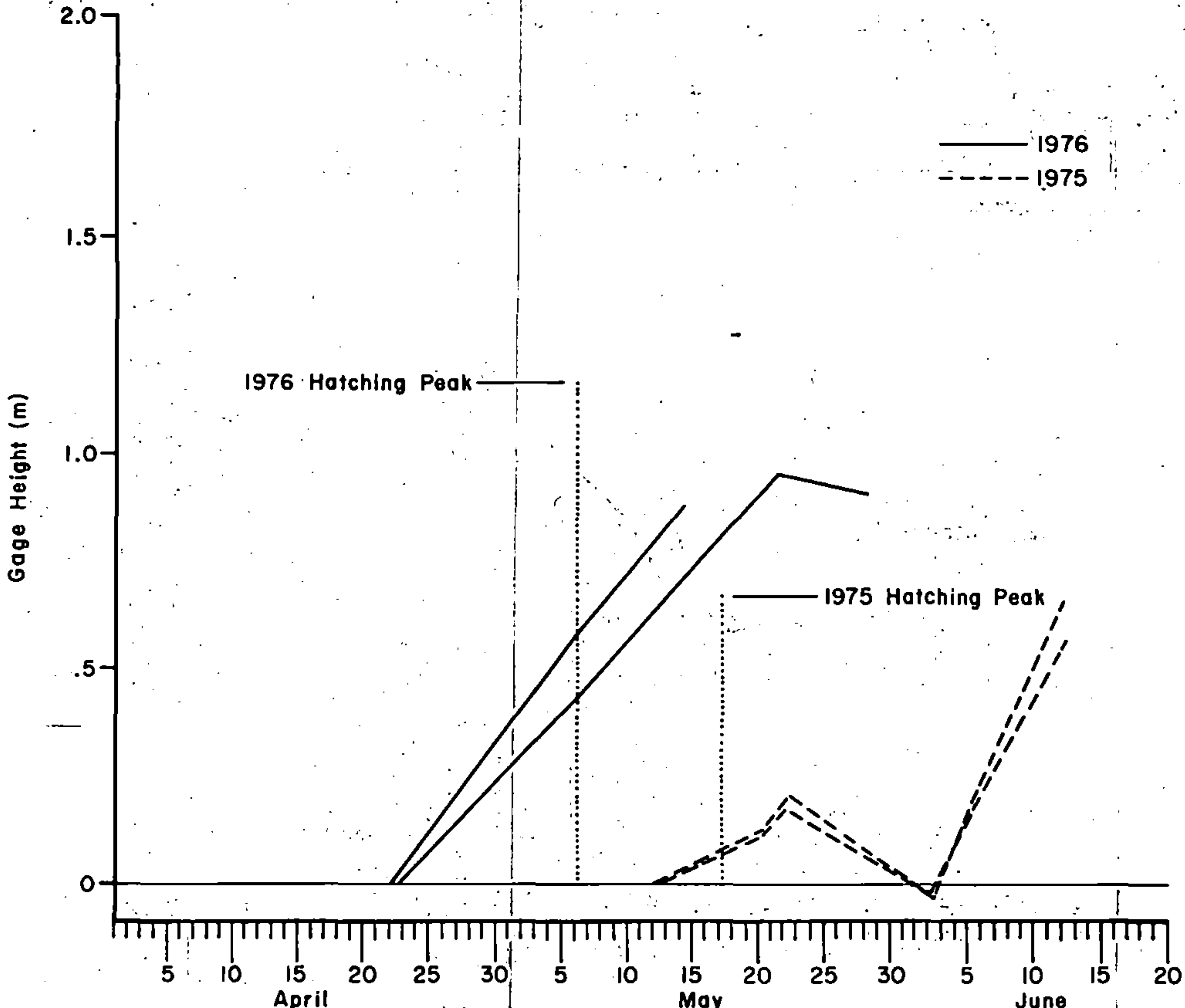

Figure 8. Gage heights from selected sites within the Miles City-to-Sunday Creek section of the lower Yellowstone River, 1975 and 1976.

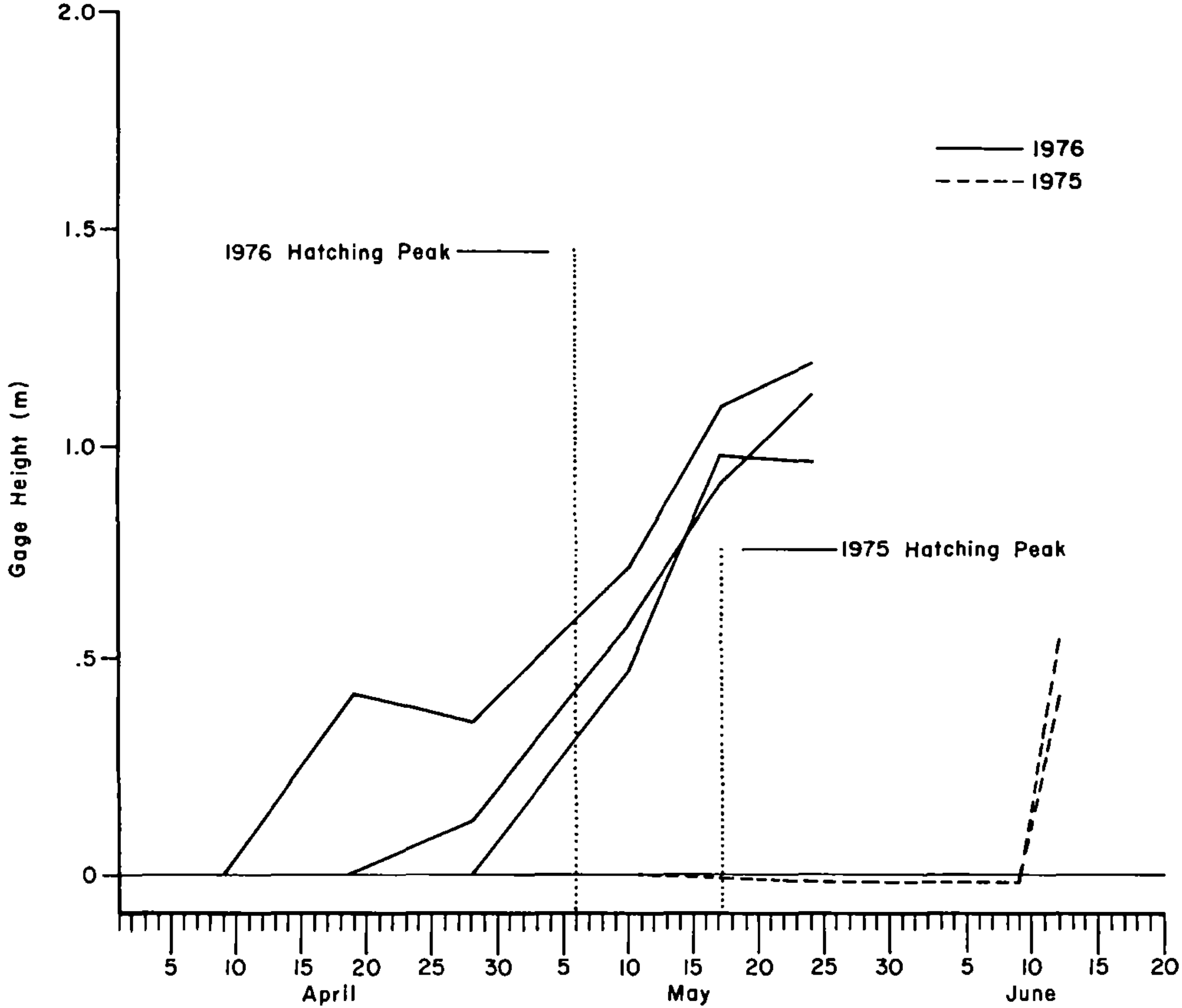

Figure 9. Gage heights from selected sites within the Fallon-to-Glendive section of the lower Yellowstone River, 1975 and 1976.

Large, high-relief islands used for nesting in the downstream sections commonly had an extensive vegetative cover. These islands were usually ice-free at the start of the nesting season. Open bars and low-relief islands were also used for nest sites in the upstream sections (figure 10) where they had been largely ice-free before nesting began or melted open during the early stages of nesting. Ice cover on islands in the downstream sections apparently did not induce geese to nest later (an observation based on hatching times of those nests) but did induce them to build their nests on island interiors where ice cover was light or absent. The tendency of ice flows moving downstream to flow past high-relief islands is illustrated in figure 11. These islands, which were mostly free from ice-gouging and flooding (see table 9), were used to a lesser degree in the upstream sections. In 1975 and 1976, the average M.C.R.'s for goose nests in study areas upstream from Miles City were 18.5 and 16.5, respectively, compared with 14.4 and 14.0, respectively, in study areas below Miles City.

TABLE 9. Mean cover ratings from goose nest sites on the lower Yellowstone River, 1975 and 1976.

Section or Reach	1975		1976	
	Number of Nests	Mean Cover Rating	Number of Nests	Mean Cover Rating
Bighorn to Hysham	29	17.7	23	15.3
Sanders to Forsyth	4	19.1	12	15.7
Hathaway to Miles City	11	18.8	4	18.6
Miles City to Sunday Creek	18	14.4	5	14.8
Sunday Creek to Terry	--	--	13	13.6
Fallon to Glendive	10	14.4	15	13.7

NOTE: Higher mean cover ratings indicate less dense cover around the nest.

Goose nests were frequently built on or near driftwood logs, as shown in table 10. The logs often afforded the only nesting cover available on otherwise sparsely-vegetated sites. Of the nests surveyed in 1975 and 1976 which were constructed on or near driftwood logs, 79 percent and 95 percent, respectively, occurred in the study areas upstream from Miles City. In both years, approximately 96 percent of the nests surveyed were constructed on islands. Peninsulas, heron rookeries, and cliffs were less important as goose nesting areas. Over 95 percent of the nests surveyed were constructed on a fine substrate--one composed primarily of sand or smaller particles. Fine substrates probably provide better insulation for the clutch. Even where all other considerations seemed favorable for nest construction, lack of a fine substrate was sufficient to discourage nest construction. Such lack was observed only on some small islands which might otherwise have been used for nesting in the upstream study sections.

Figure 10. A typical nest site utilized by Canada geese nesting in open, unvegetated areas. This site occurred near the mouth of Armells Creek, April 1974.

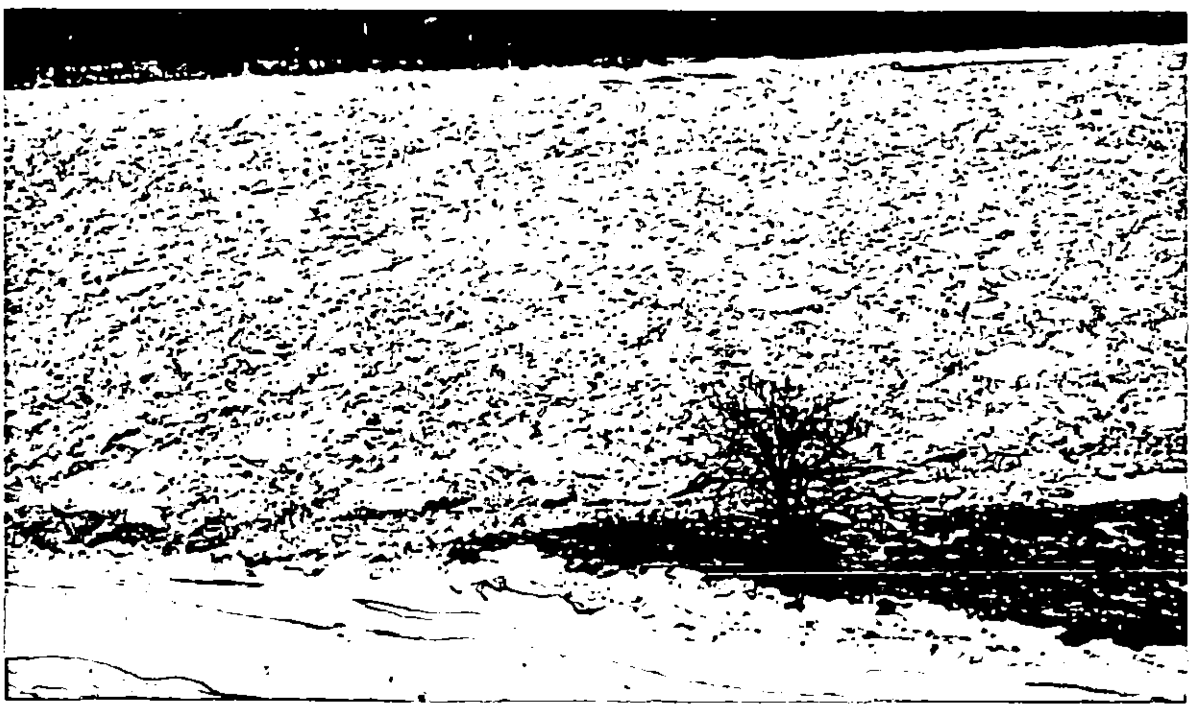

Figure 11. Ice flows moving past the vegetated portion of the downstream end of an island in the Fallon-to-Glendive section, February 1975.

TABLE 10. Frequency of association of completed Canada goose nests with selected nest site parameters on the lower Yellowstone River, 1975 and 1976. (The number of nests in each category is given in parentheses.)

	1975	1976
Percentage of nests constructed by a log	33.8 (24)	39.7 (29)
Percentage of nests constructed on islands	95.9 (70)	95.9 (70)
Percentage of nests constructed on peninsulas	4.1 (3)	2.7 (2)
Percentage of nests constructed on fine substrate[a]	95.9 (70)	97.3 (71)
Number of additional nests[b] constructed in heron rookeries	1	2
Number of additional nests[b] constructed on cliffs	1	3

NOTE: Only significant percentages are included. No attempt was made in this table to show, for example, components besides logs found around nests, since only logs accounted for a significant percentage.

[a]Substrate predominantly sand or silt composition

[b]Additional nests are those not surveyed because they were inaccessible on foot.

Clutch Sizes. Clutch size from goose nests within all study areas averaged 5.3 and 5.6 eggs per clutch in 1975 and 1976, respectively. Similar figures were reported from goose nests in other areas studied by Kossack (1950), Hanson and Browning (1959), Martin (1964), Brakhage (1965), Hanson and Eberhardt (1971) and Bowhay (1972). The frequency of clutch sizes encountered, ranging from two to nine eggs per nest, is shown in figure 12.

Nesting Success. The percentages of successful nests (those in which at least one egg hatched) in 1975 and 1976 were approximately 65 and 50 percent, respectively (table 5). Other researchers, including Steel et al. (1957), Hanson and Browning (1959), Martin (1964), and Hook (1973), reported between 70 and 90 percent nest success. The loss of 50 percent or more of the nests in at least one of the study sections on the lower Yellowstone was the result of nest flooding in 1975 and nest desertion and predation in 1976. The high number of nests lost to flooding in 1975 may represent nesting by inexperienced two- or three-year-olds (Eng 1976). Late nesting by some pairs may have increased the actual production and success rate in both years, but these late nests were not surveyed in order to prevent any further nest loss or desertion.

The high rate of nest predation which occurred in some study areas in 1976 compared with that observed in 1975 (table 5) may be related to the difference in discharges during the nesting season between these two years. According to Koch (1976a), repairs on Yellowtail Dam in the spring of 1976 necessitated reduced outflow from the dam during the first ten days of April. A comparison of the Yellowstone's discharge at Miles City during the springs of 1975 and of 1976 shows this reduction (figure 13). Shortly before and after the median date of nest initiation in 1976, the discharge of the river was considerably lower than during the same period of the nesting season in

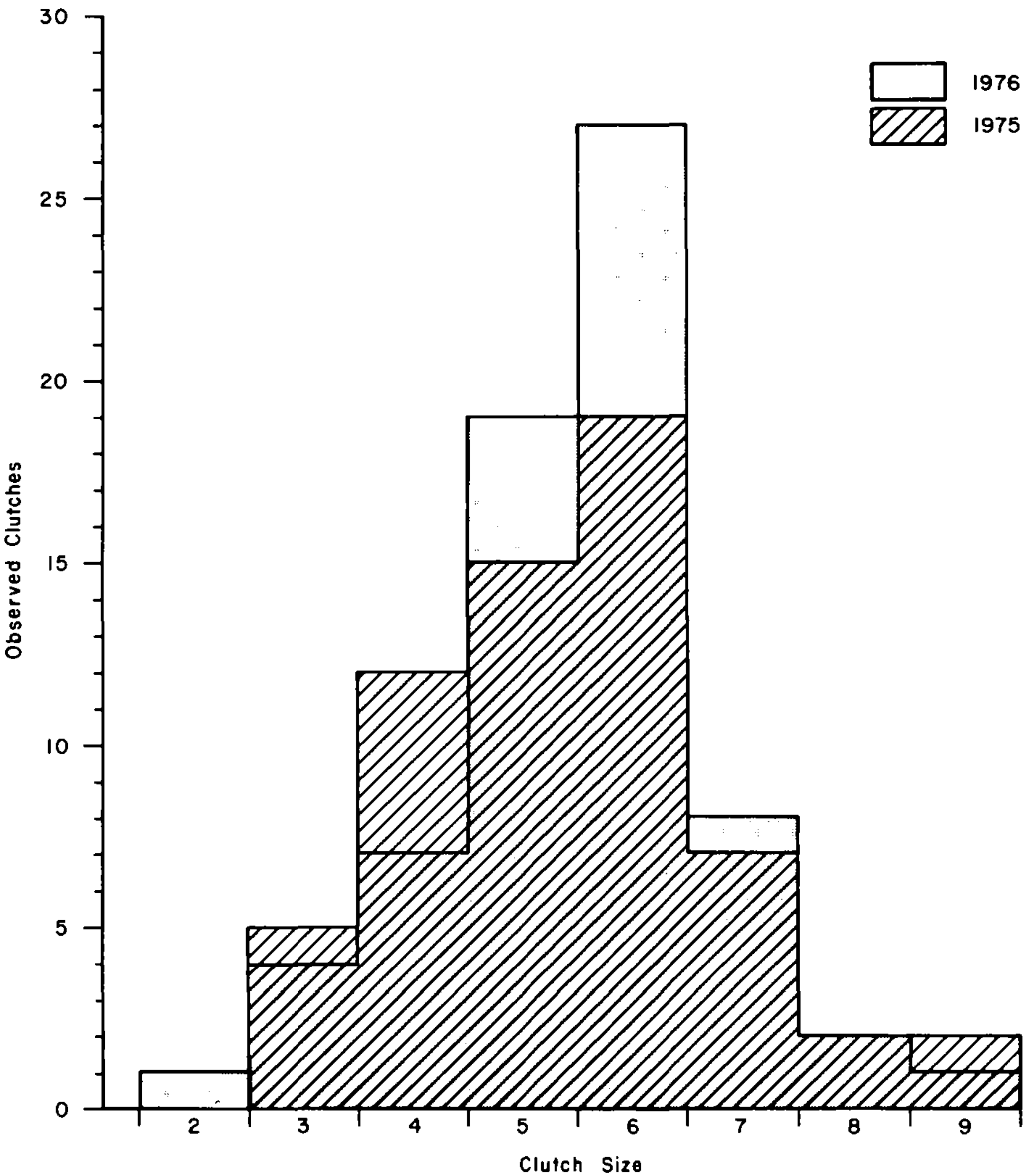

Figure 12. Frequency distribution of clutch sizes from 131 Canada goose nests on the lower Yellowstone River, 1975 and 1976.

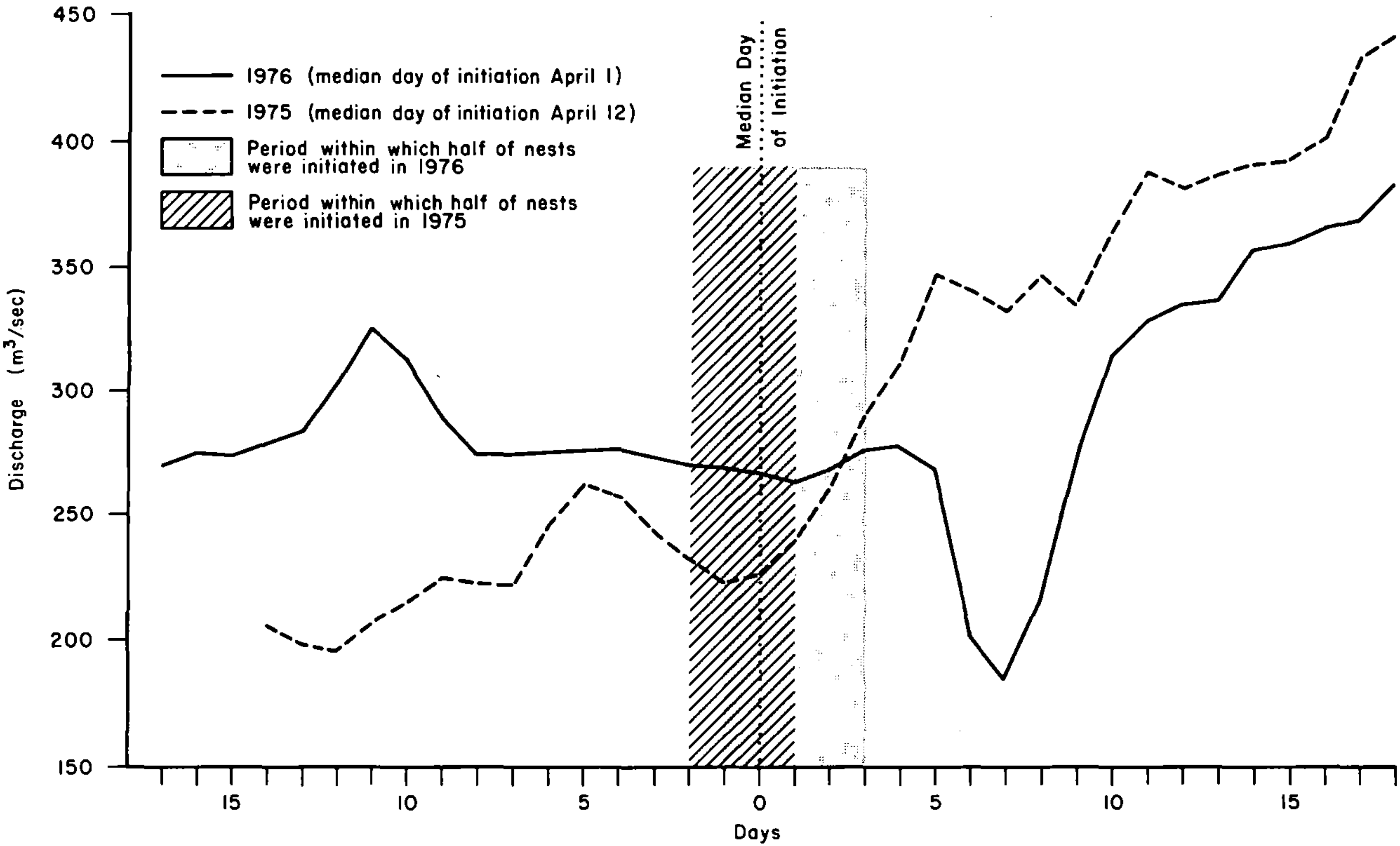

Figure 13. Discharge of the lower Yellowstone River at Miles City, Montana, during the period of initiation of Canada goose nests surveyed in 1975 and 1976.

1975. This lower discharge may have allowed greater accessibility of the nesting islands to predators due to reduced width and depth of the channels separating the islands from the main bank. In 1975, discharge of the Yellowstone at Miles City was lower around the median date of initiation than in 1976 but shortly thereafter increased and nest flooding resulted. Had this increase and subsequent flooding not occurred, losses of nests to predators during that period may have been greater. The relationship between low flows and nest losses to predation versus high flows and nest losses to flooding is more evident in the study areas near and upstream from Miles City. In the more downstream study sections, the spring changes in discharge in 1975-76 were not believed to appreciably alter channel widths. Also, because many of the islands surveyed for nests in the Sunday Creek-to-Terry reach and Fallon-to-Glendive section occur midstream with sizable channels on both sides, the ability of predators to reach them may be limited.

Egg success in successful nests in both years was approximately 86 percent (appendix E), similar to that reported by Geis (1956) in the Flathead Valley of Montana, by Steel et al. (1957) at Gray's Lake in Idaho, and by Martin (1964) at Bear River, Utah. Embryonic deaths in unhatched eggs accounted for 67 percent of the unsuccessful eggs from successful nests in 1975. These deaths were attributed to cold weather on days when nest checks were conducted, which sometimes resulted in chilling of eggs. The proportion of embryonic deaths in unhatched eggs was greatly reduced in 1976 over 1975, possibly due to warmer temperatures and/or clearer skies on nest survey days.

Eggs injected with colored dyes in 1975 were excluded from calculation of nest and egg success because the dyeing process resulted in abnormally high egg mortality in dyed clutches. Of 90 eggs injected in 18 nests, only 36 percent hatched. This poor success rate was attributed to embryonic death caused by green dye in toxic concentration, and dyes used at air temperature.

Brood-Rearing and Flightless Period

Geese Present. Numbers of geese observed during censuses conducted in this period (figure 4) are believed to be erroneously low due to the inability of the observer in the air to locate geese hidden in dense cover.

Crops and Forage Utilized. Geese grazed primarily on grasses and forbs at this time of year. Juvenile birds were believed to utilize insects in their diets as do immature grouse (Peterson 1970) and ducks (Chura 1961), but were believed to feed primarily on green forage by three weeks of age, as indicated by Lieff et al. (1970).

Movement. During the flightless period in 1975, 157 neck bands were applied to geese on the river and on nearby stockponds. Some subsequent observations of these neck-banded birds occurred during the flightless period (appendix D). Movements which occurred between these observations were believed to be similar to those of goslings from nests where clutches were injected with colored dyes. One blue-dyed gosling from a nest near Myers was observed when three to four weeks old in a hayfield across the channel from the island where it hatched. Contrary to Geis's (1956) and Caldwell's (1967) observations of goose broods in their study areas, goose broods on the Yellowstone are not believed to move long distances downstream after hatching. Two goslings approximately two weeks of age when captured on the river near Kinsey in early June were recaptured in subsequent banding trips 1.5 to 3 km (1 to 2 mi.) upstream from where they were first encountered. Three goslings of a brood dyed in a nest on the river 11 km (7 mi) southwest of Miles City exhibited greater movement; they were captured at seven weeks of age on a reservoir 10 km (6 mi) overland from the island where they hatched.

Hatching and Brood Rearing. Hatching dates were estimated to be 28 days (Atwater 1959) plus 1.5 days per egg in the clutch (Kossack 1960) after the date of nest initiation (figure 5). The peaks which occurred in the period of nest initiation were followed approximately five weeks later by the hatching peaks.

Young were encountered in nests an estimated one to two days after hatching. Brooding in the nest was also reported by Zicus (1975). After one to two days, goose pairs moved their young away from the nesting islands to brood-rearing areas, perhaps partially in response to crowding and territorial disputes on some of the nesting islands. The areas where geese were observed with young were highly diverse with respect to vegetation. The same areas were used by broods of different ages. Many brood-rearing areas were characterized by a semiopen understory with some sparse shrubbery and a cottonwood canopy. Some consisted of streamside barley fields, grazed and cleared pastureland, cornfields, alfalfa fields, and other agricultural and riparian vegetation types. All brood-rearing areas adjoined the river which served as an escape route for geese when threatened.

Flightlessness. Shortly after the young leave the nests, the adult geese begin to molt their flight feathers. The wide variation of hatching dates resulted in the occurrence of flying and flightless birds on the river at the same time.

Early Fall Resident Period

Geese Present. This portion of the goose resident period is characterized by the presence of from 1,500 to 3,500 flying birds in the study area (figure 4), possibly including nonbreeding geese returning to the study area in early fall from molt migrations to the north (Hanson 1965). Forty percent of all geese observed during aerial censuses conducted during this and the flightless period (table 11) were recorded in the Bighorn-to-Rosebud reach of the river, 20 percent of the area censused. This may reflect higher nesting density in this section and attraction of nonbreeders and/or early migrants to the area.

Crops and Forage Utilized. During the early fall resident period, most field-feeding birds were observed in fields containing barley and wheat stubble and corn cut for silage (table 2). Bossenmaier and Marshall (1958) reported similar goose utilization of wheat and barley fields in the Whitewater Lake region of southwestern Manitoba.

TABLE 11. Numbers of Canada geese observed during aerial censuses in the Early Fall Resident Period

Section	Number of Geese	Geese/km
Billings to Huntley	124	7
Huntley to Worden	142	8
Worden to Pompeys Pillar	120	9
Pompeys Pillar to Custer	1,165	27
Custer to Bighorn	678	87
Bighorn to Hysham	3,041	96
Hysham to Sanders	1,480	74
Sanders to Forsyth	4,316	105
Forsyth to Rosebud	725	37
Rosebud to Hathaway	2,161	69
Hathaway to Miles City	872	27
Miles City to Kinsey	1,257	42
Kinsey to Zero	2,200	92
Zero to Powder River	580	106
Powder River to Terry	742	35
Terry to Fallon	353	25
Fallon to Glendive	1,678	32
Glendive to Intake	311	10
Intake to Savage	546	18
Savage to Sidney	1,045	28
Sidney to Fairview	643	28

CONVERSIONS: 1 goose/km = 1.61 geese/mi

NOTE: Nine flights from time of departure of most spring migrants until arrival of large numbers of fall migrants.

[a]All flights

Movement. Movements of neck-banded geese were first intensively studied during this period. Geese were observed feeding in winter wheat fields in the general vicinity of where they were banded on the river. However, some of the geese banded between Miles City and Terry fed for a period in winter wheat fields 48 km (30 mi) north of Miles City. Movement to these fields accounts for the high value of the mean furthest distance observed from banding location exhibited by most age classes (table 12). The geese which fed 48 km north of Miles City were later observed on the river near where they were captured, indicating the tendency of families and/or individuals to limit movements up- and downstream.

Loafing geese utilized open gravel islands during this period. Where gravel islands were unavailable, such as between Terry and Fallon, geese loafed on lateral and point bars of the main bank. Loafing sites selected usually provided geese good visibility of their surroundings in all directions.

TABLE 12. Mean distances moved by age and sex classes of Canada geese marked with plastic neck collars between time of capture in 1975 and beginning of the brood-rearing and flightless period, 1976.

Age and Sex Class[a]	Number of Individuals	Mean Furthest Distance Observed From Banding Location (m)	Mean Longest Axis of Home Range[b] (m)	Mean Distance From Point Of Capture When Last Observed (m)
Adult Males	6	19.18	19.88	15.69
Adult Females	6	16.02	16.15	8.50
Subadults (both sexes)	4	8.69	12.92	8.69
Juvenile Males	30	17.19	18.74	13.68
Juvenile Females	23	14.23	14.95	9.97

CONVERSIONS: 1 km = .622 mi

[a]Adult: a bird believed to be in its second year after hatching.
Subadult: a bird in its first year after hatching.
Juvenile: a bird in its year of hatching.

[b]Obtained by plotting all observation points on a map and measuring the longest distance across the area formed by connecting the points.

Loafing sites utilized by geese during this period were often the ones frequented by geese at other times of the year, probably as a result of habitual feeding in a nearby field. From the loafing area geese flew to the feeding field twice daily, around sunrise and sunset. Length of time spent in the field varied from a few minutes to several hours, depending on weather, food availability, and disturbances. Geese fed in a given field longer during periods of cool, rainy weather and when no disturbances were present. Field-feeding periods were generally shorter in the evening. The time of departure of the field-feeding flights from the river appeared to depend on light intensity. Raveling et al. (1972) also believed morning and evening feeding flights of Canada geese to feeding fields were related to light intensity. Wind and temperature were believed to be less important in their effect on time of departure of flocks from the river. A field-feeding pattern, once developed, continued for several days until geese moved to another field.

Fields utilized by feeding geese were usually of sufficient size to allow the geese complete visibility around themselves for at least 30 m (100 ft). Smaller fields, even of favorite crop types, were avoided, especially those surrounded by dense vegetation, as reported by Sturdy (1967). Field characteristics described by Grieb (1970) as attractive to field-feeding short-grass prairie geese in Colorado were also attractive in most instances to field-feeding geese in the Yellowstone Valley during early fall.

Fall Migration Period

Geese Present. Numbers of geese observed during aerial censuses in the study area during this period were second only to those observed on a census conducted during the spring migration in 1975 (figure 4). However, more geese were present for a sustained period of time during the fall migration period than during the spring period (table 13).

TABLE 13. Numbers of Canada geese observed during aerial censuses in the Fall Migration Period

Section	Number of Geese[a]	Geese/km
Billings to Huntley	527	32
Huntley to Worden	139	7
Worden to Pompeys Pillar	40	3
Pompeys Pillar to Custer	1,589	36
Custer to Bighorn	44	6
Bighorn to Hysham	7,200	228
Hysham to Sanders	2,875	145
Sanders to Forsyth	16,508	403
Forsyth to Rosebud	5,605	288
Rosebud to Hathaway	6,222	198
Hathaway to Miles City	4,450	138
Miles City to Kinsey	4,393	147
Kinsey to Zero	1,916	80
Zero to Powder River	835	153
Powder River to Terry	843	40
Terry to Fallon	1,366	95
Fallon to Glendive	2,628	50
Glendive to Intake	1,893	58
Intake to Savage	1,397	45
Savage to Sidney	958	26
Sidney to Fairview	621	27

CONVERSION: 1 goose/km = 1.61 geese/mi

NOTE: Fourteen flights from first arrival of large numbers of fall migrants through departure of fall migrants.

[a]All flights.

Seventy-six percent of the geese observed on aerial censuses during this period occurred between Bighorn and Kinsey (table 13). The greatest concentrations within that reach occurred in the Sanders-to-Forsyth section. More geese were observed per kilometer of thalweg in that section during this period than in any other section (table 13), probably because of the large number of sprinkler-irrigated fields in that area, which serve as field-feeding areas for large numbers of waterfowl (figure 14).

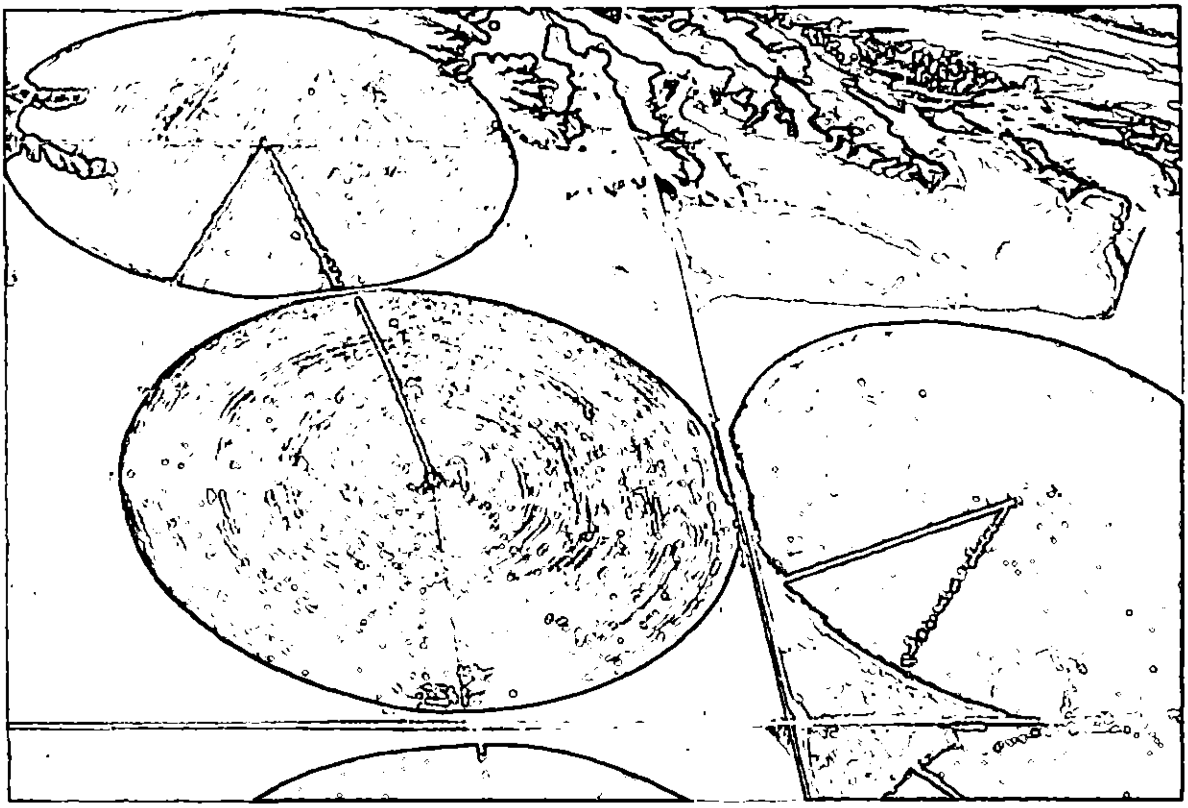

Figure 14. Center-pivot sprinkler irrigated fields between Forsyth and Sanders, feeding areas for large numbers of waterfowl.

With the onset of colder weather in early November, numbers of geese present in the study area greatly increased (figure 4). Among the geese now entering the area were flocks of small Canada geese of the shortgrass prairie and Richardson's (*B. c. hutchinsii*) subspecies. Large flocks of migrant geese often contained large and small races of Canada geese intermixed with white-fronted geese and snow geese. One flock of field-feeding geese near Rosebud observed in November 1975 contained a whistling swan (*Olor columbianus*). The presence of white-fronted geese, snow geese, small races of Canada geese, and Canada geese with orange-tinged heads, necks, and breast feathers was believed to indicate the arrival of flocks of northern migrants. R. L. Eng (1976) agreed that orange-tinged feathers on Canada geese probably resulted from iron deposits on their feathers, a trait common in waterfowl flocks frequenting iron-laden waters of the Arctic.

Neck-banded geese were reported taken by hunters soon after the waterfowl season opened in October 1975. The presence of a neck band on a hunter-harvested goose may have served as a stronger incentive for the hunter to report his kill. However, three leg bands taken from geese which had lost their neck bands by the time they were shot were reported. This neck band loss was attributed to poor bond of the adhesive used. Recoveries of geese banded in the study area, recovered between 1973 and 1976, are shown in figure 15. These recoveries occurred within their migrational and wintering distribution as described by Rutherford (1965). Canada geese taken in the study area but banded in other areas were mostly banded within the distribution limits of the Hi-Line population (figure 16) on their breeding grounds in northeastern Montana or on major wintering grounds in north-central Colorado.

Crops and Forage Utilized. Field-feeding geese were observed in greatest numbers in small grain, corn, and hay fields. Fewer geese were observed in fields cut for corn silage during this period than in the preceding one, possibly because field-feeding patterns became more diverse later in the fall. Observations of geese utilizing hayfields between Forsyth and Terry during this period indicated a preference for fields providing green forage. Use of forage crops continued through this period where barley stubble fields offered volunteer barley sprouts, winter wheat fields provided sprouted drilled wheat, and alfalfa and hay fields provided green growth under snow cover or before heavy frosts.

Movement. Movements of neck-banded geese during this period appeared to be similar to those observed in the earlier periods. Most field-feeding observations of marked individuals were recorded near where those geese were originally banded. Movements of adult and juvenile birds were similar in extent (table 12) due to the tendency of family groups to remain together (Raveling 1966). The mean longest axis of the home range of subadults was the lowest of all age-sex classes, probably due to the small sample size. Geese banded near the mouth of the Powder River were observed in fields east of Miles City in late November. These observations represent the longest up- and downstream movements of neck-banded individuals observed during the study.

Field-feeding patterns during this period were less orderly than those observed during the preceding period. Geese frequently changed loafing and feeding areas, especially when hunting occurred. In 1974, those sections were limited to the Yellowstone River downstream from the Custer-Prairie county line near Zero and upstream from the mouth of the Bighorn River. The river between Zero and the Custer-Rosebud county line near Hathaway was closed to hunting after 12 noon. Between Hathaway and the mouth of the Bighorn, the river was closed to waterfowl hunting. In 1975 no areas were open to hunting for half-days only. Areas closed to waterfowl hunting included the river reaches from Bighorn to Myers, Reservation Creek to Hathaway, 11.3 km (7 mi) southwest of Miles City to Kinsey, and from Terry to Intake. All other sections were open to hunting. Goose movements became more erratic in those areas opened to hunting in 1975 which had been closed in previous years. Some flocks moved from the river to loaf on stockponds when the waterfowl season opened. In those areas closed to hunting in 1975 which had been open previously, no discernible changes occurred in goose movements and distribution; such was also the case in those areas where regulations in 1975 were unchanged from previous years.

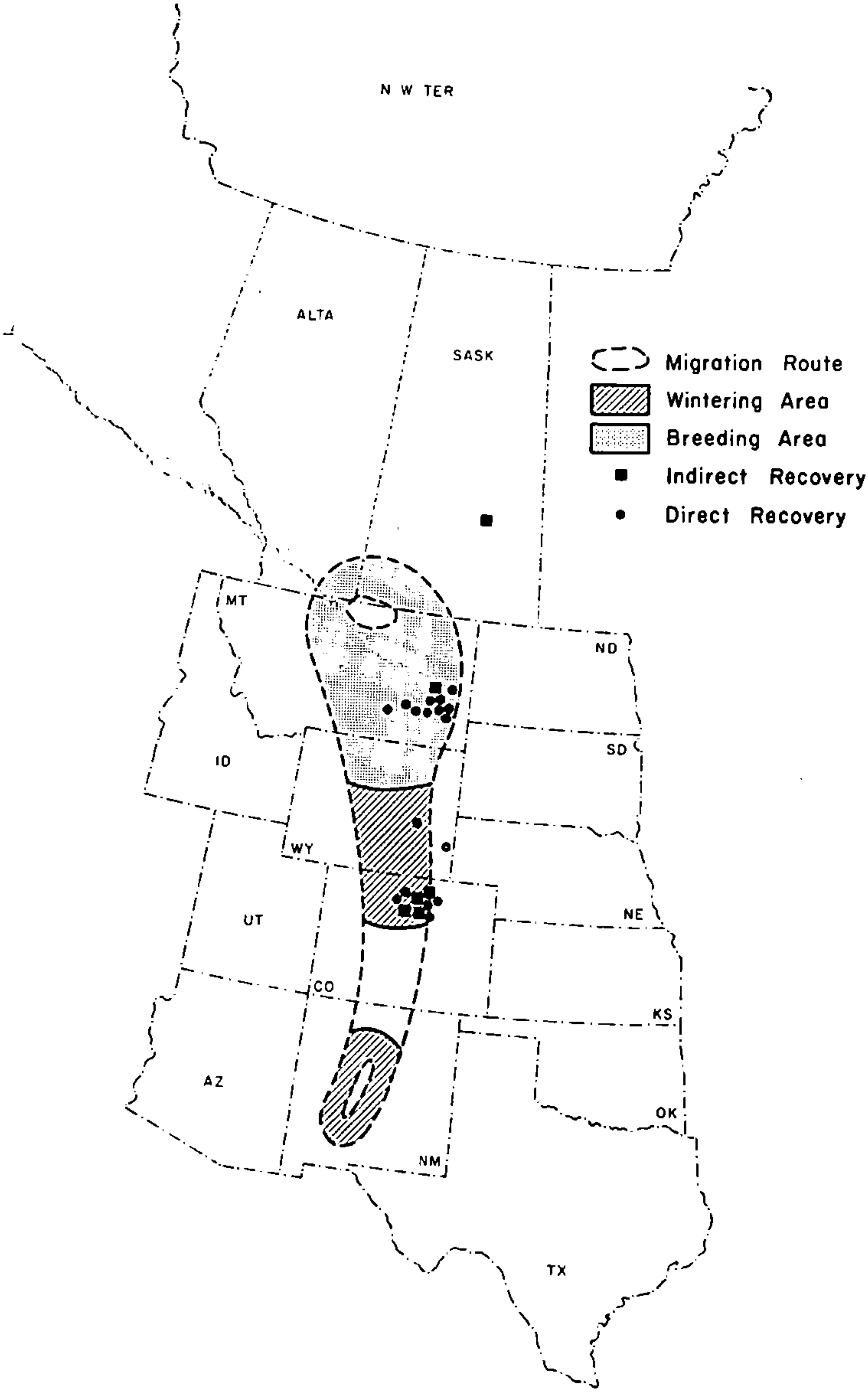

Figure 15. Distribution of recoveries of Canada geese banded in counties along the Yellowstone River from 1973 to 1976.

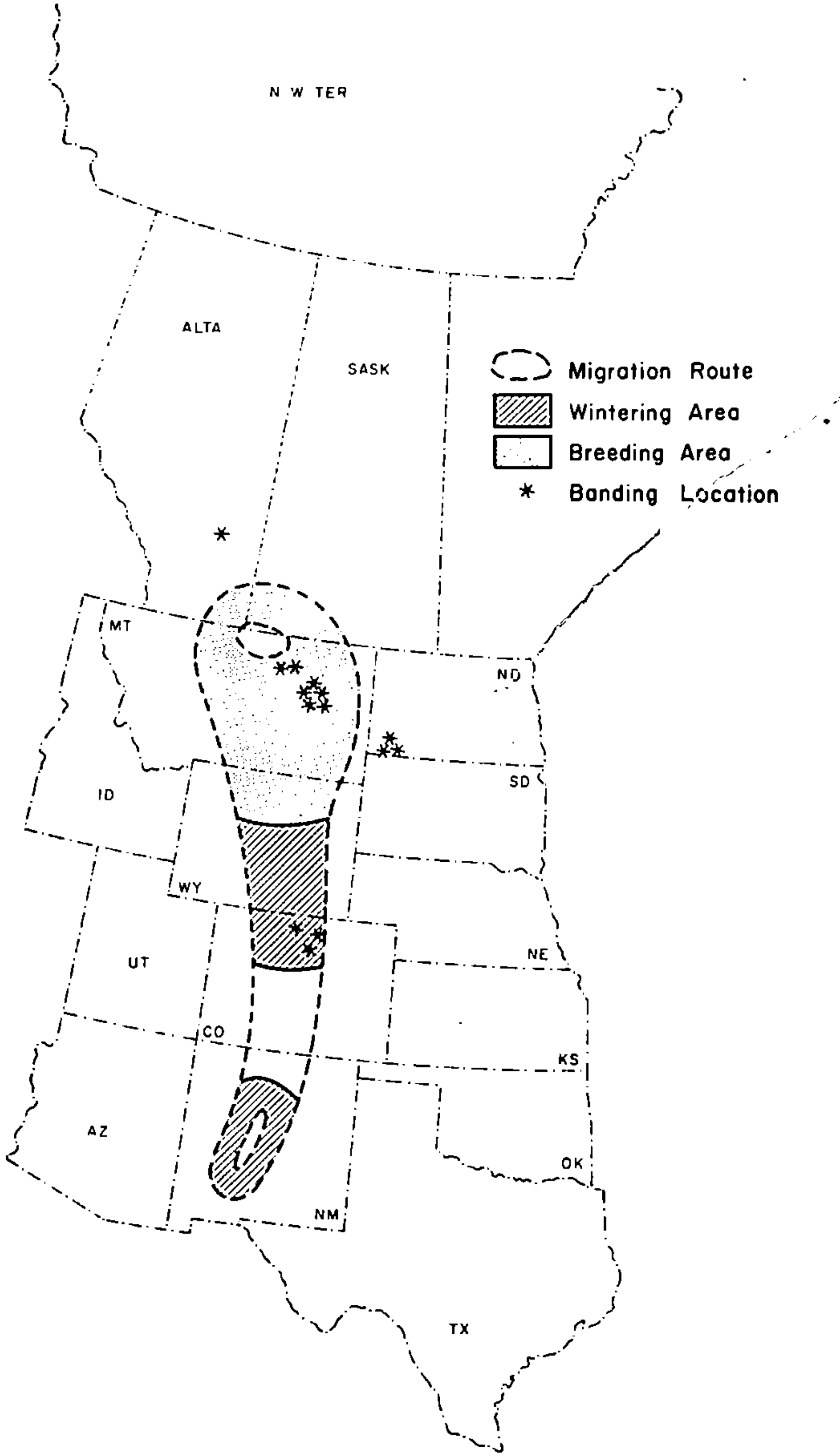

Figure 16. Banding locations of Canada geese harvested in the counties along the lower Yellowstone River.

DABBLING DUCKS

Data gathered during these duck studies were organized according to six time periods. The wintering period begins when migrations into and out of the area are much reduced and ends with the beginning of the spring migration period when duck numbers increase markedly and when dabbling species other than mallards (pintails (*Anas acuta)*, green-winged teal (*Anas crecca carolinensis)*, baldpates (*Anas americana)*, for example) appear. The disappearance of migrant flocks and the appearance of breeding ducks (territorial drakes and nesting hens) marks the end of the spring migration period and beginning of the nesting period, which ends when it is believed that most of the clutches have hatched. The brood-rearing period begins at that time and ends when most of the broods can fly and begin to congregate in water areas. The late summer period lasts from then until these groups begin to migrate out of the study area, at which time the fall migration period begins. When most migrant flocks have passed through the study area to southern wintering grounds, the wintering period begins, and the cycle is complete.

Ducks Present

Habitat utilization and population levels of dabbling ducks in the lower Yellowstone River Valley change markedly through the year. Dabbling duck numbers observed during aerial censuses along the river between Billings and Fairview are indicative of these changes (figure 17). Numbers of dabbling ducks were highest during the spring and fall migration periods and lowest during the brood-rearing and late summer periods.

Mallards (*Anas platyrhynchos)* were the most common species of dabbling duck present in the study area at all times of the year, although the percentage of mallards was highest whenever field-feeding flocks of ducks were present. Pintails also occurred in large field-feeding flocks but only for short periods during spring migration.

The first spring migrant dabbling ducks, observed in early March both years of the study, were pintails, blue-winged teal (*Anas discors)*, green-winged teal, and baldpates. Numbers of these species increased while flocks of gadwalls (*Anas strepera)*, northern shovelers (*Anas clypeata)*, and wood ducks (*Aix sponsa)* began to occur in the study area. Diving ducks, including redheads (*Aythya americana)*, canvasbacks (*Aythya valisineria)*, ring-necked ducks (*Aythya collaris)*, and lesser scaup (*Aythya affinis)*, were also observed as spring migrants, as were ruddy ducks (*Oxyura jamaicensis)* (appendix F). Only the dabbling ducks were seen throughout the spring and into the summer, nesting along the river and in stockponds near the river.

Crops and Forage Utilized

Dabbling ducks were observed feeding and/or loafing in fields throughout the year. Picked cornfields were the most heavily utilized, based on observations recorded throughout the entire study period (table 14). From spring migration through late fall, observations of ducks in barley stubble fields also accounted for a high percentage of the field-feeding observations.

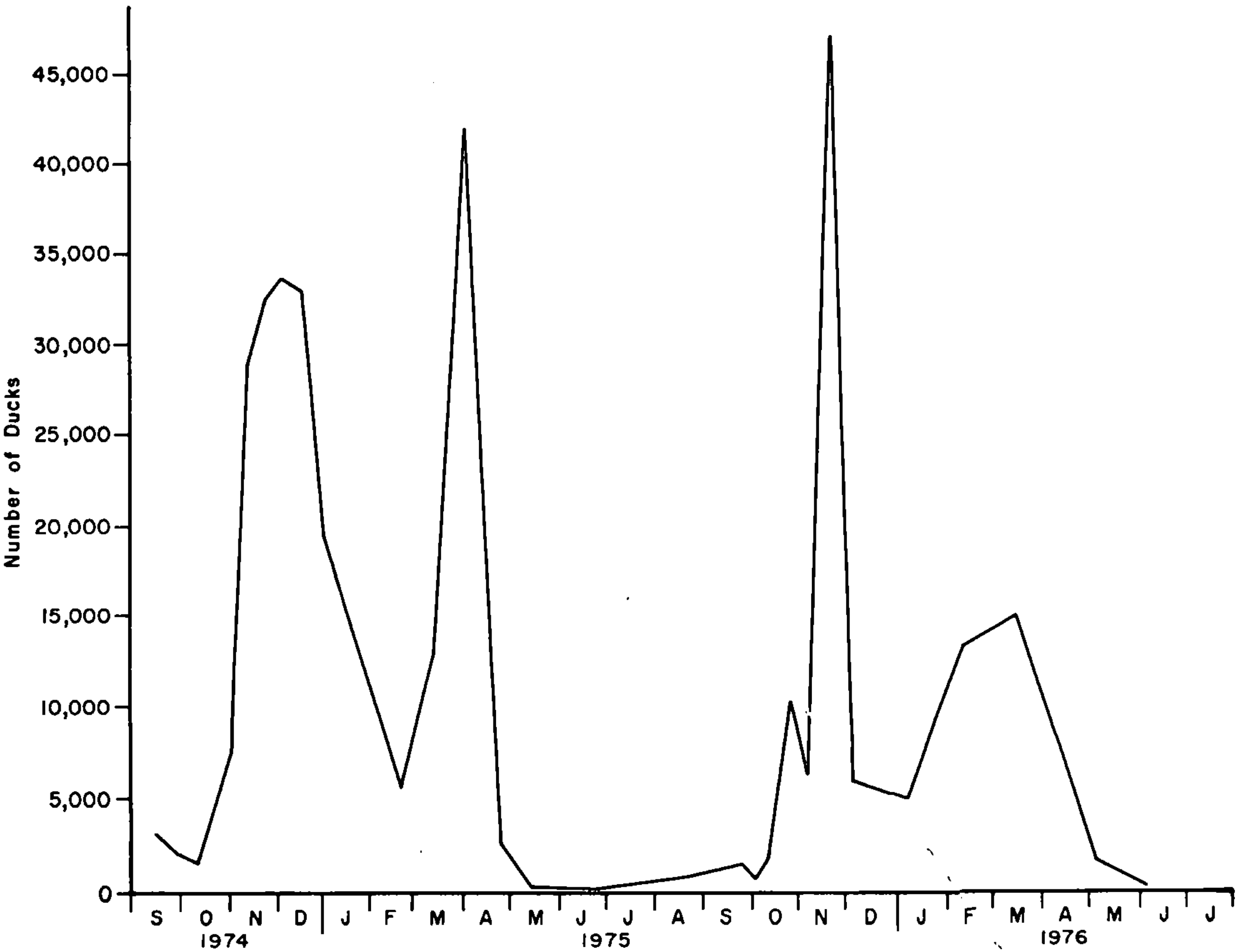

Figure 17. Dabbling Duck censuses conducted along the lower Yellowstone River between Billings and Fairview, Montana, from September 1, 1974, to August 1, 1976.

TABLE 14. Dabbling Duck utilization of selected field types over all study sections during four periods in 1975 and 1976.

Field Type	Spring Migration and Breeding Period[a]	Harvesting Period[bc]	Post-Harvest to Late Fall Period[cd]	Winter Period[e]	Overall Annual Utilization
Barley Stubble	63.4 (1,149)	70.7 (362)	41.9 (865)	5.6 (1,225)	13.6 (3,601)
Wheat Stubble	-- --	29.3 (150)	-- --	0.1 (20)	0.6 (170)
Corn Cut for Silage	0.1 (2)	-- --	58.0 (1,197)	20.4 (4,500)	21.6 (5,699)
Picked Corn	36.3 (658)	-- --	-- --	71.5 (15,740)	62.1 (16,398)
Pastures and Feedlots	0.2 (4)	-- --	-- --	2.4 (521)	2.0 (525)

NOTE: All entries are expressed first as a percentage of total observations per period, then (in parentheses) as the total number of observations in each field type per period.

[a]March 1 through May 31

[b]July 15 through corn harvest (date depending on the year)

[c]Because crop-harvesting and field-feeding patterns differ in duration from duck migration and life-history periods, the periods used in this table do not correspond exactly with those used in other phases of this duck study.

[d]Post-corn harvest through first cold weather and large influx of northern migrants

[e]Northern migrant arrival through winter

Cornfields cut for silage were utilized in fall and winter, but fewer ducks were observed in these fields than in picked cornfields. Feeding ducks were also observed in wheat stubble fields, pastures, and feedlots but less commonly than in the other crop types.

Movement

Fall duck concentrations occurred in sections of the river where picked cornfields were available for field-feeding ducks. Secure loafing areas in proximity to water and picked cornfields attracted the largest numbers of dabbling ducks (figure 18). Ducks readily utilized fields for feeding which geese avoided due to poor visibility afforded to birds in the field. Picked cornfields, for example, were avoided by geese except during spring and winter when the hunting season was closed and many of the fields had been used to pasture cattle. Ducks also typically spent less time feeding in fields than did geese, suggesting the need for fields providing a large amount of readily available grain. Ducks commonly loafed on river banks and island edges which afforded less visibility than typical goose loafing areas, indicating that geese require more security and are warier than ducks. Ducks would loaf in sections of the river which passed through towns, near farm houses, and under bridges. All of these factors resulted in a more uniform distribution of ducks than of geese within a given section of river.

Overwintering flocks of ducks between Forsyth and Custer loafed on the ice formed along banks and island margins. In other sections of the river which largely froze over in winter, loafing areas were restricted to pockets where the current was strong enough to keep the water open. Ducks also loafed on open drainage ditches in the valley. Cold weather reduced the number of ducks wintering in the study area (figure 17), but, as long as open water was available and snow in fields was not too deep to hamper feeding efforts, ducks would remain in a given area. Picked cornfields with cobs still handing on stalks provided food for ducks at this time. Ninety-two percent of the observations of ducks field-feeding in winter occurred in cornfields (table 14).

Banding locations of mallards taken by hunters in counties along the lower Yellowstone are within the limits of mallard migration corridors in the High Plains Unit of the Central Flyway outlined by Bellrose (1968) and shown in figure 19. He described a heavily utilized corridor crossing the Yellowstone River between Billings and Miles City, the existence of which may account for the occurrence between Billings and Miles City of 80 percent of all dabbling ducks observed during aerial censuses.

Nesting and Brood Rearing

Although no systematic searches of duck nesting cover were conducted, one blue-winged and one green-winged teal and two mallard nests were encountered during goose-banding operations. Both mallard nests were concealed in rose (*Rosa sp.*) bushes in the interior of large, wooded islands in the Sanders-to-Forsyth section of the river. The teal nests were found in the Myers-to-Hysham section, the green-winged teal nest in dense vegetation under a log near the edge of a large island and the blue-winged teal nest

Figure 18. Three components of fall dabbling duck habitat: a picked cornfield, island loafing area, and water.

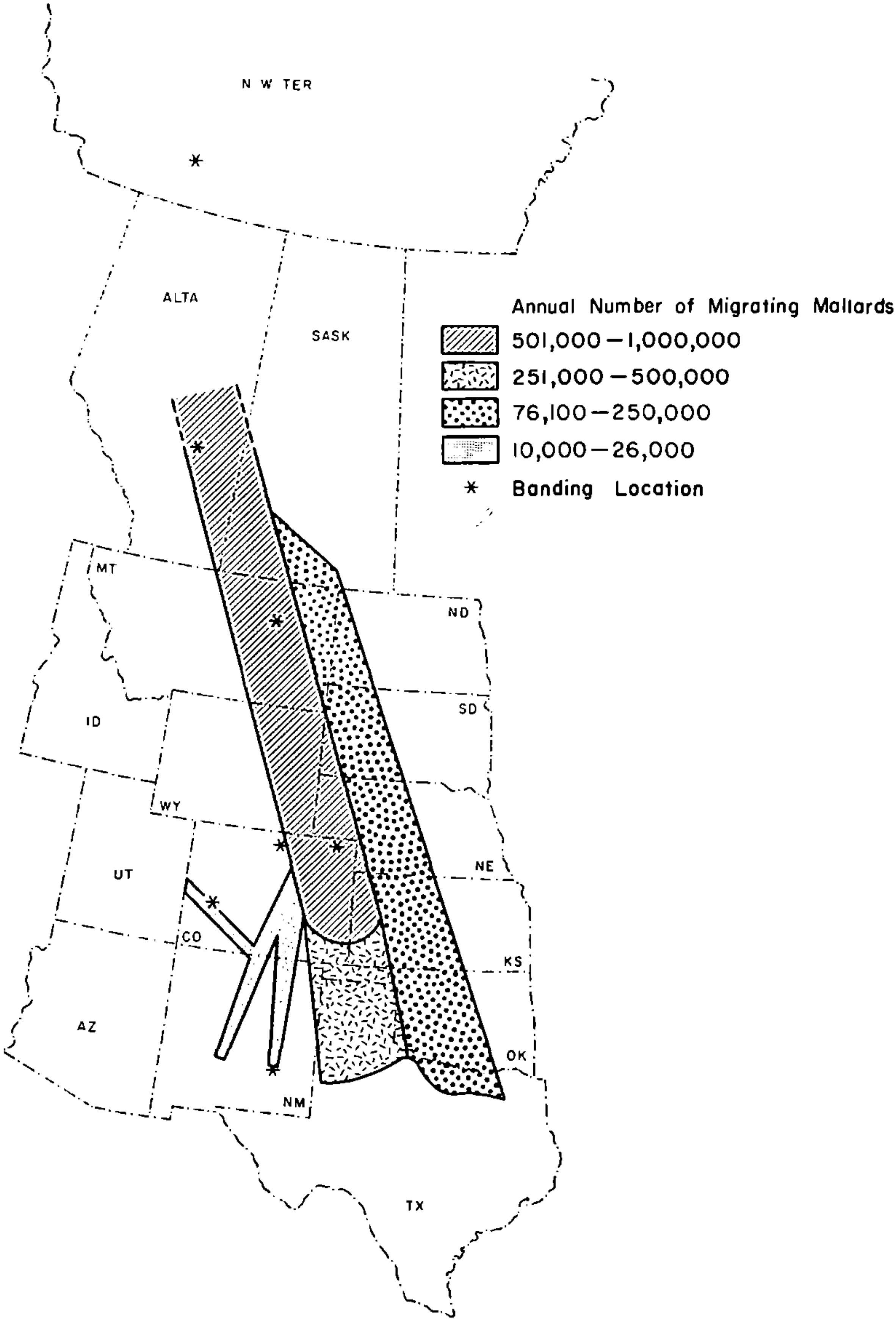

Figure 19. Mallard migration corridors in relation to banding locations of mallards harvested in the lower Yellowstone River Basin in 1973 through 1975.

on the main bank in sagebrush cover near the mouth of a creek. Territorial baldpate and gadwall drakes loafing on the river in these areas suggested that hens of these species were also nesting nearby.

Wood duck broods were observed in backwaters between Billings and Savage. All mallard broods observed occurred between Billings and Miles City. The paucity of observations of dabbler broods is believed related to the need of dabbling ducks to rear their young in lentic habitats where duckling foods are plentiful (Sugden 1973). These lentic water areas in the river valley consist of old oxbows, stockponds, marshes, roadside sloughs, and railroad ditches. The flowing water of the Yellowstone proper is probably marginal dabbling duck brood habitat.

Sex Ratios

Flocks of mallards present in the study area during late fall were composed of from 62.5 to 65.3 percent drakes (table 15). Bellrose et al. (1961) trapped black and mallard ducks in Illinois during the fall from 1939 to 1950 and found between 60 and 73 percent drakes in these samples. Sugden et al. (1974) found 70 to 73 percent drakes in flocks of mallards overwintering near Calgary, Alberta. Drewien (1968) reported 75 percent drakes in a sample of mallards trapped in northwestern South Dakota in the winters of 1950-51 and 1951-52. Bellrose et al. (1961) suggests the sex differential in mallard populations favoring drakes reflects differential migration of the sexes and higher mortality of hens during the breeding season.

TABLE 15. Proportion of drakes in mallard flocks along the lower Yellowstone River, 1974 and 1975.

Date	River Section	Number of Drakes	Number of Hens	Total Sample	Proportion of Drakes[a]
11/30/74	Miles City to Fallon	1,998	1,061	3,059	65.3
11/30/74 to 12/11/74	Rosebud to Miles City	1,064	624	1,688	63.0
11/30/74	Sanders to Rosebud	1,424	836	2,260	63.0
11/30/74	Myers to Sanders	2,137	1,165	3,302	64.7
11/25/75	Sanders to Forsyth	1,161	697	1,858	62.5

[a]Expressed as a percentage

COMMON MERGANSERS

Numbers of common mergansers (*Mergus merganser*) observed in the study area were highest from late fall through early spring (figure 20), which reflected the presence of wintering populations, most of them upstream from Miles City.

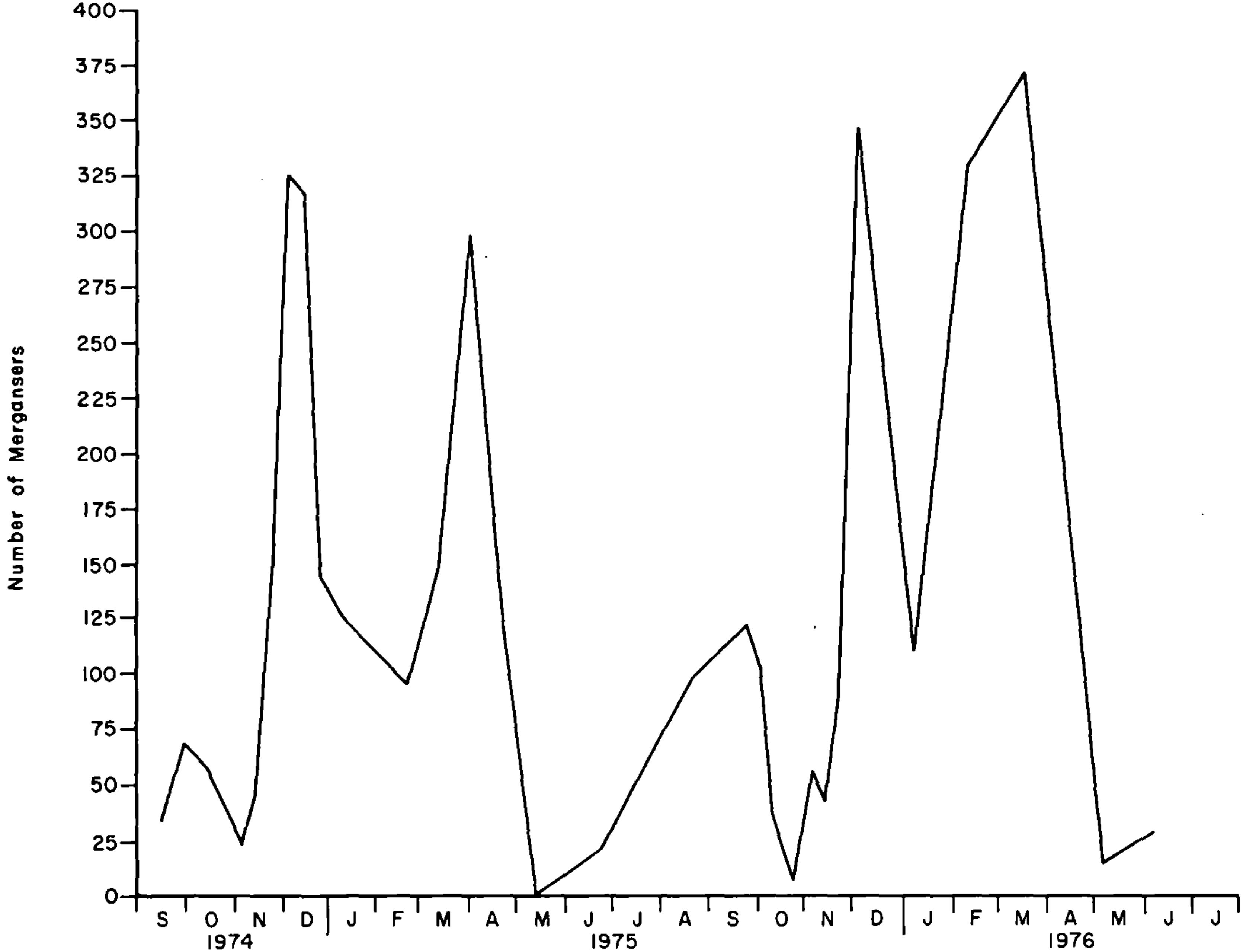

Figure 20. Common merganser censuses conducted along the lower Yellowstone between Billings and Fairview, Montana, from September 1, 1974, to August 1, 1976.

Peak numbers were observed during aerial censuses conducted in December 1974 and March 1976, when 85 and 92 percent, respectively, of the mergansers observed occurred between Billings and Miles City. The concentration of observations in this section may be the result of ice cover on the river downstream from Miles City and the tendency of mergansers to congregate in shallower waters (such as upstream from the mouth of the Bighorn River) where fishing may be more productive.

Goldeyes (*Hiodon alosoides*) and stonecats (*Noturus flavus*) were utilized by mergansers feeding on the lower Yellowstone River (appendix B). Stonecats typically inhabit riffle areas where goldeyes inhabit a variety of water types. The mergansers collected on December 9, 1975, were feeding in deep pools at the downstream ends of two islands. Pools of this type were commonly utilized for feeding areas by mergansers because goldeyes congregate in them during the colder periods of the year (Haddix 1976). Mergansers were also observed standing in and drifting through riffles, as was the drake collected on April 21, 1975 (appendix B), whose stomach contained remains of stonecats. The cooperative feeding behavior of red-breasted mergansers (*Mergus serrator*), described by Des Lauriers and Brattstrom (1965), was also exhibited by common mergansers on the lower Yellowstone. Groups of feeding mergansers would float downstream, feeding, then take flight, fly upstream, alight, and begin to drift with the current again and resume feeding.

Drake mergansers were occasionally encountered when incapable of gaining flight. Of three mergansers collected on December 9, 1975, all exhibited flightlessness and all had recently ingested large goldeyes (appendix B). It is believed that mergansers can become so engorged with fish that they are too heavy to lift off the water. No female mergansers exhibited flightlessness, however, other than those which had begun to molt. This difference is believed related to the ability of drake mergansers to swallow larger and heavier prey than can the females. Latta and Sharkey (1966) stated that the size of the merganser and girth of the food fish limited the size of the prey eaten. The larger male mergansers (Anderson and Timken 1972) were able to swallow larger fish. Latta and Shakey (1966) also stated that the most available and smaller fish were consumed first and that the upper size limit of fish that mergansers could eat ranged between 130 and 165 mm (5 and 6.5 inches) in girth. According to their conclusions, mergansers on the lower Yellowstone which fed in riffle areas were most likely to encounter and consume Cyprinids and stonecats, and those that fed in other water types, goldeyes.

Although no nests of common merganers were located in the study area, observations of merganser broods showed that mergansers do breed in the area. Nest sites utilized by mergansers in other studies included tree cavities, nest boxes, cliff ledges, and a variety of ground nest sites (Bellrose 1976). Most merganser broods observed during the study were feeding in deep water along riprapped and other steep banks. All broods observed, ranging in size from three to ten young, were between Pompey's Pillar and Hathaway. It is possible that small numbers of mergansers breed in other sections of the river.

COMMON GOLDENEYES

Common goldeneyes (*Bucephala clangula),* like common mergansers, were most numerous on the lower Yellowstone from late fall through early spring (figure 21). The higher peak numbers present in the winter of 1974-75 were the result of concentrations of goldeneyes between Pompey's Pillar and Forsyth. Those concentrations did not occur in the winter of 1975-76, possibly because warmer weather that season induced goldeneyes to winter further north. Goldeneyes were not observed during aerial censuses conducted from late spring through fall each year (figure 21) and are not believed to breed in the area.

Goldeneyes were sometimes observed loafing and feeding with common mergansers. Flocks of goldeneyes were observed flying upstream, drifting with the current, diving to feed, and returning upstream to resume feeding, as were flocks of mergansers. Goldeneyes commonly fed in the deep water of the main channel and along ice shelves at the water's edge in winter. The two goldeneyes collected for food habits analyses had eaten aquatic plants and invertebrates (appendix B).

BALD EAGLES

Bald eagles *Haliaeetus leucocephalus)* were present in the study area from September through April in 1975 and 1976 (figure 22). One pair attended a nest on the river near Sanders during June of 1975 and 1976, but close aerial observation of that nest in mid-June 1976 revealed no eggs or young present. This pair was the only bald eagles observed in the study area during the time of year that bald eagles normally raise young. Peak numbers of eagles were present during migration periods, late fall and early spring.

Twenty-nine percent of the bald eagles observed during aerial censuses throughout the study were classified as juvenile birds. Sprunt and Ligas (1963) reported 26.5, 23.7, and 21.6 percent juveniles in the continental bald eagles population in 1961, 1962, and 1963, respectively. Along the lower Yellowstone, the highest percentages of juvenile eagles in the population occurred in late December 1974, mid-to-late March 1975, and mid-March 1976 (excluding those censuses conducted when the number of eagles present was very small). The lowest percentages of juvenile eagles occurred in early December 1974, January and February 1975, and during the winter months of 1976. Thus, juvenile bald eagles appeared to comprise a high percentage of the migrant population and a low percentage of the overwintering population.

Bald eagles were observed throughout the study area, but 76 percent of those observed during aerial censuses occurred between Billings and Miles City. Concentration of eagles in the western half of the study area may be related to the river's being frozen downstream from Miles City during much of the period when bald eagles were present in the valley. Those stretches which were devoid of open water and flocks of ducks seemed to be avoided by eagles. During colder periods, when ice cover in the upstream sections was extensive, those reaches where open water was common and duck flocks present seemed to attract most of the eagles observed. These factors are believed more influential in determining bald eagle distribution along the river than any morphological

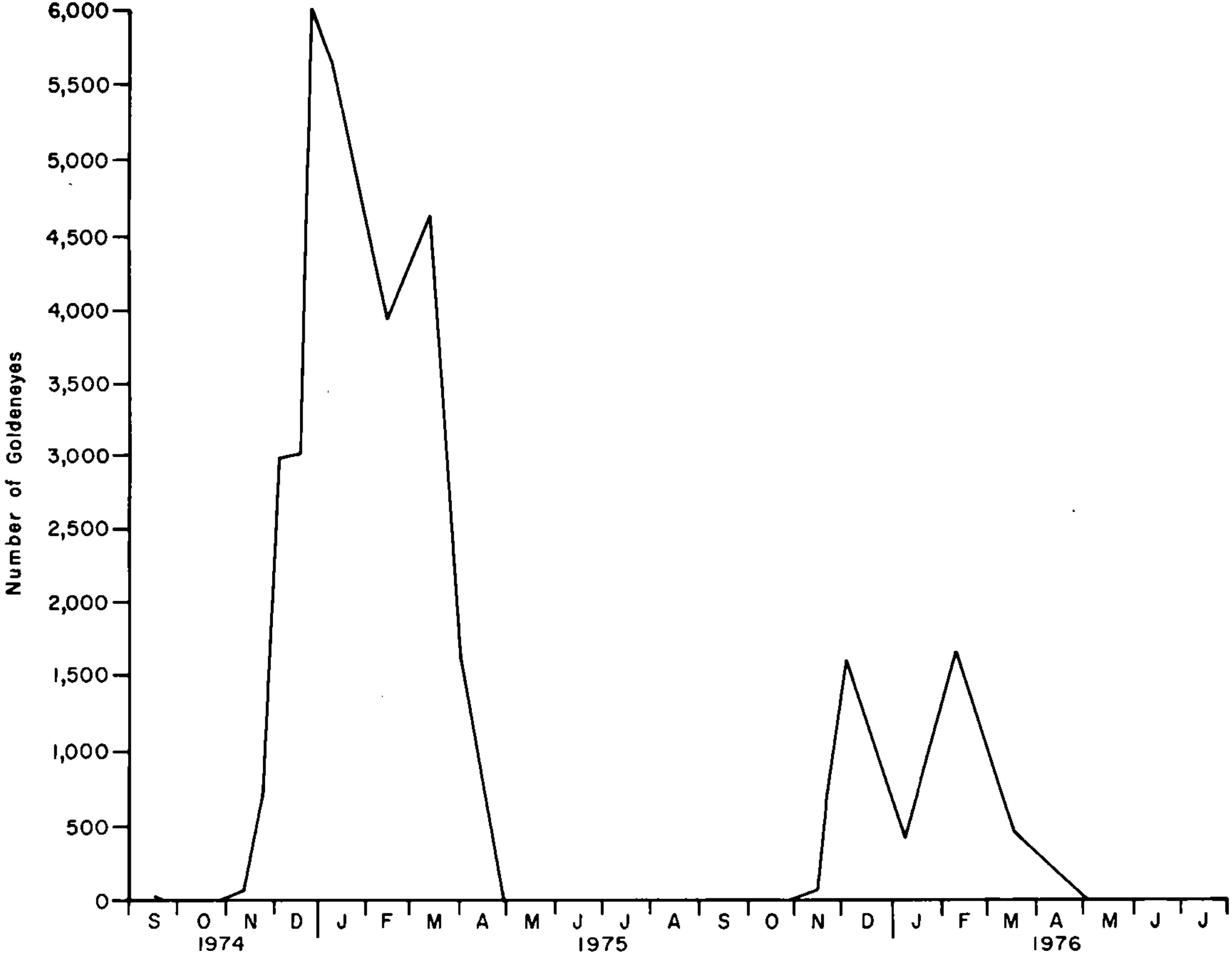

Figure 21. Common goldeneye censuses conducted along the lower Yellowstone River between Billings and Fairview, Montana, from September 1, 1974, to August 1, 1976.

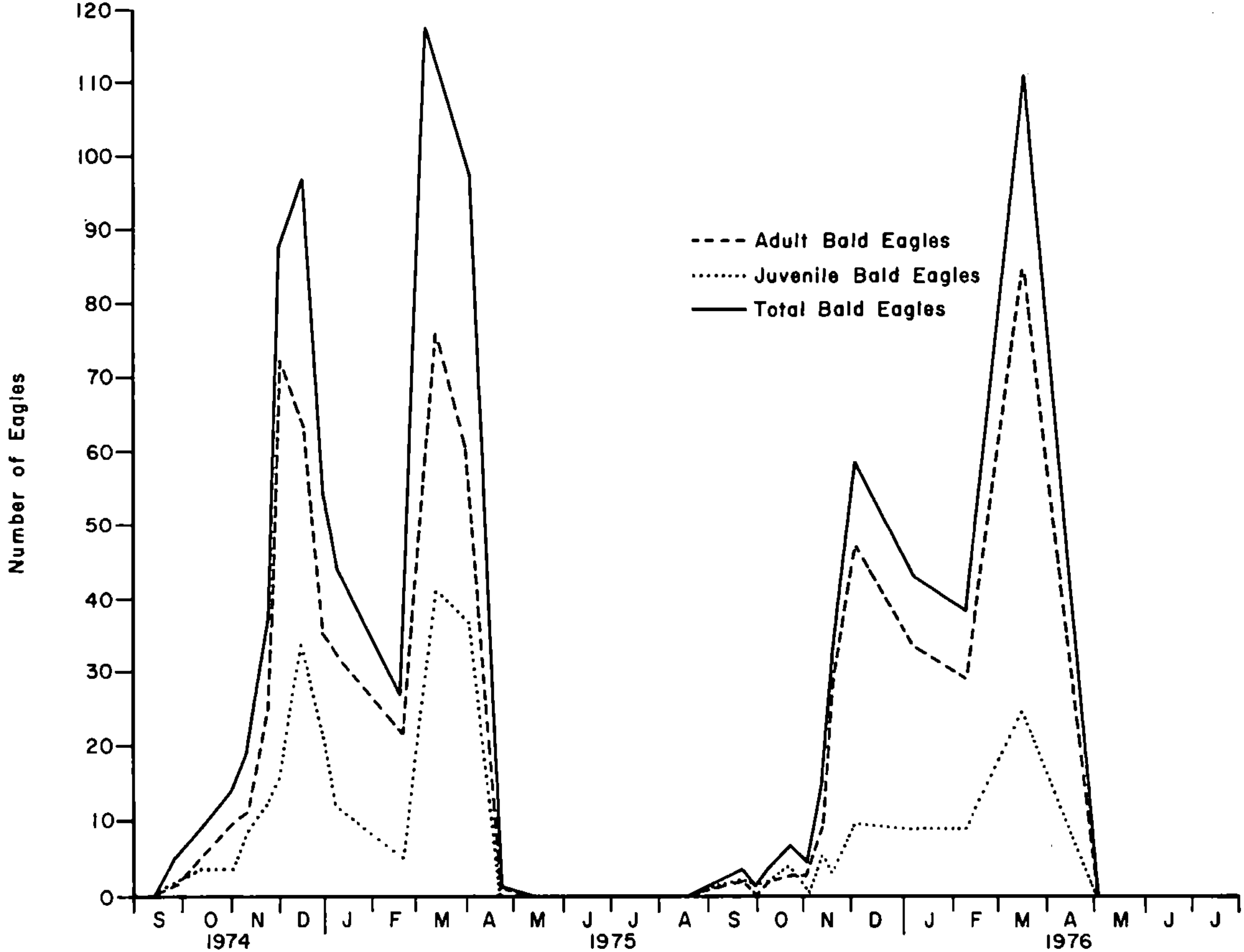

Figure 22. Bald eagle censuses conducted along the lower Yellowstone River between Billings and Fairview, Montana, from September 1, 1974, to August 1, 1976.

aspect of the river. Statistical correlation of the number of eagles observed during aerial censuses versus total number of islands, sinuosity, gravel bar area, areas of agricultural land, area of cottonwood-grassland, and area of dense cottonwoods showed no significance.

During the study period, two juvenile bald eagles which had been wing-tagged by Jon Gerrard (1976) in Saskatchewan were observed in the study area. One apparently wintered for a few weeks along the river near Rosebud (LaBree 1976) and the second was observed on one occasion near Kinsey in late March 1976 (Coleman 1976). Gerrard believed the second eagle may have been marked as a nestling at Besnard Lake in north central Saskatchewan in the summer of 1974. These observations, as well as six other similar reports from other locations in eastern Montana, show that some of the bald eagles which frequent the study area are migrants from breeding grounds 1,100 km (670 mi) north.

On a few occasions, bald eagles were observed attempting to capture ducks loafing on the river. One eagle was observed attacking a flock of feeding common mergansers, one of which regurgitated a goldeye when threatened. The eagle quickly scooped up the fish and flew with it to a streamside cottonwood perch. Although no eagles were observed actually capturing waterfowl, they reportedly do capture molting (Swenson 1975) and crippled waterfowl, including Canada geese (Wentland 1974), when available.

Patterns of roost and feeding perch attendance observed along the lower Yellowstone appeared to be similar to those described by Shea (1973). Bald eagles were observed hunting and roosting along the river at all hours of the day, although some were observed hunting away from the river, usually at midday. The streamside cottonwoods served as night roosts as well as feeding perches. Bald eagles were observed hunting in sagebrush-grassland areas north of the river on several occasions. They also frequented lambing grounds, feed-lots, pastures, and other areas where dead livestock were available. One lambing ground near Kinsey was frequented by golden eagles *(Aquila chrysaetos)* which were reported by local observers to have killed some newborn lambs. Bald eagles were also attracted to the grounds and to sites where the lamb carcasses were discarded. Carrion appeared to be the principal food source of the bald eagles on the lower Yellowstone, judging by aerial and ground observations of feeding eagles. During aerial censuses, 14 instances of eagle utilization of large mammal carcasses were observed, as well as one of fish, one of skunk, and three of other unknown small animal carcasses. Use of carrion by wintering bald eagles was also reported by Hancock (1964) in his studies in the Southern Gulf Islands of British Columbia.

GREAT BLUE HERONS

Great blue herons *(Ardea herodias)* were present in the study area from March to October (figure 23), and single birds were occasionally observed as late as December. Aerial censuses revealed the highest numbers of herons during spring migration and after adults and young had left the rookeries to feed along the river. Eighty-nine percent of the great blue heron observations recorded during aerial censuses occurred in sections of the river where rookeries were present (67 percent of the length of the river included in the study).

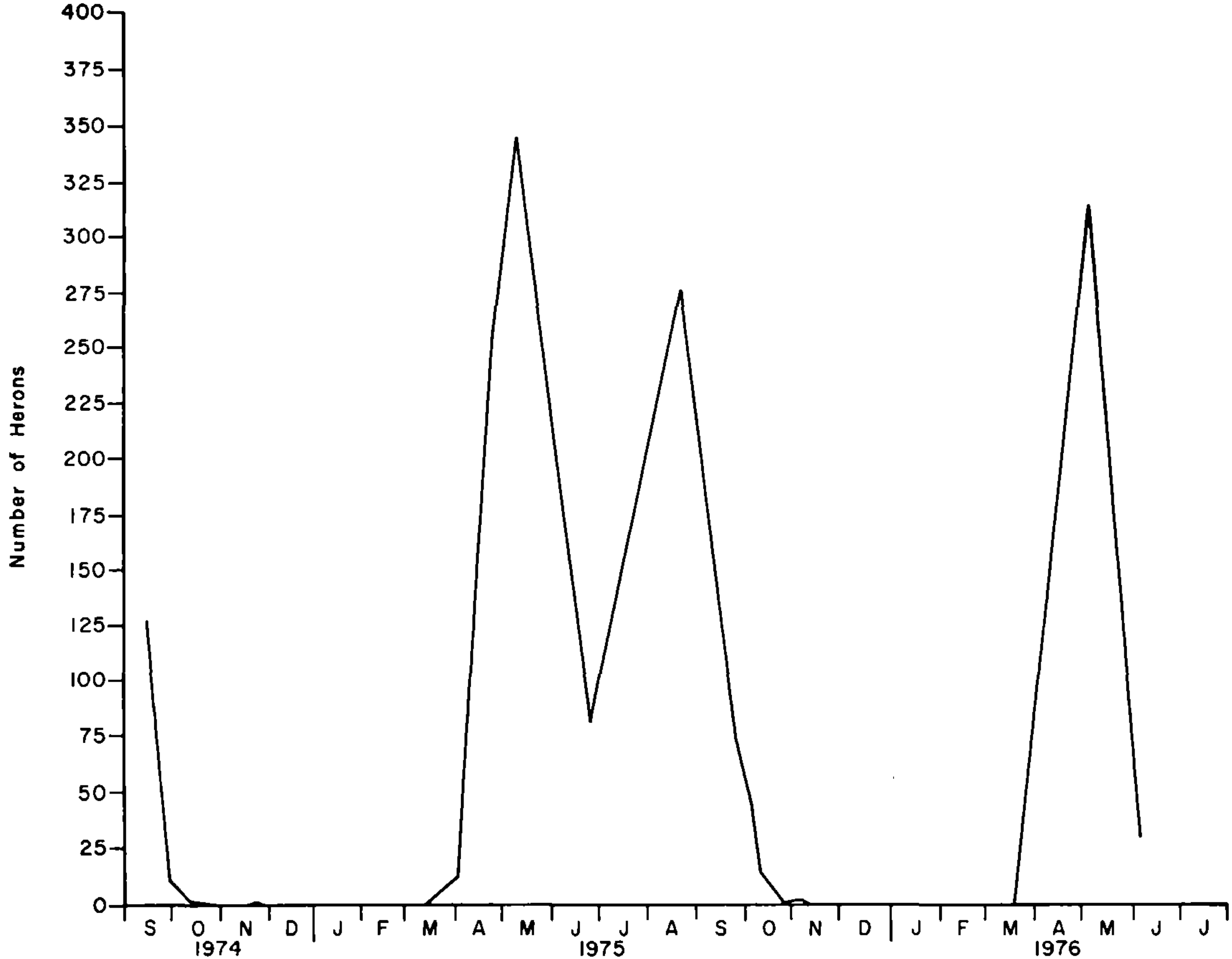

Figure 23. Great blue heron censuses conducted along the lower Yellowstone River between Billings and Fairview, Montana, from September 1, 1974, to August 1, 1976.

Heron rookery locations and numbers of pairs observed in these rookeries during aerial censuses are shown in table 16. Rookeries were located in mature cottonwood stands in the interior of islands and along edges of stands which occurred on the main banks. The total breeding populations in these rookeries were approximately 222 pairs in 1975 and 176 pairs in 1976. Two new rookeries were discovered in 1976, but three rookeries attended in 1976 were abandoned in 1976. Part of a rookery near the mouth of Armells Creek was destroyed in May of 1976 when high flows eroded the bank where it stood.

TABLE 16. Aerial censuses of great blue heron rookeries on the lower Yellowstone River in 1975 and 1976.

Location	County	1975		1976	
		Date	Number of Active Nests	Date	Number of Active Nests
SW1/4, S 8, T1N, R27E	Yellowstone	4/23	12	5/3	10
SW1/4, S13, T2N, R27E	Yellowstone	5/13	40	5/3	35
SW1/4, S 8, T3N, R31E	Yellowstone	5/13	50	5/3	5
SW1/4, S22, T5N, R34E	Treasure	5/13	50	5/3	20
NW1/4, S12, T5N, R35E	Treasure	--	--	5/3[a]	11
NE1/4, S34, T7N, R36E	Treasure	5/13	11	5/3	15
NE1/4, S14, T6N, R43E	Rosebud	4/23	10	5/3	0
SW1/4, S 8, T6N, R42E	Rosebud	5/13	5	5/3	10
SE1/4, S18, T6N, R40E	Rosebud	6/24	6	5/3[b]	10
NW1/4, S21, T7N, R46E	Custer	5/13[c]	6	3/17	0
SW1/4, S27, T7N, R45E	Custer	6/24	20	5/3	25
NE1/4, S19, T9N, R48E	Custer	6/25	4	5/4	10
NE1/4, S13, T13N, R53E	Dawson	5/14	8	5/3[d]	20
SW1/4, S10, T18N, R57E	Richland	--	-	5/4[a]	5

[a]Rookeries observed for the first time in 1976.

[b]Bank erosion destroyed most of this rookery between May 3 and May 25.

[c]On June 24 this rookery was unattended.

[d]On June 7 this rookery was unattended.

Dates of first herons in rookeries varied. The earliest rookery attended in 1975, based on observations recorded during aerial censuses, was near Pompey's Pillar and contained herons on April 1. The first date that eggs were observed in nests in 1975 was April 22, and the first young were observed on aerial censuses in late June. Based on an incubation period of 27 days (Vermeer 1969), an egg-laying interval of two days, and an average clutch size of five eggs, nests initiated in the third week in April would hatch in early June. Some incubating hens were observed in early June 1976, but the first nests had hatched by that time. Brooding at the nest occurs in June and early July. Young herons may leave the nest for the first time at 7.5 weeks of age (Vermeer 1969). Young from clutches initiated during the third week of April could leave the nests by mid- to late July.

Food items obtained from the stomachs of great blue herons are listed in appendix B. Those foods, though diverse, indicate that fish are an important food item of herons feeding on the river. Herons were observed feeding along banks and island margins in deep and shallow water, and those collected for food habits analyses were taken in both types of sites.

WHITE PELICANS

During the spring migration period, white pelicans (*Pelecanus erythrorhynchos*) were observed on the lower Yellowstone between Pompeys Pillar and Fairview. Their summer distribution was limited to areas downstream from Miles City, particularly from the mouth of the Powder River to Fairview. These summering pelicans are believed to represent nonbreeding birds from the Medicine Lake colony in northeastern Montana because most banded birds found dead during the study had been banded at Medicine Lake. John Martin (1975) estimated there are approximately 1,500 breeding pairs of pelicans in that colony. The migration routes of those birds and of those from the breeding colony at Lake Bowdoin National Wildlife Refuge in northcentral Montana may account for the higher number of pelicans observed in areas east of Miles City. Peak counts during the spring migration period showed between 300 and 450 pelicans present in the study area. During summer, numbers decreased to between 100 and 200 birds.

Pelicans collected or found dead on the river were examined to determine their food habits (appendix B). Stomachs of those birds revealed utilization only of Cyprinids. Pelicans feeding in shallow water along the river appeared to be taking fish primarily. Cooperative feeding by pelicans (Hall 1925) was observed along banks near Intake and Terry. As described by Hall, when fish were found in shallow water near shore, groups of pelicans aligned themselves in a semicircle, working toward shore, beating the water with their wings and feet. When they reached shallow water near shore, the participating pelicans scooped up the fish. Fish concentrations below the Intake diversion may attract pelicans to that area from spring through late summer. Cold weather in early fall induced pelicans to leave the river until the following spring.

Instances of pelican mortality on the river were observed on several occasions. One bird was found shot through the wing near the Terry bridge. Pelican flocks near Intake were also reportedly fired upon. According to Diem and Condon (1967), shooting is a major mortality factor of the Yellowstone Lake pelican colony. On the Yellowstone River, more pelicans appeared to die from causes other than shooting, including drowning. Feeding pelicans apparently caught their bills on roots and submerged tree limbs and eventually drowned. Others were found dead on bar and island loafing areas, the causes of their deaths unknown.

DOUBLE-CRESTED CORMORANTS

Double-crested cormorants (*Phalacrocorax auritus*), present in the study area from spring through midfall, were most common during spring migration and in late summer (figure 24). Although two cormorant breeding colonies are known in southeastern Montana, one on the Tongue River Reservoir (Knapp 1975) and one on a reservoir near the lower Powder River (Mincoff 1976), no colonies of breeding cormorants were observed on the Yellowstone River. One pair did establish a nesting territory in the heron rookery near the mouth of Armells Creek in 1976. However, when part of the rookery collapsed into the river as flows increased in May, the tree which contained the nest was lost.

The cormorants summering on the lower Yellowstone appeared to be non-breeding birds, some of which were lighter-colored juveniles. Flock sizes commonly ranged from one to ten birds, although one group of 30 was observed downstream from the refineries east of Billings. Cormorants commonly roosted on narrow tips of barren islands near the water's edge. They also roosted in cottonwood trees near the refineries east of Billings and below Intake diversion.

On two occasions, single cormorants incapable of flight were observed. This phenomenon was believed due to their ingesting a large enough quantity of fish to render them temporarily flightless, as occurred with drake common mergansers.

The low numbers of cormorants present during the high-water period in June of both years may have resulted from poor fishing success in the turbid flood waters. Absence of cormorants during the colder months of the year is believed due to their inability to withstand cold temperatures, a characteristic also exhibited by the other large piscivorous species observed on the river.

OTHER MIGRATORY BIRD STUDIES

OSPREYS

Ospreys (*Pandion haliaetus)* were observed in the lower Yellowstone Valley from mid-September to mid-October in 1974 through 1976, and in late April in 1975. Hackman and Henny (1971) reported that the highest rate of osprey passage over White Marsh in Maryland occurred during September in eight years of observation of fall osprey migrations. Sixty-five percent of the ospreys observed during the present study occurred along the Yellowstone in Rosebud and Custer counties. Osprey migrations through the study area occurred when turbidity and flow of the river were low, which probably aided ospreys in their fishing efforts.

LESSER SANDHILL CRANES

These cranes (*Grus canadensis canadensis)* were observed in the study area only during their fall migrations. Spring observations recorded in western North Dakota on two occasions indicate that cranes may follow a more direct, easterly migration route to their northern breeding grounds. In the fall, their migration appeared to span greater lengths of time and east-west distance through eastern Montana. Migrations which preceded extended periods of cold, snowy weather were the most extensive and represented passage of the largest segment of the observed population.

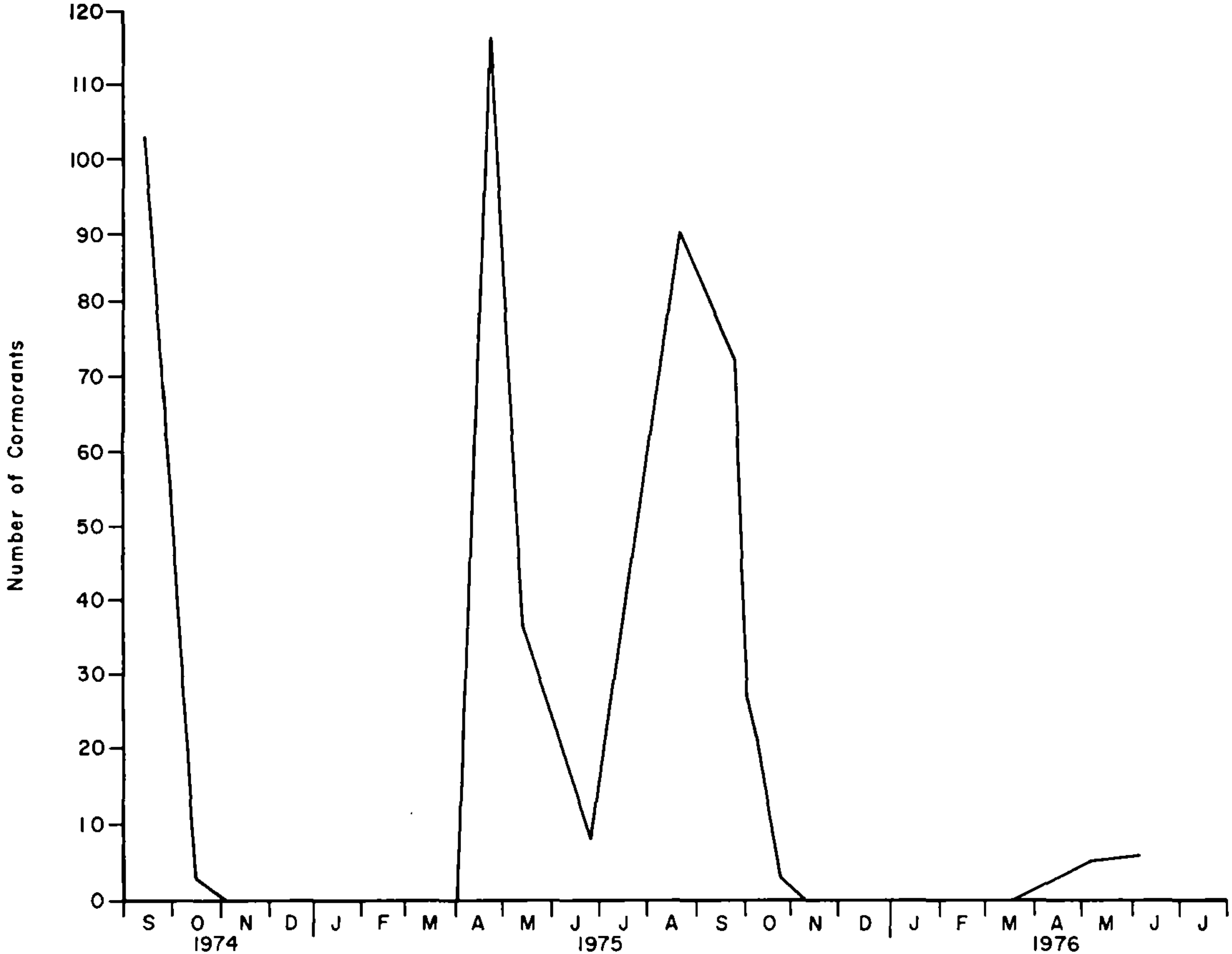

Figure 24. Double-crested cormorant censuses conducted along the lower Yellowstone River between Billings and Fairview, Montana, from September 1, 1974, to August 1, 1976.

Limited observations of cranes in winter wheat fields and reports from wheat ranchers indicate that use of this crop type by large flocks of migrating cranes is common. Smaller flocks were less commonly observed in corn and alfalfa fields near the river. Migrating cranes also stopped to roost at night on stockponds and along the river.

The most heavily-utilized crane migration corridor crosses the Yellowstone River between Hysham and Fallon. Within that corridor, most of the cranes observed during the study passed over the river between Rosebud and Kinsey. The largest number of cranes observed passing over the Yellowstone in both 1974 and 1975 were observed during the third week in October. In 1974, the earliest and latest observations of cranes passing through the study area were on October 5 and November 12, respectively, and in 1975, on September 30 and October 27, respectively.

OTHER SPECIES

All other species of large migratory birds observed during this study are listed in appendix F. Observations of these species indicated whether they nested in the study area, occurred only as fall and/or spring migrants, or if they summered or wintered in the area.

ISLAND AND VEGETATION ANALYSIS

The total area of selected vegetation types on islands, and the length of shoreline of these same types, within all sections of the study area are shown in tables 17 and 18, respectively. These vegetation types were quantified to delineate possible relationships between the numbers of the major migratory bird species present in a given section and the area and shoreline length of the types in those same sections. The absolute measurements were standardized by dividing them by the thalweg length in each section.

Land recently cleared for grazing on islands and along the main banks was uncommon in all sections. Agricultural acreage on river islands was nonexistent or small in all sections, although agricultural land did comprise some portion of the main shoreline in all sections. The cottonwood-grassland and dense cottonwood types occurred along the main shoreline in measurable areas in all sections except the Terry-to-Fallon section, where cottonwoods on the river bottom are scarce (figure 25). The cottonwood-grassland type did not occur in measurable areas on islands in the Zero-to-Powder River and Terry-to-Fallon sections because of the lack of large, forested islands in those sections (table 19). The dense cottonwood type did not occur in measurable acreages on islands from Kinsey to Fallon; the sparsity of riparian vegetation in this section is also shown in the scarcity of shrubs on shorelines and on islands. The sagebrush-grassland vegetation type was more prevalent on islands and along shorelines in the downstream portion of the study area.

Although no significant correlations were found between the numbers of Canada geese and bald eagles and the vegetative parameters measured in each section, some relationships were apparent which were not shown by these correlations. Aerial censuses of breeding geese indicated that little goose

TABLE 17. Area of vegetation types on all islands within each section of the lower Yellowstone River.

	CLEARED FOR GRAZING	AGRICULTURAL	COTTONWOOD-GRASSLAND	DENSE COTTONWOOD	SHRUBS	SAGEBRUSH-GRASSLAND	BARE GROUND
Billings to Huntley	-	-	374.90 (22.56)	580.82 (34.95)	199.80 (12.02)	-	448.58 (26.99)
Huntley to Worden	-	-	432.37 (23.87)	476.24 (26.30)	240.97 (13.31)	-	396.29 (21.88)
Worden to Pompeys Pillar	-	-	233.54 (17.42)	285.09 (21.26)	340.12 (25.36)	-	227.68 (16.98)
Pompeys Pillar to Custer	-	-	998.63 (22.79)	2,021.35 (46.13)	1,393.13 (31.79)	-	1,085.31 (24.77)
Custer to Bighorn	-	-	213.72 (27.51)	555.52 (71.50)	331.74 (42.69)	-	285.31 (36.72)
Bighorn to Hysham	-	-	997.75 (31.04)	1,753.71 (55.67)	1,066.41 (33.85)	-	686.11 (21.78)
Hysham to Sanders	-	-	712.84 (35.86)	634.52 (31.92)	258.81 (13.02)	-	399.59 (20.10)
Sanders to Forsyth	-	-	1,191.96 (29.10)	2,475.35 (60.43)	1,266.61 (30.92)	-	851.43 (20.79)
Forsyth to Rosebud	-	-	522.75 (26.85)	541.56 (27.82)	392.77 (20.17)	-	382.72 (19.66)
Rosebud to Hathaway	-	-	170.75 (5.44)	456.63 (14.55)	465.65 (14.84)	-	518.45 (16.52)
Hathaway to Miles City	-	-	138.06 (4.27)	279.84 (8.66)	682.48 (21.11)	398.48 (12.33)	647.09 (20.02)
Miles City to Kinsey	-	97.45 (3.26)	414.45 (13.86)	162.88 (5.45)	50.03 (1.67)	-	133.09 (4.45)
Kinsey to Zero	-	-	94.81 (3.95)	-	71.43 (2.98)	92.53 (3.86)	44.08 (1.84)
Zero to Powder River	-	-	-	-	11.14 (.46)	42.17 (1.76)	51.34 (2.14)
Powder River to Terry	-	-	59.02 (2.32)	-	80.74 (3.86)	103.23 (4.94)	42.45 (2.03)
Terry to Fallon	-	-	-	-	2.69 (.19)	41.16 (2.87)	-
Fallon to Glendive	-	-	1,292.03 (24.63)	996.37 (18.99)	2,015.90 (38.43)	502.07 (9.57)	503.29 (9.59)
Glendive to Intake	-	-	774.92 (23.92)	1,393.14 (43.00)	1,117.56 (34.49)	765.78 (23.64)	575.20 (17.75)
Intake to Savage	-	-	1,475.42 (47.79)	1,777.97 (57.60)	3,602.53 (116.70)	412.90 (13.38)	451.03 (14.61)
Savage to Sidney	-	1,051.85 (28.25)	863.20 (23.18)	3,940.54 (105.81)	2,958.07 (79.43)	-	121.10 (3.25)
Sidney to Fairview	11.68 (.51)	-	104.20 (4.53)	222.92 (9.69)	410.34 (17.83)	-	371.13 (16.13)

CONVERSIONS: 1 ha = 2.47 acres
1 ha/km = 3.97 acres/mi

NOTE: Entries are given first as the total area of each vegetation type within the study section indicated (in hectares), and second, in parentheses, as a standardized value (in hectares per kilometer) obtained by dividing the total areas by the thalweg length in each section.

TABLE 18. Length of shoreline per vegetation type in each section of the lower Yellowstone River.

	CLEARED FOR GRAZING	AGRICULTURAL	COTTONWOOD-GRASSLAND	DENSE COTTONWOOD	SHRUBS	BREAKS	SAGEBRUSH-GRASSLAND	GRAVEL AND BARE GROUND	INDUSTRIAL AND HOUSING
Billings to Huntley	.84 (.05)	3.11 (.21)	9.78 (.67)	5.89 (.40)	1.79 (.12)	8.27 (.56)	---	29.20 (1.99)	.90 (.06)
Huntley to Worden	-- --	3.75 (.20)	10.21 (.56)	11.95 (.66)	3.24 (.18)	11.88 (.66)	---	34.07 (1.88)	-- --
Worden to Pompeys Pillar	-- --	5.33 (.40)	6.58 (.49)	10.61 (.79)	4.62 (.34)	7.65 (.57)	---	33.50 (2.50)	.05 (tr)
Pompeys Pillar to Custer	1.88 (.04)	9.27 (.21)	13.65 (.31)	21.57 (.49)	29.00 (.66)	23.03 (.53)	.27 (.01)	91.35 (2.08)	-- --
Custer to Bighorn	-- --	2.67 (.34)	3.27 (.42)	5.76 (.74)	5.71 (.73)	1.79 (.22)	---	18.36 (2.36)	-- --
Bighorn to Hysham	3.25 (.10)	8.72 (.28)	6.24 (.20)	17.21 (.55)	15.71 (.50)	13.15 (.42)	---	60.38 (1.92)	.18 (.01)
Hysham to Sanders	-- --	3.60 (.18)	5.60 (.28)	21.15 (1.06)	6.63 (.33)	2.98 (.15)	---	28.10 (1.41)	-- --
Sanders to Forsyth	.21 (.01)	8.61 (.21)	15.27 (.37)	29.15 (.71)	21.24 (.58)	12.54 (.31)	---	74.21 (1.81)	2.40 (.06)
Forsyth to Rosebud	-- --	5.86 (.30)	6.20 (.32)	3.93 (.20)	13.95 (.72)	4.88 (.25)	---	33.73 (1.73)	.16 (.01)
Rosebud to Hathaway	.50 (.02)	9.64 (.31)	4.60 (.15)	7.45 (.24)	16.64 (.53)	3.30 (.11)	---	31.17 (.99)	.66 (.02)
Hathaway to Miles City	3.80 (.12)	8.16 (.25)	3.85 (.12)	5.07 (.16)	22.77 (.70)	4.62 (.14)	5.02 (.16)	53.72 (1.66)	.24 (.01)
Miles City to Kinsey	-- --	3.46 (.01)	13.55 (.45)	3.12 (.10)	4.30 (.14)	11.99 (.40)	7.23 (.24)	30.28 (1.02)	4.09 (.14)
Kinsey to Zero	-- --	4.83 (.20)	1.88 (.08)	-- --	4.63 (.19)	2.38 (.10)	5.49 (.23)	24.08 (1.00)	-- --
Zero to Powder River	-- --	.31 (.06)	.44 (.08)	-- --	.84 (.15)	-- --	6.73 (1.23)	6.42 (1.18)	.28 (.05)
Powder River to Terry	-- --	2.12 (.10)	1.74 (.08)	.05 (tr)	2.25 (.11)	4.75 (.23)	12.55 (.60)	25.70 (1.23)	-- --
Terry to Fallon	-- --	1.92 (.13)	-- --	-- --	1.87 (.13)	.60 (.04)	6.63 (.46)	16.36 (1.14)	-- --
Fallon to Glendive	-- --	8.88 (.17)	10.30 (.32)	4.30 (.03)	38.09 (.73)	3.22 (.06)	23.16 (.44)	86.00 (1.64)	.69 (.01)
Glendive to Intake	.05 (tr)	6.68 (.21)	8.48 (.26)	9.46 (.29)	22.95 (.71)	2.88 (.09)	6.47 (.20)	61.85 (1.91)	1.01 (.03)
Intake to Savage	-- --	3.62 (.12)	7.34 (.24)	20.33 (.66)	42.33 (1.37)	4.51 (.15)	6.60 (.21)	72.16 (2.34)	-- --
Savage to Sidney	.10 (tr)	12.96 (.35)	7.37 (.20)	28.90 (.78)	41.17 (1.11)	2.98 (.08)	3.44 (.09)	88.48 (2.38)	-- --
Sidney to Fairview	.45 (.02)	2.80 (.12)	4.60 (.20)	8.37 (.36)	14.65 (.64)	1.98 (.09)	1.00 (.04)	39.75 (1.73)	-- --

CONVERSIONS: 1 km = .622 mi
1 km/km = 1 mi/mi

NOTE: All entries consist of the length of shoreline per vegetation type (in km) and, in parentheses, those distances divided by the thalweg length (in km/km). Tr (trace) refers to values less than .01.

Figure 25. A comparison of vegetation and channel morphology for two sections of the Yellowstone River (the upper photo near Sanders, Montana, and the lower photo near Fallon, Montana.)

TABLE 19. Size classification, number, and frequency of islands within sections of the lower Yellowstone River.

	Island Size[a]											
	Less than 1.0 ha		1.0 to 6.0 ha		6.0 to 25.9 ha		25.9 to 50.9 ha		Greater than 51.0 ha		Total Number of Islands	Islands/ km of Thalweg
Sections	No.	%	No.	%	No.	%	No.	%	No.	%		
Billings to Huntley	4	(8.2)	26	(53.1)	13	(26.5)	3	(6.1)	3	(6.1)	49	2.95
Huntley to Worden	2	(4.2)	18	(37.4)	25	(52.1)	2	(4.2)	1	(2.1)	48	2.65
Worden to Pompeys Pillar	6	(14.3)	17	(40.5)	13	(31.0)	5	(11.9)	1	(2.4)	42	3.13
Pompeys Pillar to Custer	10	(8.2)	45	(36.9)	39	(32.0)	16	(13.1)	12	(9.8)	122	2.78
Custer to Bighorn	5	(18.5)	10	(37.0)	7	(25.9)	2	(7.4)	3	(11.1)	27	3.47
Bighorn to Hysham	8	(13.6)	19	(32.2)	20	(33.9)	3	(5.1)	9	(15.3)	59	1.87
Hysham to Sanders	1	(4.6)	7	(31.8)	4	(18.2)	3	(13.6)	7	(31.9)	22	1.11
Sanders to Forsyth	-	--	15	(29.5)	18	(35.3)	5	(9.8)	13	(25.4)	54	1.32
Forsyth to Rosebud	2	(8.7)	5	(21.7)	9	(39.1)	3	(13.0)	4	(17.5)	23	1.18
Rosebud to Hathaway	1	(2.6)	18	(47.4)	10	(26.3)	4	(10.5)	5	(13.2)	38	1.21
Hathaway to Miles City	2	(3.9)	21	(40.4)	19	(36.5)	6	(11.5)	4	(7.8)	53	1.64
Miles City to Kinsey	1	(7.7)	4	(30.8)	6	(46.2)	1	(7.7)	1	(7.7)	13	.43
Kinsey to Zero	1	(9.1)	5	(45.5)	4	(36.4)	1	(9.1)	-	--	11	.46
Zero to Powder River	-	--	-	--	3	(100.0)	-	--	-	--	3	.55
Powder River to Terry	-	--	2	(28.6)	4	(57.1)	1	(14.3)	-	--	7	.33
Terry to Fallon	-	--	1	(25.0)	1	(25.0)	-	--	2	(50.0)	2	.14
Fallon to Glendive	1	(1.3)	26	(34.2)	28	(36.8)	9	(11.8)	12	(15.8)	76	1.51
Glendive to Intake	3	(5.5)	22	(40.1)	15	(27.3)	7	(12.7)	8	(14.5)	57	1.76
Intake to Savage	1	(1.4)	31	(33.7)	27	(38.0)	3	(4.2)	9	(12.6)	71	2.30
Savage to Sidney	2	(3.2)	24	(38.7)	15	(24.2)	7	(11.3)	14	(22.6)	62	1.66
Sidney to Fairview	-	--	11	(45.9)	9	(37.5)	1	(4.2)	3	(12.5)	24	1.04

CONVERSIONS: 1 ha = 2.47 acres
1 island/km = 1.61 islands/mi

nesting occurred on the river between Terry and Fallon. The only two islands available for nesting in this section are readily accessible to predators during low-water periods (such as in the early part of the nesting season). The unbraided nature of this section contrasts with the more braided section between Sanders and Forsyth (figure 25). There does not appear to be a direct relationship between the number of islands in a given section of river and the size of the goose breeding population. Those sections with the most islands per length of thalweg (those above the mouth of the Bighorn River) did not have the highest densities of nesting geese. Upstream from the Bighorn, the size and vegetative characteristics of the islands, as well as that many are continuous with the banks during low water, apparently make them undesirable for nesting.

The length of shoreline bordered by agricultural land in a given section did not correlate well with duck numbers observed, probably because ducks concentrated in sections where picked cornfields were available for field-feeding. Because the agricultural vegetation type included all crop types and was not limited to cornfields, this relationship was not apparent.

During the period that eagles were present, concentrations occurred in areas having a readily-available food source. Because the location of these food sources was not directly related to the river bottom's physical parameters, eagle distribution was largely independent of vegetation types and island characteristics.

Impacts of water withdrawals

PROJECTIONS OF FUTURE USE

In order to adequately and uniformly assess the potential effects of water withdrawals on the many aspects of the present study, projections of specific levels of future withdrawals had to be made. The methodology by thich this was done is explained in Report No. 1 in this series, in which also the three projected levels of development, low, intermediate, and high, are explained in more detail. Summarized in appendix A, these three future levels of development were formulated for energy, irrigation, and municipal water use. Annual water depletions associated with the future levels of development were included in the projections. These projected depletions, and the types of development projected, provide a basis for determining the level of impact that would occur if these levels of development are carried through.

YELLOWSTONE RIVER

If flow reductions under the low, intermediate, or high level of development would be sufficient to alter the present dynamics of channel morphology through changes in sediment and bedload transport, those species which nest on islands in the river would probably be adversely affected. If the dominant discharge (that high flow recurring about every 1½ to 2 years which, through a combination of magnitude and frequency, accomplishes the most geomorphic work in a channel over time) were reduced to the point that the rates of island erosion and formation were altered (Koch 1976b), nesting goose and loafing waterfowl populations would be reduced through stabilization of bars and islands and the resultant encroachment of vegetation. Channel changes which cause loss of island separation from other land masses and the reduction in width and depth of channels would result in lower nesting success of Canada geese, ducks, and mergansers through increased accessibility of these areas to predators. Water withdrawals resulting in flows at Miles City below 255 to 283 m^3/sec (9,000 to 10,000 cfs) during the early part of goose nesting could result in poor goose reproduction. Based on flow data from Miles City in 1975 and 1976, 312m^3/sec (11,000 cfs) maintained during the early nesting period would be most conducive to successful goose nesting. Should alterations in the flow regime and channel morphology reduce ice scarification in any section of the river where it has been active most winters, plant succession on some ice-gouged sites could accelerate, lowering goose nesting success on those sites. Flow reductions sufficient to alter channel morphology could result in abandonment of some heron rookeries if the flow in the channels near the rookery were cut off as the main channel changed course.

Short-term reductions in flow could benefit pelican, cormorant, heron, merganser, and other piscivorous bird populations through concentrations of fish and stranding of fish in receding backwaters. Flow reduction for an extended period, however, would probably cause loss of fish habitat and a reduction in the number of fish in the river, thereby decreasing fishing success of these birds. The eventual effect would be a reduction in the populations of these species present on the river during migration and possibly during the breeding season.

If flow reductions during the summer result in stagnation of some backwaters, it is possible that these areas could serve as brood-rearing and feeding areas for ducks. Because the present scarcity of brood-rearing habitat is thought to limit duck nesting on the river, this could result in higher breeding duck populations along the river.

Water withdrawals during the nesting season from late March through May would probably reduce goose nesting success through increased nest predation. Merrill and Bizeau (1972) stated that maintained releases of 16,000 cfs from Palisades Dam on the Snake River prevented goose nest predation yet did not produce nest flooding. High run-off periods on the Snake before dam construction produced high nest losses due to flooding, such as now occur under similar conditions on the Yellowstone.

Water withdrawals which cause a decrease in available goldeneye food species (bottom-dwelling invertebrates and algae) or in food supply would cause a decrease in goldeneye populations.

Alterations in channel morphology which result in a reduction in the number of islands might lower the beaver *(Castor canadensis)* populations, which are highest in the braided sections of the Yellowstone (Martin 1976). In some areas, such as the Hysham-to-Bighorn section, geese frequently nest in dense willow stands which have been thinned by beaver. If beaver populations were to decline following flow alterations, the increased density of bushy cover on some islands could discourage goose nesting on sites previously utilized

Water withdrawals concentrated during the high sediment load period from May through July could alter silt deposition patterns and result in island stabilization in some areas. If open bars and small islands which are currently open and deviod of vegetation become stabilized, these sites would be less attractive to loafing waterfowl, resulting in a possible reduction in the numbers of migrant waterfowl which stop in the lower Yellowstone Valley. These open bars and islands also serve as territorial defense sites for breeding ducks and geese, and loss of them could decrease those breeding populations. Water withdrawals concentrated in late summer and early fall could further dewater the river at a time when flows historically have been low. The dewatered channel would provide extensive loafing areas for ducks and geese and secure fishing sites for herons. These areas would be more secure than those presently available due to the distance of the birds loafing along the water's edge from the edge of the riparian vegetation. For herons, the impact on the fish populations resulting from low flows in the fall and winter would nullify the benefit of improved fishing sites.

The increased acreage of agricultural land in the Yellowstone Valley would probably attract more migrant field-feeding ducks and geese in spring and fall. This would probably be more apparent in sections of the river which currently have little agricultural development near the river (e.g., near the mouth of the Powder River and between Terry and Fallon) and least apparent where extensive agriculture along the river is now present (e.g., near Huntley and Sidney). Attraction of field-feeding waterfowl to the Yellowstone Valley could be further enhanced by the development of circular sprinkler irrigation systems. Eagles could conceivably benefit from increased duck and goose concentrations, as well as from an increase in feedlots and livestock pastures on the river bottom, providing greater numbers of animal carcasses on which they could feed.

BIGHORN RIVER

Water withdrawals from the Bighorn could exaggerate the channel changes which have already occurred there since the closing of Yellowtail Dam in 1965. Changes which could occur include a further restriction of the flow into one main channel, stabilization of bars and islands, accelerated vegetational succession, and an increased rate of loss of islands.

The island loss and vegetational succession which has occurred since the Bighorn's regulation (Martin 1976) may have produced a demand for secure goose nesting sites. Further loss of island and progression of vegetational succession would probably reduce the goose breeding population further through loss of nest sites and competition for the few remaining sites. Loss of islands would also result in lower numbers of island-nesting ducks and mergansers.

Aspects of fish concentrations brought about by reduced water levels would probably resemble those in the Yellowstone River. Short-term reductions could benefit eagles, cormorants, mergansers, herons, and other piscivorous species but harm these same species if the fish habitat was reduced for too long.

Further agricultural development in the Bighorn Valley could increase feeding areas for migrant ducks and geese. Flocks arriving in the fall may be induced to winter along the Bighorn below Yellowtail due to the presence of open water and abundant food sources. Sudden winter storms followed by extreme cold could produce abnormally high mortality in those wintering populations. Large concentrations of those species could also suffer increased mortality through spread of diseases. Increased agricultural activity in the Bighorn Valley could provide for more feedlots and livestock pastures along the river, increasing the attraction of eagles to carrion in those areas.

Goldeneye populations on the Bighorn could be benefited by extensive areas of open water through the winter. However, any water withdrawals which decrease the populations of bottom-dwelling invertebrates or algae upon which goldeneyes feed could also decrease their population levels.

Summary

Studies of selected migratory birds were conducted along the Yellowstone River between Billings and Fairview, Montana, from September 1974 through November 1976. Canada geese were most intensively studied, although observations of ducks, bald eagles, and large fish-eating birds were also recorded.

MAJOR BIRD STUDIES

CANADA GEESE

Canada geese were found to be present in the study area year-around. In winter, geese were limited to areas of open water along the river, primarily between Bighorn and Hathaway. A variety of crop types were utilized by field-feeding geese in winter, although most were observed in corn and barley fields.

During the spring migration periods as many as 16,000 geese were present in the study area. Geese at this time loafed on open bars and islands on the river and fed in a variety of crop types, corn and barley again appearing to be the most heavily utilized.

The goose breeding population, estimated at between 400 and 450 pairs, initiated nests from mid- to late March, depending to some degree on the weather preceding nest initiation. Goose nests were usually constructed on islands on an open site, frequently near a driftwood log. Nest sites in the more downstream study sections typically were more densely vegetated than those in the more upstream study sections, apparently because ice covered the open portions of downstream islands and bars during the nest initiation period. Nesting densities ranged from 0.5 to 2.5 nests/hectare (0.2 to 1.0 nests/acre) on the most densely nested islands.

Clutch sizes averaged just over five eggs/clutch. Goose nesting success in 1975 and 1976 was 64 and 51 percent, respectively. Nest predation in some study sections in 1976 was as high as 57 percent, attributed to greater predator access to nesting islands in 1976 than in 1975 due to periods of low flow in early spring. To prevent this degree of nest predation, 312 m^3/sec (11,000 cfs) at Miles City may be needed during the spring.

Based on egg sizes, 20 to 25 percent of the breeding geese in the areas studied were giant Canada geese and the remainder Great Basin Canada geese or hybrids of the two races.

Goose brood-rearing areas were found to be diverse vegetatively. They were usually close to the nesting islands and immediately adjacent to the river.

The early fall resident population included resident breeders, their current year's young, returning nonbreeders, and possibly some intermixed

early fall migrants. Censuses of geese in the study area at this time showed between 1,500 and 3,500 birds. Most field-feeding geese were observed in winter wheat fields in the early part of this period and in barley and corn fields after these crops had been harvested. Loafing geese utilized open bars and islands as they had in late fall and early spring. Observations of neck-banded individuals in early fall indicated the tendency of geese to limit up- and downstream movements along the river, which later became apparent at other times of the year as well.

Goose censuses in the study area during the fall migration period occasionally totaled over 10,000. During this period geese fed most commonly in barley, wheat, corn, and hay fields. The largest concentrations of geese at this time occurred in the area between Bighorn and Kinsey, one of the more heavily-utilized migration corridors in this section.

No statistically significant correlations were found between the numbers of geese counted at a given time of year in a section of river and the morphology or vegetation of the river in that section. The characteristics measured from aerial photographs included the number of islands, sinuosity, area of gravel bars, and the area of agricultural land, cottonwood-grassland, and dense cottonwoods in each section of river.

DABBLING DUCKS

Numbers of dabbling ducks observed during aerial counts were highest during spring and fall migration periods (sometimes exceeding 45,000) and lowest during brood-rearing and late summer. Mallards were the most common dabbling ducks present in the study area. Field-feeding species utilized picked cornfields most heavily throughout the study period. Sections of the river with an abundance of secure loafing sites, water, and nearby picked cornfields attracted the largest numbers of dabbling ducks.

Nesting dabbling ducks were located on a few occasions but generally appeared to be uncommon along the mainstem Yellowstone. Dabbling duck breeding populations were thought to be limited by the paucity along the main channel of lentic water areas necessary for brood rearing.

Flocks of mallards present in the study area during late fall were composed of from 60 to 65 percent drakes.

Mallards overwintered in the study area, largely in the open water stretches used by overwintering Canada geese.

OTHER BIRDS

Common mergansers were present year-round in the study area but were most numerous during the winter. Most were observed between Billings and Miles City, possibly because of more productive fishing in that section. Merganser stomachs examined for food contents revealed utilization of stonecats and goldeneyes. Observations of merganser broods showed that they do nest on the river, although no nests were actually located.

Common goldeneyes, like common mergansers, were most numerous on the lower Yellowstone from late fall through early spring. Unlike the mergansers, however, there was no evidence obtained during the study that goldeneyes nest along the Yellowstone.

Bald eagles were present in the study area from September through April in 1975 and 1976. Peak numbers during the study exceeded 110 birds. Most of the eagles observed during censuses occurred between Billings and Miles City, partially attributable to concentrations of eagles during winter in these upstream areas where open water was available. One pair of bald eagles attended a nest site near Sanders both years of the study but was not known to have raised any young. Eagles commonly perched in streamside cottonwoods near flocks of ducks and dived at them, but most eagles observed feeding utilized deer and livestock carcasses.

Great blue herons were present in the study area from March through October in 1975 and 1976. Most herons occurred near rookeries, 14 of which were located in the study area in the tops of mature cottonwoods, usually on large islands but occasionally on the main banks. The breeding population of herons in these rookeries was estimated to be 222 pairs in 1975 and 176 pairs in 1976. Herons began nesting in April, and the first young hatched in early June. Fledglings began to leave the rookeries in mid- to late July.

White pelicans, double-crested cormorants, ospreys, and sandhill cranes were also observed and data collected.

IMPACTS OF WATER WITHDRAWALS

Generally, if the reduced flows are insufficient to alter the existing channel morphology, the impact on resident dabbling duck and goose populations would probably be small. Migrant populations of field-feeding ducks and geese would probably benefit from the increase in feeding areas resulting from increased irrigated acreages. Flows low enough to be detrimental to existing fish and invertebrate populations would probably reduce the numbers of herons, cormorants, pelicans, mergansers, and goldeneyes which feed along the Yellowstone River.

The increase in agricultural acreages in the Bighorn Valley coincident with further irrigation development could attract more ducks and geese to that area. However, large concentrations of these species induced to overwinter on the Bighorn could suffer high mortality from disease or severe winter weather. Flow reductions on the Bighorn River which accelerate changes in the channel morphology which have occurred since the closing of Yellowtail Dam could be detrimental to duck and goose breeding populations. Fish concentrations resulting from flow reductions could temporarily benefit fish-eating birds as long as the reductions did not permanently reduce the fish populations.

Appendixes

Appendix A

PROJECTIONS OF FUTURE USE

FIGURES

TABLES

In order to adequately and uniformly assess the potential effects of water withdrawals on the many aspects of the present study, projections of specific levels of future withdrawals were necessary. The methodology by which these projections were done is explained in Report No. 1 in this series, in which also the three projected levels of development, low, intermediate, and high, are explained in more detail. Summarized below, these three future levels of development were formulated for energy, irrigation, and municipal water use for each of the nine subbasins identified in figure A-1.

ENERGY WATER USE

In 1975, over 22 million tons of coal (19 million metric tons) were mined in the state, up from 14 million (13 million metric) in 1974, 11 million (10 million metric) in 1973, and 1 million (.9 million metric) in 1969. By 1980, even if no new contracts are entered, Montana's annual coal production will exceed 40 million tons (36 million metric tons). Coal reserves, estimated at over 50 billion economically strippable tons (45 billion metric tons) (Montana Energy Advisory Council 1976), pose no serious constraint to the levels of development projected, which range from 186.7 (170.3 metric) to 462.8 (419.9 metric) million tons stripped in the basin annually by the year 2000.

Table A-1 shows the amount of coal mined, total conversion production, and associated consumption for six coal development activities expected to take place in the basin by the year 2000. Table A-2 shows water consumption by subbasin for those six activities. Only the Bighorn, Mid-Yellowstone, Tongue, Powder, and Lower Yellowstone subbasins would experience coal mining or associated development in these projections.

IRRIGATION WATER USE

Lands in the basin which are now either fully or partially irrigated total about 263,000 ha (650,000 acres) and consume annually about 1,850 hm^3 (1.5 mmaf) of water. Irrigated agriculture in the Yellowstone Basin has been increasing since 1971 (Montana DNRC 1975). Much of this expansion can be attributed to the introduction of sprinkler irrigation systems.

After evaluating Yellowstone-Basin land suitability for irrigation, considering soils, economic viability, and water availability (only the Yellowstone River and its four main tributaries, Clarks Fork, Bighorn, Tongue, and Powder, were considered as water sources), this study concluded that 95,900 ha (237,000 acres) in the basin are financially feasible for irrigation. These acres are identified by county and subbasin in table A-3; table A-4 presents projections of water depletion.

Three levels of development were projected. The lowest includes one-third, the intermediate, two-thirds, and the highest, all of the feasibly irrigable acreage.

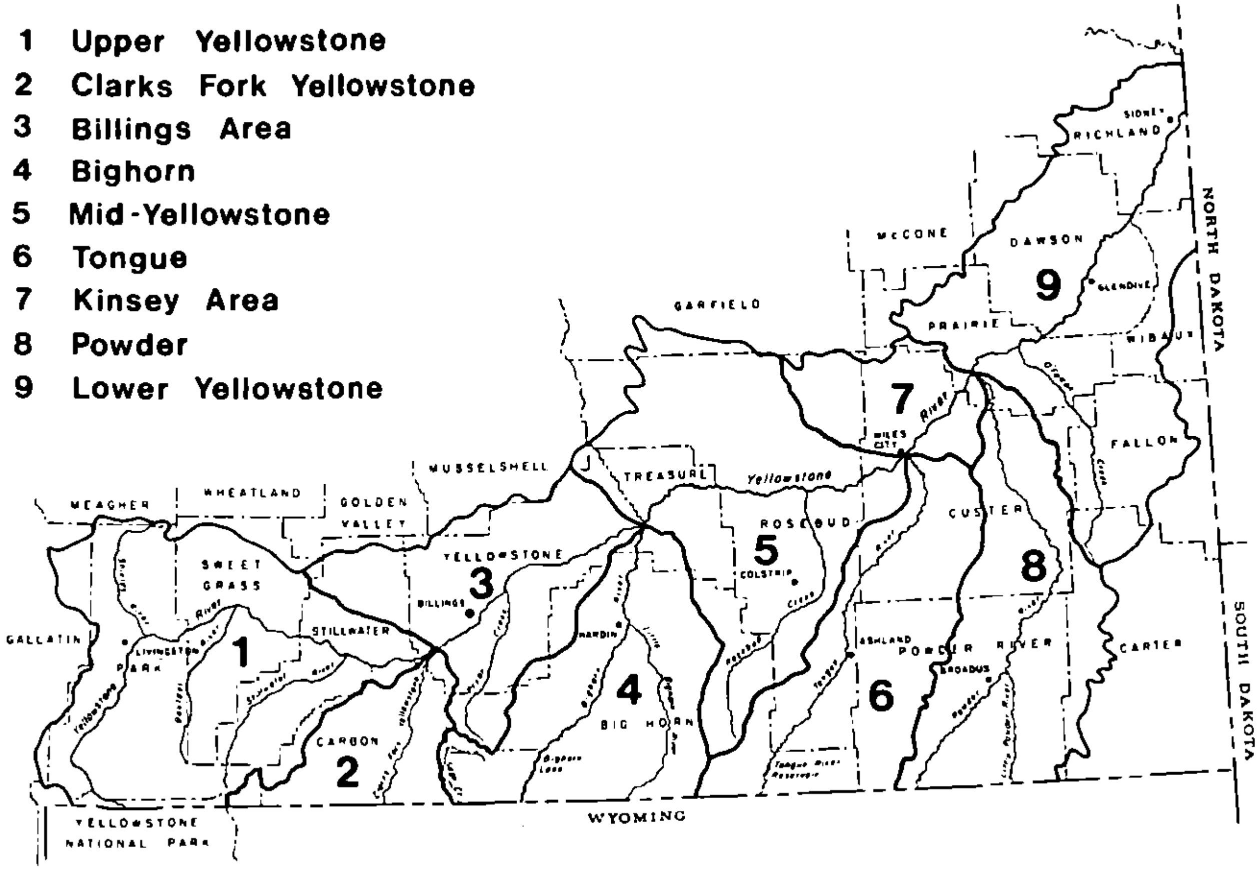

Figure A-1. The nine planning subbasins of the Yellowstone Basin.

TABLE A-1. Increased water requirements for coal development in the Yellowstone Basin in 2000.

Level of Development	Coal Development Activity						Total
	Electric Generation	Gasification	Syncrude	Fertilizer	Export	Strip Mining	
	COAL MINED (mmt/y)						
Low	8.0	7.6	0.0	0.0	171.1		186.7
Intermediate	24.0	7.6	0.0	0.0	293.2		324.8
High	32.0	22.8	36.0	3.5	368.5		462.8
	CONVERSION PRODUCTION						
Low	2000 mw	250 mmcfd	0 b/d	0 t/d			
Intermediate	6000 mw	250 mmcfd	0 b/d	0 t/d			
High	8000 mw	750 mmcfd	200,000 b/d	2300 t/d			
	WATER CONSUMPTION (af/y)						
Low	30,000	9,000	0	0	[a]	9,350	48,350
Intermediate	90,000	9,000	0	0	31,910	16,250	147,160
High	120,000	27,000	58,000	13,000	80,210	22,980	321,190

CONVERSIONS: 1 mmt/y (short) = .907 mmt/y (metric)
1 af/y = .00123 hm^3/y

[a]No water consumption is shown for export under the low level of development because, for that development level, it is assumed that all export is by rail, rather than by slurry pipeline.

TABLE A-2. The increase in water depletion for energy by the year 2000 by subbasin.

Subbasin	INCREASE IN DEPLETION (af/y) Elec. Generation	Gasifi-cation	Syn-crude	Ferti-lizer	Export	Strip Mining	Total
LOW LEVEL OF DEVELOPMENT							
Bighorn	0	0	0	0	0	860	860
Mid-Yellowstone	22,500	9,000	0	0	0	3,680	35,180
Tongue	7,500	0	0	0	0	3,950	11,450
Powder	0	0	0	0	0	860	860
Lower Yellowstone	0	0	0	0	0	0	0
Total	30,000	9,000				9,350	48,350
INTERMEDIATE LEVEL OF DEVELOPMENT							
Bighorn	0	0	0	0	4,420	1,470	5,890
Mid-Yellowstone	45,000	9,000	0	0	15,380	6,110	75,490
Tongue	30,000	0	0	0	9,900	7,000	46,900
Powder	15,000	0	0	0	2,210	1,670	18,880
Lower Yellowstone	0	0	0	0	0	0	0
Total	90,000	9,000			31,910	16,250	147,160
HIGH LEVEL OF DEVELOPMENT							
Bighorn	15,000	0	0	0	11,100	2,050	28,150
Mid-Yellowstone	45,000	18,000	29,000	0	38,700	8,710	139,410
Tongue	45,000	9,000	29,000	0	24,860	10,170	118,030
Powder	15,000	0	0	0	5,550	2,050	22,600
Lower Yellowstone	0	0	0	13,000	0	0	13,000
Total	120,000	27,000	58,000	13,000	80,210	22,980	321,190

CONVERSIONS: 1 af/y = .00123 hm^3/y

NOTE: The four subbasins not shown (Upper Yellowstone, Billings Area, Clarks Fork Yellowstone, Kinsey Area) are not expected to experience water depletion associated with coal development.

TABLE A-3. Feasibly irrigable acreage by county and subbasin by 2000, high level of development.

County	Upper Yellowstone	Clarks Fork	Billings Area	Big Horn	Mid Yellowstone	Tongue River	Kinsey Area	Powder River	Lower Yellowstone	County Totals
Park	21,664									21,664
Sweet Grass	10,204									10,204
Stillwater	6,208									6,208
Carbon		2,160								2,160
Yellow-stone			19,412							19,412
Big Horn				13,037		2,185				15,222
Treasure					9,591					9,591
Rosebud					11,408	9,727				21,135
Powder River								46,853		46,853
Custer					4,230	10,035	3,092	26,438		43,795
Prairie							1,644	1,914	8,231	11,789
Dawson									18,355	18,355
Richland									10,421	10,421
Wibaux									633	633
BASIN TOTALS	38,076	2,160	19,412	13,037	25,229	21,947	4,736	75,205	37,670	237,472

CONVERSIONS: 1 acre = .405 ha

NOTE: The number of irrigable acres for the low and intermediate development levels are one-third and two-thirds, respectively, of the numbers given here. This table should not be considered an exhaustive listing of all feasibly irrigable acreage in the Yellowstone Basin; it includes only the acreage identified as feasibly irrigable according to the geographic and economic constraints explained elsewhere in this report.

MUNICIPAL WATER USE

The basin's projected population increase and associated municipal water use depletion for each level of development are shown in table A-5. Even the 13 hm^3/y (10,620 af/y) depletion increase by 2000 shown for the highest development level is not significant compared to the projected depletion increases for irrigation or coal development. Nor is any problem anticipated in the availability of water to satisfy this increase in municipal use.

WATER AVAILABILITY FOR CONSUMPTIVE USE

The average annual yield of the Yellowstone River Basin at Sidney, Montana, at the 1970 level of development, is 10,850 hm^3 (8.8 million af). As shown in table A-6, the additional annual depletions required for the high projected level of development total about 999 hm^3 (812,000 acre-feet). Comparison of these two numbers might lead to the conclusion that there is ample water for such development, and more. That conclusion would be erroneous, however, because of the extreme variation of Yellowstone Basin streamflows from year to year, from month to month, and from place to place. At certain places and at certain times the water supply will be adequate in the foreseeable future. But in some of the tributaries and during low-flow times of many years, water availability problems, even under the low level of development, will be very real and sometimes very serious.

TABLE A-4. The increase in water depletion for irrigated agriculture by 2000 by subbasin.

Subbasin	Acreage Increase	Increase in Depletion (af/y)
	HIGH LEVEL OF DEVELOPMENT	
Upper Yellowstone	38,080	76,160
Clarks Fork	2,160	4,320
Billings Area	19,410	38,820
Bighorn	13,040	26,080
Mid-Yellowstone	25,230	50,460
Tongue	21,950	43,900
Kinsey Area	4,740	9,480
Powder	75,200	150,400
Lower Yellowstone	37,670	75,340
TOTAL	237,480	474,960
	INTERMEDIATE LEVEL OF DEVELOPMENT	
BASIN TOTAL	158,320	316,640
	LOW LEVEL OF DEVELOPMENT	
BASIN TOTAL	79,160	158,320

CONVERSIONS: 1 acre = .405 ha
1 af/y = .00123 hm^3/y

NOTE: The numbers of irrigated acres at the low and intermediate levels of development are not shown by subbasin; however, those numbers are one-third and two-thirds, respectively, of the acres shown for each subbasin at the high level of development.

TABLE A-5. The increase in water depletion for municipal use by 2000.

Level of Development	Population Increase	Increase in Depletion (af/y)
Low	56,858	5,880
Intermediate	62,940	6,960
High	94,150	10,620

CONVERSIONS: 1 af/y = .00123 hm^3/y

TABLE A-6. The increase in water depletion for consumptive use by 2000 by subbasin.

Subbasin	Increase in Depletion (af/y)			
	Irrigation	Energy	Municipal	Total
	LOW LEVEL OF DEVELOPMENT			
Upper Yellowstone	25,380	0	0	25,380
Clarks Fork	1,440	0	0	1,440
Billings Area	12,940	0	3,480	16,420
Bighorn	8,700	860	negligible	9,560
Mid-Yellowstone	16,820	35,180	1,680	53,680
Tongue	14,640	11,450	negligible	26,090
Kinsey Area	3,160	0	0	3,160
Powder	50,140	860	360	51,360
Lower Yellowstone	25,120	0	360	25,480
TOTAL	158,340	48,350	5,880	212,570
	INTERMEDIATE LEVEL OF DEVELOPMENT			
Upper Yellowstone	50,780	0	0	50,780
Clarks Fork	2,880	0	0	2,880
Billings Area	25,880	0	3,540	29,420
Bighorn	17,380	5,890	300	23,570
Mid-Yellowstone	33,640	75,490	1,860	110,990
Tongue	29,260	46,900	300	76,460
Kinsey Area	6,320	0	0	6,320
Powder	100,280	18,880	600	119,760
Lower Yellowstone	50,200	0	360	50,560
TOTAL	316,620	147,160	6,960	470,740
	HIGH LEVEL OF DEVELOPMENT			
Upper Yellowstone	76,160	0	0	76,160
Clarks Fork	4,320	0	0	4,320
Billings Area	38,820	0	3,900	42,720
Bighorn	26,080	28,150	480	54,710
Mid-Yellowstone	50,460	139,410	3,840	193,710
Tongue	43,900	118,030	780	162,710
Kinsey Area	9,480	0	0	9,480
Powder	150,400	22,600	1,140	174,140
Lower Yellowstone	75,340	13,000	480	88,820
TOTAL	474,960	321,190	10,620	806,770

CONVERSIONS: 1 af/y = .00123 hm^3/y

Appendix B

BIRDS EXAMINED FOR FOOD HABITS ANALYSIS

Species	Data Collected or Found Dead	River Location	Sex	Age	Weight (kg)	Stomach Contents
White pelican (*Pelecanus erythrorhynchos*)	5/13/75	Mouth of the Powder River	Unknown	Adult	24.80	--
	5/14/75	Intake	F	Adult?	27.01	--
	5/21/75	Savage	F	Adult	24.80	Nematodes, 1 fish hook, 5 longnose dace (*Rhinichthys cataractae*) 2 pharyngeal arches of flathead chubs (*Hybopsis gracilis*)
Common goldeneye (*Bucephala clangula*)	12/9/75	Cheyenne Island	M	Unknown	6.04	Algae, 200 Chironomidae larvae
	12/9/75	Horton Rookery	M	Unknown	5.91	Algae, diatoms, and arthropods
Common merganser (*Mergus merganser*)	4/21/75	Hathaway	M	Unknown	7.89	Pectoral spines from at least 3 stonecats (*Noturus flavus*)
	5/29/75	Forsyth	F	Juvenile	4.81	1 4-inch green sunfish (*Lepomis cyanellus*), 15 small fish ototliths, 1 Trichoptera larva, 1 swivel and fishline and 7 small Cyprinids.
	8/29/75	Paragon Bridge	F	Juvenile	4.94	2 stonecat spines and 1 Cyprinid pharyngeal arch
	12/9/75	Paragon Bridge	M	Unknown	8.91	2 11-inch goldeye (*Hiodon alosoides*)
	12/9/75	Cheyenne Island	M	Unknown	8.97	1 11-inch goldeye
	12/9/75	Cheyenne Island	M	Unknown	8.53	1 12-inch goldeye
	2/27/76	Paragon Bridge	M	Unknown	9.08	5 Nematodes and 1 fish scale
Great blue heron (*Ardea herodias*)	5/20/75	4 miles West of Miles City	F	Subadult	8.82	2 Flathead chubs and 12 longnose dace
	8/6/75	Rosebud	M	Juvenile	10.54	Plant material, grass seeds, 1 grasshopper (*Locustidae*) and Cyprinid vertebrae
	8/6/75	Rosebud	M	Juvenile	9.26	Plant material and seeds
	8/29/75	Horton Heron Rookery	F	Juvenile	13.29	1 River carpsucker (*Cyprinus carpio*), 1 stonecat, otoliths, scales, and grasshopper carapace

CONVERSIONS: 1 kg = 2.2 lb.

Appendix C

SELECTED PHYSICAL PARAMETERS MEASURED FROM
AERIAL PHOTOGRAPHS OF SECTIONS OF THE LOWER YELLOWSTONE RIVER
FROM BILLINGS TO FAIRVIEW, MONTANA

	THALWEG LENGTH (km)	DOWN VALLEY DISTANCE (km)	SINUOSITY	SHORELINE LENGTH (km)	GRAVEL BAR AREA (hectares)	GRAVEL BAR AREA / THALWEG (hectares/km)	WATER AREA (hectares)	WATER AREA / THALWEG (hectares/km)
Billings to Huntley	16.62	14.69	1.13	67.84	813.45	48.94	1,536.88	92.14
Huntley to Worden	18.11	15.89	1.14	75.09	938.35	51.81	1,738.90	109.43
Worden to Pompeys Pillar	13.41	12.63	1.06	67.41	897.13	66.90	1,498.40	111.74
Pompeys Pillar to Custer	43.82	36.33	1.21	189.88	2,691.25	61.42	4,503.27	102.77
Custer to Bighorn	7.77	6.45	1.20	37.55	228.18	29.37	424.28	54.60
Bighorn to Hysham	31.50	23.24	1.36	118.90	1,592.03	50.54	3,722.49	118.17
Hysham to Sanders	19.88	13.42	1.48	68.06	939.42	47.25	2,222.94	111.82
Sanders to Forsyth	40.96	32.95	1.24	162.82	2,547.34	62.19	9,903.00	241.77
Forsyth to Rosebud	19.47	15.21	1.28	68.75	1,824.14	93.64	2,329.61	119.65
Rosebud to Hathaway	31.38	21.86	1.44	79.89	1,194.78	38.07	3,056.20	97.39
Hathaway to Miles City	32.33	26.14	1.24	107.09	1,646.98	50.94	3,821.81	118.21
Miles City to Kinsey	29.90	26.65	1.12	77.57	1,194.14	39.94	4,055.39	135.63
Kinsey to Zero	24.00	19.36	1.24	51.03	712.53	29.69	2,543.27	105.97
Zero to Powder River	5.46	4.79	1.14	15.00	155.00	6.46	566.03	23.58
Powder River to Terry	20.91	14.53	1.44	49.17	888.53	42.49	2,334.55	111.67
Terry to Fallon	14.32	12.92	1.11	27.37	433.25	30.25	1,543.74	107.80
Fallon to Glendive	52.46	42.07	1.25	166.71	3,331.41	63.50	7,019.88	267.63
Glendive to Intake	32.40	23.91	1.35	119.85	2,268.78	70.02	4,559.24	140.72
Intake to Savage	30.87	26.30	1.17	158.26	2,508.41	81.28	3,131.04	101.43
Savage to Sidney	37.24	28.59	1.30	185.40	3,235.97	86.90	5,243.36	281.60
Sidney to Fairview	23.01	16.16	1.42	75.48	1,619.30	70.37	3,785.07	164.50
MEANS AND TOTALS	545.82	434.09	1.25	1,969.12	31,660.37	53.43	69,539.35	129.44

CONVERSIONS: 1 km = .621 mi
1 ha = 2.47 acres
1 ha/km = 3.97 acres/mi

Appendix D

DATES OF OBSERVATIONS OF CANADA GEESE
NECK-BANDED IN THE LOWER YELLOWSTONE VALLEY IN 1975
AND THE DISTANCES MOVED BETWEEN THOSE DATES

Neck Band No.	Age[a]	Sex	Dates Observed	Furthest Distance From Banding Location (km)	Longest Axis of Home Range (km)	Distance From Capture Point When Last Observed (km)
AR 01	Adult	F	6/30/75 - 7/16/75 - 11/13/75 - 3/3/76 - 3/8/76	8.53	8.53	2.25
AR 02	Adult	F	6/30/75 - 8/21/75 - 11/13/75 - 3/5/76 - 3/15/76	45.87	46.67	12.23
AR 03	Juv.	M	6/30/75 - 7/16/75[b]	17.22	17.22	17.22
AR 05	Juv.	F	6/30/75 - 7/7/75 - 8/21/75 - 10/16/75 - 11/13/75	45.06	46.67	.97
AR 08	Adult	M	7/1/75 - 11/18/75	.97	.97	.97
AR 14	Juv.	M	7/1/75 - 11/13/75	40.23	40.23	40.23
AR 15	Adult	M	7/1/75 - 8/21/75 - 11/13/75	61.16	61.16	40.23
AR 17	Juv.	M	7/1/75 - 8/21/75 - 11/13/75	61.16	61.16	40.23
AR 18	Juv.	M	7/1/75 - 11/13/75 - 3/5/76	48.28	48.28	48.28
AR 20	Juv.	M	7/1/75 - 10/8/75 - 10/20/75	.97	.97	.97
AR 21	Juv.	F	7/1/75 - 10/8/75 - 10/20/75 - 4/29/76	.97	1.61	.97
AR 22	Juv.	F	7/1/75 - 10/8/75 - 10/20/75	.97	.97	.97
AR 24	Juv.	M	7/1/75 - 10/8/75 - 11/6/75	11.43	11.91	11.43
AR 25	Juv.	F	7/1/75 - 10/20/75 - 4/29/76	9.50	9.50	9.50
AR 27	Juv.	F	7/1/75 - 10/20/75	3.70	3.70	3.70
AR 29	Adult	F	7/1/75 - 9/19/75 - 10/8/75	8.21	8.21	6.92
AR 30	Juv.	F	7/1/75 - 9/19/75 - 10/8/75	8.21	8.21	6.92
AR 37	Juv.	F	7/2/75 - 9/30/75 - 2/11/76	17.06	17.06	17.06
AR 40	Adult	F	7/3/75 - 8/26/75 - 10/30/75 - 3/8/76 - 4/21/76	6.28	6.28	4.18
AR 41	Juv.	F	7/3/75 - 9/30/75	2.74	2.74	2.74
AR 48	Juv.	F	7/3/75 - 7/18/75[b]	1.77	1.77	1.77
AR 50	Juv.	M	7/7/75 - 8/21/75 - 10/16/75 - 11/13/75	44.58	44.58	4.67
AR 51	Juv.	F	7/7/75 - 8/21/75 - 10/10/75 - 10/16/75 - 11/13/75	44.58	44.58	4.67
AR 53	Juv.	M	6/5/75 - 6/11/75 - 7/7/75[b]	18.19	20.44	18.19
AR 54	Juv.	M	7/7/75 - 9/19/75	7.40	7.40	7.40
AR 55	Juv.	M	7/7/75 - 7/16/75[b]	3.22	3.22	3.22
AR 57	Juv.	M	5/16/75 - 7/11/75[b]	10.62	10.62	10.62
AR 60	Adult	M	7/11/75 - 9/1/75 - 11/25/75	12.87	17.06	12.87
AR 61	Juv.	F	5/16/75 - 7/11/75 - 7/24/75[b]	10.62	10.62	10.62
AR 62	Juv.	F	5/16/75 - 7/11/75[b]	10.62	10.62	10.62
AR 68	Juv.	M	5/15/75 - 9/29/75	20.92	20.92	20.92

Appendix D (cont.)

Neck Band No.	Age[a]	Sex	Dates Observed	Furthest Distance From Banding Location (km)	Longest Axis of Home Range (km)	Distance From Capture Point When Last Observed (km)
AR 71	Juv.	M	7/16/75 - 11/13/75 - 11/18/75 - 3/8/76	4.67	4.67	4.67
AR 72	Juv.	F	7/16/75 - 11/18/75 - 11/25/75	7.40	7.40	7.40
AR 73	Juv.	M	7/16/75 - 11/13/75	5.31	5.31	5.31
AR 74	Adult	M	7/16/75 - 9/24/75 - 11/13/75	6.60	6.60	6.60
AR 75	Juv.	F	7/16/75 - 11/2/75	20.76	20.76	20.76
AR 76	Juv.	M	7/16/75 - 11/2/75	20.76	20.76	20.76
AR 77	Juv.	F	7/16/75 - 11/13/75	12.71	12.71	12.71
AR 78	Juv.	M	7/16/75 - 11/13/75	12.71	12.71	12.71
AR 80	Subadult	F	7/16/75 - 10/8/75 - 11/13/75	16.74	33.64	16.74
AR 83	Adult	M	7/16/75 - 11/13/75	16.74	16.74	16.74
AR 84	Juv.	F	7/16/75 - 11/13/75 - 3/5/76	25.27	25.27	25.27
AR 87	Juv.	M	7/16/75 - 8/21/75 - 10/16/75 - 10/21/75 - 11/13/75	61.16	61.16	25.27
AR 88	Subadult	F	7/16/75 - 10/8/75 - 10/14/75 - 10/27/75 - 4/15/76	8.69	8.69	8.69
AR 89	Juv.	M	7/16/75 - 11/13/75	23.17	23.17	23.17
AR 91	Subadult	M	7/16/75 - 10/15/75	8.21	8.21	8.21
AR 94	Juv.	M	7/16/75 - 10/8/75 - 10/20/75	8.53	8.53	8.53
AR 96	Juv.	M	7/16/75 - 9/25/75 - 10/16/75 - 10/21/75 - 11/13/75	37.66	37.66	35.08
AR 98	Adult	M	7/16/75 - 11/3/75	16.74	16.74	16.74
AR 99	Adult	F	7/16/75 - 10/8/75	1.45	1.45	1.45
AJ 02	Juv.	F	7/16/75 - 8/21/75 - 11/13/75	57.78	57.78	33.80
AJ 03	Juv.	M	7/16/75 - 10/8/75	.97	.97	.97
AJ 06	Juv.	M	7/16/75 - 9/19/75 - 10/8/75	11.10	11.10	10.14
AJ 07	Juv.	M	7/17/75 - 8/4/75 - 10/24/75	5.79	5.79	5.79
AJ 08	Juv.	M	7/17/75 - 8/4/75 - 10/24/75	5.79	5.79	5.79
AJ 12	Juv.	F	7/17/75 - 11/12/75	10.62	10.62	10.62
AJ 15	Juv.	M	7/17/75 - 8/6/75	1.13	1.13	1.13
AJ 16	Juv.	F	7/17/75 - 8/6/75	1.13	1.13	1.13
AJ 32	Adult	F	7/18/75 - 9/26/75 - 9/30/75	25.75	25.75	23.98
AJ 44	Subadult	F	6/26/75 - 7/21/75 - 8/25/75	1.13	1.13	1.13
AJ 45	Juv.	M	7/21/75 - 8/28/75	1.45	1.45	1.45

Appendix D (cont.)

Neck Band No.	Age[a]	Sex	Dates Observed	Furthest Distance From Banding Location (km)	Longest Axis of Home Range (km)	Distance From Capture Point When Last Observed (km)
AJ 46	Juv.	M	7/21/75 - 8/28/75 - 11/26/75	2.57	2.57	2.25
AJ 47	Juv.	F	7/21/75 - 8/28/75 - 9/10/75 - 11/26/75	4.83	5.47	2.25
AJ 48	Juv.	F	7/21/75 - 9/10/75 - 9/29/75	28.97	28.97	28.97
AJ 49	Juv.	M	7/21/75 - 8/5/75	4.67	4.67	4.67
AJ 50	Juv.	F	7/24/75 - 11/9/75	4.67	4.67	4.67
AJ 51	Juv.	M	7/24/75 - 10/18/75	13.84	13.84	13.84
AJ 52	Juv.	F	7/26/75 - 9/26/75	11.10	11.10	11.10
AJ 53	Juv.	M	7/26/75 - 9/26/75	11.10	15.61	5.47

CONVERSIONS: 1 km = .621 mi

[a]Adult: a bird believed to be in its second year after hatching.
Subadult: a bird in its first year after hatching.
Juvenile (Juv.): a bird in its year of hatching.

[b]All observations recorded while bird was flightless.

Appendix E

EGG SUCCESS OF CANADA GEESE

TABLES

TABLE E-1

EGG SUCCESS IN SUCCESSFUL CANADA GOOSE NESTS ON THE LOWER YELLOWSTONE RIVER, 1975[a]

Nest Number	Clutch Size	Number of Eggs Hatched	Eggs Unhatched			
			Number of Eggs Lost	Number of Embryo Deaths	Number Addled	Number Infertile
11	4	4	0	0	0	0
15	5	5	0	0	0	0
18	7	6	1	0	0	0
19	7	7	0	0	0	0
23	7	4	0	3	0	0
25	3	2	0	0	1	0
29	4	4	0	0	0	0
33	3	3	0	0	0	0
38	6	6	0	0	0	0
43	6	6	0	0	0	0
47	6	4	0	2	0	0
48	3	2	0	1	0	0
49	6	5	0	1	0	0
50	7	7	0	0	0	0
51	5	5	0	0	0	0
52	3	3	0	0	0	0
54	5	2	0	3	0	0
56	5	4	0	0	0	1
59	6	6	0	0	0	0
62	5	2	0	3	0	0
65	6	6	0	0	0	0
66	6	5	0	1	0	0
67	5	4	0	0	0	1
68	5	5	0	0	0	0
69	6	6	0	0	0	0
71	6	6	0	0	0	0
72	4	4	0	0	0	0
74	7	4	0	0	0	3
TOTALS[b]	148	127(85.8)	1(0.7)	14(9.5)	1(0.7)	5(3.4)

[a]Nests in which at least one egg hatched, with the exception that no nests were included in which eggs were injected with dye.

[b]Percentages of total in parentheses

TABLE E-2

EGG SUCCESS IN SUCCESSFUL[a] CANADA GOOSE NESTS
ON THE LOWER YELLOWSTONE RIVER, 1976

Nest Number	Clutch Size	Number of Eggs Hatched	Eggs Unhatched: Number of Eggs Lost	Number of Embryo Deaths	Number Addled	Number Infertile
1	6	3	0	3	0	0
2	5	4	1	0	0	0
3	5	5	0	0	0	0
6	5	4	0	0	1	0
7	7	6	0	1	0	0
8	4	3	1	0	0	0
11	7	7	0	0	0	0
12	6	6	0	0	0	0
14	3	3	0	0	0	0
15	8	6	0	1	1	0
16	6	6	0	0	0	0
21	4	4	0	0	0	0
22	6	6	0	0	0	0
23	7	5	0	0	1	1
26	6	6	0	0	0	0
28	6	3	0	3	0	0
29	4	4	0	0	0	0
30	5	4	0	0	0	1
31	6	6	0	0	0	0
32	5	5	0	0	0	0
33	5	5	0	0	0	0
35	6	3	0	0	1	2
36	4	4	0	0	0	0
37	6	4	1	0	1	0
38	5	5	0	0	0	0
39	9	9	0	0	0	0
42	4	4	0	0	0	0
44	6	6	0	0	0	0
45	6	6	0	0	0	0
46	2	2	0	0	0	0
49	6	6	0	0	0	0
50	7	5	0	0	2	0
51	6	4	1	0	0	1
52	5	4	0	1	0	0
54	7	6	0	0	1	0
55	6	6	0	0	0	0
56	5	3	0	2	0	0
57	6	3	1	1	0	1
58	8	8	0	0	0	0
60	7	6	0	0	0	1
62	4	4	0	0	0	0
63	7	6	0	0	1	0
64	4	4	0	0	0	0
67	7	5	1	1	0	0
68	6	6	0	0	0	0
69	5	5	0	0	0	0
70	5	3	0	0	2	0
TOTALS[b]	265	228(86.0)	6(2.3)	13(4.9)	11(4.2)	7(2.6)

[a] Nests in which at least one egg hatched, with the exception that no nests were included in which eggs were injected with dye.

[b] Percentages of total in parentheses

Appendix 7

SELECTED SPECIES OF BIRDS OBSERVED IN THE LOWER YELLOWSTONE VALLEY FROM SEPTEMBER 1974 TO OCTOBER 1976

	SPRING MIGRANT	BREEDING	SUMMERING[a]	FALL MIGRANT	WINTERING
Common Loon *(Gavia adamsii)*				x	
Western grebe *(Aechmophorus occidentalis)*	x		x	x	
Horned grebe *(Podiceps autitus)*	x		x	x	
Eared grebe *(Podiceps caspicus)*	x		x	x	
Pied-billed grebe *(Podilymbus podiceps)*	x	x		x	
White pelican *(Pelecanus erythrorhynchos)*	x		x	x	
Double-crested cormorant *(Phalacrocorax auritus)*	x	x		x	
Whistling swan *(olor columbianus)*	x			x	
Giant Canada goose *(Branta canadensis maxima)*	x	x		x	x
Great Basin Canada goose *(Branta canadensis moffitti)*	x	x		x	x
Lesser Canada goose *(Branta canadensis parvipes)*	x			x	
Richardson's Canada goose *(Branta canadensis hutchinsii)*	x			x	
White-fronted goose *(Anser albifrons frontalis)*	x			x	
Snow goose *(Chen hyperborea)*	x			x	
Mallard *(Anas platyrhynchos)*	x	x		x	x
Pintail *(Anas acuta)*	x	x		x	
Gadwall *(Anas strepera)*	x	x		x	
American widgeon *(Anas americana)*	x	x		x	x
Shoveler *(Anas clypeata)*	x	x		x	
Blue-winged teal *(Anas discors)*	x	x		x	
Green winged teal *(Anas crecca carolinensis)*	x	x		x	
Wood duck *(Aix sponsa)*	x	x		x	
Redhead *(Aythya americana)*	x			x	
Canvasback *(Aythya valisineria)*	x			x	
Ring-necked duck *(Aythya collaris)*	x			x	
Lesser scaup *(Aythya affinis)*	x			x	
Common goldeneye *(Bucephala clangula)*	x			x	x
Buffelhead *(Bucephala albeola)*	x			x	
Ruddy duck *(Oxyura jamaicensis)*	x		x	x	
Common merganser *(Mergus merganser)*	x	x		x	x
Red-breasted merganser *(Mergus aerrator)*	x				
Turkey vulture *(Cathartes aura)*			x		
Rough-legged hawk *(Buteo lagopus)*	x				x
Red-tailed hawk *(Buteo jamaicensis)*	x	x		x	
Golden eagle *(Aquila chrysaetos)*		x			x
Bald eagle *(Haliaeetus leucocephalus)*	x	x		x	x
Osprey *(Pandion haliaetus)*	x			x	
Prairie falcon *(Falco mexicanus)*	x	x		x	

Appendix F (Cont.)

	SPRING MIGRANT	BREEDING	SUMMERING[a]	FALL MIGRANT	WINTERING
Great blue heron *(Ardea herodias)*	x	x		x	
Black-crowned night heron *(Nycticorax nycticorax)*	x				
Lesser sandhill crane *(Grus canadensis canadensis)*				x	
American coot *(Fulica americana)*	x	x		x	
American avocet *(Recurvirostra americana)*	x		x		
Black-bellied plover *(Squatarola squatarola)*	x				
Killdeer *(Charadrius vociferus)*	x	x		x	
Long-billed curlew *(Numenius americanus)*	x				
Upland plover *(Bartramia longicauda)*	x		x		
Spotted sandpiper *(Actitis macularia)*	x	x		x	
Willet *(Catoptrophorus semipalmatus)*	x				
Greater yellowlegs *(Totanus melanoleucus)*	x				
Lesser yellowlegs *(Totanus flavipes)*	x				
Long-billed dowitcher *(Limnodromus scolopaceus)*	x				
Sanderling *(Crocethia alba)*	x				
White-rumped sandpiper *(Erolia fuscicollis)*	x				
Least sandpiper *(Erolia minutilla)*	x				
Wilson's phalarope *(Steganopus tricolor)*	x				
Common snipe *(Capella gallinago)*	x				
Ring-billed gull *(Larus delawarensis)*	x		x	x	
Franklin's gull *(Larus pipixcan)*	x				
Common tern *(Sterna hirundo)*	x	x		x	
Forster's tern *(Sterna forsteri)*	x				
Black tern *(Chlidonias niger)*	x				
Great horned owl *(Bubo virginianus)*	x	x		x	
Snowy owl *(Nyctea scandiaca)*				x	
Belted kingfisher *(Megaceryl alcyon)*	x	x		x	
Black-billed magpie *(Pica pica)*	x	x		x	x
Common crow *(Corvus brachyrhynchos)*	x		x	x	

[a]Present in summer but not known to breed in the area

Literature cited

Anderson, B.W. and R.L. Timken. 1972. Sex and age ratios and weights of common mergansers. Journal of Wildlife Management 36(4): 1127-1133.

Atwater, M.G. 1959. A study of renesting in Canada geese in Montana. Journal of Wildlife Management 23(1): 91-97.

Bellrose, F.C. 1968. Waterfowl migration corridors east of the Rocky Mountains in the United States. Illinois Natural History Survey, Biological Notes No. 61: 1-24.

_____. 1974. Wildlife Specialist. Illinois Natural History Survey. Personal Communication. November 14.

_____. 1976. Ducks, geese and swans of North America. Stackpole, Harrisburg. 544 pp.

Bellrose, F.C., T.G. Scott, A.S. Hawkins, and J.B. Low. 1961. Sex ratios and age ratios in North American ducks. Illinois Natural History Survey Bulletin 27(6): 391-474.

Bossenmaier, E.F. and W.H. Marshall. 1958. Field-feeding by waterfowl in southwestern Manitoba. Wildlife Monographs No. 1: 1-32.

Bowhay, E.L. 1972. Canada goose management on the Columbia and Snake Rivers in Washington. Proceedings of the Western Association of State Game and Fish Commissions 52: 360-373.

Brakhage, G.K.1965. Biology and behavior of tub-nesting Canada geese. Journal of Wildlife Management 29(4): 751-771

Caldwell, J.R. 1967. Breeding ecology of the Canada goose on the South Saskatchewan River. Saskatchewan Department of Natural Resources Final Report Volume 33 pp.

Chura, N.J. 1961. Food availability and preferences of juvenile mallards. Transactions of the North American Wildlife and Natural Resources Conference 26: 121-134.

Coleman, J.H. 1976. Railroad Engineer. Burlington Northern. Personal Communication. March 26.

Culbertson, J.L., L.L. Caldwell, and I.O. Buss. 1971. Nesting and movements of Canada geese on the Snake River in Washington. The Condor 73(2): 230-236.

Des Lauriers, J.R. and B.H. Brattstrom. 1965. Cooperative feeding behavior in red-breasted mergansers. The Auk 82(4): 639.

Diem, K.L. and D.D. Condon. 1967. Banding studies of water birds on the Molly Islands, Yellowstone Lake, Wyoming. Yellowstone Library and Museum Association Publication. 41 pp.

Dimmick, R.W. 1968. Canada geese of Jackson Hole, Wyo. Game and Fish Commission Technical Bulletin No. 11:1-86.

Drewien, R.C. 1968. Recovery analysis of mallards banded in the Black Hills during the winters of 1950-51 and 1951-52. South Dakota Game, Fish and Parks Commission. Federal Aid Project W-75-R-10. 16 pp.

Eng, R.L. 1976. Professor of Wildlife Management. Montana State University, Bozeman. Personal Communication. April.

Evans, C.D. 1951. A method of color marking young waterfowl. Journal of Wildlife Management. 15(1): 101-103.

Geis, M.B. 1956. Productivity of Canada geese in the Flathead Valley, Montana. Journal of Wildlife Management. 20(4): 409-419.

Gerrard, J.M. 1976. Independent Researcher. Minneapolis. Personal Communication. March 29.

Grieb, J.R. 1970. The Shortgrass Prairie Canada goose population. Wildlife Monographs No. 22: 1-49.

Hackman, C.D. and C.J. Henny. 1971. Hawk migration over White Marsh, Maryland. Chesapeake Science. 12(3): 137-141.

Haddix, M.H. 1976. Fish and Wildlife Biologist. Montana Department of Fish and Game. Personal Communication. August 31.

Hall, E.R. 1925. Pelicans versus fishes in Pyramid Lake. Condor 27(1): 147-160.

Hancock, D. 1964. Bald eagles wintering in the Southern Gulf Islands, British Columbia. Wilson Bulletin 76(2): 111-120.

Hansen, H.A. and W.H. Oliver. 1951. The status of resident Canada geese in south-central Washington, spring, 1950. The Murrelet 32(1): 2-7.

Hanson, H.C. 1965. The giant Canada goose. Southern Illinois University Press, Carbondale. 226 pp.

Hanson, W.C. and R.L. Browning. 1959. Nesting studies of Canada geese on the Hanford Reservation, 1953-56. Journal of Wildlife Management 23(2): 129-137.

Hanson, W.C. and L.L. Eberhardt. 1971. A Columbia River Canada goose population, 1950-1970. Wildlife Monographs No. 28: 1-61.

Hinz, T.C. 1974. Seasonal activity, numbers, and the distribution of Canada geese *(Branta canadensis)* in the lower Yellowstone Valley, Montana. Unpublished Thesis (M.S.).Montana State University, Bozeman, 88 pp.

Hook, D.L. 1973. Production and habitat use by Canada geese at Freezeout Lake, Montana. Unpublished Thesis (M.S.). Montana State University, Bozeman. 53 pp.

Knapp, S.J. 1975. Birney-Decker Wildlife Study. Progress Report No. 2, Prepared by Montana Department of Fish and Game for the U.S. Bureau of Land Management. 71 pp.

Koch, R. 1976a. Hydrologist. Montana Department of Natural Resources and Conservation. Personal Communication. May 13.

_____. 1976b. Hydrologist. Montana Department of Natural Resources and Conservation. Personal Communication. September 8.

Kossack, C.W. 1950. Breeding habits of Canada geese under refuge conditions. American Midland Naturalist. 43(3): 627-649.

LaBree, D.J. 1976. Railroad Engineer. Burlington Northern. Personal Communication. January 19.

Latta, W.C. and R.F. Sharkey. 1966. Feeding behavior of the American merganser in captivity. Journal of Wildlife Management. 30(1): 17-23.

Lee, F.B. 1975. Wildlife Biologist. Northern Prairie Wildlife Research Center. Personal Communication. June.

Lefebvre, E.A. and D.G. Raveling. 1967. Distribution of Canada geese in winter as related to heat loss at vary environmental temperatures. Journal of Wildlife Management. 31(3): 538-546.

Leitch, W.G. 1976. Chief Biological Consultant. Ducks Unlimited (Canada). Personal Communication. September 10.

Lieff, B.C. and C.D. MacInnes, and R.K. Misra. 1970. Food selection experiments with young geese. Journal of Wildlife Management. 34(2): 321-327.

Martin, F.W. 1964. Behavior and survival of Canada geese in Utah. Utah Fish and Game Dept. Informational Bulletin No. 64-7. 89 pp.

Martin, J.L. 1975. Refuge Manager. Medicine Lake National Wildlife Refuge. Personal Communication. July 10.

Martin, P.R. 1976. Fish and Wildlife Ecologist. Montana Department of Fish and Game. Personal Communication. September 8.

McCabe, T. 1975. Graduate Student. Oregon State University, Corvallis. Personal Communication. April 17.

Merrill, L.B. and E.G. Bizeau. 1972. Canada goose production as related to stream flow on the South Fork of the Snake River in Idaho: a preliminary survey. Idaho Cooperative Wildlife Resource Unit Publication. iii + 39 pp.

Mincoff, M. 1976. Airplane Pilot. Personal Communication. September 17.

Montana Department of Community Affairs. 1976 (December). Economic Conditions in Montana: a report to the Governor.Research and Information Systems Division, Helena. 35 pp.

Montana Department of Natural Resources and Conservation. 1977 (January). The future of the Yellowstone River ....? Water Resources Division, Helena. 107 pp.

Montana Department of Natural Resources and Conservation. 1975. Unpublished results of mail survey of Soil Conservation Service offices in Montana conducted late in 1974 and early in 1975.

Montana Department of Natural Resources and Conservation. 1976 (December). Yellowstone River Basin: draft environmental impact statement for water reservation applications. Two volumes. Water Resources Division. Helena. 412 pp.

Montana Energy Advisory Council. 1976 (June). Montana energy position paper: a Montana Energy Advisory Council staff report, by Theodore H. Clack, Jr. Helena. 56 pp.

North Central Power Study Coordinating Committee. 1971 (October). North central power study: report of phase I. Volume I. Bureau of Reclamation, Billings. 80 pp.

Naylor, A.E. 1953. Production of the Canada goose on Honey Lake Refuge, Lassen County, California. California Fish and Game 39(1): 83-94.

Peterson, J.G. 1970. The food habits and summer distribution of Juvenile sage grouse in central Montana. Journal of Wildlife Management. 34(1): 147-155.

Raveling, D.G. 1966. Factors affecting age ratios of samples of Canada geese caught with cannon-nets. Journal of Wildlife Management. 30(4): 682-691.

Raveling, D.G., W.E. Crew, and W.O. Klimstra. 1972. Activity patterns of Canada geese during winter. Wilson Bulletin 84(3): 278-295.

Ratherford, W.H. 1965. Description of Canada goose populations common to the Central Flyway. Central Flyway Waterfowl Council, Technical Communication. 18 pp.

Rocky Mountain Association of Geologists. 1972. Geologic atlas of the Rocky Mountain region: United States of America. Denver. 331 pp.

Shea, D.S. 1973. A management-oriented study of bald eagle concentrations in Glacier National Park. Unpublished Thesis (M.S.).University of Montana, Missoula. 78 pp.

Snedecor, G.W. and W.G. Cochran. 1967. Statistical methods. Iowa State University Press, Ames. 593 pp.

Southern, W.E. 1967. Further comments on subadult bald eagle plumages. Jack-Pine Warbler 45(3): 70-80.

Sprunt, A., IV. and F.J. Ligas. 1963. Continental bald eagle project: progress report No. III. A Florida Notebook (Proceedings of the National Audubon Society Convention). 27 pp.

State Conservation Needs Committee. 1970. Montana soil and water conservation needs inventory. Soil Conservation Service, Bozeman. 172 pp.

Steel, P.D., Dalke, P.D. and E.G. Bizeau. 1957. Canada goose production at Gray's Lake, Idaho, 1949-1951. Journal of Wildlife Management. 21(1): 38-41.

Sturdy, J.C. 1967. Production of forage and its utilization by Canada geese at the Salt Plains National Wildlife Refuge. Unpublished Thesis (M.S.). Oklahoma State University, Stillwater. 58 pp.

Sugden, L.G. 1973. Feeding ecology of pintail, gadwall, American widgeon and lesser scaup ducklings. Canadian Wildlife Service. Report Series No. 24. 45 pp.

Sugden, L.G., W.J. Thurlow, R.D. Harris, and K. Vermeer. 1974. Investigations of mallards overwintering at Calgary, Alberta. Canadian Field Naturalist 88: 303-311.

Swenson, J.E. 1975. Ecology of the bald eagle and osprey in Yellowstone National Park. Unpublished Thesis (M.S.).Montana State University, Bozeman. 146 pp.

Vermeer, K. 1969. Great blue heron colonies in Alberta. Canadian Field Naturalist. 83(3): 237-242.

Wentland, H.J. 1974. Game Management Biologist. Montana Department of Fish and Game. Personal Communication. November.

Wight, H.M. 1938. Field and laboratory technic in wildlife management. University of Michigan Press, Ann Arbor. 105 pp.

Williams, C.S. et al. 1948. Waterfowl populations and breeding conditions, summer 1948 - with notes on woodcock studies. U.S. Fish and Wildlife Service, Special Scientific Report No. 60. 186 pp.

Witt, D.W. 1955. A production study of Canada geese on Nelson Reservoir, Phillips County, Montana. Federal Aid Report W-39-R-6. Montana Dept. of Fish and Game, Helena. pp. 11-30.

Yocom, C.F., C.L. Buechele, and S.W. Harris. 1956. Great Basin Canada goose nesting populations at the former Lake Lenore National Wildlife Refuge, Washington. The Murrelet 37(1): 14-17.

Zicus, M.C. 1975. Capturing nesting Canada geese with mist nets. Bird-Banding 46(2): 168-169.

YELLOWSTONE IMPACT STUDY

Migratory Birds

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