Impacts of Water Levels on Breeding Canada Geese and Methods for Mitigation and Management in the Southern Flathead Valley, Montana

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IMPACTS OF WATER LEVELS ON BREEDING CANADA GEESE AND METHODS FOR MITIGATION AND MANAGEMENT IN THE SOUTHERN FLATHEAD VALLEY, MONTANA

FINAL REPORT

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Abstract: Kerr Hydroelectric Dam is located at the south end of Flathead Lake, controls water levels on the lake and the Flathead River below the dam, and is currently operated as a load control facility. Dam operations, and subsequent water levels, are primarily affected by electric power production, recreational constraints on lake levels, and operation of Hungry Horse Dam located on the South Fork of the Flathead River. Current operation of Kerr Dam creates the greatest yearly water level fluctuations on both the lake and river during the Canada goose (Branta canadensis moffitti) brood and nesting period. Data collected from 1980-82 indicated that goose nest numbers on the river were lower than during the 1950's, and that brood habitat on the lake may be limiting the goose population there. Our study was conducted from 1983-87 to determine the efects of Kerr Dam operation on Canada goose populations and habitat on the south half of Flathead Lake and the Flathed River, and to formulate management and mitigation recommendations. Historical losses of habitat on the lake and river were documented. Nesting geese on the river appeared to be negatively affected by a lack of nest sites free from predators, and responded to available artificial nest structures with an increase in nest numbers and nesting success. Under current dam operation, river channel depths and widths do not discourage access to nesting islands by mammalian predators during some years and high predation on ground nests occurs. The river ground nesting goose population maintain itself at a low level, but unable to increase because of high predation rates. Ground nesting geese on the river used sites on small islands or along the edge of large islands, with abundant cover surrounding the nest. Intensively used brood areas on the lake and river were identified and described. Brood habitat on the lake was lower in quality and quantity than on the river due to dam operations. Gosling mortality on the lake was high, almost 2X higher than on the river. Lake broods expended more energy obtaining food than river broods. When goslings were young and the lake level low, broods were forced to forage on sparsely vegetated mudflats because they would not cross the extensive mudflats to feed in upland pastures. Losses of brood habitat in the form of wet meadow marshes were documented and mitigation options developed. Management/mitigation alternatives and monitoring methods for nesting and brooding geese were identified.

INTRODUCTION

The Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Public Law 96-501) directed the Northwest Power Planning Council to develop and adopt a program to protect and enhance wildlife populations and habitats in the Columbia River Basin and its tributaries, and to mitigate for losses resulting from hydroelectric projects, including Kerr Dam (Northwest Power Planning Council, 1982:10). Our study was conducted to determine the effects of the operation of Kerr Dam, located at the south end of Flathead Lake, on western Canada goose populations and their habitat in the southern Flathead Valley, western Montana and to formulate mitigation options and management recommendations to protect and enhance the goose population and habitat. This report is a final summary of data collected from 1983-87. The Montana Department of Fish, Wildlife, and Parks conducted a similar study (Casey and Wood 1987) in the northern Flathead Valley. These studies will provide wildlife managers with the information needed to properly mitigate for and manage the Flathead Valley Canada goose population. Furthermore, information presented here will be useful throughout the Columbia River Basin and the Northwest.

Nesting populations of Canada geese on the lower Flathead River from 1980-82 were less than those documented during the 1950's, while numbers on Flathead Lake have remained relatively stable (Ball 1983). Prior to the initiation of our study, we hypothesized that recruitment rates on the river depended primarily on availability of secure nest sites, while brood habitat was a more important limiting factor on the lake. We suspected that fluctuating water levels resulting from the operation of Kerr Dam could impact goose reproductive output. When water levels are extremely low, some nest islands on the river become attached to the mainland, promoting nest destruction by mammalian predators and possibly discouraging nesting by some goose pairs. Access to grazing pastures by goose broods on the lake becomes restricted due to separation from the water by extensive mudflats. Nest flooding occurs on the river during periods of high water levels since many geese nest below the high water mark (HWM). Providing secure artificial nest sites (priamarily islands) at Ninepipe Reservoir resulted in major increases in the nesting Canada goose population during the past 20 years (Ball 1981), and there is reason to expect similar results on the Flathead River.

The brood rearing period is poorly understood, primarily because geese are exceptionally wary and secretive during this phase of the reproductive cycle. Barraclough (1954) documented several brood areas on the lake, but river brood data were limited. Very little brood data has been collected in the Flathead Valley since the 1950's. Objectives of our study were:

(A) Nest Studies:

1) Document goose production on Flathead Lake and the Flathead River.
2) Identify pair survey methods which provide a precise estimate of goose pairs and a valid estimate of the nesting goose population.

3) Determine population impacts of providing additional secure nest sites (artificial nest structures) for geese along the river.
4) Compare effectiveness of tree nest structures and natural sites with respect to:
   a) use and nest success rates,
   b) vulnerability to human disturbance,
   c) vulnerability and effect of water level fluctuations, and
   d) cost (initial, maintenance, projected life).
5) Develop techniques and guidelines that maximize effectiveness of nest structure management programs, while minimizing costs.
6) Analyze physical (including water level) and vegetative characteristics of nest sites.
7) Formulate management recommendations necessary to protect and enhance the nesting goose population and habitat.

B) Brood Studies:

1) Describe habitat selection by goose broods and relate it to water fluctuations.
2) Document the location of key goose brooding areas.
3) Describe physical and vegetative characteristics of brood rearing areas.
4) Identify potential brooding areas that could be managed to maintain and improve brood habitat.
5) Record river water levels at key brood rearing areas when broods are present and relate these levels to releases from Kerr Dam.
6) Document historical trends in availability of brood habitats.
7) Formulate management recommendations necessary to protect and enhance brood habitat and survival.

To simplify reading, a detailed introduction, methods, results, and discussion section are provided for each major heading within this report.

STUDY AREA

The lower Flathead drainage encompasses an area of about 3,900 km^2 in northwestern Montana, forming one of the state's largest river basins. The Flathead River is formed by three main tributaries originating along the west slope of the continental divide in British Columbia, Canada, and south of Glacier National Park, Montana. These three forks join and flow for approximately 74 km before entering Flathead Lake. After leaving Flathead Lake, the river flows south and then west for approximately 115 km to its confluence with the Clark Fork River.

The study area included the south half of Flathead Lake and the Flathead River from the lake to its confluence with the Clark Fork River (Fig. 1). The lake and river are separated by Kerr Hydroelectric Dam, which controls the surface elevation of the lake and flows on the river. Kerr Dam began operating in 1938, and is currently operated as a load

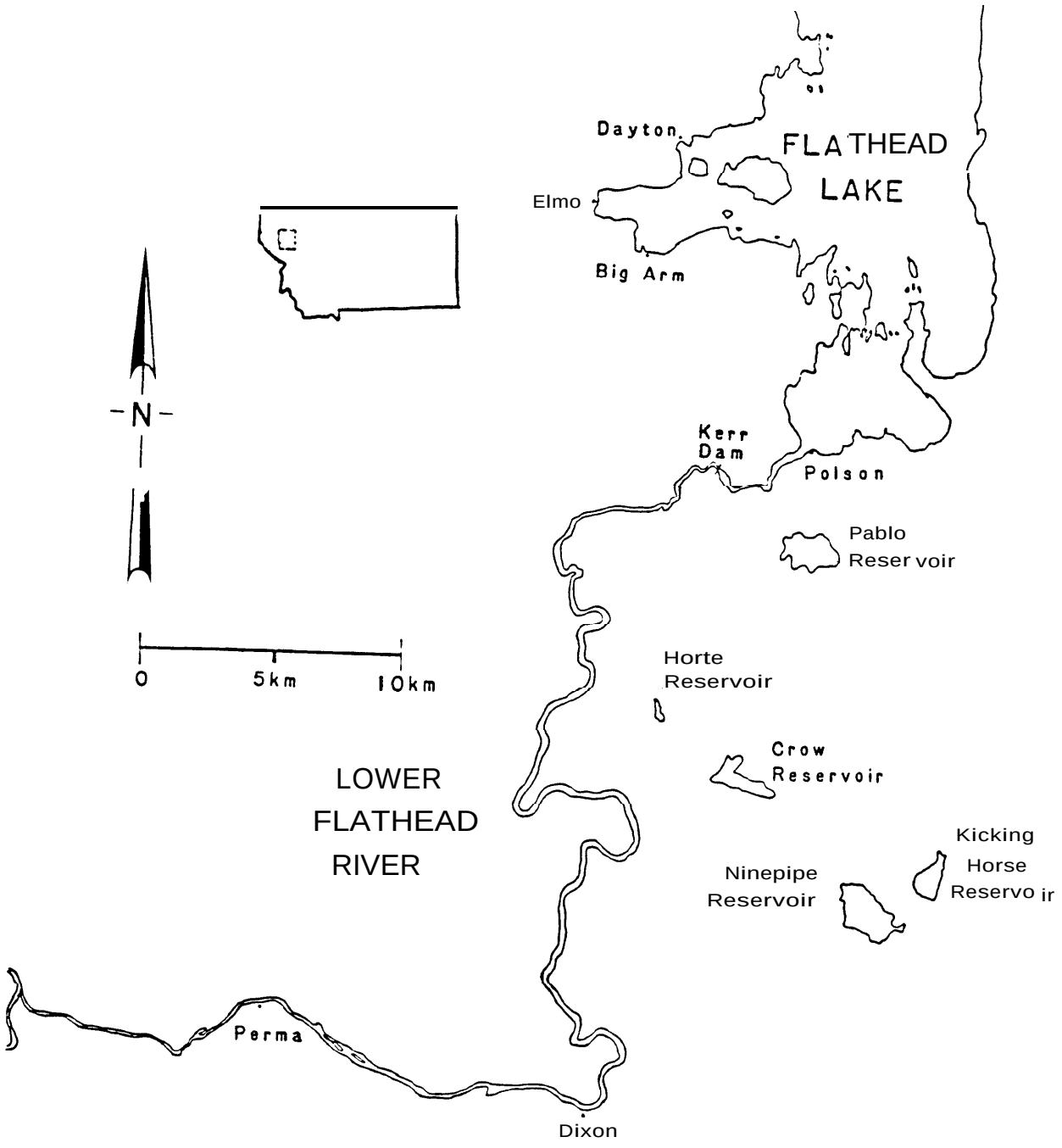

Fig. 1. Map of the study area: Flathead Lake, Flathead River, and reservoirs, southern Flathead Valley, Montana, 1983-87.

control facility. Maximum yearly releases from Kerr Dam result in the highest flows on the river between May and July (Fig. 2) due to affects of electric power production, recreational constraints on lake levels, and operation of Hungry Horse dam located on the South Fork of the Flathead River. River flows from 1980-86 varied from approximately 1,500 - 48,000 cubic feet/second (cfs) during the goose breeding period (Appendices A-C), and occassionally varied 20,000 cfs in 24 hours. Flathead Lake is gradually filled beginning in late April, from the yearly low pool elevation of 2,883 ft to the full pool level of 2,893 ft, by 1 July each year (Fig. 3). Consequently, the greatest change in water levels on both portions of the study area occur during the period coinciding with the brood rearing chronology of Canada geese.

The upstream (north) half of the river is characterized by a relatively narrow channel (approximately 100 m) with fast moving water (6.5 km/hr). Five islands occur in this section of river and range from 0.1 to 2.5 ha in size. The south half of the river has a wider channel (approximately 200 m) and slower flows (5 km/hr). This segment of river has many backwaters and sloughs, and contains 38 islands from 0.1 to 28.1 ha. The river is largely undeveloped, and the predominant riparian vegetation are: forest, including ponderosa pine (Pinus ponderosa), black cottonwood (Populus trichocarpa), and Rocky Mountain juniper (Juniperus scopulorum or dense shrubs, including red-osier dogwood (Cornus stolonifera), sandbar willow (Salix exisua), and Wood's rose (Rosa woodsii). Other vegetation along the river consists of agricultural lands and natural herbaceous types.

Flathead Lake, with a full-pool surface area of 50,992 ha, is the largest natural freshwater lake in the western United States. Most lakeshore is developed with homesites or recreational facilities; the remaining undeveloped shoreline consists primarily of forests of Douglas-fir (Psuedotsuqa menzesii), ponderosa pine, quaking aspen (Populus tremuloides, and paper birch (Betula papyifera Non-forested areas consist of herbaceous vegetation, pastures, or marshes of cattail (Typha latifolia) and hardstem bulrush (Scirpus acutus). Before yearly inundation, large expanses of nearly unvegetated mudflats occur in some bays of the lake. Twenty-one islands occur in Flathead Lake (Fig. 4). For biological reasons and to simplify discussion, we refer to Goose, Douglas, Shelter, Rock, and Cedar Islands as the "Northern Islands"; Baby Bull, Little Bull, Big Bull, Narrow's East, and Narrow's West Islands as the "Narrow's Islands"; and Big Bird, U-Shaped Bird, and Long Bird Islands as the "Bird Islands" in this report. Polson and East Bays are collectively referred to as "South Bay". River mile (RM) 0.0 begins at the Flathead/Clark Fork River confluence and increases upstream, to 72.2 at Kerr Dam.

The average rainfall in the area was about 40 cm/year (Polson weather station). Air temperatures varied from a monthly mean of 20 C in July (maxim 37 C), to a mean of -4.5 C for the month of January (minimum -34 C) (Zackheim et al. 1983).

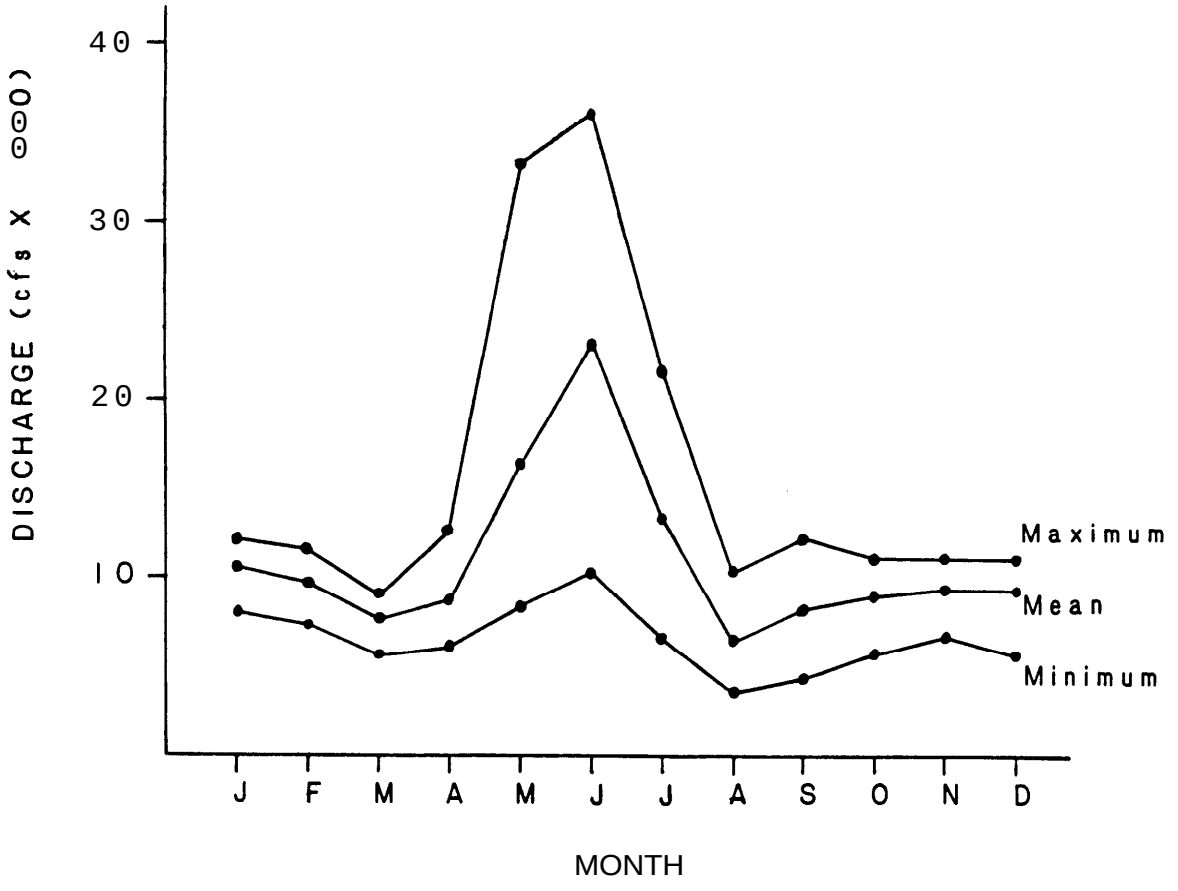

Fig. 2. Minimum, mean, and maximum monthly flows recorded for the Flathead River at the U.S. Geological Survey gaging station below Kerr Dam, Montana water years 1980-86.

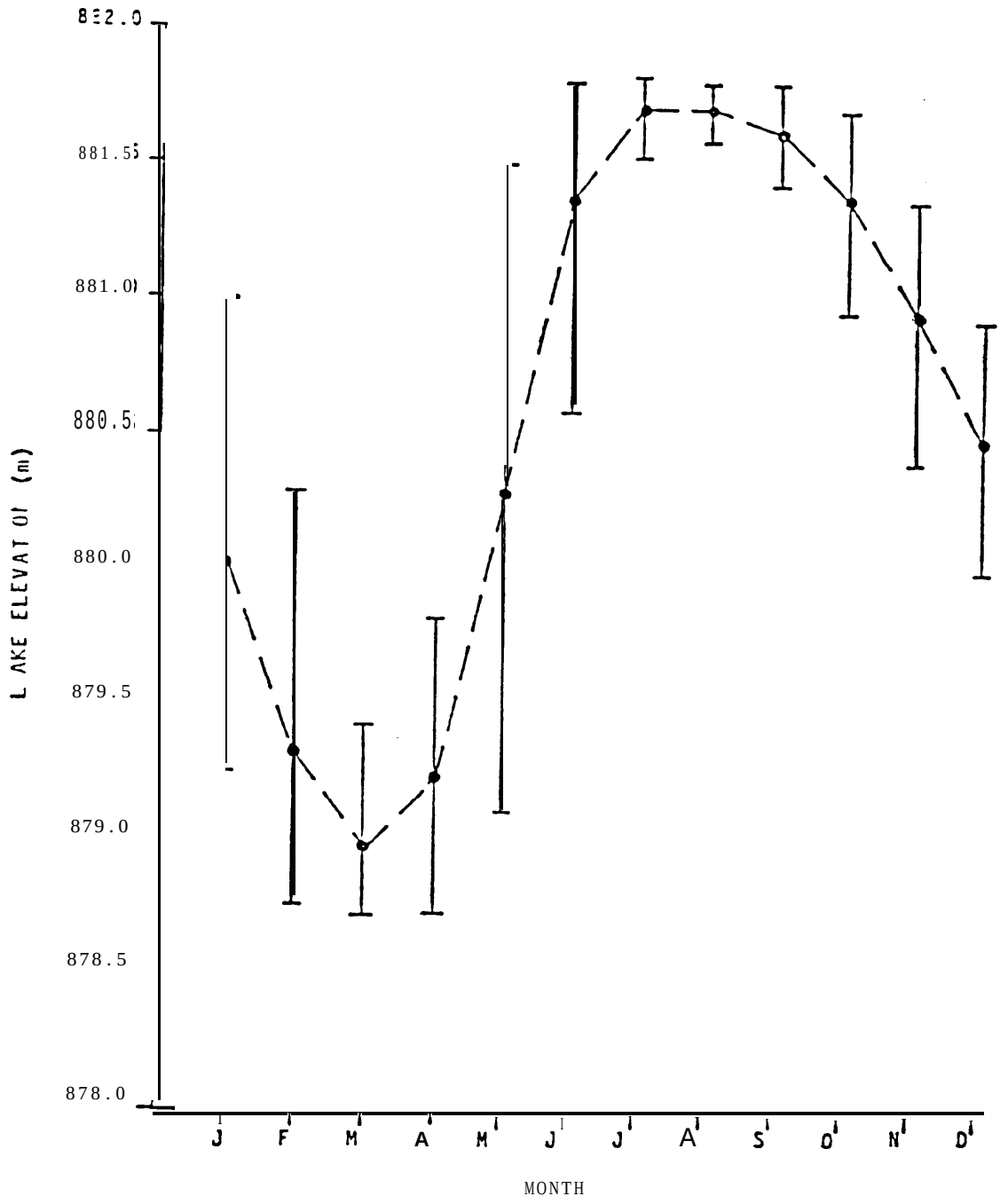

Fig. 3. Minimum, mean, and maximum monthly Flathead Lake elevations recorded at Polson, Montana 1977-83 (From Cross et al. 1987).

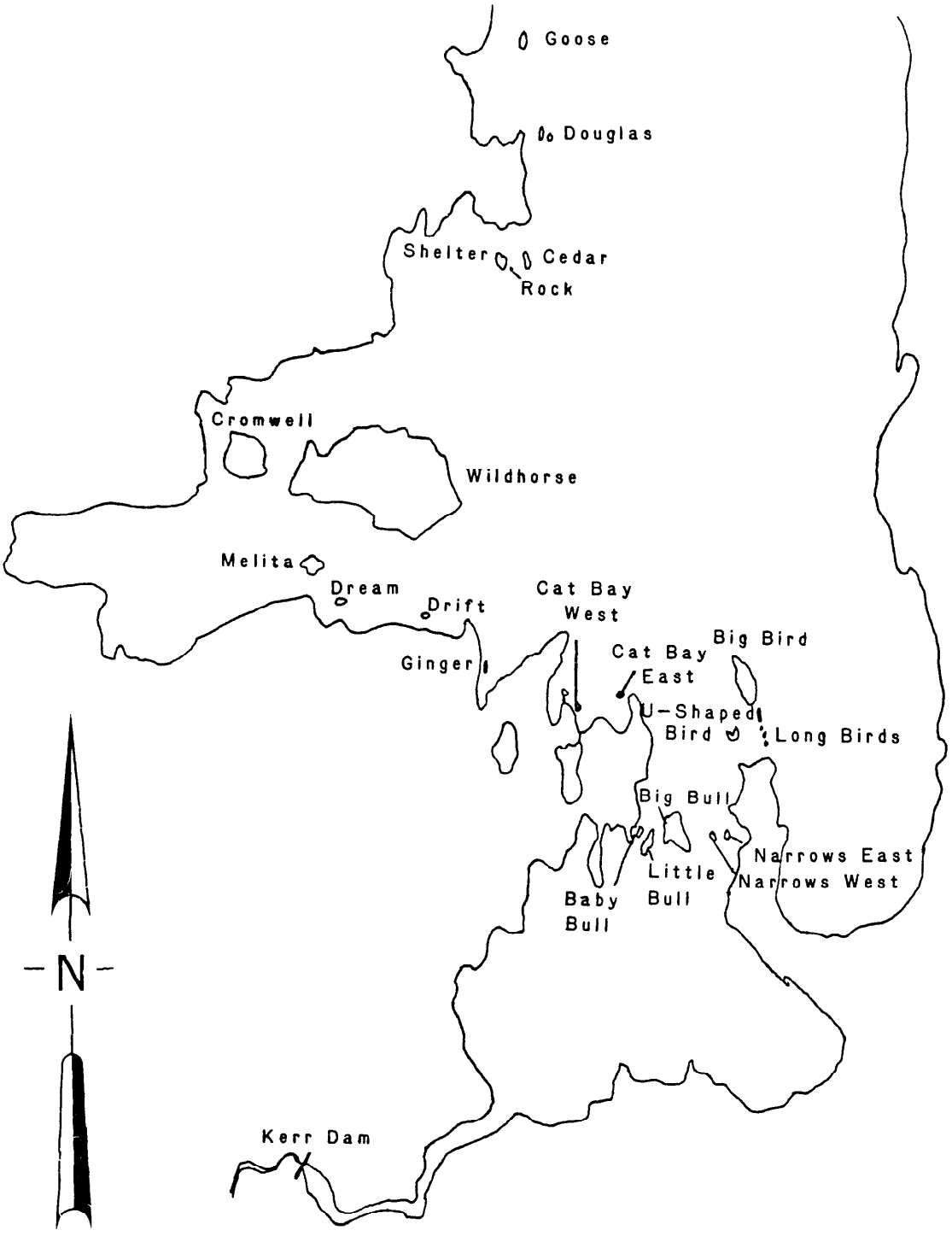

Fig. 4. Islands in the south half of Flathead Lake, Montana, 1983-87.

POPULATION DISTRIBUTION AND SEASONAL MOVEMENTS

Introduction

The Flathead Valley Canada goose population is an important waterfowl resource for hunting and non-hunting activities. Wildlife managers in the valley have in the past, and continue to dedicate extensive management efforts to the goose population. Geese in the valley use a variety of wetlands, and understanding when and how these different areas are used is important to goose management. Furthermore, since all areas within the valley are interrelated in terms of Canada goose ecology, it is important to understand how changes in one area might affect goose use of another area. Objectives of the population distribution portion of our study were to identify areas important to Canada geese on the study area and determine how and when these areas are important.

Methods

Geese were trapped using rocket nets and night-lighting, or captured by hand during the flightless period. Selected adult geese were fitted with solar transmitters (Model no. RS50-ZTM-6X, Telemetry Systems, Inc., Mequon, WI) mounted on plastic Canada goose neck collars (Craven 1979). The completed packages weighed approximately 80 g each. Locations were obtained using ground triangulation (Cochran 1980:517) aerial radio-locations (Gilmer et al. 1981>, or visual observations. For the following discussion, radio-marked geese were "classified" by the area where they nested or where they were located during the nesting period (i e., "river" geese were those located on the river during the nesting period).

Goose distribution and seasonal movement data were obtained from year-round censuses on all major wetland areas, and from locations of radio-marked geese. We attempted to census and radio-track geese weekly from 1983-87. Surveys were flown in a Piper Super Cub or Cessna 185 from 30-90 m above the ground and at airspeeds of approximately 105 km/hr. Surveys were conducted on the Flathead River and Lake, and on Ninepipe, Pablo, Kicking Horse, Crow and Horte Reservoirs. For a total census, all geese (including goslings) observed from 1983-87 were totaled for each area and a mean calculated for each month.

Results and Discussion

River.- Numbers of geese observed in spring and early summer reflected the number of geese nesting and raising broods (Table 1) After broods had fledged in July, goose numbers decreased on the river. This appeared to be a shift by river geese to the reservoirs. In addition to a drop in goose numbers, several radio-marked river geese moved to reservoirs after their broods had fledged. We believe this was likely a result of the attractiveness of high quality feeding areas (grainfields and irrigated pastures) in close proximity to open water resting areas on reservoirs. Craighead and Stockstad (1956) also observed most of the Flathead Valley goose population concentrated on

Table 1. Number of Canada geese observed during aerial surveys by month, Flathead River, Lake and Reservoirs, southern Flathead Valley, Montana, 1983-87.

		$\bar{X}$ No. Canada Geese Observed											
Area	n Flights	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flathead River	110	647	447	183	160	188	154	84	38	42	57	382	1204
Flathead Lake	101	200	256	293	125	327	345	225	49	91	370	547	468
Ninepipe Reservoir	66	0	88	236	108	287	192	451	453	402	660	658	197
Pablo Reservoir	66	0	2	67	30	198	362	334	634	502	609	505	22
Kicking Horse Reservoir	82	0	1	52	10	41	15	31	253	172	153	84	4
Crow Reservoir	66	0	31	37	21	17	11	22	216	0	31	93	0
Horte Reservoir	64	0	50	56	37	85	57	53	3	61	1	0	0
TOTAL	---	847	871	924	491	1143	1136	1200	1646	1270	1881	2269	1895

Pablo and Ninepipe Reservoirs from August through the hunting season. Goose numbers on the river remained low until November when they increased dramatically and remained high through the winter. River radio-marked geese generally used reservoirs until November when reservoirs began to freeze, at which time they (and most other geese on the reservoirs) moved to portions of the river where open water and feeding opportunities existed during most winters. During one winter (1983-84) when the south half of the river froze, most geese left the valley. Craighead and Stockstad (1956) observed that most geese left the valley in 1955 as a result of severe weather.

Lake.- Numbers of geese using the lake were more stable year-round than any other area (Table 1). We observed the lowest number of geese on the lake during August, and believe this was a result of geese leaving the lake after broods had fledged because of high levels of disturbance from recreational activities. Several radio-marked lake geese were located on Pablo Reservoir and it appears that most unmarked geese that left the lake also went to Pablo Reservoir. Good feeding opportunities around the reservoirs may also have made them attractive as we noted for river geese. With the exception of use of reservoirs in August, the lake goose population appeared to be generally independent of geese on the other areas, or at least much more independent than were the river and reservoir subpopulations. We observed no obvious corresponding changes in goose numbers between the lake and any other area except during August. Some geese spent the winter on the lake, even during severe weather; however, most of these flocks subsisted on grain provided by lakeshore landowners.

Reservoirs.- All 5 reservoirs were used by nesting and brooding geese. Outside of the breeding season, and as long as they were not frozen, the reservoirs provided feeding and loafing areas for reservoir geese as well as for geese from the river and lake. As noted above, when the reservoirs freeze, geese leave and either move to the river and/or leave the valley (Table 1). Goose numbers on Pablo Reservoir increased dramatically in May and June, and was a result of non-breeding geese migrating there to molt. Each year, we observed approximately 300 non-breeding geese at Pablo Reservoir; some non-breeding radio-marked geese from the river and lake also molted there. Krohn and Bizeau (1979) also reported Pablo Reservoir as a molting area used by geese from outside of the Flathead Valley.

General use patterns.- The number of geese using various areas was dependent on the time of year. Counts on all areas were low in April when geese were nesting (Table 1). In most areas decreases from March to April could be accounted for by the number of incubating females in that area, since females on nests were not counted. All areas except the lake and Pablo Reservoir decreased from May to June. We attribute this decrease to non-nesting and unsuccessful nesting geese leaving the areas on their northward molt migration. Molt migration of western Canada geese has been discussed by Krohn and Bizeau (1979) and Ball et al. (1981). Although approximately 20 non-breeding (adults unaccompanied by goslings) geese usually molted on Elmo Bay each year, our data showed that the other non-breeding geese on the lake migrated. This was not evident in our lake census data because it was masked by the simultaneous increase of goslings being counted during June. Pablo

Reservoir increased from May to June because of the influx of molting birds. Goose numbers began increasing in August which may have indicated molt migrants returning to the valley. Several of our non-nesting radio-marked birds that disappeared in early June reappeared in August. Numbers continued to increase throughout the fall and mid-winter and then declined after December. This pattern is likely a result of migrating birds passing through the valley.

Goose use of all the major wetland areas was interrelated to some extent: geese that nest on the river used the reservoirs in late summer and fall, reservoir nesting geese wintered on the river, and lake geese used reservoirs in late summer. Changes in land use and water management practices in one area could affect goose populations in any of the other areas, and should be evaluated in that context.

HABITAT DESCRIPTION

Introduction

Riparian plant communities are among the most diverse of any ecological zone in the northern Rocky Mountains (Brinson et al. 1981, Platts et al. 1987). This diversity and the proximity to open water contribute to the importance of this zone as wildlife habitat (Thomas 1979). The abundance of water and rich alluvial soils enable these areas to be among the most productive, but also the most vulnerable, as manipulations in water levels affect both species composition and structure.

Vegetation classifications have been developed for riparian zones in Utah, Idaho and Wyoming (Youngblood et al. 1985, Mutz and Quieroz 1983, Tuhy and Jensen 1982) for U.S.D.A. Forest Service (FS) administered areas. A general dominance-type classification is currently being developed for riparian zones on FS and Bureau of Land Management lands (Hansen 1986). No classifications currently exist for riparian areas near or on our study area, although portions of some related classifications were useful in our study.

The importance of vegetative structure to avian use of habitats has been established (Grinell 1917, Lack 1937, Karr 1984). We developed a hierarchical classification, based on vegetative structure, which can be used to generalize habitat qualities of a detailed species-specific mapping classification.

The objectives of this portion of the study were to: 1) describe and map riparian, marsh and aquatic zones on the study area; 2) categorize and map adjacent upland areas; and 3) determine possible relationships of water levels to habitats.

Methods

Habitat description sampling. - The study area was divided into 12 segments, based on physiographic characteristics, to enable a stratified

random sample of appropriate vegetation characteristics. Cover types were defined based on structual differences in existing vegetation cover (Table 2). The area was field mapped to cover types on color aerial photos at a scale of l:lO,OOO. Sampling sites were selected in areas of homogeneous vegetation representing different plant communities. Sites were situated along regularly spaced lines intersecting the shoreline. Lines created by the UTM grid were used for random selection of sampling sites on the lake, while lines created by 0.1 river mile (PM) were used on the river. Agricultural lands and homesites were excluded from sampling. Sampling sites were referenced and, when practical, sites were permanently marked so that relocation would be possible. Sampling was conducted between 1 June and 10 September 1983-85.

Site data collected at each transect included location, transect bearing, distance to and above (or below) the high water mark, cover types adjacent to the site, impacts of grazing or fire and U.S.D.I. Fish and Wildlife Service (FWS) wetland classification (Cowardin et al. 1979). Physiographic measures included slope, aspect and elevation.

Canopy cover of plant species was recorded at each site using a nested plot technique (Mueller-Dombois and Ellenberg 1974) in which smaller forms of vegetation were recorded in smaller plots and larger structures in fewer, larger plots. A 25-m transect line was placed parallel to the shoreline and formed the center of a belt transect. Herbaceous cover was recorded in 10, l-m^2 square plots, located at 5 m intervals on either side of the transect. Surface area of litter, rock and bare ground were also recorded within these plots. Heights of the shrub and herbaceous layers were recorded at 5 of the 10 small plots.

Shrub canopy cover was recorded by line intercept along the 25-m transect line (Canfield 1941). Two circular plots, 10 m in diameter, were placed with their centers 5 m from either end of the transect line. Canopy cover was recorded for trees within each circle and tree species were tallied by 10 cm diameter at breast height (dbh) classes. All cover estimates were made by species within 6 cover classes adapted from Daubenmire (1959). These were: t = <l%; 1 = l-5%; 2 = 5-25%; 3 = 25-50%; 4 = 50-75%; 5 = 75-95%; 6 = 95-100%. Cover values within individual plots were averaged for each species over the entire transect, and frequency was calculated for herbaceous species. Total overstory cover was measured from the center of each tree circle using a densiometer held at chest height, averaging 4 cardinal direction readings from each point (Lemmon 1956).

Vertical cover was mesured with a density board held 5, 10 and 15 m from the recorder at the beginning of the transect line. The density board was 0.5 m x 3.0 m, gridded into dm squares, and divided into 4 height levels (0-0-0.3 m, 0.3-1.0 m, 1.0-2.0 m and 2.0-3.0 m). The first 2 height levels were read from a crouching position and the latter 2 from a standing position (Noon 1981).

Submerged aquatic vegetation was measured using 10, l-m^2 plots placed approximately every 2 m along a 20-m line through the area. Water depth, height of plants above substrate and adjacent cover types were recorded. Horizontal cover was recorded by species for all macrophytes within the plot. As in the other cover types, cover by

Table 2. Structural cover types used for initial mapping and for stratification of sampling sites, Flathead River and Lake, Montana, 1983-86.

Code	Cover Type	Minimum Qualifications
10	Forest	25% tree canopy cover
11	Coniferous	80% coniferous trees
12	Deciduous	80% deciduous trees
13	Mixed	deciduous and coniferous trees
20	Shrub	25% shrub canopy cover
21	Dense shrub	>50 shrub cover
22	Sparse shrub	25-50% shrub cover
30	Herbaceous	25% herbaceous cover
31	Tall	>0.5 m tall
32	Short	<0.5 m tall
40	Cultivated lands	Natural vegetation obscured
41	Pasture	
42	Alfalfa	
43	Grainfield	
44	Lawn	
50	Marsh	>25% cover by emergent vegetation in standing or moving water
60	Aquatic	>25% cover by submerged aquatic vegetation
70	Unvegetated	None of the above

species was averaged over the entire transect. For all cover types, when a previously published description fit the community, less emphasis was placed on sampling that vegetative type.

Plants difficult to identify in the field were collected and pressed for later reference. Plant names follow Hitchcock and Cronquist (1973) or, if non-vascular aquatics, Fassett (1957). A species list was developed from these and other collections.

Habitat mapping. - Preliminary analysis of vegetation data in 1986 revealed that a dominant species approach would be the most practical for mapping habitats. Using cover types as a basis for a dominance hierarchy, a preliminary classification was developed by sorting association tables to species groups (Mueller-Dombois and Ellenberg 1974).

Different scales and amounts of detail were necessary for different habitat analyses. To allow for flexibility in our analyses, we used the following 4 levels for classifying habitats.

The first level of classification was based on the broad cover types used in the initial mapping and stratification of sampling. These were augmented by a second level, descriptive of broad species groups (coniferous/deciduous trees), structural characteristics within the first level (tall/short marsh), or of dramatic environmental gradations (gravel bar/wet meadow). The third level in the hierarchy was based on dominant or apparent indicator species, and the fourth level was associated species, used as necessary for the distinction of the type. The types were numbered, to facilitate mapping, by 4 digits, each successively indicating the category within the most general to most specific type. If the 3rd or 4th level were not necessary for distinction of a type, these were left as zero.

Orthophotos (scale adjusted aerial photographs superimposed on USGS topographic quads) were photographically enlarged to a scale of 1:12,000. Field mapping was done on mylar overlays of these enlarged orthophotos by comparing color photos (with better resolution) to black and white orthophotos and field checking polygons. Polygons were generally limited in size to no smaller than 0.04 ha (0.1 acre). When an area appeared to be a patchy mixture of 2 or more types, we mapped it as a mosaic and recorded the percent of the area in the each type. If a community did not fit into the classification, a new type was developed and the community was sampled using an abbreviated form of sampling similar to the habitat sampling described above.

Field maps were transcribed in the office, checked for consistency in labeling and edge matching, and digitized for inclusion into a computer mapping system. Software used was a Geographic Information System (GIS) software package called Map Overlay Statistical System (MOSS), a public domain software system currently in use by several agencies.

Soil Sampling - Soil samples were collected in 8 common river riparian community types. Samples were analyzed for various characteristics including salinity, acidity, texture, and nutrient content. The 8 habitat types sampled included 2 forest types, 3 shrub types and 3 herbaceous types. Five sites, distributed throughout the length of the river, were sampled for each community type. Samples were

taken from "A" (10-20 cm depth) and "B" (75-85 cm depth) horizons using an Oakfield tube sampler. Ten subsamples were taken every 2 m along a 20-m transect In rocky soils, 3 larger subsamples of the B horizon were taken at either end and the middle of the transect using either a post-hole auger or a shovel. Subsamples for each horizon were mixed in a bucket at the site, and the sample to be tested was drawn from this aggregate of subsamples.

Samples were tested at the Montana State Soil Testing Lab for electrical conductivity (E.C.) and pH using the saturated paste method. Organic matter (O.M., Sims and Haby 1971) and nutrient concentrations (N,P,K) were analyzed using standard methods. Soil texture was determined using the modified Day technique of mechanical analysis.

Water level mapping. - Three water levels were mapped for the lake and river shorelines reflecting low, medium (or average on the river) and high levels. Lake elevations mapped were: 2884 ft, 2888 ft, and 2893 ft. Intermediate levels (2886 ft and 2890 ft) were mapped in sane larger bays of the lake. On the river, the 3 flows mapped were 3,500 cfs, 12,000 cfs, and 36,000 cfs.

In addition to water levels, we also mapped the riparian zone on the lake and the river, as well as an upland buffer (of 100 m) along the river riparian zone. The riparian zone was defined on the river by: 1) a distinct change in vegetation from more moisture dependent to drier upland plants; 2) a 40 ft increase in elevation (as recorded on USGS topographic maps); or 3) presence of a paved road. On the lake, the first 2 criteria above were substitued with a 100 m distance inland.

Vertical aerial photographs of each of these water levels were taken through the floor of a Cessna 206 airplane with a 35mm camera, using a wide angle (35mm) lens. Slides were then superimposed on 1:24,000 orthophotos and'water levels were drawn on overlays. These overlays were consequently digitized, and analyzed using MOSS (GIS) software.

Data Analysis. - Vegetation transect data were ordered and association tables (species by stand matrices) were composed using FORTRAN programs. These consequently were sorted into species groups and reordered (Mueller-Dombois and Ellenberg 1974). Species with at least 3% cover in 1 plot, or those in at least 10% of the plots within that cover type were included in association tables. Other species were included as space allowed. Cover types were analyzed seprately, and some were subdivided through classification procedures. Areas were calculated from GIS data using MOSS and MAPS software on a DG-20 and DG-10,000 computer.

Enviromental variables and vertical cover (density board) values were compared between cover types using analysis of variance (ANOVA). Soil data were compared by A and B horizons between cover types sampled, and within shrub cover type by dominant species, to attempt to detect differences in soils in different types. ANOVA tests were performed between all cover types. Test were considered significant at $P < 0.05$.

Results and Discussion

Habitat descriptions. - A total of 217 sites was sampled throughout the study area (Fig. 5), of which 195 were complete transects and 22 were abbreviated samples done while mapping or conducting brood habitat sampling. We encountered 494 species in our sampling efforts on the study area (Appendix D) over 400 of which were in these transects. Abbreviated species names followed Garrison et al. (1976).

Species groups within the first level of the classification, including forest, shrub, herbaceous, marsh and aquatic types, are reported here. Cultivated lands and unvegetated areas were mapped but not sampled. Association tables for each cover type are listed in Appendix E.

Forest types. - Forested types were divided into coniferous, deciduous and mixed forest types. Of the 50 transects sampled, 29 were in coniferous forests, 17 in deciduous and 14 in mixed forest comities. Coniferous forest samples included 162 species, 59 of which were in at least 10% of the samples. Deciduous forest samples included 120 species, 59 of which were in at least 10% of the samples or had >5% cover in 1 transect. Mixed forest samples included 116 species, 56 of which were in at least 10% of the samples.

Coniferous forest sites were generally dominated by ponderosa pine, Rocky Mountain juniper, Douglas fir or Engelmann spruce (Picea engelmanii). Ponderosa pine was frequently associated with Rocky Mountain juniper, although both species also were found separately. On the lake, western larch (Larix occidentalis) and grand fir (Abies grandis) were frequent associates with Douglas fir and Engelmann spruce. Spruce forests commonly fit the PICEA/CLUN or PICEA,/EQAR Habitat Types (Pfister et al. 1977); however, other coniferous forest types did not fit local Habitat Type descriptions well.

Shrub understory in coniferous forest types was frequently composed of western snowberry (Symphoricarpos occidentalis), Wood's rose, Saskatoon serviceberry (Amelanchier alnifolia), or creeping Oregongrape (Berberis repens). Common grasses included compressed bluegrass (Poa compressa), cheatgrass (Bromus tectorum) and bluebunch wheatgrass (Agropyron spicatum), and forbs included dandelion (Taraxacum officionale), common yarrow (Achillea millefolium), spotted knapweed (Centaurea maculosa) and European strawberry (Fragaria vesca), Poison ivy (Rhus radicans) was present in one-third of the sites sampled.

Deciduous forests were dominated by black cottonwood, quaking aspen, paper birch/western birch (Betula papyifera/B. occidentalis), peachleaf willow (Salix- amygdaloides), and Russian olive (Eleagnus anqustifolia). Rocky Mountain maple (Acer glabrum) and robust forms of Douglas hawthorne (Crataegus donglasii) were associated with the cottonwood, birch and aspen types. Common shrubs were similar to those in the coniferous forest understory excluding creeping Oregongrape and including common chokecherry (Prunus virqiniana) and red-osier dogwood. The most frequent grasses in the understory were compressed bluegrass, redtop bentgrass (Aqrostis alba), and Kentucky bluegrass (Poa pratensis). Common forbs included feather solomonplume (Smilacina racemosa), dandelion, bitter nightshade (Solanum dulcamara), loosestrife

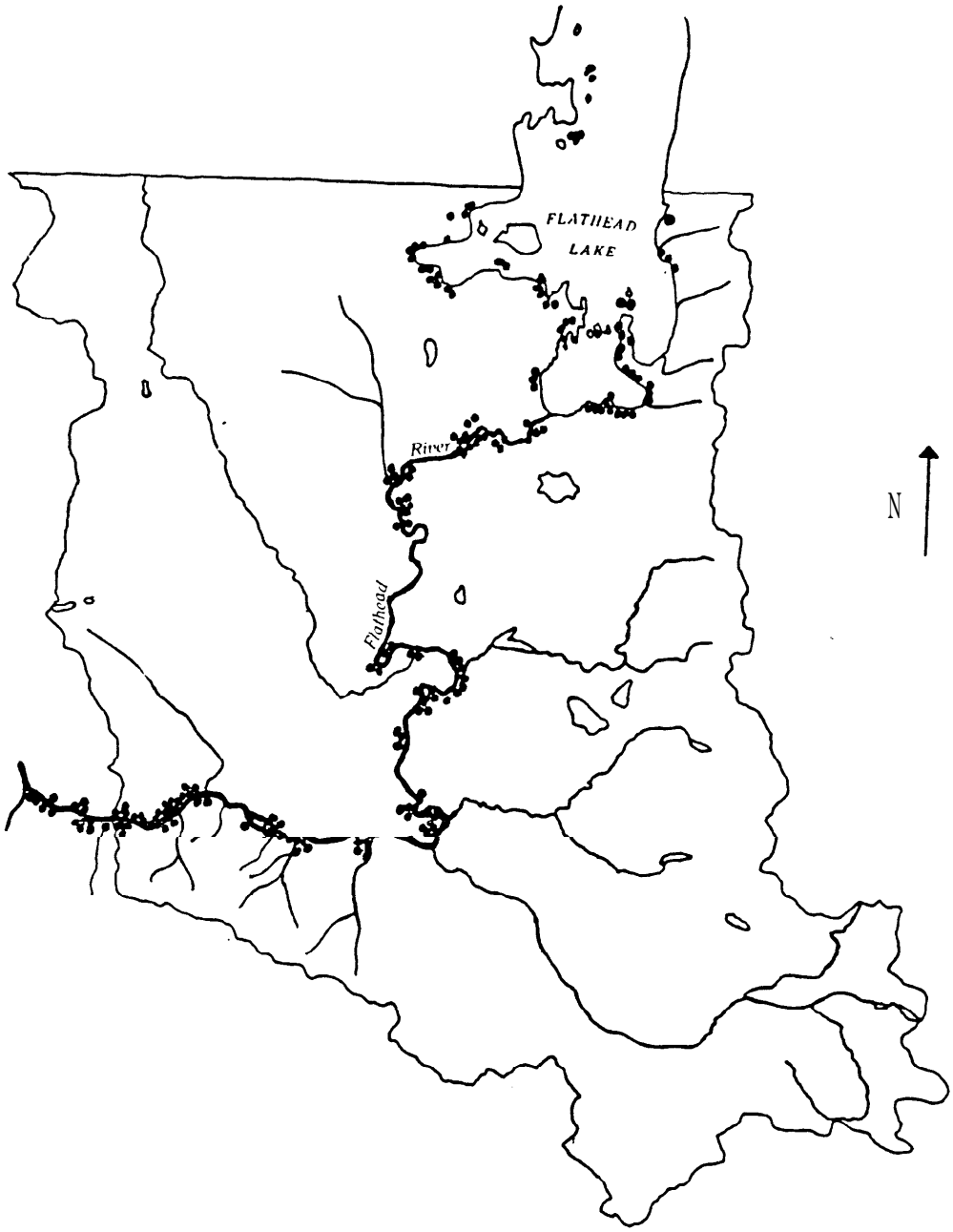

Fig. 5. Locations of transects sampled for habitat description along the south half of Flathead Lake and Flathead River, Montana, 1983-86.

(Lysimachia ciliata) Canada goldenrod (Solidago canadensis), Canada thistle (Circium arvense) , and red raspberry (Rubus ideus).

Mixed forests were highly variable in total species composition, but several dominant tree associations were recognized. Birch and Douglas fir were common together, sometimes with black cottonwood, aspen, and/or Rocky Mountain maple as well. Birch and spruce were commonly associated on lakeshore sites. Black cottonwood and ponderosa pine were frequently found together on the lower river, along with juniper, Douglas fir or aspen.

The environmental and physical characteristics of forest sites (Table 3) revealed some interesting comparisons. Coniferous forests, although highly variable, were generally found further from the HWM than deciduous or mixed forests. Shrubs and herbs were much taller, and comprised more canopy cover in deciduous and mixed forests than in coniferous forests. Meanwhile, more bare ground was present in coniferous forests. Total canopy cover was highest in deciduous forests; however, it was also high in mixed and coniferous forests.

Deciduous forests were noticeably absent from the upper river. Large stands of mixed forests were found on islands on the lower half of the river, and in portions of the lake shoreline. These forests appeared to be seral and were frequently in areas of disturbance from flooding. Otherwise, forest types were distributed throughout the study area.

Shrub types. - After analysis of stand data, shrub types were divided into riparian and upland instead of dense and sparse. Forty-eight transects were sampled in shrub communities, with 36 in riparian shrub and 12 in upland shrub types. Riparian shrub types included 167 species of which 66 were in at least 10% of the plots or had >l0% cover in at least 1 plot. upland shrub types included 93 species, of which 55 were in at least 10% of the plots or had >5% cover in 1 plot.

Sandbar willow, red-osier dogwood, Douglas hawthorne, Wood's rose, western snowberry and Bebb's willow (Salix bebbii) were the most frequent dominant shrubs in the riparian shrub type. Willow and dogwood were frequently associated with each other, and rose was frequently a co-dominant with hawthorne, dogwood, and snowberry.

Several tree species were found in a shrub-growth-form on gravel bars flooded by higher water levels. The most common of these were Rocky Mountain juniper and black cottonwood, with occasional occurences of quaking aspen and ponderosa pine. Many of the juniper and cottonwood gravel bar communities appeared to be in disclimax shrub stage due to ice caused erosion during winter , and unnatural water level fluctuations in spring and summer. Generally, these communities were distinct from adjacent communities , and did not form a gradient of increasing size and age as is frequently found on gravel bars of unregulated rivers similar to the Flathead.

Grasses frequently found in riparian shrub communities included redtop bentgrass, reed canarygrass (Phalaris arundinacea), fowl bluegrass (Poa palustris), Kentucky and compressed bluegrass, and quackgrass (Agropyron repens). Associated forbs included Canada thistle, hemp dogbane (Apocynun cannabinum), black medic (Medicago lupulina), Canada goldenrod, and loosestrife. Poison ivy was found in 42% of the sites.

Table 3. Environmental and physical characteristics ($\bar{X}$ and SD) of forest cover types, Flathead River and Lake, Montana, 1983-87.

Variable	Forest Type					
	Coniferous		Deciduous		Mixed	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Distance from HWM:						
Vertical (m)	10.3	25.4	1.2	2.6	1.8	1.3
Horizontal (m)	46.6	146.6	19.6	33.4	21.1	29.5
Shrub Height (cm)	38.4	30.7	164.0	118.9	111.2	75.5
Herb Height (cm)	27.9	15.0	67.9	39.7	36.1	16.6
Total % Cover:						
Tree	66.1	17.0	64.7	28.8	60.5	23.1
Shrub	29.9	30.1	63.6	25.5	66.3	23.9
Herb	9.1	18.0	27.1	38.1	9.0	16.2
Litter	51.2	27.3	63.8	28.6	61.7	25.9
Bareground	9.7	21.4	2.6	5.6	0.7	1.7
Surface Rock	6.6	10.3	6.0	18.4	6.3	16.5
Total % Canopy Cover	76.8	21.0	91.0	9.7	81.7	21.5

The upland shrub communities were characterized by four dominant species or species groups. Three of these were big sagebrush (Artemisia tridenizata), rubber rabbitbrush (Chrysotharmus nauseosus), and antelope bitterbrush (Purshia tridentat). The fourth was any one or a combination of creambush oceanspray (Holodiscus discolor), Saskatoon serviceberry and wax currant (Ribes cereum). This latter type was frequent on rocky outcrops along the lake.

Bluebunch wheatgrass, cheatgrass, prairie junegrass (Koeleria cristata) and Kentucky bluegrass were the most commonly encountered grasses in upland shrub communities. Fringed sagebrush (Arternisia frigida), arrowleaf balsamroot (Balsamorhiza sagittata), spotted knapweed, and flannel mullein (Verbascum thapsus) were the most common sub-shrubs and forbs.

Riparian shrub communities sampled were always near the HWN, while upland communities were sampled both near the HWM and a considerable distance inland and above the HWM (Table 4). Both sandbar willow and red-osier dogwood can tolerate flooding for more than 1 month (Gill 1970). Dominant shrubs were nearly 3X taller at riparian than upland shrub sites, while herbaceous layers were of similar height. Shrub cover averaged slightly denser at riparian sites, while herbaceous cover was considerably less. Litter, bare ground, and surface rock all averaged similar cover at riparian and upland shrub sites.

Herbaceous types. - Groupings based on relative moisture availability were used for the herbaceous types. The 4 groups classified were 1) gravel bar/mudflat (seasonlly inundated), 2) moist herbaceous, 3) dry herbaceous and 4) xeric (upland) herbaceous types. Sixty-six transects were sampled in herbaceous areas; 20 in the gravel bar/mudflat type, 16 in the moist herbaceous type, 17 in the dry herbaceous type, and 10 in the xeric herbaceous type. Samples in the gravel bar/mudflat type included 61 species, of which 41 were in at least 10% of the plots. Thoses in moist herbaceous included 98 species. Dry herbaceous plots included 141 species, and xeric types included 56 species.

The most common dominant species in the gravel bar/mdflat type were Columbia River mugwort (Artemisia lindlevana), hemp dogbane, slender spikerush (Eleocharis acicularis) field mint (Mentha arvensis), tufted hairgrass (Deschampsia cespitosa), Nevada rush (Juncus nevadensis) and compressed bluegrass. Columbia River mugwort was frequently associated with common gaillardia (Gaillardia aristata), and was the most common gravel bar community on the river. Small silty bays on the river, and the expansive mudflat exposed during spring drawdown on East Bay of the lake, frequently contained nearly monotypic slender spikerush communities.

Remaining dominants mentioned above were scattered throughout gravel bars along the river, and were frequently associated with common selfheal (Prunella vulgaris , chives (Allium schoenoprasum), Pacific aster (Aster chilensis), physostegia (Physostegia parviflora) as well as western witchgrass (Panicum occidentale) and redtop bentgrass. The Nevada rush community was restricted to a small area of the river near the mouth of Crow Creek. These communities were all restricted to areas between high and low water levels.

Table 4. Environmental and physical characteristics ($\bar{X}$ and SD) of shrub cover types, Flathead River and Lake, Montana, 1983-87.

	Shrub types			
	Riparian		Upland	
	$\bar{X}$	SD	$\bar{X}$	SD
Distance from HWM:				
Vertical (m)	0.0	0.9	29.5	41.6
Horizontal (m)	-0.3	18.6	95.5	140.8
Shrub height (cm)	172.0	101.7	64.4	69.2
Herb height (cm)	66.1	35.3	52.9	24.7
Total % cover:				
Tree	4.7	13.4	0.4	13.5
Shrub	64.8	20.7	38.2	27.6
Herb	8.3	21.9	38.7	22.5
Litter	37.4	32.5	36.6	15.5
Bare Ground	7.3	18.2	6.4	5.9
Surface Rock	12.9	29.1	13.0	21.8

Dominant species in moist herbaceous sites included several sedges, as well as rushes and grasses. These were blister sedge (Carex vesicaria), fowl bluegrass with Nebraska sedge (Carex nebraskensis), baltic rush (Juncus balticus), redtop bentgrass, and tufted hairgrass with tickseed (Coreopsis atkinsoniana) or sneezeweed (Helenium autumnale). One monotypic stand of prairie cordgrass (Spartina pectinata) was found approximtely 5 km up river from the confluence with the Clark Fork River.

These communities were all found within the flood plain or near the HWM of the lake, and are some of the most sensitive to changes in water level regimes. Additional species common to the sites included Canada thistle, quackgrass, common spikerush (Eleocharis palustris), jointed rush (Juncus articulatus), silverweed cinquefoil (Potentilla anserina), Kentucky bluegrass and dandelion. Several weedy species were also frequently present due to the high degree of disturbance this part of the riparian zone recieves from both flooding and grazing. These were some of the most productive feeding areas for geese and their broods, and many recieved intensive goose use.

Dry herbaceous sites were often on steep slopes and rocky banks adjacent to the river or lake. Many of these sites were adjacent to the riparian; few were contained within it. Three species groups were classified: western wheatgrass (Asropvron smithii) with Idaho fescue (Festuca idahoensis); bluebunch wheatgrass with rough fescue (Festuca scabrella) and Kentucky bluegrass with quackgrass. The first 2 of these are similar to Habitat Types described by Mueggler and Stewart (1980), and the latter is a disturbed community. Redtop bentgrass and Canada thistle were found in over half the samples, and spotted knapweed, common timothy (Phleum pratense), baltic rush, and prickly lettuce (Iactuca serriola) were also common.

Xeric herbaceous sites were usually further removed from the riparian, or were on especially fine and dry soils. The 3 dominant species or species groups identified were needle-and-thread (Stipa comata) with red threeawn (Aristida lonsiseta), spotted knapweed with erect cinquefoil (Potentilla recta), and sand dropseed (Soorobolus cryptandrus). Cheatgrass, fringed sagebrush, goatweed (Hvpericum perforatm and Kentucky bluegrass were frequently associated with these communities.

Many of these species were introduced, and some were troublesane weds. Fringed sagebrush, and indicator of intensive cattle grazing, was present in 50% of the samples. These areas were the most obviously impacted by grazing, some of which appeared to have been heavily grazed in the 1930's and never allowed to recover. These areas were not significantly impacted by water levels, but were used by geese because of their forage value and proximity to the river.

The environmental and physical characteristics for all herbaceous types combined indicated that, although variability was high, the average site was 4.4 m (SD 10.9) above and 5.4 m (SD 33.1) inland from HWM. Shrubs found in herbaceous types were short, averaging 11.7 cm (SD 26.4), while herb height averaged 48.2 cm (SD 32.4). Total tree, shrub and herb cover were 0.5% (SD 2.5), 2.6% (SD 4.2) and 53% (SD 42.) respectively. Herbaceous plots had the least litter (16.4%, SD 22.7) of any type measured, but the greatest amount of bare ground (10.9%, SD

21.3) and surface rock (25.7%, SD 40.0). Total overhead cover averaged less than 1% (0.9, SD 2.2).

Marsh types. - The marsh types were divided into tall (>0.5 m) and short (<0.5 m) marsh types, but due to species overlaps, are presented in one table. A total of 30 sites were sampled, and 134 species identified in these transects.

Dominant species in the tall marsh included common cattail, flowering rush Butomns umbellatus), hardstem bulrush, and reed canarygrass. Tall marshes were generally monotypic, with 60-90% cover by the dominant species. Common cattail, hardstem bulrush and reed canarygrass were all well distributed throughout the study area; however, common cattail was more abundant on shallow bays along the lake. This is apparently due to a high tolerance to fluctuating shallow water levels (Thompson 1983).

Flowering rush was found in a few small stands scattered along the south half of the lake. It is an introduced species, spreading rapidly and it appeared to be dispersed by the propellers of outboard motors from its frequent abundance in boat houses. It was used heavily by broods for food and resting cover at the north end of the lake where extensive stands have developed (Casey and Wood 1987), but it was only lightly used in one portion of our study area (Dayton Bay). Reed canarygrass was abundant on the lower river and was frequently grazed by geese.

Dominant species in the short marsh included water horsetail (Equisetum fluviatile), common spikerush, arumleaf arrowroot (Sasittaria cuneata), beaked sedge (Carex rostrata), marestail (Hippuris vulqaris) and a combination of jointed rush and slender spikerush. Field mint and curly dock (Rumex crispus) were frequent in these communities, as were redtop bentgrass and slender spikerush. Beaked sedge and marestail communities were frequently found adjacent to common cattail stands along the lake. Water horsetail, common spikerush and arumleaf arrowroot communities were common along the lower river.

Litter (residual cover) was abundant at marsh sites averaging 44.3% (SD 40.2); meanwhile, bareground only occupied 7.2% (SD 14.4) and surface rock less than 1% cover. Location of sampled sites averaged 0.66 m (SD 1.03) below the HWM, and 7.6 m (SD 15.6) into the river channel or lake bed.

These sites are vulnerable to water level fluctuations, yet are critical feeding sites for numerous shorebirds and fish, as well as geese in the late spring. As the most productive herbaceous sites, marsh types should be monitored as indicators of changes occurring due to water level fluctuations.

It is likely that the diversity of marsh habitat was greater on the river and lake before regulation of water levels. This was evidenced by the marsh at the south end of Swan Lake, a natural lake similar to Flathead Lake and approximately 16 km East of Flathead Lake, and by the Clark Fork River above its confluence with the Flathead River. The monotypic cattail and flowering rush marshes on the lake are primarily caused or encouraged by the unnatural water levels and the resultant stress caused to the communities.

Aquatic types. - Aquatic samples were difficult to differentiate into dominance groups due to overlap of species composition. Eleven sites were sampled, and 29 species identified. The algae Chara was the most ubiquitous species, occurring in 10 sites.

Dominant species and their groupings included: 1) fennelleaf pondweed (Potomogeton pectinatus and Richardson pondweed (Potomogeton richardsonii); 2) water-weed (Elodea canadensis and E. nuttallii), occasionally with spiked watermilfoil (Myriophyllum spicatum var. exalbescens); and 3) an assorted mixture of both **groups.** Other species frequently encountered were baby pondweed (Potamogeton pusillus), marestail, longbeaked bladderwort (Utricularia vulgaris) and grassleaf pondweed (Potamogeton gramineus).

Total plant cover in these plots averaged 94.5% (SD 6.6), and height of the plants (from substrate) averaged 73.1 cm (SD 32.7).

Soil sampling - Sixty-four sites were sampled, 50 in both A and B horizons and 14 in only the A horizon. Samples were divided among cover types as follows: 10 in coniferous forest, 10 in deciduous forest, 30 in riparian shrubs and 14 in herbaceous areas.

Soil texture did not vary between cover types, nor did the N, P, K, or OM content (Table 5). The pH, when compared over all levels, varied significantly ($P < 0.0001$). Higher pH levels were found in coniferous forest and shrub types, and lower levels in deciduous forest and herbaceous types. The abundant leaf litter in these types may contribute to these differences.

Within shrub types, OM, N and P were all significantly different between species groups, but no other variable differed significantly (Table 6). OM in the A horizon was highest in Douglas hawthorne sites and lowest in Salix spp. sites. The B horizon contained the highest OM in red-osier dogwood sites ($P = 0.001$). Hawthorne sites had the highest concentrations of N and P, and Salix sites had the lowest.

Habitat mapping. - Riparian habitats were mapped according to dominant species (Table 7) to the nearest 0.04 ha on more than 2200 ha along the lake and 2750 ha along the river. Upland habitats were mapped on more than 3000 ha adjacent to river riparian areas. Habitat and water level maps are available from the Natural Resources Department of the Confederated Salish and Kootenai Tribes.

The outline of the actual riparian zone on the lake resulted in 984.2 ha on the West Shore, 771.6 ha on the South Bay segment, and 257.0 ha on the East Shore, with a total of 2012.8 ha of riparian on the south half of Flathead Lake (from Goose Island on the West side, to Yellow Bay on the east side and south to the dam).

The upper river had a narrow band of riparian vegetation for most of its length, resulting in a riparian zone with 598.3 ha. The lower river had a wider and more intricate riparian zone, encompassing 2151.0 ha, nearly 4X that of the upper river. The upland area on the lower river was similar in size (1369.7 ha) to that of the upper river (1401.7 ha).

The riparian zone of the lower river was the most diverse and intricately patterned segment of the study area. Although sane water level effects were masked or complicated by land use practices (grazing

Table 5. Soil characteristic of the A and B horizons of samples collected in the Flathead River riparian zone, Montana, 1986.

	Cover Type							
	Coniferous Forest		Deciduous Forest		Riparian Shrubs		Herbaceous	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Texture - A horizon:								
SA	36.1	5.7	31.5	23.5	33.5	22.0	26.8	21.6
SI	34.4	5.5	38.0	21.0	37.1	15.4	41.5	14.2
CL	29.5	3.3	30.5	5.4	29.4	9.3	31.7	9.5
Texture - B horizon:								
SA	38.7	14.2	22.0	27.4	39.7	22.6	----	----
SI	33.0	10.4	40.0	19.1	32.5	15.0	----	a---
CL	28.3	4.5	33.6	9.8	27.8	8.2	----	----
%OM - A	2.58	0.62	3.88	1.94	3.35	1.91	3.16	1.52
B	0.65	0.15	2.33	2.31	1.01	0.60	----	----
Nutrients - A horizon								
N	0.35	0.26	2.17	2.06	1.91	1.62	1.20	1.00
P	8.40	1.64	7.70	1.78	8.89	2.88	9.19	3.50
K	60.08	27.89	67.20	13.39	73.99	60.14	69.44	69.25
PH (A)	8.14	0.24	7.36	0.44	8.01	0.43	7.49	0.73
PH (B)	8.38	0.53	7.40	0.57	8.22	0.43	----	----
	n=5		n=5		n=15		n=14	

Table 6. Soil characteristics of the A horizon in shrub sites characterized by different dominant species, Flathead River, Montana, 1986.

	Dominant Species						
	Red-osier Dogwood		Douglas Hawthorne		Sandbar Willow		Other Willow
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$
Texture:							
% Sand	30.8	14.9	19.1	6.4	46.3	30.4	68.2
% Silt	42.4	11.1	43.2	5.0	29.0	22.4	12.0
% Clay	26.8	4.6	37.7	9.1	24.7	9.0	19.8
8 OM[1]	3.24	1.73	4.92	0.99	2.22	1.78	0.56
Nutrients:							
N	2.20	1.78	2.16	1.30	1.61	2.15	0.40
P	7.98	2.19	11.14	3.38	7.70	2.06	7.00
K	42.04	13.97	139.20	62.87	39.95	26.69	43.80
PH	7.98	0.36	7.72	0.34	8.22	0.40	8.7
	n=5		n=5		n=4		n=1

[1]OM = Organic matter.

Table 7. Dominant-species types used for mapping habitats on the Flathead River and Lake, Montana, 1986.

1000 Forests

1100 Coniferous forests
- 1110 PSME
  - 1111 PSME-JUSC
  - 1112 PSME-PIPO-JUSC
  - 1113 PSME-PIPO-LAOC
- 1120 JUSC-PIP0
  - 1121 JUSC-PIPO
  - 1122 JUSC (only)
  - 1123 PIPO (only)
- 1130 PIEN
  - 1131 PIEN
  - 1132 PIEN-PSME-(PIPO)

1200 Deciduous forests
- 1210 POTR2
  - 1211 POTR2-COST
  - 1212 POTR2-SAEX
  - 1213 POTR2-ROWO
  - 1214 POTR2-CRDO
  - 1215 POTR2-other
  - 1216 POTR2-POTR
- 1220 POTR
  - 1221 POTR-SYOC
  - 1222 POTR-other
  - 1223 POTR-CRDO
  - 1224 POTR-PRVI
- 1230 BEPA
  - 1231 BEPA-POTR
  - 1232 BEPA-only
  - 1233 BEPA-POTR2
- 1240 SAAM2
- 1250 ELAN

1300 Mixed forests
- 1310 POTR2-PSME (-PIPO)
- 1320 POTR2-PIPO-JUSC
  - 1321 with POTR
- 1330 POTR-JUSC
  - 1331 with PIPO
- 1340 BEPA-PIEN
- 1350 BEPA-PSME (-ACGL)
  - 1351 PSME-ACGL
- 1360 BEPA-PSME-POTR2-POTR

2000 Shrubs

2100 Riparian shrubs
- 2110 COST-SAEX
  - 2111 COST-SAEX-POTR2
  - 2112 COST-SAEX-CAR02
  - 2113 COST-SAEX-PHAR
  - 2114 COST-SAEX-ROWO
  - 2115 COST-SAEX-AGAL
- 2120 SAEX
  - 2121 SAEX-AGAL
  - 2122 SAEX-PHAR
  - 2123 SAEX-other
  - 2124 SAEX-JUSC9
  - 2125 SAEX-ARL12
  - 2126 SAEX-POTR9
- 2130 COST
  - 2131 COST-PHAR
  - 2132 COST-JUSC
  - 2133 COST-ROWD-SYOC
  - 2134 COST-CRDO
  - 2135 COST-other
- 2140 SABE
  - 2141 SALA3
- 2150 CRDO
  - 2151 CRDO-AMAL
  - 2152 CRDO-JUSC
  - 2153 CRDO-ROWO
  - 2154 CRDO-only
  - 2155 CRCO-PRVl
- 2160 ROW-SYOC
  - 2161 ROWO-SYOC
  - 2162 ROW-only
  - 2163 SYOC-only
  - 2164 PRVI-SYOC
- 2170 Shrubby trees
  - 2171 POTR9-JUSC9
  - 2172 POTR9-only
  - 2173 JUSC9-oniy
  - 2174 POTR9-JUSC9-PIPO9

2200 Upland shrubs
- 2210 HODI (-RICE-PHMA-PHLE)
- 2220 ARTR
- 2230 PUTR
- 2240 AMAL
- 2250 CHNA

Table 7. Continued.

3000 Herbaceaus

3100 Seasonally inundated (mudflats/gravel bars)
- 3110 ARLI2
  - 3111 ARLI2-AGAL
- 3120 APCA
- 3140 ELAC
- 3150 JUNE
- 3160 DECE-MEAR3
- 3170 MEAR3
- 3180 POCO
- 3190 DIST

3200 Moist herbaceous
- 3210 SPPE
- 3220 CAVE
- 3230 POPA (-CANE)
- 3240 **DECA-HEAU-COAT**
- 3250 **JUBA-CAREX-AGAL**
  - 3251 JUBA-AGAL

3300 Dry Herbaceous
- 33 **10 AGSM-FEID**
  - 3311 **AGSM-FEID**
  - 3312 AGSM (>l0%)
  - 3313 FEID (>l0%)
- 3320 **AGSP-FESC**
  - 3321 **AGSP-FESC**
  - 3322 AGSP (>l0%)
  - 3323 FEID (>l0%)
- 3330 **FOPR-AGRE**
  - 3331 **POPR-AGRE**
  - 3332 FOPR
  - 3333 **AGRE**

3400 Xeric herbaceous
- 3410 STCO2-ARLO3
- 3420 CEMA-PORE2
- 3430 SPCR

4000 Cultivated Land

4100 Pasture
4200 Grainfield
4300 Alfalfa
4400 Orchard
4500 Lawn
4600 other
4700 Homesite
4800 Park/campground
4900 Road

5000 Marsh

5100 Tall marsh
- 5110 TYLA
- 5120 BUUM
- 5130 SCAC
- 5140 PHAR
- 5150 SCFL
- 5160 JUAR (-ELAC)

5200 Short marsh
- 5210 EQFL
- 5220 ELPA
- 5230 SACU
- 5240 CAR02
- 5250 HIW
- 5260 JUAR (-ELAC)

6000 Aquatics

6100 PORI-POPE
6200 ELCA3/ELNU
6300 PONA-POAM2
6400 POPE-RAAQ
6500 MYSPE
6600 CHARA
6700 PORI/ELCA3/MYSPE/CHARA/POAM2

7000 Unvegetated

8000 water

and cropping), significant impacts of water level regulations were suggested by analyses of these maps. These are detailed in the following section.

Water level mapping. - The total of 1834.2 ha exposed between low and high water levels on the study area were approximately evenly divided between the lake and the river (Table 8). On the lake, the three portions differed in shoreline length, accounting for some differences in area exposed at drawdown. Differences are also due to distinct characteristics of each segment. The South Bay included several large shallow bays which accounted for approximtely 65% of the drawdown area. The West Shore included several large islands and a greater amount of shoreline (approximately 77 km) than the other lake segments There were also 3 bays (Dayton, Elmo, and Big Arm) with minor amounts of mudflat exposed at low water in this segment. The East Shore was the shortest segment with the least amount of area exposed at drawdown, most of which was a relatively steep gravel beach.

The upper and lower river segments represented approximately equal lengths; however , exposed areas differed greatly. The upper river was straighter, faster, and has steeper banks and fewer islands than the lower river. The lower river included numerous back waters and sloughs dewatered at lower water levels. In addition, the lower angle of the banks and wider floodplain produced an increased area flooded at high water levels. On the lower river, wetted area at low water was 1.7X that of the upper river, but at high water it was nearly 5X the area flooded on the upper river.

HISTORICAL PERSPECTIVES

Lake

Waterfowl habitat in East and Polson bays has been dramatically altered since the construction of Kerr Dam in 1938. The majority of the habitat lost was in East Bay (Fig. 6), although 2 small bays on the west shore of Polson Bay were also affected due to changes in duration of inundation.

During our study, the majority of the 433.2 ha (1071 acres) exposed at drawdown was unvegetated mudflats. Approximately 20% of the area (bordering the HWM) was a cattail marsh, and 30% of the mudflat area contained sparse (<10%) cover of slender spikerush. The rest of the area was unvegetated. As the water rose, submerged aquatic vegetation began to develop on the flooded mudflats.

In late April, when goslings began to hatch, the entire area was exposed (Table 9). By early May, approximately 342 ha still consisted of mudflats, and the distance from water line to upland vegetation was up to 1 km. **At** this time most goslings on the lake were hatched and at their most vulnerable stage. Most broods observed stayed near the water's edge for security (escape cover) and relied heavily for feeding

Table 8. Area exposed between low[1], medium[2], and high [3]water levels and approximate shoreline length for the south half of Flathead Lake and the Flathead River, Montana, 1986.

	Area (ha) Exposed Between Water Levels			Approximate Shoreline Length (km)
	Low-Medium	Medium-High	Low-High	
Lake:				
West Shore	54.7	180.8	235.5	77.3
East Shore	14.9	49.8	64.7	33.0
South Bay	211.7	370.1	581.8	58.0
Total	281.3	600.7	882.0	168.3
River:				
Upper River	208.2	89.7	297.9	125.6
Lower River	234.9	419.4	654.3	154.6
Total	443.1	509.1	952.2	280.2

[1]Low water level on the Lake = 2884 ft. (879.0m); on the River = 3500 cfs.

[2]Medium water level on the Lake = 2888' (880.3m); medium or average the River = 11,700 cfs.

[3]High water level on the Lake = 2893 ft. (881.8m); on the River = 33,000 cfs.

Legend: Area wetted at low water, 2884'

Additional area wetted at 2886'

Additional area wetted at 2888'

Additional area wetted at 2890'

Additional area wetted at 2893'

Fig. 6. Areas wetted at different water levels on East Bay, Flathead Lake, Montana, 1986.

Table 9. Mudflat area (ha) on East and Polson Bays during the filling of the lake from low to full pool, and approximate dates when elevations were reached, Flathead Lake, Montana, 1984-86.

	Area Exposed at Lake Elevation			
	2884 ft (879.0 m)	2886 ft (879.6 m)	2888 ft (880.3 m)	2890 ft (880.9 m)
East Bay	378.0	296.8	232.3	76.2
Polson Bay	55.2	44.9	24.7	21.0
Total (South Bay)	433.2	341.7	257.0	97.2
Approximate date	15 Apr	1 May	15 May	1Jun

on the scant amount of available vegetation adjacent to the rising water. To reach the more productive pastures for grazing the flightless goslings and adults crossed the mudflats, exposing themselves to increased risks.

Three sources facilitated documentation of the vegetative characteristics of these areas prior to impoundment: 1) an aerial photograph of the southeast corner of the lake taken in July of 1934; 2) records and publications by scientists pre-1938; and 3) conversations with long term residents of the lakeshore area (pre-dam). In general, all 3 sources indicated that the mudflats were highly productive wet meadow areas that graded into an emergent marsh near the old lakeshore. **From** the photographs and conversations with the residents, it appears the area was a large grass and sedge meadow with pockets of marsh plants in low spots within the meadow, and a band of bulrush and cattails along the lake margin.

Jones (1910) referred to the East Hay area as the "Polson swamp" and remarked on the large beds of aquatic vegetation in the shallow waters. He also noted the presence of Menvanthes trifoliata, a productive wet meadow forb not found in other areas of the lake. Elrod (c.1910) wrote that "the southeastern corner (of Flathead Lake) is a large swamp with thousands of acres of meadow" and "the lake is bordered by a wide fringe of bulrushes, then a wide swampy meadow, and finally a dense jungle of brush." Norton (1919) described an extensive meadow in the southeastern comer, with mudflats and a "swamp." She noted that the meadow included various grasses, sedges and rushes, and they were submerged at high water. Ranching families in the area recall harvesting hay from many of these bays before dam construction (pers. comm. H. Sorenson, N. McAlpin, M. Slack).

The wet meadow areas adjacent to the lakeshore appeared to have been excellent brooding areas, for ducks and geese, while the upland meadows were probably good nesting habitat for upland nesting ducks. The marsh-wet meadow area may have been used by nesting swans and shorebirds. Trumpeter swans (Cygnus buccinator) were documented to have used the Flathead Valley as 1 of their last natural breeding areas in the lower 48 states (Banko 1960), and may have used these bays for nesting and brooding.

Waterfowl broods prefer a shoreline where emergent and submerged vegetation are interspersed with water. This provides security and feeding opportunities in 1 area. Aquatic invert&rates, essential to young duck broods, also abound in the emergent and submerged marsh zone. Under the current regulation of lake levels, submergent vegetation (and associated invertebrates) cannot begin development until wetted, and are not available to waterfowl at the most critical portion of the year.

On our study area, Canada geese return to specific brood areas every year. Although we had no data on goose brood distributions before impoundment, geese did use each of the 5 bays in the 1950's (Barraclough 1954). Only 2 of the 5 bays were commonly used by brooding geese during our study. In place of the lush wet meadow were mudflats, which, in their most densely vegetated areas, produced <0.1X the biomass of a grass-sedge meadow. In addition to the lack of available forage,

goslings and flightless adult geese crossed the exposed mudflats to reach pastures with good forage, requiring greater energy expenditure and increased exposure to predation.

We also noticed several areas along the south shore of South Bay, and the south and west shores of Elmo Bay, where forested habitat had been lost due to inundation. Erosion has occurred along much of the lakeshore (Hauer et al. 1986), and was evident on the middle of U-Shaped Bird Island, the west side of East Bay, and the west shore of Elmo Bay near Big Arm. This erosion is likely to continue until a new stabilized land profile is established which compensates for the increased duration of high water levels and consequent wave action (pers. comm. M. Lorang). The effects of this erosion to geese appeared to be minor at this time, but should continue to be monitored as all the brood areas identified above high water were within 10 m of the lake margin and may be susceptible to losses from erosion.

River

Aerial photographs of pre-dam conditions were obtained fran FS flights which overlapped a few portions of the reservation adjacent to FS lands. We advertised locally for pre-dam oblique photos of the lake and river but received only a few. The major source of pre-1938 oblique photos was the Elrod collection, located in the archives of the University of Montana's Mansfield Library. From these sources, habitat changes were apparent on the river.

Several islands on the lower river (Knowles, Grassy, and others) appeared to have been devoid of vegetation before the dam. This was likely due to the tremendous floods (relative to the past 5 decades) which historically occurred about once a decade. predam flows on the river exceeding or equaling 75,000 cfs (for a week's duration) occurred 4 times in the 30 years between 1907 and 1937 (USGS data acquired through Univ. of Montana Biological Station).

Many of these islands now contain grass and shrubs but are altered by large blocks of ice which are dragged over them during extremely cold winters. We observed this phenomena during January of 1985, and in the succeeding months noticed many areas of shrub and juniper cover along the banks of the main channel and islands which were sheared and eroded. Predam conditions may have included ice-caused erosion, but river flows during winter months were generally low (<3,000 cfs). The damage, therefore, would have been minimal compared to present conditions, where water levels are normally above 8-10,000.cfs during that time period.

Another area of impact is the gravel bar/shoreline area between low and medium water levels. Although in some locations, this area is sparsely vegetated, much of this zone is devoid of vegetation. This appears to be due to the constantly fluctuating water levels, which, if kept higher, would encourage submerged aquatic and emergent marsh species to grow, or if kept lower, would allow more terrestrial grasses, forbs and sedges to become established. Only those species which can tolerate daily or even hourly changes in status between being submerged or dry, can survive. This littoral area encompassed 238.5 ha on the lower river. These areas were important to geese year round, both for loafing and feeding due to their proximity to the water.

Deciduous forests also appeared to have been impacted by the operations of Kerr Dam. Approximtely 15 trees of different diameters and different locations were aged using an increment borer. Ages of other cottonwood trees of similar size were inferred from this sample. From our observations, it appeared that most of the black cottonwood forests on the lower river were 50-100 years old. The few island and backwater areas which supported cottonwood stands less than 30 years in age, appeared to be insufficient to sustain the natural abundance of cottonwoods along the lower river. The reduction or lack of regeneration in Populus species on regulated rivers has been well documented (Hosner 1957, Hosner 1958, Fenner et al. 1985). As cottonwood forests degenerate over the next 100 years, the impact of the lack of replacement will become more apparent.

Current water levels appeared to be impacting cottonwood regeneration in 2 major ways: 1) flooding of banks for extended periods of time during June and July inhibited germination and growth of young cottonwood trees (Moss 1938, Wilson 1970), and 2) lack of extreme floods reduced the amount of "pioneering" habitat available for primary successional species. Sandbar willow, also a "pioneering" species, tolerates longer periods of inundation during its initial growth phase (Walters et al. 1980), and therefore occupied much of the available habitat.

The lack of regeneration, however, is not entirely due to water levels. Young cottonwood trees are also readily grazed by cattle, and used by beaver (Castor canadensis). Most of these effects are localized, while the water level effects are general and encompass the entire lower river.

The lack of mature cottonwoods is not likely to be evident until the current population degenerates and is replaced by conifers, as the next successional phase. Numerous wildlife species, dependent on these mature cottonwood forests, may be affected. Further study of this impact is needed to fully assess the situation.

The lack of catastrophic events due to the control of water levels imposed on the river by Kerr Dam has reduced the diversity of habitats downstream (White 1979). If periodic (i.e. once a decade) simulations of water levels during extreme wet and dry years could be incorporated into the management and operations of Kerr Dam, this problem could be at least partially alleviated.

SURVEYS OF TERRITORIAL PAIRS

Introduction

Annual aerial surveys of territorial goose pairs are currently used by waterfowl managers in the Flathead Valley as an index to the nesting goose population. Aerial surveys are an efficient way to count geese in this area, especially where nest densities are low and ground counts would not be as cost-effective. Counts of goose pairs may be useful in

estimating the number of nests in an area if the ratio of indicated pairs/nest does not change between years. Other studies have found Canada goose pair surveys unsuitable in estimating nesting populations (Geis 1956, Hanson and Eberhardt 1971, Tacha and Linder 1978). We evaluated pair surveys on several wetland components within our study area to identify a suitable method for each component. If each component could be censused accurately, a total production figure for the study area could be obtained, by adding components. Objectives of our pair surveys were: 1) evaluate the effectiveness of surveys at estimating the goose nesting population and recommend suitable survey methods, and 2) identify areas where pair surveys would be useful for monitoring nesting geese.

Methods

Pair surveys were conducted by plane and boat weekly from the last week in March through mid-April (peak incubation period) during 1983-87 on the river and 1984-87 on the lake. Therefore, the number of nesting goose pairs should be at a maximum during this time. Plane surveys on the river were conducted during the morning (0900-1030 hours) and afternoon (1330-1500 hours) of the same day, and river boat surveys from 0730 to 1800 during a single day. All surveys were conducted from north to south on the river.

The perimeters of 6 island groups in the lake were surveyed by plane and boat. From 1984-86 Melita, the Bird, and the Northern islands were surveyed, and in 1986 Dream, Drift, and the Narrow's islands were also included. All surveys were conducted in the morning between 0800 and 1200 hours. We did not intentionally flush geese from islands to maximize counts as is usually done during surveys by management agencies.

Plane surveys were conducted using a Cessna 185 airplane flown at heights of approximately 30 m and a mean airspeed of 120 km/hr. Boat surveys were conducted in boats from 4-5 m in length and powered by 25-70 horsepower outboard motors. Geese were classified as indicated territorial pairs or non-breeding birds using methods similar to Hanson and Eberhardt (1971), and Allen et al. (1978). Pairs of geese were counted as indicated territorial pairs if they were at least 10 m from any other geese when observed. Single geese similarly spaced were considered to represent the male of a nesting pair, and hence were also counted as indicated territorial pairs. Flocked geese (>2 birds) were considered non-breeding birds.

River pair survey data from 1983-86 were analysed using a multi-method statistical analysis (Carter 1981). This procedure compared 2 survey methods (indicated pairs from 2 survey methods) to a known standard (nest numbers from ground searches) and identified which of the 2 methods gave the most reliable estimate. Furthermore, a corrected equation was derived from the procedure that provides the most reliable estimate (in our case nest numbers from indicated pairs) for a given method.

Sample sizes on the lake were too small to use the Carter (1981) method; therefore, we used the ratio of indicated pairs (ip)/observed nests (n) to estimate nest numbers using the formula:

$$\text{estimated nest numbers} = \frac{\text{number of indicated pairs}}{ip/n}.$$

Percent error rates, which were the percent difference between the estimated number of nests and the observed nest number, were calculated as follows:

$$\text{percent error} = \frac{\text{estimated nests - observed nests}}{\text{observed nests}} \times 100.$$

Aerial pair survey data were also collected on the reservoirs when possible.

Results

River. The number of indicated pairs observed on morning plane surveys were greater than afternoon surveys, and error rates for estimates using the ip/n method were in general, less for morning surveys (Table 10). The ip/n ratios were greater than 1.0 and the mean for all years was 1.29 ip/n for morning plane surveys. The number of indicated pairs observed, ip/n ratios, and error rates were similar for morning plane surveys and boat surveys (Tables 10 and 11).

The corrected equation used to estimate nest numbers on the river from indicated pairs observed on morning plane surveys was: estimated number of nests = $-1.338 + 0.845\ X_1$, where X_1 = the mean number of indicated pairs observed on morning plane surveys. Using this equation to estimate nest numbers, error rates were very low in 1985 and 1986 (Table 12). Pair survey data in 1987 were independent of the nest estimate equation since these data were not used in calculation of the equation. The error rate in 1987 was only 2.58, compared to 5.1% error for 1987 data using the ip/n nest estimation method (Table 13).

Lake. - The ip/n ratios observed on the lake were less than 1.0. For the 3 major island groups (Melita, Birds, and Northern Islands) we observed approximately l/2 of the indicated pairs that were actually there (i.e. ratios were approximately 0.5 ip/n) (Table 14). More indicated pairs were observed on boat surveys than plane surveys (Tables 14 and 15), but ip/n ratios were generally less than 1.0. Error rates for the 3 major island groups ranged from 0-28.6% for plane surveys and were similar between plane and boat surveys. Using 1987 lake pair survey data as a test of accuracy for the ip/n estimation method, error rates ranged from 7.1-8.3% for the 3 major island groups (Table 13). Error rates for Dream, Drift, and the Narrow's Islands were high; however, our data were limited to only 1 year on these islands.

Table 10. Counts of Canada goose indicated territorial pairs from aerial surveys, Flathead River, Montana, 1983-86.

		No. Nests	$\bar{X}$ Indicated Pairs[a]		Indicated Pairs/Nest		% Error[b]	
Year	n	Observed	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon
1983	3	53	72	50	1.36	0.94	5.7	-9.4
1984	3	56	81	74	1.45	1.32	12.5	25.0
1985	3	71	85	76	1.20	1.07	-7.0	1.4
1986	3	66	79	58	1.20	0.88	-7.6	-16.7
$\bar{X}$ All Years	4	61	79	64	1.29	1.05	-	-

[a] Indicated pairs = singles + pairs.

[b] Error = percent difference between estimated and observed nest number estimated nests = $\bar{X}$ indicated pairs / y indicated pairs/nest, y= 1.29 for morning and 1.05 for afternoon surveys %error = (estimated nests - observed nests / observed nests) x 100

Table 11. Counts of Canada goose indicated territorial pairs from boat surveys, Flathead River, Montana, 1983-84.

Year	n	No. Nests Observed	$\bar{X}$ Indicated Pairs[a]	Indicated Pairs / Nest	% Error[b]
1983	3	53	66	1.24	-11.3
1984	3	56	85	1.52	+ 8.9
$\bar{X}$ All Years	2	54	75	1.39	

a Indicated pairs = singles + pairs.

b Error = percent difference between estimated and observed nest numbers; estimated nests = X indicated pairs / $1.3\bar{9}$ indicated pairs/nest; % error = (estimated nests - observed nests / observed nests) x 100.

Table 12. Estimated Canada goose nest numbers and error rates observed using a population estimation equation[a] derived from 1983-86 morning plane surveys of indicated territorial pairs, Flathead River, Montana, 1983-87.

Year	n	$\bar{X}$ No. Indicated Pairs[b] Observed	Estimated No. Nests	Observed No. Nests	% Error[c]
1983	3	72	59	53	11.3
1984	3	81	67	56	19.6
1985	3	85	70	71	-1.4
1986	3	79	65	66	-1.5
1987[d]	3	97	81	79	2.5

[a]Estimated no. nests = -1.338 + 0.845X1; Where Xl = $\bar{X}$ number of indicated pairs observed on morning plane surveys of the river for the respective year.

[b]Indicated Pairs = singles + pairs.

[c]Error = percent difference between estimated and observed nest numbers; estimated nests = $\bar{X}$ indicated pairs / y indicated pairs/nest; % error = (estimated nests - observed nests / observed nests} x 100.

[d]Data from 1987 were not used in calculation of the population estimate equation and are independent of the equation.

Table 13. Estimated nest numbers and error rates from 1987 plane Canada goose territorial pair surveys calculated using previously established indicated pair/nest ratios, Flathead Lake and River, Montana, 1987.

Area	n	No. Indicated Pairs[a] Observed in 1987	Indicated Pairs / Nest Used for Estimation[b]	No. Nests Estimated	No. Nests Observed	% Error[c]
LAKE:						
Melita Island	3	14	0.54	26	24.3	+8.3
Bird Islands	3	21	0.54	39	42.1	-7.1
Northernd Islands	3	33	0.62	53	49.2	+8.2
RIVER:	3	97	1.29	75	79.1	-5.1

[a]Indicated pairs = singles + pairs

[b]Ratios used were obtained from mean values presented for the respective areas in Table 25 for the lake and Table 21 ($\bar{X}$ morning) for the river.

[c]Error = percent difference between estimated and observed nest numbers; estimated nests = X indicated pairs / y indicated pairs/nest; % error = (estimated nests - observed nests / observed nests) x 100.

[d]Includes: Cedar, Shelter, Rock, Goose, and Douglas Islands.

Table 14. Counts of Canada goose indicated territorial pairs from aerial surveys, Flathead Lake, Montana, 1985-86.

Area	Year	n	$\bar{X}$ Indicated Pairs[a]	No. Nests Observed	Indicated Pairs / Nest	% Error[b]
Melita Island:	1984	3	20	37	0.54	13.5[d]
	1986	3	5	14	0.36	-28.6[d]
	$\bar{X}$ 84-86	2	12	25	0.48	-
Bird Islands:	1984	3	34	63	0.54	0.0[d]
	1985	3	34	65	0.52	-3.1[d]
	1986	3	22	38	0.58	+7.9[d]
	$\bar{X}$ 84-86	3	30	55	0.54	-
Northern Islands[c]:	1984	3	28	39	0.72	+15.4[d]
	1985	3	27	40	0.67	+7.5[d]
	1986	3	23	48	0.48	-22.9[d]
	$\bar{X}$ 84-86	3	26	42	0.62	-
Dream Island:	1986	3	4	20	0.20	-65.0[e]
Drift Island:	1986	3	5	16	0.31	-43.7[e]
Narrow's[c] Islands:	1986	3	8	8	1.00	+87.5[e]
$\bar{X}$ All Areas:	84-86	11	19	35	0.54	-

[a] Indicated pairs = singles + pairs.

[b] Error = percent difference between estimated and observed nest numbers; estimated nests = $\bar{X}$ indicated pairs / y indicated pairs/nest; % error = (estimated nests - observed nests / observed nests) X 100.

[c] Includes: Cedar, Shelter, Rock, Goose, and Douglas Islands.

[d] The indicated pairs/nest ratio used to calculate % error was the $\bar{X}$ ip/n for the respective area.

e The ip/n ratio used to calculate % error was the X ip/n for all the areas combined (i.e., 0.54 ip/n).

Table 15. Counts of Canada goose indicated territorial pairs from boat surveys, Flathead Lake, Montana, 1984-85.

Area	Year	n	$\bar{X}$ Indicated Pairs[a]	NO. Nests Observed	Indicated Pairs / Nest	% Error[b]
Melita Island:	1984	3	19	37	0.51	-27.0[d]
Bird Island:	1984	3	42	63	0.67	+1.6[e]
	1985	2	42	65	0.65	-1.5[e]
	$\bar{X}$ 84-85	2	42	64	0.66	
Northern Islands[c]:	1984	2	30	39	0.77	-12.8[e]
	1985	2	40	40	1.00	+12.5[e]
	$\bar{X}$ 84-85	2	35	39	0.89	
$\bar{X}$ All Areas:	84-85	5	35	49	0.71	

a Indicated pairs = singles + pairs.

b Error = percent difference between estimated and observed nest numbers; estimated nests = X indicated pairs / y indicated pairs/nest; % error = (estimated nests - observed nests / observed nests) x 100.

c Includes: Cedar, Shelter, Rock, Goose, and Douglas Islands.

d The ip/n ratio used to calculate % error was the $\bar{X}$ ip/n for all areas combined (i.e., 0.71 ip/n).

e The ip/n ration used to calculate % error was the $\bar{X}$ ip/n for the respective area.

Reservoirs. - Error rates of pair surveys on the reservoirs were higher than on the lake or river, however, our data set was limited to l-2 surveys annually (Table 16). Error rates were highest on Ninepipe, where most nesting geese occurred. The ip/n ratio was 1.39 and was similar to ratios observed on the river.

Discussion

Numbers of goose pairs on the river were consistently **greater in the** morning than afternoon. This is likely caused by either some birds leaving the study area in the afternoon, or by birds using river habitats in the afternoon where they were less visible. The first explanation seems to be the most likely since pairs observed on our afternoon boat surveys were also less than on morning surveys (Mackey et al. 1985, Matthews et al. 1986), and during boat surveys most birds flushed regardless of the habitat they were using.

The number of pairs observed on plane and boat surveys were similar for the river; however, on the lake the numbers of pairs were usually greater on boat surveys than plane surveys. On the river it appeared that most geese present were observed, regardless of the survey method. The river was a long, narrow study area with relatively open habitats. Furthermore, most geese used island or mainland shorelines and were easily observed. In contrast, lake geese used the interior of large densely timbered islands, and were difficult to observe unless flushed. Lake boat surveys likely resulted in more observations of pairs because pairs using island interiors were more likely to be flushed by a boat than by a plane.

The ip/n ratios were very different between the lake and river. Ratios on the lake were generally 0.5-0.6 ip/n, whereas on the river they were 1.2-1.3 ip/n. This was a result of differences in observability of pairs between the 2 areas. These differences in ratios illustrate the need to document ip/n ratios for different environments before selecting a ratio to use. If a ratio of 1.3 ip/n was used on the lake as was used on the river and by Ball et al. (1981), the number of nests would have been greatly underestimated. In areas with relatively open habitats, and where most pairs were readily observable, ip/n ratios ranged from 1.2-1.4. This is further supported by observed ratios of 1.2 ip/n by Hanson and Eberhardt (1971) and 1.3 by Ball et al. (1981) in eastern Washington.

Aerial pair surveys showed promise as an efficient means of predicting nest numbers on the river, Melita, Birds, and Northern islands. The nest number estimation equation calculated for morning aerial surveys on the river was very accurate at predicting nest numbers; the error rate was only 2.5% for 1987 data. Morning plane surveys were selected for the equation analysis because: 1) aerial surveys are currently being conducted by management agencies and will likely continue in the future, and 2) morning plane surveys provided the most reliable method, and 3) our sample sizes were largest for this method. Using the ip/n ratio method on the 3 lake island groups resulted in nest estimates within 10% of the actual nest number with the 1987 independent data set. We recommend that ratios of 0.54 ip/n be used for Melita and the Bird islands, and 0.62 ip/n for the

Table 16. Counts of Canada goose indicated territorial pairs from aerial surveys of reservoirs, southern Flathead Valley, Montana, 1985-86.

Reservoir	Year	n	$\bar{X}$ Indicated Pairs[a]	NO. Nests Observed	Indicated Pairs / Nest	% Error[b]
Ninepipe:	1985	1	166	72	2.31	+65.3
	1986	2	82	87	0.94	-32.2
	$\bar{X}$ 85-86	2	124	79	1.57	–
Kicking Horse:	1985	1	9	7	1.29	-14.3
	1986	2	9	6	1.50	0.0
	$\bar{X}$ 85-86	2	9	6	1.50	–
Crow:	1986	2	8	8	1.00	-25.0
Horte:	1986	2	19	16	1.19	-12.5
Pablo:	1985	1	5	11	0.45	-63.6
	1986	2	17	16	1.06	-25.0
	$\bar{X}$ 85-86	2	11	13	0.85	–
$\bar{x}$ All Areas:	85-86	8	39	28	1.39	–

[a] Indicated pairs = singles + pairs.

[b] Error = percent difference between estimated and observed nest numbers; estimated nests = X indicated pairs / 1.39 indicated pairs/nest; % error = estimated nests - observed nests / observed nests x 100.

Northern Islands. We stress that these ratios are only valid when used with our survey methods (i.e., geese were not intentionally flushed to maximize counts by "buzzing" islands).

Although pair surveys in some areas are relatively accurate at predicting nest numbers (likely within 10%), they have limited value in estimating production by the nesting goose population because nest success is not considered. During years of low nest success such as we observed on the river in 1985 and 1986, use of pair survey data could be misleading.

Our pair survey data on the reservoirs were limited. Hopefully, these data will be useful to future research. Data should be collected on these areas to document ip/n ratios on each reservoir before using pair survey data to estimate nest numbers.

NESTING / ARTIFICIAL NEST STRUCTURES

Introduction

Canada goose nest surveys have been conducted in the Flathead Valley since the 1950's. Nest numbers on the Flathead River below Kerr Dam were lower from 1980-82 than in the 1950's (mean number of nests = 31 from 1980-82 vs. 46 in the 1950's) (Ball 1983). Nest success rates observed from 1980-1982 (mean = 57%) were somewhat low compared to other studies. Bellrose (1978:161) noted that the average nest success rate reported in studies of Canada geese is approximately 70%. The primary cause of low nest success on the river from 1980-1982 was mammalian predation; low and fluctuating water levels allowed predators access to nesting islands (Ball 1981). High river water levels in 1982 caused several nests to be flooded (I. J. Ball, unpublished data).

If water fluctuations were affecting production of the river goose population, we reasoned that providing artificial nest structures in trees along the river, free from water fluctuations might: 1) increase the nesting population; 2) allow ground nesting geese to shift use to structures; and/or 3) increase production by increasing nest success. Artificial nest structures for Canada geese have been described by several authors (Yocom 1952, Craighead and Stockstad 1961, Brakhage 1965, Will and Crawford 1970, Rienecker 1971, Cooper 1978, Atkins and Fuller 1979, Fielder 1979, Giroux et al. 1983, and others). Although use of nest structures by Canada geese is will documented, few studies have addressed the fundamental question of whether use of structures results in increased populations. Craighead and Stockstad (1961) pointed out that such information is essential before the use of nest structures can be evaluated as a management technique. Krohn and Bizeau (1980) noted that the question of whether nest structures increase local goose populations is unanswered.

Practical problems inherent in using nest structures as a management tool include the necessity of replenishing nest material (substrate) every year or two, and frequent damage of structures by waves, ice, or

other forces. Although substrates acceptable to geese have been identified by several authors (Craighead and Stockstad 1961, Brakhage 1965, Will and Crawford 1970, Rienecker 1971, Cooper 1978, Atkins and Fuller 1979, Giroux et al. 1983), no substrates have been described that remain in nest structures longer than a few years. Craighead and Stockstad (1961) evaluated the use of elevated nest structures by Canada geese in the Flathead Valley, the same study area we used. The slow but powerful forces of tree growth have destroyed most of the wooden nest boxes installed in the 1950's for that study, but at least 5 of those structures have survived to the present and would be suitable as nest sites today if filled with substrate. The surviving structures were mounted on top of snags or on flat Limbs away from the boles; we reasoned that a flexible nest structure could easily survive 30+ years and that a more durable substrate could greatly decrease costs and improve efficiency.

Although nest numbers and nest success on Flathead Lake were somewhat higher from 1980-1982 than in the 1950's, the potential impacts of various water level scenarios on nesting geese have not been previously investigated. Future changes in land use and water management practices may have significant impacts on the lake and river, and data collected now will prove useful in the future.

Objectives of our study were: 1) document the nesting habits of geese on the river and lake; 2) document the effects of nest structures on the river goose population; 3) identify a substrate that was acceptable to nesting geese and would remain in nest structures for an extended period of time; 4) develop a durable but unobtrusive metal nest structure suitable for placement in trees; 5) determine the effects of water level fluctuations on nesting geese; and 6) develop mitigation / management options for nesting Canada geese on the river and lake.

Methods

Data were collected from April 1983 to June 1987. Nest searches were conducted during late April and early May. Previous studies (Geis 1956, Ball 1981) documented that virtually all nesting by Canada geese on the study area occurred on islands; therefore, mainland areas were not searched unless observations of geese indicated that a nest may have been present. Production estimates were obtained from intensive ground searches for nests on all islands of the study area during late April and early May. Ground crews completely searched islands and mainland areas where observations of goose pairs indicated a nest may be present. On Wild Horse and Cromwell Islands on the lake, and Bear and Beaver Islands on the river, only the area within 20 m of the shoreline was searched because pair survey data indicated geese did not use the interior of these islands. Artificial nest structures and nests of ospreys (*pandion haliaetus*), red-tailed hawks (*Buteo jamaicensis*), and great blue herons (*Ardea herodias*) were also checked for nesting geese.

Data recorded at each nest were: l)location, 2) number of eggs laid, 3) number of eggs hatched, 4) stage of egg development, 5) nest type, and 6) nest fate. Stage of egg development was classified by recording the position of eggs when immersed in water (Westerskov 1950). Nest fate was determined by classifying egg shell fragments as hatched or

depredated using methods described by Rearden (1951). A nest was considered abandoned if all the eggs were cold and unbroken in the nest. Nests destroyed by flooding were recorded. We attempted to visit all nests at least twice, before and after completion of the nesting attempt. Geese using nest structures or other elevated sites were only checked after the nesting attempt was completed. Hatching success was calculated as the percent of eggs that hatched in successful nests, and a mean clutch size of 5.5 was used to calculate hatching success (Geis 1956). Nest success was calculated as the percent of total nests of known fate that hatched at least one egg (Geis 1956).

Elevated artificial nest structures were placed in ponderosa pine trees on the study area. The 61x96x15 cm nest baskets were constructed of 13x1 mm expanded metal and supported by a frame made of 9 mm diameter reinforcing bar. Nest structures were placed on a limb to increase stability, and attached to the tree trunk with 2 lag bolts above and 2 below the nest basket. Nest structure plans and assembly instructions are presented in Appendix F.

Fifty-two nest structures were placed in trees along the river, 18 in February 1983, and 34 during the summer and fall of 1983. A set of 2 structures was located along systematically selected 0.6 km segments of the river, with sets spaced approximately every 2 km. All nest structures were placed in trees selected to maximize structure life and visibility of structures to geese. Trees selected for structure placement were: 1) ponderosa pines >30 cm in diameter at breast height; 2) within 15 m of the high water mark and relatively isolated from other trees; 3) positioned at least 100 m from other nest structures, osprey nests, and goose nests from previous years to avoid territorial interactions; and 4) situated away from human access points. Structures were placed 6-13 m above the ground and facing the river. We assumed that each structure in a set had an equal chance of being observed by geese.

We had observed Canada geese nesting successfully on seemingly harsh substrates such as gravel, rocky ledges, and cobble. Consequently, we suspected that substrates much coarser than the straw, wood chips or litter usually used in artificial nest structures might prove acceptable to geese and fulfill the objective of increased durability. Secondary criteria in selecting substrates to test was that the material be readily and economically available. The 2 substrates selected for testing were large size decorative ponderosa pine bark chips and expanded shale rock (mean diameter = 12 mm). Both products are widely available from landscaping businesses. One of the 2 substrates was randomly assigned to one structure of each set and the other substrate to the second structure of the set. The amount of substrate remaining in structures after 2.5 years was measured to estimate longevity. The nest substrate experiment on the river was completed after the 1986 nesting season. Prior to the 1987 nesting season, structures were refilled with a substrate mixture of 75% shale and 25% bark and 18 more structures were placed on the river making a total of 70 available structures.

On Wild Horse Island, 24 nest structures were installed during the summer of 1985 to evaluate the feasibility of growing vegetation in structures to reduce or eliminate the need for replenishing substrates.

Structures were located within 24 randomly selected 0.5 km segments of the shoreline with tree selection conducted as on the river. Kentucky bluegrass (Poa pratensis), crested wheatgrass (Agropyron cristatum), and Idaho fescue (Festuca idahoensis) were seeded or transplanted into a peat/moss-soil mixture containing 200 g of Vitera Planta-gel (Nepera, Inc., Harriman, NY). All plantings were watered thoroughly at the time of structure placement.

Simple regression analysis (Zar 1984:261, Norusis 1986:B-197) was used to evaluate changes in numbers through time and test significance (t-test of Ho:B = 0). Contingency tables (Zar 1984:64, Norusis 1986:b-93) were used to test the hypothesis that: 1) Nest success was independent of nest type, substrate, or year, 2) hatching success was independent of substrate, and 3) use of nest structures was independent of substrate. Tests were considered significant at $P < 0.05$.

To provide suitable waterfowl nesting islands, other authors have recommended minimum channel depths ranging from 30-70 cm and minimum widths from 60-170 m (Hammond and Mann 1956, Sherwood 1968, Giroux 1981). Even at high flows on the Flathead River, channel depths and widths surrounding many nesting island fall short of these recommendations. Furthermore, these recommendations were for lake environments (i.e., water with no or very little current) and flowing water likely discourages predators to some extent. Therefore, we subjectively selected a suitable minimum channel depth of 50 cm and a width of 20 m as being suitable to protect nesting islands from access by mammalian predators on the river. We calculated channel depths and widths at different flows on the river using surveyed cross-sectional profiles and staff gages installed at 8 islands on the south half of the river. These islands were chosen because of their use by ground nesting geese and because shallow channels connected them to the mainland. Depth discharge relationships were calculated from water surface elevations and surveyed cross-sectional flow areas using "normal depth analysis", a solution of the Manning Uniform Flow Equation (Chow 1959: 128-140). Discharges reported are estimated to be accurate within 15%.

The existing Federal Energy Regulatory Commission Kerr Dam License (License no. 2) has established an interim minimum instantaneous river discharge of 3200 cfs. This creates a mean discharge of approximately 4300 cfs. We used a downstream flow model to predict the amount of time Kerr Dam could be operated at a mean discharge of 4300 cfs and still maintain adequate channel depths and widths. The model considered Kerr Dam discharges and downstream flow lag-time relationships. For 2 months in 1986 (mid-May to mid-July , an automated stream stage recorder (OMNIDATA DP320 was placed at RM 45.5 (upstream from Sloan's bridge). Data from this point, and from the USGS gage station at Perma (RM 10.5) were used to calibrate a USGS streamflow routing model (Doyle et. al. 1983) for the river. Using this model, flows were predicted at 4 points downstream (RM 45.5, 31.0, 17.5 and 10.5) from selected flow scenarios at Kerr Dam.

Results

Tree nest structures and island ground nests were the 2 nest types used most by Canada geese on the Flathead River (Table 17). The total number of nests on the river increased from 25 in 1980 to 79 in 1987 ($P < 0.001$; B = 7.8), but numbers of island ground nests did not change (P = 0.731; B = 0.4). The number of geese using tree structures increased from 3 in 1983 to 47 in 1987 (p = 0.005; B = 11.0). Seventy-eight percent of the structures on the river were used over a five year period. Maximum use of structures during any single year was 73%.

The population response to nest structures was considerably higher on the north half of the river (where islands were rare) than on the south half. Eighty-nine percent of the nests on the north half were located in tree structures in 1987 compared to 44% on the south half. In a 22 km segment of the northern river, where we had observed no nests prior to placement of structures, 6 geese nested in tree structures in 1987. The total number of nests on the north half increased 6.7X from 4 in 1982 (the year before structures were available) to 27 in 1987. On the south half, nest numbers increased 1.6X from 32 to 52.

Nest success of geese using tree nest structures was 91% over all years (Table 18), and was not significantly different between years ($X2$ = 5.48; DF = 4; P = 0.241). Success of island ground nests was variable and dependent primarily on the level of predation. Island ground nests had higher success in 1983, 1984, and 1987 than in 1985 and 1986 ($X2$ = 25.10; DF = 1; $P < 0.001$) due to high levels of predation. Nest success was greater for geese using structures than for those using ground nests during years when success of ground nesting geese was high (1983, 1984, and 1987) ($X2$ = 5.41; DF = 1; P = 0.020) as well as during years when success was low (1985 and 1986) ($X2$ = 35.01; DF = 1; $P < 0.001$). Observations of egg shell remains indicated that most predation (approximately 75%) was done by mammals. Coyotes (Canis latrans) and raccoons (Procvon lotor) were common on the river and were observed on nesting islands several times.

Once a structure was used it was likely to be used again the following year; 72% of the structures were used the year following their first use. This pattern has been observed by others (Craighead and Stockstad 1961, Giroux et at. 1983), and in our study it created difficulties in interpreting data on preference between substrates because selection depended partially on whether a structure was used the preceding year. Use of structures containing bark was consistently greater than those containing shale (Fig. 7). If dependency of these data is reduced by considering each structure used or not at any time during the study period regardless of how many times (Lumsden et al. 1986), use of structures was independent of nest material ($X2$ = 0.81; DF = 1; P = 0.367) (Table 19). The highest single year use rate (73%) was observed in 1987 when a substrate mixture of shale and bark was provided.

Hatching success was 94% for geese using structures. There was no significant difference in hatching success between geese using the 2 substrates ($X2$ = 0.04; DF = 1; P=0.840); hatching success was 95% for geese using bark and 93% for those using shale. Nest success of geese using tree structures was independent of substrates ($X2$ = 0.24; DF = 1;

Table 17. Use of nest types by Canada geese, Flathead River, Montana, 1980 - 87.

	n Nests			
Year	Island Ground Nests	Tree Nest Structures	Other[a]	Total
1980	24	b	1	25
1981	28	b	4	32
1982	27	b	9	36
1983	39	3	11	53
1984	40	7	9	56
1985	37	26	8	71
1986	27	29	10	66
1987	25	47	7	79
All Years	247	112	59	418

[a]Includes nests in raptor and great blue heron nests, and other types of artificial nest structures.

[b]No tree nest structures available.

Table 18. Fate of Canada goose nests by nest type, Flathead River, Montana, 1983 - 87.

	Island Ground Nests						Tree Structures					
Fate	1983	1984	1985	1986	1987	All Years	1983	1984	1985	1986	1987	All Years
Hatch: n	27	30	7	9	14	87	2	6	21	27	33	89
%	75	77	26	36	70	59	67	86	84	93	97	91
Predation: n	5	9	19	16	5	54	1	0	2	0	0	3
%	14	23	70	64	25	37	33	0	8	0	0	3
Abandoned: n	2	0	0	0	1	3	0	1	2	2	1	6
%	5	0	0	0	5	2	0	14	8	7	3	6
Flooded: n	2	0	1	0	0	3	0	0	0	0	0	0
%	5	0	4	0	0	2	0	0	0	0	0	0
n Known Fate Nests:	36	39	27	25	20	147	3	7	25	29	34	98

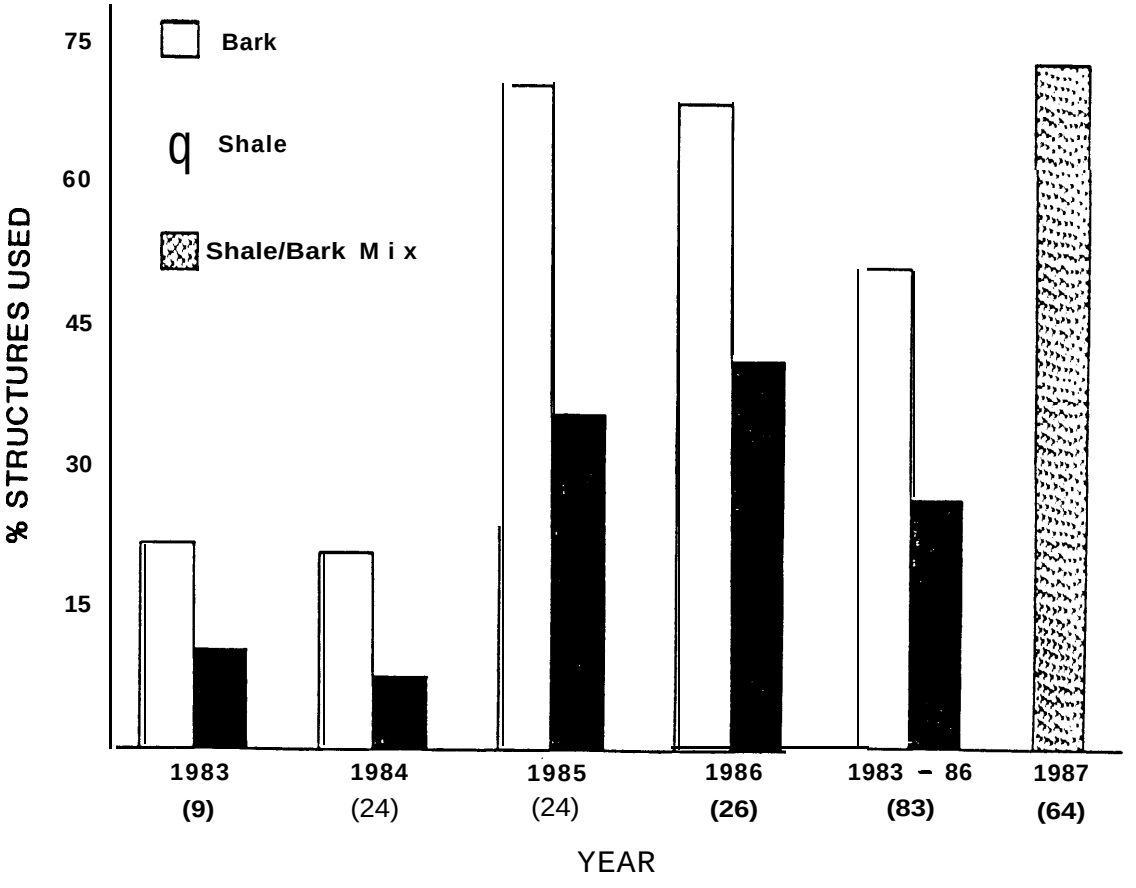

Fig. 7. Use of substrates by Canada geese nesting in artificial nest structures, Flathead River, Montana, 1983 - 87. (Numbers in parentheses indicate the number of structures available of each substrate).

Table 19. Use[a] of bark versus shale substrate by Canada geese, independent of reuse during subsequent years, Flathead River, Montana, 1983 - 86.

Substrate	n Available	n used	% Used At Least 1 Year
Bark	26	20	77
Shale	26	16	61

[a]Use independent of substrate ($x2 = 0.81$; DF = 1; $P = 0.367$).

P = 0.622). Ninety percent of the nests on bark hatched and 83% hatched on shale (Table 20). No measurable loss of shale, and a mean bark loss of 49% (range = 25 – 68%) was observed after 2.5 years.

Twenty-nine percent (7 of 24) of the structures on Wild Horse Island were used by geese the second year they were available, and nest success was 100% Geese successfully nested on each of the vegetation types and formed nest bowls in 87% (21 of 24) of the structures. All vegetation in the structures died, apparently due to lack of moisture. Even without live vegetation, soil and residual vegetation remaining from the plantings would likely provide suitable nest substrate for at least 5 years.

River channel width/depth analysis at various water level regimes showed that channels surrounding nesting islands on the south half of the river became too shallow at flows less than approximately 7,400 cfs (Table 21). During 1985 and 1986, when predation rates on ground nests were high, flows recorded on the south half of the river during the nesting period were generally greater than 7,400 cfs and greater than flows in 1984 when nest success was relatively high for gound nesting geese (Table 22 and 23). River flow predictions revealed that a constant discharge at Kerr Dam of 12,000 cfs can drop immediately to 4,300 cfs, be held there for approximately 2 hours, and still maintian flows of approximately 7,000 cfs in the south half of the river where 88% of the goose nesting islands occur (Table 24).

Geese used island ground nests more than any other type on the lake. The total number of nests on the lake increased slightly from 1984 - (P = 0.017; B = 2.6) (Table 25). Nest success was less in 1985 than during the other 3 years. Success was low on Melita, Big Bird, U-Shaped Bird, Cedar, and Drift Islands as a result of high predation and/or abandonment rates. No nests were observed below the high water mark on the lake, and water levels do not reach the high water mark until well after the nesting period under current lake water management practices.

Discussion

Population response to nest structures. - The population response was much more rapid in the 1980's than observed in the 1950's by Craighead and Stockstad (1961). The design of our nest structure study was built upon their recommendations for maximizing effectiveness of structures by placing them: 1) on mainland shores or large islands, 2) relatively high (>6 m) in trees, and 3) away from human disturbance. We suspect that the first of these recommendations had the most important impact: logically, the tendency to select an elevated nest site should be highest where risk of predation is highest, and Hanson and Browning (1959) showed that acceptance of elevated structures was very low where ground nesting was traditional and relatively successful. Craighead and Stockstad (1961:364) placed 54% of their structures on small islands, which are the favored traditional ground nesting sites of geese in the Flathead Valley (Geis 1956); we placed no structures on small islands.

Another important difference between the studies was that our structures were located on the Flathead River, while in the 1950's, structures were dispersed throughout the river, Ninepipe Reservoir, and Flathead Lake. This resulted in a greater density of structures

Table 20. Fate of Canada goose nests on bark and shale substrates in nest structures. Southead River. Montana, 1983 - 86.

	Bark Substrate					Shale Substrate				
Fate	1983	1984	1985	1986	All Years	1983	1984	1985	1986	All Years
Hatch: n	2	5	13	17	37	0	1	8	10	19
%	100	100	81	94	90	0	50	89	91	83
Abandoned: n	0	0	2	1	3	0	1	0	1	2
%	0	0	12	6	7	0	50	0	9	9
Predation: n	0	0	1	0	1	1	0	1	0	2
%	0	0	6	0	2	100	0	11	0	9
n Known Fate Nests:	2	5	16	18	41	1	2	9	11	23

Table 21. Minimum (critical) flow required to maintain a channel 50 cm deep and 20 m wide between 8 important[a] goose nesting islands and the mainland, Flathead River, Montana, 1986.

Island Name	Critical Flow (cfs)
Goose 1	2000
Goose 2	2500
Grassy	3400
Big Pine	3700
Agency	4000
Little Agency	4000
MacDonald	5100
Revais	7400
3 - Islands	9000

[a]These islands supported approximately 60% of all ground nests on the river.

Table 22. Average minimum and mean flows recorded during the Canada goose nesting period on the southern half of the Flathead River, Montana, 1984-86.

	Average Minimum Flows (cfs)			Average Mean Flows (cfs)		
Time Period	1984	1985	1986	1984	1985	1986
March l-10	9964	8341	10662	10900	9019	12030
March 11-20	8037	7787	9539	9303	8653	10599
March 21-31	6566	6575	8320	8104	7775	9520
April l-10	6245	5757	9637	7429	7032	12300
April 11-20	7162	7252	12030	7968	8231	12730
April 21-30	9700	9314	12790	10745	10093	13360
May l-10	10553	12027	12010	11569	12870	12850
May 11-20	8200	12370	6836	9495	12950	9665
May 21-31	3672	19700	16072	4402	22245	18005

Data obtained from U.S. Geological Survey gage station at Perma, Montana; Data unavailable for water years previous to 1984.

Table 23. Minimum and mean flows observed during the Canada goose nesting period on the southern half of the Flathead River, Montana, 1984-86.

	No. Days Minimum Flow was < 7400 cfs			No. Days Mean Daily Flow was < 7400 cfs		
Time Period	1984	1985	1986	1984	1985	1986
March l-10	0	1	0	0	0	0
March 11-20	2	1	1	0	0	0
March 21-31	8	11	2	1	1	0
April l-10	10	10	2	4	7	0
April 11-20	8	6	0	1	2	0
April 21-30	0	0	0	0	0	0
May l-10	0	0	0	0	0	0
May 11-20	3	0	8	3	0	0
May 21-31	10	0	3	10	0	2
Entire Nesting Period	41	29	16	19	10	2

Data obtained from U.S. Geological Survey gage station at Per-ma, Montana; Data unavailable for water years previous to 1984.

Table 24. Projected flows at 2 locations on the south half of the Flathead River resulting from several discharge scenarios at Kerr Dam, Montana 1987.

Initial High Constant Discharge (cfs)	Amount of Time Discharge Held Constant at 4300 cfs (Hrs.)	Projected Flow (cfs)	
		Foust Slough	Perma
20,000	4	6758	10688
	5	5518	9432
	6	4959	8489
	7	4616	7753
	8	4410	7091
	9	4349	65%
	10	4319	6143
	11	4304	5859
	12	4301	5669
	13	4301	5507
	14	4300	5379
16,000	3	6908	10392
	4	5704	9262
	5	5152	8401
	6	4655	7714
	7	4451	7055
	8	4383	6541
	9	4321	6157
	10	4307	5885
	11	4304	5691
	12	4301	5508
	13	4300	5384
12,000	2	6989	9526
	3	5927	8666
	4	5412	7968
	5	4763	7387
	6	4566	6885
	7	4397	6439
	8	4337	6099
	9	4319	5854
	10	4304	5668
	11	4301	5502
	12	4301	5387

Table 24. Continued.

Initial High Constant Discharge (cfs)	Amount of Time Discharge Held Constant at 4300 cfs (Hrs.)	Projected Flow (cfs)	
		Foust Slough	Perma
10,000	2	6106	8374
	3	5304	7770
	4	4808	7264
	5	4596	6812
	6	4402	6403
	7	4343	6086
	8	4320	5854
	9	4305	5660
	10	4302	5502
	11	4301	5392
8,000	1	6221	7776
	2	5430	7335
	3	4987	6928
	4	4634	6583
	5	4452	6273
	6	4380	6002
	7	4322	5802
	8	4308	5625
	9	4304	5488
	10	4301	5390

Table 25. Canada goose nest numbers and success, Flathead Lake, Montana, 1984-86.

Island Name	1984 NO. Nests	1984 Success (%)	1985 No. Nests	1985 Success (%)	1986 No. Nests	1986 Success (%)	1987 NO. Nests	1987 Success (%)
Melita	37	97	8	0	14	86	24	76
Big Bird	27	77	28	0	13	80	10	100
U-Shaped Bird	24	48	24	25	9	67	17	65
Long Bird	12	90	13	88	16	75	15	86
Cedar	22	83	25	38	25	76	26	96
Shelter	5	67	4	50	9	62	8	86
Douglas	7	57	7	86	7	85	9	88
Goose	4	100	4	75	6	83	5	100
Drift	6	83	16	42	16	0	10	70
Dream	3	100	6	100	20	90	14	92
Ginger	4	0	3	67	1	0	2	100
King Point Marsh	4	0	5	20	2	100	4	0
Rock	1	100	0	--	1	100	1	0
Narrows East	2	0	1	100	2	100	2	100
Narrows West	2	0	3	0	4	25	3	100
Baby Bull	1	0	2	0	0	--	0	--
Little Bull	0	--	3	0	2	0	4	100
Big Bull	1	0	0	--	0	--	0	--
cat Bay East	1	0	1	100	2	100	2	100
Cat Bay West	0	--	9	75	7	0	8	62
Upper River	1	0	1	0	0	--	0	--
Wildhorse	--	--	3	33	8	100	7	100
Cromwell	--	--	0	--	0	--	--	--
Other	--	--	--	--	4	100	1	--
Entire Lake	164	72	166	40	168	66	172	83

available to nesting geese in the 1980's than in the 1950's. Natal philopatry in large Canada geese seems to be very strong (Sherwood 1967); consequently, occupation of structures should proceed more rapidly if maturing geese have access to structures near their natal area than if the nearest available structure is further away. In addition to being concentrated in a general sense, our structures were located in areas used by geese, but where safe nest sites were relatively rare. Areas with these characteristics apparently offer the most desirable opportunities for efficient structure programs (Rienecker 1971).

The population of nesting geese on the river increased significantly when nest structures were provided. The increase was greatest (6.7X) in the north half of the river, where safe, natural nest sites were rare. Only 5 of 43 islands on the river occurred in the north half, and the number of other natural nest sites such as osprey or red-tailed hawk nests were also limited. We attribute the increase in nests to an increase in the supply of safe nest sites.

The number of island ground nests on the river did not change, although structure nests and the overall population increased. We believe that the island ground nesting and structure nesting segments of the population are largely independent, and that island ground nesting will persist so long as their recruitment regime is adequate to meet or exceed current mortality rates. Craighead and Stockstad (1961:371) observed a decline in island ground nests as structure nests increased slowly, and concluded a cause-and-effect relationship. We note the alternative explanation that hunting mortality was heavy on both segments (p. 376), but that relatively high nest success allowed structure nesting geese to increase slowly while ground nesting geese decreased because recruitment did not exceed losses. If heavy hunting mortality did not occur in the 1950's, numbers of structure nesting geese may have increased rapidly and ground nesting geese remained stable. This was the situation we observed during the 1980's.

The colonization rate of structures in the 1980's was much more rapid than was biologically feasible if a few "new" geese selected structures each year with the remaining increment based on recruitment of "imprinted" young geese (Brakhage 1965, Giroux et al. 1983). This means that much of the increment was made up either of pairs that would have nested elsewhere (immigration) , or that would not have nested at all, if nest structures had not been provided. A corresponding drop in nesting populations elsewhere in the Flathead Valley would provide support for the in-migration hypothesis, however, we observed the other nesting populations either remain stable or increase (unpublished data). Alternatively, if the presence of structures encouraged nesting by pairs that were present but would not have nested due to a lack of suitable nest sites, the ratio of pairs censused to nests found should have decreased as structure nesting increased. On the north half of the river, where response to structures was strongest, we observed the ip/n ratio decrease from 2.1 in 1983 to 1.1 in 1987.

Hatching success of geese using our structures was high and similar to rates observed by Geis (1956), Hanson and Eberhardt (1971), and Cooper (1978). Nest success on our structures was significantly greater than that of geese nesting on the ground during years of heavy predation

by mammals Lower predation rates and higher success for geese nesting on artificial structures compared to those nesting on the ground was observed by Craighead and Stockstad (1961), Brakhage (1965), Will and Crawford (1970), and Cooper (1978). Abandonment was somewhat higher in structures than on the ground. We suspect that this difference occurred because some of our ground nests were destroyed by predators after abandonment, and were recorded as predation.

Prior to the availability of nest structures on the river, most geese were produced from island ground nests. Ground nest densities on the river were very low, and likely resulted from a limited number of nesting geese caused by low nest success every 2 or 3 years. Our data indicate that through time, the island ground nesting segment of the nesting population has been able to maintain itself, but not increase. In 1987, after structures had been available for 5 years, nest structures were the primary nest type used. As a result, the nesting population is currently dependent on geese using a nest type which should provide consistently high success rates.

Nest substrates and structure design - The nest substrates tested on the Flathead River were considerably coarser and harsher than materials used in other nest structure programs. Yet both structure use and nest success recorded on our study ranged to the high end of published figures (Table 26). Geese seemed to prefer bark, but a tradition for nesting on shale clearly developed through time. Although use rates were lower on shale than on bark, rates would likely have been greater if only shale had been available. Hatching and nesting success was high and did not differ significantly between the substrates. We conclude that although geese may prefer soft substrates such as straw or litter, they certainly do not need them. Furthermore, we suggest that the maintenance demands created by providing such "traditional" substrates often represent a costly and unnecessary trade off. Shale was clearly the most durable substrate, and it apparently will last as long as the structures. Mixing shale with bark, wood chips, or flax straw produces a substrate that should increase initial acceptability to geese while still providing virtual freedom from maintenance. Bark chips alone would not reliably provide suitable nest substrate much beyond 3 to 4 years.

Nest structure design was the least important aspect of our study, except in concept (i.e., structures should be extremely durable and aesthetically acceptable or unobtrusive to humans). Our structures have shown no sign of deterioration after 6 years. Mounting the structures in trees represented a potential trade off between aesthetics and durability, and the risk of predation. Raccoons are common along the river, but apparently they either seldom climb ponderosa pines or can be repelled by geese nesting in structures.

Our attempts to minimize aesthetic impacts were apparently successful. We spoke informally with fishermen, canoeists, and fisheries biologists who used the river; in nearly all cases, they did not see our structures. We soon learned that cutting limbs was neither necessary nor desirable. Geese had no trouble gaining access to structures when few limbs were removed, and leaving limbs significantly reduced obtrusiveness of structures. No negative comments were received about any of our structures. In contrast, we received 6 unsolicited

Table 26. Summary of reported nest data of Canada geese using artificial nest structures.

Reference	n Structures Available	% of Structures used Annual[a]	% of Structures used Total[b]	Nest Success (%)	Substrate
Hanson and Browning (1959)	81	0	0	--	--
Craighead and Stockstad (1961)	76	21	41	69	Soil and Duff
Brakhage (1965)	140	--	--	73	Straw/Sawdust
Will and Crawford (1970)	201	68	-	76	Wood Shavings
Rienecker (1971)	68	53	--	98	Hay/Wood Chips
Cooper (1978)	89	67	--	77	Grass Hay
Atkins and Fuller (1979)	16	--	38	--	phragmites Cattails/Straw
Fielder (1979)	7	57	--	25	Soil & Grass
Krohn and Bizeau (1980)	687	--	--	91	--
Giroux et al. (1983)	496	--	22	85	Wheat Straw/ Flax Straw
This Study (River Only)	70	73	79	91	Tree Bark/ Shale Rock

[a]Maxirtam % of structures used during any single year.

[b]Percant of all structures used at least once during the study period.

complaints about the few (4-6) other structures on the river (4-post platforms and unpainted metal washtubs in trees).

Costs of producing geese on the Flathead River using a durable nest structure and shale substrate was low. We believe a 20-year maintenance-free life for this structure/substrate combination can be expected, and is likely a very conservative estimate. Nest structures, including substrate, were approximtely $30.00 each, and labor costs for construction and placement were $48.00 (6 man hours x $8.00/hour). Using a life expectancy of 20 years, a use rate of 15% the first 2 years and 70% the next 18 years, a nest success rate of 90%, and 5.2 goslings hatched per successful nest, we calculated a cost of $1.29/gosling hatched. Giroux et. al. (1983) reported costs of $10.35/gosling from small rock islands and $11.25/gosling from round straw bales. Giroux (1981) reported costs of $4,80/bird (ducklings and goslings) from larger rock islands, and Lokemoen (1984) reported that ducklings fledged from nest structures cost $8.54 in North Dakota and $25.62 in western Minnesota.

Managers and others using artificial nest structures often seen to focus almost solely on initial costs and, in doing so, may make unwise decisions relative to aesthetics, structure longevity, substrate durability, and maintenance requirements. Virtually all published accounts show that occupancy by geese increase gradually over several years. Increasing occupancy reduces costs per bird hatched, but unless maintenance-free techniques are used (or an aggressive maintenance program is pursued), then the structure program may fail long before peak efficiency is reached.

Lake nesting population. - Numbers of goose nests on the lake increased slightly over the study period and were similar to nest numbers observed in the 1950's by Geis (1956). Nest success was generally high on the lake except for the 40% success observed in 1985. During the winter of 1985 the entire lake froze and the goose nesting islands were surrounded by ice and attached to the mainland until April 11 when break-up occurred, 2 weeks longer than ever recorded. Consequently, the geese delayed nest initiation until after ice break-up; approximtely 2-3 weeks later than during most years.

In 1985, observations indicated a coyote crossed the ice to Melita Island and remained there after break-up. Nest numbers on the island in 1985 dropped to 8 from the 37 nests observed in 1984 and all of the known fate nests were depredated. Drift Island, a small 2 ha island near Melita, increased 10 nests from 1984. We believe that the coyote on Melita Island caused geese that would have nested there to move to Drift Island. The low success rate on Drift Island in 1985 appesred to be primarily a result of overcrowding and territorial strife.

On U-Shaped Bird and Big Bird islands in 1985, nest success rates were low due to predation by a raptor (most likely a great horned owl). Six geese were killed on nests and the remaining nests were destroyed by common ravens (Corvus corax We believe that most of the nests destroyed by ravens had been abandoned previously, probably a result of disturbance from the great horned owl.

The lake nesting goose population appears to be relatively stable, and will likely remain at its present level unless nesting habitat is disturbed or destroyed by changes in land use practices.

Effects of water levels on nesting geese. - The effects of fluctuating water levels on nesting geese were primarily limited to those geese that nest on the ground. Geese nesting in elevated structures or elevated natural sites were seldom adversely affected by water levels.

Canada geese that nest on the ground typically use islands or other sites which are relatively free from access by mammalian predators (Geis 1956, Hammond and Mann 1956, Vermeer 1970, Hanson and Eberhardt 1971, and others). We did not observe any ground nests on mainland shorelines or on islands where channels were dry or shallow (i.e., < approximately 15 cm deep). Furthermore, there were no major differences in vegetation species composition or structure between river islands and mainland shorelines. We conclude that river channels around islands were the primary factor discouraging access to nesting islands by mammalian predators. We believe that if channels did not exist (i.e., if islands became equivalent to the mainland because of non-existent or too shallow river channels), island ground nesting geese would either: 1) not nest; or 2) if they did nest, predation rates would be so excessive that the ground nesting segment of the population would be driven to extinction.

Based on our selection of a minimum river channel depth of 50 cm and minimum width of 20 m as the critical depth/width to maintain secure nesting islands, there were few differences in channel depths and widths between years of high and low predation. During 1986, when predation rates were high, discharges (and consequently channel depths and widths) were substantially greater than in 1984 when predation rates were low.

The high predation rates observed during 1985 and 1986 occurred over the entire river and were not created by isolated cases of heavy predation. Therefore, whatever the factors were that led to predation, they were common to the entire river. High predation rates were also observed in the northern Flathead Valley in 1985 (Casey et al. 1986), and indicates that the factors causing heavy predation may have been valley-wide. If the prey base (and in particular the microtine population) necessary to sustain the predator population was low, predators may have been forced to swim to river islands in search of food. This hypothesis would tend to explain why predation was heavy over the entire river during years when the primary deterents to predators (channel depth and width) were as great or greater than during years of low predation. It appears that although during some years channels surrounding river islands create suitable nesting habitat by discouraging access to islands by mammalian predators, there are other factors (such as prey base) which also influence whether predators gain access to islands.

Changes in operation of Kerr Dam would have effects on the river nesting goose population. River flow scenarios less than those observed from 1983-86 would likely result in higher predation rates on ground nests than we observed. We believe that flows on the south half of the river maintained between 12,000-18,000 cfs from March through May would be ideal, and would result in lower predation rates on ground nests.

Under current dam operation, current predator populations, and current goose mortality rates, the number of ground nests will likely remain at about current levels indefinitely.

Under current water management scenarios on the lake, ground nesting geese do not appear to be negatively affected by water levels. Water levels would have to reach or exceed the high water mark during the nesting period to have negative effects. The major threat to nesting geese on the lake is loss of secure island nesting habitat by human disturbance or development.

NEST SITE SELECTION

Introduction

The importance of vegetation structure and species composition to nesting waterfowl and other birds has been established (James 1971, Heagy and Cooke 1979, Whitmore 1981, Hines and Mitchell 1983, and others). Vegetative composition, density and canopy cover can be influenced by water level fluctuations (Bell 1980, Hupp 1982, Harris et al. 1985, Stevens and Waring 1985). Although water levels fluctuate on unregulated rivers, on our study area the operation of Kerr Dam has increased daily fluctuations and caused changes in seasonal fluctuations.

Previous researchers on our study area (Geis 1956, Ball 1981, I. J. Ball, unpublished data) found that most goose nests were island ground nests. They described general characteristics of ground nests, but did not quantify observations. Western Canada goose nesting habitat has been described (Craighead and Craighead 1949, Dimmick 1968, Hanson and Eberhardt 1970, Vermeer 1970) but data concerning nest site selection and the relationship of habitat variables to nesting success are unavailable. McCabe (1979) described nest site selection in Washington, but those habitats were different from ours. The objectives of our study were: 1) to statistically evaluate vegetation and physiographic characteristics of Canada goose nesting habitat, and 2) to evaluate how habitat variables effect nesting success.

Methods

Sampling was conducted during May and early June, 1984-86. Habitat variables were collected at island ground nest sites and at randomly located control sites to compare use and availability. We assumed that islands surrounded by water during the early nesting period (March) were available to nesting geese and were therefore considered in the selection of control sites. Forty-four islands were mapped to vegetative cover types and their areas calculated using a dot grid with 55 squares/ha. Control sites were selected using 1,000 computer generated random points overlaid on aerial photos (l:lO,OOO scale) of the islands. Orientation of the overlay was randomly selected between

the 8 patterns possible using a random numbers table. Points were numbered and control sites were randomly selected using computer generated random numbers. Sample size was considered sufficient when the proportion of cover types at control sites was similar to cover type proportions calculated from mapping.

At each ground nest and control site we recorded: elevation above or below the HWM, horizontal distance to the HWM, total overhead cover, percent canopy cover of tree, shrub and herbaceous layers, vertical cover, and plant species composition.

Elevation above or below HWM was recorded in 8, 0.5 m classes, from >l m below to >2 m above HWM. Horizontal distance to HWM was recorded as either below HWM, or in 1 of 7 classes above the HWM. These were 5, l-m classes up to 5 m, and 2 classes from 5-10 m and >lO m above the HWM.

Total overhead cover was estimated using a densiometer (Lemmon 1956) held at 0.5 m height over the nest bowl or plot center. Four readings from cardinal directions were averaged. The percent canopy cover of tree, shrub and herbaceous layers was recorded inside of 2 circles, 1 m and 5 m in radius, using occular estimates within 6 cover classes (Daubenmire 1959). Vertical cover was measured using a 0.5x3.0 m density board (Noon 1981), which was gridded to 1 dm and divided into 4 height levels (0.0-0.3 m, 0.3-1.0 m 1.0-2.0 m, and 2.0-3.0 m). The board was held 5 m from the center in each of 4 cardinal directions, and data were averaged for each height level.

Cover types were recorded at each nest and control site. Forested types had at least 25% tree cover and were classified as coniferous, deciduous, or mixed forest types depending on the dominant cover of tree species present. Shrub types had at least 25% shrub cover and less than 25% tree cover. These were divided into dense shrub (>50% shrub cover) and sparse shrub (25-50% shrub cover). Herbaceous types had at least 25% herbaceous cover with less than 25% shrub or tree cover. Tall Op.5 m) and short (<0.5 m) herbaceous types were differentiated. In addition, a species list, and the two most dominant species were recorded.

Nest densities were calculated by island (nests/ha) and islands were grouped into 3 size classes: small (0.1-0.9 ha), medium (1.0-4.9 ha), and large (5.0-30.0 has). To test for differences in nest densities between island size groups, Kruskal-Wallis nonparametric analysis of variance was used.

Chi-square (χ^2) goodness of fit analysis (Zar 1984:62) was used to test the hypothesis that cover types were used randomly, and that nests were at random distances vertically and horizontally from the HWM. Methods of Marcum and Loftsgaarden (1980) were used to determine significant differences within categories through simultaneous confidence intervals (alpha = 0.10). Pearson product-moment correlations (Norusis 1986:C-28) were used to test for differences in the amount of forest, shrub and herbaceous cover on islands of different size groups. Multivariate analysis of variance (MAN0VA, Norusis 1986b:B103) was used to test the hypothesis that nest and control sites had equal proportions of tree, shrub and herbaceous canopy cover.

Vertical cover and total overstory cover were campared using t-tests (Zar 1984:126) when distributions were normal, and Mann-Whitney U-tests

(Norusis 1986:B-192) for non-normally distributed data. Two-way contingency tables and χ^2 tests (Zar 1984:61) were used to test the hypothesis that certain plant species were dominant at nest sites more than at control sites. Presence or absence of plant species were also tested in this way. Mann-Whitney U-tests were used to test the differences between hatched and depredated nests for island size, percent canopy cover of tree, shrub and herbaceous plants, overstory cover, and vertical cover. Throughout this section, means were expressed + the standard error (SE) and all tests were considered significant at $p < 0.05$.

Stepwise discriminant function analyses (Klecka 1975, Norusis 1986b:Bl-B25) were performed to create classification functions contrasting nest and control sites. Different combinations of variables were used in the function until the best classification was achieved. The percent of samples correctly classified by each discriminant function was calculated.

Results

Nest site selection. - We sampled 101 nest sites, 4 of which were used more then once during the 3 years of the study. These 4 were only considered once for the nest site selection analyses, but were included where appropriate in island nest density and fate calculations. Plant species lists were recorded at 63 nest and 59 control sites. Vertical cover measurements were not inluded on 6 nests sampled.

Nineteen islands on the river were classified as small (<1.0 ha), 14 as medium (1.0-4.9 ha), and 11 as large (>5.0 ha). Numbers of nests were similar among island size groups over the 3 years of the study. Of the 101 nests, 35 were on small, 35 on medium and 31 on large islands. Nest densities varied among size groups (Table 27) with higher nest densities on small islands. To further test the potential influence of island size on other factors, analyses were conducted among size groups when appropriate.

Ground nests were located closer to the HWM than expected both vertically (χ^2 = 25.45, 3 df, $p < 0.001$) and horizontally (χ^2 = 39.97, 4 df, $p < 0.001$). Geese used sites from 0.5 m below to 1.0 m above the HWM more, and sites <0.5 m below and >1.5 m above the HWM less then expected (Fig. 8). On small islands, 75% (21) of the nests were between 0.5 m below and 1.0 m above the HWM, while medium and large islands had 62% (23) and 56% (18) respectively. Vertical distributions of nest and control sites were different on medium islands (χ^2 = 13.36, 2df, p = 0.0l), but not on large islands (χ^2 = 5.66, 2df, p = 0.06).

Nests were located more than expected in a zone 0-4 m inland from the HWM and less than expected >l0 m inland (χ^2 = 40.04, 3df, $p < 0.001$, Table 28). Horizontal distributions differed for both medium (χ^2 = 6.56, 2 df, P= 0.04) and large islands (χ^2 = 32.05, 2 df, $p < 0.001$). Small islands were not tested due to the limited number of control sites.

More nests were located in shrub and coniferous forest than expected, and fewer nests in short herbaceous types (χ^2 = 26.7, 4df, $p < 0.001$, Table 29). There were no differences between distributions in dense and sparse shrub, or in mixed and deciduous forest types.

Table 27. Mean areas (ha) and Canada goose ground nest densities (nests/ha) for 3 island size groups, Flathead River, Montana, 1984 - 1986.

Size Class	n	X Area per Island	x Nest Density	Sizevs. Density	Kruskal-Wallis p values
Small (S)	19	0.4	6.2	>M+L	0.005
Medium (M)	14	2.7	0.9	<s	0.011
Large (L)	11	11.8	0.3	<S[a]	0.001

[a]Medium and large island densities did not differ significantly (p = 0.136).

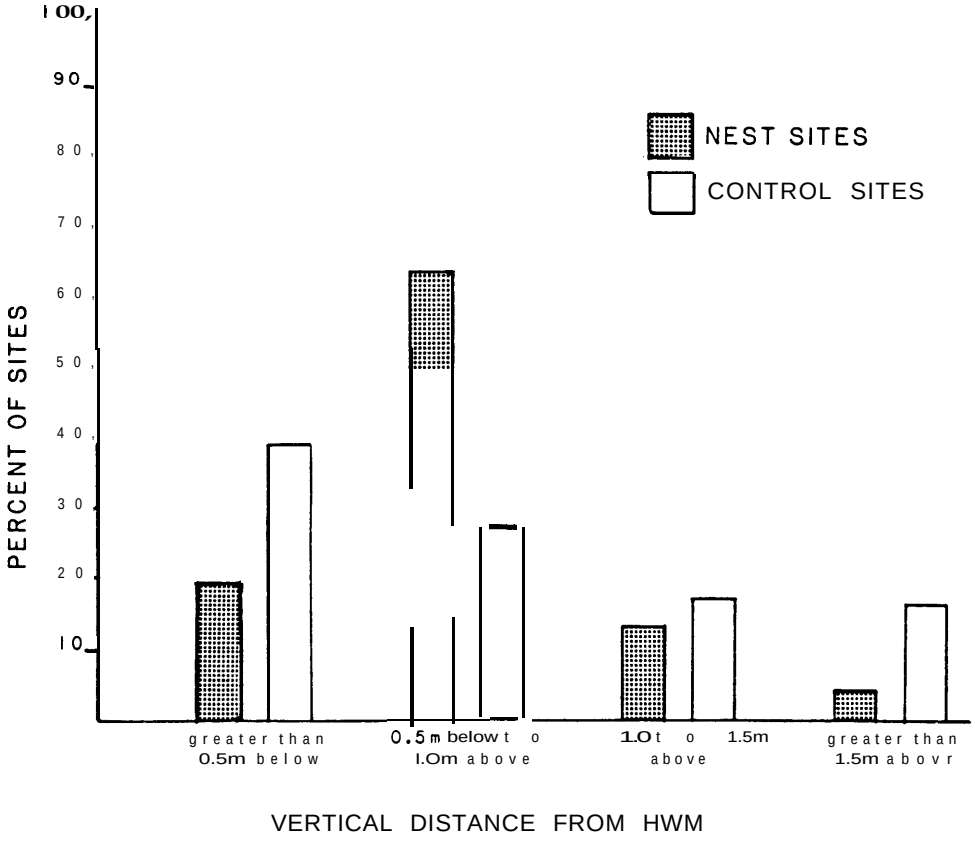

Fig. 8. Vertical location of Canada goose ground nests relative to the high water mark (HWM), Flathead River, Montana, 1984-86.

Table 28. Horizontal distance of nests and control sites relative to the high water mark (HWM) on medium, large, and on all islands, Flathead River, Montana, 1984-86.

Distance from HWM	Medium Islands				Large Islands				All Islands			
	Nests		Control		Nests		Control		Nests		Control	
	n	%	n	%	n	%	n	%	n	%	n	%
Below HWM	17	45.9	17	73.9	11	34.4	20	37.7	46	47.4	40	50.0
0 -4m In and[a]	11[b]	29.7	1[b]	4.3	17[b]	53.1	2[b]	3.8	33	340	4	5.
4-10 m In and									14	14.4	9	11.3
10 m Inland[a]	9	24.3	5	21.7	4	12.5	31	58.5	4	4.1	27	33.8
Total	37	99.9	23	99.9	32	100.0	53	100.0	97	99.9	80	100.1

[a]Significantly different at 0.90 simultaneous confidence interval (Marcum and Loftsgaarden 1980) for all islands combined.

[b]Sites between HWM and 10m inland listed for medium and large islands.

Table 29. Vegetative cover types at Canada goose nesta and control sites, Flathead River, Montana, 1984-86.

	Nest Sites		Control Sites	
Cover Type	n	%	n	%
Coniferous Forest[b]	12	12.4	5	6.3
Mixed/Deciduous Forest	10	10.3	17	21.3
Shrub (Dense & Sparse) b	59	60.8	26	32.5
Tall Herbaceous	7	7.2	4	5.0
Short Herbaceous[b]	9	9.3	28	35.0
Total	97	100.0	80	100.1

[a]Overall X^2 = 26.7, 4df, $p < 0.001$.

[b]Significantly different at 90% simultaneous confidence intervals (Marcum and Loftsgaarden 1980).

Smaller islands on the river had less forested and more herbaceous area than larger islands, while shrub cover was not correlated with island size (Table 30). Differences were found within small ($p < 0.001$), medium ($p = 0.011$) and large ($p = 0.035$) islands, with consistently more nests in shrub cover and fewer in herbaceous cover than expected. MANOVA analysis indicated there was a significant difference between nest and control sites in the percent canopy cover of trees, shrubs and herbs within both a 1 m and a 5 m radius from the plot center; however, of these 3 forms, only shrub cover differed significantly within both circles (Table 31).

Mean vertical cover between 0.0 m and 2.0 m height (the lower 3 height levels) was greater at nest sites than at control sites, for all island sizes combined (Table 32). Overstory cover did not differ between nest (33.1 + 3.2) and control sites (28.1 + 3.7) on all islands combined ($p = 0.312$). On medium sized islands, both vertical cover at all height levels (0.0-3.0 m), and overstory cover were greater at nest than at control sites. On large islands, only the middle 2 height levels (0.3-2.0 m) of vertical cover were different between nest and control sites. Small islands were not tested due to the small sample size of control sites.

Twelve plant species were dominant at 80% of the nest and random sites sampled (Table 33). Red-osier dogwood, reed canarygrass and Wood's rose were dominant at more nest sites, while Columbia River sagebrush, and common gaillardia were dominant at more control sites.

Over 100 species were recorded as present at nest or control sites (Table 34). Four of these species were present at more nests than control sites, including the 3 dominant species mentioned above as well as goatweed. Four other species were present at more control than nest sites: black cottonwood, ponderosa pine, dandelion, Pacific aster, and smooth aster (Aster laevis).

Stepwise discriminant function analysis indicated that island size was the most important factor in nest site selection. Numerous combinations of variables were tested (Table 35) with the best function correctly classifying 82.4% of the nest sites and 62.5% of the control sites, or 73% combined, (Table 36). This function used only 3 variables: island size, and the vertical cover at the 2 lowest levels (0.0-0.3 and 0.3-1.0). Distance to the HWM did not improve the classification because nest values were low at the ends (near and far from the HWM) but high in the middle. Using only the values for shrub cover within 1 m and 5 m of the site center, 70.1% of the nest sites were correctly classified.

Nest success. - Nest success varied among years (Table 37) and was significantly higher in 1984 (75.7%) than in 1985-86 combined (32.0%). Data from 1984 were separated from the next two years because of this difference. In all, 87 nests with known fates were sampled; 37 the first year and 50 the second 2 years. All of the unsuccessful nests were classified as depredated; none were abandoned or flooded.

Island size was the most important variable considered in relation to nest success. Successful nests were on smaller islands than unsuccessful nests in both 1984 ($P = 0.035$) and 1985-86 ($P = 0.010$). In

Table 30. Percent cover and correlation of forest, shrub and herbaceous cover with island size, Flathead River, Montana, 1984-86.

Island Size	Percent Cover		
	Forest	Shrub	Herbaceous
Small	5.0	32.5	62.5
Medium	17.4	30.5	52.2
Large	34.0	30.2	35.8
Correlation:	$r = -0.33$	$r = -0.16$	$r = 0.71$
Significance:	$p = 0.013$	p 0.163	$p < 0.001$

Table 31. Percent canopy cover of shrubs, trees, and herbs within 1 m and 5 m of nest and control sites, Flathead River, Montana, 1984-86.

	Percent Canopy Cover (X + SE)		
Site	Shrub	Tree	Herb
Within 1 m:			
Nest	51.7 + 5.8	16.4 + 5.8	35.9 + 5.6
Control	29.7 + 6.1	14.6 + 5.4	36.2 + 5.5
Within 5 m:			
Nest	50.8 + 5.2	14.7 + 5.3	36.2 + 5.2
Control	33.8 + 5.8	16.1 + 5.3	36.2 + 5.2

Table 32. Percent vertical cover at Canada goose nests (n=91) and control sites (n = 80), Flathead River, Montana, 1984-86.

	Percent Vertical Cover (X 2 SE)	
Height Level (m)	Nest Sites	Control Sites
0.0 - 0.3[a]	85.7 ± 2.2	64.7 ± 4.3
0.3 - 1.0[a]	67.5 ± 2.9	43.6 ± 4.4
1.0 - 2.0[a]	39.3 ± 3.3	27.2 ± 3.7
2.0 - 3.0[b]	27.7 ± 3.0	20.3 ± 3.2

[a]Significant difference, t-test, $p < 0.05$.

[b]Significant difference, Mann-Whitney U-test, $p < 0.05$.

Table 33. Dominant plant species[a] at Canada goose nest (n = 97) and control (n = 80) sites, Flathead River, Montana, 1984-1986.

	Nest Sites		Control Sites	
Plant Species	n	%	n	%
Cornus stoloniferaa	41	42	19	24
Phalaris arundinacea[a]	25	26	6	8
Rosa woodsii[a]	22	23	8	10
Juniperus scopulorum	17	17	11	14
Symphoricarpos occidentalis	16	16	8	10
Populus trichocarpa	12	12	16	20
Salix exigna	11	11	4	5
Pinus ponderosa	10	10	8	10
Poa compressa/P. pratensis	8	8	9	11
Artemisia lindleyana[a]	1	1	20	25
Gaillardia aristata[a]	1	1	16	20

[a]Two species were recorded per site, and those dominant in at least 80% of the nest and control sites are listed here.

[b]Significant difference using contingency tables and X^2 analysis, $P < 0.05$.

Table 34. Thirty-two[a] of the 104 plant species found at Canada goose ground nest and control sites, Flathead River, Montana, 1984-86.

Trees:

- Populus trichocarpa (L)[b]
- Pinus Ponderosa (L)
- Juniperus scopulorum

Shrub:

- Rosa woodsii (M)[b]
- Cornus stolonifera (M)
- Symphoricarpos occidentalis
- Salix exisua
- Prunus virsinianus
- Amelanchier alnifolia
- Rhus radicans

Forbs:

- Hypericum perforatum (M)
- Taraxacum officionale (L)
- Aster spp. (L) (mostly A. laevis or A. chilensis)
- Allium schoenoprasum
- Cirsium arvense
- Smilacina stellata
- Artemisia lindleyana
- Solidgo canadensis
- Apocynum cannnabinum
- Equisetum fluviatile
- Barbarea verna
- Centaurea maculosa
- Solanum dulcamera
- Lysimachia ciliata
- Verbascum thapsus
- Meliotus alba
- Clematis columbiana

Graminoids:

- Phalaris arundinacea (M)
- Poa compressa
- Poe pratensis
- Agropyron spp. (mostly A. repens)
- Carex spp.

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[a]Those species found in at least 10% of the site .

[b]Species present at significantly more (M) or less (L) nest sites are so indicated ($P < 0.05$).

Table 35. Classification results from stepwise discriminant function analyses using different combinations of the following 7 variables: island area (IA); vertical cover for 0.0-0.3m height (VC1), 0.3-l.0m height (VC2), and l.0-2.0m height (VC3); overstory cover (OC); and percent shrub canopy cover within lm (Sl) and 5m (S5) of nest or control plot, Flathead River, Montana, 1984-86.

	% Correctly Classified			Additional
Variables	Nest	Control	Total	Variables a
IA, VC2, VCl	82.4	62.5	73.1	oc, Sl
IA, VC2, VCl, VC3	81.3	62.5	72.5	OC
IA, VC2, Sl, VCl, VC3	80.2	62.5	71.9	oc
IA, VC2	79.1	65.0	72.5	S5
IA, Sl	77.3	63.8	71.2	S5
IA, VC2, Sl	76.9	62.5	70.2	
VC2, VCl	75.8	55.0	66.1	
VCl	74.7	41.3	59.1	
vc2	72.5	57.5	65.5	
IA	71.1	62.5	67.2	
Sl, S5	70.1	65.0	67.8	

aAddition of these variables resulted in no change to the classification results.

Table 36. Variables and results of stepwise discriminant function (DF) analysis of nest (n = 91) and control (n = 80) sites[a], Flathead River, Montana, 1984-86.

Variable	Nest Sites[a]	Control Sites[a]	Wilks' Lambda	Cannonical DF Coefficients
Island Area (ha)	4.7 + 2.3	10.5 + 2.3	0.8542	0.76216
VC Level 1[c]	85.7 + 4.6	64.7 + 6.2	0.7669	-0.35633
VC Level 2[d]	67.5 + 5.3	43.6 + 6.3	0.7593	-0.35623
% Correctly Classified	82.4	62.5		

[a](Wilks' lambda = 0.7593, 73% overall correct classification).

[b]Mean + SE

[c]Vertical cover at lowest height level (0.0-0.3m)

[d]Vertical cover at second height level (0.3-l/Om)

Table 37. Percent of successful and unsuccessful Canada goose ground nests (n = 87) sampled during 1984-86, Flathead River, Montana.

Nest Fate	1984		1985		1986	
	n	%	n	%	n	%
Successful	28	75.7	7	26.9	9	37.5
Unsuccessful	9	24.3	19	73.1	15	62.5
Total	37	100.0	26	100.0	24	100.0

1984, all of the nests on small islands hatched. In 1985-86, 60% of the small island nests hatched, but only 12% of the nests on large islands hatched.

Few other habitat variables were different between hatched and depredated nests. In 1984, only tree canopy cover within 1 m ($p = 0.009$) and 5 m ($2 < 0.001$) of the nest differed, with less cover at hatched nests. In 1985-86, only 3 variables differed: overstory cover ($P = 0.006$), and vertical cover from 1.0-2.0 m ($p = 0.003$) and from 2.0-3.0 m ($p = 0.035$). All of these were less at hatched nests.

Discussion

Security from predation appeared to be the major factor affecting site selection for ground nesting geese on the Flathead River. Although many comparisons between control and nest sites were significantly different, our data should be considered conservative because some of the control plots may have fallen on suitable nest sites.

Other studies concluded that nesting on islands was a mechanism to counteract mammalian predation (Hammond and Mann 1956, Vermeer 1970, Dimmick 1968). Geis (1956) observed higher nest densities on small islands of Flathead Lake, and surmised that the same was true on the river. Our data showed that not only were nest densities higher on small river islands, but success was much greater on small islands. Small islands may offer greater protection from predators than large islands due to reduced prey opportunities on small islands for similar efforts of swimming to the 2 island sizes. In addition, smaller islands contain proportionately more areas near the water, frequently allowing access to the water in several directions. This allows the geese greater security during incubation. However, the probability of nesting near the edge increased as island size decreased. Therefore, this may not be a biological factor.

Our data indicated a preference for nest sites near the island edge. The reference point used was the HWM because it was stable and easily recognized compared to the constantly fluctuating actual water levels. Actual levels, however, averaged 1.0-l.5 m vertically below the HWM during the 3 nesting seasons studied. The HWM was normally reached during high flows in early or mid-June, after nesting was completed.

The zone containing more nests equated to a zone from approximately 0.75 m to 2.25 m (vertically) above the average actual water level. Horizontal measures were more difficult to translate due to a wide range of slopes on the banks of different islands. In general we can surmise that on most islands, the area within 4 m of the HWM roughly translates to an area within 6 to 10 m inland from the actual water.

Geese used sites near the island edge but avoided sites subject to flooding from frequent daily water level fluctuations. From 1983-87, a major rise in water levels occurred between 1 June and 20 June, well after the geese had hatched. However, if Kerr Dam operations were to change such that this flush of water was a few weeks earlier, a majority of the ground nests would be flooded.

The high proportion of nests in shrub and coniferous forest areas is unusual. Canada geese generally avoid the use of forest or dense shrub cover for nest sites (Sherwood 1968, Kaminski and Prince 1977, Cooper

1978, and others) . Lebeda and Ratti (1983) reported heavy use of forest cover by Vancouver Canada geese (B. C. fulva) on Admiralty Island, Alaska. Geis (1956) noted that heavy brush cover was used by geese nesting on our study area.

Several of our results described dense cover near frequently used nest sites. Increased shrub canopy cover within 1 m and 5 m of all the nests, the higher density of vertical cover and the greater proportion of nests in shrub cover types all combine to indicate a trend for placing nests in dense cover.

We initially suspected that the preference for small islands was influencing the apparent use of cover types by the limited availability of different cover types on small islands. However, we found that herbaceous cover was most prevalent on small islands, but it was the least used cover type. Meanwhile, shrub cover was not correlated with island size but contained the majority (61%) of the nests. Possibly, the interspersion of cover and forage on small islands, as was afforded by the shrub and herbaceous cover types was an attractant to the geese. Shrub cover averaged the same at the nest bowl (within 1 m) as it did surrounding the nest (within 5 m), suggesting selection for dense cover not only at the nest but also surrounding it.

The more frequent occurrence of certain plant species at nest or control sites appears to be related to both the cover these species provide, and similar physical requirements of the plants and nesting geese (Heagy and Cooke 1979). Red-osier dogwood and reed canary grass grow near the edge of islands or on river banks where they are frequently flooded. Wood's rose is not as tolerant to flooding but tends to grow in disturbed sites from the river banks to higher upland sites, frequently in small patches near clearings. All 3 of these plants provide dense growth and residual cover below 1 m height. Two species, Columbia river mugwort and blanket flower, were less common at nests than expected. Both of these species are frequent on practically unvegetated gravel bars in the littoral zone, and are not found associated with goose nests because of their physical positioning as well as the lack of cover they provide.

It is common in our study area to have 1 year with high success rates followed by 2 or 3 years with low success rates (I. J. Ball unpubl. data). We had relatively high success in 1984 and low success in 1985 and 1986, and used this to explore the possible influence of habitat variables on nest success within high and low success years. Island size was the most influential factor in both years, and although sane forms of cover were less at hatched than at depredated nests, the differences between fates and years were usually not significant. Those that were significant can be directly related to the higher proportion of forest cover on large islands, and the lower success rate on large islands. It appears that other than island size, habitat variables are not directly influencing nest fate but other factors in the environment, such as channel depth and prey cycles may be more of an influence.

Mammalian predation is the major cause of nest losses to the ground nesting population, as well as the potential threat of flooding if water level patterns were to increase earlier in the spring. Keeping channels wetted sufficiently to improve island security, while avoiding sudden and large increases until after nesting would help alleviate sane of the

pressure on these geese, but the best way of providing secure nest sites appears to be the use of artificial structures.

The majority of natural nest sites used by Canada geese in our area are ground nest sites on islands. Although the nesting population can be maintained and augmented through the use of elevated artificial nest structures, the natural ground nest sites should not be ignored but should be maintained for 2 reasons: 1) a lack of structure maintenance, change in funding levels, or natural disaster (such as a widespread tree disease or forest fire) could reduce effectiveness of nest structures and; 2) long term ecological effects of replacing the ground nesting population with elevated nest platforms are as yet unknown.

BROOD HABITAT AND MOVEMENTS

Introduction

Barraclough (1954) documented several Canada goose brood rearing areas on our study area during the 1950's. Since that time, little information has been collected concerning brooding geese in the Flathead Valley. Poor quality brood habitat could negatively effect brood survival by increasing the chance of predation and/or failing to meet the energy requirements of goslings. Data on habitats used by goose broods and how they use these habitats are important for goose management on our study area. Objectives of this aspect of our study were: 1) identify all major brood areas on the river and lake, 2) describe how goose broods use these areas, and 3) describe habitat characteristics of brood areas.

Methods

Broods were located using radio-telemetry, aerial surveys, observations during time-budget sampling, and incidental observations. All brood sightings were recorded to identify brood areas. Methods for determining brood habitat use and activities were the same as for the brood time-budget section of this report.

Habitat characteristics were measured within selected major brood areas to describe plant composition, structure and biomass available to brooding geese. Ten 0.1 m^2 frames were placed every 2 m along a 20 m transect extended parallel to the water in the area with the most evidence of use (highest scat density). Within each frame, we estimatti the percent cover of each vascular plant (with at least 5% cover), the total vegetative canopy cover, andtheprimaryand secondary dominant herbaceous heights (cm). Three of the 10 plots were clipped and all herbaceous vegetation was air dried for at least 2 weeks. These biomass samples were later oven dried for 48 hours at 105 C, and then weighed to the nearest 0.1 g.

Results and Discussion

River broods. - Nine brood areas were identified on the river (Fig. 9). The Buffalo, Foust Slough, Upper and Lower Mission Creek, and Goose Islands areas were used the most intensively, and all but the Goose Islands area were used every year of our study.

The use of brood areas appeared to be partially related to nest success in that area. In 1985, when nest success was very low in the Goose Islands area, no broods were observed. Conversely, on the north half of the river, where the goose nesting population increased dramatically, and nest success was high due to artificial structures, the number of broods observed using brood areas steadily increased.

The brood area use/nest success relationship indicated that broods tend to use the general area where they were hatched Two of 3 radio-marked broods hatched within a major brood area (1 in the Buffalo area and 1 in the Foust Slough area) and both remained in their respective area the entire brood period. We did observe 2 cases of major brood movements. One radio-marked female with a brood moved approximately 23 km downstream to a brood area on the Clark Fork River within a week after hatching. In another case, a color-marked brood (and apparently the entire gang brood to which it belonged) moved approximately 22 km upstream from the Goose Islands area to both Mission Creek areas during the last half of the brood period. In these cases tradition appeared to be the primary factor determining brood area use since both these broods passed suitable areas that other broods had previously used.

There were several common characteristics of river broad areas, and the manner that broods used these areas. All brood areas except Upper Mission Creek were along the river and were comprised of herbaceous habitats (which were used for feeding) and forest or shrub habitats (which were used for resting or hiding cover). Upper Mission Creek was comprised of a wheatfield with a creek (approximately 10 m wide) running through it, and provided excellent feeding (wheat) and escape (creek) habitats.

Unless broods were disturbed, we did not observe then farther than 75 m from the river or creek and they were usually within 50 m. This illustrates the importance of habitats close to water. When a perceived threat came from land, broods immediately walked or ran to water. However, when broods were threatened from disturbance on water (i.e., boats, canoes, etc.) they ran from the river, sometimes as far as 200 m, and hid in shrub or tree cover until the threat had passed. We believe there is at least potential for high brood mortality on the river (as a result of increased predation) if boat traffic significantly increased. However, there does not seem to be a problem with the current level of boat traffic.

For approximately the first week after hatching, broods remained solitary and were usually intolerant of other broods. They slowly became more tolerant, and usually within 2 or 3 weeks had joined with other broods into a gang brood which traveled about as a unit. By the time goslings were half grown, broods had joined gang broods and were in their respective brood area where they remained until they fledged.

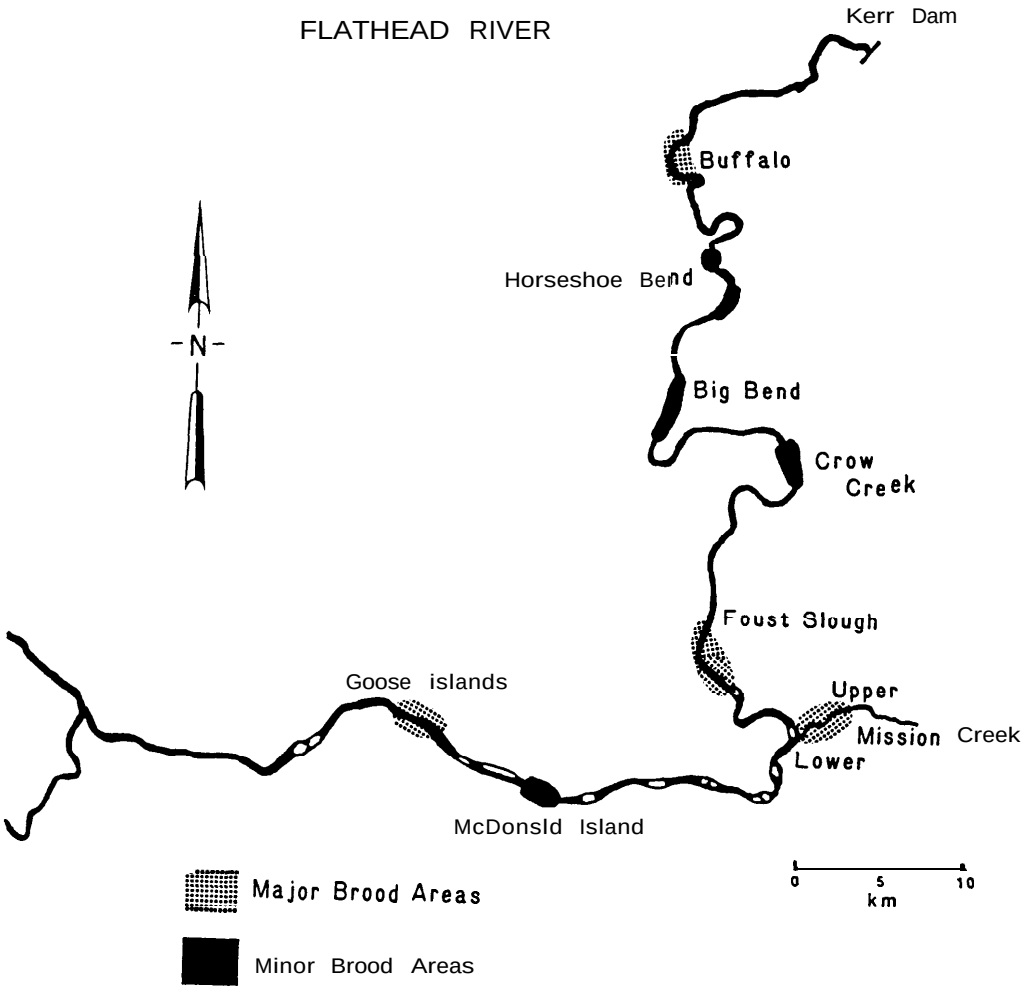

Fig. 9. Location of major and minor brood areas, Flathead River, Montana, 1983-86.

There was usually only 1 gang brood per brood area. The intensively used brood areas were very important to brood-rearing since during the last half of the brood period they supported 100%of the goose population.

Brood habitat on the river appeared to be adequate and the river could probably support more broods. During our study, the number of broods using all the brood areas increased, a new area was used that we do not believe had been used before (Crow Creek), and we believe there are several areas that are suitable for brood-rearing geese but are not used because of the low number of geese on the river and/or these areas lack a tradition of past brood use. There does not appear to be any threat to current or potential brood areas on the river by changes in land use practices.

Lake broods.- From the 21 nesting islands in Flathead Lake, broods moved to 4 major and 6 minor brood areas (Fig. 10). Most brood movement appeared to be from each nesting island to the closest brood area. Most broods that hatched on Goose and Douglas Islands appeared to move to the Flathead Waterfowl Production Area (WPA) at the north end of the lake. Analysis of our radio-telemetry data indicated that geese nesting on Cedar Island moved their broods to the north end WPA and to the Dayton brood area. Radio-marked geese nesting on Melita and Dream Islands moved to the Big Arm and Elmo brood areas. The largest concentration of broods on our study area was at East Bay. Based on our radio-telemetry data, most broods using East Bay were hatched on the Bird Islands. This movement pattern was also observed by Barraclough (1954).

Movement from nesting islands to lake brood areas was relatively slow, often taking 7-10 days. After this period, adult geese became tolerant of other broods and gang broods began forming. Once gang broods were formed, and the broods were located within brood areas, they usually remained there until fledging. This behavior pattern was similar to that observed on the river.

The 4 major brood areas on the lake (East Bay, Big Arm, Elmo, and Dayton), occurred where creeks enter the lake and deltaic processes have taken place over the years. The most drastic example was in East Bay. This area was the largest brood area, supported the greatest number of broods, and was the most affected by lake drawdown. East Bay had over 300 ha of virtually unvegetated mudflats at low pool. Consequently, this habitat caused broods to spend approximately 60% of their feeding time pecking (Table 38). Likewise, gosling grazing time at East Bay was about l/2 the level at the Elmo brood area and l/3 the level at Big Arm.

Broods at Dayton, Big Arm, and East Bay spent over 50% of their time feeding, 17% resting, and 22-25% locomoting (Table 38). In sharp contrast is the Elmo area where broods spent only 42% of their tin-e feeding . Most surprising, however, is the relatively large percentage of time spent locomoting (walking and swimming) and the small amount of time spent resting at Elmo. The time spent in disturbed behavior was higher at Elmo than any other area on Flathead Lake and 4x greater than at nearby Big Arm. A large percentage of the time spent locomoting was due to broods swimming away from distrubances. Most of the disturbance at Elmo was from several landowners (and their dogs) who dislike the presence of goose broods on their property.

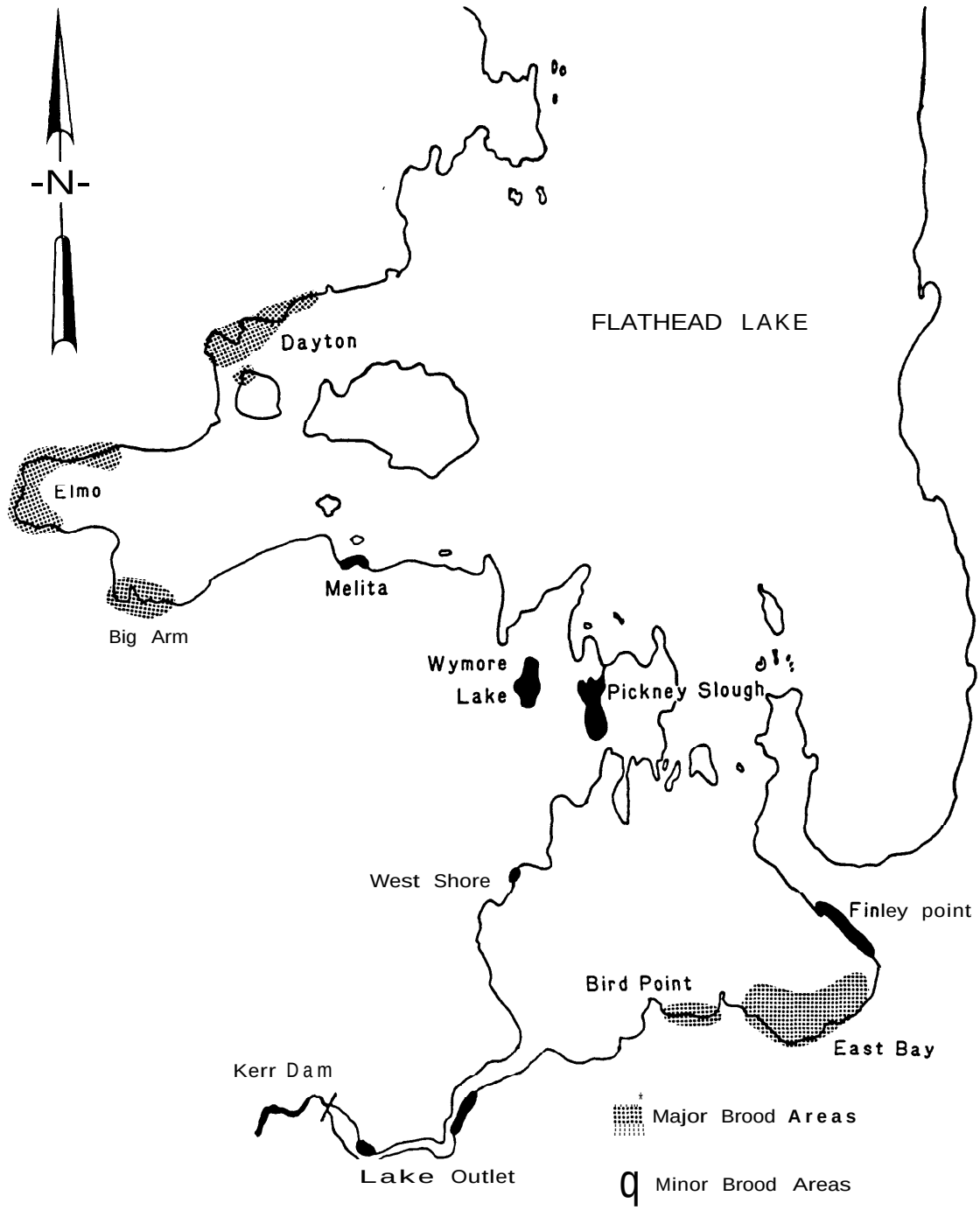

Fig. 10. Location of major and minor brood areas, Flathead Lake, Montana, 1984-86.

Table 38. Percent time spent in activities by Canada goose goslings and associated adults in the major brood areas of Flathead Lake, Montana, 1984-86.

	Brood Area									
	East Bay		Big Arm		Elmo		Dayton		Others	
Activity	Goslings	Adults	Goslings	Adults	Goslings	Adults	Goslings	Adults	Goslings	Adults
Total Feeding	51.7	37.5	54.9	27.2	42.0	20.8	52.7	27.6	46.0	30.2
Grazing	15.1	9.8	50.2	24.5	27.1	13.1	42.2	22.0	37.2	24.5
Pecking	34.9	24.0	3.6	1.7	12.6	5.9	8.1	3.5	4.7	2.1
Other Feeding[a]	1.7	3.7	1.1	1.0	2.3	1.8	2.4	2.1	4.1	3.6
Resting	16.7	7.7	16.9	8.9	10.8	4.1	16.7	9.3	35.5	9.0
Walking	11.0	13.0	10.3	10.1	7.9	7.8	8.1	8.2	6.6	7.0
Swimming	12.8	9.7	11.7	10.6	32.0	30.3	16.2	14.6	9.4	9.2
Disturbed	0.8	0.8	0.3	0.5	1.2	1.1	0.7	0.7	0.1	0.1
Alert	0.0	22.2	0.0	35.1	0.0	28.7	0.0	29.9	0.0	30.6
Other[b]	7.0	8.1	5.9	7.6	6.1	7.2	5.6	8.7	2.4	13.9

[a]Includes hawking, gleaning and tipping.

[b]Includes comfort movements, social interactions and brooding.

In contrast to brood habitat on the river, lake brood habitat is not abundant and many areas that are presently used are not of high quality. Even at high water, areas of undisturbed herbaceous cover are not abundant on the lake, and those lawns and pastures that are available are often very near human activity and intentional or unintentional human disturbance. At low water many herbaceous pastures are separated fram water by extensive mudflats and broods are forced to forage in sparsely vegetated areas. In addition, the quantity of brood areas will likely decrease in the future as the lakeshore is further developed.

Brood habitat description. Sampling of brood habitat characteristics was conducted from mid-May to mid-July 1986 in order to sample the productivity of the sites at or near the time the broods were using them. A total of 22 sites at brood areas were sampled; 14 areas along the river and 8 on the lake. Over 100 plant species were encountered in these transects. Species coverage on the river and lake brood areas sampled are in Appendix F.

Brood areas sampled on the river were located at the mouth of Mission Creek (RM 28.1, east bank), on McDonald Island (RM 17.8), on the south bank below McDonald Island (17.6), 4 near Foust Slough Island.(RM 31.8 - 33.0), 3 on or near Goose Islands (RM 13.6), across from Long Island (RM 27.9, north side), near Crow Creek (RM 42.8; east side), near Buffalo Bridge (64.7, north side) and near Goose Pond Island (RM 62.3, east side).

These areas were predominately herbaceous, although 1 had 60% ponderosa pine cover. The most frequently encountered forb was knapweed, although Kentucky blue grass, dandelion and cheatgrass were also common. An assortment of forbs and grasses followed, with 3 species of wheatgrass forming important cover in some sites. It appeared, from the grazed tops, that the geese were using wheatgrass, bluegrass and some forbs extensively. The high degree of variability in species beyond the few mentioned above suggest that location and access to water are more important than species composition in brood habitat selection.

River brood areas averaged 12.5 species/transect (Table 39), ranging from 4-21 species. The plot with only 4 species contained 53% knapweed cover. The primary height averaged 27.7 cm, and the secondary height (when present) averaged 39.9 cm. Total cover averaged 76.8%, ranging from 51-100%. Biomass data were obtained for 11 of the 14 sampled areas, and ranged from 56-156 gm/m^2 (499-1391 lbs/acre), averaging 100.4 g/m^2 (895.8 lBS/acre). This is similar to biomass of steppe grasslands in Washington State, which averaged 100-150 g/m^2 (Daubenmire 1970).

Lake brood areas were sampled at East Bay, Dayton, and the north, south, and **central parts** of Elmo Bay These areas averaged 10.4 species/transect, ranging from 1 to 18 species (Table 39).

Only 1 plot was sampled in East Bay, where slender spikerush, the only species present, averaged 29% cover. This plot only represented portions of the mudflat in East Bay, which were the more densely vegetated areas. The reminder of the mudflat area was essentially barren, except the cattail marsh near the HWM, and areas bordering the emergent marsh. These areas contained predominantly marestail, and a few other forbs. The East Bay plot had the least biomass (53.8 g/m^2) of

Table 39. Habitat characteristics of brood areas, on the Flathead River and Lake, Montana 1986.

	Biomass (gm/m^2)	Primary Height (cm)	Secondary Height (cm)	Total Cover (%)	No. of Species
River:					
Mean	100.4	27.7	39.9	76.8	12.5
SD	30.8	9.3	28.2	14.6	5.1
Minimum	55.9	9.7	7.0	51.5	4.0
Maximum	155.9	45.0	97.0	100.0	21.0
n	11	14	9	14	14
Lake:					
Mean	206.3	26.6	27.6	84.3	10.4
SD	197.5	22.3	24.5	25.8	5.4
Minumum	53.8	2.0	5.0	25.0	1.0
Maximum	616.8	69.8	67.0	100.0	18.0
n	7	8	6	8	8

any plot sampled with approximately 25% of the biomass of the average on the lake, and 50% of the average on the river. Slender spikerush has been noted in gosling diets elsewhere, and was used in an experiment testing food preferences of young (penned) geese where it ranked 5 out of 6 grass and sedge choices given to goslings (Lieff et al. 1970).

The other brood areas on the lake had variable species composition, generally with more sedges and rushes than in the river brood areas. The 5 most common species (in 50% of the plots) were Kentucky bluegrass, baltic rush, orchard grass (Dactylis glomerata), Canada thistle, and Douglas sedge (Carex douslasii).

On the south side of Elmo Bay, a site contained 32% arrowgrass (Trislochin maritimus) which had been heavily grazed by geese. A similar species of this genus was an important food for cackling geese and goslings in the Yukon Delta of Alaska (Sedinger and Raveling 1984). Arrowgrass from mudflats was also reported to be very high in protein (30.1%). It may be possible to encourage this plant in some shoreline mudflat areas to enrich the forage available to goslings.

Other sites around Elmo Bay had significant cover of Kentucky and compressed bluegrass orchard grass, baltic rush, redtop bentgrass and salt-grass (Distichilis stricta). The site with the highest biomass had 79% cover of baltic rush and 26% cover of redtop bentgrass, producing 617 g/m^2.

The Dayton area plot was in a meadow frequently grazed by cattle, and geese. Water sedge (Carex asuatilis), dandelion, Douglas sedge and field clover (Trifoilium repens) composed most of the cover. On the mudflat near this plot, geese had grazed the flowering rush stands that appeared to be expanding. Flowering rush was one of the most important forage species for goose broods at the north end of Flathead Lake, where large monotypic stands flourish (Casey and Wood 1987).

Biomass of brood areas on the lake more variable than those on the river. Although mean biomass values of sampled areas on the lake averaged twice those on the river, actual biomass produced in all brood areas was probably less on the lake than the river. Our sampling was designed to reflect the diversity of brood habitats on the river and lake. The East Bay brood area was the largest; however, due to its homogeneity, it was sampled with only 1 transect, and had the least mean biomass per unit area of any brood site. Similarly, the sample on the lake with the largest biomass represented only a small strip of shoreline north of Elmo.

Primary height was also more variable on lake brood areas than the river. The minimum height of any sample (2 cm) was from the large brood area at East Bay. This, in combination with the extremely low productivity of the area as a whole contributes to the poor quality of habitat available to broods using this site.

BROOD TIME BUDGETS AND HABITAT USE

INTRODUCTION

Environmental factors potentially limiting brood survival should be identified for adequate management of breeding waterfowl populations. We studied the effects of fluctuating water levels on time budgets and habitat use of western Canada goose broods on Flathead Lake and the Flathead River, Montana. On our study area, Geis (1956) documented gosling mortality of 22-24% on Flathead Lake and 8-9% on the Flathead River; this level was approximately 3X the weighted mean of several other studies (Krohn and Bizeau 1980:34). Gosling mortality rates observed during our study were similar to those reported by Geis (1956).

Food availability as influenced by water levels can be a major determinant of waterfowl daily activities (Burton and Hudson 1978, Minot 1980). Water levels on Flathead Lake and River are controlled by a hydroelectric dam, and on both areas, the most dramatic water level fluctuations occur during the goose brood-rearing period from mid-April through June. During the early brood period on Flathead Lake, virtually unvegetated mudflats up to 400 m wide separate the security of open water from feeding opportunities in upland pastures and marsh areas. River water levels peak during the brood period, and extensive flooding of riparian habitat occurs.

Time budgets can be useful to determine specific environmental requirements for a species or to evaluate the importance of a particular area (Siegfried 1974). Time spent in different activities can influence reproductive ability, and consequently each species should exhibit an optimal time budget of activity for given environmental conditions (Asplund 1981). Deviations from optimum use of time and resources may affect energy balance (Burton and Hudson 1978) and should occur when an individual or population encounters an altered or changing environment. When this happens, selection should favor those individuals best able to adapt their use of time to the altered environment. This is especially critical with feeding activity because the amount of time spent obtaining energy is directly related to energy levels (Schoener 1971). Therefore, for species with fixed energy requirements, a reduction in quality, quantity, or availability of forage increases the time spent feeding (Estes et al. 1986). Time budget research has been conducted on ducks (Siegfried 1974, Dwyer 1975, Minot 1980, Asplund 1981, Titman 1981, Hickey and Titman 1983, Paulus 1984, and others), and snow geese (Burton and Hudson 1978, Frederick and Klaas 1982, Giroux et al. 1984, 1986). However, we found no published quantitative information on Canada goose brood time budgets, and only 1 publication (Sedinger and Raveling 1984) dealing with brood habitat use by Canada geese.

Objectives of our research were to identify time budgets and habitat use by goslings and associated adults (presumed parents), and to determine the effects of fluctuating water levels. First, we describe differences in brood activities and habitats used for 2 gosling age classes and several water levels, for the river and lake broods. Second, we compare differences between the river and lake and, within each area, between goslings and adults.

METHODS

Data were collected from the earliest brood sightings in late April until fledging in late June or early July, 1984-86. We distributed sampling efforts over the entire diurnal period. Activity time budget sampling was performed by an observer on the ground with a 15-60X spotting scope, using instantaneous sampling (Altmann 1974) with one minute intervals. If several broods were together in a gang brood (Warhurst et al. 1983), one brood (focal brood) was randomly selected for sampling. We attempted to monitor the focal brood for at least 30 consecutive minutes, unless that brood went out of sight for more than 5 consecutive minutes, or became mixed with another brood, at which time another focal brood was randomly selected.

Activity and habitat type (Table 40) were recorded each minute for the gosling and adult (focal individuals) closest to the first gosling seen (key gosling) within the focal brood. Since this process was repeated each minute, focal individuals were selected for each observation; we did not attempt to uniquely identify either adults or goslings. Data were recorded for only 1 adult and gosling because of the inherent dependency of activities among adults and goslings within a single brood. Age of goslings was estimated (Yocum and Harris 1965) and data were pooled for analyses as young (days 1-15) and old (days 16-40).

Water levels were recorded for each 30 minute sampling period. River water levels were divided into 3 groups: low (<lO,OOO cfs), medium (lO,OOO-20,000 cfs), and high (>20,000 cfs). Lake pool elevations were categorized as: low (<880.00 m), medium (880.00-880.72 m), high (880.72-881.36 m), and full (>881.36 m). Percentages of time spent by goslings and associated adults in activities and habitat types were calculatd if 10 or fewer of the 30 observations were "out of sight" values. These summary percentages for each 30 minute sampling period became our experimental units and were used for all statistical comparisons. Since goslings and adults in the same brood occupied the same habitat type, the values of both groups were summarized to express habitat use for the entire brood, rather than for goslings and adults separately. Time budgets and habitat use were analyzed from a total of 987 30-minute observations, composed of 491 from the river and 496 from the lake.

To detect differences in activities and habitat use between age groups and among water levels, we used Kruskal-Wallis tests (Conover 1980:229). Mann-Whitney U-tests (Conover 1980:216, Norusis 1986:B177) were used to detect differences in brood activity between the lake and river, and Sign tests (Conover 1980:122, Norusis 1986:B180) were used to detect differences in activities between adults and goslings.

RESULTs

River

Effects of Gosling Age.- Young broods used herbaceous habitat types and water more (P < 0.Ol), and cultivated areas 2.5X less (P < 0.001) than old broods (Table 41). Goslings and adults walked and swam more when goslings were young than when they were old (Table 42). Goslings spent more time (P < 0.001) resting when old (35% vs. 25%), but the time

Table 40. Activity and habitat type categories used for Canada goose brood time budgets, Flathead Lake and River, Montana, 1984-86.

Activity	Habitat Type
Grazing	Forest
Pecking[c]	Shrub
Other Feeding: Hawking Tipping Gleaning	Herbaceous: Grasses Forbs
Resting	Cultivated: Pasture
Walking	Grainfield[b]
Swimming	Alfalfa[b]
Disturbed	Orchard[a]
Alert	Lawn[a]
Other: Comfort Movements Social Interactions Brooding	Marsh[a]
	Aquatic[b]: Submergent Plants
Out of Sight	Gravel
	Mudflat[a]
	Water

[a]Habitat type occurred on lake only.

[b]Habitat type occurred on river only.

[c]Defined as feeding on sparsely vegetated areas (<l0% vegetation cover).

Table 41. Percent time spent in habitat types by young and old Canada goose goslings and associated adults, Flathead River and Lake, Montana, 1984-86.

	River			Lake		
Habitat Type	Young Broods	Old Broods	Differences[a]	Young Broods	Old Broods	Differences[b]
Forest	8.0	8.7	NS	0.1	1.6	*
Shrub	1.5	2.0	NS	0.5	0.7	NS
Herbaceous	59.0	47.1	**	25.1	35.3	***
Cultivated	11.3	28.1	***	4.6	8.1	NS
Lawn	-[c]	-	-	8.2	10.7	NS
Aquatic	1.6	1.1	NS	-	-	-
Marsh	-	-	-	4.9	4.9	NS
Gravel	1.2	3.2	NS	11.5	4.9	NS
Mudflat	-	-	-	30.6	7.2	***
Water	16.6	9.5	**	14.4	24.3	***

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$, NS = not significant.

[a]Significant with Kruskal-Wallis and multivariate and univariate analysis of variance on the ranks.

[b]Significant with Kruskal-Wallis test only.

[c]Habitat type did not occur on the area.

Table 42. Percent time spent in activities by young and old Canada goose goslings and associated adults, Flathead River, Montana, 1984-86.

	Goslings			Adults With Goslings		
Activity	Young	Old	Differences	Young	Old	Differences
Grazing	34.6	32.3	NS	165	174	NS
Other Feeding	7.1	6.6	NS	3.8	3.6	NS
Total Feeding	41.7	38.9	NS	20.3	21.0	NS
Resting	24.9	34.9	***	9.6	11.7	NS
Walking	10.9	7.4	***	8.6	7.1	*
Swimming	15.3	8.2	**	13.4	7.2	**
Disturbed	1.4	1.3	NS	1.4	1.3	NS
Alert	0	0	NS	38.9	42.3	NS
Other[a]	5.8	9.3	–	7.8	9.4	–

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. NS = not significant.

[a]Includes comfort movements, social interactions, and brooding.

adults spent resting did not change from approximately 10%. The time spent feeding, disturbed, and alert did not change with age; goslings spent approximately 40% of their time and adults 20% of their time feeding for both age groups.

Effects of Water Levels. Use of forest and shrub types increased as water levels increased from a combined use of 2.9% at low water and 17.7% use at high (Table 43). Aquatic (submergent) vegetation was used less as water levels increased ($p < 0.01$): aquatic vegetation was used less at medium than low flows, and was not used at high flows. Similarly, gravel bars were used more at low water levels ($p < 0.01$), and were not used at high levels. Use of water was inversely related to the magnitude of river flows: broods used water less at high flows than at medium, and low levels ($p < 0.01$). Cultivated areas were used more at low than high water levels ($p < 0.05$). Use of herbaceous types did not change with water levels.

At low flows, both goslings and adults fed less ($p < 0.01$) than at high flows (Table 44). Conversely, time spent swimning, like the use of water, decreased as the river levels increased ($p < 0.01$). There were no differences in time spent grazing, resting, walking, disturbed, and alert for goslings or adults with respect to water levels. Time spent resting averaged approximately 29% for goslings and 11% for adults, and time spent walking averaged <10% for both groups.

Lake

Effects of Gosling Age. - Young broods used mudflats more, and shoreline forests and herbaceous areas less than old broods (Table 41). Similarly, differences in activities appeared to be those associated with these habitats. Young broods pecked (defined as feeding on sparsely vegetated areas, ie., mudflats) more than old broods (Table 45). Conversely, broods grazed (primarily in herbaceous areas) more when goslings were old ($p < 0.001$).

Effects of Water Levels. - Use of herbaceous habitat was greater at full pool than the lower 3 levels, and was greater at high than at medium or low water (Table 43). Use of marsh habitat at high and medium water was greater than use at full or low ($p < 0.01$). Mudflat use at low and medium water levels was >8X more than use at high or full ($P < 0.01$), and use at high was greater than at full pool ($p < 0.01$). In contrast to the pattern on the river, use of water by lake broods increased with water levels: use at low and medium was less than use at high or full pool levels ($p < 0.05$).

Goslings and adults walked less at full pool than at other lake levels (Table 46). Adult alert behavior was greater at high and full levels than low and medium ($p < 0.05$). The level of brood disturbance was greatest at full pool ($p < 0.01$). Time spent resting and total feeding did not change.

Although the total time spent feeding by goslings and adults did not change from low to full pool, grazing and swimming increased while pecking on sparsely vegetated areas decreased (Table 46). Goslings spent almost twice as much time grazing at high and full than at low and medium water levels ($p < 0.01$). Adults spent less time grazing than goslings at each water level, but like goslings, spent a greater amount

Table 43. Percent time spent in habitat types by Canada goose g°slings and associated adults, by water levels, Flathead River an° Lake, Montana, 1984-86.

	River Wat erLevels			Lake Water Levels			
Habitat Type	Lo	Med ùm	High	Low	Medium	High	Full
Forest	2.9 M,H[a]	9.4 L,h	13.9 L,m	0.0	1.0	0.0	0.6
Shrub	0.° m,H	1.8 1,h	3.8 L,m	0.0	1.0	0.2	0.9
Herbaceous	50.2	55.7	60.0	18.0 H,F	11.9 H,F	26.4 L,M,F	50.4 L,M,H
ª ltivated	18.3 h	13.9	13.6 1	6.⊙	2.4	7.3	5.7
Lawn	–[b]	–	–	4.7	13.4	7.9	11.Ξ
Aquatic	3.4 H	1.3 H	0.° L,M	–	–	–	–
Marsh	–	–	–	0.7 M,H	6.9 L,F	15.7 L,F	0.5 M,H
Mudflat	–	–	–	45.3 H,F	41.5 H,F	4.8 L,M,F	0.2 L,M,H
Gravel	4.4 M,H	0.5 L,H	0.° L,M	14 ⊼	8.6 h	12.2 m,F	3.9 H
Water	18.8 H	15.6 H	8.7 L,M	10.2 H,F	13.3 h,F	21.3 L,m	25.5 L,M

[a]Differences between means are indicated by the first letter of levels differing (ie. L = Low, etc.); lower case abbreviations differ at 0.01 < P < 0.05, upper case at P < 0.01.

[b]Habitat type did not occur on the area.

Table 44. Percent time spent in activities by Canada goose goslings and associated adults by 3 river levels, Flathead River, Montana, 1984-86.

	Water Levels					
	Goslings			Adults		
Activity	Low	Medium	High	Low	Medium	High
Grazing	25.0	35.8	32.3	12.8	16.8	18.4
Other Feeding	8.4	4.4	9.5	4.6	2.2	5.5
Total Feeding	33.4 m,H[a]	40.2 l	41.8 L	17.4 H	19.0 h	23.9 L,m
Resting	30.0	28.0	28.5	12.0	10.8	10.9
Walking	10.2	10.1	8.4	9.4	7.9	7.8
Swimming	15.° H	14.5 H	9.7 L,M	12.6 H	12.7 H	8.9 L,M
Disturbed	0.8	1.3	2.°	0.7	1.4	1.9
Alert	0.0	0.0	0.0	36.9	40.9	35.9
Other[b]	10.6	5.9	9.6	11.°	7.3	10.7

[a] Differences between means are indicated by the first letter of the levels differing (ie. L=Low etc.); lower case abbreviations differ at 0.01 <P < °.05, upper case at P <0.01.

[b] Includes comfort movements, social interactions, and brooding.

Table 45. Percent time spent in activities by young and old Canada goose goslings and associated adults, Flathead Lake, Montana, 1984-86.

	Goslings			Adults With Goslings		
Activity	Young	Old	Differences[a]	Young	Old	Differences[a]
Grazing	26.0	40.0	***	14.3	20.9	***
Pecking	24.3	5.9	***	14.7	4.3	***
Other Feeding	1.3	3.5	NS	2.4	3.0	NS
Total Feeding	51.6	49.4	NS	31.4	28.2	NS
Resting	15.7	18.4	NS	7.8	7.6	NS
Walking	11.7	4.9	***	12.5	5.4	***
Swimming	13.2	22.3	***	10.8	20.8	***
Disturbed	0.7	0.9	*	0.7	1.0	*
Alert	0	0	NS	27.5	28.5	NS
Other[b]	7.1	4.1	-	9.3	8.5	-

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$, NS = not significant

[a]Significant with Kruskal-Wallis test only.

[b]Includes comfort movements, social interactions and brooding.

Table 46. Percent time spent in activities by Canada goose goslings and associated adults, by 4 levels. Flathead [illegible]e, Montana, 1984-86.

	Water Levels							
	Goslings				Adults			
Act ty	Low	Medium	High	Ful	Low	Medium	High	Full
Grazing	18.1 H,F[a]	22.0 H,F	31.5 L,M,F	45.2 L,M,H	10.9 H,F	12.2 H,F	18.0 M,L	22.4 M,L
Pecking	32.3 H,F	30.0 H,F	13.6 L,M,F	1.1 L,M,H	20.5 H,F	20.0 H,F	6.6 L,M.F	0.6 L,M,H
Other Feeding	0.5	0.1	4.9	3.1	2.3	0.7	3.9	3.1
Total Feeding	50.9	52.1	50.0	49.4	33.[illegible]	32.9	28.5	26.1
Resting	15.9	15.7	20.2	16.0	9.2	5.7	11.3	6.2
Walking	12.3 F	13.8 H,F	8.6 M,F	4.8 L,M,H	14.[illegible] H,F	15.1 H,F	8.3 L,M,F	5.2 L,M,H
Swimming	9.4 H,F	12.1 H,F	17.6 L,M	24.7 L,M	6.5 H,F	10.8 F	15.5 L	22.8 L,M
Disturbed	0.7	0.3 h,F	0.8 m	1.0 M	0.8 F	0.3 F	0.7	1.[illegible] L,M
Alert	0	0	0	0	23.1 h,F	27.0 f	28.6 l	31.6 L,m
Other[b]	10.8	6.0	2.8	4.1	12.7	8.2	7.1	7.1

[a]Differences between means are indicated by the first letter of the levels differing (ie. L = Low etc.); lower case abbreviations differ at $0.01 < P < 0.05$, uppercase at $P < 0.01$.

[b]Includes comfort movements, social interactions and brooding.

of time grazing at high and full pool than at low and medium ($p < 0.01$). Adults spent less time pecking than goslings, and both groups spent the least time pecking at higher water levels ($p < 0.01$). Time spent swimming by broods increased almost 3X for both goslings and adults as the lake was filled (Table 46). Goslings swam more at high and full pool than at low and medium ($p < 0.01$).

Comparisons of River and Lake

Goslings and adults on the lake spent more time feeding ($p < 0.001$) than on the river (Table 47). This difference was due to the greater time spent in "other feeding" activities (which on the lake was comprised primarily of pecking) on the lake ($p < 0.001$). Goslings grazed more on the river than the lake ($p < 0.05$), but adults did not. River goslings rested 1.7X more than goslings on the lake ($p < 0.001$), and river adults rested 1.4X more ($p < 0.01$). Adults on the river were alert more than those on the lake ($p < 0.001$), although there was no difference in the level of disturbance between the 2 areas. Goslings and adults spent the same amount of time swimming on both areas ($P < 0.05$).

Comparsions of Goslings and Adults

The time spent in all activities except disturbance were different between goslings and adults on both the lake and river (Table 47). Goslings spent >1.7X more time feeding ($p < 0.001$) than adults on both areas. Goslings rested >2X more than adults on the lake and almost 3X more on the river ($p > 0.001$). Goslings swam more than adults on the lake and river and walked less on the lake and more on the river. Adults were more alert than goslings ($p < 0.001$).

DISCUSSION

Time Budgets and Habitat Use Relative to Gosling Age

Goose broods on the lake used areas ranging from private lawns to undeveloped sites. Attitudes of the lakeshore landowners towards geese, and their activities (intentional and unintentional disturbance, fences, etc.) were often a factor affecting brood activity and habitat use. In contrast, geese on the river were a more natural, wild population, and we did not observe these types of human related effects on brood activity or habitat use. For these reasons, we considered differences in activities or habitat use for river broods "typical" for Canada geese on our study area that were not affected by human habitation, and when differences were observed between the 2 populations we assumed the lake geese were much more affected by human habitation than river broods.

Young broods on the river used herbaceous types more, and walked and swam more than when they were old. This was likely due to their need for, and ability to select high quality food (Sedinger and Raveling 1984). Geese graze in a manner that allows them to maximize nutrient intake (McLandress and Raveling 1981 a, b), and Harwood (1977) observed adult greater snow geese increase feeding behaviors as the standing crop

Table 47. Percent time spent in activities by Canada goose goslings and associated adults, Flathead Lake and River, Montana, 1984-86.

	Lake		River		Goslings vs Adults		Lake vs River	
Activity	Goslings	Adults	Goslings	Adults	Lake	River	Goslings	Adults
Grazing	30.6	16.4	33.0	16.5	***	***	*	NS
Other Feeding[a]	20.0	13.7	6.6	3.6	***	***	***	***
Total Feeding	50.6	30.1	39.6	20.1	***	***	***	***
Resting	16.5	7.7	28.9	10.9	***	***	***	**
Walking	9.5	10.2	9.7	8.1	*	**	*	NS
Swimming	16.6	14.6	12.8	11.4	***	**	NS	NS
Disturbed	0.7	0.8	1.3	1.3	NS	NS	NS	NS
Alert	0	27.8	0	39.4	***	***	NS	***
Other[b]	6.1	8.8	7.7	8.8	-	-	-	-

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$, NS = not significant.

[a]Includes pecking, tipping, gleaning and hawking; most "other feeding" on the lake was pecking on sparsely vegetated habitat types.

[b]Includes comfort movements, social interactions, and brooding.

of green vegetation and crude protien content increased. On the river, selection of areas that contained vegetation high in protein, where a high rate of food intake could occur, may have required increased travel time by young broods.

As river goslings became older, use of cultivated areas increased 2.5X, while use of herbaceous types decreased. The delayed phenology of cultivated vs. wild plants on our study area, and the tendency of broods to select the most succulent vegetation available (Sedinger and Raveling 1984), likely explains why broods increased their use of cultivated land and reduced use of herbaceous areas. Cultivated areas on the river (primarily crops of alfalfa and wheat) were also likely higher in quality, and were at least as great in quantity than natural herbaceous areas, especially late in the brood period. In addition, since cultivated types were farther away from the river than many herbaceous areas, cultivated areas were likely used more when broods were older and more mobile. While use of habitat types did change with brood age, time spent feeding did not. This indicated that although broods may have changed habitat use patterns in response to changing food quality and/or quantity, the amount of effort they expended to obtain adequate forage did not change.

The only activity on the river that increased when goslings were old was resting, whereas, time spent resting by adults was over 2.5X less than goslings and did not change with brood age. Old goslings rested 10% more and locomoted (walked and swam) 10% less while all other activities did not change. We believe that goslings were able to rest more when old because they did not have to travel as much. This could have been due to: 1) greater food quality/quantity (especially with respect to cultivated areas), thereby reducing the need to travel for adequate food, and/or 2) more efficient exploitation of food resources as a result of increased feeding efficiency and mobility when broods were old.

The effects of gosling age on activities and habitats used on Flathead Lake were less clear than on the river because of water level effects. Changes in water levels on the lake and river were dramatically different, and as a result, effects of water levels on brood habitat use and activities were very different between the 2 areas. Each year, lake water levels gradually increased from low pool when goslings were hatched, to high when goslings fledged. This created gradual decreasing availability of some habitats and increasing availability of others as the lake level rose. On the river, water levels changed rapidly, often fluctuating between levels every l-2 weeks, and the chronology of river flows was very different between years. As a result, brood habitit use and activities were only temporarily affected by river flows. We believe habitat use differences attributed to the age of lake goslings primarily reflected habitat availability and accessibility as influenced by water levels: mudflats were much more available at low than full pool because they were located at the water's edge, whereas, herbaceous and forested areas were less available because at low pool they were usually separated from water by extensive mudflats. We seldom observed broods farther than 75 m from water, which they used as escape cover, and broods were never observed crossing low pool mudflats to feed on upland herbaceous areas. Although

the use of mudflats was >4X greater when goslings were young compared to old, use of this type was >225X greater at low compared to full pool because mudflats were inundated and unavailable at full pool. Similarly, the use of herbaceous areas and lawns increased 1.4X from young to old, but 2.7X from low to full pool as they became more accessible to broods. Consistent with habitat use relationships, broods pecked more (on mudflats) when young and the water was low, but grazed more (on herbaceous areas) when old and the lake was full. We believe that habitat use and feeding activity pattens which differed by gosling age were caused by changing habitat availability as the lake level rose rather than an age related difference in habitat selection.

Time Budgets and Habitat Use Relative to Water Levels

On our study area water level fluctuations affected geese during the brood rearing period, not only through a direct effect on food availability, but also because water provided the primary means of escape to broods. Apparently, broods must remain relatively close to water during this period, and adjust their feeding strategies to maintain adequate energy levels. For these reasons, we observed the most dramatic effects on brood time budgets and habitat use when we compared them by water levels rather than gosling age groups.

Broods on the river swam less and fed more at high water levels than at low. The sum of the time spent feeding and locomoting from low to high flows differed by only 1.3%, and no other activities were different with respect to water levels; we believe this indicates an inter-dependence between feeding and locomotion. Use of aquatic vegetation and gravel areas was greatest at low flows, and these types were not used at high water because they were inundated and unavailable. Low flows dewatered backwater areas and shorelines, and consequently increased availability of aquatic vegetation and other succulent forage. We believe that broods either: 1) swam more at low water to seek out adequate food, but when food was located, they were able to feed less because of high quality forage; 2) swam less at high flows because the swifter currents discouraged movements and/or decreased travel efficiency; and/or 3) decreased swimming at high flows because flooding of backwater and lowland areas adjacent to the river provided access to previously inaccessible food sources.

Use of forest and shrub habitats increased as river flows increased, from a combined total of 3% at low to 18% at high water. A zone of herbaceous and gravel areas that was adjacent to the waters edge at low flows, was inundated and became unavailable as flows increased. Broods were apparently forced to use forrest and shrub habitats more at high flows since these habitats coincided with the water line at high flows. Use of cultivated areas on the river decreased as water levels rose, and may have been due to broods using natural herbaceous areas that were flooded during high flows.

Time spent walking by lake broads was gradually reduced but swimming increased as the lake was filled. In contrast, time spent walking by river broods did not change and swimming decreased as water levels rose. The level of lake brood disturbance, and time spent alert by adults increased as the lake was filled, whereas, on the river disturbance and

alert behaviors did not change with water levels. Flathead Lake was increased from high to full pool elevations between Memorial Day and 1 July each year, and the ensuing level of human recreation increased tremendously. We believe that the increase in swimming and alert behavior at full pool was primarily a result of increasing levels of human related disturbances, in the form of boats and lakeshore landowners reoccupying cabins for the summer. Giroux et al. (1986) reported greater snow goose brood locomotion rates which were <l/2 of rates we observed at full pool on the lake.

Goslings on the lake spent roughly 50%, and adults 30% of their time engaged in feeding, and more time feeding and less time resting than broods on the river. Although the overall time spent feeding did not change over the 4 lake levels, the type of feeding did. The amount of time lake broods spent in herbaceous habitat types, and the corresponding time spent grazing, increased >2X from low to full pool. This was primarily due to increased accessibility of herbaceous areas as the lake level rose. The amount of time spent on mudflats decreased from 45% to <l% as the lake was filled, and the associated time broods spent pecking there decreased approximately 30X. Again, habitat use was related to availability because mudflats were slowly inundated as lake water levels increased, and were unavailable at full pool. The lake mudflats were virtually barren of vegetation, and feeding on these areas was limited to extremely sparse growths of slender spikerush, unknown quantities of invertebrates, and dessicated remains of submergent aquatic vegetation which had been exposed during the previous winter drawdown. It was obvious to us that at low water, lake broods would have preferred shoreline herbaceous vegetation or the often fertilized lawns (Gwen et al. 1977), but usually would not risk the exposure to predation entailed in traveling far from the water's edge, and were therefore forced to use mudflats. We believe that greater feeding and less resting behavior on the lake than the river and use of sparsely vegetated lake mudflats at low water indicate that lake broods had more difficultly maintaining adequate energy levels than river broods. At high water, lake broods were able to use the higher quality herbaceous types, but were forced to swim more due to increased disturbance, and/or because quality brood pastures were more dispersed. The percentage of time spent resting by lake broods was approximately half that observed on the river, less than that reported by Giroux et al. (1986), and likely resulted from broods needing to feed more on the lake.

The use of marsh areas on the lake increased from low to high pool, then decreased at full pool. This situation further illustrates how broods followed the water's edge as the lake was filled. At low water, cover provided by stranded growths of cattail and bulrush were too far from water for broods to use. Furthermore, the quality and quantity of food there appeared to be only slightly better than on mudflats. As the lake level increased, use of marsh increased 10X at medium pool, and 22X at high level, as the water's edge gradually moved closer to, and then inundated marsh areas. However, by the time the lake reached full pool, access to previously underexploited and preferred herbaceous areas was provided, and marsh use dropped 3lX as broods shifted use to herbaceous areas. This further supports the hypothesis that lake geese have

adapted their use of time to the existing environmental constraints of lower quality and quantity food at low water levels.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Canada goose broods on our study area exhibited different time budgets in response to different environments. Differences in activities and habitat use by goose broods were related primarily to age of the goslings and water levels on the river, and water level fluctuations on the lake. Differences between age groups were primarily related to strategies allowing young goslings to maximize the quality and quantity of food resources, and maintain adequate energy levels for growth. Other age related differences resulted from changes in the efficiency of resource exploitation as goslings matured. Differences in activites and habitat use related to water levels were primarily reflected in use of habitats most easily accessible from water.

We believe differences between the lake and river indicate that the 2 brood populations are faced with either different habitat quality or population levels. If the breeding population on the lake is at equilibrium with the available brood habitat, the river population must be below the level that the available brood habitat could support. Conversely, if the river brood population is at equilibrium with the available habitat, the lake brood habitat is insufficient in quality, quantity, or both. We strongly believe that the brood population on the river is well below that which could be sustained by the available habitat. There appeared to be an abundant supply of herbaceous grazing area available to river broods, and brood densities were very low compared to the lake. Furthermore, the river population appears to be limited by a lack of secure nesting habitat not a lack of brood habitat. Greater feeding and less resting by both goslings and adults on the lake, clearly indicates that it took more time for lake broods to maintain proper energy levels than river broods. Flathead Lake brood habitat could be improved, but otherwise the brood population is likely at a maximum with the available habitat. In contrast, brood habitat on the river appears ideal for an increase in overall population, if nesting security can be improved.

Low water levels are likely detrimental to broods, particularly on Flathead Lake. Brood habitat on the lake could be created by: 1) seeding barren mudflats yearly; 2) creation of dikes where water levels in sub-impoundments could be managed to create adequate feeding areas; and/or 3) fencing and annually burning important brocd areas (Mackey et al. 1987). Annual monitoring of brood survival after initiation of habitat enhancement, is essential to determine if augmentation of brood habitat produces the desired results.

BROOD HABITAT ENHANCEMENT

Introduction

We discovered a method of providing goose broods with succulent green forage in areas where forage may be lacking. This method could potentially be used for yearly augmentation of brood habitat on the lake.

In late April of 1984, we noticed profuse sprouts of wheat around sane large gravel and cobble on an exposed section of lake bed. This area had been used as a rocket-net trapsite that was heavily baited with wheat during the previous winter. The wheat kernels that the geese were unable to retrieve from under the edges of large stones had sprouted due to excellent germination conditions. Very young broods passing by this site were observed feeding on the succulent sprouts. Due to the limited area involved, all sprouts had soon been consummed. Evidence suggested that when the wheat leaves were grazed, the entire kernel and roots came with it and the entire seed sprout was consumed.

Methods

In the early spring of 1986, we planted 2 dewatered, unvegetated mudflats with untreated wheat. Both sites were located within traditionally used brood areas and were oriented perpendicular to the shoreline, so that broods could continually utilize the sprouts as water levels rose.

Mudflats were tilled with a small 3 wheel cycle pulling a harrow. After tillage, feed wheat was sowed using a hand-crank seeder. Seeding rate was approximately 800 kernels/m^2. After seeding, the wheat was pushed into the soil by running over the tilled areas with the 3 wheeler. After passing over the entire plot at least once, the wheat was left to germinate.

Results and Discussion

Initial germination began as early as 10 days after planting and peak "green up" occured approximately 3 weeks later. Aerial estimates of germination were made during brood counts and the level of cover appeared excellent with the densest areas usually adjacent to the rising water. Neither plot was large enough to provide substitute food for the numbers of broods that used these areas, but in both areas adults and goslings fed intermittently on wheat sprouts and supplemented their natural diet with this additional forage. Sprouts were grazed down to ground level quickly and in some cases the entire plants were pulled from the mud, especially after a few mm of water had inundated the edges. Goslings were potentially more vulnerable to mammalian predation if they crossed mudflats, therefore, broods remained close to escape cover provided by the water and the only portion typically used was those areas within approximately 30 m of the water. when mdflats were completely covered by water, the planted wheat was unavailable, however, broods no longer needed it because they had access to riparian pastures and natural short herbaceous feeding areas.

Management Implications

Planting mudflats with acceptable, palatable, and nutritious foods could be used on the lake to accomplish a diversity of objectives from augmentation of poor quality habitat to concentrating goose broods in selected areas. On the lake, the brood period is the most critical time of the year, and feeding areas available to young broods is of poor quality. Consequently, the ability to provide goose broods with adequate quality and quantity forage during this critical time each year is both a desireable and relatively inexpensive management alternative. In addition, wheat will grow without any attention subsequent to initial planting, and once flooded or eaten, will not maintain its growth or reproduce and become a pest.

BROOD CENSUSES

Introduction

To estimate gosling mortality, and determine recruitment, estimates of the number of goslings that fledge are necessary. Wildlife managers in the Flathead Valley currently estimate production using gosling counts obtained during a single valley-wide aerial survey. However, the accuracy and precision of these estimates are unknown. Objectives of our brood census work were to evaluate the suitability of aerial brood censuses in estimating gosling production, identify potential sources of bias, and recommend suitable brood census methods.

Methods

Aerial surveys were conducted weekly from mid-May through the first week in July. The river was surveyed using the same methods as for pair surveys. The lake shoreline, Wymore Lake, and Pinkney Slough were also surveyed by plane. When geese were observed, the number of adults and goslings, and location was recorded. Surveys were conducted in the morning using the same methods as for aerial territorial pair surveys.

Results and Discussion

River. - Counts of goslings were variable, and often differed 30 to 40 goslings from 1 survey to the next (Table 48). This was a result of missing entire gang broods during some flights, and illustrates a major problem with brood censuses on the river. Broods often rest in forest or shrub areas where they are extremely difficult to observe from the air. In addition, high water on the river may "force" broods to spend more time in forest or shrub areas by flooding open herbaceous areas along the river. If one gang brood was missed, the total number of goslings was greatly underestimated. By flying only once per year the chance of underestimating gosling production is high. We believe that

Table 48. Number of Canada goose adults and goslings observed during aerial brood censuses, Flathead River, Montana, 1984-86.

	No. Canada Geese Observed	
Date	Adults	Goslings
5/15/84	22	46
5/17/84	32	67
5/21/84	20	42
5/24/84	43	82
6/01/84	55	113
6/04/84	48	86
6/07/84	53	126
6/11/84	29	52
6/13/84	49	85
6/18/84	26	62
6/27/84	16	36
6/29/84	22	40
7/02/84	13	16
5/13/85	16	27
5/20/85	26	48
6/05/85	51	82
6/11/85	25	57
6/18/85	44	83
6/26/85	93	91
7/03/85	74	51
5/05/86	24	52
5/12/86	53	122
5/19/86	50	118
5/28/86	60	154
6/02/86	64	149
6/09/86	49	108

data from 1 or even 2 aerial river brood surveys has little value in terms of estimating gosling production, and could lead to erroneous management decisions.

During each year the number of goslings observed was usually greatest during the last week in May through first week in June. Numbers were likely lower earlier because many individual broods had not joined gang broods, and were secretive and difficult to observe. Gosling numbers in late June declined because some broods had fledged, and virtually all broods had fledged by the second week of July. These data indicated that if brood censuses are to be done, they should be conducted during the last week in May or first week in June.

Lake. - We compared the highest count of goslings observed on aerial surveys to the estimated number of goslings hatched during each year (Table 49). The percent of goslings observed increased from 29% in 1984 to 66% in 1986. We believe this was due to our increasing familiarity with brood areas and brood behavior in these areas through the years which resulted in our being more and more successful at locating broods. It is important to note that error rates in 1984 or 1985 are likely similar to rates that would occur with observers who had not done extensive goose brood work in the area (such as observers on most of the current yearly aerial brood surveys). We recognize that same of this error rate is due to other factors such as gosling mortality; however, even with a mortality rate of 20% the error rate would still be approximately 50%.

During early June 1986, we conducted an aerial census along with simultaneous ground counts. Broods were censused from the air in each brood area and then ground crews flushed broods onto the lake and counted all goslings. The difference in the number of goslings observed between the 2 methods was calculated as the error rate of aerial surveys. The number of goslings observed on aerial surveys was less than on ground surveys in each brood area. Error rates ranged from 12-15% over all areas.

Similar to the river, the highest gosling counts on the lake occurred the first week in June, and if brood surveys are to be conducted in the future they should be done at this time. We attempted to conduct some lake brood censuses by boat, however, broods invariably ran inland before they could be counted.

GOSLING MORTALITY

Introduction

In addition to nest numbers and nest success, the number of goslings that fledge is valuable information to wildlife managers since it is the actual number of geese recruited into the population. Canada goose gosling mortality is usually low; Krohn and Bizeau (1980) reported weighted mean gosling mortalities from 10 studies of Western Canada geese from 5-8%. However, of these 10 studies, Geis (1956) reported the

Table 49. Number of Canada goose nests, nest success, estimated gosling production, and observed gosling numbers, Flathead Lake, Montana, 1984-87.

Year	NO. Nests	% Nest Success	Estimated No. Goslings[a] Hatched	Highest Aerial Gosling Count	% Of Goslings counted[b]
1984	164	72	531	152	29
1985	166	40	299	106	35
1986	168	66	499	326	65
1987	172	83	642	421	66

[a]Estimated no. goslings hatched was calculated by: [(no. nests) (% nest success)] X 4.5 goslings / nest.

[b]Percent of the total number of goslings that hatched that were counted during aerial censuses.

highest mortality rate (24% and 22%) for Flathead Lake, and observed rates on the Flathead River (8% and 9%) more typical of the other studies. Cur objective was to determine gosling mortality on the river and lake to see if there were differences between the areas, and to compare with data collected by Geis (1956).

Methods

We determined gosling mortality by calculating the proportional difference between the number of goslings hatched and the number fledged. This method gives more reliable results than estimates from mean brood size (Krohn and Bizeau 1980), and was used by Geis (1956) on our study area. Furthermore, our mean brood size data would not give reliable estimates because of extensive gang brooding (Geis 1956). Gosling mortality was calculated as:

$$\text{percent gosling mortality} = 1 - \frac{\text{number goslings fledged}}{\text{number goslings hatched}} \times 100; \text{ where,}$$

the number of goslings hatched = (number nests hatched) X (4.5 goslings/nest) , and the number of goslings fledged was determined from maximum counts of goslings within each brood area at the end of the brood season. On the river, the number of goslings fledged was determined from a combination of aerial censuses, and ground observations during time budget data collection. On the lake, these data were calculated from the maximum count of goslings during aerial censuses. The maximum gosling count on the lake was increased by 15% because previous comparisons of simultaneous aerial/ground counts indicated we missed approximately 15% of the goslings during aerial surveys (see Brood Censuses).

Results and Discussion

Gosling mortality on the river in 1986 was 12%, and on the lake mortality was 20% in 1985 and 19% in 1986. These rates are similar to the 8-9% observed on the river, and 22-24% observed on the lake in the 1950's by Geis (1956). Mortality rates on both the river and lake are greater than most rates reported by Krohn and Bizeau (1980), however, the lake was much higher. Furthermore, the rates we observed for the lake were calculated for the entire lake portion of our study area, but we suspect that gosling mortality on the East Bay brood area (which is the largest area and used by more broods than any other area) and the Elmo brood area, are even higher. Higher mortality rates were observed in the East Bay area by Geis (1956) than for the lake as a whole.

Gosling mortality on the lake was likely a combination of: 1) goslings being killed by predators as a result of habitat deficiencies (extensive mudflats), and 2) goslings being unable to meet energy requirements because of a lack of food quality/quantity, and/or excessive disturbance. We observed one case of coyote predation of several goslings on East Bay when broods were caught on mudflats. In

the Elmo area, we observed landowners chasing broods fran their land, and we observed a landowner's dog attacking and killing several goslings.

on the river we observed nothing to indicate that gosling mortality was excessive. River broods appear to have an abundant supply of good habitat and we saw no successful predation attempts.

MANAGEMENT AND MITIGATIONS IMPLICATIONS

Management/Mitigation Alternatives

River. - Ground nesting geese are dependent on river channels surrounding nesting islands to provide secure nest sites by discouraging predators from accessing islands. High river flows (>15,000 cfs) can result in nest flooding. Under current dam operations, the ground nesting goose population is maintaining itself at a low level, but unable to increase because of high predation rates. However, if future dam operations significantly reduce or increase flows during the nesting period (i.e., mean flows often <7,000 cfs or >15,000 cfs in the south half of the river), significant losses of ground nests could occur. To maintain the ground nesting goose population, flows on the south half of the river should be between 7,000-15,000 cfs during March, April, and May.

The tentative management goal for river nesting geese is 170 nests as set at the 1986 annual meeting of the Flathead Valley Interagency Canada Goose Committee. This is approximately 2.5X the current goose nesting population level on the river.

Options for providing suitable nest sites and reaching management goals and/or mitigating for future losses of nests are:

1) Use of nest structures on the river to provide secure nest sites. For example: to meet the management goal of 170 total nests and mitigate for losses created by low flow scenarios that have resulted in complete loss of the ground nesting population, 230 nest structures would have to be available to geese (230 structures X 70% occupancy rate = 161 structures used; 161 nests + 9 nests in other natural elevated nest types = 170 total nests).
2) Create nesting areas along the river by diking old river channels and sloughs, fill the areas with water pumped from the river or existing wells, and build artificial islands within impoundments. With a moderately intensive construction project of 2-3 impoundments, 50 nests could likely be produced. This option also has potential benefits for fish, raptors, nesting ducks and pheasants, and furbearers.
3) Enhance goose nesting habitat on off-site areas in the valley. The most likely areas for this option would be the 5 irrigation reservoirs or the pothole area surrounding Ninepipe and Kicking Horse reservoirs. In these areas a nest structure program could be initiated, or nesting islands developed in potholes or reservoirs. Creation of nesting islands would also have benefits for upland nesting ducks.

Monitoring before and after an option is implemented is mandatory in order to evaluate effectiveness of the option and "fine-tune" management programs. To thoroughly understand the nesting goose population dynamics created by any option, data should be collected from ground nest searches and should include: total nest numbers and overall nest success, and nest numbers and nest success by nest type. Three to 5

years after an option is initiated, the management program should be critically reevaluated to determine if goals will be met. If the management goals will not be met, the management program should be changed so they will.

At this time, brood habitat on the river appears to be adequate in both quality and guantity, and we believe could support substantially more broods than current levels. Brood habitat use should be monitored through the years to identify potential problems resulting from any increase in the goose nesting population, and to mitigate for any losses or changes in habitat quality or quantity resulting from future dam operation or other factors.

Impacts to river habitats include: 1) the loss of marsh and gravel bar habitat between low (3,500 cfs) and average (11,700 cfs) flows on the river, 2) the restricted regeneration of deciduous tree species, in particular cottonwood and aspen, 3) the lack of diversity in riparian shrub communities and 4) destruction of habitat from ice caused erosion due to high winter flows.

Kerr Dam operations could be altered in the following ways to mitigate for these losses: 1) minimizing daily fluctuations to encourage more growth of vegetation in littoral areas, 2) allow high flows of 60,000-75,000 cfs once a decade to simulate the 10 year flood pattern and create habitat for primary succession communities, and 3) reducing winter flows (to approximately 4,000 cfs) to reduce the impacts of ice caused erosion.

Using non-operational methods, additional wetland and riparian areas could be developed adjacent to the river by diking backwaters and developing old river channels. Livestock grazing is currently impacting many of these areas and if controlled, along with water levels, mitigation for some habitats lost, as well as enhancement of desireable marsh and riparian habitats could be achieved. Mechanical scouring of sites (accompanied by grazing controls) could be used to encourage the regeneration of cottonwood and aspen communities. Suitable sites are abundant between Foust Sough (RM 30.5) and Perma (PM 11.2).

Lake. - A management goal of 165 nests was set by the Interagency Canada Goose Committee in 1986, and is essentially equal to the current lake nesting population level. The major threat to nesting geese on the lake is loss of secure nesting habitat due to human disturbances in the future through increased land development. For example, Melita Island is currently for sale, and if sold and developed, approximately 20 nests could be lost. Nest losses such as this may be compensated for using a nest structure program as on Wild Horse Island, and/or by purchasing and managing goose nesting islands on the lake.

Lake water levels created by Kerr Dam have reduced brood habitat quality and availability in most of the shallow bays, with the largest loss (350 ha of unvegetated mudflats) occurring in East Bay.

Mitigation for lost brood habitat could be accomplished by several options:

1) Alter lake water levels so that the current high water level (2893 ft) would be reached by the beginning of the brood period (15 April) each year. This would provide goose

broods access to upland feeding areas and stimulate fall food production for waterfowl.

2) Construct impoundments within the East Bay area by diking the southern portion of the bay. Two large cells, approxtitely 100 ha each, could be subdivided into subimpoundments which could be manager for goose and duck broods, non-game waterbirds, raptors, furbearers, and fish. Islands could be created within the impoundments to provide secure waterfowl nest sites. This area could possibly be used to reintroduce trumpeter swans and encourage breeding of common loons (Gavia immer) .

3) Acquire and manage 350 ha of lakeshore brood habitat, suitable for and accessible by broods (under current lake level scenarios) from 15 April through June.

4) Purchase and manage land in other areas of the lower Flathead Valley (such as the Ninepipe area) that could be enhanced for waterfowl nesting and brooding. The area purchased should be equated to the 350 ha of marsh/wet meadow lost in terms of relative productivity.

5) Brood habitat could be improved in specific brood areas through the following suggestions:

East Bay: Mudflats could be planted with wheat, rice, or other suitable seed to provide additional food near the water as the lake levels rise during the brood period. Impoundments could be created by diking.

Bird Point Bay: Improvement and expansion of existing short herbaceous habitat in this area would likely improve brood conditions substantially. A spit in southeast comer of the bay has previously been offered, by the owner, for a goose brood area. This spit is covered with short herbaceous and grass types, but is extremely limited in size for the large numbers of broods using this area. Clearing riparian shrubs, pothole blasting, and cattail burning or grazing should be examined. A dike could also be constructed across this bay, similar to Fast Bay.

Finley Point: This area, on the north side of East Bay, is a dense cattail stand at present and could be opened up to encourage goose brood use. This could be accomplished with pothole blasting and/or cattail eradication. If openings extended to the riparian fields bordering on the north they may benefit broods. For its size, this area receives little use by broods, which we believe is primarily related to the current dense habitat conditions.

Big Arm: This area is primarily natural marsh and lowland habitat types that could be improved for broods. Reducing the dense cover to improve visibility, and light grazing on the upland area would likely result in higher brood use. The orchard to the north of this area would make a good

brood area if undergrowth, weeds, and grass were cleared or burned before mid-April. This area is currently used extensively by broods, but brood movement inland in the area only amounts to a few meters because of high vegetation density.

Elmo: Parts of the area could be improved by conversion into open, short herbaceous/grass types. As before, this can be accomplished by grazing, burning, or clearing. One part of this area would make a good site for an impoundment, or for planting mudflats. Another area is lightly forested, and could be cleared, planted in grasses, and burned or mowed annually to provide good grazing conditions for broods. All of these areas in Elmo should be fenced, to keep dogs out, so that brood security is maximized.

Dayton The single most important site is on the south side of the mouth of Dayton Creek, in the pastures owned by Delbert Hawkins; the remaining areas are used all season, but this area seems to be heavily used by broods. Pasture improvements could be conducted on Cromwell Island to improve brood habitat, and nest structures constructed to improve nesting.

Bird-Pinkney Slough: Without improving nesting conditions here, it is not feasible to improve brooding conditions. There are usually 5 nests on the 2 islands in this slough, but predation is usually high, often 100%. If a nest structure program was implemented and hatching success improved, the south shore of this slough offers excellent potentials for brood habitat improvement. The area is currently used early in the brood period, but broods appear to eventually move into Stone Quarry Bay, and then down the west shore of the lake. The area south of the slough consists of a wet meadow, and could be cleared and fenced for brood security. Nest structures could be placed in the trees surrounding the slough, or the structures that are there refurbished. These structures are single posts placed in the water with wooden crates on top. They have not contained nest material during our study.

Lake Outlet: This brood area was used intermittently during our study, and appeared to be used primrily by broods along the west shore moving south when human disturbance on the lake increased. The level of disturbance here is very low. Fencing, burning, and clearing cattails would greatly improve the potential for the area.

The longer duration of high water lake levels has impacted the littoral areas (between low and high water) by reducing the amount of wet meadow/marsh area, and replacing these with large expanses of barren gravel and mudflats. The greatest loss has been in East Pay. Numerous

other bays, including several bays on Finley Point, Rocky Point, Big Arm, Elmo, Dayton and the lake outlet, have also been impacted. In addition, higher levels of erosion are occurring in many areas of the lake, as a result of high water, reducing some deciduous forest shoreline vegetation, and causing actual land loss.

These losses could be mitigated through creation of impoundments (as discussed above) or acquiring and enhancing off-site wet meadow/marsh areas. Acquisition and protection of existing marshes (such as Bird-Pinkney Slough) would reduce the impact of these losses. The loss of diversity in marsh plant communities could be mitigated, in part, by intensive management of the extensive cattail stands at the south and north sides of East Bay, and in other areas. These monotypic stands could be broken up into smaller patches through burning, blasting, or cutting to allow other emergent marsh communities to develop.

Territorial Pair and Nest Survey Methods

If Canada goose mitigation scenarios are to be monitored and evaluated by wildlife managers, efficient and reliable survey techniques must be used. On all areas, the best method of determining the number of goslings that hatch was nest counts by ground crews. Ground surveys are clearly the best method because they result in an accurate census of nests, and an estimate of nesting success. The drawback to ground nest counts is that they are more time consuming and labor intensive than pair surveys and, therefore, more costly. Ground surveys on the lake and reservoirs are more cost-effective than on the river. We recommend that management agencies conduct ground nest counts on <u>all</u> nesting areas because ground surveys are the best method and comparable data are available back to the 1950's. If ground surveys cannot be conducted on all areas, pair surveys can be used for the river, Melita Island, the Bird Islands, and the Northern Islands to estimate the number of goose nests using our survey and estimate methods; all other valley nesting areas (reservoirs and the remaining lake islands) should be ground searched for nests since the usefulness of pair surveys in these areas is questionable at this time.

Aerial territorial pair surveys appear to be an efficient means of estimating the number of goose nests on several areas. If ratios and survey equations from our study are used, our methods must be duplicated. If methods different than ours are used, the data obtained by using our ratios and equations will likely be erroneous. We recommend conducting at least 2 morning pair flights from the last week in March through mid-April on the river, Bird Islands, Northern Islands, and Melita Island. For the river, the equation:

nest numbers = -1.338 + 0.845 (Xl); where Xl = mean number of indicated

pairs observed on morning plane surveys. For each of the 3 island groups on the lake, the formula: nest numbers = mean number indicated pairs observed / ip/n ratio for the area (ip/n = 0.54 for Melita and the Bird Islands, and 0.62 for the Northern Islands) should be used. Our estimates in these areas using our methods appear to be within

approximately + 10%. Other areas such as Dream, Drift and the Narrow's Islands, and all the reservoirs should be searched for nests by ground crews until reliable ip/n ratios can be identified.

Pair surveys cannot provide as accurate or as reliable a data set as nest counts by ground crews and I since no estimate of nest success is obtained they have somewhat limited value in estimating the number of goslings hatched. Some estimate of nest success from previously determined success rates on the study area should be used when estimating production. Nest success can vary greatly between years for ground nesting geese (this study) and geese using elevated sites (Casey and Wood 1987). We recommend doing ground nest counts on all areas at least every 3 years to check nest success on all nest types and to obtain known nest number data to reevaluate the accuracy of pair surveys.

Brood Survery Methods

Aerial brood surveys are of little value in estimating the number of goslings that fledge. On the lake unless observers become familar with brood use of areas, and at least 2 (preferably 3) flights are made each year, gosling numbers could easily be underestimated by 50%. Furthermore, if this level of effort must be expended to obtain useful data, the time and effort would likely be better spent (at least on the lake) obtaining accurate goslings counts from the ground at major brood areas. Aerial brood surveys are useful in identifying areas used by broods to detect changes in use patterns over the years.

Since brood habitat and survival appeared to be important factors affecting the lake goose population we recommend conducting 2-3 aerial surveys on the lake each year to monitor changes in use of brood areas, and sinultaneous ground counts in each of the major brood areas (Dayton, Elmo, Big Arm, and East Bay) to obtain an estimate of the number of goslings fledged. On the river, since brood habitat and survival do not appear to be problems at present, we recommend using the money and effort expended on brood surveys to monitor the nesting population. If brood related problems arise on the river in the future, a monitoring program could be established.

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APPENDICES

Appendix A. Minimum monthly flows for water years 1980-86, Flathead River, Montana.

Water Year	Minimum Monthly Flows cfs)											
	J	F	M	A	M	J	J	A	S	O	N	D
1980	6160	1830	1630	2560	7900	10900	6030	2700	2760	4020	7030	7110
1981	4710	11800	7790	5080	11100	19300	6740	2900	3000	4100	6060	4000
1982	6530	6340	6290	8420	10900	4240	9700	3180	2710	7250	7260	4840
1983	9870	8600	5990	8130	11100	8880	9580	3310	4810	3510	4840	5130
1984	9490	8130	5470	6090	1490	11200	3940	3500	3680	7150	6050	6410
1985	9300	7060	5680	4990	10900	11100	5830	5890	9280	4550	7880	8280
1986	10000	7700	6970	7360	3220	10300	3770	336°	381°	9350	791°	381°
$\bar{X}$ All Years	8009	7351	5689	6090	8087	10846	6513	3549	4293	5704	6719	5654

Data from U. S. Geological Survey Water Data Report: MT-80-2 through MT-86-2, Helena, MT.

Appendix B. Mean monthly flows for water years 1980-86, Flathead River, Montana.

	Mean Monthly Flows (cfs)											
Water Year	J	F	M	A	M	J	J	A	S	O	N	D
1980	7717	5602	2326	5131	17540	21120	9882	5026	7533	8065	10930	10220
1981	10960	12300	9479	9196	22100	34320	16100	5283	6006	8768	8539	10710
1982	10620	8634	7669	10040	21620	29410	20420	6363	5372	10400	9396	7670
1983	11310	11250	7865	10480	15310	17340	17430	6556	8959	5388	6669	7312
1984	10890	10010	8683	7925	7204	19800	10040	6136	7911	9974	10030	9574
1985	10810	9810	7176	7580	15740	20350	9657	9807	11730	9605	9025	10590
1986	11310	10940	9226	11540	12680	21450	7703	4493	8654	10630	10580	10070
$\bar{X}$ All Years	10517	9792	7489	8842	16028	23399	13033	6238	8024	8976	9310	9449

Data from U. S. Geological Survey Water Data Report: MT-80-2 through MT-86-2, Helena, MT

Appendix C. Maximum monthly flows for water years 1980-86, Flathead River, Montana.

	Maximum Monthly Flows (cfs)											
Water Year	J	F	M	A	M	J	J	A	S	O	N	D
1980	9630	7560	3130	11900	48000	33400	13200	11700	11200	12300	12200	12100
1981	12700	12700	12000	12100	41600	46400	27100	8460	11000	11400	11200	12700
1982	12300	11900	886°	12100	32200	4190°	4120°	946°	732°	12000	1200°	10400
1983	12400	12800	8590	14600	32100	26100	28900	10300	12100	7450	8610	8640
1984	12100	11900	10800	10900	11900	33700	17900	10700	11400	12000	12000	11800
1985	12200	11700	8180	12100	31700	33100	11600	14300	20800	11500	9900	11900
1986	12200	12200	10700	13400	35700	38700	11400	6830	11500	11900	12000	11600
$\bar{X}$ All Years	11933	11537	8894	12443	33314	36186	21614	10250	12189	11221	11130	11306

Data from U. S. Geological Survey Water Data Report: MT-80-2 through MT-86-2, Helena, MT.

Appendix D. Species list for aquatic, riparian, and adjacent upland areas of the south half of Flathead Lake and River, Montana, 1983-87.

Gram.= Graminoid

Code	Genus	Species	Family	Form
ABGR	ABIES	GRANDIS	`	Tree
ACGL	ACER	GLABRUM	ACERACEAE	Tree
ACM1	ACHILLEA	MILLEFOLIUM	ASTERACEAE	Forb
ACCA	ACORUS	CALAMUS	TYPHACEAE	Forb
ACRU	ACTAEA	RUBRA	RANUNCULACEAE	Forb
ADBI	ADENOCAULON	BICOLQR	ASTERACEAE	Forb
AGGL	AGOSERIS	GLAUCA	ASTERACEAE	Forb
AGCA	AGROPYRON	CANINUM	POACEAE	Gram.
AGCR	AGROPYRON	CRISTATUM	POACEAE	Gram.
AGDA	AGROPYRON	DASYSTACHYUM	POACEAE	Gram.
AGIN	AGROPYRON	INTERMEDIUM	POACEAE	Gram.
AGRE	AGROPYRON	REPENS	POACEAE	Gyam.
AGSM	AGROPYRON	SMITH1 I	POACEAE	Gram.
AGSP	AGROPYRON	SPICATUM	POACEAE	Gram.
AGAL	AGROSTIS	ALBA	POACEAE	Gram.
AGEX	AGROSTIS	EXARATA	POACEAE	Gram.
AGIN3	AGROSTIS	INTERRUPTA	POACEAE	Gram.
AGSC	AGROSTIS	SCABRA	POACEAE	Gram.
AGTH	AGROSTIS	THURBERIANA	POACEAE	Gram.
ALAE	ALEOPECURUS	AEQUALIS	POACEAE	Gram.
ALGR	ALISMA	GRAMINEUS	ALISMATACEAE	Forb
ALPL3	ALISMA	PLANTAGO-AQUATIICA	ALISMATACEAE	Forb
ALCE	ALLIUM	CERNUUM	LILIACEAE	Forb
ALSC	ALLIUM	SCHOENUPRASUM	LILIACEAE	Forb
ALIN	ALNUS	INCANA	BETULACEAE	Shrub
ALAL	ALYSSUM	ALYSSOIDES	BRASSICACEAE	Forb
ALDE	ALYSSUM	DESERTORUM	BRASSICACEAE	Forb
AMRE	AMARANTHUS	RETROFLEXUS	AMARANTHACEAE	Forb
AMAL	AMELANCHIER	ALNIFOLIA	ROSACEAE	Shrub
ANMA	ANAPHALIS	MARGARITACEA	ASTERACEAE	Forb
ANGE2	ANDROPOGON	GERARDII	POACEAE	Gram.
ANSC	ANDROPEGON	SCOPARIUS	POACEAE	Gram.
ANAL	ANTENNARIA	ALPINA	ASTERACEAE	Forb
ANLU	ANTENNARIA	LUZULOIDES	ASTERACEAE	Forb
ANMI	ANTENNARIA	MICROPHYLLA(rosea)	ASTERACEAE	Forb
ANNE2	ANTENNARIA	NEGLECTA	ASTERACEAE	Forb
ANPA3	ANTENNARIA	PARVIFOLIA	ASTERACEAE	Forb
ANTI	ANTHEMIS	TINCTORIA	ASTERACEAE	Forb
APCA	APOCYNUM	CANNABINUM	APOCYNACEAE	Forb
ARGL	ARABIS	GLABRA	BRASSICACEAE	Forb
ARHO	ARABIS	HOLBOELII	BRASSICACEAE	Forb
ARNU2	ARABIS	MICROPHYLLA	BRASSICACEAE	Forb
ARNu2	ARABIS	NUTTALLII	BRASSICACEAE	Forb
ARLA3	ARCTIUM	LAPPA	ASTERACEAE	Forb

Appendix D. (cont.)

ARMI3	ARCTIUM	MINUS	ASTERACEAE	Forb
ARUV	ARCTOSTAPHYLOS	UVA-URSI	ERICACEAE	Shrub
ARC02	ARENARIA	CONGESTA	CARYOPHYLLACEAE	Forb
ARLA2	ARENARIA	LATRIFLORA	CARYOPHYLLACEAE	Forb
ARMA3	ARENARIA	MACROPHYLLA	CARYOPHYLLACEAE	Forb
ARNU	ARENARIA	NUTTALLII	CARYOPHYLLACEAE	Forb
ARSE	ARENARIA	SERPYLLIFOLIA	CARYOPHYLLACEAE	Forb
ARLO3	ARISTIDA	ICIONGISETA	POACEAE	Gram.
ARC0	ARNICA	CORDIFOLIA	ASTERACEAE	Forb
ARSO	ARNICA	SORORIA	ASTERACEAE	Forb
ARBI	ARTEMISIA	BIENNIS	ASTERACEAE	Forb
ARCA4	ARTEMISIA	CAMPESTRIS	ASTERACEAE	Forb
ARDR	ARTEMISIA	DRACUNCULUS	ASTERACEAE	Forb
ARFR	ARTEMISIA	FRIGIDA	ASTERACEAE	Shrub
ARLI2	ARTEMISIA	LINDLEYANA	ASTERACEAE	Forb
ARLU	ARTEMISIA	LUDOVICIANA	ASTERACEAE	Forb
ARTR	ARTEMISIA	TRIDENTATA	ASTERACEAE	Shrub
ASSP	ASCLEPIAS	SPECIOSA	ASCLEPIADACEAE	Forb
ASOF	ASPERAGUS	OFFICIANALIS	LILIACEAE	Forb
ASPR	ASPERUGO	PROCUMBENS	BORAGINACEAE	Forb
ASCH	ASTER	CHILENSIS	ASTERACEAE	Forb
ASFO	ASTER	FOLIACEOUS	ASTERACEAE	Forb
ASLA	ASTER	LAEVIS	ASTERACEAE	Forb
ASPA	ASTER	PANSUS	ASTERACEAE	Forb
ASAG	ASTRAGALUS	AGRESTIS	FABACEAE	Forb
ASIN	ASTRAGALUS	INFLEXUS	FABACFAE	Forb
ASMI	ASTRAGALUS	MISER	FABACEAE	Forb
ASPU	ASTRAGALUS	PURSHII	FABACEAE	Forb
ATFI	ATHYRIUM	FILIX-FEMINA	POLYPODIACEAE	Fern
BASA	BALSAMORHIZA	SAGITATA	ASTERACEAE	Forb
BAVE	BARBAREA	ORTHOCEREUS	BRASSICACEAE	Forb
BESY	BECKMANNIA	SYZIGACHNE	POACEAE	Gram.
BERE	BERBERIS	REPENS	BERBERIDACEAE	Shrub
BEER	BERULA	ERECTA	APIACEAE	Forb
BEER	BESSEYA	RUBRA	SCROPHULARIACEAE	Forb
BEGL	BETULA	GLANDULOSA	BETULACEAE	Tree
BEOC	BETULA	OCCIDENTALIS	BETULACEAE	Tree
BEPA	BETULA	PAPYIFERA	BETULACEAE	Tree
BICE	BIDENS	CERNUA	ASTERACEAE	Forb
BRDO	BRODIAEA	DOUGLAS11	LILIACEAE	Forb
BRCA	BROMUS	CARINATUS	POACEAE	Gram.
BRIN	BROMUS	INERMIS	POACEAE	Gram.
BRJA	BROMUS	JAPONICUS	POACEAE	Gram.
BRMO	BROMUS	MOLLIS	POACEAE	Gram.
BRTE	BROMUS	TECTORUM	POACEAE	Gram.
BRW	BROMUS	VULGARIS	POACEAE	Gram.
BUUM	BUTOMUS	UMBELLATUS	BUTOMACEAE	Forb
CARU	CALAMAGROSTIS	RUBESCENS	POACEAE	Gram.
CAHE2	CALLITRICHE	HERMAPHRODITICA	CALLITRICHACEAE	Forb
CAVE2	CALLITRICHE	VERNA	CALLITRICHACEAE	Forb
CABu2	CALYPSO	BULBOSA	ORCHIDACEAE	Forb
CAR03	CAMPANULA	ROTUNDIFOLIA	CAMPANULACEAE	Forb

Appendix D. (cont.)

CABU	CAPSFT	BURSA-PASTORIS	BRASSICACEAE	Forb
CAPE4	CARDAMINE	PENSYLVANICA	BRASSICACEAE	Forb
CAAP3	CAREX	APERTA	CYPERACEAE	Forb
CAAQ	CAREX	AQUATILIS	CYPERACEAE	Gram.
CAAT	CAREX	ATHROSTACHYA	CYPERACEAE	Forb
CAAU	CIAREX	AUREA	CYPERACEAE	Gram.
CABE	CAREX	BEBBII	CYPERACEAE	Gram.
CABR5	CAREX	BREVIOR	CYPERACEAE	Gram.
CACA4	CAREX	CANESCENS	CYPERACEAE	Gram.
CAcu2	CAREX	CUSICKII	CYPERACEAE	Gram.
CADI2	CAREX	DIANDRA	CYPERACEAE	Gram.
CADI	CAREX	DISPERMA	CYPERACEAE	Gram.
CADO	CAREX	DOUGLASII	CYPERACEAE	Gram.
CAHO	CAREX	HOODII	CYPERACEAE	Gram.
CAHY	CAREX	HYSTRICINA	CYPERACEAE	Gram.
CAIN5	CAREX	INTERIOR	CYPERACEAE	Gram.
CALA3	CAREX	LANUGINOSA	CYPERACEAE	Gram.
CALA4	CAREX	LASIOCARPA	CYPERACEAE	Gram.
CANE	CAREX	NEBRASCENSIS	CYPERACEAE	Gram.
CAOE	CAREX	OEDERI	CYPERACEAE	Gram.
CAPR8	CAREX	PRIONOPHYLLA	CYPERACEAE	Gram.
CARE	CAREX	RETRORSA	CYPERACEAE	Gram.
CARO	CAREX	ROSSII	CYPERACEAE	Gram.
CAR02	CAREX	ROSTRATA	CYPERACEAE	Gram.
CASC5	CAREX	SCOPULORUM	CYPERACEAE	Gram.
CAST	CAREX	STIPATA	CYPERACEAE	Gram.
CAVE	CAREX	VESICARIA	CYPERACEAE	Gram.
CAVU	CAREX	VULPINOIDEA	CYPERACEAE	Gram.
CAH12	CASTILLEJA	HISPIDA	SCROPHULARIACEAE	Forb
CALU3	CASTILLEJA	LUTESCENS	SCROPHULARIACEAE	Forb
CESA	CEANOTHUS	SANGUINEUS	RHAMNACEAE	Shrub
CEVE	CEANOTHUS	VELUTINUS	RHAMNACEAE	Shrub
CEMA	CENTAUREA	MACULOSA	ASTERACEAE	Forb
CERE	CENTAUREA	REPENS	ASTERACEAE	Forb
CEAR	CERASTIUM	ARVENSE	CARYOPHYLLACEAE	Forb
CEVU	CERASTIUM	VULGATUM	CARYOPHYLLACEAE	Forb
CEDE	CERATOPHYLLUM	DEMERSUM	CERATOPHYLLACEAE	Forb
CHARA	CHARA	(VULGARIS?)	(ALGAE)	Algae
CHAL	CHENOPODIUM	ALBUM	CHENOPODIACEAE	Forb
CHAM	CHENOPODIUM	AMBROSOIDES	CHENOPODIACEAE	Forb
CHLE	CHENOPODIUM	LEPTOPHYLLUM	CHENOPODIACEAE	Forb
CHME	CHIMAPHILA	MENZIESII	ERICACEAE	Forb
CHTE	CHORISPORA	TENELLA	BRASSICACEAE	Forb
CHLE2	CHRYSANTHEMUM	LEUCANTHEMUM	ASTERACEAE	Forb
cHvI2	CHRYSOPIS	VILLOSA	ASTERACEAE	Forb
CHNA	CHRYSOTHAMNUS	NAUSEOUS	ASTERACEAE	Shrub
CHVI	CHRYSOTHAMNUS	VISCIDIFLORUS	ASTERACEAE	Shrub
CIDO	CICUTA	DOUGLASII	APIACEAE	Forb
CILA2	CINNA	LATIFOLIA	POACEAE	Gram.
CIAL	CIRCAEA	ALPINA	ONAGRACEAE	Forb
CIAR	CIRSIUM	ARVENSE	ASTERACEAE	Forb
CIFL	CIRSIUM	FLODMANII	ASTERACEAE	Forb

Appendix D. (cont.)

CIUN	CIRSIUM	UNDULATUM	ASTERACEAE	Forb
CIVU	CIRSIUM	VULGARE	ASTERACEAE	Forb
CLPU	CLARKIA	PULCHELLA	ONAGRACEAE	Forb
CLCO	CLEMATIS	COLUMBIANA	RANUNCULACEAE	Forb
CLLI	CLEMATIS	LIGUSTICIFOLIA	RANUNCULACEAE	Forb
CLSE	CLEOME	SERRULATA	CAPPARIDACEAE	Forb
COPA	COLLINSIA	PARVIFLORA	SCROPHULARIACEAE	Forb
COUM	COMMANDRA	UMBELLATA	SANTALACEAE	Forb
COAR2	CONVOLVULUS	ARVENSIS	CONVOLVULACEAE	Forb
COSE	CONVOLVULUS	SEPIUM	CONVOLVULACEAE	Forb
COCA2	CONYZA	CANADENSIS	ASTERACEAE	Forb
COAT	COREOPSIS	ATKINSONIANA	ASTERACEAE	Forb
COST	CORNUS	STOLONIFERA	CORNACEAE	Shrub
COAU	CORYDALIS	AUREA	FABACEAE	Forb
CRCO	CRATAEGUS	COLUMBIANA	ROSACEAE	Shrub
CRDO	CRATAEGUS	DOUGLAS11	ROSACEAE	Shrub
CRDO9	CRATAEGUS	DOUGLASII-tree	ROSACEAE	Tree
CRRU	CREPIS	RUNCINATA	ASTERACEAE	Forb
CRAM	CRYPTANTHA	AMBIGUA	BORAGINACEAE	Forb
CYOF	CYNOGLOSSUM	OFFICIONALE	BORAGINACEAE	Forb
CYAC2	CYPERUS	ACUMINATA	CYPERACEAE	Gram.
DAGL	DACTYLIS	GLOMERATA	POACEAE	Gram.
DEBI	DELPHINIUM	BICOLOR	RANUNCULACEAE	Forb
DECA	DESCHAMPSIA	CESPITOSA	POACEAE	Gram.
DEPI	DESCURAINIA	PINNATA	BRASSICACEAE	Forb
DIAR	DIANTHUS	ARMERIA	CARYOPHYLLACEAE	Forb
DITR	DISPORUM	TRACHYCARPUM	LILIACEAE	Forb
DIST	DISTICHILIS	STRICTA	POACEAE	Gram.
DRVE2	DRABA	VERNA	BRASSICACEAE	Forb
ECCR	ECHINCCHLOA	CRUSGALLI	POACEAE	Gram.
ELCA4	ELATINE	CALIFORNICA	ELEATINACEAE	Forb
ELTR4	EllATINE	TRIANDRA	ELEATINACEAE	Forb
ELAC	ELEOCHARIS	ACICULARIS	CYPERACEAE	Gram.
ELAN	ELEAGNUS	ANGUSTIFOLIA	ELEAGNACEAE	Tree
ELPA	ELLEOCHARIS	PALUSTRIS	CYPERACEAE	Gram.
ELPA2	ELEOCHARIS	PAUCIFLORA	CYPERACEAE	Gram.
ELCA3	ELODEA	CANADENSIS	HYDROCHARITACEAE	Forb
ELNU	ELODEA	NUTTALLII	HYDROCHARITACEAE	Forb
ELCA	ELYMUS	CANADENSIS	POACEAE	Gram.
ELCI	ELYMUS	CINEREUS	POACEAE	Gram.
ELGL	ELYMUS	GLAUCUS	POACEAE	Gram.
EPAN	EPILOBIUM	ANGUSTIFOLIUM	ONAGRACEAE	Forb
EPGL	EPILOBIUM	GLABERRIMUM	ONAGRACEAE	Forb
EPMI	EPILOBIUM	MINUTUM	ONAGRACEAE	Forb
EPPA2	EPILOBIUM	PALUSTRE	ONAGRACEAE	Forb
EPPA	EPILOBIUM	PANICULATUM	ONAGRACEAE	Forb
EPWA	EPILOBIUM	WATSONII	ONAGRACEAE	Forb
EQAR	EQUISETUM	ARVENSE	EQUISETACEAE	Forb
EQFL	EQUISETUM	FLUVIATILE	EQUISETACEAE	Forb
EQHY	EQUISETUM	HYEMALE	EQUISETACEAE	Forb
EQLA	EQUISETUM	LAEVIGATUM	EQUISETACEAE	Forb
EQPA	EQUISETUM	PALUSTRE	EQUISETACEAE	Forb

Appendix D. (cont.)

EQPR	EQUISETUM	PRATENSE	EQUISETACEAE	Forb
EQVA	EQUISETUM	VARIAGATUM	EQUISETACEAE	Forb
ERCO	ERIGERON	CORYMBOSUS	ASTERACEAE	Forb
ERFI	ERIGERON	FILIFOLIUS	ASTERACEAE	Forb
ERPU	ERIGERON	PUMILIS	ASTERACEAE	Forb
ERSP	ERIGERON	SPECIOSUS	ASTERACEAE	Forb
ERHE	ERIOGONUM	HERACLEOIDES	POLYGONACEAE	Forb
ERCI	ERODIUM	CICUTARIUM	GERANIACEAE	Forb
ERGA	ERUCASTRUM	GALLICUM	BRASSICACEAE	Forb
ERCH5	ERYSIMUM	CHEIRANTHOIDES	BRASSICACEAE	Forb
ERGR	ERYTHRONIUM	GRANDIFLORUM	LILIACEAE	Forb
EUES	EUPHORBIA	ESULA	EUPHORBIACEAE	Forb
EUGL	EUPHORBIA	GLYPTOSPERMA	EUPHORBIACEAE	Forb
FEID	FESTUCA	IDAHOENSIS	POACEAE	Gram.
FEOC	FESTUCA	OCCIDENTALIS	POACEAE	Gram.
FEOC2	FESTUCA	OCTOFLORA	POACEAE	Gram.
FEOV	FESTUCA	OVINA	POACEAE	Gram.
FEPR	FESTUCA	PRATENSIS	POACEAE	Gram.
FERU	FESTUCA	RUBRA	POACEAE	Gram.
FESC	FESTUCA	SCABRELLA	POACEAE	Gram.
FIAR	FILAGO	ARVENSIS	ASTERACEAE	Forb
FRVE	FRAGARIA	VESCA	ROSACEAE	Forb
FRVI	FRAGARIA	VIRGINIANA	ROSACEAE	Forb
FRPE	FRAXINUS	PENNSYLVANICUS	OLEACEAE	Tree
FRLA	FRITILLARIA	LANCEOLATA	LILIACEAE	Forb
GAAR	GAILLARDIA	ARISTATA	ASTERACEAE	Forb
GAAP	GALIUM	APARINE	RUBIACEAE	Forb
GABO	GALIUM	BOREALE	RUBIACEAE	Forb
GATR3	GALIUM	TRIFIDUM	RUBIACEAE	Forb
GATR	GALIUM	TRIFLORUM	RUBIACEAE	Forb
GADI	GAYOPHYTUM	DIFFUSUM	ONAGRACEAE	Forb
GEBI	GERANIUM	BICKNELLII	GERANIACEAE	Forb
GEVI	GERANIUM	VISCOSISSIMUM	GERANIACEAE	Forb
GEMA	GEUM	MACROPHYLLUM	ROSACEAE	Forb
GETR	GEUM	TRIFLORUM	ROSACEAE	Forb
GLBO	GLYCERIA	BOREALIS	POACEAE	Gram.
GLGR	GLYCERIA	GRANDIS	POACEAE	Gram.
GLST	GLYCERIA	STRIATA	POACEAE	Gram.
GLLE	GLYCYRRHIZA	LEPIDOTA	FABACEAE	Forb
GRSQ	GRINDELIA	SQUARROSA	ASTERACEAE	Forb
HADE	HACKELIA	DEFLEXA	BORAGINACEAE	Forb
HEAU	HELENIUM	AUTUMNALE	ASTERACEAE	Forb
HENU	HELIANTHUS	NUTTALLII	ASTERACEAE	Forb
HEPE	HELIANTHUS	PETIOLARIS	ASTERACEAE	Forb
HEMA2	HESPERIS	MATRONALIS	BRASSICACEAE	Forb
HEDU	HETERANTHERA	DUBIA	PONTEDERIACEAE	Forb
HECY	HEUCHERA	CYLINDRICA	SAXIFRAGACEAE	Forb
HIAL	HIERACIUM	ALBIFLORUM	ASTERACEAE	Forb
HICA	HIERACIUM	CANADENSE	ASTERACEAE	Forb
HIOD	HIEROCHLOE	ODORATA	POACEAE	Gram.
HIVU	HIPPURIS	VULGARIS	HIPPURIDACEAE	Forb
HODI	HOLIDISCUS	DISCOLOR	ROSACEAE	Shrub

Appendix D. (cont.)

HOBR	HORDEUM	BRACHYANTHERUM	POACEAE	Gram.
HOGE	HORDEUM	GENICULATUM	POACEAE	Gram.
HOJU	HORDEUM	JUBATUM	POACEAE	Gram.
HYPE	HYPERICUM	PERFORATUM	HYPERICACEAE	Forb
IMAU	IMPATIENS	AURELLA	BALSAMINACEAE	Forb
IRPS	IRIS	PSEUDACORUS	IRIDACEAE	Forb
JUAC	JUNCUS	ACUMINATUS	JUNCACEAE	Gram.
JUAL	JUNCUS	ALPINUS	JUNCACEAE	Gram.
JUAR	JUNCUS	ARTICULATUS	JUNCACEAE	Gram.
JUBA	JUNCUS	BALTICUS	JUNCACEAE	Gram.
JUEN	JUNCUS	ENSIFOLIUS	JUNCACEAE	Gram.
JUNE	JUNCUS	NEVADENSIS	JUNCACEAE	Gram.
JUTE	JUNCUS	TENUIS	JUNCACEAE	Gram.
JUSC	JUNIPERUS	SCOPULORUM	CUPRESSACEAE	Tree
Jusc9	JUNIPERUS	SCOPULORUM-shrub	CUPRESSACEAE	Shrub
KOCR	KOELERIA	CRISTATA	POACEAE	Gram.
LASE	LACTUCA	SERRIOLA	ASTERACEAE	Forb
LAAM	LAMIUM	AMPLEXICAULE	LAMIACEAE	Forb
LAOC	LARIX	OCCIDENTALIS	PINACEAE	Tree
LEMI	LEMNA	MINOR	LENNACEAE	Forb
LEPE	LEPIDIUM	PERFOLIATUM	BRASSICACEAE	Forb
LERE	LEWISIA	REDIVIVA	PORTULACAEAE	Forb
LIAQ	LIMOSELLA	AQUATICA	SCROPHULARIACEAE	Forb
LIDA	LINARIA	DALMATICA	SCROPHULARIACEAE	Forb
LIVU	LINARIA	VULGARIS	SCROPHULARIACEAE	Forb
LIBO2	LINNAEA	BOREALIS	CAPRIFOLIACEAE	Forb
LIPE	LINUM	PERENNE	LINACEAE	Forb
LIPA	LITHOPHRAGMA	PARVIFIQRA	SAXIFRAGACEAE	Forb
LIRU	LITHOSPERMUM	RUDERALE	BORAGINACFAE	Forb
LOAM	LOMATIUM	AMBIGUUM	APIACEAE	Forb
LODI2	LOMATIUM	DISSECTUM	APIACEAE	Forb
LOMA	LOMATIUM	MACROCARPUM	APIACEAE	Forb
LOTR	LOMATIUM	TRITERNATUM	APIACEAE	Forb
LOCI	LONICERA	CILIOSA	CAPRIFOLIACEAE	Shrub
LOCO3	LOTUS	CORNICULATUS	FABACEAE	Forb
LUAR3	LUPINUS	ARGENTEUS	FABACEAE	Forb
LUSE	LUPINUS	SERICEUS	FABACEAE	Forb
LYUN	LYCOPUS	UNIFLORUS	LAMIACEAE	Forb
LYAM	LYSICHITUM	AMERICANUM	ARACEAE	Forb
LYCI	LYSIMACHIA	CILIATA	PRIMULACEAE	Forb
LYTH	LYSIMACHIA	THYRSIFOLIA	PRIMULACEAE	Forb
LYSA	LYTHRUM	SALICARIA	LYTHRACEAE	Forb
MAVU	MARRUBIUM	VULGARE	LAMIACEAE	Forb
MAVE	MARSILEA	VESTITA	MARSILEACEAE	Forb
MELU	MEDICAGO	LUPULINA	FABACEAE	Forb
MESA	MEDICAGO	SATIVA	FABACEAE	Forb
MEAL	MELILOTUS	ALBA	FABACEAE	Forb
MEOF	MELILOTUS	OFFICINALIS	FABACEAE	Forb
MEAR3	MENTHA	ARVENSIS	LAMIACEAE	Forb
MINU	MICROSERIS	NUTANS	ASTERACEAE	Forb
MIGR	MICROSTERIS	GRACILIS	POLEMONIACEAE	Forb
MIFI	MIMULUS	FLORIBUNDUS	SCROPHUIARIACEAE	Forb

Appendix D. (cont.)

MIGU	MIMULUS	GUITATUS	SCROPHULARIACEAE	Forb
MOFI	MONARDA	FISTULOSA	LAMIACEAE	Forb
MODI	MONTIA	DICHOTOMA	PORTULACAEAE	Forb
MOPE	MONTIA	PERFOLIATA	PORTULACEAE	Forb
MUAS	MUHLENBERGIA	ASPERIFOLIA	POACEAE	Gram.
MYAR	MYOSOTIS	ARVENSIS	BORAGINACEAE	Forb
MYLA	MYOSOTIS	LAXA	BORAGINACEAE	Forb
MYMI	MYOSOTIS	MICRANTHA	BORAGINACEAE	Forb
MYSC	MYOSOTIS	SCORPOIDES	BORAGINACEAE	Forb
MYSPE	MYRIOPHYLLUM	SPICATUM (v. exalb.)	HALORAGACEAE	Forb
MYSPS	MYRIOPHYLLUM	SPICATUM (v. vert.)	HALORAGACEAE	Forb
NAFL	NAJAS	FLEXILIS	NAJADACEAE	Forb
NAST	NARDUS	STRICTA?	POACEAE	Gram.
NECA	NEPETA	CATARIA	LAMIACEAE	Forb
OPPO	OPUNTIA	POLYCANTHA	CACTACEAE	Forb
ORAS	ORYZOPSIS	ASPERIFOLIA	POACEAE	Gram.
OSCH	OSMORHIZA	CHILENSIS	APIACEAE	Forb
OSDE	OSMORHIZA	DEPAUPERATA	APIACEAE	Forb
OXBE	OXYTROPIS	BESSYEI	FABACEAE	Forb
OXPE	OXYTROPIS	CAMPESTRIS(v.grac.)	FABACEAE	Forb
PACA	PANICUM	CAPILLARE	POACEAE	Gram.
PAOC	PANICUM	OCCIDENTALE	POACEAE	Gram.
PECO	PmSTEMON	CONFERTUS	SCROPHULARIACEAE	Forb
PEER	PENSTEMON	ERIANTHERUS	SCROPHULARIACEAE	Forb
PENI2	PENSTEMON	NITIDUS	SCROPHULARIACEAE	Forb
PEWI	PENSTEMON	WILCOXII	SCROPHULARIACEAE	Forb
PEGA2	PERIDERIDIA	GAIRDNERI	APIACEAE	Forb
PHHA	PHACELIA	HASTATA	HYDROPHYLLACEAE	Forb
PHLI	PHACELIA	LINEARIS	HYDROPHYLLACEAE	Forb
PHAR	PHALARIS	ARUNDINACEA	POACEAE	Gram.
PHLE2	PHILADELPHUS	LEWIS11	HYDRANGEACEAE	Shrub
PHPR	PHLEUM	PRATENSE	POACEAE	Gram.
PHMA	PHYSOCARPUS	MALVACEUS	ROSACEAE	Shrub
PHPA	PHYSOSTEGIA	PARVIFLORA	LAMIACEAE	Forb
PIEN	PICEA	ENGELMANII	PINACEAE	Tree
PIPO	PINUS	PONDEROSA	PINACEAE	Tree
PIPO9	PINUS	PONDEROSA-shrub	PINACEAE	Shrub
PLSC2	PLAGIOBOTHRYS	SCOULERI	BORAGINACEAE	Forb
PLLA	PLANTAGO	LANCEOLATA	PLANTAGINACEAE	Forb
PLMA	PLANTAGO	MAJOR	PLANTAGINACEAE	Forb
PLPA	PLANTAGO	PATAGONICA	PLANTAGINACEAE	Forb
POBU	POA	BULBOSA	POACEAE	Gram.
Poco	POA	COMPRESSA	POACEAE	Gram.
POCU	POA	CUSICKII	POACEAE	Gram.
POIN	POA	INTERIOR	POACEAE	Gram.
PONE	POA	NERVOSA	POACEAE	Gram.
PONE2	POA	NEVADENSIS	POACEAE	Gram.
POPA	POA	PALUSTRIS	POACEAE	Gram.
POPR	POA	PRATENSIS	POACEAE	Gram.
PORE	POA	REFLEXA	POACEAE	Gram.
POSA3	POA	SANDBERGII	POACEAE	Gram.
POSC	POA	SCABRELLA	POACEAE	Gram.

Appendix D. (cont .)

POTR3	POA	TRIVIALIS	POACEAE	Gram.
POMI	POLEMONIUM	MICRANTHUM	POLEMONIACEAE	Forb
POPU	POLEMONIUM	PULCHERRIMUM	POLEMONIACEAE	Forb
POAM2	POLYGONUM	AMPHIBIUM	POLYGONACEAE	Forb
POAV	POLYGONUM	AVICULARE	POLYGONACEAE	Forb
POCO4	POLYGONUM	COCCINEUM	POLYGONACEAE	Forb
PODO	POLYGONUM	DOUGLAS11	POLYGONACEAE	Forb
POHY	POLYGONUM	HYDROPIPER	POLYGONACEAE	Forb
POHY2	POLYGONUM	HYDROPIPEROIDES	POLYGONACEAE	Forb
POLA	POLYGONUM	LAPATHIFOLIUM	POLYGONACEAE	Forb
POPE	POLYGONUM	PERSICARIA	POLYGONACEAE	Forb
POPU4	POLYGONUM	PUNCTATUM	POLYGONACEAE	Forb
POHE2	POLYPODIUM	HESPERIUM	POLYPODIACEAE	Fern
POMO	POLYPOGON	MONOSPELIENSIS	POACEAE	Gram.
POAN2	POPULUS	ANGUSTIFOLIA	SALICACEAE	Tree
POTR	POPULUS	TREMULOIDES	SALICACEAE	Tree
POTR8	POPULUS	TREMULOIDES-shrub	SALICACEAE	Shrub
POTR2	POPULUS	TRICHOCARPA	SALICACEAE	Tree
POTR9	POPULUS	TRICHOCARPA-shrub	SALICACEAE	Shrub
POAM3	POTAMOGETON	AMPLIFOLIUS	POTAMOGETONACEAE	Forb
POFR3	POTAMOGETON	FREISII	POTAMOGETONACEAE	Forb
POGR3	POTAMOGETON	GRAMINEUS	POTAMOGETONACEAE	Forb
PONA2	POTAMOGETON	NATANS	POTAMOGETONACEAE	Forb
POPE2	POTAMOGETON	PECTINATUS	POTAMOGETONACEAE	Forb
POPR3	POTAMOGETON	PRAELONGUS	POTAMOGETONACEAE	Forb
POPU5	POTAMOGETON	PUSILLUS	POTAMOGETONACEAE	Forb
PORI2	POTAMOGETON	RICHARDSONII	POTAMOGETONACEAE	Forb
POZO	POTAMOGETON	ZOSTERIFORMIS	POTAMOGETONACEAE	Forb
POAN4	POTENTILLA	ANSERINA	ROSACEAE	Forb
POFL	POTENTILLA	FLABELLIFOLIA	ROSACEAE	Forb
POGL	POTENTILLA	GLANDULOSA	ROSACEAE	Forb
POGR	POTENTILLA	GRACILIS	ROSACEAE	Forb
PORE2	POTENTILLA	RECTA	ROSACEAE	Forb
PRVU	PRUNELLA	VULGARIS	LAMIACEAE	Forb
PRVI	PRUNUS	VIRGINIANA	ROSACEAE	Shrub
PSME	PSUEDOTSUGA	MENZIESII	PINACEAE	Tree
PTAQ	PTERIDIUM	AQUILINUM	POLYPODIACEAE	Fern
PTAN	PTEROSPORA	ANDROMEDEA	ERICACEAE	Forb
PUTR	PURSHIA	TRIDENTATA	ROSACEAE	Shrub
RAIN	RANUNCULUS	ABORTIVUS	RANUNCULACEAE	Forb
RAAc2	RANUNCULUS	ACRIFORMIS	RANUNCULACEAE	Forb
RAAQ	RANUNCULUS	AQUATILIS	RANUNCULACEAE	Forb
RACY	RANUNCULUS	CYMBALARIA	RANUNCULACEAE	Forb
RAFL2	RANUNCULUS	FLAMMULA	RANUNCULACEAE	Forb
RAGL	RANUNCULUS	GLABERRIMUS	RANUNCULACEAE	Forb
RAGM	RANUNCULUS	GMELINII	RANUNCULACEAE	Forb
RALO2	RANUNCULUS	LONGIROSTRIS	RANUNCULACEAE	Forb
RARE	RANUNCULUS	REPENS	RANUNCULACEAE	Forb
RATE	RANuNcuLus	TESTICULATUS	RANUNCULACEAE	Forb
m a	RHUS	GLABRA	ANACARDIACEAE	Shrub
RHRA	RHUS	RADICANS	ANACARDIACEAE	Shrub
RIAM	RIBES	AMERICANUM	GROSSULARIACEAE	Shrub

Appendix D. (cont.)

RIAU	RIBES	AUREUM	GROSSULARIACEAE	Shrub
RICE	RIBES	CEREUM	GROSSULARIACEAE	Shrub
RILA	RIBES	LACUSTRE	GROSSULARIACEAE	Shrub
RISE	RIBES	SETOSUM	GROSSULARIACEAE	Shrub
ROPS	ROBINIA	PSEUDOACACIA	FABACEAE	Tree
ROIS	RORIPPA	ISLANDICA	BRASSICACEAE	Forb
RONA	RORIPPA	NASTURTIUM-AQUATICUM	BRASSICACEAE	Forb
ROGY	ROSA	GYMNOCARPA	ROSACEAE	Shrub
ROWO	ROSA	WOODSII	ROSACEAE	Shrub
RUAC	RUBUS	ACAULIS	ROSACEAE	Forb
RUID	RUBUS	IDAEUS	ROSACEAE	Shrub
RUPA	RUBUS	PARVIFLORA	ROSACEAE	Shrub
RUAC	RUMEX	ACETOSELLA	POLYGONACEAE	Forb
RUCR	RUMEX	CRISPUS	POLYGONACEAE	Forb
RUSA	RUMEX	SALICIFOLIUS	POLYGONACEAE	Forb
SACU	SAGITTARIA	CUNEATA	ALISMATACEAE	Forb
SAAM2	SALIX	AMYGDALOIDES	SALICACEAE	Tree
SABE	SALIX	BEBBIANA	SALICACEAE	Shrub
SADR	SALIX	DRUMMONDIANA	SALICACEAE	Shrub
SAEX	SALIX	EXIGUA	SALICACEAE	Shrub
SALA2	SALIX	LASIANDRA	SALICACEAE	Shrub
SARI	SALIX	RIGIDA	SALICACEAE	Shrub
SASC	SALIX	SCOULERIANA	SALICACEAE	Shrub
SARA	SAMBUCUS	RACEMOSA	CAPRIFOLIACEAE	Shrub
SCAC	SCIRPUS	ACUTUS	CYPERACEAE	Gram.
SCFL	SCIRPUS	FLUVIATILIS	CYPERACEAE	Gram.
SCMI	SCIRPUS	MICROCARPUS	CYPERACEAE	Gram.
SCLA	SCROPHULARIA	LANCEOLATA	SCROPHULARIACEAE	Forb
SCGA	SCUTELLERIA	GALERICULATA	LAMIACEAE	Forb
SELA2	SEDUM	LANCEOLATUM	CRASSULACEAE	Forb
SEPS	SENECIO	PSEUDAUREUS	ASTERACEAE	Forb
SHCA	SHEPHERDIA	CANADENSIS	ELEAGNACEAE	Shrub
SHAR	SHERARDIA	ARVENSIS	RUBIACEAE	Forb
SIDO2	SILENE	DOUGLASII	CARYOPHYLLACEAE	Forb
SIAL	SISYMBRIUM	ALTISSIMUM	BRASSICACEAE	Forb
SIAN	SISYRINCHIUM	ANGUSTIFOLIUM	IRIDACEAE	Forb
SISU	SIUM	SUAVE	APIACEAE	Forb
SMRA	SMILACINA	RACEMOSA	LILIACEAE	Forb
SMST	SMILACINA	STELLATA	LILIACEAE	Forb
sODu2	SOLANUM	DULCAMERA	SOLANACEAE	Forb
SOSA2	SOLANUM	SARRACHOIDES	SOLANACEAE	Forb
SOCA	SOLIDAGO	CANADENSIS	ASTERACEAE	Forb
SOOC2	SOLIDAGO	OCCIDENTALIS	ASTERACEAE	Forb
SOUL	SONCHUS	ULIGNOSIS	ASTERACEAE	Forb
sOsc2	SORBUS	SCOPULINA	ROSACEAE	Shrub
SPAN	SPARGANIUM	ANGUSTIFOLIUM	SPARGANIACEAE	Forb
SPEU	SPARGANIUM	EURYCARPUM	SPARGANIACEAE	Forb
SPMI2	SPARGANIUM	MINIMUM	SPARGANIACEAE	Forb
SPPE	SPARTINA	PECTINATA	POACEAE	Gram.
SPBE	SPIRAEA	BETULIFOLIA	ROSACEAE	Shrub
SPPO	SPIRODELA	POLYRHIZA	LEMNACEAE	Forb
SPCR	SPOROBOLUS	CRYPTANDRUS	POACEAE	Gram.

Appendix D. (cont.)

STPA2	STACHYS	PALUSTRIS	LAMIACEAE	Forb
STCA2	STELLARIA	CALYCANTHA (sitchana)	CARYOPHYLLACEAE	Forb
STRU	STEPHANOMERIA	RUNCINATA	ASTERACEAE	Forb
STCO	STIPA	COLUMBIANA	POACEAE	Gram.
STCO2	STIPA	COMATA	POACEAE	Gram.
STVI	STIPA	VIRIDULA	POACEAE	Gram.
SYAL	SYMPHORICARPOS	ALBA	CAPRIFOLIACEAE	Forb
SYOC	SYMPHORICARPOS	OCCIDENTALIS	CAPRIFOLIACEAE	Forb
TAOF	TARAXACUM	OFFICINALE	ASTERACEAE	Forb
TECA	TETRADYMIA	CANESCENS	ASTERACEAE	Forb
THOC	THALICTRUM	OCCIDENTALE	RANUNCULACEAE	Forb
THAR	THLASPI	ARVENSE	BRASSICACEAE	Forb
THPL	THUJA	PLICATA	CUPRESSACEAE	Tree
TOLEP	TOLYPELLA	SPP	(ALGAE)	Algae
TRDU	TRAGOPOGON	DUBIUS	ASTERACEAE	Forb
TRAG	TRIFOLIUM	AGRARIUM	FABACEAE	Forb
TRPR	TRIFOLIUM	PRATENSE	FABACEAE	Forb
TRRE	TRIFOLIUM	REPENS	FABACEAE	Forb
TRMA2	TRIGLOCHIN	MARITIMUS	JUNCAGINACEAE	Forb
TRCA	TRISETUM	CANESCENS	POACEAE	Gram.
TYLA	TYPHA	LATIFOLIA	TYPHACEAE	Forb
ULAM	ULMUS	AMERICANA	ULMACEAE	Tree
URDI	URTICA	DIOICA	URTICACEAE	Forb
UTVU	UTRICULARIA	VULGARIS	LENTIBULARIACEAE	Forb
VEBL	VERBASCUM	BLATTARIA	SCROPHULARIACEAE	Forb
VETH	VERBASCUM	THAPSUS	SCROPHULARIACEAE	Forb
VEAM	VERONICA	AMERICANA	SCROPHULARIACEAE	Forb
VEAN	VERONICA	ANAGALLIS-AQUATICA	SCROPHULARIACEAE	Forb
VEAR	VERONICA	ARVENSIS	SCROPHULARIACEAE	Forb
VEPE	VERONICA	PEREGRINA	SCROPHULARIACEAE	Forb
VESE	VERONICA	SERPYLLIFOLIA	SCROPHULARIACEAE	Forb
VIAM	VICIA	AMERICANA	FABACEAE	Forb
VIAD	VIOLA	ADUNCA	VIOLACEAE	Forb
WOOR	WOODSIA	OREGANA	POLYPODIACEAE	Fern
XAST	XANTHIUM	STRUMARIUM	ASTERACEAE	Forb
ZIVE	ZIGADENUS	VENENOSUS	LILIACEAE	Forb

Appendix E.
Table 1. Species composition and percent cover of dominant or frequently encountered plants in plots sampled in the coniferous forest cover type, Flathead River and Lake, Montana, 1983-86.

SPP (Freq)	Percent Cover																												
Plot #	16	70	71	140	85	49	89	1	41	189	5	121	28	48	13	84	19	9	148	4	21	8	11	9	116	80	8	144	145
JUSC (.86)	92	19	61	34	53	50	38	50	56	15	15	15	50	--	--	--	10	53	26	30	68	8	10	8	1	8	1	1	--
PIPO (.76)	10	1	1	--	--	--	20	15	20	53	92	15	20	68	42	85	76	38	9	--	--	10	3	2	15	--	15	--	9
BERE (.66)	--	--	--	--	--	--	8	--	1	--	38	--	1	1	18	35	3	1	12	6	--	1	5	12	44	1	88	2	15
SYOC (.62)	1	20	--	18	--	1	--	8	1	--	13	1	1	1	89	10	4	1	--	--	40	--	6	--	56	--	12	--	--
ROWO (.59)	6	6	--	--	--	4	1	1	--	1	--	1	--	7	1	1	1	1	--	--	1	1	2	--	--	1	1	--	--
POCO (.52)	20	23	6	6	--	--	--	27	24	1	--	1	1	--	--	1	22	1	--	--	1	--	--	--	--	--	1	4	--
PSME (.48)	--	--	--	--	--	--	2	--	--	--	1	--	--	--	--	--	--	3	68	90	83	83	1	42	68	92	38	76	2
TAOF (.48)	1	9	1	--	1	1	--	1	1	1	--	--	--	--	--	--	1	1	--	--	--	2	1	1	--	--	--	5	--
ACMI (.45)	1	1	--	--	1	--	1	--	--	--	--	--	--	1	--	--	1	1	--	1	--	1	1	--	1	--	1	--	1
AMAL (.38)	--	--	--	--	--	--	1	--	--	--	1	10	--	--	18	32	1	1	--	--	6	--	--	1	1	--	8	--	--
SYAL (.34)	--	--	--	--	--	--	23	--	--	10	--	--	--	--	--	--	--	8	9	6	--	1	12	42	--	--	--	14	26
JUSC9(.31)	--	1	4	--	--	--	10	1	--	--	--	--	39	--	--	2	--	9	--	2	--	--	--	--	--	--	--	1	--
PRVI (.31)	--	1	--	--	--	--	1	--	--	--	--	--	--	1	19	2	1	--	--	--	1	--	9	--	--	1	--	--	--
RHRA (.31)	1	16	--	--	--	1	--	1	--	--	--	--	--	1	16	--	1	1	--	--	1	--	--	--	--	--	--	--	--
BRTE (.28)	--	--	1	--	1	--	--	1	--	--	--	1	1	1	--	--	2	1	--	--	--	--	--	--	--	--	--	--	--
CEMA (.24)	1	--	--	2	--	--	--	2	--	14	--	1	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
FRVE (.24)	--	--	--	--	--	--	1	10	--	--	--	--	--	1	--	--	--	1	1	--	--	--	1	--	--	--	--	--	1
AGSP (.21)	--	--	--	--	--	--	1	--	--	4	--	1	--	1	--	--	--	1	--	--	--	1	--	--	--	--	--	--	--
ASLA (.21)	1	--	--	2	--	2	--	--	--	1	--	--	--	--	--	--	1	--	1	--	--	--	--	--	--	--	--	--	--
MELU (.21)	--	2	1	4	1	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--
VIAM (.21)	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	1	1	2	--	--	--	--	--	--	--	--	3	1	--
ARFR (.17)	--	--	1	--	1	--	--	--	1	--	--	1	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--
BASA (.17)	--	--	--	--	--	--	5	--	--	--	--	--	--	--	--	--	--	1	--	--	--	1	--	--	--	--	1	--	17
FEID (.17)	--	--	--	--	--	--	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	4	--	--	3	1	--
GABO (.17)	--	--	--	--	--	--	7	1	--	4	--	--	--	--	--	--	--	1	--	--	--	--	--	1	--	--	--	--	--
MEOF (.17)	--	--	--	2	--	1	--	1	--	--	--	--	--	5	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--
PEWI (.17)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	1	--	1	1	--	--	--	--	--	1
POPR (.17)	--	--	--	16	4	--	7	--	--	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	3	--
RICE (.17)	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	1	--	--	--	1	2	1	--	--	--	--	--	--
AGAL (.14)	1	20	--	--	--	42	--	--	--	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ALSC (.14)	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	1	--	1	--	--
CARO3(.14)	--	--	--	1	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	1	--	--	--
CHNA (.14)	--	--	--	--	1	--	--	--	--	--	--	1	--	--	--	--	--	1	--	--	--	--	1	--	--	--	--	--	--
DAGL (.14)	--	--	--	16	--	10	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--
PUTR (.10)	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	4	12	--	--	--	--	--	--	--	--	--	--	--
SOOC2(.10)	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	1	--	--	--	--	--	--	--	--	--
AGRE (.07)	14	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AGSM (.07)	28	--	--	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ARUV (.07)	--	--	--	--	--	--	16	--	--	--	--	--	--	--	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--
SMRA (.07)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	11	--	6	--
SPBE (.07)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4	--	--	3	--
STVI (.07)	--	--	--	--	--	--	--	--	14	--	--	--	--	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ANAL (.03)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--
ANMI (.03)	--	--	--	--	--	--	--	--	13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Appendix E.
Table 2. Species composition and percent cover of dominantor frequently encountered plants in plots sampled in the deciduous forest cover type, Flathead River and Lake, Montana, 1983-86.

SPP (Freq)	Percent Cover																	
Plot #	109	40	32	53	54	127	91	172	83	68	122	162	81	147	177	154	156
ROWO (.82)	34	—	76	28	—	16	6	19	42	1	8	10	—	14	11	30	7
COST (.71)	63	—	2	—	2	76	1	30	24	—	1	19	1	—	1	8	—
SMST (.65)	2	—	1	1	2	—	1	—	4	1	1	1	—	1	--	--	1
POTR2 (.59)	19	46	98	49	98	53	76	42	—	1	—	—	—	—	—	1	—
TAOF (.53)	—	--	—	—	1	—	1	--	—	1	—	4	1	1	1	1	1
AMAL (.47)	—	—	—	—	1	—	1		28		—	4	10		31	28	—
CRDO (.47)	—	--	1	88	—	—	12	—	7	--	--	1	--	1		4	1
POTR (.47)	—	—	1	—	—	—	1	38	38	83	19	92	—	8	--	—	—
POCO (.41)	--	--	1	--	7	--	--	—	1	33	1	—	--	--	1	1	—
RHRA (.41)	2	—	12	1	1	—	6	—	—	1	1	—	—	—	—	—	—
SYOC (.41)	56	--	1	18	--	—	1	--	51	53	36	—	--	--	—	--	—
AGAL (.35)	—	—	—	—	1	—	2	—	1	—	—	14	—	2	—		34
POTR9 (.35)	—	20	7	—	15	27	32	—	—	--	—	—	--	--	—	5	—
SODU2 (.35)	10	—	1	—	—	—	—	16	—	—	—	—	1	—	1	—	1
BEPA (.29)	—	--	--	--	--	--	--	--	—	—		42	68	68	6	--	--
LYCI (.29)	—	—	—	—	6	6	2	25	4	—	—	—	—	—	—	—	—
POTR8 (.29)	—	—	2	—	--	—	7	—	6	4	—	--	—	2	--	--	—
SOCA (.29)	—	—	1	—	—	—	2	1	8	—	—	—	—	—	—	—	1
SYAL (.29)	—	--	—	--	—	--	—	32	—	—	—	6	--	72	--	3	21
CIAR (.24)	8	—	—	—	—	—	—	7	—	—	--	—	—	—	14	—	1
CRDO9 (.24)	—	—	—	92	—	—	8	—	1	—	—	—	--	2	--	--	—
POPR (.24)	—	—	—	—	—	—	2	—	—	—	—	—	—	1	51	—	17
RUID (.24)	—	--	--	--	—	—	—	4	7	—	2	--	--	--	1	--	—
AGRE (.18)	—	—	—	—	—	—	1	—	—	—	—	—	—	—	4	—	12
CAPR8 (.18)	—	—	—	—	2	3	9	—	--	—	—	—	--	—	--	--	—
FRVE (.18)	—	—	—	—	--	—	—	—	—	8	1	2	—	—	—	—	—
PHPR (.18)	—	--	--	--	1	—	—	—	--	8	--	--		2	—	—	—
PRVI (.18)	—	—	—	1	—	—	--	—	—	1	—	2		—	--		—
PRVU (.18)	--	--	1	—	—	--	—	—	—	1	--	4	—	—	—	—	—
SAAM2 (.18)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	77	98	26
SASC (.18)	—	--	--	--	--	—	9	8	—	—	27	--	--	—	—		—
BERE (.12)	—	—	—	—	—	--	—	—	—	1	—	16		—	—		—
CLCO (.12)	17	--	--	--	--	--	1	—	—	—	—	—	—	—	—	—	—
ALIN (.06)	—	—	—	—	—	—	—	—	—	—	—	—	—	19	—	—	—
BRIN (.06)	—	--	--	--	--	--	—	—	—	—	—	—	—	—	11	--	—
CAST (.06)	--	—	—	—	—	--	—	--	—	--	—	18	--	—	—		—
POPA (.06)	—	--	--	—	--	—	—	50	—	--	--	--	--	—	—		—
EQPR (.06)	--	--	—	—	—	—	—	—	—	--	—	45	--	—	—	--	—
LYAM (.06)	—	--	--	--	--	--	--	—	--	--	--	--	82	—		—	—
PHAR (.06)	—	—	—	—	—	—	—	—	—	--	--	—	—	--	—	12	—
POTR3 (.06)	—	--	--	--	--	—	—	—	--	--	--	15	--	--	--	--	—
RUAC3 (.06)	--	—	—	—	—	--	—	—	—	—	--	6	--	—	—	—	—
SAEX (.06)	8	—	--	—	—	—	—	—	—	--	—	—	—	—	—	—	—

Appendix E.
Table 3. Species composition and percent cover of dominant or frequently encountered plants in plots sampled in the mixed forest cover type, Flathead River and Lake, Montana, 1983-86.

SPP (Freq)	Percent Cover													
Plot #	151	82	143	78	171	31	6	133	94	25	120	13	113	117
ROWO (.93)	19	—	2	36	1	1	4	5	4	18	2	29	1	8
AMAL (.79)	14	—	15	1	22	4	10	1	22	—	4	8	—	1
SYOC (.79)	—	62	—	1	61	5	46	1	—	31	20	11	1	6
VIAM (.71)	1	—	1	--	1	1	—	1	—	1	1	1	1	1
BERE (.64)	4	1	1	1	—	8	1	—	4	—	—	l	-	1
JUSC (.64)	--			53	19	—	15	8	1	20	-	68	53	19
PIPO (.64)	19	—	—	15	42	68	—	—	76	34	19	—	1	19
TAOF (.64)	2	1	1	1	1	—	1	1	—	1	—	—	1	—
POTR2(.57)	—	—	—	8	—	—	—	1	15	34	2	20	26	15
RHRA (.57)	—	—	2	16	—	5	5	—	1	2	1	—	8	—
SMST (.57)	1	1	1	1	—	1	1	—	—	1	--	4	--	—
POPR (.50)	1	—	3	8	—	—	6	59	—	1	—	—	15	—
CEMA (.43)	—	—				1	—	1	—	1	6	1	2	—
FRVE (.43)	1	—	2	—	1	—	—	1	—	1	—	l	-	—
POTR (.43)	34	—	—	—	8	1	75	53	—	10	—	—	—	—
CIAR (.36)	—	1	—	—	1	—	2	1	—	—	—	4	-	-
COST (.36)	1	4	17	24	—	—	—	—	—	28	—	—	—	—
CRDO (.36)	10	—	4	—	—	—	—	2	4	—	14	—	—	—
ELGL (.36)	1	1	1	1	—		—	—		13	—	--	—	—
POTR9(.36)	—	—	—	1	—	—	—	6	—	17	12	--	—	9
PRVI (.36)	—		14	—	—	24	30	—	48	—	--	—	—	1
PSME (.36)	2	1	26	—	—	—	—	—	8	—	--	—	—	8
TRDU (.36)	—	—	1	—	—	1	—	—	--	1	1	—	2	—
ASLA (.29)	—	—	1	—	1	—	—	2		—	—	l	-	-
GAAP (.29)	—	1	1	1	--	—	1	—	—	—	—	—	—	—
MELU (.29)	—	—	—	—	—	1	—	1	—	—	1	—	1	—
POCO (.29)	—	—	—	—	9	6	—	--	—	—	50	--	1	—
POTR8(.29)	1	—	—	—	—	1	—	17	—	4	—	—	—	—
ACGL (.21)	1	4	28	—	—		—	—	—		—	--	—	—
AGAL (.21)	1	—	—	—	—	—	—	9			—	—	22	—
BEPA (.21)	34	3	8	—	—	—	—	—		—	—	—	—	—
SHCA (.21)	1	—	13	—	—	—	—	—	—		—	—	—	1
SYAL (.21)	74	—	42	—	—			—	28	—	—	—	—	—
AGCA (.14)	—	—	—	—	—	8	—	—	—	—	4	—	—	—
AGRE (.14)	—	—		—	—	—	—	3	—	—	—	—	—	1
ARUV (.14)	—	—	1	—	—	—	—	—	—	—	—	—	—	6
BQAR (.14)	—	1	—	—	—	—	—	—	—		—	17	—	—
JUSC9(.14)	—	—	—	11	—	—	—	—	—		-	-	2	--
OSDE (.14)	4	—	—	—		—	14	—			—	—	—	—
PIEN (.14)	34	38	—	—		—	—	—	—	—	—	--	—	—
POGR (.14)	—	2	—	—			—	3	—	—	—	—	—	—
ABGR (.07)	8	—	—	—	—	—	—	--	—	—	—	—	—	—
ARLI2(.07)	—	—	—	—	—	—	—	18	—	—	—	—	—	—
ARNU (.07)	—	29			—		—	—	—	—	--	—	--	—
EQHY (.07)	6	—		—	—	—	—	—	—	—	—	—	—	—
FERU (.07)	--		—	—	21	—	—	—	—		—	—	—	—
SADR (.07)	—		—		--	—	—	9	—	—	—	—	—	—
SASC (.07)	--		—	—	8		—	—	—	—	—	—	—	—
SODU2(.07)	—	—	--		—	—	—		—	—	—	7	—	—

Appendix E.
Table 4. Species composition and percent cover of dominant or frequently encountered plants in plots sampled in the riparian shrub cover types, Flathead River and Lake, Montana, 1983-86.

SPP (Freq)	Percent Cover
Plot #	50 66 69124 17 23174110 46 36 22108166 77 62112107 38 74 60 30 97 26101102 67 93155 57 gg 39136 86132125138
ROWO (.78)	1 - - - 3 - 1 1 1 - 427 - 1 - 5 2 2 20 0 53 11 31 64 12 59 7 1 16 1 2 17 66 60 77 65
SAEX (.44)	30 49 50 36 44 67 - 75 81 76 12 33 79 - 8 - - - 2 1 - 1 - - - - - - - - - - - - - -
COST (.42)	- - - - - - 1 26 78 13 32 59 16 - - - - - 6 60 64 92 26 11 24 12 - - - - - - - - - - -
RHRA (.42)	1 - - - 1 - - 1 - 6 1 - - 1 - - -57 - - 4 3 4 442 - 5 -25 -28 - - - - - -
AGAL (.39)	1 - 38 -21 - 19 8 - - - 1 611 - 314 -74 - - - - - - - 1 - - 2 - - - 5 - -
CIAR (.39)	- - - - 1 - 2 2 - 1 - - - - - - - - - 7 - 2 1 - 2 - - - 19 - - 1121120 -13
SYOC (.39)	- - - - 1 - - - - - - - - - 1 - - - 14 - - - - 14 12 33 - 21 - 59 1 34 55 28 38 - 1
APCA (.36)	- 1 - - - 1 4 5 - - 21 1 - - - - - - 1 - - 2 1 1 3 - - 7 - - - - - - - - 5 -
MELU (.36)	- - 1 - - - 1 - - - - - 1 - 1 1 1 - - - - - - 3 - 4 1 - 1 - 4 - 24 - 1
PHAR (.36)	- 96 - 80 - 1 - 25 1 29 1 - - - - - - - 110 631 -20 - - - - - - - - - - - 39 -
POPA (.36)	- - - -22 -13 1 - - 4 3 2 - - - - - - 115 -11 - 715 - 5 - - - - - - - - - 12 -
SOCA (.36)	- - - - - 4 - 8 - - 12 - - - - - - - - - - - - 1 3 - 1 1 2 - - 1 1 - - 2 1 - 7 26 -
SODU2(.36)	- - - 2 - - 1 1 -52 - 1 - - - - - - - - - 14 1 - - 2 8 16 - 1 - - 3 - - 5
POPR (.33)	- - - - - - - 13 9 - - - - - 1 - - - - - 60 - - - - - 2 - 4 - 5 1 6 - -6; 1 - - 35
AGRE (.31)	- - - - - 10 - - 1 - - - - - - - - - - - - - - 1 - 3 - 4 - - 411 - - - 418 1 -26
LYCI (.28)	- - - - 22 - 1 3 12 5 16 20 - - - - - - - - - - 1 - 17 - - - - - - - - - - - - - -
CRDO (.25)	- - - - - - - - - - - - - - - - - - - 14 - - - - - 7 20 85 62 17 30 69 - - - - - - 1
POCO (.25)	- - 15 - 9 - - - - - - - 10 1 8 4 1 1 - - - - - - - - - - - - - - - 34 - - - - - -
POTR9(.25)	- - - - - - - - 1 - - -3924201525 1 - - - - - - - 5 - 4 - - - - - - - - - - - - -
JUSC (.22)	1 - - - - - - 2 - - - - - - - 1 - 1 - - - - - 1 - 1 - - - - - - - 26 1 - - - - -
MEAL (.22)	- - - - - - - - 1 - - - - - 16 1 - 2 14 2 - - - - - - - - 5 - 9 - - - - - - - - - -
TAOF (.22)	- - 1 - - - - - - - - - - - - - 1 - - 1 - - 1 - - 1 - - - - - - - - - -
AMAL (.19)	- - - - - - - - - - - - - - 1 1 - - - 3 - - - - - - - - 9 - - 14 2 - - - - - I - -
ARLI2(.19)	1 - - - - 5 - 4 - - - - - - 110 1 2 - - - - - - - - - - - - - - - - - -
FRVE (.17)	- - - - - - - 1 - - - - - - - 2 5 - - - 1 - - - - - - - - - - - 1 - - - 27 - - - - -
JUSC9(.17)	- - - - - - - - - - - - - - - - 1 -5137 - - - 1 - - - - - - - - - - - - 12 2 - - - - -
MEAR3(.17)	- - - 8 1 - - - 1 - - 3 - - - - - - - - - 12 - 1 - - - - - - - - - - - - - -
PIPO (.17)	- - - - - - - 8 - - - - - - - - 2 1 - - 1 - 1 - - - - - - - - - - - - 1 - - - - - - -
AGCA (.14)	- - - - - - - - - - - - - - - - 1 - 1 2 - - - - - - - - - - - 1 - - 4 - - - - - - -
CALA3(.14)	- - - - 4 - 1 - - - - - - 1 - - - - - - 1 - - 1 - - - - - - - - - - - - - - - - -
PAOC (.14)	2 - - - - - - - - - - - - - 2 1 3 14 - - - - - - - - - - - - - - - - - - -
ROIS (.14)	- - - 1 - - - - - - 9 - - - - - - - - - - - - 5 - 1 - - - - - - - - - - - - - 1 -
SARI (.14)	- - - - - - - - 1 1 - - - 3 - - - - - - - - 4 - 32 - - - - - - - - - - - - -
AGSP (.11)	- - - - - - - - - - - - - - 1 1 - - - - - - - - 1 - - - - - - - 1 - - - - - -
CEMA (.11)	- - - - - - - - - - - - - - - - 6 - - - - - - - - - 1 - - 32 - - - - - - - - - 4
LASE (.11)	- 7 - - - 3 - 18 - 4
POTR8(.11)	- - - - - - 2 - - - - - - - - - - - 20 I I - - - - - - - - - - 8 - 3 - - - - - -
PRVI (.08)	- 12 - - - 12 - 20 - - - - - -
SABE (.08)	- - - - - - - 67 - - - - - - 1 - - - - - - - - - - 1 - - - - - - - - - - - - -
CARE (.06)	- - - - - - - - - - - - - 25 - - - - - - - - - - - 1 - - - - - - - - - - - - - -
CARO2(.06)	- - - - - - - 11 - - - - 23 -
CRDO9(.06)	- - - - - - - - - - - - - - - - - - - 1 - - - - - - - - - - - - 26 - - - - - -
MUAS (.06)	- - - - - - - - - - - 12 1 -
SOOC2(.06)	- - - 13 - - - - - - - - 7 -
SYAL (.06)	- - - - - - - 5 - 95 - - - - - - - - -
CACU2(.03)	- -12 12 - -
CRCO (.03)	- 40 - - - - - - - - -
DECA (.03)	- - - - - - - - - 12 -
PHLE (.03)	- 33 - - - 5 7 - - - - - - -
POIN (.03)	- -

Appendix E.
Table 5. Species composition and percent cover of dominant or frequently encountered plants in plots sampled in the upland shrub cover types, Flathead River and Lake, Montana, 1983-*86.

SPP (Freq)	Percent Cover											
Plot #	179	150	149	72	10	47	7	37	27	218	222	211
AGSP (.83)	7	1	--	--	5	1	10	21	10	15	38	38
BRTE (.75)	--	1	1	1	10	13	63	1	36	3	--	--
ACMI (.67)	2	--	1	1	3	1	1	3	1	--	--	--
ARFR (.58)	--	--	--	1	1	--	1	--	2	15	3	3
BASA (.50)	7	--	10	--	--	4	9	1	1	--	--	--
CHNA (.50)	--	--	--	--	--	1	1	--	9	15	38	38
CEMA (.42)	--	--	--	--	--	12	--	--	23	15	3	3
PUTR (.42)	--	--	--	--	5	24	19	24	18	--	--	--
KOCR (.33)	--	--	--	--	1	1	--	--	1	15	--	a-
POPR (.33)	2	--	2	--	--	8	1	--	--	--	--	--
RICE(| 33)	--	9	20	--	--	6	--	--	1	--	--	--
VETH (.33)	--	--	--	1	1	--	2	--	4	--	--	--
AMAL (.25)	1	8	8	--	--	--	--	--	--	--	--	--
CHVI (.25)	--	--	--	1	1	--	--	--	9	--	--	--
ELCI (.25)	--	--	--	--	1	--	--	--	--	--	3	3
FEID (.25)	16	--	2	--	--	--	--	1	--	--	--	--
HODI (.25)	20	2	16	--	--	--	--	--	--	--	--	--
LODI2(.25)	18	12	10	--	--	--	--	--	--	--	--	--
POCO (.25)	--	--	--	33	10	--	--	--	1	--	--	--
SYAL (.25)	--	13	8	--	--	1	--	--	--	--	--	--
SYOC (.25)	--	--	--	1	--	1	--	--	--	3	--	--
ARTR (.17)	--	--	--	24	11	--	--	--	--	--	--	--
FESC (.17)	--	--	--	--	--	22	--	34	--	--	--	--
PHMA (.17)	29	75	--	--	--	--	--	--	--	--	--	--
PLPA (.17)	--	--	--	--	--	--	--	1	--	3	--	--
ALCE (.08)	--	--	5	--	--	--	--	--	--	--	--	--
ARUV (.08)	--	--	34	--	--	--	--	--	--	--	--	--
CESA (.08)	--	13	--	--	--	--	--	--	--	--	--	--
EPPA (.08)	--	--	--	--	30	--	--	--	--	--	--	--
SMRA (.08)	--	5	--	--	--	--	--	--	--	--	--	--

Appendix E.

Table 6. Species composition and percent cover of dominant or frequently encountered plants in plots sampled in the gravel bar/mudflat herbaceous cover type, Flathead River and Lake, Montana, 1983-86.

SPP (Freq)	Percent Cover																			
Plot #	64	35	128	134	44	24	212	216	219	221	63	104	129	75	29	210	59	213	12	215
ARLI2(.85)	10	26	14	12	15	17	--	3	15	15	13	12	14	8	7	15	--	14	--	7
MEAR3(.60)	1	--	1	1	--	--	15	--	--	3	8	--	1	--	1	3	2	1	--	1
AGAL (.55)	--	--	--	--	--	--	--	38	98	15	6	6	7	--	1	15	1	7	--	1
POCO (.55)	4	--	--	1	2	1	--	3	--	--	--	11	13	2	1	--	--	13	--	1
GAAR (.50)	1	2	--	2	1	4	4	--	3	--	--	--	20	--	--	1	--	1	--	1
PAOC (.50)	6	--	1	--	1	-	-	15	--	--	--	12	5	1	6	--	--	5	--	6
PRVU (.45)	1	--	--	--	--	--	--	--	--	3	1	1	13	--	2	3	--	13	--	2
ALSC (.35)	4	1	--	--	--	--	--	--	1	--	2		--	--	8	--	--	--	--	8
ASCH (.35)	1	--	--	12	1	--	--	--	--	--	4	5	7	--	--	--	4	7	--	--
ROWO (.35)	2	--	--	--	1	--	--	3	--	--	1	3	1	--	--	--	--	1	--	--
PHPA (.30)	--	--	--	--	--	--	--	--	--	--	--	--	1	1	1	--	1	1		
SAM (.30)	--	--	--	--	-	1	--	--	3	3	--	-	--	1	--	3	1	--	--	--
DECA (.25)	--	--	--	--	u	--	--	1	1	15	5	-	--	--	--	15	--	--	--	--
POTR9(.25)	1	--	--	1	-	1	--	--	--	--	--	1	--	2	--	--	--	--	--	--
ASLA (.20)	--	1	--	--	--	--	--	3	--	--	--	--	--	--	1	--	--	--	--	1
HEAU (.20)	--	--	--	--	--	--	--	--	--	--	1	-	3	--	--	--	1	3	--	--
MEAL (.20)	2	--	--	--	--	--	--	--	--	--	--	--	1	1	--	--	--	1	--	--
TAOF (.20)	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1	1	--	--		
AGSP (.15)	1	1	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EQHY (.15)	--	--	--	--	--	--	--	--	--	--	1	--	--	--	1	--	--	--	--	1
JUSC(.15)	1	--	--	--	--	--	--	3	--	--		1-	--	--	--	--	--	--	--	--
PIPO (.15)	1	--	--	--	--	--	--	--	--	--	--	--			1	--	--	--	--	1
POAN4(.15)	--	--	--	--	--	--	--	--	--	--	--	--	-1	--	--	--	1	1	--	--
AGCA (.10)	--	--	--	--	1	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--
ALCE (.10)	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ASOF (.10)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1
CAOE (.10)	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1	--	--
CLLI (.10)	1	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
COAT (.10)	--	--	--	1	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--
EPPA2(.10)	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1	--	--
EQPA (.10)	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1	--	--
HYPE (.10)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--		
IRPS (.10)	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	1	--	--	--	--
JUAR (.10)	--	--	--	--	--	--	--	--	--	3	--	--	--	--	--	3	--	--	--	--
JUSC9(.10)	2	--	--	--	--	--	--	--	--	--	--	--	--	2	--	--	--	--	--	--
JUTE (.10)	--	--	--	--	--	--	--	--	--	1	--	--	--		--	1	--	--	--	
LYCI (.10)	--	--	--	--	--	--	--	--	--	--	--	--	1	II	--	--	--	1	--	II
MELU (.10)	--	--	--	--	--	--	--	--	--	--	1	--	--	1	--	--	--	--		--
PLMA (.10)	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1	II	--
POTR2(.10)	1	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SARI (.10)	--	1	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--
APCA (.05)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	14	--	--	--

Appendix E.
Table 7. Species composition and percent cover of daninant or frequently encountered plants in plots sampled in the moist herbaceous cover type, Flathead River and Lake, Montana, 1983-86.

SPP (Freq)	Percent Cover																
Plot #	56	43	175	204	87	205	130	52	208	170	202	176	187	214	206	188	
CIAR (.50)	1	1	2	—	1	1	—	—	—	—	1	3	—	—	1	—	
MEAR3 (.44)	2	2	—	—	--	—	1	1	1	—	2	—	—	3	—	—	
HEAU (.38)	1	3	—	—	—	—	9	1	1	—	3	—	—	—	—	—	
JUBA (.38)	—	--	5	—	—	--	—	—	—	16	—	1	60	3	—	7	
AGAL (.31)	—	—	62	—	—	—	—	—	—	48	—	1	5	—	—	3	
AGRE (.31)	—	—	6	15	58	58	—	—	—	—	—	—	—	—	58	—	
DECA (.31)	—	12		—		—	5	10	10	—	12		—		-----		
ELPA (.31)	—	5	—	—	—	--	--	1	1	—	5	—	—	—	—	1	
JUAR (.31)	—	1	1	—	—	—	6	—	—	1	1	—	—	—	—	—	
POAN4 (.31)	1	10	—	—	--	—	5	—	—	—	10	—	—	3	—	—	
POPR (.31)	—	—	—	—	17	17	—	—	12	—	—	17	—	17		—	
TAOF (.31)	—	—	1	—	2	2	--	—	—	17	—	—	—	—	2	--	
CEMA (.25)	—	—	—	—	11	11	—	—	—	—	—	—	1	—	11	—	
PLMA (.25)	—	—	4	—	—	—	1	—	—	5	—	—	—	15	—	—	
POAM2 (.25)	—	1	—	—	—	—	—	—	—	—	1	5	—	3	—	—	
POPA (.25)	9	2	29	--	—	--	—	—	—	—	2	--	—	—	—	--	
SOOC2 (.25)	4	1	—	—	—	—	—	—	—	—	1	—	48	—	—	—	
AGSP (.19)	—	--	--	--	--	--	—	—	—	—	—	1	8	—	—	4	
ASLA (.19)	—	—	7	—	—	—	—	26	26	—	—	—	—	—	—	—	
CAAT (.19)	15	8	—	—	—	—	—	—	—	—	8	—	--	—	—	—	
CAVE (.19)	77	71	—	—	—	—	—	—	—	—	71	—	—	—	—	—	
EQHY (.19)	—	—	--	—	--	--	—	1	1	24	—	—	—	—	—	—	
HOJU (.19)	—	1	—	—	—	—	—	—	—	—	1	—	61	—	—	—	
JUTE (.19)	—	3	--	—	—	—	—	—	—	6	3	—	—	—	—	—	
PHAR (.19)	4	—	—	—	—	—	—	4	4	—	—	—	—	—	—	—	
PHPA (.19)	—	—	—	--	—	—	3	3	3	—	—	—	--	—	—	—	
PLLA (.19)	—	1	11	—	—	—	—	—	—	—	1	—	—	—		—	
TRMA2 (.19)	—	--		--		--	1	—	—	—	—	--	15	3		—	
CARO2 (.13)	—	—	5	—	—	—	—	—	—	—	—	1	—	—	—	—	
COAT (.13)	—	—	—	—		--	--	16	16	—	—	—	—	—	—	—	
FEPR (.13)	—	—	—	68	—	—	—	—	—	20	—	—	—	—	—	—	
IRPS (.13)	—	4	--	—	—	—	—	—	—	—	4	—	—	—	—	—	
LASE (.13)	—	—	8	—	—	—	—	—	—	—	—	—	10	—	—	—	
PHPR (.13)	—	--	13	--	—	--	—	—	—	8	—	—	--	—	—	--	
POCO (.13)	—	—	—	—	—	—	1	—	—	—	—	—	13	—	—	—	
SAEX (.13)	—	—	—	—	—	—	—	4	4	—	—	—	—	—	—	—	
AGIN3 (.06)	—	—	—	15	—	—	—	—	--	—	—	—	—	—	—	—	
CANE (.06)	—	--	--	—	—	—	—	—	—	18	—	—	--	--	--	—	
DIST (.06)	—	—	—	15	--	—	—	—	—	—	—	—	--	—	—	—	
FEOV (.06)	—	—	—	—	—	—	—	—	—	—	—	71	—	—	—	—	
FESC (.06)	—	—	—	—	—	—	—	—	—	—	—	39	—	—		—	
HEKI (.06)	—	--	—	—	—	--	—	—	—	—	--	--	—	—	—	80	
MELU (.06)	—	—	—	—	--	—	--	—	—	--	—	36	—	—		—	
POGR (.06)	—	—	16	—	—	—	—	—	—	--	--	--	--	—	—	—	
PONE2 (.06)	—	—	--	15	—	—	--	—	—	--	—	--	--	—	—	—	
POTR2 (.06)	—	—	—	—	—	--	--	--	--	—	—	8	--	--	—	—	

Appendix E.
Table 8. Species composition and percent cover of dominantor frequently encountered plants in plots sampled in the dry herbaceous cover type, Flathead River and Lake, Montana, 1983-86.

SPP (Freq)	Percent Cover																	
Plot #	33	58	131	173	88	180	178	100	2	161	79	51	146	3	203	139	92
AGSP (.65)	—	—	—	1	1	2	16	4	12	31	5	18	10	10	—	—	—
POPR (.59)	56	12	—	15	17	—	—	—	7	40	37	—	1	—	—	47	11
AGAL (.53)	—	34	18	85	40	—	—	17	—	1	—	26	—	—	18	22	—
CIAR (.53)	—	9	16	13	—	—	—	—	—	2	13	l--	l6		1		1
AGSM (.47)	11	25	27	10	12	—	—	—	—	—	—	—	—	—	27	1	3
CEMA (.41)	1	1	—	—	--	14	—	—	22	—	8	--	—	—	—	8	1
ACMI (.35)	—	—	—	—	—	1	1	—	1	—	1	—	5	1	-	-	-
=(.35)	4	1	—	4	1	—	—	--	—	1	—	—	--	—	—	—	2
JUBA (.29)	—	—	12	5	1	—	—	—	—	—	—	—	—	—	12	11	—
JUTE (.29)	1	2	—	—	4	—	--	1	—	—	--	2	—	—	--	--	--
LASE (.29)	—	—	18	—	—	—	—	—	—	1	1	—	—	—	18	2	—
TAOF (.29)	11	--	—	5	1	—	—	9	—	—	1	—	—	—	—	—	—
FEID (.24)	—	—	—	—	12	18	9	—	—	—	—	—	1	—	—	—	—
MELU (.24)	—	—	5	—	—	—	—	1	—	—	—	--	--	—	5	1	--
POPA (.24)	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	7	10
AGRE (.18)	—	--	17	—	—	--	--	—	—	—	—	--	—	—	17	--	2
CARU (.18)	—	48	5	—	—	—	--	—	—	--	—	—	—	—	5	—	—
CIVU (.18)	—	--	7	10	—	—	—	—	—	—	—	—	—	—	7	—	—
DAGL (.18)	—	—	—	1	1	—	—	—	—	43	—	—	—	—	—	—	—
PLMA (.18)	—	--	—	1	4	—	—	1	—	—	—	--	--	—	—	--	—
POSA3 (.18)	—	—	—	—	—	1	5	—	1	—	—	—	—	—	—	—	—
ARNU (.12)	--	--	--	--	--	--	—	5	—	—	—	—	2	—	—	—	--
CHVI (.12)	—	—	—	--	--	—	—	—	4	—	—	--	—	5	—	—	—
COAT (.12)	46	4	—	—	—	—	—	—	—	—	—	--	—	—	—	--	—
FEPR (.12)	—	—	5	—	—	—	—	—	—	—	—	—	—	—	5	—	—
FESC (.12)	--	--	—	—	—	—	—	—	—	—	--	—	14	46	--	--	--
GLLE (.12)	—	—	8	—	—	—	—	—	—	—	—	—	—	—	8	—	—
JUSC (12)	—	—	--	--	--	—	—	—	—	—	—	—	1	5	—	--	--
KOCR (.12)	—	—	—	—	—	—	—	—	—	—	—	—	1	2	—	—	—
LIRU (.12)	—	--	—	—	—	—	—	—	--	—	—	—	5	1	—	--	--
MEAL (.12)	—	—	6	—	—	—	—	—	—	—	—	—	—	—	6	—	—
POHY2 (.12)	—	—	3	—	--	—	—	--	—	—	—	—	--	—	3	--	--
ROWO (.12)	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	4	—
TRPR (.12)	1	—	--	4	—	—	—	--	--	—	—	--	--	—	—	—	--
AGCA (.06)	—	—	—	—	—	—	—	—	--	--	—	—	—	—	—	—	25
APCA (.06)	—	—	--	--	--	--	—	--	—	—	—	—	--	—	—	—	10
BASA (.06)	--	—	—	—	—	--	--	—	--	—	—	—	31	—	—	—	—
BRJA (.06)	—	--	—	—	—	—	—	--	--	—	28	—	—	—	—	—	—
CAAT (.06)	—	—	—	—	—	—	—	—	—	—	—	40	—	—	—	—	—
CHLE2 (.06)	—	--	--	18	—	—	--	—	--	—	—	--	--	—	—	—	—
HOJU (.06)	—	—	—	—	—	—	—	—	—	--	—	11	--	—	—	—	—
MEAR3 (.06)	--	--	—	—	—	--	—	—	—	--	—	15	--	—	—	—	—
PHAR (.06)	--	—	—	—	—	—	—	—	—	—	—	--	—	—	—	16	—
POIN (.06)	—	—	—	—	—	—	—	58	—	--	—	—	--	—	—	—	—
SYAL (.06)	—	--	--	—	—	—	—	—	—	--	--	—	6	—	—	—	—
SYOC (.06)	—	—	—	—	—	—	—	—	--	--	--	--	—	6	—	—	—

Appendix E.
Table 9. Species composition and percent cover of dominant or frequently encountered plants in plots sampled in the xeric herbaceous cover type, Flathead River and Lake, Montana, 1983-86.

SPP (Freq)	Percent Cover									
Plot #	201	105	114	42	18	152	14	111	137	223
CEMA (.70)	15	1	5	--	--	29	54	45	18	--
ACMI (.60)	--	1	4	1	1	--	1	--	5	--
BRTE (.60)	15	9	--	2	25	1	9	--	--	--
ARFR (.50)	3	6	1	8	1	--	--	--	--	--
ASPA4(.50)	3	--	1	1	--	--	1	--	5	--
STCO2(.50)	15	31	6	17	1	--	--	--	--	--
HYPE (.40)	--	2	1	--	1	--	1	--	--	--
POPR (.40)	--	--	16	--	--	--	--	50	36	22
ERFI (.30)	--	1	1	1	--	--	--	--	--	
ERHE (.30)	--		1	2	1	--	--	--	--	--
PLPA (.30)	--	13	1	--	--	--	--	--	--	1
POCO (.30)	--	--	--	--	1	1	19	--	--	--
TRDU (.30)	--	--	1	1	--	--	--	2	--	--
VEBL (.30)	--	--	1	--	1	--	1	--	--	--
AGRE (.20)	--	--	--	--	--	1	--	--	3	--
AGROP(.20)	--	--	--	1	--	--	--	7	--	--
ARLO3(.20)	--	--	18	11	--	--	--	--	--	--
CHVI2(.20)	15	7	--	--	--	--	--	--	--	--
DIAR (.20)	--	--	--	--	1	--	--		16	--
LUSE (.20)	--	5	12	--		--	--	--	--	--
AGSM (.10)	--	--	--	--	--	--	--	--	--	13
AGSP (.10)	--	--	--	--	--	--	--	--	17	--
ANMI (.10)	--	--	--	7	--	--	--	--	--	--
CIAR (.10)	--	--	--	--	--	--	--	--	8	--
CIFL (.10)	--	--	--	--	--	--	--	--	3	--
MEAL (.10)	--	--	--	--	--	--	--	--	21	--
POGR (.10)	--	--	--	--	--	--	44	--	--	--
PORE2(.10)	--	--	--	--	62	--	--	--	--	--
SPCR (.10)	--	--	--	--	--	--	--	--	--	40

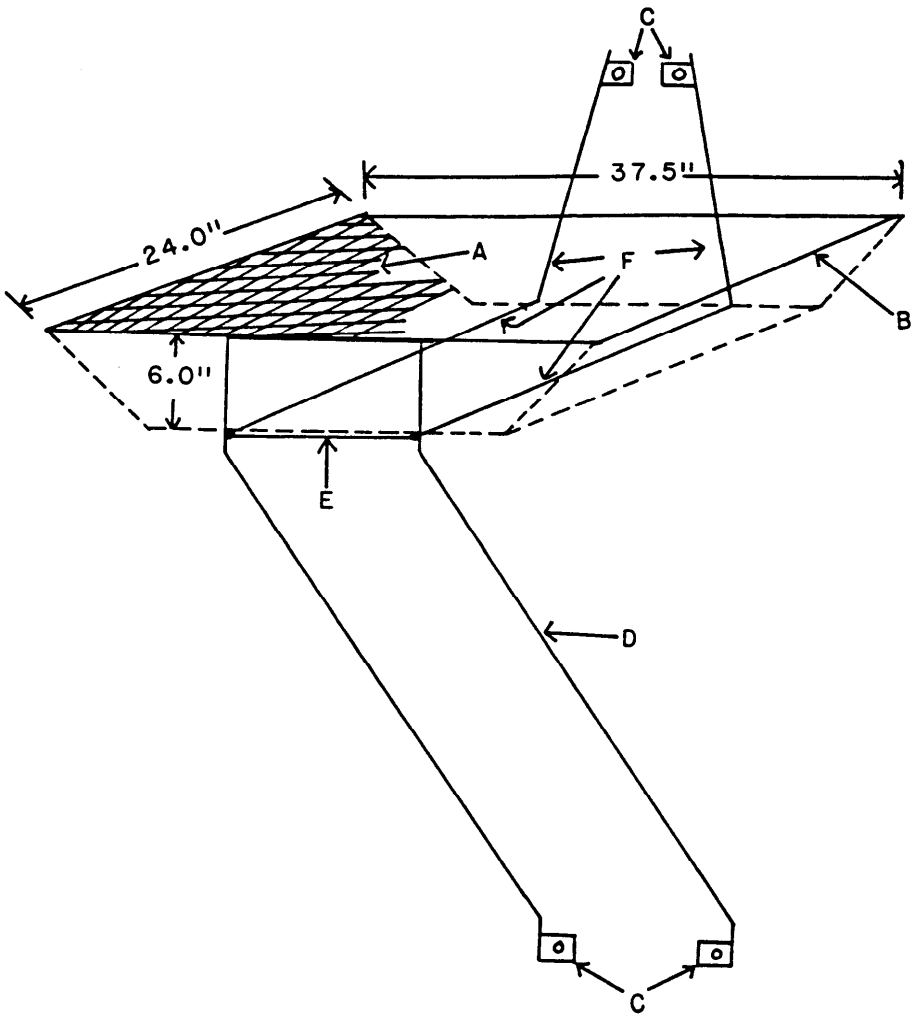
Appendix E.
Table 10. Species composition and percent cover of dominant or frequently encountered plants in plots sampled in the marsh cover type, Flathead River and Lake, Montana, 1983-86.

SPP (Freq)	Percent cover																													
Plot #	45	23	34	76	183	98	96	26	61	65	58	153	165	15	186	160	207	169	191	164	42	119	94	217	220	213	2	63	141	95
PHAR (.40)	2	--	1	--	3	47	96	98	81	9	10	--	--	--	--	--	90	--	--	--	--	--	--	90	--	--	--	--	--	4
ELPA (.37)	2	--	83	39	74	31	--	--	--	--	1	--	--	1	13	--	--	--	--	--	--	1	--	--	--	--	1	--	--	--
EQFL (.33)	92	98	--	--	14	9	--	2	--	--	--	--	--	--	1	1	--	--	--	--	--	1	4	--	--	--	--	--	--	5
LEMI (.30)	--	--	--	--	--	--	--	--	--	--	4	--	--	--	--	--	--	1	--	1	1	--	--	--	1	1	--	3	--	--
MEAR3(.30)	1	--	1	2	4	--	--	1	14	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3
RUCR (.23)	--	--	1	3	2	1	--	--	1	--	--	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SCAC (.23)	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	65	82	55	5	--	--	--	55	--	1	--	--	--
TYLA (.23)	--	--	--	--	--	--	--	--	--	--	80	66	74	26	--	--	--	--	--	1	--	--	--	--	1	74	--	--	--	--
APCA (.20)	--	--	--	--	--	--	1	--	--	4	--	--	--	4	--	--	1	--	--	--	--	--	--	1	--	--	--	--	--	45
AGAL (.17)	--	--	--	3	--	--	--	--	8	--	--	--	--	--	21	2	--	--	--	--	--	--	--	--	--	--	1	--	--	--
MYSPE(.17)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	22	40	--	--	1	1	--	--	--	--	--	2	--
POAN4(.17)	--	--	--	--	1	--	--	--	2	1	--	--	--	--	4	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--
PORI2(.17)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	1	--	--	1	--	1	--	--	--	1	--
RAAQ (.17)	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	5	--	--	1	--	--	--	1	--	1	--	--
SACU (.17)	--	--	1	--	6	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	47	54	--	--	--	--	--	--	--
ELAC (.13)	--	--	54	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	7	--	--	--	--	--	1	--
POAM2(.13)	7	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	30
SAEX (.13)	--	--	--	--	--	--	--	--	10	1	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2
BUUM (.10)	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	1	--	92	--	--
CARO2(.10)	--	--	--	--	--	--	--	--	--	--	--	--	--	62	28	95	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CHARA(.10)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	13	-9	--	--	--	12	--	--	--	--	--	--	--
HIVU (.10)	--	--	1	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	4-	--	--	--	--	--	--	--	--	--	64	--
POPE2(.10)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4	0	--	--	--	6	--	--	--	--	--	--	--
PRVU (.10)	--	--	--	18	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1	--	--	--
CANE (.07)	--	--	--	--	--	--	--	--	--	--	--	--	--	5	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CAVE (.07)	1	--	--	11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EQVA (.07)	--	--	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	38	--	--	--

Appendix E.
Table 11. Species composition and percent cover of dominant or frequently encountered plants in plots sampled in the aquatic cover type, Flathead River and Lake, Montana, 1983-86.

SPP (Freq)	Percent Cover										
Plot #	159	168	182	185	192	181	184	193	196	195	190
CHARA(.91)	82	68	--	66	90	14	68	4	53	5	51
POPE2(.91)	90	48	--	20	14	4	7	15	8	10	17
MYSPE(.82)	1	1	--	--	50	24	20	1	2	1	7
PORI2(.73)	1	--	--	30	11	--	29	29	9	1	13
POPU5(.64)	--	--	44	49	22	13	--	4	4	17	--
ELNU (.45)	1	--	--	1	--	--	--	19	40	60	--
HIVU (.45)	1	1	--	1	12	--	1	--	--	--	--
RALO2(.45)	--	--	--	--	1	--	1	63	21	2	--
ELCA3(.36)	--	--	--	--	--	40	41	--	--	18	18
UTVU (.36)	6	15	--	1	1	--	--	--	--	--	--
NAFL (.27)	--	1	--	6	1	--	--	--	--	--	--
POGR3(.27)	--	1	--	2	--	46	--	--	--	--	--
PONA2(.27)	--	2	--	--	--	--	1	12	--	--	--
POZO (.27)	--	--	--	--	--	--	--	1	--	1	9
RAAQ (.27)	5	--	--	2	--	--	--	--	--	--	34
CAVE2(.18)	27	--	--	1	--	--	--	--	--	--	--
CEDE (.18)	--	--	10	--	1	--	--	--	--	--	--
SACU (.18)	--	--	43	--	--	--	--	1	--	--	--
BUUM (.09)	--	--	--	1	--	--	--	--	--	--	--
ELK (.09)	--	--	--	--	--	--	--	1	--	--	--
ELCA (.09)	--	--	--	--	2	--	--	--	--	--	--
EQFL (.09)	--	--	12	--	--	--	--	--	--	--	--
POAM2(.09)	--	--	--	4	--	--	--	--	--	--	--

Appendix F. Plans for artificial Canada goose nest structure for placement in trees, Flathead River, Montana, 1987.



List of Materials:

A) 1/2" x 1/16" guage expanded metal grating basket (cut 36" x 42")
B) 3/8" rebar frame, 123" long
C) 2" x 2 1/2" plates with 7/16" holes
D) 1/2" rebar lower legs, 112" long
E) 1/2" rebar cross-piece, 12" long
F) 1/2" rebar upper legs, 44" long

1/4" hot rolled steel rod 121" long was used to secure a liner of 60 mil EPDM membrane (Firestone Brand) roofing material cut 42" x 34".

Appendix G.
Table 1. Percent cover and frequencies of plant species in brood areas sampled on Flathead Lake, Montana, 1986.

SPP (Freq)	Percent Cover							
Plot No.	2	3	4	5	18	19	20	21
CADO (.50)	--	1	--	25	--	--	3	1
CIAR (.50)	--	--	5	--	14	3	5	--
DAGL (.50)	--	8	14	1	30	--	--	--
JUBA (.50)	--	26	8	5	--	79	--	--
POPR (.50)	--	--	89	--	22	1	33	--
ACMI (.38)	--	6	1	--	--	--	1	--
AGAL (.38)	--	--	--	--	6	26	--	28
AGRE (.38)	--	--	--	--	--	3	16	27
CEMA (.38)	--	25	7	--	--	--	10	--
FEPR (.38)				--	--	6	1	1
TRRE (.38)	--	-1	--	15	1	--	--	--
AGSM (.25)	--	2	1	--	--	--	--	--
CALA3(.25)	--	--	--	--	--	1	--	8
HOJU (.25)	--	--	--	--	--	--	1	1
LASE (.25)	--	--	--	--	1	2	--	--
MELU (.25)	--	--	--	--	--	7	1	--
POAN4(.25)	--	--	--	--	--	4	--	14
TAOF (.25)	--	--	--	41	1	--	-	-
AGEX (.13)	--	--	--	--	1	--	--	--
AGIN (.13)	--	--	--	--	--	--	1	--
APCA (.13)	--	--	--	--	2	--	--	--
ARSE (.13)	--	--	--	--	--	--	1	--
BRJA (.13)	--	--	--	--	--	--	1	--
CAAQ (.13)	--	--	--	40	--	--	--	--
CHAL (.13)	--	--	--	--	1	--	--	--
CHLE2(.13)	--	--	--	--	1	--	--	--
CIVU (.13)	--	--	--	--	1	--	--	--
COSE (.13)	--	--	--	--	--	--	1	--
DIST (.13)	--	--	--	--	--	--	20	--
ELAC (.13)	29			--				--
ELPA (.13)	--	--	--	--	--	--	--	2
EQAR (.13)	--	--	--	--	1	--	--	--
FIAR (.13)	--	--	--	--	--	--	1	--
GRSQ (.13)	--	--	--	--	--	--	1	--
MEAL (.13)	--	--	--	--	1	--	--	--
MEAR (.13)	--	--	--	--	--	1	--	--
PLLA (.13)	--	--	--	--	--	--	1	--
PLMA (.13)	--	--	--	--	1	--	--	--
POA (.13)	--	--	--	37	--	--	--	--
POAM2(.13)	--	--	--	1	--	--	--	--
POCO (.13)	--	54	--	--	--	--	--	--
POGR (.13)	--	--	1	--	--	--	--	--
ROWO (.13)	--	--	--	--	6	--	--	--
SYOC (.13)	--	--	--	--	6	--	--	--
TRMA (.13)	--	--	--	--	--	--	--	32
TYLA (.13)	--	--	--	--	--	--	--	2
VETH (.13)	--	--	--	--	1	--	--	--
VIAD (.13)	--	--	4	--	--	--	--	--

Appendix G.
Table 2.. Percent cover and frequencies of plant species found in brood areas on the Flathead River, Montana, 1986.

SPP (Freq)	Percent Cover													
Plot No.	6	7	8	9	10	11	12	13	14	15	16	17	22	23
CEMA (.71)	--	1	2	39	32	1	--	33	--	53	2	24	--	12
POPR (.64)	62	78	18	25	1	-	22	12	--	22	--	35	--	--
TAOF (.50)	8	9	4	l	-	--	--	--	2	--	9	--	6	-
BRTE (.43)	--	--	1	-	5	--	--	1	22	--	--	3	-	15
AGSM (.36)	--	--	--	-	-	1	13	1	2	--	--	7	--	--
ARSE (.36)	--	--	--	-	1	-	-	1	--	2	--	14	--	6
MELU (.36)	20	--	--	2	--	--	--	--	1	8	1	--	-	-
POCO (.36)	--	--	--	--	--	--	--	6	26	--	77	--	22	12
TRDU (.36)	--	--	--	1	--	--	1	1	--	--	--	1	--	1
TRRE (.36)	--	2	2	1	--	--	--	--	--	--	2		l	-
ACMI (.29)	--	--	--	8	1	--	1	--		--	--	1	--	--
AGSP (.29)	46	--	--	4	1	10	--	--	--	--	--	--	--	--
BRIN (.29)	1	22	8	--	--	--	--	--	--	--	1	--	--	--
THAR (.29)	--	--	--	--	1	--	--	1		--	--	--	1	1
AGRE (.21)	--	--	70	--	--	--		--	--	--	3		--	4
ERCI (.21)	--	--	--	--	--	--	--	1	1	--	--	--	--	2
PHPR (.21)	--	--	5	3	-	--	--	--	--	--	2	--	--	--
PLLA (.21)	6	--	--	--	--		--	--	1		1		--	--
POBU (.21)	--	--	--	--	2	10	--	1		--	--	--	--	--
AGAL (.14)	--	--	--	--	--	--	--	--	--	--	12	--	40	--
AGCR (.14)	--	--	--	--	1	60	--	--	--	--	--	--	--	--
AMAL (.14)	--	--	--	4	5	--	--	--	--	--	--	--	--	--
BRJA (.14)	--	--	--	--	--	--	1	--	4	--	--	--	--	--
CIAR (.14)	4	1	--	--	--	--	--	--	--	--	--	--	--	--
CRDO (.14)	--	--	--	1	10	--	--	--	--	--	--		--	--
EUES (.14)	--	--	10	--	--	--	--	--	13	--	--	--	--	--
KOCR (.14)	--	--	--	--	--	--	--	6	--	--	--	1	--	--
MESA (.14)	--	--	--	-	15	--	--	1	--	--	--	--	--	--
PRVU (.14)	--	--	--	--	--	--	--	--	--	--	2		2	--
SPCR (.14)	--	--	--	-	-	--	39	--	--	--	--	--	--	12
SYOC (.14)	--	--	--	1	--	--	--	--	--	--	--	2	--	--
VETH (.14)	--	--	--	--	--	--	--	1	--	--	--	--	--	5
ARLO3 (.07)	--	--	--	--	--	--	--	5	--	--	--		--	--
ASLA (.07)	--	--	--	--	--	--	--	--	--	--	--	--	10	--
CABR5 (.07)	--	--	--	4	--	--	--	--	--	--	--		--	--
CHAL (.07)	--	--	--	--	--	--	--	--	16	--	--	--	--	--
DAGL (.07)	--	--	3	--	--	--	--	--	--	--	--	--	--	--
JUAR (.07)	--	--	--	--	--	--	--	--	--	--	--	--	4	--
LEPE (.07)	--	--	--	--	--	35	--	--	--	--	--	--	--	--
PIPO (.07)	--	--	--	-	60	--	--	--	--	--	--	--	--	--
PLMA (.07)	--	--	--	--	--	--	--	--	--	--	--		8	--
PODO (.07)	--	--	--	--	--	--	--	--	6	--	--		--	--
ROWO (.07)	--	--	--	--	3	--	--	--	--	--	--	--	--	--
STCO2 (.07)	--	--	--	--	--		--	14	--	--	--	--	--	--
STVI (.07)	--	--	--	--	--	--	--	6	--	--	--	--	--	--