CRESTON VALLEY WILDLIFE MANAGEMENT AREA: HABITAT MANAGEMENT AND WILDLIFE RESPONSES, 1968 - 1991

Steven F. Wilson

TECHNICAL REPORT SERIES No. 162
Pacific and Yukon Region 1992
Canadian Wildlife Service

Environment Canada
Environnement Canada

Canadian Wildlife Service
Service Canadien de la faune

Canada

TECHNICAL REPORT SERIES
CANADIAN WILDLIFE SERVICE

This series of reports, established in 1986, contains technical and scientific information from projects of the Canadian Wildlife Service. The reports are intended to make available material that either is of interest to a limited audience or is too extensive to be accommodated in scientific journals or in existing CWS series.

Demand for these Technical Reports is usually confined to specialists in the fields concerned. Consequently, they are produced regionally and in small quantities; they can be obtained only from the address given on the back of the title page. However, they are numbered nationally. The recommended citation appears on the title page.

Technical Reports are available in CWS libraries and are listed with the DOBIS system in major scientific libraries across Canada. They are printed in the official language chosen by the author to meet the language preference of the likely audience. **To determine whether there is significant demand for making the reports available in the second official language, CWS invites users to specify their official language preference. Requests for Technical Reports in the second official language should be sent to the address on the back of the title page.**

SÉRIE DE RAPPORTS TECHNIQUES
DU SERVICE CANADIEN DE LA FAUNE

Cette série de rapports donnant des informations scientifiques et techniques sur les projets du Service canadien de la faune (SCF) a démarré en 1986. L'objet de ces rapports est de promouvoir la diffusion d'études s'adressant à un public restreint ou trop volumineuses pour paraître dans une revue scientifique ou l'une des séries du SCF.

Ordinairement, seuls les spécialistes des sujets traités demandent ces rapports techniques. Ces documents ne sont donc produits qu'à l'échelon régional et en quantités limitées; ils ne peuvent être obtenus qu'à l'adresse figurant au dos de la page titre. Cependant, leur numérotage est effectué à l'échelle nationale. La citation recommandée apparaît à la page titre.

Ces rapports se trouvent dans les bibliothèques du SCF et figurent aussi dans les listes du système de référence DOBIS utilisé dans les principales bibliothèques scientifiques du Canada. Ils sont publiés dans la langue officielle choisie par l'auteur en fonction du public visé. **En vue de déterminer si la demande est suffisamment importante pour produire ces rapports dans la deuxième langue officielle, le SCF invite les usagers à lui indiquer leur langue officielle préférée. Il faut envoyer les demandes de rapports techniques dans la deuxième langue officielle à l'adresse indiquée au verso de la page titre.**

CRESTON VALLEY WILDLIFE MANAGEMENT AREA: HABITAT MANAGEMENT AND WILDLIFE RESPONSES, 1968 - 1991

Steven F. Wilson

Technical Report Series No. 162
Pacific and Yukon Region 1992
Canadian Wildlife Service

This series may be cited as:

Wilson, S. F. 1992. Creston Valley Wildlife Management Area: habitat management and wildlife responses, 1968-1991. Technical Report Series No. 162. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

Issued under the Authority of the
Minister of Environment
Canadian Wildlife Service

Catalogue No. CW69-5/162 E
ISBN 0-662-20090-X
ISSN 0831-6481

Copies may be obtained from:
Canadian Wildlife Service
Pacific and Yukon Region
P.O. Box 340,
Delta, British Columbia
Canada V4K 3Y3

Printed on recycled paper

ABSTRACT

A variety of habitat management techniques have been used on the Creston Valley Wildlife Management Area (CVWMA) since its inception in 1968. Data on vegetation changes and wildlife use were collected annually. This report summarizes the habitat management activities and their impact on the general habitat characteristics and wildlife populations of the CVWMA. Habitat management projects were never vigorously evaluated, and the data collected did not clearly indicate the response of vegetation and wildlife to specific prescriptions; however, based on the data that were available, and on the knowledge and opinion of CVWMA staff, several long-term trends were evident. Major vegetation changes occurred following the control of Kootenay River floodwaters by diking and with the reduction of domestic livestock grazing. Large expanses of open water and mudflats (at high and low water, respectively), were replaced by permanent deepwater ponds, persistent emergent vegetation, and extensive areas of dense grass cover. With these changes, use by breeding ducks and geese increased dramatically. Annual peak use by migrating waterfowl declined, probably due to changes in continental waterfowl populations as well as habitat changes on the CVWMA and elsewhere in the Creston valley. Interest in the area by waterfowl hunters initially increased and then declined (due in part to access restrictions, but also following a nation-wide decline in the number of waterfowl hunters), but the success of the remaining hunters increased. Other birds, such as Ospreys and grebe species that rely on small fish as a food source, also benefitted from the new permanent water. Most marsh-dwelling birds and mammals increased as vegetation invaded areas dominated previously by mudflats and open water.

RÉSUMÉ

Différentes techniques d'aménagement des habitats ont été appliquées à l'aire de protection de la faune de la vallée de Creston (APFVC) depuis sa création en 1968. Des données sur les changements de la végétation et sur l'utilisation par la faune ont été recueillies chaque année. Ce rapport fournit un résumé des mesures d'aménagement adoptées et de leur effet sur les caractéristiques générales de l'habitat et sur la faune de l'APFVC. Les programmes d'aménagement n'ont jamais été évalués de facon très poussée et les données recueillies no montrent pas clairement la réponse de la végetation et de la faune à des mesures spécifiques; toutefois, compte tenu des résultats disponibles et de l'opinion ainsi que des constations du personnel de l'APFVC, on dénote certaines tendances à long terme. Il s'est produit une transformation majeure de la végétation après l'endiquement de la riviére Kootenay pour contenir les crues et par suite de la diminution du broutage par des animaux domestiques. De grands plans d'eau libre et des vasiéres (àhaute et basse marée, respectivement), ont été remplacés par des lagunes d'eau profonde permanentes, une végétation émergent persistante et de vastes surfaces d'herbacées en couverture dense. Ces changements ont permis aux oies et aux canards nicheurs d'exploter beaucoup plus les lieux. L'utilisation de pointe annuelle que faisait la sauvagine en migration a diminué; cela est probablement attribuable à des changements dans les populations continentales de la sauvagine ainsi qu'à des changements del'habitat de l'APFVC et d'autres secteurs de la vallée Creston. Au commencement, la chasse à la sauvagine a connu un regain dans la région, qui a été suivi d'un déclin (en partie à cause de l'accès restreint, mais c'est aussi une tendance nationale), mais le succès des chasseurs restants s'est accru. D'autres oiseaux, comme la balbuzard et les espèces de grèbe qui s'alimentent de petits poissons ont aussi

bénéficié de la création du nouveau plan d'eau permanent. Les populations de la plupart des oiseaux et mammifères qui vivent dans les marécages se sont accrues à mesure que la végétation a envahi les secteurs antérieurement dominée par les vasières et les eaux ouvertes.

ACKNOWLEDGEMENTS

Most of the data presented in this report were collected by B. G. Stushnoff, formerly the Management Biologist (1972 to 1987) and currently the Area Manager. His records, experience, and memory were essential in compiling methods and results. Early data were collected by the late D. D. Moore, the first Area Manager of the CVWMA. In addition, many seasonal assistants, naturalists, and graduate students collected data over the years. A. Breault, R. Butler, R. McKelvey, B. Stushnoff, and G. Townsend made many helpful comments on the manuscript. This report was compiled and written while I was employed as the Wildlife Biologist for the Creston Valley Wildlife Management Authority.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The Creston Valley Wildlife Management Area (CVWMA) was established by an act of the British Columbia legislature in 1968. Under the Creston Valley Wildlife Act, approximately 7 000 ha of the Kootenay River floodplain south of Kootenay Lake were protected for "wildlife conservation, management and development...in particular, as a waterfowl management area" (Province of British Columbia 1979). The CVWMA is managed by a "Management Authority", consisting of one member from each of the governments of British Columbia and Canada, and a public member appointed by the provincial Minister of Environment. The area is funded by the federal and provincial ministries of environment, private donations, and by revenues from commercial operations (lease of agricultural land, permit sales, etc).

In addition to wildlife conservation goals, public recreation was recognized as an important part of the Authority's mandate. The CVWMA has operated seasonally since 1985 a public wildlife centre (originally a Canadian Wildlife Service Interpretation Centre) and much of the Management Area is used by hunters (both waterfowl and big game), and by non-consumptive users (biking, hiking, canoeing, etc.). A contractor operates a campground on behalf of the Management Authority.

To meet conservation goals, habitat management for the benefit of wildlife has been conducted on the area since its inception. CVWMA staff conducted annual surveys of vegetation and wildlife populations, but analysis of these data was rare. Butler *et al.* (1986) examined some of the data when they reviewed habitat changes throughout the Creston region and described changes in the avian fauna since Munro (1950, 1957) originally surveyed the area that eventually became the CVWMA.

The purposes of this report were: to summarize the habitat management procedures that have been used on the CVWMA, to describe the general habitat changes that have resulted, and to report changes in various wildlife populations. Results and conclusions are drawn

from analyses of historical data, where possible. The experience and opinion of CVWMA staff is also reported where data were inadequate.

STUDY AREA

The general geographic and climatic characteristics of the Creston Valley are summarized in Butler *et al.* (1986). Units within the CVWMA where water levels are controlled are considered "managed". Management of water levels was made possible by the construction of a number of dikes and water control structures. Ducks Unlimited Canada directed much of the construction prior to 1976. B. C. Hydro and the Inland Natural Gas Company were also responsible for some pump installations and diking. The managed portion of the CVWMA is comprised of : Duck Lake, Duck Lake Nesting Area, and most of the marshes of Six Mile Slough, Leach Lake, and Corn Creek (Figure 1; Table 1). The rest of the Management Area consists of unmanaged marshes, forest, riverine habitats, and portions designated for other uses (Figure 1; Table 1). In total, the Management Area has more than 30 km of diking, 35 water control structures, and covers approximately 40% of the Kootenay River floodplain south of Kootenay Lake.

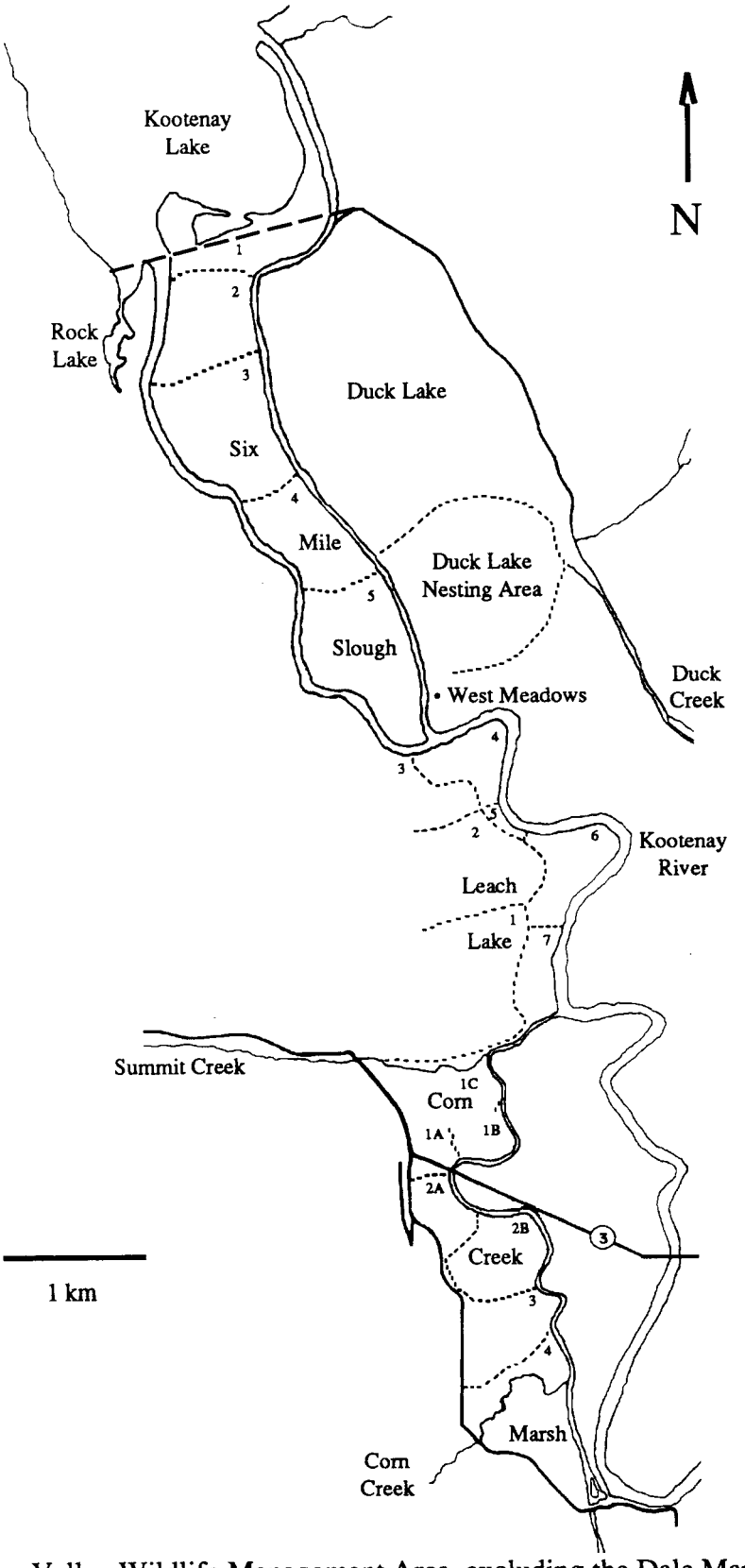


Figure 1. Creston Valley Wildlife Management Area, excluding the Dale Marsh (located 10 km south of Corn Creek).

Table 1. Size of CVWMA managed and unmanaged units.

Managed		Unmanaged	
Unit	Area (ha)	Unit	Area (ha)
Duck Lake (main)	1498.2	Six Mile Slough pond 1	110.1
Duck Lake Nesting Area	427.8	Corn Creek pond 1	229.9
Six Mile Slough pond 2	279.6	Corn Creek pond 4	128.3
Six Mile Slough pond 3	244	Kootenay Lake	829.2
Six Mile Slough pond 4	186.2	Summit Creek Campground	157
Six Mile Slough pond 5	316.5	West Meadows Farm	148.5
Leach Lake pond 1	359	West Slopes	499.4
Leach Lake pond 2	272.8	Rock Lake	110.1
Leach Lake pond 3	94.3	Kootenay River	292.6
Leach Lake pond 4	99.9	Old Kootenay Channel	21.9
Leach Lake pond 5	9.7	Highways	21.4
Leach Lake pond 6	142.8	Dale Marsh	74.5
Leach Lake pond 7	58.7		
Corn Creek pond 2	249.3		
Corn Creek pond 3	116.5		
Total	4355.3	Total	2622.9

1. HABITAT MANAGEMENT

INTRODUCTION

The goal of habitat management on the CVWMA was to improve selected aspects of Management Area lands to ensure continued and/or enhanced use by targeted wildlife species. Efforts were first aimed at establishing a breeding population of waterfowl. Historically, most of the Management Area flooded with the spring freshet, scouring away most of the rooted vegetation. The water then receded in summer to expose vast mudflats. Seasonal vegetative cover was provided by moist-soil plants such as horsetail (*Equisetum* spp.) and sedge (*Carex* spp.) species (Munro 1950). Traditional livestock grazing privileges were maintained over most of the area, reducing upland grass cover. Ducks attempting to nest were faced with floodwaters, poor nesting and brood cover, and limited permanent water.

As a result, early habitat management focused on controlling water levels and encouraging emergent and upland vegetative cover. Later the focus turned to maintaining the productivity of the marshes in the face of ecological succession.

METHODS

Dikes were constructed to control water levels, reduce flooding during the nesting period, encourage the growth of persistent emergent and upland vegetation, and provide permanent water areas. The Management Area first started to manage water levels with the completion of the Duck Lake Nesting Area in 1972. Most of the area came under active water level management in 1975.

With water level control came ecological succession. Generally, wetlands with stable water regimes are less productive than wetlands with variable water levels (Weller and Fredrickson 1974, Kantrud and Stewart 1977). CVWMA staff began a program of drawdowns in an attempt to increase wetland productivity. Complete draining, or drawdown, was planned for each pond every seven to 10 years. Drawdowns are a common

water management tool that encourage the decomposition of accumulated organic matter, and increase plant diversity by stressing existing monotypic stands and encouraging the germination of moist-soil vegetation. The effects of drawdowns are well-studied but site-specific (Harris 1957, Kadlec 1962, Fredrickson and Taylor 1982, Welling *et al.* 1988).

A drawdown gave Management Area staff the opportunity to create a better interspersion of open water and emergent vegetation where emergents had encroached substantially into the open water area of a pond. The goal was a 50:50 interspersion of open water to emergent vegetation. This often required labour-intensive procedures. Mowing and tilling, when used in concert with flooding was used to reduce the re-growth of vegetation in seasons after the drawdown. Controlled burns or baling were used to reduce the litter left after mowing.

In practice, drawdowns were used frequently for purposes other than habitat management. Often the draining of ponds was necessary to allow the repair of dikes and water control structures. Table 2 lists the drawdown history of ponds on the Management Area.

In the uplands, livestock grazing was gradually reduced through attrition to encourage grass cover. Succession also impacted upland areas; mechanical brushing and burning was used to control woody vegetation that encroaching into nesting meadows.

Along with these extensive habitat management techniques, more intensive procedures were used to provide specific aspects of habitats that appeared to be limiting. This usually involved erecting nesting boxes, baskets, and platforms. Up to 450 nest boxes and 101 nest platforms were available from 1973 to 1986. Management Area staff also sought to increase food available to wildlife by planting crops such as corn, barley, Alfalfa (*Medicago sativa*), Wild Rice (*Zizania aquatica*), and Japanese Millet (*Echinochloa crusgalli*). Baiting with grain was also used to attract waterfowl.

Table 2. Drawdowns undertaken on the CVWMA, by pond unit.

Pond	Year																	
	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
Duck Lake Nesting Area							•											
Six Mile Slough pond 2	•	•	•					•							•			
Six Mile Slough pond 3	•	•	•			•										•		
Six Mile Slough pond 4		•	•	•		•											•	
Six Mile Slough pond 5		•	•	•	•													
Leach Lake pond 1	•	•	•	•								•	•					•
Leach Lake pond 2	•	•		•		•	•											
Leach Lake pond 3	•	•		•		•	•	•	•	•	•		•					
Leach Lake pond 4	•	•		•		•				•			•					
Leach Lake pond 6		•																
Leach Lake pond 7		•																
Corn Creek pond 2 (A)*											•							
Corn Creek pond 2B*																	•	
Corn Creek pond 3																	•	•
Dale Marsh																		

*pond 2 was split into 2 compartments with the construction of a cross dyke in 1987

Surveys

Strip-transect vegetation sampling was used from 1974 to 1985 to monitor changes in wetland and upland vegetation. Three or four permanent transects were established in each pond, and vegetation was sampled within a 10 cm^2 quadrat at sites every 2 m along each transect. The occurrence of each plant species was recorded. Oblique aerial photographs of ponds were taken in most years. Since 1988, vertical aerial photo mosaics of ponds have been assembled, and acreages of major cover types recorded [Cattail (*Typha latifolia*), Bulrush (*Scirpus* spp.), sedge, horsetail, grass, forbs, moist-soil vegetation, mudflats, open water, shrub, trees].

Mostly anecdotal records were made of seeding, cropping, and baiting procedures.

Analysis

The strip-transect sampling produced extremely detailed vegetation data; however, it was difficult to extrapolate from the data any general changes in the vegetation characteristics of ponds. As a result, I did not use these data to examine historical habitat changes. Photographs were more useful for recording vegetation changes, and the current method of assembling photo mosaics of ponds provided records that were easily compared between years. Photos were detailed enough to distinguish different cover types, and the vertical perspective allowed these cover types to be accurately quantified. Results presented here are based on these photographs and on the opinion of CVWMA staff.

RESULTS

The general habitat characteristics of the CVWMA have changed dramatically since diking stabilized water levels. The changes in water regimes and the gradual reduction of domestic grazing pressure altered available habitats. Most striking was the establishment of large upland nesting meadows dominated by Reed Canarygrass (*Phalaris arudinacea*), which reached heights of 2 m. Undisturbed, these grass stands successfully out-competed

pioneering species such as Canada Thistle (*Cirsium arvense*) and Sow Thistle (*Sonchus arvense*), which were first to appear on newly created upland areas. Invasion by willows (*Salix* spp.) into these nesting areas became a concern. Wetland areas were dominated by emergent Cattail, and to a lesser extent, bulrush species. In many areas, Cattail formed expansive monotypic stands where new growth was vigorous and old plants were slow to decompose. In other areas, Cattail was confined to the margins of deepwater marshes, or interspersed throughout the marsh with other emergents and areas of open water. The most common submergent species included Water Milfoil (*Myriophyllum exalbescens*), Bladderwort (*Utricularia* spp.), Coontail (*Ceratophyllum demersum*), Canada Waterweed (*Elodea canadensis*), and moss (*Fontinalis antipyretica*). Moist-soil vegetation on drawdown areas was dominated by Smartweed (*Polygonum lapathifolium*), Dwarf Spikerush (*Eleocharis acicularis*), Nodding Beggar-ticks (*Bidens cernua*), and often young Cattail. Unmanaged areas of the CVWMA did not experience such extensive changes in habitats as water regimes remained relatively unchanged, although some areas of higher ground experienced some new invasion of upland vegetation due to the reduced flooding following the construction of Libby Dam in 1974.

In the marshes, early season drawdowns were effective in producing extensive stands of Smartweed, but left ponds vulnerable to invasion by persistent emergents such as Cattail and Reed Canarygrass. Much of the Cattail now dominating ponds germinated during drawdowns. If Reed Canarygrass shoots were visible on the mudflats when the pond was reflooded, plants would successfully grow up through a metre of water. In subsequent years, the grass would often form large floating mats that would take years of deep flooding to kill.

With the invasion of open water by persistent plant species, the purpose of drawdowns also came to include the control of emergent vegetation. Cattail could be controlled by mowing, and then flooding over the cut stems. Tillage was effective in controlling Reed Canarygrass. Litter from mowing created a problem when not removed by burning or baling,

since decomposing Cattail takes two years to decompose and inhibits the growth of submergent plants during this time by shading the pond bottom and creating anoxic conditions in the water.

Through experience, a drawdown procedure was developed that suited the CVWMA marshes. A complete drawdown is conducted in spring, then areas of emergent cover are mowed in late summer (usually of dense stands of Cattail and Reed Canarygrass), followed by removal of litter (by baling or other means), tillage, and immediate reflooding. Aspects of this technique are used in many areas, but the procedures have been modified to meet the specific goals of the CVWMA (Ringelman 1991). The treatment provides stands of moist-soil annuals in the drawdown season, and a good response by a diversity of submergent species in subsequent years. It also provides long-term control of emergent vegetation. Timing is critical: if the pond dries too quickly, the mudflats are too dry for moist-soil plants to germinate; if mowing and tillage occur too soon, vegetation begins to re-grow before flooding and no control is achieved.

In upland areas, brushing and burning effectively controlled the invasion of willow and Black Cottonwood trees (*Populus balsamifera* spp. *trichocarpa*) into nesting meadows. Mowing and burning were also used to control noxious weeds (mostly Canada Thistle), although these measures were less effective than leaving areas idle and allowing grasses to invade.

DISCUSSION

There were many factors that affected the success of drawdowns and other specific habitat manipulations. Variation between ponds with respect to their topography, hydrology, pedology, and community structure, and variation between years with respect to temperature and rainfall, influenced the outcome of most management actions. With such a large numbers of variables influencing the success of management prescriptions, sufficient data collection to allow detailed quantitative analyses of the programs was impossible. Only through

experience with a number of drawdowns did Management Area staff begin to establish procedures that achieved their specific goals.

Even after 15 years of water management experience, the results of some drawdowns mystify CVWMA staff. For example, following a drawdown in Leach Lake Pond 1 in 1991, all Reed Canarygrass stands died regardless of whether or not the stands had been mowed and/or reflooded. This was contrary to the response of this species in virtually every other drawdown conducted on the CVWMA. Clearly, the cause and effect between habitat management techniques and observed changes in the marsh can be discussed in only the most general terms.

Despite the occasional surprises, avoiding detailed quantitative anaylsis of routine management procedures such as drawdowns is probably the best policy for the CVWMA. The volumes of data required is expensive to collect and analysis is complex. For example, vegetation transects provided very detailed data but were never used to make management decisions, nor were they used for this report. It was impossible to get a sense of overall marsh characteristics from the details of small quadrats. The scale of evaluation should approximate the scale of the treatment; hence, a few notes and photographs of the unit within and between years are sufficient to record the successes and failures of vegetation management.

2. WILDLIFE RESPONSES

INTRODUCTION

Wildlife surveys were used in the years following the creation of the CVWMA to justify the habitat development that was quickly transforming the area (diking, livestock grazing reductions, etc.). After most of the diking was completed, wildlife survey results were to be used in making habitat management decisions. Due to the mandate of the CVWMA, waterfowl have always been the focus of the surveys, although data on many other species, principally other waterbirds, were collected coincidently. Other rare or highly visible species were often surveyed because of their public appeal.

METHODS

Waterfowl use surveys:

Before 1988, waterfowl abundance was estimated by periodic total counts or estimates through ground or aerial surveys. Methods were variable, and the timing of most surveys varied from year to year. Aerial surveys of the entire Management Area were conducted most years on 1 April and 1 October to estimate peak waterfowl migration numbers.

An aerial transect survey was started in 1988. Surveys were conducted weekly from mid-March to mid-November, 1988-1991. Waterfowl and other identifiable waterbird species were counted within two 30 m or 60 m transects by two observers. The lengths of the transects were limited to the flooded area of the unit being surveyed. Two to five passes covering 10-20% of the flooded area of each unit were flown. All units except the Dale Marsh and Leach Lake ponds 5, 6, and 7 were surveyed. Numbers of birds per unit by species were multiplied by a constant k [k = (total flooded area of a pond) / (flooded area of pond covered by transects)] to estimate the abundance of species in each unit. The calculation method assumed that bird densities did not differ between the portions of the units surveyed, and those portions not covered by the transects.

Waterfowl breeding surveys:

Waterfowl breeding populations were estimated using a variety of techniques. Uplands areas were searched (1975-1980) with two all-terrain vehicles linked by a drag-chain. The area searched each year varied between 25.5 and 215 ha, and covered between four and 12% of the estimated upland nesting area available. Breeding populations were extrapolated from the areas searched to represent the entire nesting meadow areas of the CVWMA. Nesting islands were searched every year from the initial construction of 95 islands in the Duck Lake Nesting Area in 1972, to 1986, when 164 islands were available for nesting throughout the CVWMA. Nest success was determined by post-hatch checks of nest material. The presence of one or more embryo sacs indicated a successful nest. Breeding populations of Mallards (*Anas platyrhynchos)* and Redheads (*Aythya americana*) were estimated in 1991 with pair counts using the aerial transect method, timed to correspond with the peaks of nest initiation for the two species. Estimates were based on the "indicated breeding pairs" method described by Dzubin (1969). Waterfowl brood numbers were also estimated using airboat transects, corrected for unit size, during 1974 to 1987.

Cavity-nesting populations were assessed by annual nest box inspections after the nesting season. Species nesting in the boxes were determined from eggshell and down characteristics of the nest remains. A nest was considered successful if at least one embryo sac was found in the box. Nesting by species using other nesting structures (ie. baskets) was also censused by inspecting structures after the nesting season. Canada Goose (*Branta canadensis*) nests on nesting structures and other sites were censused annually by ground and/or aerial surveys.

Other birds:

Species with highly visible and/or colonial nests such as Great Blue Herons (*Ardea herodias*) and Western Grebes (*Aechmophorus occidentalis*) were usually counted on nests in the spring. Management Area staff also kept anecdotal nest or sight records of other species.

Mammals:

The only formal assessment of mammal use was annual surveys, from aircraft or from the ground, of Muskrat (*Ondatra zibethica*) houses. Anecdotal records were kept of use by Elk (*Cervus elaphus*) and White-tailed Deer (*Odocoileus virginianus*), Coyotes (*Canis latrans*) and other rarer species.

Human use:

Management Area staff made opportunistic checks of waterfowl hunters to estimate the use of the CVWMA by hunters, and their success (measured by birds bagged per hunter-day). Total hunter-days were estimated from vehicle counts, and the average number of waterfowl hunters per vehicle. Harvest was estimated using the average number of birds bagged per hunter. Sampling was stratified by weekend and weekdays, and by month.

Use of the CVWMA by big game hunters was more difficult to assess, and was rarely estimated. I estimated big game hunting pressure in 1991 using vehicle counts and the average number of big game hunters per vehicle, stratified as above.

Analysis:

Sample means are reported ±1 SD for descriptive purposes. Sample means were compared by ANOVA, and if significant, pairwise comparisons were made between means using the t-method for unplanned comparisons (Sokal and Rohlf 1981). Proportional data were square-root arcsine transformed for all tests. Significance level for tests was $p=0.05$.

Because data collection methods were variable, statistical tests were inappropriate for many of the results presented. Tests were not performed on such data.

RESULTS

All CVWMA wildlife surveys are summarized in Wilson and Stushnoff (1992).

Waterfowl migration:

Figure 2 illustrates peak migration numbers of ducks, geese, and swans. The actual dates of the recorded peaks varied between 6 March and 12 April in the spring, and 28 September and 8 November in the fall. Table 3 lists the waterfowl species present in the CVWMA during migration. Peak spring and fall use of the CVWMA by Tundra Swans (*Cygnus columbianus*) is shown in Figure 3. Spring peaks in use by swans occurred between 13 March and 13 April. Fall peaks occurred between 1 October and 5 December. Figure 4 illustrates the composition of 1991 spring and fall waterfowl observations. The aerial survey technique used since 1988 allowed me to calculate the use of CVWMA units in terms of waterfowl use-days throughout the annual survey period. The total waterfowl use of the CVWMA per hectare of water is illustrated in Figure 5.

Waterfowl breeding:

Table 3 lists the waterfowl species that nest commonly on the CVWMA at present. Rare nest records are reported in Butler *et al.* (1986). Data from Munro (1950) indicate that, prior to the creation of the CVWMA, spring flood waters prevented successful nesting on the flats by all waterfowl species except cavity-nesters [Wood Ducks (*Aix sponsa*), Common Goldeneyes (*Bucephala clangula*), Hooded Mergansers (*Lophodytes cucullatus*) and occasionally Common Mergansers (*Mergus merganser*)], and Canada Geese which used Osprey (*Pandion haliaetus*) nests. Mallard nests, and occasionally nests of other dabbling duck species, were found on benchlands and mountain slopes adjacent to the flats.

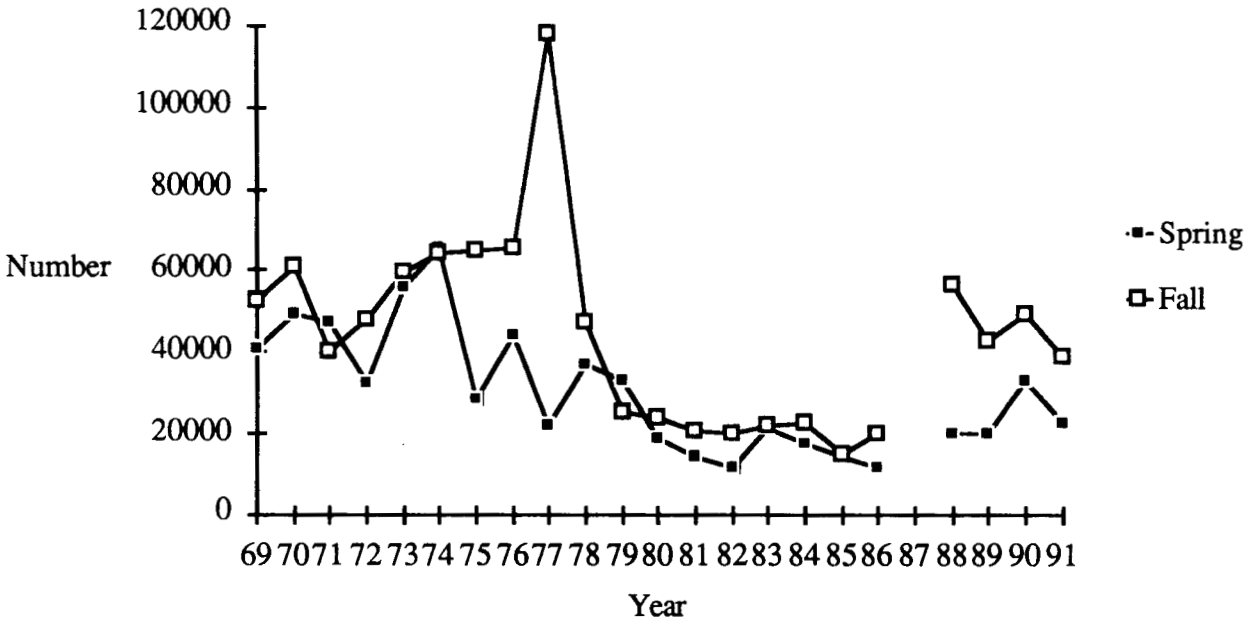


Figure 2. Estimated spring and fall peak numbers of waterfowl using the CVWMA. No surveys were conducted in 1987.

Table 3. Common and scientific names of waterfowl species found on the CVWMA during migration and breeding seasons.[1]

Common Name	Scientific Name	Commonly nests?
Tundra Swan	*Cygnus columbianus*	no
White-fronted Goose	*Anser albifrons*	no
Canada Goose	*Branta canadensis*	yes
Wood Duck	*Aix sponsa*	yes
American Wigeon	*Anas americana*	no
Gadwall	*Anas strepera*	yes
Green-winged Teal	*Anas crecca*	yes
Mallard	*Anas platyrhynchos*	yes
Pintail	*Anas acuta*	no
Blue-winged Teal	*Anas discors*	yes
Cinnamon Teal	*Anas cyanoptera*	yes
Northern Shoveler	*Anas clypeata*	yes
Canvasback	*Aythya valisineria*	no
Redhead	*Aythya americana*	yes
Ring-necked Duck	*Aythya collaris*	yes
Greater Scaup	*Aythya marila*	no
Lesser Scaup	*Aythya affinis*	yes
Bufflehead	*Bucephala albeola*	no
Common Goldeneye	*Bucephala clangula*	yes
Hooded Merganser	*Mergus cucullatus*	yes
Common Merganser	*Mergus merganser*	yes
Ruddy Duck	*Oxyura jamaicensis*	yes

[1]More detailed information about breeding frequency is available in Butler *et al.* (1986).

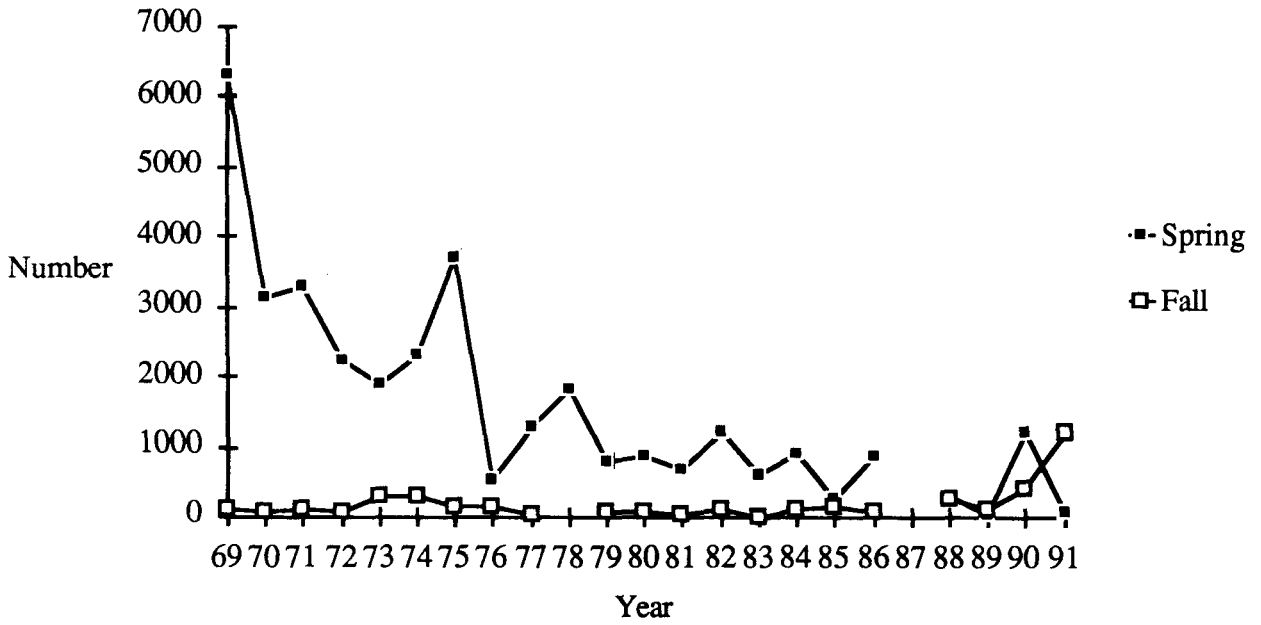
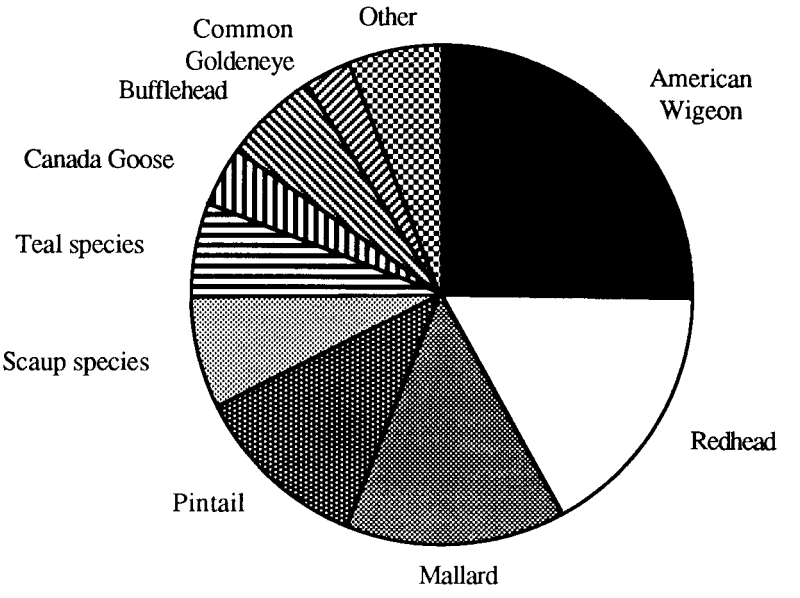


Figure 3. Peak use of the CVWMA by Tundra Swans (*Cygnus columbianus*) in spring and fall. No surveys were conducted in 1987.

Spring



Fall

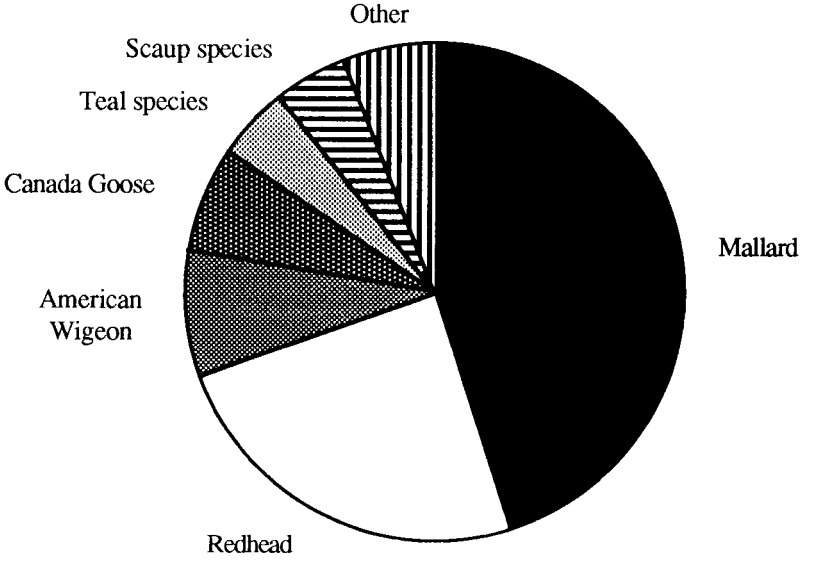


Figure 4. Waterfowl species found most frequently on the CVWMA by proportion and season (1991). Spring migration data were compiled from surveys conducted prior to 1 May. Fall data were from surveys conducted after 15 September.

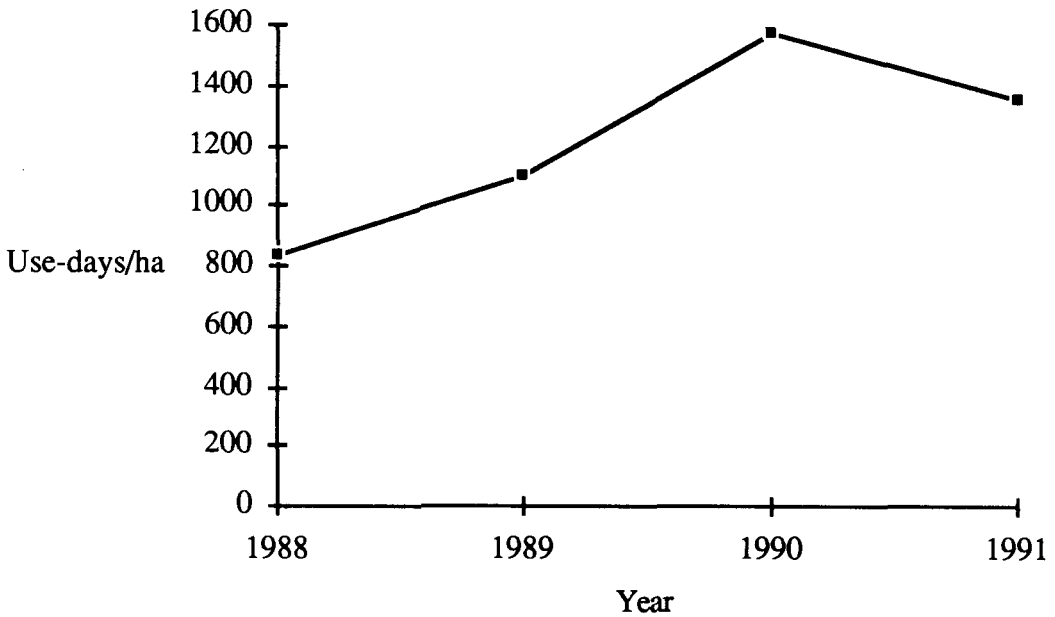


Figure 5. Use of CVWMA by waterfowl expressed in use-days per hectare of water. Calculated annually from aerial surveys conducted from late March to mid-November 1988-1991.

The availability and use of nest boxes by waterfowl species is presented in Figure 6 (includes data from Wilson (1990)). Success of waterfowl nests in boxes averaged 74±15% between 1972 and 1990. Success data were not kept by species; however, Wilson (1990) reported a nest success rate of 51±1% for Wood Ducks during 1988-1990.

Up to 29 nest baskets were used by ducks (mostly Mallards). Nest success in baskets was generally high (79±30%), but occupancy of the structures was low, averaging only 14±9%.

Nests found during upland nest searches varied between seven in 1975 to 97 in 1977. Teal (47±13%) and Mallard (39±15%) nests were encountered most often, along with occasional Northern Shoveler (*Anas clypeata*) and Gadwall (*Anas strepera*) nests (<5% of nests found). Nest density never exceeded 1 nest/ha. Success of nests found on uplands surveys averaged 40±18%.

Use of nesting islands by ducks was 0 nests in 1972 and increased to a peak of 63 nests in 1983. Island nest success averaged 49±27%.

The success of duck nests differed between different types of sites (ANOVA: $F=22.43$, $df=3, 32$, $P<0.01$). Nests located in uplands and on nesting islands were equally successful. Nests in nesting baskets and boxes were also equally successful; however, nests on the ground (either uplands or islands) were significantly less successful than nests in baskets or boxes (all t-method graphical comparisons, Sokal and Rohlf 1981).

Estimates of the numbers of breeding Mallards are presented in Figure 7. These estimates were derived from ground nest searches and the 1991 data from aerial surveys of breeding pairs. I also estimated a breeding population of 130 Redhead pairs in 1991.

Nesting by Canada Geese and the availability of goose nesting structures is illustrated in Figure 8. Other sites used by nesting geese included: Osprey nests, nesting islands, round bales, Muskrat houses, and upland nesting meadows. Up to 50% of the Osprey nests along the margins of the CVWMA were occupied by Canada Geese each year. Up to 31 Muskrat houses per year have been used as goose nesting sites. Goose nesting success averaged

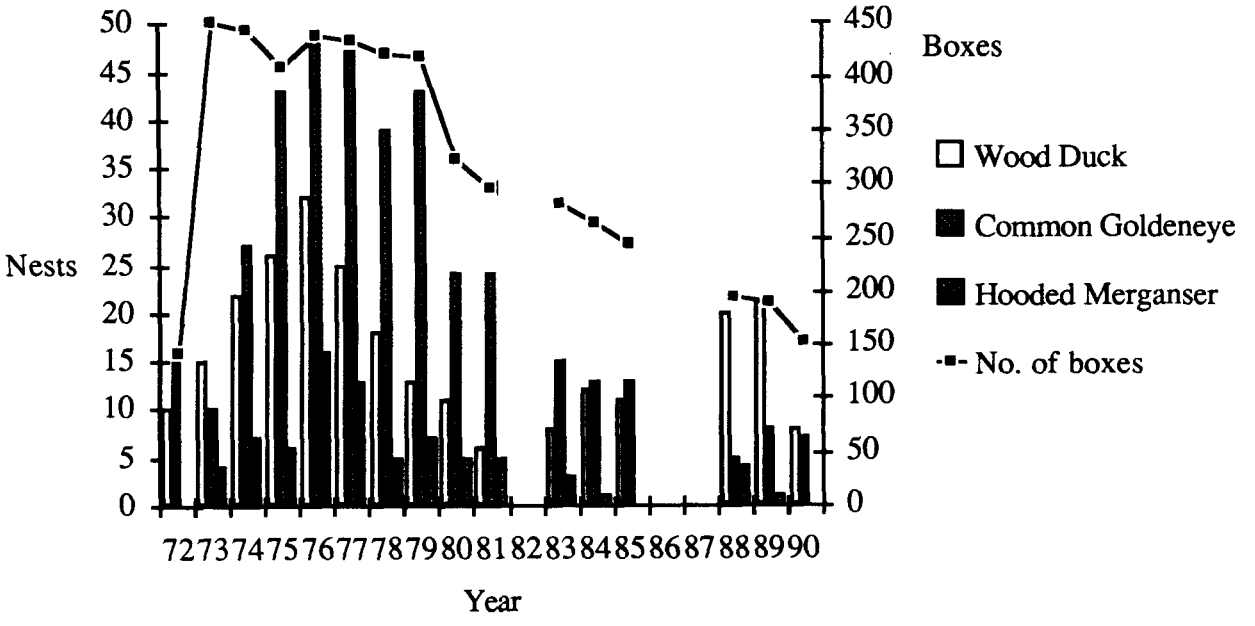


Figure 6. Availability and use of nest boxes by waterfowl. No data were collected in 1982 and 1986-7.

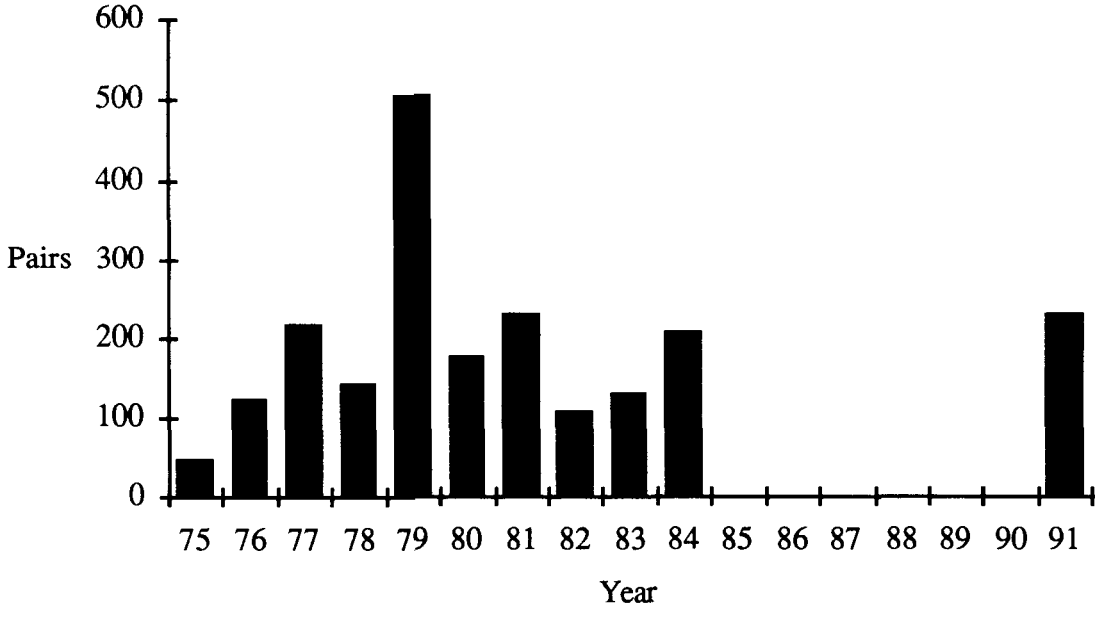


Figure 7. Estimated breeding population of Mallard pairs. Data prior to 1991 were extrapolated from ground nest searches. Data from 1991 were collected from an aerial pair count. No data were collected in 1985-90.

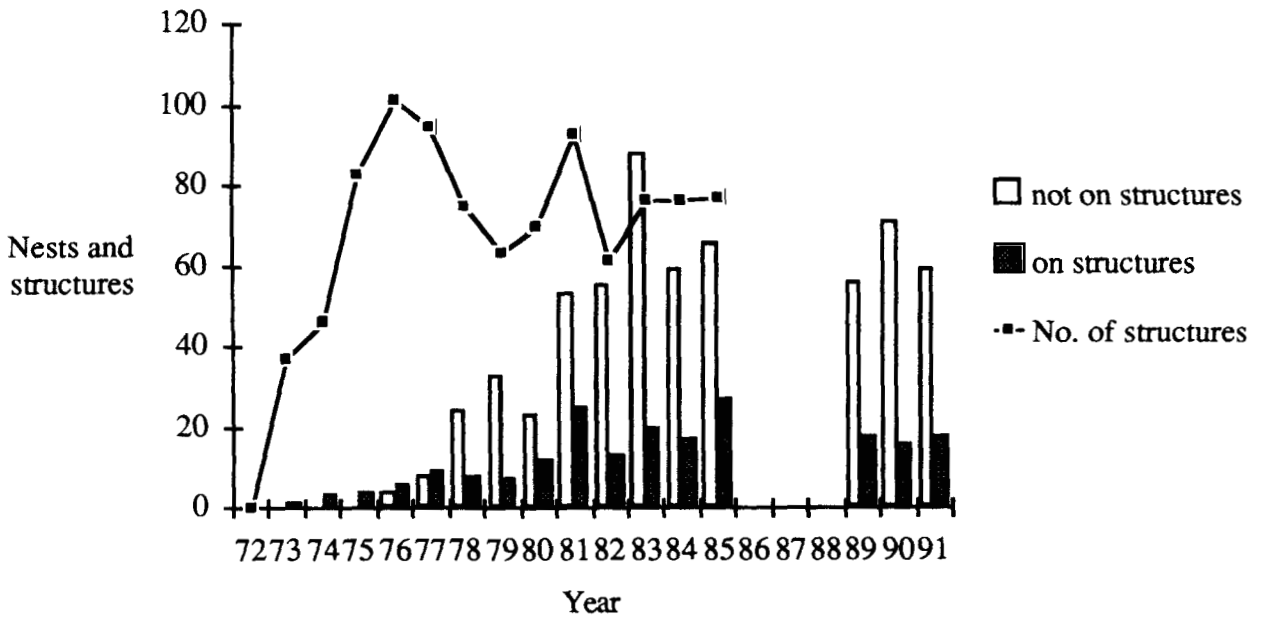


Figure 8. The availability of goose nesting structures and the number of Canada Goose nests found on structures and on other sites. No data were collected in 1986-8.

95±4%. There was no difference between the success of goose nests on nesting structures, and nests on nesting islands (paired T-test: n=22, T=1.05, P=0.32).

Duck broods were censused with airboat transects during 1974-1986 (Table 4). Broods seen averaged 1.12±0.35/km of transect.

Great Blue Herons:

A colony of Great Blue Herons has existed near Duck Lake for many years (Figure 9), at least since Munro's (1950) survey. The colony site was abandoned in 1989, and a new colony was established in 1990 on Leach Lake. No young fledged in 1990, and only one nest was reported on the CVWMA in 1991 in the former colony site at Duck Lake. Despite reproductive failure in 1990-91, Great Blue Herons were still common on the Management Area throughout the summer and fall of 1991.

Western Grebes:

Although common summer residents, Western Grebes did not begin to nest on Duck Lake until sometime in the early 1960's (Forbes 1984). Nest records are scant, but 15 nests were reported in 1968, 40 in 1973, 65 in 1976, 48 in 1978, and 75-90 nests in 1981-3 (Forbes 1984). Nearly all nesting occurred in Duck Lake, although four nests were found in Kootenay Lake in 1982 (Forbes 1984). The Western Grebes did not nest in 1990, and delayed nesting until late July 1991. Only one brood was observed in each of 1990 and 1991.

Other birds:

No formal counts of nesting Ospreys were conducted by CVWMA staff; however, the population has been the focus of a long-term university research project (Steeger 1989, Forbes 1989). A stable population of about 60 pairs nest annually on the CVWMA and

Table 4. Abundance (%) of broods seen on surveys, 1974-86.

Species	mean	SD
Mallard	23.6	8.3
Teal species	22.0	8.9
Goldeneye	18.7	5.8
Wood Duck	12.7	4.0
Redhead	10.3	6.7
other	16.4	4.4

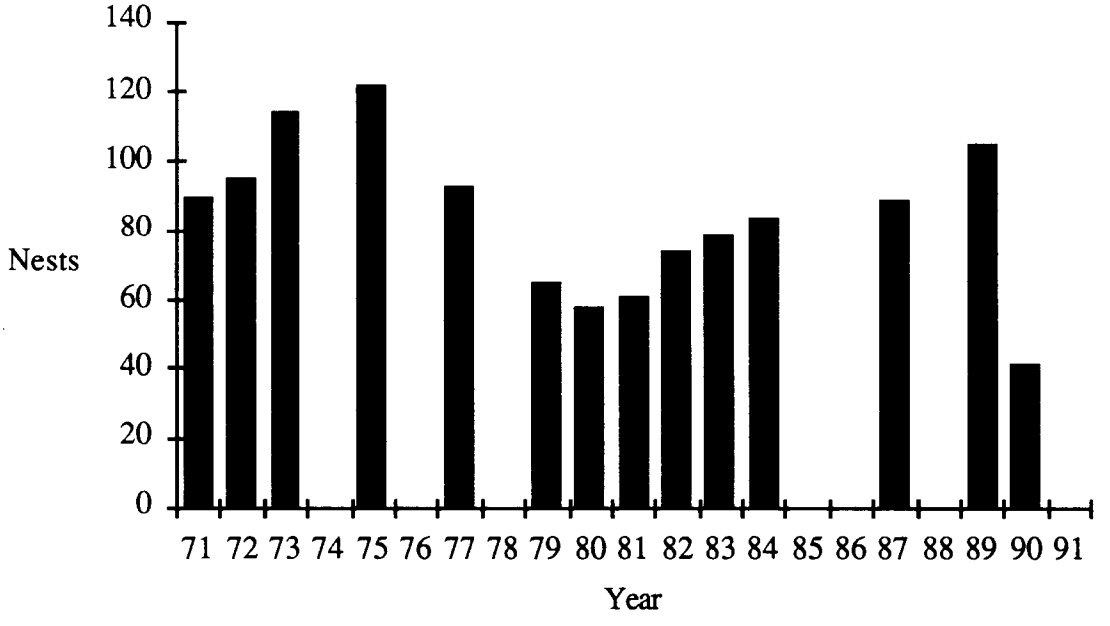


Figure 9. Great Blue Heron nests counted at the Duck Lake (1971-1989) and Leach Lake (1990) nesting colonies. Data were not available for 1974, 1976, 1978, 1985-6, and 1988.

adjacent lands (Forbes 1989). Nest sites are primarily Black Cottonwood snags and pilings in the Kootenay River. The population has doubled since water level management began.

There were obvious increases in other bird species following water level management Butler *et al.* 1986). Red-necked (*Podiceps grisegena*) and Pied-billed (*Podilymbus podiceps*) Grebes benefitted from the availability of small fishes, as did Black (*Chlidonias niger*) and Forster's Terns (*Sterna forsteri*). Species usually associated with marshes, such as Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus*), American Bitterns (*Botaurus lentiginosus*), and Soras (*Porzana carolina*), also increased. With the loss of mudflats, shorebird use declined during migration periods, although nesting by shorebirds probably increased in the absence of severe flooding.

Mammals:

Highest annual numbers of Elk observed on the Management Area are presented in Figure 10. Elk herds were seen consistently on the area throughout the year and were one of the few mammal species for which abundance could be estimated. Unfortunately, records were not found for several years although Elk were certainly present on the CVWMA. White-tailed Deer are also very common; however, estimates of use of the CVWMA by deer were difficult to establish through anecdotal sight records. Up to 15 Coyotes have been observed at a time on the Management Area, but accurate population estimates were not available.

Muskrats increased their use of the CVWMA after water level management (Figure 11). They were abundant in ponds dominated by horsetail, such as Corn Creek Marsh Pond 3.

Human use:

The only records, except Wildlife Centre attendance, of human use on the CVWMA are estimates of use by ungulate and waterfowl hunters, and their success. There are anecdotal records of big game known to have been harvested on the CVWMA, but their relationship to

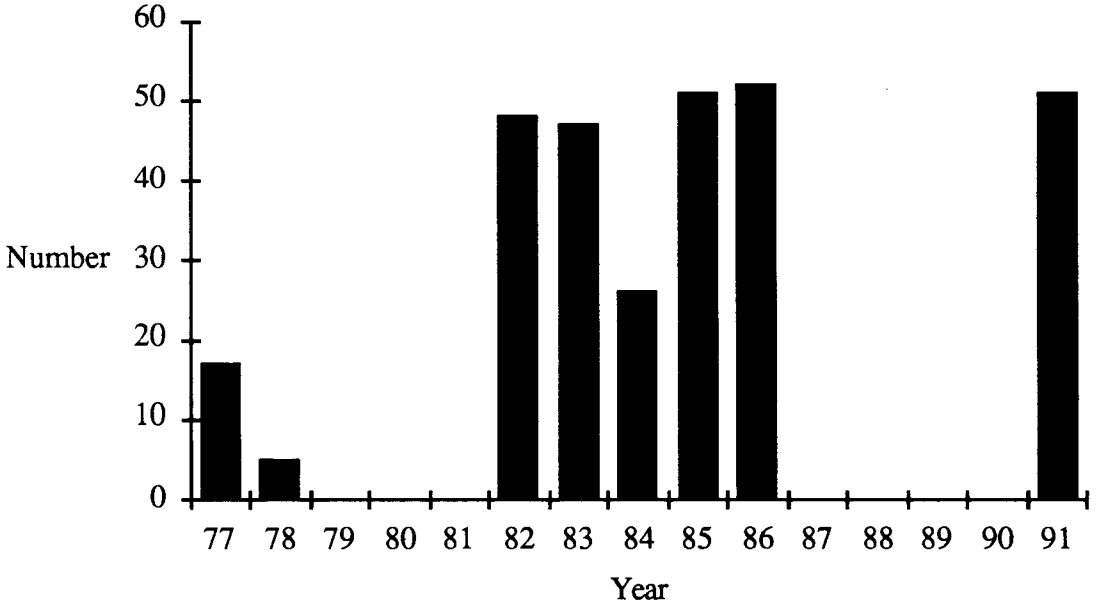


Figure 10. Highest observed use of the CVWMA by Elk. No records were found for 1979-81 and 1987-90.

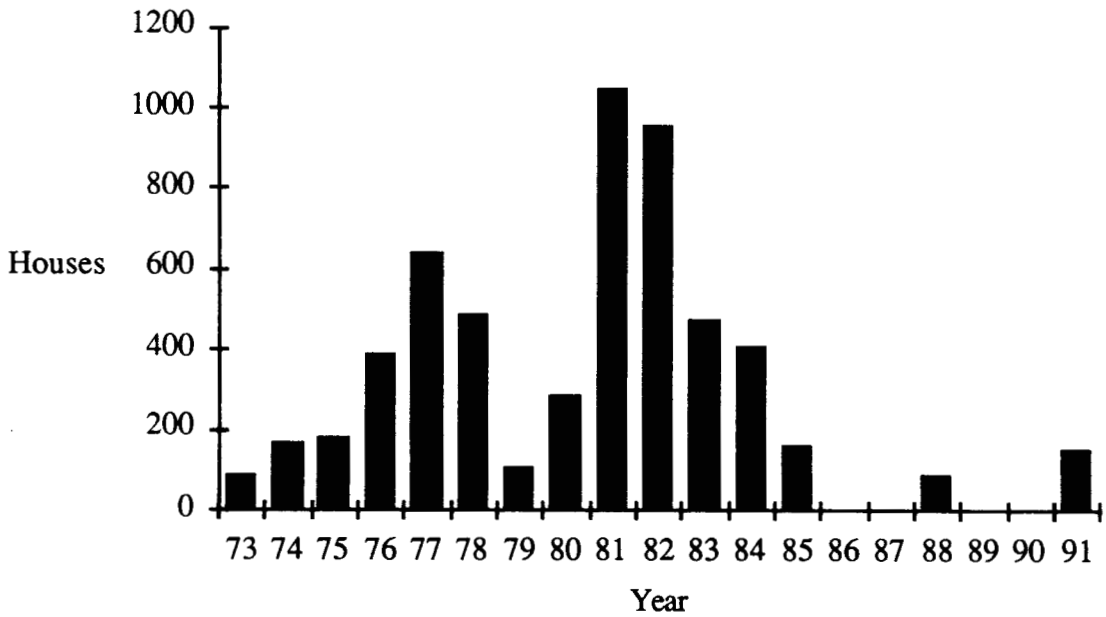


Figure 11. Muskrat houses counted on the CVWMA. Data were no available for 1986-7 and 1989-90.

the total harvest of animals is not known. In 1991, I estimated that the CVWMA supported 823 big game hunter-days. I did not attempt to estimate the success of the hunters.

More accurate records of waterfowl hunters are available. Although the use of the area has declined over the years, the remaining hunters are enjoying excellent hunting success (Figure 12). By far, the most common species shot were Mallards and American Wigeon (Table 5).

DISCUSSION

Waterfowl migration:

Peak waterfowl migrations on the CVWMA appear to have increased somewhat from the steady decline recorded since the mid-1970's; however, this increase in numbers coincided with a change to a sampling method which tended to over-estimate the size of large aggregations of birds. Breeding populations of many species of ducks appear to be declining continent-wide, and this decline is most pronounced on the prairies (Dickson 1989). Band returns from the Creston valley suggest that many migrants that pass through the CVWMA breed in the prairie and parkland regions. Others breed in the boreal forests farther north where populations are steady or increasing (Dickson 1989). The contribution of many breeding areas to the migrant population seen in Creston makes it difficult to relate the long-term trend in migration peaks recorded on the CVWMA to trends in duck breeding populations elsewhere; however, declining flyway populations have probably had some effect on waterfowl use on the Management Area during migration.

Canada Goose populations are increasing continent-wide (Cummings *et al.* 1992) and this trend is evident in the Creston valley as a whole; the number of geese in the valley during the summer appears to be increasing. Since Canada Geese may travel large distances to moulting areas (Ringelman 1991), the origin of the summer resident flock is not known. The increase is not evident in CVWMA survey data. The breeding goose population on the CVWMA has stabilized after a period of rapid expansion and non-breeding geese tend to remain on Lower Kootenai Band marshes where domestic livestock grazing has created large

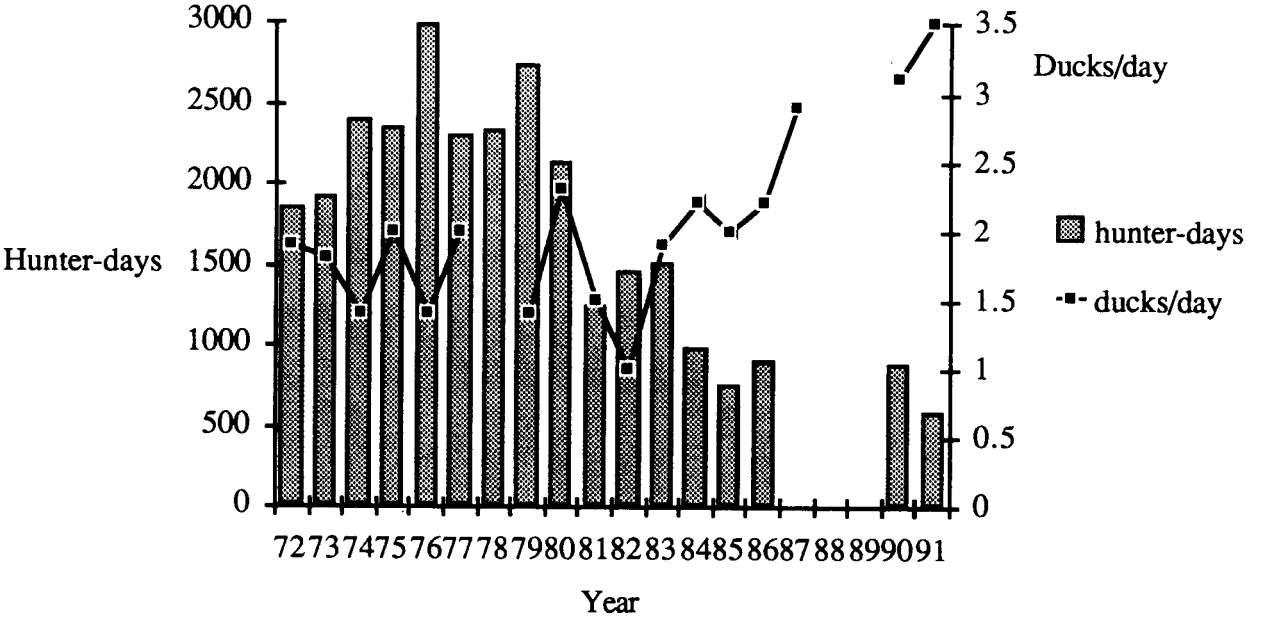


Figure 12. Estimates of waterfowl hunter use and success on the CVWMA. Limited data were available for 1987-9.

Table 5. Relative abundance (%) of waterfowl species found in hunter's possession, 1972-1991 (excluding 1978 and 1988 for which no data were available).

Species	mean	SD
Mallard	29.2	13.5
American Wigeon	28.5	11.6
Green-winged Teal	9.6	5.8
Pintail	7.4	3.2
Blue-winged Teal	5.5	5.2
other	19.1	7.7

areas of attractive goose pasture. This has led to waterfowl depredation problems on adjacent agricultural lands. Coping with increasing goose damage is a major concern for resource managers across North America (Williams and Bishop 1990) and depredation concerns are being considered in the planning of new habitat management activities on the CVWMA.

Using peak migration numbers may not be the most suitable method of indexing the use of the CVWMA by migrating waterfowl. Weather and other factors may influence the length of the migration period, and a "snapshot" of migration at its peak may not reflect the actual numbers throughout the migration period. The current survey method yields a better estimate of waterfowl use; however, it will take several years of surveys to establish baseline data against which to measure trends in waterfowl use of the CVWMA.

Changes in the habitats available to migrating birds throughout the Creston valley have influenced use of the CVWMA by waterfowl in spring and fall. Crops grown by farmers on the valley bottom changed in the 1970's from grains to forage crops and, consequently, an important food source for migrating waterfowl disappeared. Improved drainage on agricultural lands reduced attractive sheetwater ponds. The completion of Libby dam in 1974 eliminated peak flood waters and allowed the invasion of vegetation into places that had traditionally provided shallow feeding areas. More seriously, the decline in bird use in recent years may indicate that the pace of marsh management has been too slow to maintain, in general, those habitat requirements necessary for high waterfowl use. Clearly, a number of factors influence the peak use of the Management Area by migrating waterfowl, and the effect of habitat management alone is difficult to determine.

Waterfowl breeding:

Establishing a breeding population of ducks and geese at Creston has been one of the successes of the CVWMA. Although data collection methods were variable, and accurate annual estimates of breeding ducks were not available, it is clear that nesting by ducks was rare before the creation of the Management Area (Munro 1950). Stabilizing water levels

during the spring was the most significant habitat change that allowed successful breeding by ground-nesting waterfowl. Reducing livestock grazing pressure to establish dense nesting cover was also critical. With marsh management came Muskrats, and Muskrat huts provided important breeding sites for Canada Geese. As well, the increase in permanent water areas improved habitat for broods and moulting birds.

Nesting structures were used successfully by ducks and geese, however, the actual contribution of nest boxes, baskets, structures, and even nesting islands to the increase in the nesting populations is unclear, since many other changes were occurring at the same time. Once water levels were stabilized and upland cover improved, there were large areas of suitable habitat for upland nesting waterfowl. The data suggest that the use of "natural" nesting sites increased quickly and contributed more to the breeding populations of ducks and geese than artificial sites. Canada Geese nested more often in sites other than nesting structures, and nesting baskets were used infrequently by Mallards. Suitable tree cavities would be the most likely limited nest site, but recent observations suggest that production of cavity-nesting waterfowl from natural nest sites exceeds that from nest boxes (Wilson 1990).

Available artificial nesting structures were not necessarily safer from predators than natural sites. Nest success was similar for Canada Geese on structures and on other sites, and although the success of duck nests in baskets was high, few baskets were used. Success data for baskets may be biased; nest predation rates were thought to be quite high, but were underestimated because avian predators frequently carried off eggs and unsuccessful nests went undetected. Data were not available on the success of nests in natural cavities. Average duck nest success on the ground greatly exceeded the 15% required to replace the breeding population (Cowardin *et al.* 1985) and, therefore, populations of nesting ducks would have increased in the absence of nesting structures. However, nesting structures do play an important role; they are easy to check for nesting activity, and can indicate overall trends in the breeding populations of some species (Zicus and Hennes 1987).

Nest success rates were not adjusted for days of exposure (Johnson 1979); however, observed rates were encouraging. Goose nest success rates in all survey years were above the 70% considered "average", and duck nest success rates were "good" (above 40%) in most years (Ringelman 1991).

Great Blue Herons:

Disturbance is the most likely reason Great Blue Herons abandoned their traditional nesting colony at Duck Lake and then again at the Leach Lake site. This species is very sensitive to human intrusion, particularly during the early nesting period (Forbes *et al.* 1983). However, these colonies appear to be better protected than many other colonies in the province, and documented disturbances that have caused abandonment of colonies elsewhere are far more disruptive than anything experienced by the CVWMA colonies (Forbes *et al.* 1983). Also, there has been no obvious increase in the populations of predator species such as Bald Eagles (*Haliaeetus leucocephalus*). The precise disturbance that has caused the nesting failure of herons remains a mystery.

Western Grebes:

Failure of the Western Grebe colony in 1990 was probably the result of high water levels in Duck Lake. Nesting was also disrupted during the high water years of 1974 and 1983, and they did not nest locally before peak flows were regulated in Duck Lake in the 1960's (Forbes 1984). A stable water regime appears essential for the success of the nesting colony. Water must be shallow enough to allow the Western Grebes to pull vegetation into nesting mounds, and stable enough that nests are not flooded by sudden increases in the water level. Wind action can swamp exposed nests; dense cattail stands force grebes to nest in more exposed areas, leaving them vulnerable during summer storms. Disturbance of the colony by fishermen has been a continuing concern. The lake is closed to all boat motors, but the degree of disturbance varies with the location of the colony from year to year.

Other birds:

The dense population of nesting Ospreys on the CVWMA has attracted a great deal of public attention. The increase in the population since water level control is probably due to the newly established fish populations in permanent ponds on the CVWMA (Flook and Forbes 1983). Butler *et al.* (1986) documented changes in other bird populations since Munro's (1950, 1957) study. Changes since 1986 are not known.

Mammals:

The Elk observed on the CVWMA are transient, moving between agricultural lands to the east, and areas to the west of the Management Area. Elk appear to be crossing the CVWMA and on to agricultural lands in increasing numbers. Changes in agricultural practices, including extensive plantings of highly palatable species such as Alfalfa, have probably encouraged this change in behaviour. Elk on agricultural lands throughout the Kootenays are an increasing concern for producers.

Depredation of waterfowl nests by Coyotes has been suggested as a major cause of nest loss on the Management Area. However, dummy nests studies (CVWMA, unpubl. data) have suggested that Coyotes are inefficient nest predators, and their impact on nests is negligible compared to predation by corvids. There is no evidence of a detrimental impact by Coyotes on the management goals of the Authority.

The presence of Muskrats on the CVWMA has been very costly. Muskrats tunnel into dikes, eventually causing them to fail. Much of the current damage probably has yet to be discovered. However, Muskrat activity can create beneficial openings in dense stands of vegetation; particularly in marshes dominated by *Equisetum* species, their preferred habitat on the CVWMA and elsewhere (Danell 1978). The major sources of mortality of Muskrats on the CVWMA are unknown, and the roles of disease and predation in the observed population dynamics are also unknown. The distribution of preferred Muskrat habitat has changed since water levels were stabilized; in general, stands of *Equisetum* species have declined and have

been replaced with Cattail and areas of open water. Where *Equisetum* still dominates, such as in Corn Creek Marsh pond 3, Muskrat density is highest. Trapping by commercial trappers and by CVWMA staff has been insufficient to impact significantly on the Muskrat population over the years.

Human use:

The number of waterfowl hunters using the CVWMA has followed the trend in national migratory bird permit sales, but hunting success has increased to double the mean daily bag reported by B. C. waterfowl hunters in 1991 (Legris and Lévesque 1991). Access to the CVWMA is relatively restricted compared to other hunting areas in the B. C. interior and, with declining waterfowl numbers, and only the most serious waterfowl hunters continue to hunt on the CVWMA.

Waterfowl are not shot on the Management Area in proportion to their abundance. The five most common species in hunters' bags are all dabbling ducks, despite large numbers of migrating diving ducks, such as Redheads and scaup. This is due in part to hunter preference; locally, dabbling species are the preferred table fare. Also, the few diving ducks shot result from hunting methods on CVWMA lands. Most hunting is done over decoys in shallow areas of Leach Lake and Six Mile Slough. Diving ducks typically raft in large numbers on open bodies of water such as Duck Lake, the Kootenay River, or in the larger ponds. In these areas, birds are essentially inaccessible to hunters.

CONCLUSIONS

Since the creation of the Creston Valley Wildlife Management Area in 1968, dramatic changes have occurred in the types of habitats available to wildlife, and in the wildlife populations that use them. The most striking changes occurred prior to Butler's *et al.* (1986) summary. Data collection has not been as comprehensive since 1986 and methods have changed, making it difficult to compare accurately the recent changes to those that occurred

before 1986. Pair counts for breeding ducks have replaced nest searches and brood counts. Weekly surveys of migrating birds have replaced biannual censuses. These new surveys provide information on waterfowl use that is adequate for the purposes of the Management Authority. They are also less expensive, and hopefully will not be plagued by changes in CVWMA resources as were earlier, more intensive survey methods.

The success of drawdowns and other habitat management procedures were influenced by many variables beyond the control of Management Area staff. The responses of vegetation to management prescriptions were variable and complex, and cause and effect between habitat management and vegetation responses could be established in only the most general terms. Through experience, the CVWMA staff established procedures that generally produced the desired vegetation responses. Detailed vegetation surveys were not useful because the scale of such surveys was too small to relate to the scale of habitat manipulations.

The most extensive habitat management programs, the stabilization of water levels and the reduction in livestock grazing, resulted in a waterfowl breeding population on the Creston flats where none existed before. This was one of the main objectives of the Creston Valley Wildlife Act, and measured against this objective, the CVWMA has been successful.

Clearly, the challenge for the Management Authority is to keep the vast marsh complexes of the Creston Valley Wildlife Management Area in a productive state for wildlife, given limited resources.

LITERATURE CITED

Butler, R. W., B. G. Stushnoff, and E. McMackin. 1986. The birds of the Creston Valley and southeastern British Columbia. Can. Wildl. Serv. Occas. Pap. No. 58.

Cowardin, L. M., D. S. Gilmer, and C. W. Shaiffer. 1985. Mallard recruitment in the agricultural environment of North Dakota. Wildl. Monogr. 92.

Cummings, J. L., D. L. Otis, and J. E. Davis. 1992. Dimethyl and methyl anthranilate and methiocarb deter feeding in captive Canada Geese and Mallards. J. Wildl. Manage. 56: 349-355.

Danell, K. 1978. Ecology of the Muskrat in Northern Sweden. SNV PM 1043, Nat. Swed. Environ. Protect. Board. Stockholm, Sweden.

Dickson, K. M. 1989. Trends in the sizes of breeding duck populations in western Canada, 1955-89. Can. Wildl. Serv. Prog. Note No. 186.

Dzubin, A. 1969. Assessing breeding populations of ducks by ground counts. Can. Wildl. Serv. Rep. Series No. 6, pp. 178-230.

Flook, D. R., and L. S. Forbes. 1983. Ospreys and water management at Creston, British Columbia. *In:* D. M. Bird [chief ed.]. Biology and management of Bald Eagles and Ospreys. Harpell Press, Ste. Anne de Bellevue, PQ.

Forbes, L. S. 1984. The nesting ecology of the Western Grebe in British Columbia. Unpubl. Report, Can. Wildl. Serv., Pacific and Yukon Region, BC.

_____. 1989. Environmental variability and genotypic conflicts during reproduction in families of Ospreys. Ph.D. diss., Simon Fraser Univ., Burnaby, BC.

_____, K. Simpson, J. P. Kelsall, and D. R. Flook. 1983. Great Blue Heron colonies in British Columbia. Unpubl. Report, Can. Wildl. Serv., Pacific and Yukon Region, BC.

Fredrickson, L. H., and T. S. Taylor. 1982. Management of seasonally flooded impoundments for wildlife. US Fish Wildl. Serv. Res. Publ. 148.

Harris, S. W. 1957. Ecological effects of drawdown operations for the purpose of improving waterfowl habitat. Ph.D. diss., Univ. Minnesota, St. Paul, MN.

Johnson, D. H. 1979. Estimating nest success: the Mayfield method and an alternative. Auk 96: 651-661.

Kadlec, J. A. 1962. Effects of a drawdown on a waterfowl impoundment. Ecology 43: 267-281.

Kantrud, H. A., and R. E. Stewart. 1977. Use of natural basin wetlands by breeding waterfowl in North Dakota. J. Wildl. Manage. 41: 243-253.

Legris, A. M. and H. Lévesque. 1991. Migratory game birds harvested in Canada during the 1990 hunting season. Can. Wildl. Serv. Prog. Note No. 197.

Munro, J. A. 1950. The birds and mammals of the Creston region, British Columbia. BC Prov. Mus. Occas. Pap. No. 8.

_____. 1957. The birds and mammals of the Creston region, British Columbia: a supplement. BC Prov. Mus. Nat. His. Anthropol. Rep.

Province of British Columbia. 1979. Creston Valley Wildlife Act. R. S. B. C. 1979 c. 82.

Ringelman, J. K. 1991. Evaluating and managing waterfowl habitat. CO Div. Wildl. Div. Report No. 16.

Sokal, R. R., and F. J. Rohlf. 1981. Biometry. 2nd edition. W. H. Freeman and Co., New York, NY.

Steeger, C. 1989. Proximate and ultimate aspects of seasonal variation in the reproductive performance of Ospreys. M.Sc. thesis, Simon Fraser Univ., Burnaby BC.

Weller, M. W., and L. H. Fredrickson. 1974. Avian ecology of a managed glacial marsh. Living Bird 12: 269-291.

Welling, C. H., R. L. Pederson, and A. G. Van Der Valk. 1988. Recruitment from the seed bank and the development of zonation of emergent vegetation during a drawdown in a prairie wetland. J. Ecology 76: 483-496.

Williams, B. K., and R. Bishop. 1990. Perspectives on goose management in North America: challenges and opportunities for the 90's. Trans. North Am. Wildl. and Nat. Resour. Conf. 55: 283-285.

Wilson, S. F. 1990. Behavioural responses of host Wood Ducks (*Aix sponsa*) to brood parasitism and its threat. M.Sc. thesis, Simon Fraser Univ., Burnaby, BC.

_____, and B. G. Stushnoff. 1992. Wildlife surveys conducted on the Creston Valley Wildlife Management Area, 1969-1991. Tech. Rep. Series No. 161. Can. Wildl. Serv., Pacific and Yukon Region, BC.

Zicus, M. C., and S. K. Hennes. 1987. Use of nest boxes to monitor cavity-nesting waterfowl populations. Wildl. Soc. Bull. 15: 525-543.

Appendix . Common plant species found on vegetation transects.

Scientific Name	Common Name
Agropyron repens	Quack Grass
Agrostis alba	Red Top
Anaphalis margaritacea	Pearly Everlasting
Arctium minus	Common burdock
Asclepias speciosa	Milkweed
Aster sp.	Aster
Bromus tectorum	Downy Chess
Calamagrostis canadensis	Bluejoint
Centaurea maculosa	Spotted Knapweed
Cirsium arvense	Canada Thistle
Cirsium vulgare	Bull Thistle
Dactylis glomerta	Orchard Grass
Galium aparine	Bedstraw
Impatiens spp.	Jewelweed
Medicago sativa	Alfalfa
Melilotus alba	White Sweet Clover
Myosotis scorpioides	Forget-me-not
Plantago major	Common Plantain
Poa pratensis	Kentucy Blue Grass
Polemonium humile	Blue Jacob's Ladder
Solidago canadensis	Goldenrod
Sonchus arvensis	Perennial Sow Thistle
Tanacetum vulgare	Tansey
Taraxacum officinale	Dandelion
Trifolium repens	White Clover
Verbascum thapsus	Mullein
Achorus calamus	Sweet Flag
Alopecurus aequalis	Water Foxtail
Bidens cernua	Nodding Beggar-ticks
Carex spp.	Sedges
Echinochloa pungens	Barnyard Grass
Epilobium glandulosum	Willow-herb
Equisetum spp.	Horsetail
Glyceria grandis	American Managrass
Glyceria borealis	Northern Managrass
Hippuris vulgaris	Mare's-tail
Lysichitum americanum	Skunk Cabbage
Lysimachia ciliata	Fringed Loosestrife
Mentha arvensis	Wild Mint

Appendix (continued)

Scientific Name	Common Name
Phalaris arudinacea	Reed Canarygrass
Phleum pratense	Timothy
Polygonum lapathifolium	Smartweed
Polygonum natans	Water Smartweed
Rumex crispis	Curled Dock
Alisma spp.	Water Plantain
Eleocharis acicularis	Dwarf Spike Rush
Eleocharis palustris	Spike Rush
Phragmites communis	Reed
Sgittaria cuneata	Arrowhead
Scirpus lacustris	Soft stem bulrush
Scirpus microcarpus	Small Fruited Bulrush
Scirpus validus	Bulrush
Sparganium eurycarpum	Burreed
Typha latifolia	Cattail
Ceratophyllum demersum	Coontail
Chara vulgaris	Muskgrass
Elodea canadesis	Canadian Waterweed
Fontinalis antipyretica	Moss
Megalodonta beckii	Water Marigold
Myriophyllum exalbescens	Water Milfoil
Nuphar variegatum	Yellow Pond-lily
Potamogeton filiformis	Pondweed
Potamogeton foliosis	Leafy Pondweed
Potamogeton friesii	Pondweed
Potamogeton pectinatus	Sago Pondweed
Potamogeton richardsonii	Richardson's Pondweed
Potamogeton zosteriformis	Flat-stemmed Pondweed
Ranunculus aquatilis	White Water Crowfoot
Utricularia spp.	Bladderwort