Canadian Wildlife Service

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Minister of the Environment
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Canadian Wildlife Service

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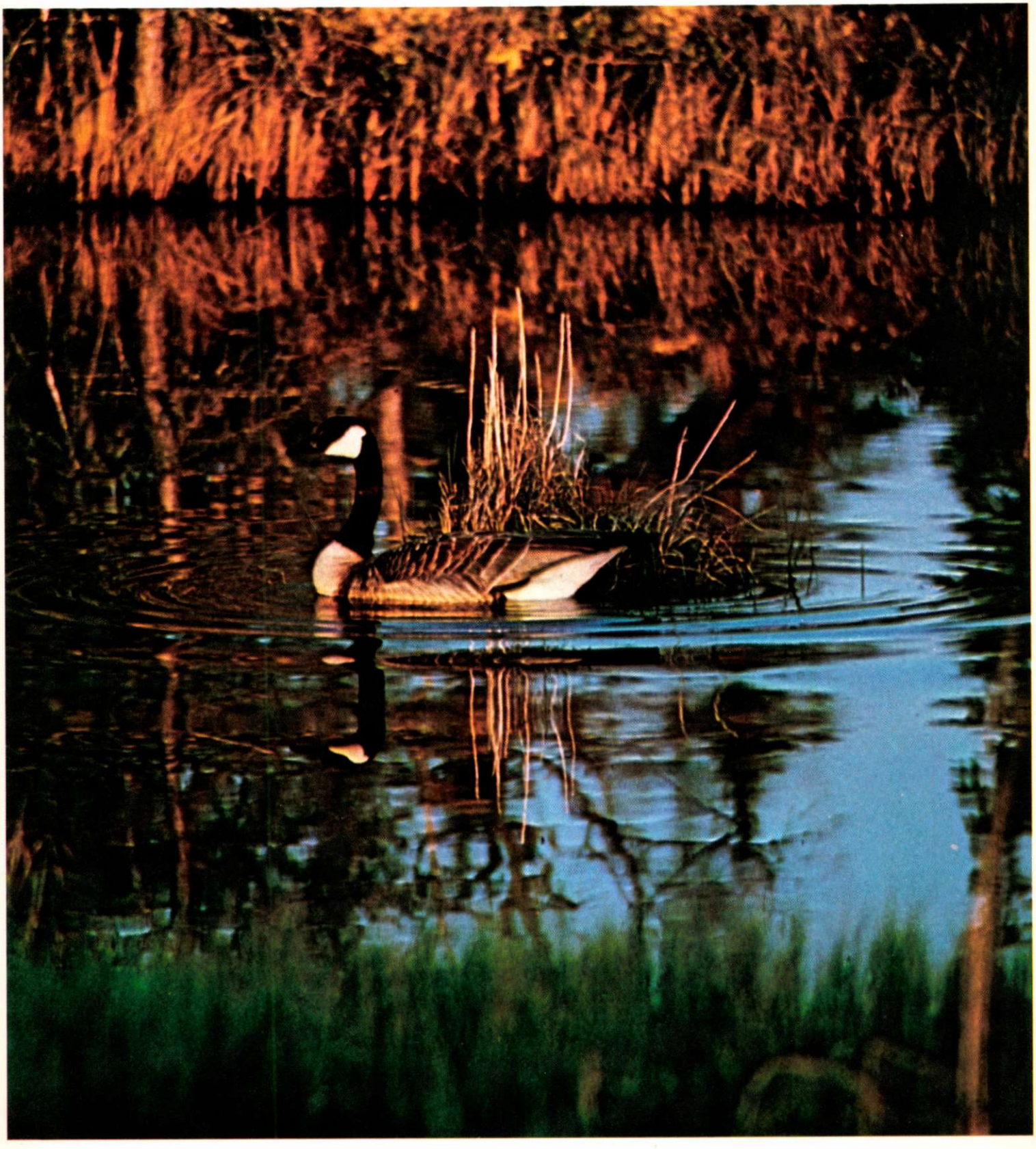
Front cover: Common puffins. Great Island off Newfoundland.

Back cover: Muskoxen take up the defensive position.
Cornwallis Island, NWT.
Photos by Fred Bruemmer.

Contents

Canada goose. CWS has undertaken a number of studies on the biology, distribution, numbers and habitat of this bird.
CWS photo by T. C. Dauphiné.



Foreword

Like a man suddenly aware that he is no longer young, and certainly not immortal, our country is now looking with dismay into a mirror held up by the ecologist to see a prematurely aged face seamed by the ravages of misuse. Even some of our broadest lakes and deepest rivers now contain deadly pollution that has made game fish inedible. And our list of endangered species of wildlife has grown depressingly long for a country that some people consider still largely undeveloped wilderness.

We know that the hour is late and that the 1970s will be the critical decade when action – by individuals as well as agencies – will determine whether a quality environment can be developed and preserved.

Although the outlook is dark, there is encouragement to be gained from the sudden upsurge of public interest in the environment and in ecology, the science that studies how living things relate to each other and their surroundings. It is an intellectual awakening that may prove to be as significant to the history of man as the renaissance of the fifteenth century.

Man rightfully takes pride in civilization and carefully preserves the great works of the past. But ecologists notice that many of the works of early civilizations stand on land that has been abused beyond recovery. We now have the ecological wisdom to do better and to combine the advantages of our highly evolved technology with a carefully preserved and richly varied environment. If we do accomplish this it will be, in part, because many of us have come to realize the profound significance of wildlife and its role in our world. To learn that in its remote arctic fastness the polar bear contains DDT in its tissues is one of many startling bits of evidence of the oneness of this biological world. Your actions and mine, as well as those of industries large and small, all affect the quality of our environment and the kinds of life it can support.

Another encouraging influence has been a cultural flowering of good literature, photography and films on the environment and wildlife. The magnificent life forms and the mysteries and delights of wilderness are being portrayed by some of the finest photographs and best popular writing of our time. Perhaps this work is not yet as popular as the more pervasive abstractions and obscurities of our urban culture, but at least it is there to provide relief and perhaps to compel more people to save themselves and other beings from ecological misery.

While *Canadian Wildlife Service '71* will not rank as literature I hope you will find it an interesting report on the efforts of CWS to study, manage and preserve the wildlife populations of Canada, in cooperation with other agencies and conservation organizations in this country. I hope it will be of interest to those who care, as well as those who may not yet know the pleasures of going afield.

John S. Tener
Director
Canadian Wildlife Service

The federal role in wildlife management

By the first decade of this century, energetic, acquisitive North Americans everywhere were busy "conquering" nature. The passenger pigeon and the great auk were extinct, the prairie bison had practically disappeared and massive widespread programs to control the wolf, considered a harmful competitor, had not only eliminated this animal from many parts of the continent, but had also endangered other species, such as the kit fox.

Hunters were much fewer then, but prolonged shooting matches, in which hunters might bag 50 or more birds a day, and heavy spring shooting of waterfowl were beginning to make serious inroads on bird populations. Because most game waterfowl nest in Canada then migrate south of the border in the fall, Canada and the United States signed a Migratory Birds Treaty in 1916. Under the British North America Act each province is given control of the natural resources within its boundaries. However, the new treaty and the resulting Migratory Birds Convention Act that parliament passed in 1917 created a federal responsibility for the management and protection of migratory birds.

A superintendent of wildlife protection was appointed in the parks branch of the Department of the Interior and, subsequently, three enforcement officers—one each for the Maritimes, for Ontario and Quebec and for the western provinces—were named. Besides being responsible for enforcing hunting regulations over a mere million or so square miles, each performed other duties, such as serving as justice of the peace, lecturing and writing popular pamphlets.

The development of reliable float-mounted aircraft eventually shrank the wilderness somewhat, but the number of trained men and the amount of money devoted to this work increased very slowly during the years between the two wars, while a rising population was placing increasing strains on this resource. Large-scale mechanized methods of farming, forestry and open pit mining, the damming of rivers to meet the insatiable demands for more hydro-electric power and changes wrought by the automobile in our life style have profoundly affected wildlife. While Canada's efficient resource-based industries helped it to surge ahead from being the backward dominion of another power to its present position as a nation with one of the highest standards of living in the world, the country has paid full price in terms of effects on the environment.

Because wildlife is so vulnerable to deteriorating habitat, population changes are very good indicators of what has been happening to our environment. It may be reassuring to cite instances where deer and ruffed grouse have become more plentiful because lumbering has opened up forests and farming has cleared land. But we can hardly be reassured by many other instances where pollution has killed game fish, dammed rivers have drowned forests, and clear-cutting of trees has eroded hills and made them barren.

The post-war population boom, immigration and increased leisure and affluence were accompanied by a growing interest in outdoor recreation. Effective management of wildlife demanded more information based on sound research. To meet this demand the Canadian Wildlife Service was created as a division of the National Parks Branch, Department of Indian Affairs and Northern Development.

Joint federal–provincial responsibility for managing wildlife has made for close and continual co-operation since the early days. Federal–provincial conferences on wildlife management, held since 1922, have reinforced the day-to-day consultation and have been the occasions of formal agreements on hunting regulations. An annual event since 1945, its scope has broadened over the years, with discussion of a variety of management topics. The recommendations of these conferences and consultation with conservation groups formed the basis of National Wildlife Policy and Program tabled in the House of Commons in 1966.

This policy and program declared that the federal government would study the relationship between wildlife and forests and the health of wildlife populations; it would provide research services to the provinces on request and support research and management related to wide-ranging wildlife populations. The information program would also serve the interests of provincial and territorial governments. Steps would be taken to increase the numbers of wildlife biologists. Every attempt would be made to save any endangered species.

When tabling the new policy and program the minister announced that in view

Blue and snow goose banding on Baffin Island, NWT. Left to right: field assistants James O'Shaughnessy and David Lampard, biologist Richard Kerbes. CWS photo.

of its increased responsibilities CWS would be made a branch of the department.

The increasing sophistication of field biology reflects the need for greater certainty in management decisions for the 1970s. There are no longer the reserves and there are too many species now considered endangered to allow large margins for error. In southern Canada wilderness and waterfowl habitat are fast disappearing. The fragile ecology of the Arctic will allow only a bare minimum of trial and error.

To prepare itself for the '70s CWS has completed a review of its policies and objectives. While the migratory birds program remains the most important activity of CWS, the central fact of our time is that neither bird nor beast can survive if its habitat is gone or degraded past the point where it can support life. Thus the quality of the environment—the environment which we share with wildlife—has demanded increasing attention. This awareness of the habitat's importance to the survival of wildlife and humans has brought about formation of the Department of Environment to which CWS was transferred in 1971.

Wildlife are our companions on this planet Earth. Whether we are reminded of their presence by the cheerful song of a chickadee on a cold grey winter's day, or a robin's call from our lawn that announces spring, our relationships to other forms of life are still only partly known or understood. Before any man can say with assurance that the loss of a few dozen whooping cranes or a few more species of birds is really only evolution at work and a small price to pay for the progress of our man-made world, let him show that their fate is completely independent from ours and that if we do continue to survive we will not be made a great deal poorer by this loss.

Gannet colony on Bonaventure Island, Quebec. Photo by R. W. Fyfe.

Migratory birds

Introduction

The activities of the Migratory Bird Populations Section are related primarily to administration of the Migratory Birds Convention Act and include annual revision of the regulations governing hunting seasons and bag limits for migratory game birds, legislation, enforcement, field surveys, the nest records scheme, banding, and data integration, analysis and retrieval.

Regulations, legislation, the nest records program, banding records and data retrieval are all centralized in the Ottawa headquarters. The Canadian and the U.S. bird banding offices have joint custody of records of banded birds now totalling nearly thirty million. Some 450 workers band an average of 200,000 birds in Canada each year, and they are supported by a staff of four, in the Canadian banding office, which audits and verifies their records. In 1970 arrangements were made to obtain from the U.S. Bird Banding Office duplicate magnetic tapes of all bird banding and recovery records for North and Central America. By 1971 the Canadian banding office will be able to retrieve all data required by Canadian banders.

Each year the Migratory Bird Populations Section co-operates with the provinces to revise regulations covering a wide range of activities, such as permits to band and to enter sanctuaries; crop damage control; season dates and bag and possession limits. These regulations are based on analysis of data collected during co-operative breeding ground surveys, the species composition and harvest surveys and pre-season banding programs. The regulations are widely publicized before the season opens by distribution of related posters, abstracts and booklets amounting to almost 1,500,000 pieces.

The Migratory Birds Convention of 1916 calls for considerable liaison with the U.S. Bureau of Sport Fisheries and Wildlife, especially in data collection. Increasing use of computers has brought about vast improvement in the exchange of data between the two countries.

The Royal Canadian Mounted Police and provincial conservation agencies have the main responsibility for enforcement of the act and regulations with CWS co-ordinating their activities through a staff of six. Convictions for contravening the act and regulations has increased by 100 per cent per annum since 1966, a result of more uniform enforcement throughout the country and greater efficiency from use of helicopters and two-way radios.

Research into migratory birds is a long-range program to improve the efficiency and effectiveness of CWS operations. Data collection, on the other hand, provides information for immediate use in designing habitat acquisition programs and setting hunting seasons. The following material delineates CWS responsibilities for most surveys, banding, pollution control, enforcement and research carried out by the eastern and western regions. In addition the scope of its research program is described.

F. G. Cooch

Surveys in eastern Canada

Newfoundland

At the request of the province, the Canadian Wildlife Service has been making surveys, since 1967, to find out the extent and location of waterfowl production in Newfoundland; the importance of waterfowl as game compared to non-migratory species; which species (if any) could support greater exploitation and how.

The study began with a review of previous surveys and a general aerial survey of insular Newfoundland. These led to more specific studies particularly of Canada geese and sea ducks.

A program in co-operation with the provincial wildlife division was developed to assess the relative values of migratory and non-migratory species, the extent to which they were utilized by sportsmen and their economic value.

Pilot studies will determine if the sea duck population, the species with the most apparent potential for increased exploitation, can be more effectively harvested. Present hunting methods will be assessed, in the light of existing regulations, and more effective means to increase the harvest will be tested.

Aerial photography and photo interpretation

Newfoundland supports one of eastern North America's largest wintering populations of eider ducks. Aerial surveys initiated in 1967 to determine their numbers and distribution quickly made it evident that our existing methods were inadequate.

Our associates in Ontario had made some progress in using aerial photography to assess fall diving duck concentrations, but our attempts met with varying degrees of success. Problems lay not only in the photographic techniques but in methods of interpreting the results. A team of experts was assembled in 1968 from a variety of disciplines to investigate the problems. D. I. Gillespie and Denes Bajzak, an expert in photogrammetry formerly with the Canada Department of Fisheries and Forestry and now at Memorial University, St. John's, are co-leaders.

The objectives of the investigation are as follows: 1. Selection of the best combination of film, filters and lenses; appraisal of vertical and oblique photography to determine which would be more satisfactory; and selection of the type of aircraft, possible adaptations of the aircraft and optimum altitude for photographing the birds. We have achieved this with a film–filter–lens combination that provides transparencies showing the characteristics we feel will answer our questions on quantity and quality of flock composition.

2. Mechanical separation of the components of the flock—sex and age classes if possible—and mechanical counting of these components. This problem was investigated during the winter of 1969–70.

3. Application of this technique to other species. This has been casually pursued and the results so far indicate that it has considerable potential.

D. I. Gillespie

Maritimes

Spring and fall surveys are flown in the Maritimes to determine numbers, species and location of migratory flocks of waterfowl. Periodic Canada goose surveys are also conducted throughout the fall in co-operation with the U.S. Fish and Wildlife Service.

Breeding pair counts and brood surveys are carried out during spring and summer in the New Brunswick–Nova Scotia border area. The use of helicopters for conducting brood surveys has proven to be a very thorough and time saving technique. The development of new techniques will no doubt lead to expansion of migration and production surveys.

To obtain important data on migratory movements, mortality and survival, the Canadian Wildlife Service annually bands 7,000 ducks. This project is conducted with the provincial governments of the Maritimes, the U.S. Fish and Wildlife Service and Atlantic flyway states. Five banding stations are operated by student assistants, under the direction of CWS staff. The stations are located in Debert Sanctuary and Cape Breton, Nova Scotia; Tabusintac, New Brunswick; the New Brunswick–Nova Scotia border area; and eastern Prince Edward Island. The U.S. Fish and Wildlife Service operates an airboat, specially equipped to capture waterfowl at night, on the Saint John River estuary and CWS operates a similar airboat in other areas.

To estimate the size of woodcock breeding populations in the Maritimes we have been surveying their singing grounds since 1957. This annual survey is made on 49 transects in late April and early May with the co-operation of provincial game agencies and interested individuals. Random survey routes were established in Nova Scotia in 1968 and in New Brunswick and Prince Edward Island in 1969.

Allan D. Smith
William R. Whitman

Quebec

Aerial waterfowl surveys have been conducted since spring 1966 along sections of the St. Lawrence River in Quebec, more particularly between Lake St. Peter east to l'Islet. The surveys are carried out weekly throughout the spring and autumn.

The main objectives are to determine the extent to which the habitat is used by various species of waterfowl, to indicate the relative numbers of each species, and to obtain information on the magnitude and timing of migratory movements. With appropriate methods of analysis and greater refinement of survey techniques it is becoming possible to measure changes in the composition of the stocks of most species in the fall. The extent to which local birds and early migrants mix before the opening of the hunting season is of special interest. This information, especially in the settled part of the province, is absolutely necessary if we are to preserve and increase waterfowl breeding populations.

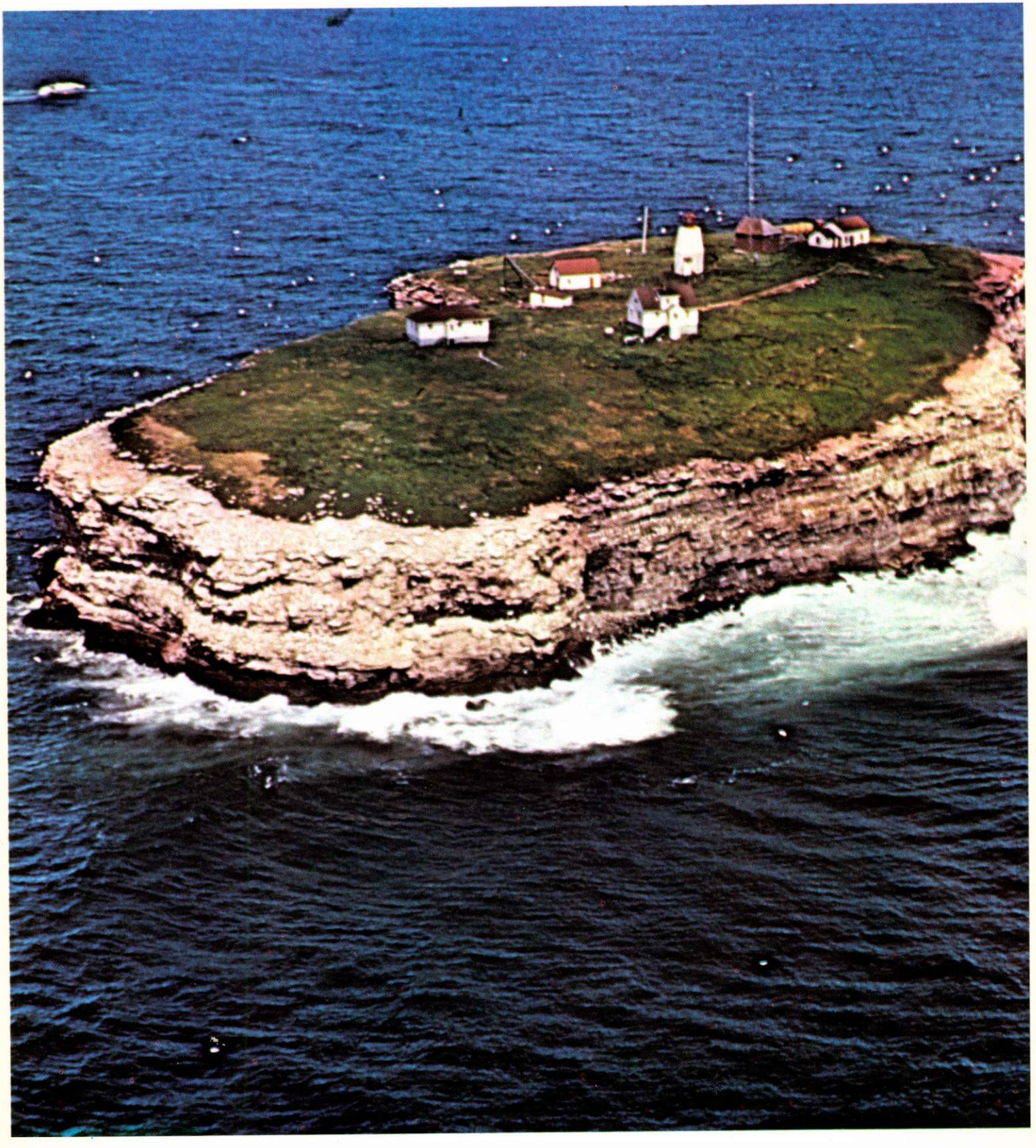
Hugh Boyd's preliminary analysis of the raw data collected along that section of the St. Lawrence suggests that over 90 per cent of the available black ducks present on the opening day (around September 20) of the hunting season are likely to be local birds. This indicates that, for the latter part of September at least, the hunting pressure is mainly on local populations.

Detailed analysis of the results began at the end of 1970, after five years of surveying.

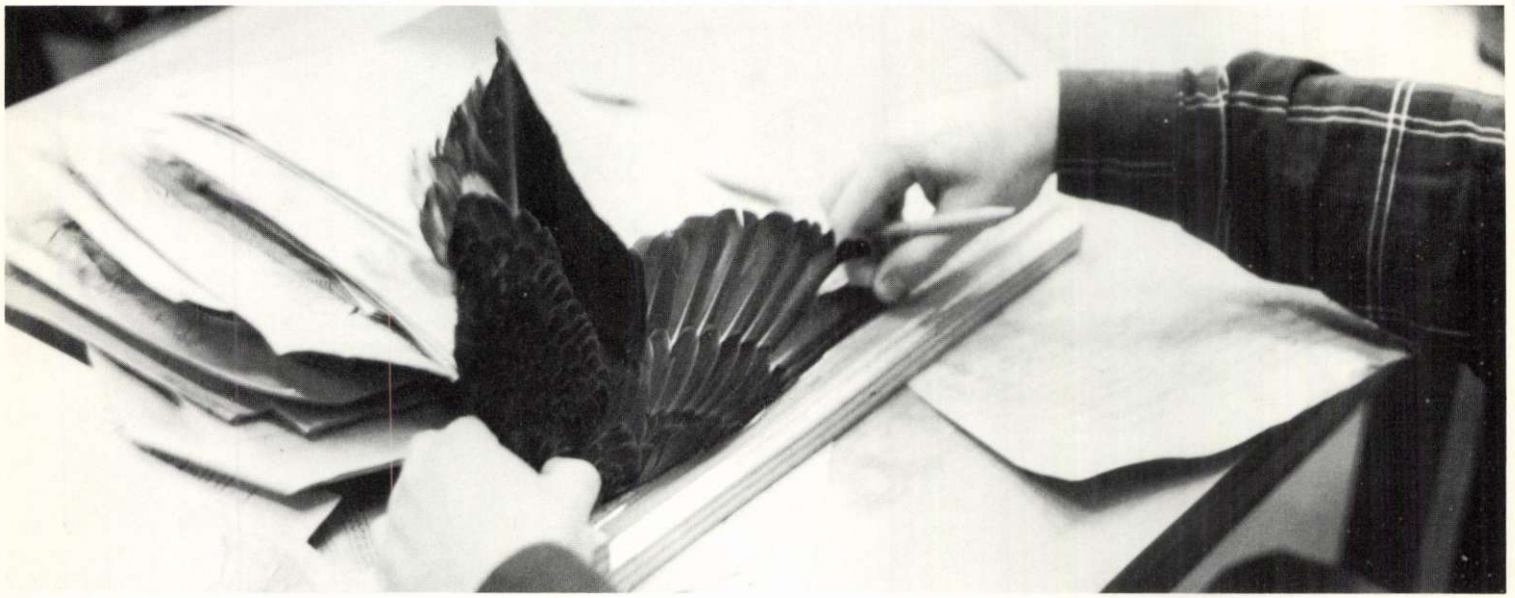
There has been a substantial increase, since 1966, in utilization of the St. Lawrence River by Canada geese in the spring with more than half the weekly use being located around Lake St. Peter. The numbers of greater snow geese have remained high in both fall and spring. There were about 130,000 present at one time in the fall of 1970, the largest number of this species so far recorded.

Marcel Laperle

Bird Rocks, a sea-bird sanctuary 16 miles NE of Magdalen Island, Quebec.
CWS photo by A. D. Smith.



Colour patterns and size of the wings of most ducks indicate species, sex and age. Each year hunters send duck wings and goose tails of birds shot to CWS for the harvest survey; wing bees are then held to identify these parts.
CWS photo by W. R. Whitman.



Ontario

Waterfowl on the southern wetlands

To assess the value of wetlands to waterfowl in southern Ontario we have been conducting aerial surveys since 1967. The large marsh complexes at Lake St. Clair are regularly surveyed by fixed-wing aircraft during spring and autumn migration and ducklings are counted from a helicopter. Survey of smaller wetlands is less regular but future years will bring more intensive coverage.
D. G. Dennis
R. E. Chandler

Duck population index survey

In the summer of 1970 efforts were renewed to find out how many ducks, particularly mallard and black ducks, nest in the settled parts of the province. It is hoped to complete this task within three years, using a combination of sample surveys from the air and from the ground.

Aerial surveys were begun in 1969 on 22 wetland areas noted as stopovers for migrant ducks on earlier extensive surveys. Counts were made on each area immediately before the opening of the hunting season and, with one exception, at the expected time for peak numbers of migrant ducks. These wetlands will be surveyed for a number of years and the data used to calculate an annual population and production index for some species and to arrive at long term population trends.
D. G. Dennis

Photographic surveys

Large concentrations of diving ducks, primarily redheads and canvasbacks, occur in southern Ontario during autumn. Visual observation produces unreliable estimates as these waterfowl sometimes number more than 100,000 in a raft several miles long. Aerial photos were taken of redheads near Long Point, where their concentrations have been greatest, in the autumn of 1967 and 1968 and we now have precise information on their numbers for these years.

Photos were taken from elevations of 1,800, 1,200 and 450 feet with an aerial camera capable of producing nine-inch square negatives. A photo taken from 1,800 or 1,200 feet could include a complete raft of ducks for counting; while a photo taken from 450 feet could be used to identify the species composition of the raft. Waterfowl movement occurring between photos makes impossible the use of standard stereo photography. The survey will be continued, though in 1969 and 1970 the number of diving ducks found were markedly reduced.
D. G. Dennis

Banding

Bait trapping stations are operated at Lake St. Clair where up to 1,700 waterfowl are banded annually. Smaller wetlands where most waterfowl production in Ontario occurs are not large enough to warrant full-time bait trapping stations. Here an additional sample of birds are captured at night by airboat. The U.S. Fish and Wildlife Service operates two airboats under general CWS direction and with assistance from personnel of the Ontario Fish and Wildlife Branch and CWS. Also co-operating in the annual banding program are the Atlantic flyway states and private banders.
D. G. Dennis

Surveys in western Canada

Surveys and banding

Waterfowl hunting is a sport highly popular throughout Canada. During the 1969–70 hunting season 436,953 waterfowl fell to the guns of 389,325 hunters in this country. This large harvest, combined with an even greater one as the birds migrate from their Canadian breeding grounds to their winter homes in the United States and Latin America, demands that we keep close watch on waterfowl populations. Data obtained from various surveys conducted in the western provinces are the basis for hunting regulations which provide for maximum harvest, while ensuring it is not so great that the population declines.

To set proper regulations we must know the *fall flight*, that is, how many birds will be present each fall after breeding and fledging of young and just before hunting begins. CWS therefore co-operates with the U.S. Fish and Wildlife Service to conduct a Waterfowl Breeding Pair Survey in May. An area extending from north central U.S.A., through much of western Canada and into Alaska is surveyed for the number of adult breeders by species, and abundance of water bodies—the major factor in reproductive success of waterfowl breeding populations. The southern half of the Prairie Provinces is the North American waterfowl's major breeding ground.

Waterfowl are counted along quarter-mile-wide sampling strips, called *transects*, from light aircraft flown 100 feet above ground at about 100 miles an hour. Small portions of the aerial route are double checked by ground crews making complete counts to determine the proportion of waterfowl overlooked from the air.

Regulations for hunting waterfowl in Canada must normally be fixed by mid July to allow for printing and distribution before seasons open in September, but broods continue to hatch throughout July. Reproductive success is therefore predicted indirectly, using arithmetical formulae whose main variables are the numbers of water bodies counted in the May survey.

To arrive at the surplus waterfowl which can be harvested from the fall flight, we subtract the numbers needed to repopulate breeding areas, taking into account natural mortality (from causes other than hunting) between autumn and spring, from the numbers in the fall flight.

In the U.S., where hunting seasons open later, regulations are based on a July Waterfowl Production Survey in which the young are counted. Methods used in the Breeding Pair Survey are modified for this survey. For example, the transects are just one-eighth-mile wide as visibility in July is lowered by foliage.

Once we arrive at the surplus waterfowl which can be harvested from the fall flight, we must decide on bag limits which would bring about the allowable harvest, basing this decision on experience of past hunting seasons. Information on the levels of harvest that occur in Canada with various regulations is obtained through two surveys of hunters conducted by the Biometrics Section. The Migratory Game Bird Harvest Survey gives the total numbers of waterfowl harvested; the Species Composition Survey gives the species in the harvest. Similar surveys are conducted annually in the U.S.

In late summer, just before hunting seasons open, CWS, the U.S. Fish and Wildlife Service, Ducks Unlimited and provincial widlife agencies all co-operate in banding waterfowl trapped at various locations throughout the breeding range. Recovery of bands by hunters in various regions tells us where the birds go after breeding and indicates how changes in hunting pressure affect waterfowl across their breeding range.

We are conducting four studies to detect faults in the survey methods and possibly improve them. In the first study, air–ground comparison transects used in the May Breeding Pair Survey are investigated to determine if proportions of waterfowl observed by air crews are representative of those seen on the regular aerial transects. In addition we are looking into the advantages of relocating air–ground transects along regular survey routes.

In the second study we are comparing the abundance of waterfowl and water bodies along on-road and off-road survey routes in an attempt to discover whether biases would arise if aerial transects were located along section lines, many of which are marked by roads.

In the third study we are testing the validity of banding sites now located on large lakes and marshes used in migration. We are banding waterfowl at the present sites, and at smaller marshes used mainly for breeding and rearing to determine the variation in the harvest characteristics of waterfowl using such different habitats.

In the fourth study we are comparing production surveys made from the air with those made on the ground to determine how effective they are in assessing annual reproductive success of waterfowl.

Michael F. Sorensen

Manitoba

In southern Manitoba the U.S. stratifying and sampling system is being evaluated using the Canada Land Inventory (CLI) waterfowl capability maps as a guide. Preliminary assessment indicates that further evaluation may be possible. One problem is that information gathered along the 2,500 miles flown on transects in southern Manitoba can be fully evaluated only when it is compared with data collected on the ground. The interpretation of these data is further limited because there are no air–ground comparison transects fully representative of all areas and air–ground data from adjacent areas are used. Over the next three years new air–ground transects will be established to limit the problem. At the same time a more intensive ground survey with a subsequent reduction in aerial coverage is tentatively planned to enable more direct use of better raw data. Concurrent with the expansion of air–ground surveys, data were gathered for six-mile segments along selected operational transects to facilitate comparison with CLI maps. The present 18-mile segments most often include portions of several CLI classes, while 6-mile segments more frequently fall within one CLI class. In 1970 we used aerial photos of those transects surveyed in six-mile segments to further evaluate the association of various waterfowl species to habitat types. In gathering data along operational transects using six-mile segments, we can still make comparisons with historical data by lumping information together. Thus transition from the old to a possible new survey scheme is provided for.

It is hoped that more accurate and precise information concerning waterfowl use of areas of individual CLI classes will be available so that optimum allocation of sampling can be determined for each. It is believed that the cost of these surveys may well drop once this is achieved.

D. R. Halladay

Ducks are trapped before banding.
Photo by R. W. Fyfe.

British Columbia

Many Canadians think of British Columbia as a vast rocky mountain area producing few waterfowl of interest to hunters. However, while the province has some spectacular mountain ranges, it also has many valleys and extensive plateaus which produce a large number of waterfowl. In 1969 approximately 32,900 waterfowl hunters took a total of 286,000 ducks and geese, not including sea-ducks. This harvest is greater than the combined take of comparable waterfowl species in Newfoundland, Prince Edward Island, Nova Scotia and New Brunswick for the same season. British Columbia ranks sixth in numbers of waterfowl hunters in Canada.

Population surveys are conducted by the Surveys and Enforcements Section in Vancouver. Surveying waterfowl here is not as simple as it is on the prairies because much of the terrain is mountainous. As we cannot use ordinary survey methods we have tried to develop a survey technique utilizing the CLI waterfowl habitat classification.

In the first phase we examined 11 of the ecological units or biomes in the province. These ranged all the way from the tundra of the mountain tops and higher plateaus down to the semi-arid, desert-like south central portion of the province, to the rain forest on the coast of Vancouver Island and around the city of Vancouver. We first attempted to evaluate the various types of production by species and numbers for each of these units, but found the task too great with the staff available.

In the second phase we tried to evaluate whether the CLI evaluation of waterfowl areas could be used to develop a standard sampling technique in each of the biotic areas. We assumed a relationship between actual waterfowl utilization of areas and their potential production as evaluated by CLI field crews. We selected for three-year study the Cariboo parklands where a large amount of work had already been done. Ten lakes were randomly selected from each CLI classification within a mile of unpaved road. The information gathered on these lakes allowed us to evaluate the species occupying them and the relative numbers and sizes of the broods for each class. We sampled the various lakes to determine if some index of pairs and brood by species production could be developed and related to the whole biotic area's total production. Preliminary analysis shows little correlation between actual populations and CLI classifications but we cannot complete our evaluation until we have analyzed all the data.

Peter Larkin of the Department of Zoology, University of British Columbia, drew up the experimental method and assigned one staff member to program the incoming data for analysis by computer.
William A. Morris

Law enforcement

Perhaps one of the oldest approaches to wildlife management, restriction of hunting—by laws and their enforcement—is an integral part of the total program. Without it, no program could accomplish its objective of managing, restoring, developing and conserving its wildlife resource. The ever increasing number of users demands that enforcement be organized and planned in much the same manner as management or research.

Wasted waterfowl are usually considered birds lost by crippling, lead poisoning and botulism. Less attention has been paid to losses caused by illegal hunting, probably because accurate statistics are not easily obtained. But the illegal kill in Canada may be as high as all crippling losses and may sometimes exceed 50 per cent of the legal kill. Since 1966 the Canadian Wildlife Service has responded to the need for better co-ordination of law enforcement activities by recruiting a staff of four—three in the east, one in the west—specially trained in that field. The RCMP too has improved its enforcement activities by setting up a special squad.

The enforcement co-ordinators advise federal (RCMP) and provincial enforcement agencies on the Migratory Birds Convention Act and Regulations. They instruct RCMP and provincial enforcement officers—the men who have actual contact with hunters—on the purpose of the act and regulations, bird identification and distinctive enforcement methods and ensure that effort is co-ordinated within and among agencies, including those of the United States federal and state governments. The co-ordinators also address fish and game clubs, elementary and high schools, naturalist clubs and conservation agencies. In addition they conduct courses for fish and game clubs and school groups.

Each CWS region has a regional supervisor (W. R. Miller in the east, R. H. Mackay in the west) of surveys and enforcement who provides general supervision, but the methods and assignment of priorities vary considerably from area to area depending on local needs. Because the job is new, progress is reviewed critically from time to time to determine where the most promising local developments can be adapted to the national scene. The following reports cover a few of the projects.

Atlantic provinces

Illegal hunting of migratory birds in the early spring is one of the major enforcement problems in the Atlantic Provinces. Of the many methods used, one is shown on page 16. In mid April 1969 poachers placed a set of mud decoys on the ice in Northumberland Strait about 200 yards off shore. Dressed in white, the poachers hid behind a snow and ice blind near the decoys. A helicopter patrol spotted the blind and found, within a radius of 1,000 yards, three sets of decoys and other blinds manned by 18 poachers waiting for Canada geese. Some of the poachers were caught and shotguns, ammunition, boats and birds seized. The poachers were later convicted.

Hunting has been a traditional way of life to many people of the Atlantic Provinces. Egging was commonplace and the coastal fisherman's diet was supplemented when possible, by nesting birds and their eggs. Educating the public on the need and reasons for sound game laws is therefore of paramount importance.

Husbandry of migratory bird sanctuaries is also one of the co-ordinator's many duties.

J. A. Poitras

Quebec

Since 1950 CWS has employed as many as 12 seasonal caretakers at its migratory bird sanctuaries on the north shore of the St. Lawrence River between Seven Islands and Blanc Sablon. With employment of an enforcement co-ordinator, these caretakers have undergone training in law enforcement techniques and their duties have been more specifically outlined. A five-year reorganization program has included extending the caretakers' employment from three months a year to six and increasing their salaries; and providing necessary camping equipment, fast, seaworthy outboards for apprehending poachers and preventing illegal hunting, and up-to-date ship-to-shore radios. This re-organization has resulted in more prosecutions during the last two years than during the previous 18 years.

In a province the size of Quebec, success in enforcement can be achieved only by using diverse methods of which education is one of the most important. To reach as many people as possible, CWS staff train representatives of fish and game associations

Enforcement officers make their rounds by helicopter. They have landed here to inspect clay decoys used by poachers to lure geese in spring. CWS photo by J. A. Poitras.

to lecture members of their groups on law enforcement, waterfowl recognition and the general aims of resource conservation. In addition, lecture aids and pertinent pamphlets are provided. Eventually each fish and game association in the province will have one trained member. With this system, a very small CWS team can indirectly reach 6,000 hunters.

The enforcement co-ordinator also issues and monitors the use of various permits. For example, CWS grants permits to collect eiderdown for commercial marketing. While not many permits are issued, they cover a vast area ranging from the Maritimes to the Arctic Circle and they are granted to individuals as well as to Indian and Eskimo co-operatives. Illustrated instructions on how to collect eiderdown have been prepared in English, French and Eskimo and are distributed to permit holders. The instructions stress management of the resource and include suggestions for improving the quality of down through properly constructed artificial nesting structures. An experimental nesting structure program is also being conducted on the St. Mary's Island Migratory Bird Sanctuary located on the north shore of the St. Lawrence River. There, a relatively stable population of eiders produces from 900 to 1,200 nests each year under the watchful eye of a resident caretaker. Various types of nesting structures are being tried under diverse nesting site conditions.
J. A. St. Pierre

Ontario

Staff of the RCMP and the Ontario Department of Lands and Forests carry out enforcement in Ontario. These enforcement agencies deal with approximately one-third of the hunters who hold Canada migratory game bird hunting permits. The agencies co-operate well and have carried out individual and joint programs throughout the province. Both agencies conduct training courses in enforcement and waterfowl identification, with CWS assistance when required.

Public education is one of the more important aspects to be dealt with. However, human nature being what it is, we will probably never see the end of poachers or people who think that game laws apply to everyone but themselves. These are fortunately in the minority and more and more people are taking an active interest in wildlife preservation.
J. A. Stoner

Western provinces

In developing and organizing a uniform migratory birds enforcement program for the west I have maintained close liaison with provincial personnel, particularly those responsible for wildlife administration and supervision of field staff, and with RCMP officers.

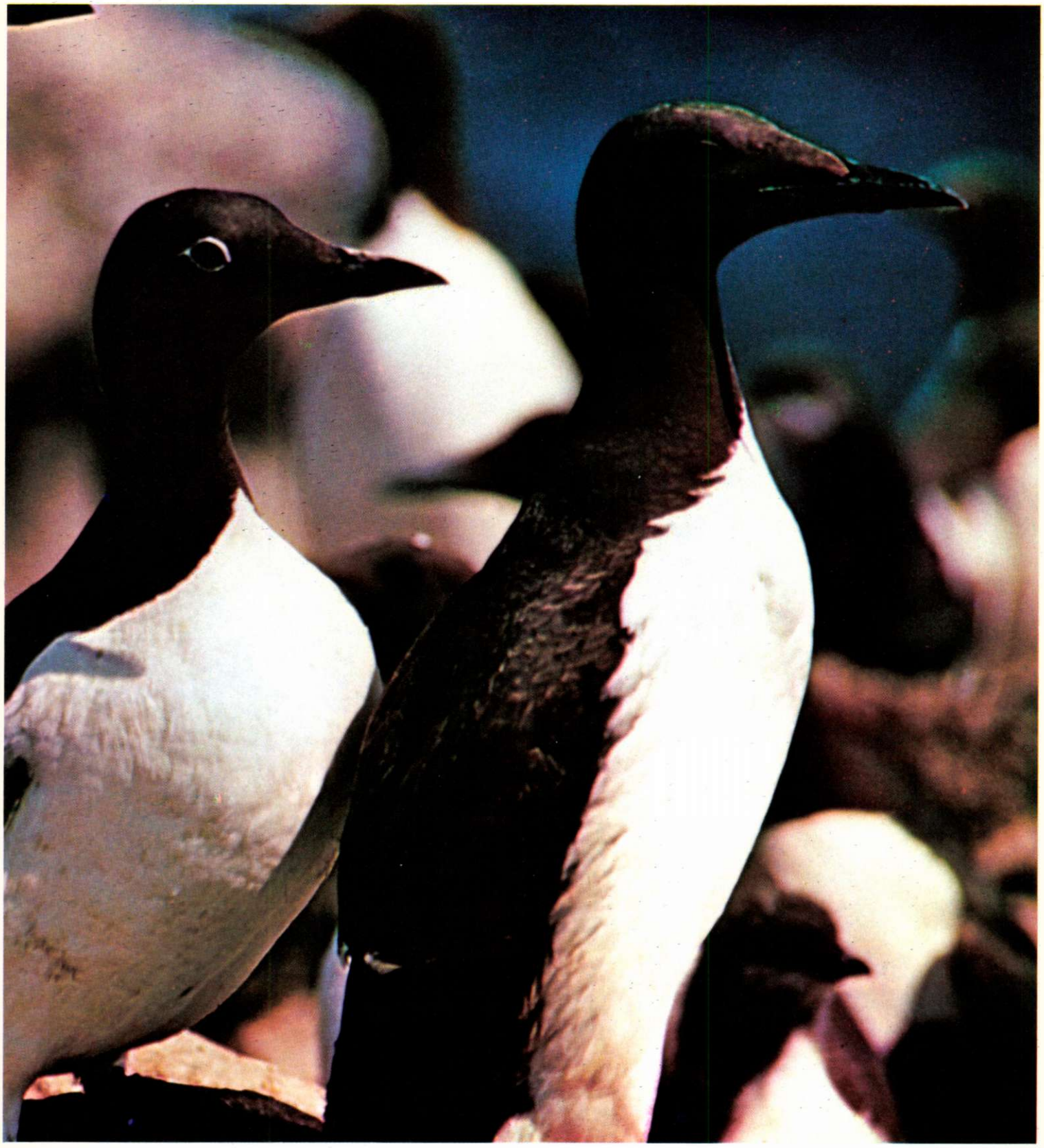
Staff from the west have taken part in a training session for RCMP special squad members organized in February 1970 by the Eastern Region and held in Winnipeg. A workshop on wildlife law enforcement, held in Calgary, was attended by 56 delegates from the western provinces, the territories and Alaska, the RCMP, the Department of Fisheries and Forestry, the National Parks Branch of Indian Affairs and Northern Development, Canada Customs and the U. S. Fish and Wildlife Service. Formation of the Northwest Law Enforcement Association was one result of the workshop.

Gaining public understanding and co-operation, a main objective of the enforcement program, may be achieved through attendance at fish and game conventions and outdoor sports and vacation shows. In May 1970 a CWS exhibit at the Pacific Outdoor Sports Vacation Show in Vancouver drew 35,000 visitors.

The enforcement section is also responsible for issuing scientific and propagation permits. In 1970, 323 Permits to Possess were issued in western Canada. These covered some 7,100 migratory birds held in captivity, including approximately 2,000 mallards and 2,600 Canada geese.
J. C. Shaver

Research by the eastern region

Murres. A CWS research station on Great Island provides facilities for studying sea-bird populations of Newfoundland.
Photo by Fred Bruemmer.



Kittiwake on Bonaventure Island, Quebec. CWS is also studying the distribution of sea-birds. Photo by R. W. Fyfe.

The status and ecology of birds of Newfoundland

The island of Newfoundland, with its boreal forests influenced on the east coast by Arctic waters, is an interesting region for bird life. More than 300 species have been recorded from the island, many of which are accidentals from Europe or drift migrants from the subtropics. Volunteer observers and a co-operative nest record scheme have contributed greatly to the knowledge of the status and distribution of the land-birds of this region. A small research station on Great Island, Witless Bay, has provided permanent facilities for investigating Newfoundland sea-bird populations.

Sea-birds

Contour maps of all the major islands in Witless Bay have been completed, and will be used primarily to census Leach's petrels. About 5,000 sea-birds are banded annually on the Witless Bay Islands. Several colonies are monitored for residual pesticides by collecting eggs to determine any progressive lessening of the thickness of the shells.

Approximately 50,000 murres have been banded in Newfoundland and the Canadian Arctic since 1951. Considerable abrasion and erosion of common murre bands in the Newfoundland colonies have made some two-year-old bands scarcely legible. Only six bands used for more than six years have been recovered; one of these was 16 years old. Bands put on thick-billed murres at Cape Hay are still being recovered at an even rate, mostly in West Greenland, 12 years later. It is suspected that bands suffer less abrasion on this cliff-nesting species, and less erosion in the colder, less saline, polar waters.

The Funk Island gannetry containing seven pairs of gannets in 1936 increased to 2,768 nests in 1959 but production has since been dropping. On July 10, 1967 the gannetry contained 2,460 nests with eggs or chicks and an additional 500 rebuilt nests. In 1968, 1,370 chicks, about 50 per cent of the eggs laid, were raised to fledgling size. On July 8, 1969 out of 1,916 nests with eggs or chicks 37 contained dead chicks or broken eggs; and an additional 880 rebuilt nests were empty. Thus the total occupied nests have not changed appreciably since 1959 but production seems to be decreasing significantly.

Land birds

A gradual trans-island extension of the breeding range of the grackle, red-winged blackbird and blue-winged teal has been documented since 1966. Evening grosbeaks are wintering in increasing numbers. Baltimore orioles occur regularly and possibly breed. The ruby-throated humming bird was recorded breeding for the first time in 1969, and the mocking bird continues to do so. The eastern extension of these birds probably results from improved climate, and following up their status will be interesting. New specimens collected during the past two years include Hudsonian godwit, woodcock, rough-winged swallow, black-burnian warbler, bay-breasted warbler and chestnut-sided warbler.

Common snipe

The common snipe, a widely distributed bird in North America, breeds in areas of organic soils from Newfoundland to Alaska and from the Mackenzie Delta in the Arctic Ocean to the northern United States. During migration, it is found most frequently in wet pastures and marshy localities. It winters in substantial numbers in British Columbia and California and in small numbers as far north as the ground is unfrozen. However, the principal wintering areas are in subtropical regions where the present agricultural practices of alternating rice fields and reclaiming marshes for cattle pastures have created important wintering biotopes in the southern United States, the West Indies and Venezuela. Possibly this newly expanded winter range has made the snipe population more abundant in North America than ever before.

Breeding studies were carried out in Newfoundland and northern Manitoba, fall migration studies in Newfoundland and northern Ontario, and winter studies in the southern United States, mostly Louisiana. The field research has now been completed and the data are being prepared for publication in the CWS monograph series.

Among the features of the snipe's biology are the breeding of yearlings and the sharing of the brood although the male does not incubate.

Juvenal common snipe undergo partial moults in late summer and again in winter, retaining juvenal feathers in the median and lesser upper-wing coverts which dis-

tinguish the first age class in the fall and winter. The sex of most adult birds can be determined by the length of the outer tail feathers. The birds' parasitic loads are higher in summer than in winter. Most food studies have not taken into account that snipe regurgitate pellets five to six hours after feeding and that the birds take in plant fibres, seeds and grit accidentally while searching out insects. Banding has indicated that snipe return each winter to the same localities and that the various populations have discrete migration routes. Thus Newfoundland snipe winter in the West Indies and Venezuela, while those from northern Ontario winter mostly in Florida.

In the fall and winter, snipe are attracted to wet, mucky or organic soils rich in invertebrates, especially larvae, and with nearby cover. To improve habitat for snipe, vegetation in marshy localities should be mowed, piled up, allowed to rot so as to attract insect larvae, then raked over before the birds arrive. The beds should preferably be prepared the previous year and given a surface cover of manure or offal. During a dry period, water should be pumped into the beds which should be frequently raked or disked.
Leslie M. Tuck

Breeding ecology of the common puffin

A study of the breeding ecology of the common puffin in Newfoundland began in 1967. The investigation was limited in 1967 and 1968 to Great Island off the southeast coast of the Avalon Peninsula, but was extended in 1969 to Small Island in the Wadham Archipelago, and the offshore Funk Island.

Detailed information on the breeding cycle of common puffins at Great Island has been recorded for three seasons. It includes arrival dates, settlement behaviour, colony structure, egg-laying, hatching, chick-rearing and departure, but emphasizes habitat selection and factors of reproductive success.

If nest density indicates habitat preference and habitat selection is an adaptive activity, then reproductive success should be greatest in those areas where nest burrows are densest. To test this hypothesis we have been examining intrapopulation variation in nest-site selection within the major habitat type and comparing this variation with breeding success.

We have compared burrow density with such measurable habitat characteristics as angle of slope and distance from the cliff edge using a preliminary multiple regression analysis. This indicated that the physical determinants of nest-site selection, or preference, at Great Island are the angle of slope and the distance from the cliff edge. Burrow density is highest towards the cliff edge where the angle of slope is greatest.

From studies of 600 nests we have learned that breeding success is associated with nest-site characteristics. Puffins nesting on areas with a steep slope experienced higher hatching and fledging success, and their fledgings left the nest in better condition, than those on level ground.

Interference by great black-backed gulls and herring gulls during incubation and rearing apparently causes lower breeding success among birds nesting on flattish ground. Here, eggs are more exposed to gull predation because incubating birds are more given to panic. In addition birds nesting on level ground are more frequently robbed of their food loads (fish caught for the chicks) than those nesting on slopes. These combined factors account for the observed variation in breeding success.
David N. Nettleship*

Sea-bird distribution

It is important to know what effect the increasing pollution of the sea by oil, pesticides and other wastes is having on the birds which feed there. As the pelagic ecology of sea-birds is very poorly understood, two schemes have been organized to collect more information. In co-operation with the Dalhousie Institute of Oceanography, CWS has organized Canadian Sea-bird Observers (CANSO), in which part-time observers, such as ship's officers and oceanographers, record sightings of sea-birds. This is integrated with Programme intégré dans recherches sur les oiseaux pélagiques (PIROP), organized by the Université de Moncton, in which full-time ornithologists take part in oceanographic and fisheries research cruises.

As the records accumulate it will be possible to map sea-bird distribution and correlate them with variations in sea-water temperature and salinity, the plankton fauna, and so on. It is already possible to do so for some of the commoner species, and preliminary maps of the distribution of the fulmar, gannet, kittiwake, herring gull and great black-backed gull have been prepared. These maps will provide yardsticks for future population changes.
R. G. B. Brown

*Mr. Nettleship made this contract study when he was a graduate student at McGill University; in 1971-72 he will be an NRC post-doctoral fellow, University of Oxford, England.

A waterfowl ecological nesting study at Iles-de-la-Paix

A group of small islands named Iles de la Paix, located in the western end of Lake St. Louis near Beauharnois, Quebec, were purchased in 1967 by the federal government for a national wildlife area. Because the main purpose of these areas is to preserve waterfowl habitat, the Canadian Wildlife Service in 1968 began studying waterfowl populations breeding on the islands, their nesting success, and production rate in relation to available habitat.

Five species of ducks were found nesting there in 1968; but only three in 1969, because a very high water level throughout the breeding season discouraged ground nesting species. Water level variations also affected selection of nest sites in both years. Fifty-one per cent of all nests were located in trees in the first year, compared with 92 per cent in the second. This different selection of nest sites was found to be equally valid for the very adaptable black duck and mallard.

Broods were reared in different habitats in the two years of the study. In 1968, when the water level was normal, broods were reared in the emergent aquatic vegetation. However, in 1969, broods spent almost all of their time in the transition zone between the forest and the marsh, that is, in the flooded shrub zone characterized by willows, alders, hawthorns, dogwood and buttonbush.

Although the breeding characteristics were different in the two years of the study, the overall nest success was almost identical: 59.0 per cent of all nests hatched in 1968 compared with 56.0 per cent in 1969. These figures compare favourably with those obtained in similar studies elsewhere.

Results obtained during this study have been used to prepare a detailed management plan for the area.
Marcel Laperle

Distribution of duck kill in Ontario

By delineating areas in Ontario where hunters kill waterfowl we can learn more about waterfowl distribution in the settled portions of the province during the hunting season. Such information can be used to operate more effectively the land acquisition and enforcement programs, Canada Land Inventory, and hunter performance survey.

For the annual wing or species composition survey, CWS asks waterfowl hunters to submit one wing from each duck shot. From the wings the species can be identified and the species composition of the harvest learned. The special envelopes in which the wings are enclosed tell when and where the birds were shot and are used as source documents for the project on waterfowl kill areas. From envelopes returned in the 1968 and subsequent hunting seasons, we plotted kill locations on 1:500,000 maps of Ontario, then listed the major and minor waterfowl kill areas. The project is continuing.

D. G. Dennis

Bird damage to fruit in the Niagara Peninsula

Migratory song-birds (passerines) cause considerable damage to vineyards and orchards in the Niagara Peninsula, sometimes taking 25 per cent or more of the crop. The species mainly responsible for this are robins (early sweet cherries, sour cherries, wine grapes), starlings (late sweet cherries, sour cherries), grackles (early sweet cherries) and Baltimore orioles (early table grapes).

The Canadian Wildlife Service has been conducting widely based research on the biology of these birds since 1965, as a thorough understanding is essential before any effective control measure can be devised.

Variety preferences

Robins seem to prefer the earliest cherry variety that ripens in an orchard, sometimes taking it after other varieties are ripe. They may concentrate on individual trees while ignoring other nearby trees of the same variety. However, the presence of early varieties does not generally distract the birds from the later ones, nor does it act as a "loss leader" to bring birds into the orchard.

Tests with caged robins and starlings show that they prefer black to green varieties of grapes and dark red to light red varieties of cherries, using redness as a guide to sugar content. Birds fed a mixture of dark red sweet cherries, light red sour cherries and gold sweet maraschino cherries at first chose dark then light then gold, but quickly came to prefer the gold maraschinos to the sours. They also quickly learned to eat green grapes. These tests confirm the situation in the field, where light red cherries and green grapes are usually little damaged. But they also show that there would be little point in using fruit colour to develop a "bird-proof" cherry or grape, since the birds readily take the light varieties when they have no choice.

Balance between animal food and fruit

Robins start to take cherries even before they are fully ripe, usually when rainfall in the Niagara Peninsula is low. The birds may eat cherries for their fluid content, or because the dry ground reduces the availability of worms. There is some evidence that thirst may stimulate robins to eat cherries; however, when there is water close to an orchard damage to the fruit is not reduced. On the other hand, observations on feeding robins and analyses of their faeces show that the birds actually prefer fruit to animal food. Nutrition is a complicating factor here. Nestlings and moulting birds need a protein-rich, animal diet for proper growth; on the other hand, migrants need sugar-rich foods, such as fruit, to build up the fat needed for energy reserves. Much of the damage is done by migrating birds, which means that it will be almost impossible to switch them over to a non-fruit diet. Fortunately, the birds may prefer the wild fruits which ripen around migration time.

Timing of migration

Flocks of juvenile robins and starlings which move into the Niagara fruit belt in late summer do much of the damage. The size and timing of these migrations vary from year to year. For example, starling migration was three weeks later in 1969 than in 1968, to the advantage of the later cherry varieties. Further understanding of these variations might lead to a bird forecast system to predict when bird damage was most likely to occur. Through the Ontario Bird Banding Association, CWS has organized a network of amateur observers in southern Ontario to collect more information on this.

Protective systems

Any protective system must be tailored for the species causing the damage, as ease in driving out of orchards and vineyards varies with the species. No single system will cover them all. The system must also pass two economic tests. It must substantially reduce damage, and must cost less than the value of the crop saved. Most systems fail on one or both counts. For example, suspended hawk silhouettes are cheap, but deter birds only from eating the fruit immediately beneath them; decking a tree with aluminum foil is cheaper but even less effective. On the other hand, covering the tree or vine with netting, probably the only defence against Baltimore orioles, is effective but expensive. Most Niagara growers use exploders powered by acetylene or bottled gas. These are fairly cheap and effective against starlings and grackles, especially when reinforced by shotgun patrols, but have no effect on robins. Workers in the United States claim that robins can be driven off by broadcasting their alarm and/or distress calls. CWS is experimenting with this, but the results to date are disappointing.

R. G. B. Brown

Experiments on the counting behaviour of waterfowl observers

The aerial waterfowl count is one of the basic tools of wildlife management. Observers are required to make snap judgements of the numbers of birds which they see, but it is hard to assess how accurate these estimates are. We have been testing observers to check their accuracy.

Observers are shown photographs of sago grains and/or gunshot in varying numbers and proportions, and at different densities, and are given 15 seconds to estimate how many objects are present. The results so far show that all observers underestimate, giving only 40 to 80 per cent of the correct total. They also differ in the consistency of their estimates. For example, some observers consistently estimate only 50 per cent of the real total, but do so time and again; others average 75 per cent but vary unpredictably from test to test.

This technique will help "calibrate" individual observers, and lead to a training programme to help improve their estimates in the field.

R. G. B. Brown

Penned geese (blue, snow, little Canada, Atlantic brant) on Baffin Island, NWT, await banding. Photo by R. H. Kerbes.

Geese of Baffin Island

A vast expanse of flat, marshy tundra, the Great Plain of the Koukdjuak on Baffin Island, Northwest Territories, probably has more nesting geese than any area of comparable size anywhere in the world. Adjacent to the shallow ice-filled waters of Foxe Basin, this nesting ground carries an estimated summer population of one million brant, blue, lesser snow and Canada geese. The geese there were extensively studied by aerial survey in June 1966 and by a ground party with helicopter support during the summers of 1967 and 1968.

Most of the birds are blue and lesser snow geese. Their nesting success was very high in 1966, when the nesting area was about 670 square miles; and moderate in 1967. In 1968, when the nesting area was 20 times smaller than in 1966, nesting density was very much lower than in the two previous years. The decline in 1968 was caused by exceptionally heavy snow cover in spring which delayed exposure of the grounds.

In 1967 and 1968 we also undertook study of the nesting biology of Canada geese and banding of flightless moulting geese. We banded approximatety 10,000 blue and lesser snow geese, 2,000 Canada geese and 60 brant. Band returns will eventually be analysed to determine migration routes, hunting mortality and other aspects of population dynamics.

As geese from the Great Plain are hunted throughout eastern and central North America, the results of this study are used for continental management of these birds.

Richard H. Kerbes

Research by the western region

Willow ptarmigan, an Arctic grouse, are seen hatching.
Photo by C. G. Hampson.

Feather chemistry and origin of waterfowl

The ability to trace waterfowl and other migratory birds in their seasonal migrations is essential to their management. Present methods include direct observations, particularly with such strongly goal-oriented species as Ross's goose, telemetry, banding and recovery. Direct observation and telemetry are obviously limited, and while banding can theoretically solve most problems inherent in bird movement, in practice it has some severe limitations. For example, it often costs too much, or is not practical, to band adequate numbers of desired birds.

Feathers contain a wide spectrum of chemical elements, and most waterfowl moult and grow new flight feathers in one locality once a year. It is therefore reasonable to assume that proportions of the chemical elements in flight feathers will reflect, although not necessarily directly, the locality in which they were grown. Some preliminary work in the United States at two different localities suggests that this assumption is sound. Thus the Illinois Natural History Survey indicates that geese which moult on Southampton Island may be distinguished from geese which moult at Cape Churchill, wherever they are taken on their range, by relatively large amounts of iron, manganese, aluminium and boron, and relatively small amounts of sodium, potassium and magnesium in their feathers. If such constant correlations between feather chemicals and local waterfowl populations can be found, even for only a few species or for particular situations, waterfowl management will have a new and valuable tool.

There are other possibilities in this line of research. For example, the ability to sex immature black ducks and most geese by plumage or to determine their age more precisely, would be useful to management.

This project started in 1968 and is designed to explore this whole field of feather chemistry of migratory birds.

Four waterfowl species were arbitrarily selected for experimental purposes: white-fronted goose, mallard, black duck and lesser scaup. A first series of analyses have been conducted to determine, largely through atomic absorption spectrometry, what chemical elements are found in the plumage of these species. Of 38 elements sought in analysis, 31 were actually found. They included not only common and essential elements, such as calcium, magnesium and phosphorous; but also a good many of the less common trace elements, such as gold, silver, strontium and tellurium. A second set of analyses to determine whether whole primary feathers should be analyzed, or only the more highly mineralized vane portions, suggest that the former would be better.

For this project arrangements were made with the Alberta Fish and Wildlife Division to hatch, raise and maintain on a standardized diet 200 waterfowl at the Wildlife Research Station in Brooks, Alberta. Plumage from these birds will be analyzed to determine whether differences are inherent between species, and between age and sex groups within species. Experimental material is taken from wild birds collected for this project and from wings, especially of banded birds, annually submitted by hunters during waterfowl sample surveys across the United States and Canada.

If waterfowl are traceable in some circumstances through feather chemistry, other animals may be similarly traceable through the chemical composition of fur, scales, antlers or skeletal parts. Theoretically, the technique could be applied to migratory butterflies, giant sea turtles, anadromous fish (those ascending rivers to spawn), hatchery-reared game birds, migratory birds other than waterfowl, the far-ranging oceanic birds, the nomadic great kangaroos, whales, seals and migratory ungulates.

John P. Kelsall

Population dynamics of Mississippi Valley Canada geese

The Mississippi Valley population of Canada geese is one of the best known in the world. It nests in the muskeg lowlands of Ontario inland from the coasts of James and Hudson Bays, stops in large numbers during migration at Horicon National Wildlife Refuge in east-central Wisconsin, and winters on refuges in southern Illinois. U.S. federal and state agencies put much effort into determining the annual population in winter and the harvest taken by hunters in fall. Thousands of geese have been banded each year. The Mississippi Flyway Council, with co-operation from the Ontario Department of Lands and Forests and CWS, supported a study of nesting geese in the Ontario lowlands during 1967, 1968 and 1969. Statistics are gathered annually on age and sex ratios of geese trapped for banding and killed by hunters.

Despite the wealth of knowledge available on this flock, confusion and disagreement still exist over which methods best measure its age composition, thus reproductive success. Estimates are usually based on trap samples, but these can vary widely and contain biases.

Research was undertaken in 1964 to measure the age structure of the population before U.S. hunting seasons open by extrapolating from the frequency of different size groups of geese at the moment the geese land in a field. The project was supported until 1966 by the U.S. National Science Foundation and the Cooperative Wildlife Research Laboratory of Southern Illinois University; and since 1967 by CWS in co-operation with the U.S. Bureau of Sport Fisheries and Wildlife and the Wisconsin Department of Natural Resources. Research has shown that goslings hatched in the summer stay with their parents through the following winter. Canada geese do not nest until they are at least two years of age, so the population contains many non-breeding yearlings. Most yearlings are singles but some rejoin their old families or remain in pairs or sibling groups. Even when flying in a large flock, families, pairs and single individuals have been observed to split apart just before landing.

Our research will indicate what proportion of singles and pairs are adults, "orphaned" young and yearlings. Basically, the proportion of pairs to groups of three or more observed landing reveals the percentage of pairs that were successful in bringing a family south, that is, the percentage which succeeded in raising one or more goslings to flying age. The proportion of singles indicates the numbers of yearlings.

These family counts have been conducted at Horicon, Wisconsin, since 1964. Results have paralleled population trends evident from other sources, such as the nesting studies and winter population size after hunting. For example, in 1967, studies in Ontario predicted this population would have a poor reproductive year. Autumn family counts indicated that 42 per cent of breeding age females were successful in

Male mallard duck is weighed in a weighing can.
CWS photo by J. P. Kelsall.

Primary feathers are being clipped from a male mallard duck for chemical analysis.
CWS photo by J. P. Kelsall.

hatching an average of only 1.95 young per female. The age structure in September was estimated at 54 per cent adult, 23 per cent yearling, 23 per cent young. The 1967 winter population after hunting was the same as or slightly lower than the previous year, even though hunters had killed fewer geese. Nesting studies in 1968 predicted a good hatch. Family counts in Wisconsin in September indicated that 60 per cent of the breeding age females were successful at a rate of 2.46 young per female. The age structure of the population was 51 per cent adult, 11 per cent yearling (reflecting the poor 1967 hatch which carried over into 1968 as a small yearling age class) and 38 per cent young. The winter population size after hunting showed a large increase over the previous year.

This research is continuing. Correction factors used in proportioning the different ratios of age classes in singles, pairs and families must be perfected so that the age composition before hunting can be determined. Comparing these data with weather conditions during the nesting season over a number of years may lead to a system of parameters which can be used to predict success of an entire population.

When the age composition of the geese killed by hunters is known this can be subtracted from the age composition derived by family counts before hunting started. Thus the age structure of the population returning north to nest is known and, if the numbers returning north is also known, family counts the next autumn can be used to estimate the size of the fall population available to hunting. The ultimate aim is more refined management of an important and heavily harvested flock and an understanding of the biological factors important in regulating an animal's numbers.
Dennis G. Raveling

Canada geese of Manitoba

Status and distribution

A variety of races or separate flocks are represented by Canada geese nesting or migrating through Manitoba. These flocks utilize different habitat, have more or less distinctive migration routes and are harvested in varying numbers by hunters in Manitoba and elsewhere. Objectives of this study are to record the numbers of Canada geese in various marshes or lakes used in

Canada geese on a frozen pond.
Note the leg band on the goose, lower right.
Photo by D. G. Raveling.

southern Manitoba during autumn migration; relate their distribution to total hunting harvest and the proportions of the different areas; relate data on harvest in Manitoba to results obtained eslewhere on the migration route so as to assess the effect of hunting on the growth or decline of any particular nesting flock. The study was made jointly with the Wildlife Branch of the Manitoba Department of Mines and Natural Resources.

Canada geese nesting in the aspen parklands, from the Minnesota border in the southeast to The Pas, are large (9–13 pounds), pale-coloured geese known as giant Canadas. Four to five thousand birds nesting in the southeast corner of the province migrate to southern Wisconsin and northern Illinois for the winter and it is from these two states that 66 per cent of the total band recoveries for this population come. Limited banding results indicate hunting pressure at or above the level that this flock can sustain.

The Interlake flock of giant Canadas, between Lakes Manitoba and Winnipeg, is increasing with 12,000 to 15,000 birds, most of which migrate to Rochester, Minnesota, in the fall. Manitoba turns in about 65 per cent of the bands recovered.

We do not know how many giant Canadas nest in the area west of Lake Manitoba to The Pas. The flock is not large, however, and indirect data from banding and censuses on U.S. refuges in the winter suggest a decline.

Canada geese nesting in the muskeg lowlands of Manitoba near Hudson Bay and in the forested interior of northern Manitoba are smaller (6–9 pounds) and generally darker than the giant Canadas of the prairie and parklands. This is a large flock with a fall flight before hunting of about 180,000. The Canadian Wildlife Service and the Manitoba Wildlife Branch studied, in 1969, nesting Canada geese on the Churchill River in the interior of northern Manitoba and established that their numbers west of

the Hudson Bay lowlands were greater than previously believed. As part of this co-operative venture, Canada geese were banded here for the first time in July 1969.

Most of these geese, known as the eastern prairie population, migrate to north central Missouri. About 13 per cent of band recoveries from banding done on U.S. wintering areas come from Manitoba. Important stopover points in southern Manitoba include the Shoal Lakes, Delta, Netley–Libau, Big Grass and Riverton Marshes. Important harvest areas in northern Manitoba are Churchill, York Factory and Kaskattama. This population has been more or less stable for the past eight years.

Small Canadas, known as Richardson's or lessers, nest in the arctic tundra near the Hudson Bay or arctic coastlines of the Northwest Territories. They weigh from three to six pounds. These birds are more erratic during fall migration than their larger relatives. In some years several thousand may stop in the Big Grass, Delta and Netley Marsh areas; usually, however, few stop in southern Manitoba. They migrate into the Dakotas and finally spend the winter in Oklahoma and Texas. About eight per cent of the recoveries from U.S. bandings are obtained in Manitoba. We are concerned that this population has declined in recent years. Their wide distribution makes it difficult to assess the flock's total size, but estimates vary from 100,000 to 300,000.

The total estimates of the 1968 harvest of Canada geese in Manitoba vary between 12,000 and 18,000, based on analyses of banding data and hunter questionnaire reports. The CWS survey of kill distribution reveals that the Interlake is the most important harvest area. Fifty-nine per cent of 136 tail fans of Canada geese shot and submitted by hunters in 1968 came from this area. The major migration stopover point in the Interlake is West Shoal Lake. The kill here is about 80 per cent medium-sized geese from northern Manitoba, 16 per cent small Canadas from the tundra, and 4 per cent giant honkers. In contrast, harvest elsewhere in the Interlake is about 68 per cent locally raised giants, 30 per cent muskeg-forest geese, and 2 per cent small Canadas. Giants also predominate in the harvest in the southeast corner of the province and at The Pas.

The final objective of this study is to relate the numbers, distribution, kill and habitat available and necessary for each flock's welfare to its status. As different areas are important both for the birds and hunters of each flock, this information will be valuable in determining the flexibility needed to assess the management of each flock; it will also contribute to our knowledge of the biology of the distributions and migrations of these geese.

Biology of the giant Canadas

Once prevalent nesting birds throughout the prairies, giant Canada geese, largest of the Canadas, were almost totally eliminated when the region was settled. This race, or subspecies, was considered extinct until it was discovered at its wintering ground near Rochester, Minnesota by H. C. Hanson of the Illinois Natural History Survey.

CWS undertook a study of the Manitoba flock, in 1968, to learn its distribution, numbers, habitat needs and mortality from hunting; and, with the Wildlife Branch of the Manitoba Department of Mines and Natural Resources and the Minnesota Department of Conservation, has developed a plan to increase its numbers. A number of private citizens in Manitoba and the U.S. Bureau of Sport Fisheries and Wildlife have also lent their support to this study. Five hundred geese are marked each year with individually numbered, brightly coloured plastic neck-collars. Marking is done with the help of owners of the East Meadows Ranch on the southeast shore of Lake Manitoba, nesting ground of the largest single component of the Interlake flock. The Delta Waterfowl Research Station established this flock in the 1950s within a goose sanctuary set up by the Manitoba government.

As the areas they inhabit are readily accessible, we are also studying the sociology and behaviour of individual geese. The neck-collars allow repeated observation of the same individuals and families. Every time a marked goose is observed and identified it is just like receiving a band recovery from a hunter, only more valuable, as further information may yet be gathered on the same individual. This is how we obtain data on the associations and behaviour of geese whose age, sex and past history are known.

We can study movements at all times of the year, not just during the hunting season as with band recoveries from hunters. Reproductive success of geese of different ages, family sizes, dispersal of nesting geese, family ties and age and time of pair formation are also being investigated. Mortality can be calculated from the numbers of marked geese known to be still alive, rather than depending on reports from hunters who have killed birds.

In fall 1968 the flock comprised about 30 per cent young of the year; and mortality up to mid-winter was about 11 per cent. There was some additional mortality in spring, but reproduction remained the same as in 1968 and the flock increased by about 15 per cent. In fact, average annual growth since 1960 has been about 13 per cent.

The flock has responded well to the protection of refuges in Manitoba and Minnesota, its numbers ranging between 12,000 and 15,000 by summer 1969. An increased effort to acquire and manage habitat for this flock, along with yearly monitoring of its mortality, should enable wildlife agencies to maintain this growth. Managed in this way, the flock could increase to 30,000 birds and provide countless hours of recreation to hunters, bird watchers and the general public throughout the year. Thousands of persons view this flock when it is concentrated in winter at Rochester, and increasing awareness of its existence brings visitors to the nesting and autumn gathering places in Manitoba.

Dennis G. Raveling

Food and nutrition of wild ducks

Since 1969 we have been investigating four aspects of duck nutrition and foods, at the Prairie Migratory Bird Research Centre in Saskatoon. The experiments are conducted in a temperature- and light-controlled room. Ducklings are hatched from artificially incubated eggs collected from nests of wild ducks and are reared in poultry battery brooders.

The contents of the gullet and gizzard of ducks killed in the wild have been the source of most information on their diet. But this has not been reliable because hard items, such as seeds, remain intact in the gizzard much longer than softer animal food. We are therefore testing the reliab-

This trumpeter swan pair has raised cygnets in captivity at Cherryville, B.C.
CWS photo by W. A. Morris.

ility of material found in the esophagus and proventriculus by force-feeding measured amounts of foods in different combinations. The duck is then killed after a predetermined time and the material in its esophagus and proventriculus measured and compared with the food it was given.

Ducks do not always eat foods in proportions in which they are available. Selection must therefore be influenced by other factors. To find out why ducks eat certain food and not others we are measuring the response of lesser scaup in diving tanks to various situations, such as density of prey, different prey combinations, size of prey, water depth and water turbidity. Understanding these factors will help us interpret data on diet.

We now rate the quality of food largely on the relative amounts eaten. However, this tells us nothing about each food's contribution to the duck's nutrition. Food resources cannot be evaluated unless the true quality of each food is known. We are therefore measuring metabolizable energy in various foods eaten by mallards. We have begun with cereal grains and will compare our results with values published for chickens to see if the short-cut formulae derived for these birds are also applicable to ducks. Later on we will measure energy in the more important natural duck foods.

Energy is used for growth and maintenance, and some is wasted. To determine these factors we are measuring the energy consumed by mallards from hatching to flying at weekly intervals. Knowledge of waterfowl energy requirements will enable managers to make more precise evaluations of food resources.

Lawson G. Sugden

Birds of British Columbia

Trumpeter swans

About half the world's population of trumpeter swans winter in British Columbia. The Vancouver office of the Canadian Wildlife Service attends to these birds in a number of different ways.

The largest wintering population in British Columbia is at Lonesome Lake where they are fed by Mr. and Mrs. Turner, under CWS contract. Until last year, the total number of swans had increased substantially to about 450. Feeding the birds has been a problem since the remoteness of the area makes it difficult to supply the required eight tons of grain, which must be shipped by boat to Bella Coola then transported by truck and pack to the storage site on Lonesome Lake. Attempts to move some of these birds to the coastal area by use of scaring techniques have, until recently, been unsuccessful.

Another large wintering population is found on the northern half of Vancouver Island on remote inland lakes, or on river tidal flats. There is also a substantial population which winters each year on the Queen Charlotte Islands. Additional birds winter in the north central part of the province, but most of these are associated with fast flowing rivers or warm springs, which prevent the water from freezing during subzero temperatures. The birds on the mainland and on Vancouver and Queen Charlotte Islands are surveyed by aerial counts in co-operation with mid winter waterfowl inventory in the Pacific Flyway Council.

There are also a number of non-flying birds located in zoos, the Reifel Refuge and in central British Columbia. They are encouraged to nest under natural conditions in the hope that the numbers may be built up to the point where their progeny can be released back into the major valleys of B.C. There they might produce young of their own and thus re-establish wild, free-flying birds in habitat not occupied by these swans since the early part of this century. Each year a number of these birds, the largest waterfowl in north America, are killed or wounded by irresponsible hunters.

For this reason we have a public relations program to make the general population aware of these birds. This is being done by providing a coloured poster on the trumpeter swan to every school on Vancouver

Island, Queen Charlotte Islands and the western slope of the coastal range. Similar material has also been sent to RCMP detachments, logging camps and other groups working in the remote areas where these birds may winter.

Trumpeter swans were recently removed from the endangered species list, but a sudden outbreak of disease or loss of habitat could again place the population in serious jeopardy.

Band-tailed pigeons

Funds provided by CWS have made possible research into the ecology and feeding habits of band-tailed pigeons in British Columbia by G. L. March, graduate student at Simon Fraser University. These birds eat grain in spring but make a radical change to small fruits of the cascara and elderberry, almost to the exclusion of all other food, in summer. This apparently gives rise to a dietary deficiency and the birds then move to areas near sea-water or mineral springs where certain salts can be obtained. This need for salts is apparently related to the reproductive cycle. The concentration of birds in these areas may mean that we can count individuals there.

Mr. March has demonstrated that it may be possible to determine the stage of the reproductive cycle from the condition of the reproductive organs and crop analysis. This study suggests that some populations may still be nesting when the traditional hunting season starts on September 1.

This program is continuing and additional data useful in setting seasons on these unique Pacific Coast birds will undoubtedly be accumulated.

W. A. Morris

Birds of the Arctic

Waterfowl distribution in the western Arctic

Pacific brant, snow geese, white-fronted geese and whistling swans—all arctic waterfowl—are the subject of a life history study. For this study we have banded 20,000 birds in the vicinity of Anderson River, Banks Island and the Mackenzie Delta; flown nearly 75,000 miles to explore waterfowl habitats, surveyed and checked environmental conditions, migration routes and concentration points in the Northwest Territories, Yukon Territory and northern Alaska.

The four species nest close to each other at the Anderson River Delta in summer, but their different migration routes take them to widely separated regions for the winter. The swans take the Great Lakes route diagonally across the continent, from Great Bear Lake to Lake Erie and Ontario, to their wintering grounds along the Atlantic coast of the United States. The white-fronted geese fly up the Mackenzie Valley south across the parklands and great plains to the gulf coast of Texas and Mexico. The snow geese follow the white-fronts as far as Alberta and Saskatchewan but cross the Rocky Mountains, from southern Alberta and Montana, to their winter range extending from the Sacramento Valley of California south into Mexico.

The banded waterfowl have varying destinies in the course of their travels. Some birds encounter man and are reported as band returns. Some encounter other animals and their bands may be recovered from fox dens, eagle nests or gull colonies. Some geese, especially brant which spend most of their lives in salt water, outlast their aluminum bands. As these disintegrate in two or three years, special non-corrosive bands must be used. Most geese return to the same nesting grounds year after year: as many as 40 per cent of the captured flightless birds were banded in previous seasons. We assume that few geese die of old age, although we have recovered brant banded 12 years before, when they were at least three years old.

Through our survey flights we have located the favourite moulting and staging areas used by geese year after year. Techniques for capturing flightless waterfowl are different for each species and for each location. With new equipment and methods we hope to band new segments of the various goose populations.

The surveys have also delineated several massive concentrations of sea-ducks, such as oldsquaw, eider and scoter, about which we know comparatively little. We have begun preliminary study of their habits during the moult to develop techniques for banding studies and to examine other aspects of their life history.

The nesting ground ecology of whistling swans

Whistling swans, large white birds that build large nests and lay large eggs, are easy to see and count from an airplane. Whistling swans nest primarily north of tree line along the Arctic coast of North America. About 22,000 spend the summer in the Mackenzie Delta region in the zone of coastal plain stretching from Herschel Island on the west to Paulatuk and Cape Parry on the east. The centre of this population is around the Eskimo Lakes and Liverpool Bay while a few pairs are found south of tree line as far as Great Bear Lake.

Migrating diagonally across the continent from wintering grounds in Chesapeake Bay and the Atlantic coast of Virginia and the Carolinas, this population arrives at its summer haunt in early May. A bird as large as a swan must take every possible advantage of the short arctic summer to nest and rear its young before freeze-up in late September to mid October. The swans are among the first birds to arrive on the tundra nesting grounds and the last birds to leave in the fall. Any abnormal conditions of the arctic climate affect their success in nesting and rearing young. Late-melting snow in spring, summer storms or snow, an early freeze-up all reduce the number of young swans that head south in the fall. Conversely, an early thaw, pleasant summer, and late freeze-up increase swan production.

Twenty-five thousand white-fronted geese nest in the same geographic area. The white-fronted goose is an important game species in Saskatchewan and along the central flyway south to the gulf coast of Texas and Mexico. These birds, unlike the swans, are brown and blend with the tundra vegetation; they are very secretive and nearly impossible to see or count accurately from an aircraft. Yet they are like the swans in that their reproduction is similarly affected by some factors of the arctic climate. On this premise, we are testing methods for using the whistling swan as an indicator of reproductive success of white-fronted geese in the same area. We hope this will enable us to adjust annual hunting regulations for these geese to reflect more realistically the annual changes in their numbers.

Willow ptarmigan of the arctic and coastal plain

The scrub willow tundra of the coastal plain between the tree line and the Beaufort Sea gives the impression that it is the ancestral

home of both the willow and the willow ptarmigan. Nearly 25 willow species cover the area and, in peak years, the nesting willow ptarmigan is nearly as ubiquitous. The willow is the predominant food of the ptarmigan through most of the year.

Ptarmigan migrate relatively short distances into the tree line, as far south as the northern boundaries of the provinces, presumably to avoid much of the dark winter period, as well as the hard-packed snow which makes it difficult for them to burrow for protection from the cold. Nonetheless, the wintertime distribution is usually associated with the presence of willows along lakes, streams and muskegs.

When the ptarmigan go back to their nesting grounds, shortly after the return of sunlight to the north, the scrub willow is filled with wind-hardened snow. Feeding flocks course the tundra, snipping off willow growth sticking out through the snow.

Nesting territories are established in early May, with little change in boundaries as the snow melts away. Nests are denser on the coastal plains where, in 1969, they averaged a distance of 110 meters between nests. Here, too, egg clutches are larger (8–21 per clutch) than in other parts of the ptarmigan range. The dense distribution and large clutches could give rise to a "population explosion" if environmental conditions are ideal. Since most of the ptarmigan nesting is synchronized, occurring within a seven-day period, adverse environmental conditions could result in nearly complete reproductive failure. Such a collapse occurred in 1969 when a late heavy snow covered most nests and caused flooding when it melted.

Willow ptarmigan populations fluctuate from year to year in patterns commonly called cycles. During the last two population highs we noticed large flocks of up to 1,000 male birds on the nesting grounds. Unlike most grouse, ptarmigan are monogamous, and the absence of females is perplexing. We know that flocks separate in the winter into units of like sex and age, and that adult females tend to move farther south than the males. The sex ratio of willow ptarmigan appears equal at hatching, but we have not yet been able to trace differential mortality. Predation observed on the nesting grounds indicates that the more conspicuous males suffer the greatest losses. We can only speculate that females are apparently lost during the winter, but continuing research may supply some answers.

The ptarmigan is an important but secondary food for native residents of the Arctic, usually providing a change of diet or emergency supplies. Hunters take about 40 per year in March or April when other food is scarce. One independent old woman netted 600 ptarmigan near the mouth of the Anderson River one September; and these, along with some dried fish, were her main food supply until the following June.

Utilization of birds by residents of the Mackenzie Delta Region

Birds, because they are smaller, are a less important food source than such large creatures as moose, caribou, seal, fish and whales. Nonetheless, their numbers or seasonal occurrence can make them a vital food to many residents. I know of one instance in which some members of an Eskimo family died from starvation; death of the entire family was prevented only by the timely arrival of flocks of snow buntings in early April. However, social assistance programs and the tendency of the population to concentrate in the settlements have lessened the value of birds, or their eggs, as a necessity of life.

As information on general hunting licences returned in the Northwest Territories is not specific, and residents of the NWT are not required to obtain migratory birds hunting permits, we were unable to measure in the usual way the extent to which residents used birds and other game. To do so, personal interviews were conducted with as many hunters and heads of households as could be contacted during two seasons.

Mary Carpenter, a resident of Sach's Harbour on Banks Island and former Canadian Wildlife Service employee in Inuvik and Edmonton, conducted the interviews. She made at least one visit to the settlements, and the fishing, whaling and hunting camps at Arctic Red River, Fort Macpherson, Aklavik, Peel River, Reindeer Station, Kendall Island, Kittigazuit, Tuktoyaktuk, Paulatuk, Sach's Harbour and Holman Island. Residents of Inuvik were not interviewed because the percentage of wage employment there is high, the equipment is sophisticated, and hunting there is primarily a sport. In addition the few Inuvik residents who earn their living primarily from hunting and trapping were my friends and neighbors.

Utilization of birds varies considerably from place to place because the migration routes, the birds' habitat and their seasonal availability all differ, as do the hunters' traditional hunting patterns, their tastes and size preferences. For instance, eider ducks are most readily available at Holman Island and are taken in large numbers there, whereas they are taken at Sach's Harbour only during seal and polar bear hunting trips when hunters are not successful with those animals. Eiders are actively sought only very early in the season before the snow geese arrive. They are considered to be a scrawny but welcome change to the long winter diet. In Tuktoyaktuk, many eiders are available along the leads in the ice offshore, but few people care for their taste. Snow geese, white-fronted geese and brant, also available here, are more popular.

In Aklavik, where very few waterfowl are shot in the spring, white-winged scoter is preferred, as they are in Old Crow Flats, Yukon Territory, where a large variety of waterfowl is available. Size and legality seem to be a factor in selection of game.

Ptarmigan are a year-round standby everywhere, particularly during late winter and early spring when little else is available. Most people agree that they should not shoot swans, but when circumstances warrant, the swan's size and wariness often rate the use of a high-powered rifle over a .22 or a shotgun. Snowy owls are an important winter delicacy at Sach's Harbour only. There, as at Tuktoyaktuk and Kittigazuit, ice houses in the permafrost are used to store waterfowl shot in the spring for the rest of the year, especially those intended for Christmas dinner. It is very difficult to get geese in these settlements in the fall.

Trade and gifts of birds and other game are quite common. Prices ranged up to five dollars per goose. Buyers were usually temporary wage earners with the transportation companies or with oil exploration crews, people who craved fresh goose but could not get away from work for the hunt. This was most common in Inuvik, but also occurred in Tuktoyaktuk and Aklavik. Gifts or trading of food were confined mostly to species absent in certain areas. For example,

Whooping crane eggs on a nest in a cattail marsh.
Photo by E. Kuyt.

nearly 40 ten-gallon kegs of muktuk were gifts, or were sold, to Sach's Harbour residents from Kendall Island and Tuktoyaktuk. Some of these shipments were handled by the free trader in Inuvik. Spring geese from Tuktoyaktuk are sometimes traded to Aklavik people for caribou.

Attitudes toward hunting and fishing varied. For the Tuktoyaktuk people the rites of spring begin with a large gathering of families in tent camps on the ice of Eskimo Lakes where, lying on the ice and peering down fishing holes, fishermen jig large lake trout from the brackish water. Over 40 tents have been counted there. The fish run ends just as the geese migrate along the shores of Kugmaluk Bay, and the camps are then moved by dog team and snow vehicles to the wind-cleared beaches where a festive few weeks of hunting snow and white-fronted geese begin. Some shift camp again to Toker and Warren Points for brant which migrate later. Twenty-three families have been counted along about 50 miles of beaches on a day in late May, and the school at Tuktoyaktuk is closed during the sunny trout-jigging and goose-shooting days of May. Hunters near Inuvik often dive into snow banks or pull their parkas over their heads to avoid detection when the area is checked from the air in spring. But near the outer settlements a hearty wave from the hunters greets the patrolling plane.

The cultural and economic changes in the Arctic permit fewer people to take time off from work or school for the hunt. The need for hunting food is decreasing, but the need for cultural identity is still strong. As one resident put it: "As a wolf just has to howl at the moon I just got to get out there when the wavies are flying."
Thomas W. Barry

Whooping crane management

The whooping crane is North America's most widely publicized bird. The species has increased by only one bird a year during the last 27 years, a low rate caused, in part, by the loss of nearly one half the crane's nesting effort. Although the birds normally lay two eggs, the arrival of twin young at the Aransas winter headquarters is a rare occurrence. The Canadian Wildlife Service and the U.S. Bureau of Sport Fisheries and Wildlife embarked in 1967 on a program to collect whooping crane eggs from the wild. This will hopefully result in a captive flock of whooping cranes, at the Patuxent Wildlife Research Centre in Maryland, from which young whooping cranes can be released to bolster the existing wild population.

Six eggs were picked up in 1967, nine eggs and a recently hatched chick in 1968, ten eggs in 1969. The numbers of known breeding pairs in 1967, 1968 and 1969 were 11, 10 and 12, and these produced nine, six and five young respectively. Fourteen breeding pairs were counted in 1970 but a pick-up was not made, so the number of young produced is not known.

Of the 31 nests observed during the four summers, 28 contained two eggs, the remaining three nests contained a single egg. Both eggs in one nest found in 1969 failed to hatch; the eggs were infertile or else died at an early stage as no identifiable embryo could be found.

It is not known why 5 to 6 chicks died in 1969. The extremely dry summer could have caused difficulties in the feeding routine of the whooping crane families. In addition, the dried up ponds would have made nests more accessible to the larger terrestrial predators.

Following the 1970 breeding season 51 wild adult whooping cranes and six young returned to the Aransas National Wildlife Refuge. This was an increase of one from 1969. The addition of 21 captive birds brings the world population of whooping cranes to 78.
Ernie Kuyt

Non-game bird population studies

Man's activities are changing the environment in many ways: some affect his own well-being, some affect bird populations. Detection and measurement of year-to-year changes in numbers of birds may reflect unseen changes in the environment, such as those due to insidious pollution, as well as obvious ones, such as replacement of forest and farmland by housing and industry.

The Canadian Wildlife Service is responsible for protection and well-being of song- and water-birds described as "migratory insectivorous birds" and "migratory non-game birds" in the Migratory Birds Convention Act. But it was not until 1968 that its Migratory Birds Populations Section began population studies of these species, chiefly song birds. The more vulnerable water birds are being investigated by the Toxic Chemicals Section. Our population studies are greatly dependent on the efforts of volunteer bird students across Canada, who have done much of the groundwork for two major projects: the breeding bird survey, a co-operative effort with the U.S.A.; and the nest record programs. I have been co-ordinating work done by volunteers.

In addition I have been studying densities of breeding birds in the northern forests of Canada, and testing census and analysis methods at the same time, since 1968. Work was done in the Miramichi area of central New Brunswick in 1968 and 1969; and in the Lake Abitibi area near the Quebec–Ontario border in 1970. The study will continue in the latter region in 1971 and farther west in subsequent years.

The co-operative breeding bird survey in Canada

The breeding bird survey was started by the United States Fish and Wildlife Service in 1966 and Canada has been participating since 1968. The survey covers all provinces but Newfoundland. It is co-ordinated through volunteer organizers in each province, and is restricted to those areas which have an adequate road network, that is, the southern parts of most provinces. In the Maritimes, coverage is more extensive as the roads are more widespread.

Assessment of trends over wide areas is most conveniently done by random sampling. Each survey route is based on a randomly chosen starting point and direction, and each comprises 50 stops of three minutes each, at half-mile intervals along a road. Each route is surveyed once, under favourable conditions, during June, starting half an hour before sunrise. At each stop, all birds heard and seen are listed on forms; and the time and weather conditions at the start and finish are also noted.

Year-to-year changes are compared for routes with similar coverage. Analyses in Canada have so far been restricted to reasonably uniform areas within which at least 15 routes were comparably covered in successive years. Such comparisons were possible in the Maritimes for 1966–70 and in the agricultural region of southern Quebec and Ontario for 1968–70.

Few changes with statistical significance (at the 95 per cent level) have been detected. Several changes, between 1966 and 1967 in the Maritimes, were well correlated with cold, wet weather in April and May 1967. Other changes were in species whose seasonal numbers have previously fluctuated widely, probably from variations in food supplies, particularly seed crops of various trees, but detailed studies are lacking. Another significant change was caused by unseasonably late migration by blue jays in the Maritimes in 1968. While the scarcity of significant changes will be held up by some critics as evidence that the method is insensitive we are encouraged by the fact that nearly all changes detected can be correlated with known causes. Widespread decreases of a serious nature have not yet been indicated and we are annually examining the data for long-term trends.

The Canadian nest record programs

Nesting data are essential to studies of breeding biology. Published accounts of nesting of a species may be based on as little as fragmentary observations on one nest, or as much as detailed records of many hundreds, even thousands, of nests. These accounts are not definitive as they often stem from work done by a single worker in a small area. The need for more definitive accounts has led to development of nest record cards to assemble data from as many observers, over as wide an area, as possible.

The first nest record program began in England in 1939. In Canada, the first such program began in 1955 in British Columbia through the efforts of M. T. Myres who had worked on one of the early analyses of

The white-crested sparrow is one species censured in the non-game bird population study.
Photo by R. W. Fyfe.

data in the British Nest Records Scheme. This was followed by programs in Ontario, 1956 (little activity until 1963); the Prairie Provinces, 1958; Quebec, 1959 (little activity until 1969); the Maritime Provinces, 1960; and Newfoundland, 1969. The regional headquarters for the Canadian programs are located in Vancouver, Toronto, Winnipeg, Montreal, Saint John and St. John's.

Observers enter certain prescribed information relating to the nesting of birds on standard nest record cards (usually a separate one for each nest). At the end of each nesting season all completed cards for each region are assembled at one of the six headquarters where they are available for study. For 1970 about 10,000 nest record cards were assembled in the six Canadian files.

Although CWS personnel were active in setting up the Maritimes and Newfoundland programs and its biologists gave individual support to most of the other programs it was not until 1968 that CWS actively began to co-ordinate the regional programs. The six regions have since reached agreement on objectives and methods: approval of a standard format for the record cards; examination of cards on certain major species to see what proportion gives the data required for particular analyses; and preparation of material to give guidance on how best to collect and use nest record data. An important future step will be use of a computer to store data. This will permit storage of duplicate records in a convenient location where they can be easily retrieved for study, while the original cards remain at the regional centres. The format of the new card will facilitate transfer of data to punch-cards, and experimental coding and key punching of data should begin in 1971.
A. J. Erskine

Bird hazards to aircraft

A review

In the early days, when birds struck an aircraft they damaged the flimsy body but not the robust piston engine. As aircraft became sturdier, they suffered less damage, but introduction of turbine engines brought new problems. Ingestion of solid objects, such as birds, caused serious damage to engines.

The first human fatality caused by collision between bird and aircraft was in 1910. Birds and aircraft have since had many encounters. A bird strike in 1960 caused a crash near Boston which killed more than 60 people and drew international attention to this air hazard. Another strike in 1962 near Baltimore caused 17 deaths.

These crashes resulted in formation of the Associate Committee on Bird Hazards to Aircraft of the National Research Council (NRC) in 1962. The Departments of Transport and National Defense, NRC, CWS, major airlines, air engine manufacturers and the Canadian Airline Pilots Association are all active on the committee.

What kinds of birds cause damage? Where do they occur? Why are they there? These questions all needed answers. Three-quarters of Air Canada's accidents caused by birds take place near or on airfields, one-quarter occurs at higher altitudes. High speed military aircraft flying at low altitudes where birds are numerous have more in-flight accidents.

We tackled the problem of collisions near and on airfields first, listing common species and examining bird remains in engines and on the ground to find out which species most often collided with aircraft. We then sought reasons why these birds were attracted to airports. The reasons were obvious. Some species headed for such places as garbage dumps and drive-in theatres where food was exposed; some sought open water; some found shelter, and perhaps insects or small mammals, in tall vegetation.

Ecological surveys of each area enabled us to pinpoint the attractions. Garbage dumps were then removed, standing water drained away, low-lying areas filled, trees, shrubs and other tall vegetation cut down. Insects were controlled and some vegetative cover changed. For example, where commercial crops growing near runways were attractive to birds they were replaced with less attractive crops.

As airports are numerous, and some are large, making ecological changes took time. But the results were impressive. One major airline spent an average $238,000 a year to replace parts damaged by birds from 1959 through 1963, but only $125,000 a year from 1964 through 1968. Subsequent increase in use of jet aircraft has been accompanied by an increase in bird strikes; but the number per 10,000 aircraft movements has been constant since 1966, 30 per cent below levels which existed before the ecological control program began.

Dealing with bird hazards in the air has been more difficult, but we have made progress. The regular plan position radar used in air traffic control is suitable for seeing birds under all weather conditions and at all times. Single frame 16 mm movies are taken of each sweep of the radar antenna. When the movies are projected at regular speed—a speed-up of 240 times—a whole day's radar observation can be examined in a matter of minutes. The compressed time scale makes bird movement very obvious and easy to analyse.

A country-wide radar study told us a great deal about the extent of major bird movements. On one occasion 19 radar stations, stretching almost from coast to coast, were operated simultaneously. From this we discovered that much bird migration is a broad front phenomenon: birds were simultaneously moving south over an area several hundred miles wide. Radar studies confirmed what we had long suspected: many species migrate mainly at night, they begin and carry on major movements when winds are favourable and terminate or reverse them when weather is unfavourable.

Knowing the relationship between bird migration and weather patterns, we can base a migration forecast on a weather forecast and can predict migration accurately enough for flight training programs of the Department of National Defense.

The system pioneered in Canada is now being tried in several European countries. France has made most progress for it trains air traffic controllers to interpret and use radar data on bird migration. Studies made by a network of European radar stations have shown that bird migration in Europe is also related to weather patterns. But it may be more difficult to achieve our level of accurate forecasting because of the more subtle weather changes on that continent.

We do not understand the triggering mechanism in North America so we still have difficulty in forecasting the initiation of some movements. In some species favourable weather, wind speed and direction lasting a number of hours apparently trigger migration. The birds may then make an exploratory downwind flight of an hour or more and at altitudes reaching several thousand feet. If they judge conditions satisfactory for long-range migration they may continue; if not, they may return to their departure point. There they may wait until weather conditions once again send them into the air to test the situation.

We are correlating masses of weather data and radar records of bird migration in an attempt to simulate by computer the double decision the birds apparently make before beginning the long haul which may take them several hundred non-stop miles.

Although difficult, research on bird migration and the hazard to aircraft operation is rewarding because the results are immediately applicable to improving flight safety.

V. E. F. Solman

Radar studies of bird movements

Civil passenger aircraft cruise at 15,000 feet or higher and normally meet birds during climb and descent, especially on take-off from and landing at the airfield. The main problem is therefore keeping birds away from airfields by ecological modification, use of scaring devices and related techniques.

Military fighter aircraft speed along at a few hundred feet and collide with birds while in flight. The main problem here is forecasting bird movements. From 1964 through 1969 the Canadian Armed Forces (CAF) lost 12 CF-104 Starfighter aircraft to bird strikes, six of them from the Canadian Armed Forces Base (CFB) at Cold Lake in east central Alberta.

Operation Bird Track is a CWS-CAF attempt to reduce the number of in-flight bird strikes by developing a simple system for forecasting intensity of bird migration based on weather forecasts. Most studies have been carried out at Cold Lake where films were made of radar images and then analysed for correlation of bird movements with the weather.

Experimental forecasts during fall 1968 were 70 per cent accurate. During fall 1969

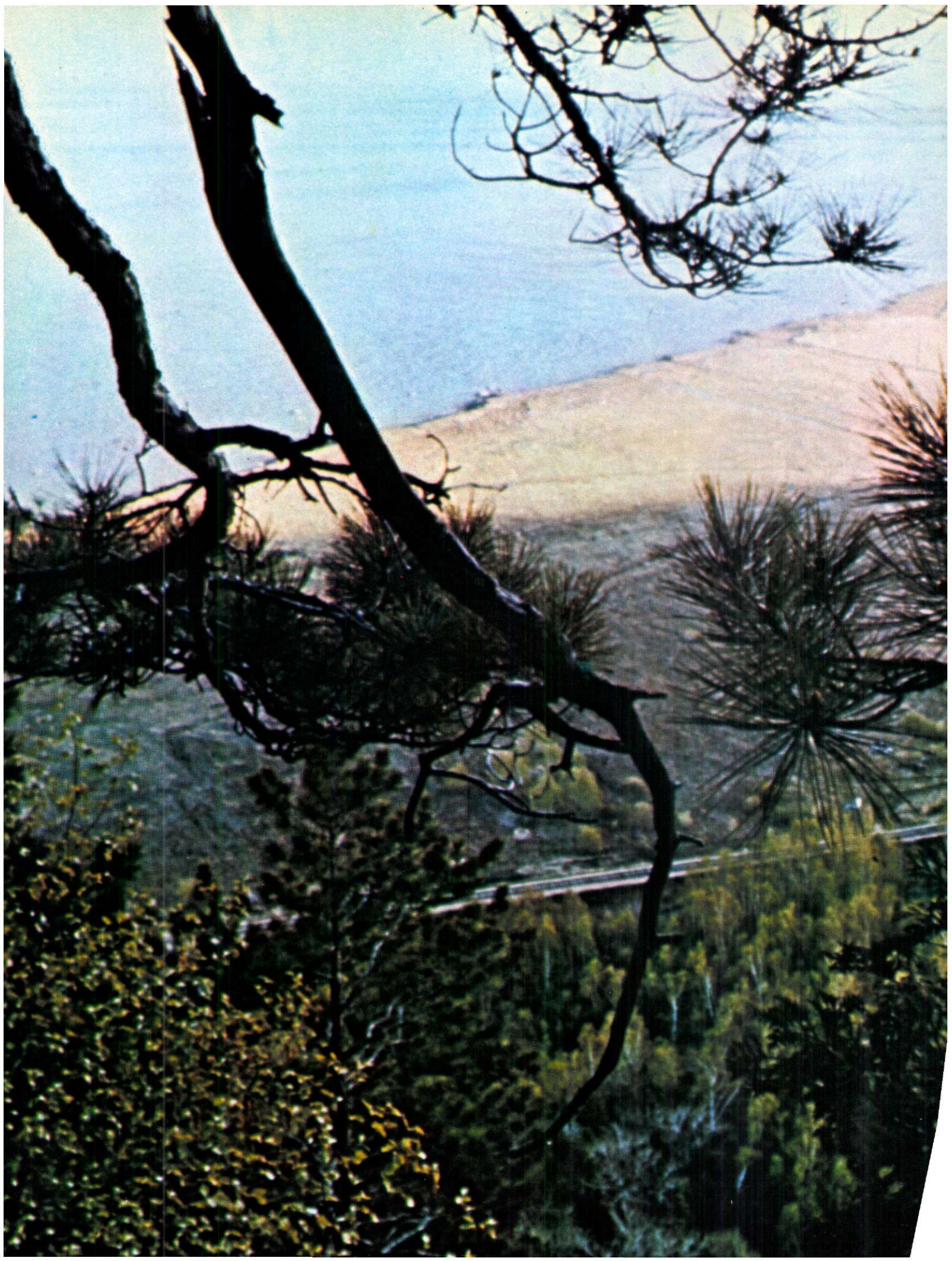
Whistling swans are also a hazard to aircraft with which they may share air routes. CWS and NRC have co-operated in tracking a number of birds, fitted with high frequency radio transmitters, to learn more about their migratory movements. Photo by A. H. Carmichael.

daily migration forecasts were given at the pilot's briefing at CFB Cold Lake. Further studies are being carried out to increase the forecasts' accuracy and usefulness.

The height of migration was studied with an anti-aircraft tracking radar to provide information requested by the pilots. The radar's narrow, circular beam was kept in a vertical position. The height of a bird flying through the beam could be determined directly from the position of the bird echo on the screen, although the radar could not detect birds below 1,200 feet. Analysis of the films showed that of birds flying above 1,200 feet, about 50 per cent were less than 3,500 feet above ground level, 90 per cent were less than 5,000 feet and 99 per cent were less than 10,000 feet. Indications that birds tried to select a height at which they had a good tail wind have prompted further investigations to determine whether forecast of migration height is possible.

Size, shape and speed of bird echoes on the radar screen do not generally indicate the species and number of birds; however recurring, distinctive movements sometimes indicate the species. For example, one particular movement occurring during the day in summer and consisting of large, slowly moving echoes represented local flights of pelicans. High-density movements near airports, such as roosting and feeding flights, are another serious but predictable hazard. These are being studied by radar for some major airports.

H. Blokpoel



Cap Tourmente National Wildlife Area, Quebec.
CWS photo by Christian Herdeg.

Land management

The preservation of our waterfowl resource at desired population levels is dependent on the maintenance and development of suitable habitat. Programs aimed at achieving this include wetland easement and acquisition and establishment of national wildlife areas throughout the country.

Waterfowl habitat in eastern Canada

Maritimes

Wetlands throughout the Maritimes have been listed in order of importance and individual marshes will be bought according to their rating. There are three national wildlife areas in this region: Sand Pond and Chignecto in Nova Scotia and Tantramar in New Brunswick. Several areas have been proposed for acquisition; some will need only maintenance in their natural state, while others will need extensive management development before their full value to wildlife can be realized.

For Tintamarre National Wildlife Area, a federal–provincial management committee has prepared a comprehensive management plan. Three water control structures have been established, ponds have been blasted with ammonium nitrate, cattail control plots have been set up, roads have been repaired and launching sites for boats have been built. In addition four small water impoundments were created on a portion of drained marshland. Similar projects are planned for other units. Ducks Unlimited (Canada) have provided funds for extensive work at the Tantramar area and for construction of a water control structure and fishway at the Sand Pond National Wildlife Area.

Allan D. Smith
William R. Whitman

Quebec

Marshland acquisition

The program for acquisition and development of marshlands in Quebec, undertaken in 1966, has progressed well. The program is aimed at recovery and preservation of waterfowl breeding grounds, wintering areas and migration points, all threatened with extinction. These areas, largely situated in populated regions, are endangered by industrial growth, housing developments and even agriculture. Ten areas have been proposed.

The Canadian Wildlife Service has already bought the Iles-de-la-Paix, islands situated in Lac St. Louis not far from Montreal, and land at Cap Tourmente some 30 miles downstream from Quebec City. Purchase of two other marshlands has been approved and negotiations are underway. These areas include islands, marshlands already drained for agriculture, marshlands almost drained and marshlands so dense that their yield of waterfowl is insufficient.

The acquisition program tries, first of all, to preserve good quality areas not yet needing management control. It also buys lower quality areas unattractive to waterfowl. Factors affecting the quality of such lands will be studied and defined so that appropriate management solutions can be put into effect.

Each area will be treated according to its condition: the quality and resources of the area will be evaluated, factors limiting development identified, a development plan emphasizing corrective techniques to be used drawn up, appropriate management instituted and the results assessed.

Marcel Laperle
Jean-Pierre Lamoureux

Description of aquatic plant associations

A study of some aquatic plant associations in the Montreal area was undertaken in parallel with our marshland acquisition program. The emerging annuals may present themselves in various forms, depending upon environmental conditions. Certain annuals attract migratory bird populations, others do not. Furthermore, a particular combination of factors will determine the presence or success of certain plants in competition with others.

The purpose of the study is to describe in detail the floristic composition of groupings of cattails, bulrushes, arrowheads and pickerelweeds under prevailing conditions. The abundance and dominance of the species will be correlated with such factors as water depth, soil acidity, texture and fertility. It is hoped that the main characteristics of the vegetation groupings will emerge from such correlation.

This information will be applicable to overall management of the marshlands. Here it is important that growth of useful aquatic plant species be controlled to a level favourable to waterfowl.

Jean-Pierre Lamoureux

Ontario

The wetland evaluation and acquisition program has been co-ordinated with the waterfowl sector of CLI and ensures that endangered major waterfowl areas will be purchased as soon as possible. Some possible national wildlife areas in southern Ontario have been given priority ranking. These listings are subject to periodic reassessment. A similar evaluation for northern Ontario is in progress.

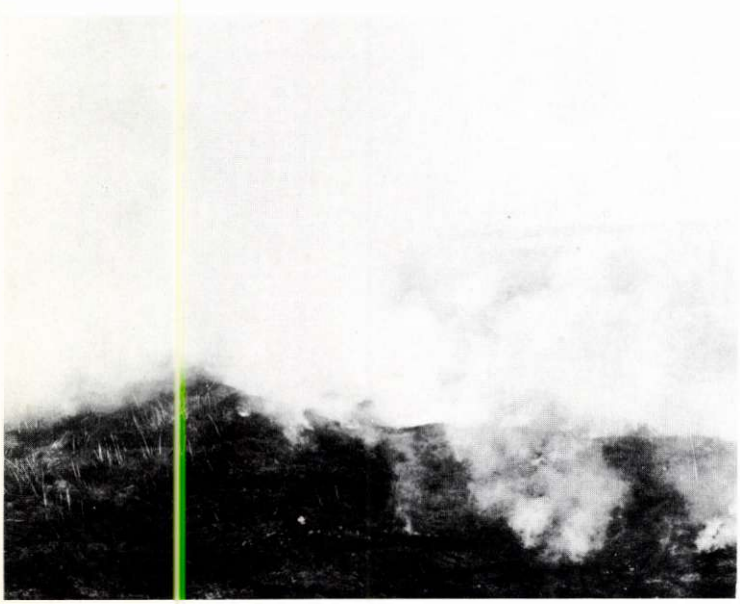
In southern Ontario we have bought one small parcel of land in Prince Edward County, we are negotiating purchase of two other areas and are preparing proposals for other major areas. Such acquisition will ensure preservation of important wetlands and will afford future development and management.

D. G. Dennis
R. E. Chandler

Dredging for cottage developments is a major threat to the marshes, important waterfowl habitat, in southern Ontario. Pigeon Lake, Ontario (upper).
CWS photo by R. E. Chandler.

When farmers burn marshes in springtime, valuable nesting cover for waterfowl is disturbed. Tantramar Marsh, New Brunswick (lower left).
CWS photo.

Pond created by blasting and wood duck nesting box at Front Lake, Tintamarre National Wildlife Area, New Brunswick (lower right).
CWS photo by A. D. Smith.



Waterfowl habitat in western Canada

The Prairies

Ways of preserving wetlands

A program to evaluate large marshes and buy wetlands within the parkland regions of the Prairie Provinces was begun in 1967. This program is co-ordinated with the basin easement program so that vehicles, aircraft, maps, aerial photos and technical help can be shared.

The first part of the project, listing of wetlands larger than 50 acres, was completed in fall 1970. Map reading, determining of wetland areas and legal description of the land were done mostly by summer students. The figures listed may not necessarily correspond with the actual size of the wetlands, but are useful as they give the numbers of basins larger than 50 acres.

The second part of the project is more complex. We must first consult provincial water conservation agencies to find out which of the areas listed are likely to be drained. We then make aerial surveys of all the wetlands in the region and select for high priority study those of good production quality which have been marked for future drainage. Biological surveys are then made so that the potential production per dollar spent may be assessed. From this we select wetlands for possible acquisition. Titles are searched, total costs of each area estimated and proposals prepared. The Real Estate Branch of the Department of Transport negotiates the purchase.

Suitable wetlands are also being preserved by lease agreements with landowners. This program was begun in 1967 and has covered 65,113 acres in western Canada. Under this program a landowner accepts annual payments for 10 years in exchange for his agreement not to drain or fill ponds important to waterfowl, or burn the associated marsh vegetation. Prompted by requests for integrated use of wetlands for ducks and agriculture we are making a detailed study of the value of wetlands to farmers. This will provide invaluable guidelines for achieving integrated uses at least expense to farmers and to CWS. The easement program is continuing but at a low level of activity.

An attempt is also being made to preserve waterfowl habitat through development and manipulation of water levels. Water development assistance is being granted to other agencies, usually after they have initiated development of the wetlands in question. As of February 1, 1971, 2,606 acres were covered by agreements.

Carl Surrendi
A. J. Goodman

Last Mountain Lake

Sandhill cranes and waterfowl at the north end of Last Mountain Lake, Saskatchewan, have seriously damaged commercial cereal crops in the last twenty years. This acute problem has been aggravated by the rising cost of farming. To alleviate depredation problems there, CWS has bought 14,260 acres of marginal farm lands which, combined with approximately 8,500 acres of crown land administered by the province of Saskatchewan and the Last Mountain Lake Bird Sanctuary, forms the Last Mountain Lake Wildlife Area.

Formation of the wildlife area has brought changes in land use. By September 1970, over 8,000 acres of former grain-producing land had been converted to forage production to provide nesting cover for birds and act as buffer zones between lure crops and commercial cereal crops growing outside the area. Local farmers will be allowed to cut and remove forage after the waterfowl nesting period is over. This will promote green forage for grazing geese and reduce the fire hazard.

Barley sown in lure crops discourages depredation by sandhill cranes and waterfowl on surrounding commercial crops. Lure crops planted on eighteen 60-acre plots are strategically located around the wildlife area. Grazing is limited to seven small pastures.

Last Mountain Lake Wildlife Centre will be established nearby. One of a chain of wildlife interpretation centres to be set up across the country, it will tell visitors about the natural features and management operations of the area.

J. P. Hatfield

British Columbia

A co-operative Inventory

The Federal–Provincial Co-operative Wetland Inventory in British Columbia is a data collection program covering all important waterfowl habitats in the province. Eventually the CWS Vancouver office will have on file the name and ownership of all major wetlands, the purposes for which they are used by birds and humans, and other pertinent information. Water acreages will be determined later. Under this program we are encouraging provincial personnel to reserve from sale all provincial crown lands known to be valuable to waterfowl. The Canada Land Inventory has been useful to this program as it already has data on a number of wetlands and we therefore need to examine fewer areas.

A wildlife management area

The Creston Valley Management Area is a 16,000-acre wetland established in 1968 by special legislation which placed its management under the British Columbia Fish and Wildlife Branch and CWS, with federal and provincial governments sharing administrative costs. Legal complications concerned with water use rights and local and international agreements held up development for some time, but major water control structures are now being built.

Indian reserve lands

Three thousand acres of choice marshlands belonging to the Lower Kootenay Band of Creston, British Columbia, are being preserved for a five-year period under lease agreement which may be extended. Ducks Unlimited (Canada) has begun a small water control project in part of the marsh and if this is extended the marsh can be improved to optimum production.

Payments under the lease agreement have greatly increased the band funds and made possible new housing construction. The band could take part in marsh development and management, hunting, trapping, guiding and associated tourist activities.

R. D. Harris

Canada Land Inventory

Good waterfowl habitat exists near Cartwright, Manitoba.
CWS photo.

The Agricultural and Rural Development Act (ARDA) passed in 1961 was intended to help farmers in depressed areas use the land more productively and thus increase their income. Consolidating small uneconomical farms, improving methods of cultivation, and abandoning submarginal farms were possible solutions. A knowledge of farm quality, age and education of farmers, and capability of land for other than agricultural purposes was needed to decide on the best solution.

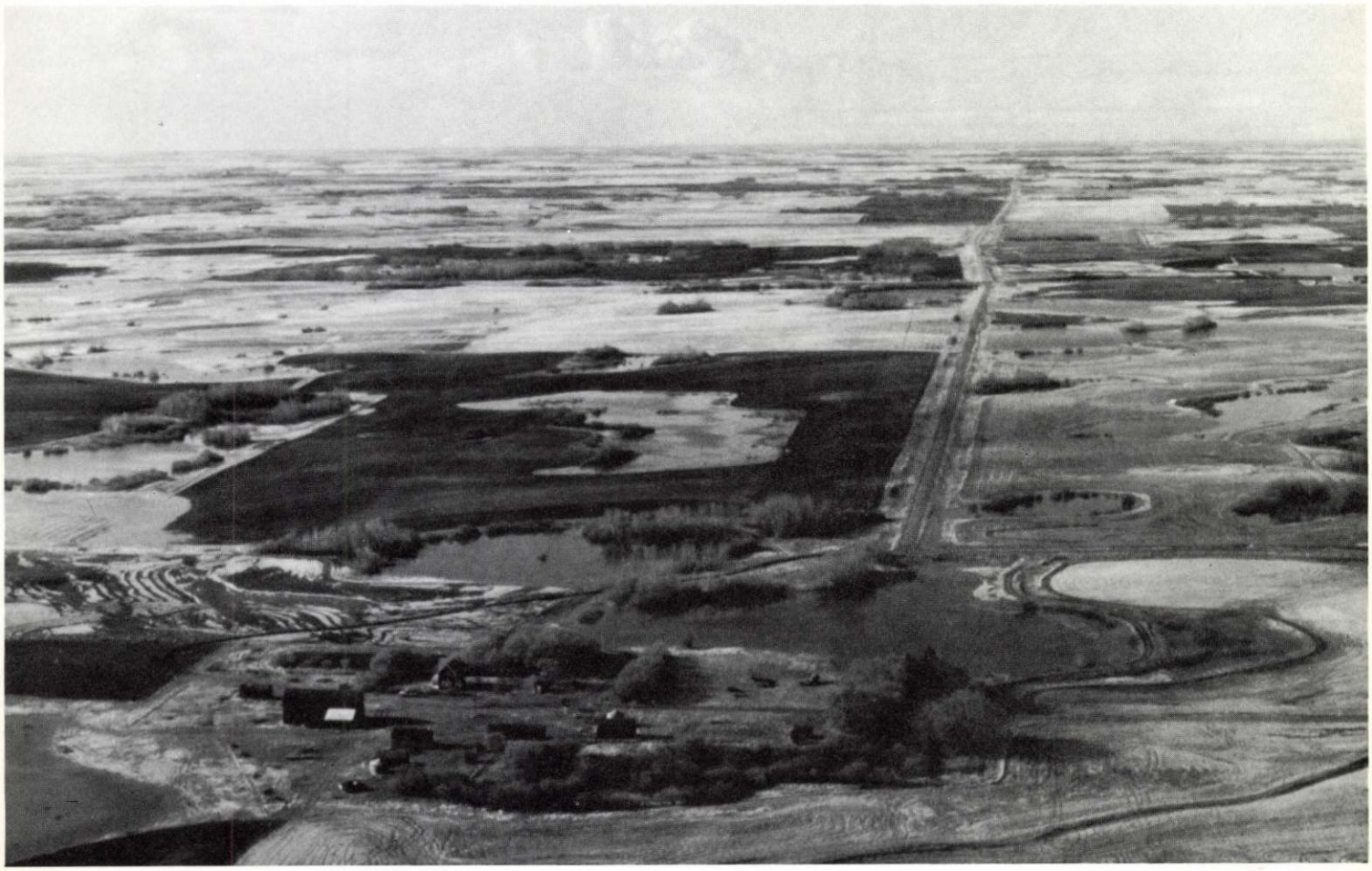
The Canada Land Inventory is gathering data on capability of land to support agriculture, forestry, recreation and wildlife in an area of nearly a million square miles across southern Canada. This data will be presented on maps. Capability mapping in the wildlife sector is being done by the Canadian Wildlife Service and the provincial wildlife agencies with financing by the Department of Regional Economic Expansion.

The co-ordinator of the wildlife sector, co-operating with CWS and provincial biologists, has developed a classification system for wildlife capability. Classes range from 1 (highest potential for waterfowl production) to 7 (unsuitable for waterfowl). All classes but 1 are further subclassified to show why a particular area was assigned to a particular class. Water depth and permanency, quality and quantity of emergent and submergent vegetation, acidity or alkalinity of soil, topographic factors governing abundance of ponds, and climate are some factors taken into account. One or several of these conditions may limit production by their absence (vegetation) or excess (acidity). Data on water quality was also collected but its relationship to waterfowl use or productivity of wetlands is not yet clear. Preliminary mapping was from aerial photos. Further ground and aerial studies were made.

Maps are produced in two forms. Highly detailed maps (for every capability but game fish) on a scale of one mile to the inch (1:50,000) are stored by computer with data on current land use and socio-economic conditions. These maps are available only to personnel engaged in land management, rural and urban planning and associated studies. Simplified colour maps at a scale of five miles to the inch (1:250,000) are sold to the public in Information Canada bookshops at 35 cents a copy. The wildlife sector's colour series will include 196 waterfowl and 196 ungulate maps and will be completed by 1972 or 1973.

CWS biologists in provinces where work preliminary to mapping has been completed are taking part in land-use planning projects at municipal and regional levels. Their participation in planning ensures that other agencies are more aware of the extent of wildlife resources and the need to protect or improve wildlife habitat during the early stages of an area's development.

V. E. F. Solman



Mammalogy

Barren-ground caribou. CWS studies on the Kaminuriak population will provide important information necessary to management. Photo by W. J. Stephens.

Research by the eastern region

Biologist Dick Russell examines polar bear skulls in the Eastern Region laboratory. Skulls are used to determine age and differences in polar bear populations.
Photo by G. Ben, Department of Biology, University of Ottawa.

Ecology of the snowshoe hare in the Maritimes

The snowshoe or varying hare is an important game species in the Maritimes which may have a considerable effect on forestry values. Investigation of the hare in relation to the forest ecology of the region was begun in 1967.

A very pronounced 10-year cycle has been described in snowshoe hare populations in western Canada, with associated changes in production of young and survival of animals of all ages. Hare populations in central New Brunswick are being monitored through a trap-release program in an attempt to describe in more detail the fluctuations occurring there. Live-trapping is carried out during spring, summer and autumn on a 500-acre study area. Each animal is permanently marked with an ear tattoo and metal tags between the toes, and data are recorded on breeding state and body condition. Population density is estimated from the frequency with which marked animals are recaptured.

Annual variations in reproductive rates, juvenile and adult survival, habitat selection, food habits and movements are derived from live-trapping kills and observations. These variations are studied and related to fluctuations in population size.

Available and utilized browse tallied in spring are used to determine patterns of food selection in winter. Important browse species are analyzed to estimate variations in the nutritive values of available food.

With co-operation of wildlife branches of New Brunswick, Prince Edward Island and Nova Scotia large numbers of hares are collected from ecologically diverse areas in those provinces. The specimens are examined for data on reproduction, morphology and parasitology which will indicate possible variations in populations. Data from this study will also contribute to knowledge of hare-forest relationships in an area where study of the hare has been inadequate, and will provide a basis for better understanding of its ecological role in Maritime forests.
Thomas J. Wood

Structural adaptation of Canadian mammals to snow

We can judge the ability of mammals to move about and feed in snow of varied depth and physical quality by taking certain body measurements. With these measurements we can also compare the efficiency of age and sex groups and, more important, of competing species and prey and predator species. Scientists in the U.S.S.R. have pioneered in this field and it is only recently that North American ecologists interested in winter environments have taken note of it.

A simple measurement, not taken on most Canadian mammals, is the chest height. When an animal must travel in belly-deep snow for a long time it is usually in trouble. Some forested areas are almost devoid of large mammals simply because winter snow is always too deep. Their longer legs make it possible for moose to live in winter in some of the deep snow areas in Canada's Atlantic provinces which are out of bounds to deer. Wolves rarely inhabit some areas of the boreal forest, probably because their legs are too short for travelling during the winter through deep soft snow.

A second useful measurement is the weight-load-on-track. To determine this the weight of the animal is divided by the area of its hoofs or feet. The result, usually given as pounds/square inch or grams (g)/square centimeter (cm^2), indicates the depth to which an animal will sink in snow of given hardness or density. For example, a moose with a weight-load-on-track of perhaps 1,000 g/cm^2 will sink much further into hard snow than a caribou with a weight loading of perhaps only 200 g/cm^2, or a wolf with a weight loading of perhaps only 150 g/cm^2.

Furthermore, careful, and perhaps some experimental, measurement should make it possible to express quantitatively how efficiently certain mammals can increase the size of their feet to meet particularly soft

Tom Manning straddles a drugged polar bear while Charles Jonkel carries out the ear tagging operation. Tagging a live bear enables the biologist to determine its movements.
CWS photo.

and deep snow. For example, on a soft and difficult surface caribou, moose and, perhaps, deer can spread their hoofs and use the whole area from the tip of the hoof to the dew claws as a bearing surface.

Data on chest heights and weight loadings of our common fur and game mammals will give bio-ecologists and zoogeographers a new parameter for studying mammals, their range limits and their winter environment. Canadian Wildlife Service projects collectively offer a splendid opportunity to gather data required over a long term with little special effort or cost, but other sources of comparative data will also be used. The first measurements were taken in 1969 when surplus game mammals were slaughtered in national parks. Results will be published from time to time as sufficient data are collected.

John P. Kelsall
E. S. Telfer

Polar bear project

The early stages of our polar bear research project, begun in 1961, were concerned with general ecology and life history. Bear denning areas and habits were studied in the field and through literature review. We are now emphasizing studies of bear density, movements, growth rates, reproductive rates, food habits, behaviour, taxonomy and harvest. Particular attention has been given to capture techniques, the recovery of marked animals and the collection of biological specimens from harvested animals.

We have been conducting aerial surveys in the southern Hudson Bay area, in cooperation with the provinces of Manitoba and Ontario, and are testing various other census techniques. Concurrent studies of sex and age structure indicate a marked segregation during summer and autumn periods along the Manitoba–Ontario coastline and in March and April in James Bay.

Our marking program resulted in the capture of about 150 polar bears by the end of 1969. All bears were marked with ear tags and lip tattoos, and some were fitted with radio transmitter collars. Aerial surveys, recaptures, and kills by Eskimo and Indian hunters have resulted in the observation or recovery of 105 marked bears, including 31 recovered after a significant lapse of time. Our data indicate that certain bears do not move great distances. For example, bears fitted with transmitters at Churchill, Manitoba, and tracked by radio telemetry, moved to the sea ice of Hudson Bay by late November in 1968 and 1969, but they did not travel more than 100 miles from shore or 250 miles north of their tagging site.

Polar bear harvest studies show that the kill in Canada has declined significantly since the peak year of 1966–67 when over 700 bears were killed. During the 1967–

Pestered by mosquitoes along the Kazan River, NWT, David Lampard weighs organs of caribou. Examination of visceral and reproductive organs will give information on the animal's condition and breeding activity.
CWS photo by T. C. Dauphiné.

68 and 1968–69 seasons fewer than 500 bears were killed or captured in each of the two subsequent seasons.

Morphometric studies of the world polar bear population, being carried out by T. H. Manning under CWS contract, indicate that discrete populations of polar bears do exist (*Geographical variation in the polar bear, Ursus maritimus Phipps* by T. H. Manning, CWS Report Series No. 13, 1971). Polar bear food habits are being studied in co-operation with a graduate student from the University of Alberta, Edmonton. He has described the feeding behaviour of polar bears and compared the food habits of island and mainland polar bear. The study will eventually include relationships between polar bears and seals, and the relationship between latitudinal variations in diet with growth and reproductive rates.

A study of the behaviour of polar bears on North Twin Island in James Bay, Northwest Territories, is being conducted, with CWS co-operation, by a Manitoba student doing graduate work at the University of Montana. His studies are closely related to our mainland behavioural work, and may include comparative studies on Cape Churchill and in the High Arctic.
Charles Jonkel

Barren-ground caribou

Studies on the Kaminuriak population

Canadian barren-ground caribou have had more careful study than all but a very few groups of wild animals. Recruitment rates, mortality rates, range relationships and year-to-year variability of these factors are, nevertheless, not sufficiently understood. As a result, management of this species in northern Canada is not adequately based on these important aspects of caribou ecology.

A research project was designed in 1964 and 1965 to answer specific questions on the ecology of the barren-ground caribou, solve outstanding management problems and, subsequently, devise a joint pilot management scheme with the responsible provincial and territorial wildlife agencies. Applied research on wide-ranging wildlife populations is so demanding of skilled manpower and money that our study had to be restricted to a single population and a three-year period. We have called this population the Kaminuriak population, following the practice of naming populations after their

calving areas. Tagging by the Manitoba Wildlife Branch and by the research team has made us confident that the Kaminuriak population is sufficiently discrete from adjacent groups and, except perhaps for certain animals habitually wintering on the tundra regions, sufficiently intermixed to be described as a population.

This population supplies food and other products to inhabitants of southern and central Keewatin in summer and early fall, and to those of northwestern Manitoba and northeastern Saskatchewan in winter and early spring. J. P. Kelsall, CWS biologist, has set the value of a barren-ground caribou carcass at 60 dollars and using this figure, the meat from this population alone would amount to nearly one-quarter of a million dollars.

Between April 1966 and July 1968, 999 barren-ground caribou were collected for study. The initial animals were taken in spring and autumn 1966 and 1967 and in spring 1968 on their wintering range in the taiga of northwestern Manitoba. In spring 1967 we also took caribou from groups that had moved westward to northeastern Saskatchewan and northward to the transitional forest zone, beyond the province's northern boundary, in the District of Mackenzie, Northwest Territories.

From 1966 to 1968 caribou were collected on the calving ground between Gibson Lake and Kaminuriak Lake, District of Keewatin, NWT. In late summer and early autumn 1966 caribou were collected from the transitional forest zone west of the north end of Tatinnai Lake and in 1967 on the tundra south of Maguse Lake and north of Camp Lake, District of Keewatin. During July 1968 we took subsamples of caribou south of Baker Lake from the Kaminuriak population and southwest of Aberdeen Lake from the Beverly population.

To foster a sense of individual research accomplishment, each of four biologists, whose reports follow, was assigned a particular series of investigations. I was project leader responsible for planning, management and co-ordination during the first year of field work. F. L. Miller took over as project leader for the second year, and for subsequent laboratory work. G. D. Tessier, head technician and laboratory manager at the Eastern Region headquarters, assisted the team.

Of the four studies, three were concerned primarily with the population's condition, age composition and sex class. One is a study of winter range, with particular reference to plant composition and productivity.
Andrew H. Macpherson

Determining the age

The objective of my study was to develop methods of aging live caribou for obtaining data on band and herd composition. The jaws of animals killed at known dates during the year were used to determine the eruption schedule of the teeth and to study annulations in the cementum of the teeth. Cementum deposition in the teeth of caribou is more rapid in the summer than in the winter. This alternation in deposition rate shows up as rings close together (summer growth) and rings further apart (winter growth). An annulation is the set of rings showing the full year's growth. By counting these annulations it is possible to arrive at the age of the caribou, much as one would arrive at the age of a tree by counting its growth rings. Detailed examination of the teeth was completed in April 1969 and the data are being processed by computer.

This study will enable other project members to better evaluate physical condition, reproductive rates, food habits and population estimates for the Kaminuriak population.
Frank L. Miller

Condition and reproduction

The objectives of my phase of the project were to determine the productivity of females related to the incidence of ovulation, conception and birth of young; and to determine, for each sex and age group, the degree and significance of nutritional changes caused by differences in breeding activity and seasonal availability of food.

From each specimen I measured body weight, body size, fat deposits and some of the visceral and reproductive organs. Female reproductive organs were examined for evidence of current breeding activity, and microscope mounts from the ovaries were used to determine aspects of past breeding activity.

The results support the view that the animals are well adapted to northern environment. Despite the poor quality of food in winter and the arduous spring migration, almost 90 per cent of the adult females produced a calf each June. In addition, marked seasonal fluctuation in the balance between energy intake and expenditure was indicated by varying amounts of fat deposits, yet no serious malnutrition was encountered in any of the specimens.

Compared to other North American caribou and reindeer, the Kaminuriak population apparently withstands an unusually difficult environment. This is indicated by the comparatively slow growth and accumulation of fat reserves, particularly in young animals, which results in the delayed sexual maturity of some females. Half of the females first bred at 28 months of age, most of the remaining half not until 40 months of age. These factors are certainly liabilities to the population's potential growth and must be considered in its management.
T. Charles Dauphiné

Seasonal distribution and total numbers

Intensive aerial surveillance of the Kaminuriak population from May 1966 to October 1968 provided detailed information on seasonal distribution and extent of range utilization.

The total range is approximately 282,310 square kilometres (sq km), bordered on the north by Chesterfield Inlet and Baker Lake and on the south by the Churchill River and latitude 57° N. The western boundary extends southwest from Baker Lake to Selwyn Lake, NWT, and southeast to Reindeer Lake on the Manitoba–Saskatchewan border.

The summer range is about 160,606 sq km and lies north of a line extending westward from the mouth of the Caribou River, south of Caribou Lake, and across Nueltin Lake to the north end of Snowbird Lake in the District of Mackenzie, NWT. The winter range in the open boreal forest or taiga is about 121,704 sq km. During the study, however, most caribou wintered on the western half of this area. Some caribou winter on the coastal lowland tundra west of Eskimo Point and Rankin Inlet, but their numbers are usually relatively low and may vary from year to year.

A total population estimate was derived from a combination of winter aerial transect surveys, a random grid sampling survey of the calving ground, post-calving aerial photography in July, and data on sex and

Caribou migrate to their calving ground between Gibson and Kaminuriak Lakes, District of Keewatin, NWT.
Photo by G. R. Parker.

age composition. Before calving in May 1968, the population was estimated at 63,120. In 1950, Banfield reported a population of 120,000. Loughrey estimated it at 149,000 five years later; McEwan at 30,000 to 50,000 in 1959. The population apparently decreased sharply from 1950 to 1959 and remained relatively stable until 1968.

Mortality of calves is high with 78 per cent not surviving the first year in 1968. Of these, 68 per cent died during their first four to five weeks. Factors contributing to this high mortality immediately after birth are unknown. By spring, calves comprised approximately 9 to 10 per cent of the total population.

Native hunters took an estimated 5.3 per cent of the caribou older than one year in 1967–68, a sharp decrease from the annual harvest of 29 per cent estimated in 1947–48. The combined mortality factors—hunting, predation, accidents and disease—are apparently preventing substantial increase of the population.

During the winter months of 1966–67 and 1967–68 caribou were herded by plane from frozen lakes into the bush, where they were captured in nets set across their trails. A series of data were recorded from each animal and identifying collars were placed around their necks. Aerial observations of the collared animals assisted in determining seasonal and daily movement patterns.
G. R. Parker

Winter range

Research on the Kaminuriak population's food habits in winter, condition of winter range and its capacity to support animals using it began in June 1966. The data have not been completely analysed but my observations suggest that the winter range is in good condition and adequately sustains the current use.

Snow depth and hardness primarily determine availability of forage on the winter range and this in turn affects the caribou's feeding habits. In early winter snow cover does not limit movement and the animals have access to most of the forage. As winter progresses snow cover becomes deeper, drifts and crusts are formed on exposed sites by wind action and forage remains available only on protected sites. During mid winter caribou feed in forested places where the snow is soft. In late winter the lengthening daylight and increasing solar heat cause intermittent freezing and thawing of snow. In addition, caribou dig feeding craters in the snow. These factors cause hardening of the snow which limits the supply of ground forage. The caribou adapt by browsing on trees and arboreal lichens, but go back to eating ground forage as soon as it reappears on southern exposures when heat from the sun melts away the snow crusts.

The snow-covered winter range is little affected by caribou. But the patches of slow-growing ground lichens, which appear in early spring, undergo heavy cropping. These lichens make up 50 per cent of the winter-spring diet. Fortunately, the appearance of lichen patches marks the start of spring migration towards the calving grounds and range damage is negligible.
Donald R. Miller

Research by the western region

Biologist Andrew Radvanyi applies a numbered ear tag to a deer mouse on a logged lodgepole pine study area near Hinton, Alberta.
CWS photo.

Influence of small mammals on forest regeneration

We have been studying the influence of small mammals on forest regeneration in western Alberta since 1962. Our preliminary work with tracking coniferous seeds treated with radio-isotopes has been described in *CWS '66*. This phase of the study revealed that small mammals destroy up to half the seed sown, even when they are treated with an insecticide, a fungicide and an aluminum-latex coating. The study also showed that mid or late winter is a better time for sowing than late spring.

A new seed coating treatment has been developed to replace the highly dangerous and not too effective insecticide, endrin. The new substance is a potent rodent repellent which, when mixed with graphite powder and placed around the seed, retains the dull black colour that makes it nearly invisible on dark soil. Under laboratory conditions the repellent has been more than 99 per cent effective as a deterrent to small mammals, and the treated seed have had a higher germination rate.

To compare their effectiveness under natural conditions, radio-tagged white spruce seeds were treated with endrin and with the repellent. The former were sown on study plots in winter and early summer 1969 and 1970, the latter in early summer 1970. The winter seeding resulted in higher germination than the early summer seeding; and germination of repellent coated seeds was 29 per cent higher than that of endrin coated seeds sown at the same time. As the federal government has banned use of endrin, the new coating could substantially contribute to Canadian forestry.

Andrew Radvanyi

Caribou and reindeer nutritional studies

Data on nutrition of caribou and reindeer are required for their management. Both species are important to the economy of northern Canada and are valuable sources of food for residents of the region. Caribou and reindeer are kept under controlled conditions at a laboratory of the University of British Columbia, Vancouver. The animals have become tractable, despite their captive environment.

We have undertaken experiments to determine their energy and nitrogen requirements for growth up to two years, a task made difficult in wild ruminants because they have a cyclical rather than a continuous growth pattern. Caribou and reindeer feed in winter largely on lichen, a plant low in nitrogen, and we are investigating their ability to recycle urea.

Accumulated body fat makes up a large portion of the summer weight of both captive and adult animals. Studies of body composition of an adult male reindeer weighing 210 kilograms (kg) showed that fat made up 20 per cent of the total weight. Since oxidation of fat yields 9.3 kilocalories per gram (kcal/g), that stored energy represented about 37,000 kcal. In wild adults the replenishment of fat deposits in late summer and autumn undoubtedly enhances their survival during the crucial winter period.

We already know that inclement weather is a factor in calf mortality and are investigating others. Our experiments will determine the requirements, particularly of energy and nitrogen, for pre- and post-natal development. The mean daily energy intake for lactating caribou and reindeer is more than three times the adult maintenance level. The newborn calf's energy intake from birth to weaning is also being assessed. A lactating cow can produce daily about 1.5 litres of milk, which represents digestible energy of about 3,900 kcal/day.

The daily water turnover rate indicates the amount of milk taken by the calf. If the mother's milk is injected with tritium, the calf takes the dye into the digestive system when it nurses and eliminates it in the urine. The extent to which the tritium is diluted in the urine is a measure of how much water comes from the milk.

Understanding calf mortality also requires information on the newborn's blood chemistry and on post-natal changes, and these factors are being studied.

E. H. McEwan

Studies in the Barren-lands

Wolf–caribou interrelationships

Wolf studies on summer and winter range of barren-ground caribou were carried out from 1960 to 1965. Study of the feeding ecology of wolves on barren-ground caribou range, an important aspect of wolf–caribou research, has been completed and a report prepared for publication.

The relationships between wolves and caribou were studied in the Thelon Game Sanctuary, NWT. Photo by E. Kuyt.

Wolves were studied during spring and summer 1969 in the Thelon Game Sanctuary with supplementary work on caribou winter range north of Yellowknife and east of Fort Smith, Northwest Territories. Thirty-one young wolves from 11 different litters were ear-tagged. Of these, nine (29 per cent) were recovered, one as far away as 225 air miles from the den site. The tagging studies confirm the suspected close interrelationships between tundra wolves and migrating barren-ground caribou. These wolves are found in close association with caribou throughout the year, except for a two-month period when the breeding wolves stop following the caribou herds northwards to raise their young. During the denning period, wolves cannot rely on caribou for food and must turn to other prey species.

Analysis of 595 summer wolf droppings from two broad age groups (cubs and wolves other than cubs) and from two regions (one occupied by caribou, the other devoid of caribou) shows that of 1,039 identified food items 38 per cent were remains of adult caribou, and 9 per cent were remains of calf caribou. Lemmings and mice were eaten by adults and cubs alike, regardless of the caribou's presence. These small mammals were an important 13 per cent of the wolf's diet. Small birds, ptarmigan, birds' eggs, fish and insects were utilized to a much greater extent by southern wolves—to whom caribou were inaccessible during part of the denning season—than by northern wolves which were in relatively frequent contact with caribou. Available muskox and ground squirrel were not important as prey species of wolves.

Mortality rates of young wolves in the southern part of the breeding area were greater than those of young wolves raised farther north. Average litter size of wolf cubs about five to seven weeks old was 4.3 cubs in northern areas and only 2 cubs in southern areas devoid of caribou. Adult wolves and some cubs survived in areas where caribou were not found during part of the summer, but wolves in areas where caribou ranged for a larger part of the time raised larger litters.

Examination of stomach contents of wolves killed on caribou winter range in forested areas confirmed that caribou are the staple diet in winter. Throughout the year, caribou calves suffer heaviest mortality. Caribou eight years old and over are also subject to heavy wolf predation and females are easier victims than males.

The act of predation is rarely witnessed but examination of caribou freshly killed by wolves has shown that the neck or shoulder is the initial point of attack. That area is bitten by the wolf, the caribou is pulled or knocked down, then killed by a crushing bite in the neck. None of the caribou known to have been killed by wolves was brought down by "ham stringing." Wolves prefer the flesh of the neck and throat, tongue, liver, heart, kidneys and lungs. When a wolf kills a caribou in winter he invariably devours it completely. In summer, he frequently leaves parts of the carcass on which a host of mammals and birds can scavenge. It is estimated that a free-living wolf would eat an average of about 23 caribou annually. During brief periods of maximum winter compression of barren-ground caribou densities of one wolf per 6.9 square miles have been recorded. Such high densities are temporary and only occur locally.

Studies of captive wolves were completed and the animals donated to a zoo. During their last three years of captivity the wolves ate about 3½ pounds of meat, fat and dog food per day, and more than that when they were growing cubs.

A brief report on the anlysis of wolf milk has been published and a report on parasites of wolves is given in the pathology section.

Wolverine

We have also been studying the distribution, food habits, weights and measurements of wolverine in the Mackenzie District, NWT. Specimens of wolverine carcasses have been obtained from a predator control hunter and an examination of these specimens will give data on parasites, reproduction and age.

We are also attempting to report on sex, weights and distribution of wolverine north of Yellowknife. This will be based on collections made from 1954 to 1960 during predator control operations there.

Ernie Kuyt

Furbearers of the Mackenzie Delta

Population studies of muskrat, beaver, mink and marten, particularly valuable furbearing animals of the Mackenzie Delta, are being made by the Canadian Wildlife Service. Muskrat and beaver are being given particular emphasis. Mink and marten will be the subjects of closer study once the investigation of the other species is completed.

Muskrat

As muskrats have primary importance in the harvest they are being intensively investigated. The work done by W. E. Stevens, E. H. McEwan and J. E. Bryant is the basis for our study. We have chosen muskrat populations in selected lakes in the Mackenzie Delta and are attempting to learn more about their ecology by studying fluctuations in the environment, and changes in population caused by natural and artificial factors. Data on this selected population will be related to the delta's total population. We have followed a complete population cycle of animals in the study area. Populations were high in 1962, but declined markedly in 1963. The resulting low densities from 1963 through 1966 were followed by a recovery in 1967 and high densities in 1968. Another decline of lesser magnitude occurred in 1969.

Our investigations were less intensive in 1967 and 1968, with minimal live-trapping, harvest sampling and density determination. Field work was also limited in 1969 and 1970. We have processed a large quantity of biological samples and field data and a final report is pending.

Beaver

The beaver studies have been greatly reduced since our last report in *CWS '66*. A portion of the studies was completed in 1968 and reported in Michael Aleksiuk's thesis, a part of which is summarized here.

The beaver's energy regime fluctuates widely in the northern portion of its range. The animal has free access to growing plants in summer but has only a store of cached saplings in winter. In the Mackenzie Delta the animals grew rapidly in summer and not at all in winter. Immature animals lost weight in winter. The adults put on fat in the autumn, kept it in the winter, lost it in the spring and remained lean in the summer. Thyroid glands weighed more in the summer, less in the winter. We concluded that the beaver's expenditure of energy is high in summer when food is abundant and low in winter when food is limited.

In seeking out extrinsic causes of this annual pattern in northern beavers, we hypothesized that the thyroid gland had the major effect on the animal's metabolic pattern; and light intensity, acting as a timing device, tied the expenditure of energy to environmental conditions. We kept California and Arctic beavers in Vancouver and allowed them free access to a constant ration. The California beavers did not undergo major seasonal changes in thyroid activity, food intake or growth. On the other hand, the Arctic beaver's thyroid activity was depressed, food intake was reduced by 40 per cent and growth stopped. These results bear out our conclusion that the annual metabolic pattern is inherent to northern beavers in the wild.

We manipulated light conditions in the same way for all animals. California beavers kept in constant darkness were not detectably affected. Arctic beavers ate nothing after 17 and 22 days, lost weight and underwent complete muscular paralysis. A drop in body temperature did not occur. We exposed the beavers to constant incandescent light after 24 days of darkness and their body activities returned to normal. Continued exposure to light in winter resulted in the arctic beaver's rapid growth and high food intake. From these experiments we concluded that naturally decreasing intensity of light in autumn induces metabolic depression in the northern beaver and increasing intensity in spring dispels it.

We questioned our thyroid hypothesis because food intake dropped to zero rather than to a low basal level during the depression. We were unable to deduce the nature of the muscular paralysis caused by darkness, but hypothesized that it represents peripheral control that reduces winter activity to a minimum.

In addition to the experimental study described above, we gathered information on the composition, distribution and density of the beaver population in the study area, in an attempt to relate them to productivity factors on the Mackenzie Delta. We have, however, been unable to use these data because of the difficulty in obtaining comparative biological and population data from various areas of the delta. We attempted to get data and specimens from the commercial harvest, but failed in this because it was impossible to travel to the trappers' camps during the hunting season which takes

Art Pearson fastens a metal tag to the ear of a drugged grizzly bear.
CWS photo.

place at the spring breakup. It was also difficult to communicate to the trappers precise procedures for collecting and reporting.

A technique for censusing beaver colonies from the air was developed and applied. We listed beaver food caches on a random sample of one-square-mile blocks throughout the relatively uniform habitat of 4,000 square miles. From this information a management plan has been developed and tentative harvest quotas have been established. Another survey attempted in September 1969 could not be completed because formation of ice obscured food caches hidden in the water. We will continue our efforts to obtain information on changes in population density by aerial survey and on the status of the population by samples from the commercial harvest. Such information will allow us to evaluate the effects of current management practices and revise the basic plan where necessary.
Vernon D. Hawley

Studies in the Yukon Territory

Grizzly bear ecology

A program begun in 1964 to study grizzly bear ecology was completed in late October 1969 and the results should be published by 1972. Forty-eight grizzly bears were captured and marked on a 500-square-mile study area in the Kluane Game Sanctuary in southwest Yukon, and a further 12 were identified but not marked.

Three cases of adult grizzlies being killed by other grizzlies were documented. Mortality of young before they were separated from the family group (2¼ years) was recorded but the causes were not identified.

The reproductive rate was low in the population under study with an average litter size of less than two. Young females did not reach sexual maturity until at least six years of age, after which a three- or four-year interval occurred between litters.

Information on the home range and movement of grizzlies was obtained by radio tracking. Animals were captured by shooting with drugs from a pursuing helicopter. A radio transmitter was attached by a neck collar and the bears subsequently tracked from the ground and air.

During 1968 and 1969 the Yukon Territory Department of Game made it mandatory for hunters to collect the skulls of grizzlies killed in the Yukon. The skulls were examined for size and age characteristics and returned to the hunters if so desired. This information will be used to characterize the grizzly population in the Yukon Territory.

Other biological investigations

A number of diverse subjects have been studied since 1962.

Information has been collected from the animals killed annually by the predator control program of the territorial government. With the co-operation of Dr. Bruce Baker of Macdonald College, Quebec, milk from several species of mammals has been analysed, to determine constituents and energy.

The success of an introduced herd of elk has been followed, as has the failure of a group of introduced bison. Mule deer have been moving into the Yukon from the southeast and this spread has been recorded.

Information on general matters pertaining to wildlife in the Yukon has been supplied to the Yukon Administration and the Territorial Council for better management of the resource in the territory.
Arthur M. Pearson

Big game management in the Mackenzie Mountains

Until 1965 big-game hunting in the Northwest Territories lay solely in the hands of Indians and other residents and hunting pressure was light. In that year the territorial government opened up over half the Mackenzie Mountains to non-resident hunters. In 1967 it opened up another large portion of the Mackenzies.

The big-game harvest has increased since 1965, but is still lower than harvests in the Yukon Territory and the provinces. The number of outfitters licensed to operate in

A Super Cub on balloon tires is used for aerial surveys in the Mackenzie Mountains. Near Yukon-NWT border, west of McMillan Pass.
Photo by N. M. Simmons.

Glacier in the Ragged Range west of Mount Sidney Dobson, Mackenzie Mountains, NWT.
Photo by N. M. Simmons.

the Mackenzies has increased from five to eight. Hunting through these outfitters has covered, nevertheless, only about 30 per cent of the 56,100 square-mile mountain terrain, mainly because transportation is difficult and costly.

Light hunting by Indians has continued and is usually limited to one river drainage. It is carried out mainly by Fort Norman residents on government-supported hunts in late winter. In addition, small bands of moose hunters from Fort Wrigley take occasional trips into the eastern edge of the mountains.

Despite the high outfitting expense, sport hunting and other forms of recreation in the Mackenzies will increase. The need for wise management of the area's natural resources will therefore be vital. Improvements to the old Canol Road between Ross River in the Yukon and McMillan Pass in the Northwest Territories have already made access to the Mackenzie wilderness easier. High performance aircraft and shallow-draft jet boats now enable visitors to enter areas in the mountains that, until very recently, have been seen only by a few Indians.

The Canadian Wildlife Service is gathering the information needed to develop a management plan for the Mackenzie Mountains. We are giving special attention to Dall sheep and woodland caribou in areas of non-resident hunting, as the Dall ram is a very highly prized trophy animal and the caribou, along with the moose, is the most important natural food source for Fort Norman Indians.

To evaluate hunting success, the project leader accompanies Indians on organized hunts and obtains information from non-resident hunters through personal interviews and specially designed report-form booklets. The ages of most big game animals killed are determined by counting horn annuli and tooth cementum layers. The distribution and abundance of each species are estimated from intensive aerial surveys and interviews with hunters, guides, outfitters, pilots, and others who spend time in the Mackenzies.

Surveying Dall sheep habitat by air is particularly difficult and hazardous. Fixed-wing aircraft are used as it is much too expensive to ferry helicopters over long distances to the survey areas. The aircraft

The South Nahanni River plunges 294 feet over Virginia Falls in the Mackenzie Mountains, NWT. Photo by N. M. Simmons.

must be specialized enough to manoeuvre at low speeds in steep-walled, narrow canyons, and to land and take off in a short distance on rough terrain. Helio Couriers and Piper Super Cubs on balloon tires have been most suitable for this project. In addition surveys can be carried out only under ideal weather conditions. Several surveys have been cancelled because of turbulence or uneven snow cover.

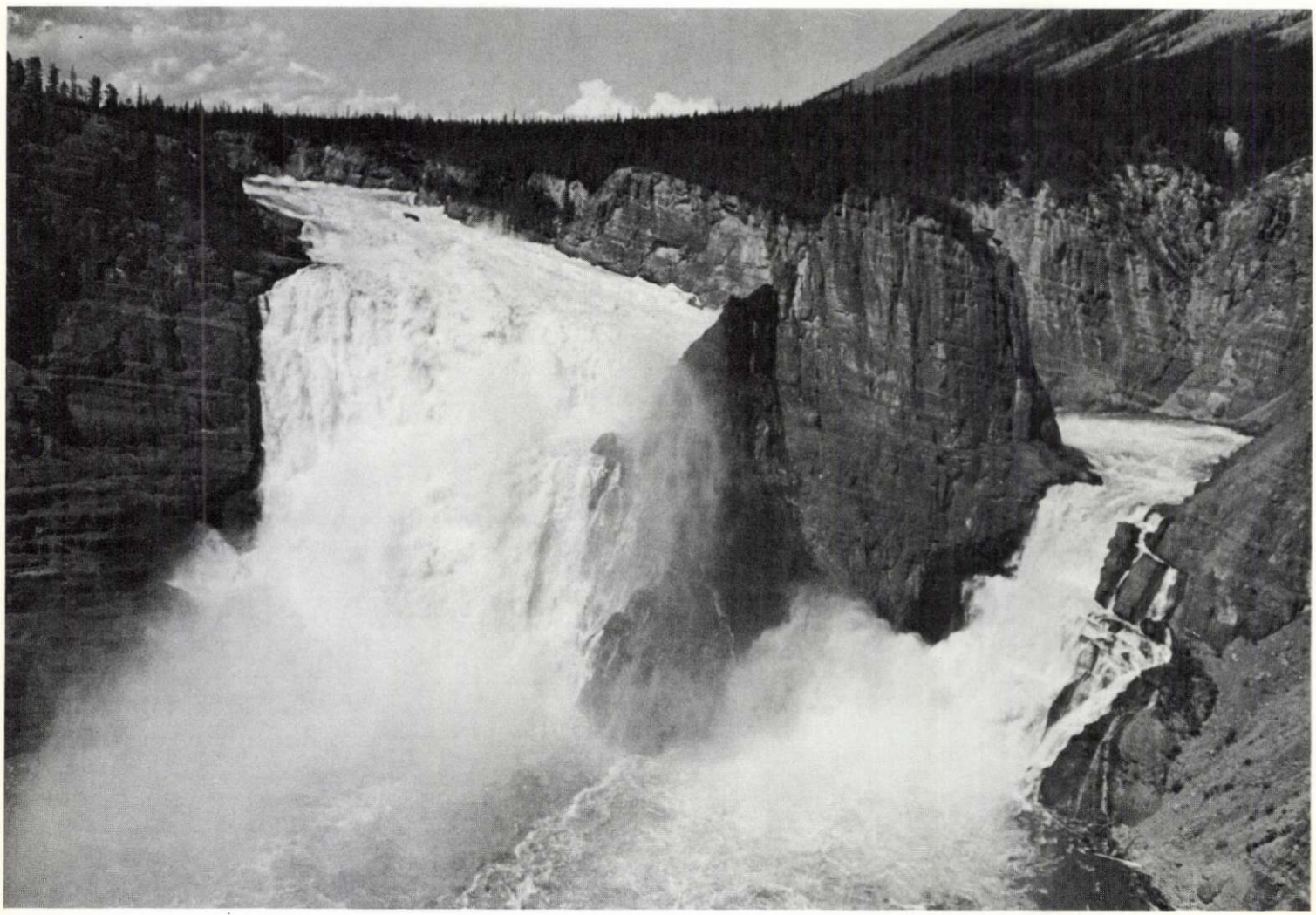
An effort is being made to identify the Dall sheep and caribou seen during the aerial surveys so as to determine the seasonal movements of animals counted. In 1969, we initiated a live-trapping program with the help of an experienced warden of the National Park Service. Traps were constructed with polyethylene cargo netting at natural mineral licks. Trapped animals were weighed, measured and marked with a combination of horn notches, ear tags and streamers, brass screws in the horns, and paint on horns, antlers and hair. Several aerial sightings of marked Dall sheep have already been made. Experiments are underway to determine the feasibility of spraying Dall sheep with non-toxic dye from aircraft. This method may prove to be the most economical way of temporarily marking large numbers of sheep so that their movements can be followed.

The project leader spent two summers becoming familiar with the mountains, planning, and gathering preliminary data on abundance and distribution of game and hunter success. The project then began in late winter 1968. Progress has been passed on to territorial game management officers through interim reports. By 1972 a management plan should be ready for submission to the territorial government which will be responsible for implementing it.
Norman M. Simmons

Research and planning in the national parks

The Canadian Wildlife Service conducts ecological research in the national parks. Its biologists undertake long-range projects concerned with the basics of resource preservation and make short-term studies into specific problems. Advice is given on wildlife management in the parks, as well as on management studies by individual wardens.

In addition, research biologists have reviewed, from an ecological viewpoint, provisional master plans for most of the western national parks, and have taken part in preparing final master plans for some parks. With such participation ecological prin-



ciples are applied during the important planning stage to protect wild plant and animal communities endangered when facilities are built or when thousands of visitors tramp through the parks.

Ecological surveys were conducted in the Val Marie area of Saskatchewan, the Bloodvein River region in Manitoba and the Wickanninish Beach area on the west coast of Vancouver Island when they were proposed as national parks. These surveys were the basis for reports to the Planning Division, National Parks Branch, giving background information necessary for planning future parks. Recommendations were made on setting boundaries to provide wildlife with suitable habitat and ensure their continued well-being. Conflicts between commercial development and preservation in Riding Mountain, Prince Albert and Glacier National Parks were discussed, and recommendations were made to resolve them.

CWS biologists will provide park wardens with guidelines for collecting quantitative wildlife information to be used for management. In consultation with the staff of individual parks we are designing a framework for systematic wildlife inventories. This will make it possible to compare data from a number of parks, yet be flexible enough to suit the conditions existing in each park.

Horseback riding in the parks poses another conservation problem. Horses cause deterioration of the landscape in several western parks by grazing and trampling. In addition, their faeces often contain seeds of exotic plants which are disseminated in the parks. Growth of these plants could damage the natural areas. As a first step to understanding these problems, the warden service in Waterton Lakes National Park has started a study, with CWS guidance, to determine forage production in meadows throughout the park. A grazing management plan will eventually be developed to protect the landscape by limiting grazing and trampling to certain areas. Similar studies have been made at Banff and on the Ya-Ha-Tinda Ranch.

Festuca scabrella association in Prince Albert National Park

Modern farming practices and other human activities have greatly changed the floral composition of most of western Canada's native grasslands. What remains of these areas should therefore be protected in parks and other nature preserves. A study was designed to describe the nature and extent of rough fescue prairie in Prince Albert National Park, Saskatchewan.

Detailed maps of all upland grassland areas were first drawn from aerial photos and forest cover maps. In 1967 two major rough fescue prairie areas were sampled by the point-transect method. In summer 1968, all areas identified by ground inspection as rough fescue prairie were sampled by the quadrat method. Vascular plant species within a set of five three-foot-square quadrats were recorded and evaluated on a cover abundance scale, and sampling locations spaced at 300-foot intervals.

Small areas of rough fescue prairie, surrounded by aspen groves, existed throughout the southwestern and southern portion of the park. As far as is known, these are the northernmost rough fescue prairie areas described for Saskatchewan. Aspen commonly encroach on grassland areas in the park. The rate of encroachment was assessed by examining aerial photographs of the same areas taken in 1947 and 1962. Wapiti, moose and deer browsing on young aspen saplings in some areas have slowed their advance on the prairie. Winter aerial surveys of the grassland areas yielded densities of 1.5 wapiti, 1.6 moose and .2 deer per square mile. From trapping of small mammals, species lists were obtained for the grassland and surrounding shrubland.

More intensive research, including manipulation of plant communities to maintain the remnant native prairie within the park, can now be done.

Ludwig N. Carbyn

Biotic communities in the western parks

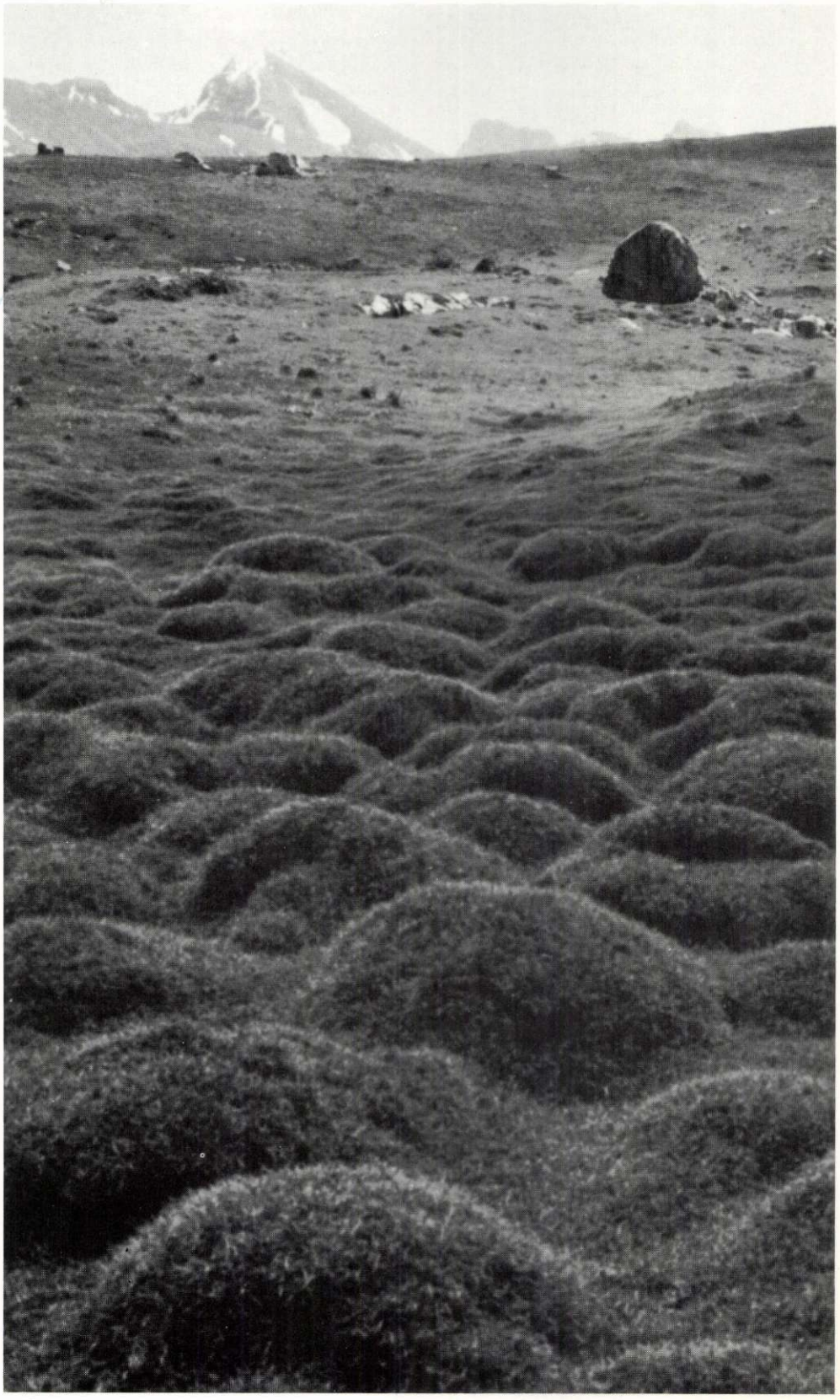
Single species were once the centre of our investigations in the mountain national parks. Animal species are now studied in the context of the biotic community to which they belong. This is the only valid approach to wildlife problems in national parks whose primary purpose is protection and preservation of naturally occurring biological systems, rather than some components of a system at the expense of others.

In Jasper, Yoho and Glacier National Parks the construction of roads and buildings to cater to the recreational needs of visitors could result in destruction of irreplaceable natural features. To learn more about their ecology, the Canadian Wildlife Service carried out an ecological inventory in parts of these parks during the summers of 1969 and 1970. Major vegetative types were first delineated on aerial photographs, located on the ground and sampled for their faunal and floral components. Circular plots, 100 feet in diameter, were used to sample the forest cover. Diameter, height and age of trees were measured by species. Four quadrats, two metres square, located at the north, south, east and west points of the circular plots were used to sample the understory. A species list was compiled and the relative abundance of cover estimated. Bird species were listed from sightings made on trips into and out of the sampled areas, but were not counted because birds were rare. Small mammals were estimated from captures in live traps, ungulates and other large mammals from sightings. Their relative abundance was assessed from the numbers seen on a unit distance travelled. Animals were counted in early spring aerial surveys which also indicated the extent to which the areas were utilized in winter. From these findings we will evaluate the study areas in relation to other areas in the park and in relation to other national parks. The extent of certain communities in the national park system will decide the degree of protection needed to preserve them.

Studies of the biotic community will be extended to the basic problem of the effects of human developments on the wilderness biota. Encroaching development and the phenomenal increase in park visitors are fast reducing the wilderness areas. Humans can so overrun the wilderness that it can become incapable of functioning as an ecological entity. We must therefore define the point at which this can occur and ensure that our activities do not destroy our wilderness.

The size of most wilderness areas should be determined by the needs of their inhabitants. The grizzly bear, most symbolic of the wilderness, will be studied to define its habitat requirements. The influence of human waste on the feeding and distributional patterns of this species will be demonstrated and recommendations made to minimize, and possibly eliminate, such interference.

Hummocks in an alpine region. Research into hummock formation and other aspects of alpine ecology will provide information for the development of interesting interpretive programs for the increasing number of park visitors.
Photo by Dalton Muir.



By 1972 we should reach this project's basic objective, providing quantitative and qualitative information on what must be done to maintain wilderness areas and their inhabitants in the national parks of western Canada.
Laszlo I. Retfalvi

Ecology of alpine vegetation
Studies of alpine ecosystems in western Canada have been few and these have been limited in scope and treatment. In the national parks this lack of information may cause unwise management leading to marked deterioration of the landscape.

Greater accessibility and use of alpine regions have made it more necessary to obtain data on the effects of human activity on the ecology of these areas. We know little about how alpine community types are affected by visitors walking, removing rocks, littering, picking flowers, taking plants, skiing and horseback riding. We have observed, however, the alpine communities change rapidly but recover slowly after some of these activities.

To facilitate good land-use planning we will conduct studies of the structure and composition of plant communities, soil factors and other parameters within the alpine zones of the western national parks. Our objectives are as follows:

1. to describe the composition and structure of plant community types within alpine zones;
2. to describe the soils within all recognizable plant community types;
3. to determine the major environmental factors controlling plant distribution and soil development;
4. to determine the distribution and to compare major plant community types over a broad geographic region;
5. to learn the nature and effects of man-made factors damaging or destroying alpine communities;
6. to formulate recommendations on park planning and practices so as to provide adequately for preservation of alpine communities.

Knowledge of relative abundance and distribution of the various plant community types will enable us to advise on placing of trails, roads and other developments so as to avoid destroying rare, fragile or otherwise unique communities. Knowing the

Bighorn sheep at Waterton Lakes National Park are herded through chutes into corrals for weighing and measuring. An animal's weight and measurement in different seasons can indicate its general growth rate.
Photo by John G. Stelfox

natural potentialities and limiting factors of each plant community type, we can determine to what extent an area can be used and still kept unimpaired for future generations to enjoy. Such programs are particularly appropriate in alpine regions where visitors can more easily see and understand the relationships among plants, soils and environment than in other kinds of terrain.
George W. Scotter

Bighorns of the Canadian Rockies

Majestically moving over the rugged mountainous terrain of Jasper, Banff, Waterton Lakes and Kootenay National Parks, the bighorn sheep is a thrilling sight. Occasionally its herds decline to a level of scarcity, only to rise again until animals in large herds of 50 to 100 roam the mountain grasslands. What causes these periodic die-offs?

To find the answer the Canadian Wildlife Service embarked on a five-year ecological study of the bighorn sheep in the national parks of the Rockies in fall 1966. Information is needed on habitat requirements, environmental factors influencing the bighorn's welfare, and management practices required to ensure its future well-being. And to obtain this has taken the efforts of one full-time biologist, two part-time wildlife technicians and one summer assistant; and the co-operation of 20 wardens of the National Parks Branch, Department of Indian Affairs and Northern Development.

Although disease has usually been associated with these die-offs, unfavourable conditions of weather and range, and competition from elk, have evidently been contributing factors. These environmental factors fluctuate markedly from year to year, so a five-year study can take into account as much variation as possible.

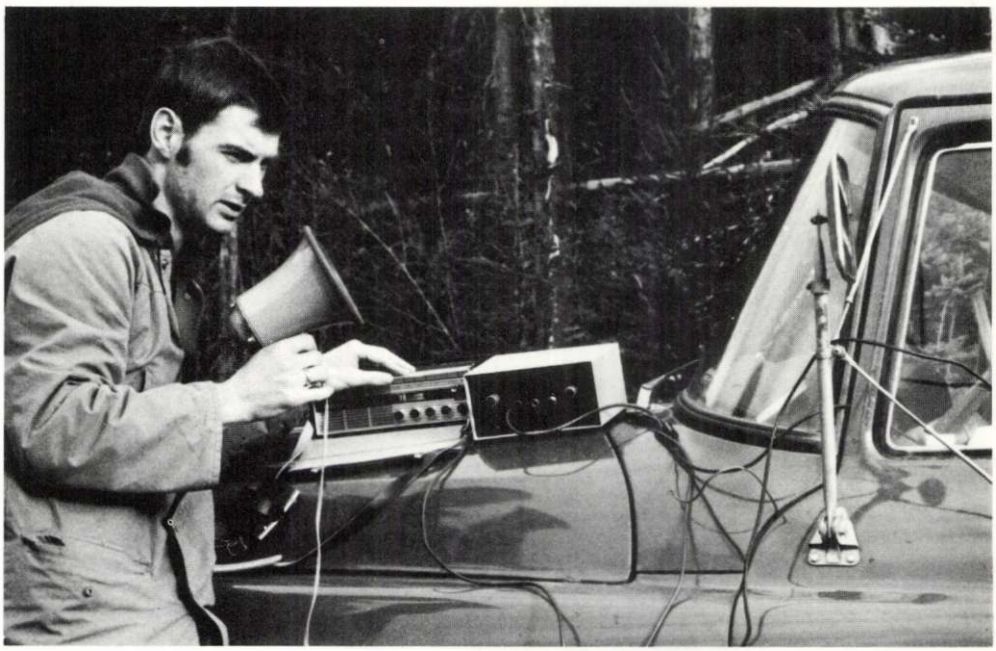
The first phase of the study was a historic review of populations dating back to 1800 when Duncan McGillivray and David Thompson collected the specimens, near Banff, Alberta, which formed the basis for taxonomic description of the subspecies. The pattern has been one of population fluctuations from various causes. Five major die-offs between 1937 and 1950 were caused by pneumonia-lungworm disease and three severe winters from 1946 to 1949. However, poor range condition resulting from overpopulation was apparently the underlying factor. Improvement in range conditions and mild winters then followed; herds gradually increased until bighorns totalled 10,000 by 1966. In 1966 and 1967 the Kootenay herd declined by 75 per cent. Going by past population patterns of bighorns in the Canadian Rockies, this is merely the beginning of another general die-off.

The second phase is a study of current population densities of bighorns and other competitive ungulates on summer and winter grassland ranges. Their distributions are plotted according to five range types occupied annually. These are the summer range from July to September, the fall migration range during October, the "rutting" range during November and December, the winter range from January to April, and the spring migration range during May and June. Three years of extensive aerial and ground surveys have shown that wild ungulates in the Canadian Rockies usually winter on 10 per cent or less of the mountainous range. Several wintering ranges support large densities. The Athabasca valley north of Jasper supports 820 bighorns on approximately 20 square miles of grassland, or 41 per square mile. In addition, 600 elk and 200 mule deer winter along this 20-mile valley and extensively use the lower grassland slopes. In February 1967 a helicopter survey of Waterton Lakes showed 350 bighorns, 264 elk, 235 mule deer and 14 mountain goats wintering on 23 square miles of mountainous grasslands, or 37.5 per square mile.

The third phase documents changes in population, reproduction, mortality and vitality during the five-year period. Except for die-off of the Kootenay herd in 1966-67, populations and reproduction remain high along the east slopes of the Rockies in Alberta. Malnutrition and reduced vitality indicate high internal parasite loads and overuse of several winter ranges. Mortality rates have been low, although some mortalities from avalanches, unfavourable snow condition and predation have been recorded.

Bighorns from several herds throughout the parks are trapped alive in corrals, or immobilized with drugs, for weighing and measuring in different seasons. This will show the general growth rate of individual animals, weight gain and loss in summer and winter respectively, and differences in the weight of animals of similar age in the four parks. Weight loss during winter is apparently affected by quality, quantity and

Ludwig Carbyn uses a wolf howler to locate rendez-vous sites of wolves in Jasper National Park. CWS photo.



availability of forage, and severity and length of winter. Lambs weigh 10 to 15 pounds at birth, reach a weight of 160 to 190 pounds for ewes, and 275 to 300 pounds for rams in prime condition just before the fall rutting period. Mature rams lose about one pound per day during the two-month breeding period, and ewes about one-third pound per day.

The fourth phase is a disease-parasite study to compare the health of herds within the four parks and correlate the degree of parasitism with animal and range conditions and climate. Parasitism is a general condition of which the intensity and influence on the host are directly correlated with range conditions, stocking rates and climate. The pneumonia–lungworm disease evidently reaches a lethal level only when the animal's condition becomes poor from malnutrition and is worsened by severe winter weather.

The fifth phase is a detailed ecological study of six wintering ranges, two each in Jasper, Banff and Waterton Lakes. The seasonal abundance and distribution of all ungulates are recorded. Forage production and utilization, range condition and trend, are correlated with conditions of atmosphere, soil and climate, and with ungulate densities. The distribution, depth and hardness of snowpack conditions throughout the winter are recorded and associated with ungulate use of the winter ranges.

During periods of deep snow the sheep move onto recently avalanched slopes to forage on exposed vegetation. They are very sensitive to atmospheric changes as was evident during the unusually cold and deep-snow winter of 1968–69. For a three-month period, average temperatures were well below zero along the Athabasca Valley in Jasper park, below the 4,500 foot elevation, while snow depths continued to increase. At higher elevations, temperatures were warmer and snow was shallower because of persistent temperature inversions and strong upper winds. The sheep reacted to this, probably through barometric pressure impulses, by leaving the low wintering ranges and moving up towards the summer ranges where they remained, from December to March, until weather conditions improved on the lower ranges.

Gathering data for this study has been hazardous because of the constant threat posed by avalanches and severe weather. Despite his knowledge of avalanche safety and experience with this terrain, John Wackerle—a warden at Banff—was caught in an avalanche while working on this study. Fortunately, he was buried only up to his neck and was able to claw his way out of the debris. Such harrowing experiences should be reduced by further precautions we have since taken.

John G. Stelfox

Wolves of the western parks

Overpopulation of wapiti and other ungulates poses a persistent wildlife problem in some of the western national parks. High densities in restricted areas deplete the range and often impair other natural features. Die-offs may eventually result from a combination of such factors as malnutrition, disease and high parasite loads. To protect the winter range it has often been necessary to conduct controlled slaughters.

Man's efforts to control ungulate populations do not follow the principles of natural selection. Control programs do not eliminate the old, the sick and the weak as would normally occur. Furthermore, control in less accessible ranges is inadequate as the carcasses must be salvaged. Biological methods of population control in national parks must therefore be investigated and should be allowed to proceed as much as possible without man's interference. In addition, efforts are being made to delineate the boundaries of new national parks so that all the faunal components of the park are protected within complete ecological units.

The wolf is the most common large predator in the western national parks. Its low densities and wide ranging habits in winter make it particularly difficult to preserve this carnivore. A study of the population status, movements and food habits of wolves in the western national parks was initiated with the co-operation of the National Parks Branch, Department of Indian Affairs and Northern Development, in 1968.

Investigations are being conducted in three phases. The initial one-year phase determined the abundance and distribution of wolves in Riding Mountain, Prince Albert, Jasper and Banff National Parks, and was based on sightings of tracks and animals recorded by park wardens. Periodically in winter we patrolled, by air, poison bait stations for provincial predator control programs adjacent to national parks. In summer 1969 wolf howling surveys were conducted in Prince Albert and Jasper parks. Tape recordings of wolf howls were amplified and broadcast at regular intervals to elicit responses from family groups and thus locate pack activity centers. Location of rendezvous sites supplemented the data obtained during the winter surveys.

During a CWS study of wolves in national parks, these wolves were observed outside the boundaries of one park. They had been killed in a predator control program.
CWS photo by Ludwig G. Carbyn.

Phase two is scheduled to last two years. Further information on distribution, abundance and movement of wolves is being gathered by personnel of the National Parks Branch and the Canadian Wildlife Service. At the same time wolf–ungulate interrerelationships are being intensively studied in a 300-square-mile valley system with high ungulate populations in Jasper National Park. Three permanent weather stations and 20 snow stations are located at different altitudes within the study area. And monthly winter surveys by helicopter will provide complete counts and distribution of prey populations of mountain goat, bighorn sheep, wapiti, moose, mule deer, white-tailed deer and caribou. Data on hunting techniques of predators and vulnerability of prey are being gathered by tracking wolf packs on their winter hunting circuits. Information is recorded at each kill site on the number of wolves in the chase and the distance travelled since the last kill, length of pursuit, physical conditions of snow, nature of vegetation cover, slope of terrain and physical condition of prey species. Pup and adult droppings collected at nursery dens and rendezvous sites in the summer, are analyzed for food composition. These data will provide a clearer understanding of the effect of wolf predation on protected and unharvested ungulate populations.

In phase three intensive research will be continued for two years. It will investigate management techniques to maintain wolf populations within the parks and encourage re-establishment of wolf populations in areas within the larger national parks now free of wolves.
Ludwig G. Carbyn

Gill nets are used to sample fish through the ice.
CWS photo by A. H. Kooyman.

Limnology

Atlantic parks

Newfoundland

To develop a sound program for management of Terra Nova National Park's aquatic resources, we began an inventory of all its water bodies in 1967. In that year 21 lakes were surveyed, of which four were later investigated for productive capacity. We studied growth rate and feeding habits of brook trout in these four lakes, then attempted to estimate the biomass (weight of living matter) and sustained yield of these populations.

A carbon-14 radio isotope technique was used in an intensive study of the aquatic plant growth in five lakes, varying in shape and dimension but similar in chemical composition. Surface area ranged from 2 to 118 hectares, maximum depth from 1.6 to 22.0 metres (m), mean depth from 0.4 to 9.2 m. Salinity in four lakes ranged from 16 to 22 parts per million (ppm); in one lake it was 40 ppm.

The five lakes were monitored for one year for changes in water temperature, light penetration, chemical composition of water, phytoplankton biomass (total weight of tiny floating plants) and aquatic plant production, particularly noting the influence of mean water depth on the last factor. Plant production was extremely low when the lakes were covered with ice, from mid December to mid April, and remained so until the water temperature exceeded 50°F, about early June. Growth was more intensive from mid June until late October, varying between 10 and 30 milligrams (mg) carbon per square meter on sunny days. Scarcity of nutrients and dimness of light penetrating the cloudy water, which was brown from dead organic matter in nearby bogs, limited aquatic plant growth.

A lake's shape greatly affects plant growth. Several simultaneous experiments were conducted in a lake which had both a deep (mean depth 92 m) and a shallow (mean depth 2.6 m) basin. Primary production per unit surface area was lower in the shallow basin than in the deep one, but vice versa per unit volume. Average primary production was 16.4 mg carbon/sq m per day at the deepest point in each basin. As the five lakes monitored gave similar results, we concluded that shallow lakes receive less energy per surface area, and more per unit volume, than deep lakes. Therefore

zooplankton can use shallow lakes more effectively and fish can feed at a faster rate while expending less energy.

In Newfoundland we also studied brook trout and Atlantic salmon, investigated parasites affecting arctic char in Terra Nova National Park, and made a preliminary survey of waters in Gros Morne National Park.

New Brunswick

When Fundy National Park was established in 1948 Atlantic salmon were extinct in the Upper Salmon (Alma) River, for an old logging dam prevented them from entering. Subsequently the dam was partly washed away, and the Upper Salmon has once again become a significant salmon-producing river. In 1967, 1,200 spawning fish were counted and approximately 200 fish were taken by anglers. Point Wolfe River, on the west side of the same park, is also obstructed by a dam and we have recommended opening a passage through which salmon may ascend.

In New Brunswick we have also made a preliminary survey of waters in Kouchibouguac National Park.

J. J. Kerekes

Prairie parks

Prince Albert National Park

An angler harvest survey was conducted in Prince Albert National Park from 1967 to 1969. The harvest rose from 1967 to 1968 but dropped in 1969 apparently because fishing was poorer over a wide area on the prairies.

Waskesiu Lake

Pike and walleye, the main game fish in Waskesiu Lake, are not plentiful, as their populations have been declining for some time, possibly because deterioration of the spawning areas has limited natural reproduction. Light spring run-off, extensive beaver activity and increasing boat traffic have made two tributary streams less suitable for spawning.

The Mud Creek–Beartrap Creek watershed, a major tributary to Waskesiu Lake, was once used extensively as spawning and nursery grounds by pike and walleye, and many adult pike still ascend this tributary system if spring run-off is adequate.

We are experimenting with fish culture techniques for pike in an attempt to increase their numbers in Waskesiu Lake. In addition, we are experimenting with flooding the grassy margins of a small lake in the lower part of the watershed. Pike produced about 8,000 fingerlings here in 1968 and encouraged by this success we are considering control of water levels in three small lakes in the watershed to increase pike reproduction there.

Walleye reproduction no longer takes place in Mud Creek and is low in the Kingsmere River, another inlet to Waskesiu Lake. The low rate here may be due to heavy predation on newly spawned eggs followed by high mortality among surviving eggs from physical disturbance and siltation caused by heavy boat traffic. To increase the walleye population we have begun a hatchery program for which we are taking eggs from the Kingsmere and from a run that moves from Crean Lake to Heart Lake. In 1970 some 17,200,000 fry were stocked in Waskesiu Lake.

Crean Lake

The lake trout population in Crean Lake has been low for the past 25 years, perhaps because of over-exploitation by commercial fishermen and subsequent low reproduction in years when spawning reefs were not adequately covered by water. The lake level has been restored partly by water control measures and we have attempted to increase the brood stock of trout. Over 2,000 marked adult fish were transferred in the 1950s and 1960s from Wassegam Lake in the northern part of the park to Crean Lake. Recovery of the lake trout population is nevertheless slow. Angling in Crean Lake improved only in 1968 when about 300 trout were caught mainly from one deep area. Adults transferred to the lake in 1964 and 1966 comprised a large proportion of the catch. These were identified by the markings placed on the fish before they were placed in the lake. As little is known of the many aspects of the life history of lake trout in Crean Lake, we do not yet understand adequately the status of its population here and its relationship with other species of fish, such as walleye, pike, cisco and whitefish. Extended study is therefore needed.

Halkett Lake

Until 1966, pike was the only game species in Halkett Lake. Attempts to establish walleye have not been successful. This lake in the southern part of the park covers five square miles. It is over 180 feet deep and therefore develops a strong thermal stratification (warm top layers, cold bottom layers) during the summer months, with high oxygen content in the deep waters. Except for the absence of suitable forage fish, these conditions are well suited to lake trout. Adult lake trout were transferred from Wassegam Lake in 1966 and 1968 and cisco were introduced to provide forage. Anglers caught some of the trout in the winter of 1966-67 and in subsequent springs and summers. The trouts' condition has probably declined because forage fish were insufficient, but additional plantings of cisco may help to correct this.

Cisco in the prairie parks

Cisco play an important role in the food web of many aquatic communities. They feed on microscopic plant and animal life in the water and are fed upon in turn by such game fish as lake trout. Cisco are therefore a vital link in converting the basic productivity of the lake into desirable game species.

The group is widely distributed in North America and contains many species. But its taxonomy is confused at this time and studies have been undertaken to find out in what forms they occur. Two forms occur in Waskesiu Lake and we are investigating their role in the ecology of the lake to determine how they may be used in the management of lake trout and other game fish.

Riding Mountain National Park

We are now evaluating introduction of additional species of game fish to lakes in Riding Mountain National Park over a long period since the 1920s. The following are reports on some of the findings.

Lake trout in Clear Lake

Stocking of Clear Lake with fingerling lake trout began in the 1920s. Transfer of adult trout from Clearwater Lake in northern Manitoba began in the 1940s. Yearling lake trout have been transferred from the Maligne River hatchery several times since 1950.

Hundreds of adult trout move into a spring fed stream at the east end of Clear Lake each fall and leave again before spawning. Their presence confirms the survival of planted fish marked at stocking time.

Adult lake trout are anesthetized and bagged at Wassegam Lake for transfer to Halkett Lake, Prince Albert National Park.
CWS photo by A. H. Kooyman.

Lake trout are evidently not reproducing successfully in Clear Lake. Young fish are rarely seen and those that have been examined usually bear marks indicating they are survivors from hatchery plantings. Spawning grounds for lake trout are abundant in the lake. It is virtually certain that the trout spawn normally, but hatching success seems to be very limited. The species is otherwise well adapted to Clear Lake as is shown by the survival and excellent condition of the planted fish.

Walleye in Clear Lake

Walleye may once have been indigenous to Clear Lake. Walleye fry planted in earlier years apparently did not survive, but adult fish transferred to Clear Lake from nearby Winnipegosis in the mid 1950s have thrived and are now reproducing successfully. Young walleye are extremely abundant and the lake has developed into an important fishery for this species in the past two years.

Trout in Katherine and Deep Lakes

Lakes Katherine and Deep are typical pothole lakes occurring in the glacial tills of this region. Their areas are less than 100 acres each. Maximum depth of Katherine Lake is 30 feet, and of Deep Lake just over 40 feet. Introduced trout species usually thrive in such lakes and these are no exception. Both lakes have produced good catches of rainbow and brook trout from stock planted after original fish populations, mostly perch and suckers, were eradicated. But a decline in water levels, which intensified oxygen deficiency, was responsible for lower survival and consequent lower angling success in recent years.

The survival of the two species in each lake has been variable, rainbow trout being more successful in Katherine Lake and brook trout in Deep Lake. In each case, populations of the other species were also present. Both species are essentially stream spawning fish but these lakes have no suitable tributary streams. The populations are therefore maintained by regular plantings of fingerling trout from the Maligne River Trout Hatchery at Jasper.

Destratification of Katherine Lake to overcome eutrophication

Once thermal stratification has developed in Katherine Lake during the summer the

A glass-bottomed viewer is used to search underwater for pike eggs or small fry.
CWS photo by A. H. Kooyman.

water becomes deficient in oxygen (eutrophic). This makes the cool lower layers unsuitable for trout which require well oxygenated water.

Compressors and perforated plastic tubing were installed in Katherine Lake during June 1969 to aerate the water in summer and winter. Aeration was undertaken several times during the summer when oxygen levels dropped in deep water. In addition, extremely windy weather helped counteract the decline by mixing surface and deep waters, thus upsetting the normal thermal stratification. Semi-permanent installation of the equipment will allow us to aerate the lake whenever necessary. If this method is successful it may be applied to other lakes with a similar problem.

Creel census studies
A fairly intensive angler harvest survey of Riding Mountain National Park during 1968, which continued less intensively in 1969 and 1970, showed that visitors are more interested in fishing in Prince Albert National Park than in Riding Mountain. In this park, pike fishing in Audy Lake during spring and early autumn is good. At Katherine Lake, the angling harvest is low, probably because habitat conditions were marginal; gill netting tests however reveal good numbers of rainbow and brook trout. At Clear Lake angling is light and the catch per angler low. The steady increase in walleye, between 1966 and 1969, will no doubt generate more enthusiasm for fishing in this lake. Winter angling is becoming more popular with good catches of whitefish in some areas of Clear Lake. A contour map of water depths in Clear Lake is being developed to guide anglers and boaters using the lake.

Elk Island National Park
Development of angling in Elk Island National Park is limited because its lakes are shallow. Astotin Lake, the main body of water, has a long history of fish die-offs from oxygen deficiencies which invariably develop when the lake is frozen over. Past attempts to alleviate this have been unsuccessful. A research group from the University of Alberta has studied the aquatic vegetation to develop some method of controlling the abundant plants and algae so annoying to summer visitors, and its application may also improve the habitat for fish.

Wood Buffalo National Park
The fishery resources of Wood Buffalo National Park have not been closely investigated as it is remote and rarely used by the public. Several small bodies of water adjacent to the only road from Fort Smith were investigated. Pine Lake and Rainbow Lake were stocked with different species of trout. Local anglers have been taking good catches from these lakes and the stocking program is being continued.
A. H. Kooyman

Rocky Mountain parks

Lakes with stunted trout populations
Some mountain lakes contain trout too small to be of interest to anglers. In these usually cool and relatively unproductive lakes trout reproduce successfully, but angling pressure is insufficient to prune their numbers to a point where they can grow to a desirable length.

In Caledonia Lake, Jasper National Park, over-populated rainbow trout had to compete with lake chub for inadequate food resources and were therefore stunted. Angling pressure became steadily less, and competition for existing food organisms became so acute that the trout suffered even more stunting.

We began a program in 1966 to control natural reproduction activities and remove enough fish to allow those remaining to grow bigger. Fish spawn very successfully

Two cyclopoid copepods prey on the cladoceran *Diaphanosoma* in Patricia Lake, Jasper National Park. The copepods are about 1/25 inch long. CWS photo by R. Stewart Anderson.

in the inlet and outlet creeks of Caledonia Lake. The fish run was larger at the inlet so we set traps there to collect the entire spawning migration and take it to a nearby lake. At the same time we introduced eastern brook trout to Caledonia Lake, where they could feed on chub and reduce the population. Rainbow trout were apparently not preying on the chub.

Over one thousand trout have been transferred from the lake and reproduction has dropped drastically. Rainbow trout in the spawning migration are larger, and eastern brook trout taken with gill nets have weighed up to three pounds. Lake chub have not appreciably declined, so competition from that species will not diminish unless we can remove some of them while reducing the trout. We are continuing our investigations and may gain enough experience to apply the results to other lakes where trout are small.

Hatchery planting and angler success

Beauvert Lake in Jasper National Park was treated with rotenone in 1964 to kill suckers, lake whitefish and other trout competitors. Patricia Lake was reclaimed in 1966. Hatchery-reared trout have since been planted in these lakes to determine how well they would survive and to what extent fishing would improve.

Some rather curious trends have developed. In the first year eastern brook trout tended to predominate in both lakes, especially early in the season. But at Patricia Lake, rainbow trout increased in number as the season progressed until they made up almost the total catch by autumn. During the second year eastern brook trout dominated early catches in both lakes, rainbow trout dominated summer and autumn catches. This pattern has been maintained, except that each year eastern brook trout catches decrease and rainbow trout catches increase.

Soon after its reclamation some unwanted fish species began entering Lac Beauvert from the Athabasca River, because the screening device was not operating properly. This decreasing competition caused lower success of hatchery plantings.

Patricia Lake has no unwanted species of fish and success with stocked trout has been fairly constant. Planting of yearlings has been the most productive, however no more than one per cent of the total planting survives beyond two years. Yearlings stocked in autumn survive the winter encouragingly well, but are still quite small in spring when migrant loons take them in large quantities. We are now trying autumn plantings of two-year-old rainbow trout which may not suffer as much predation as the smaller yearlings. Larger populations may in this way be available for early season anglers.

Winter kill operations

Lack of oxygen in the water is a cause of winter kill in fish populations. To overcome this we have replenished the dissolved oxygen by various aeration methods. Simply pumping water out of one hole in the ice and running it over the ice surface into a second hole has been the most effective method. The water is aerated as it runs over the ice surface just as it would in a running stream. We successfully applied this method, using a fire pump, at one lake in Banff National Park. The lake was small and the weather good for outdoor work, so the trout survived the winter.

Water can also be aerated by pumping air through perforated pipe laid on the lake bottom. The action of the air bubbles creates a flow of warm water from the bottom to the top layers which melts the ice and presumably aerates the water at the same time. This method at first showed great promise but gave poor results in two of the lakes where it was tried. Admittedly, vegetation grew heavily in the two lakes and when decay started the oxygen decreased too rapidly for the system to handle. Lacking oxygen, the trout population died.

For this kind of aeration to work, conditions must be ideal. The system is effective when started early and run all winter, providing weeds do not grow too thickly or the pumps do not fail for even short periods. In effect, the aeration process keeps areas of the lake ice-free, allowing light to penetrate to the vegetation. Instead of dying and rotting, thus robbing the lake of its oxygen reserve, the weeds continue to live and their photosynthesis adds oxygen to the water. If the pumps fail, or very cold, dull, cloudy weather lasts for an extended period, the oxygen is rapidly reduced to levels lethal to fish.

Splake trout investigations

We are still studying naturally reproducing splake trout from Agnes Lake. These are the progeny of a cross between lake trout and eastern brook trout made in 1961. These investigations are leading towards a better understanding of what takes place in the hybridization processes and the influence of particular genes on the development of enzyme genotypes. At the same time we have followed the development of enzymes in the embryo to discover at what stage the various embryonic enzymes become active. Enzymes in wild eastern brook trout differ from those in hatchery-raised trout. Additional crosses will help in our study of hybridization.

Sucker control and its effect on trout in Pyramid Lake

Improving the fishery at Pyramid Lake in Jasper National Park without using fish toxicants to rehabilitate the lake has been attempted since 1966. Pyramid Lake covers 320 acres, has a maximum depth of 62 feet and a mean depth of 40 feet. It supports a fishery composed of lake and splake trout mainly, and smaller populations of rainbow, cutthroat and eastern brook trout. Competing with these for food is the longnose sucker, and smaller numbers of Rocky Mountain whitefish and lake chub.

To improve trout fishing we have been removing as many suckers as possible, especially those in spawning condition so as to reduce or eliminate reproduction. In addition we have planted more splake trout, for these do a superior job of preying on the small suckers and the lake chub, particularly in summer when surface temperatures

The crew count pike and other species in a specially designed frame and rod trap on Mud Creek, Prince Albert National Park. This site is also used for taking spawn from fish.
CWS photo by A. H. Kooyman.

reach 65°F. At that time, the splake remain in warmer waters where they continue to feed on small fish. Populations of rainbow, cutthroat and eastern brook trout are not large enough to have any appreciable effect on the small fish. Our attempts to increase these populations have not brought about any noticeable changes. The increase in splake introduction has been very successful, and splake trout now make up at least 80 per cent of the catch.

Spawning areas for lake and splake trout were made by depositing coarse gravel at suitable sites. These new grounds are now being used by spawning splake in the fall.

No attempt is made to control Rocky Mountain whitefish because anglers take them in sufficient numbers each June to check the population. Anglers are taking larger whitefish, no doubt because there is less competition from suckers and food is available in greater quantities.
J. C. Ward

Alpine lakes

Physical-chemical limnology in small lakes
Chemical composition, temperatures, dissolved oxygen levels, light penetration, ice conditions, morphometry (contour depth, size, shape) and water renewal rates of small alpine lakes were poorly known before 1967. Studies have determined that water chemistry in most lakes in Banff and Yoho National Parks and in many in Jasper National Park is fairly uniform, although some Jasper lakes have almost the purity of distilled water. Most of the lakes are very cold all year and generally the oxygen levels are at saturation point when the surface is free of ice. These lakes are poor in nutrients for plankton organisms, and have delicately balanced environments. We must therefore take care in planning activities and development near these lakes if their natural state is to be preserved.

Primary production in Snowflake Lake
The phytoplankton community in Snowflake Lake, Banff National Park, was studied from 1966 to 1969, using radio-isotope techniques to measure the inorganic carbon used in photosynthesis. Although the plant community has changed from year to year, the level of photosynthesis has remained about the same. The highest rate of photosynthesis occurs under the ice in late spring; in autumn and winter it is very slow. Phytoplankton seems to be only a small part of the zooplankton food supply in most alpine lakes.

Zooplankton studies
The species distribution and community composition of crustacean plankton have been studied in a large number of lakes and ponds in the mountain national parks and vicinity. Studies of growth and reproductive rates of copepods in some of the high lakes are underway. Here growth is slower, communities simpler and, thus, community composition varies less with the seasons. Field work and experimental studies on the food inter-relationships among fish, crustacean zooplankters and rotifers are contributing significantly to our knowledge of species distribution and lake productivity. One new species has been reported.

Effects of rotenone on zooplankton
In autumn 1966 and 1967, Celestine and Patricia Lakes in Jasper National Park were treated with rotenone to improve growth and survival of trout by eradicating coarse fish not native to these lakes. The zooplankton was affected but took only one year to return to former numbers. Pre-treatment community compositions were slowly re-established, with some previously rare species flourishing during the first or second year. Phytoplankton levels in both lakes were unusually high soon after treatment as grazing by small zooplankton populations was too sparse to control their numbers.
R. Stewart Anderson

Ecology

Vehicle tracks from summer explorations at Drake Point mar the high arctic landscape where environmental damage can sometimes take hundreds of years to repair.
Photo by Dalton Muir.

Committee on water

In February 1970 the tanker "Arrow" struck Cerberus Rock in Chedabucto Bay off the coast of Nova Scotia. Its cargo of Bunker C oil covered a large area of the bay and spread out to pollute the coast line. Biologists of the Canadian Wildlife Service made observations on mortality of birds, oil movements, its secondary effects on birds and effects on the habitat. In addition a CWS biologist served as adviser and observer on the federal task force led by P. McTaggart-Cowan. Later in the same year, the Athabaska River and Hudson Strait were the scene of another oil spill, this time from a pipeline.

Immediate action is needed if the ecological impact of such disasters is to be reduced. The Interdepartmental Committee on Water initiated task forces in 1969 to draw up contingency plans should such accidents occur and an interim plan, co-ordinated by the Ministry of Transport, was brought into effect in July 1970. Fisheries and Forestry, Transport, Indian Affairs and Northern Development, Energy Mines and Resources, National Health and Welfare and the Emergency Measures Organization are all members of the committee.

The disastrous effects of oil on the environment and on wildlife are already well known. But this is not the only, or most hazardous, pollutant. Many kinds of poisonous materials, some used as pesticides, are transported on coastal waters, the St. Lawrence Seaway and the Great Lakes system. We know enough about some of their effects to know that we need more restrictions on methods of transporting them.

In 1969 pesticide spilled into the Rhine River contaminated water supplies for human consumption in Germany and Holland and killed an estimated 40 million fish. Also posing hazards are leakage from shore installations—as occurred at Bathurst Mine, New Brunswick in November 1970—and leakage from shore transport. Serious pollution of a harbour by combined discharge of chemicals from two neighbouring industries was stopped only because it was realized in time that while these substances alone would be harmless, together they would spell danger to the environment.

Such events hastened production of a master plan to deal with spillage of various pollutants. And steps are being taken to

Oil spills, such as that from the tanker "Arrow" in Chedabucto Bay, Nova Scotia, 1970, spell disaster for many forms of marine life.
CWS photo by A. D. Smith.

make federal–provincial arrangements to ensure its implementation in most Canadian waters.

Once released into the environment, many compounds cannot be contained or removed. These should be shipped in containers heavy enough to withstand severe impact without breaking. Liquid chlorine is shipped in heavy containers but they have not always proved adequate. In some cases chlorine has leaked into the atmosphere and the inhabitants have had to be evacuated from the spill area. Regulations and strict enforcement are needed for safe transport of all poisonous materials capable of creating environmental havoc and disaster for humans.

Even when precautions are taken, materials dangerous to man and wildlife will be accidentally released. A quick warning system must be devised so that emergency action can be taken. Perhaps the Emergency Measures Organization is best equipped for that job.
V. E. F. Solman

The Arctic Ecology Map Series
In January 1971 the Canadian Wildlife Service issued a series of maps and booklets describing habitats which support valuable wildlife populations in the Arctic. The series was conceived as a guide to industries and government agencies operating in the north and was compiled by Renewable Resources Consulting Service. Much of the information was obtained from interviews with experienced northerners.

Some of the adverse effects which could result from unplanned human activity in this area are already widely known: the danger to sea-birds and other marine creatures from oil spills; the foolhardy disturbance of the breeding grounds of an endangered species; the fatal attraction of bears to garbage dumps. However the possible consequences to other species are not generally recognized. Arctic foxes are, like bears, attracted to dumps and consequently easily shot. Muskrat and beaver need the shelter and food provided by relatively stable and deep water conditions and these are affected by dam and road construction. Low flying aircraft are a serious hazard for some species. Human activities on caribou migration routes in spring or fall might seriously delay the herds.

The 24 maps do not portray the total distribution of wildlife. They show "critical" and "important" habitat for concentrations of various species during breeding, wintering, migration or throughout the year. The species affected, the function of the habitats and the seasons in which they are important are marked on the maps, for these factors determine what activity is undesirable. A pamphlet accompanying each map provides further information.

Recommendations range from warnings that the areas where the peregrine falcon nests should be totally undisturbed in spring and summer, to suggestions that roads built in Dall sheep and goat country could result in excessive hunting.

This delineation of specific habitat areas is only a first step in safeguarding Canadian wildlife resources in the North. CWS hopes that industry and government agencies will refer to these maps before embarking on northern activities and so ensure that the delicate balance of nature in the North will not be upset. CWS will incorporate users' and biologists' observations in future revisions.
A. H. Macpherson

Effects of flooding on waterfowl habitat
A marked relationship exists between water depth and aquatic plant distribution and between plant distribution and waterfowl usage. Consequently flooding creates a new pattern of distribution and usage. We embarked on a study near Carillon, Quebec, in 1962 to learn which habitat conditions promote maximum waterfowl use.

In spring 1963 Quebec Hydro completed a dam at Carillon which raised the level of the Ottawa River by about six feet for a distance of about 60 miles. Permanent aquatic plant transects laid out in 1962, before flooding, have since been surveyed each year; and the changes in water depth and plant composition recorded. The pioneering aquatic plants were cinquefoil, smartweed, river bullrush and buttonbush. Spring and autumn waterfowl inventories are being conducted to correlate concentration areas with plant succession. The waterfowl breeding pair index increased from 1.4 per mile of shoreline in 1963 to 6.5 in 1966 and has since decreased to 3.8 in 1969.
William T. Munro

An emergence trap is set below the water surface to catch midges, dragonflies and mayflies. CWS photo by E. A. Driver.

Limnological studies of prairie potholes

The limnology unit has been working with the migratory birds research section to study prairie potholes. Begun in 1967, the study's objectives are primarily to ascertain how permanent and productive are prairie potholes, and to develop a limnological classification for wetlands. Its secondary objectives are to assist in planning management programs for manipulation of marshes and to co-operate with other agencies in monitoring biocides and their residues in aquatic habitats.

Study areas include Floral and St. Denis, Saskatchewan, in 1968 and 1969 respectively; and Minnedosa and Boissevain, Manitoba, in 1969. From potholes in these areas we collected adult and immature invertebrates, to obtain data on their distribution and relative abundance. These include water boatmen, caddis flies or case builders, midges, beetles and the immature stages of damsel flies and dragonflies.

We captured larvae of damsel flies and dragonflies, and adult water boatmen and beetles with an artificial substrate sampler. This is a series of tempered masonite plates held closely together and suspended from a rope beneath the water surface. We took midges, dragonflies and mayflies with an emergence trap, consisting of an inverted clear vinyl plastic cone with an eight-ounce jar at its apex, set just below the water surface. We also collected insects with standard gear.

Water and soil were analysed for chemical composition and data gathered on light, temperature, water levels and precipitation. Minimal summer precipitation and high temperature are necessary for a rapid rise in total dissolved solids in small prairie ponds. Conversely, high precipitation and moderate to low temperature cause little change, sometimes even a decline, in total dissolved solids. Water levels are apparently influenced by precipitation and temperature in a similar manner.

E. A. Driver

Wetland habitat investigation in Saskatchewan

Investigation of wetland habitat in Saskatchewan began in 1962, with co-operation of the Saskatchewan Research Council, and ended in 1969 when collection of data on water level, vegetation and waterfowl use was completed. Particular study was made of factors affecting the permanence of wetlands.

Preliminary analysis of data, in 1966, suggested a relationship between rate of water loss and the length of shoreline per unit area, that is, the size and shape of the wetlands. Data were based on constant basin measurements taken from aerial photos and not on measurements determined from varying water levels at different times of the year. To test the initial findings we surveyed all study basins at Saskatoon and Swift Current and reanalyzed water loss data for 1963–69 on the basis of actual water area and length of shoreline. Detailed contour maps (contours at approximately six-inch intervals) prepared from survey records were used as the basis for calculating area and length of shoreline for various water depths in each basin. Our reanalysis confirmed and increased the accuracy of our earlier observations.

A study was undertaken in 1969 to devise a method of estimating actual water area and length of shoreline, without going through the time-consuming process of surveying basin contours. Using two diameter measurements with the formulae for the area and perimeter of an ellipse we can produce results within 10 per cent of the actual values, providing the outline of the wetland is reasonably regular. With this technique it was possible to reanalyse the data for Melfort basins, which were not included in the contour mapping program.

St. Denis Research Area

The St. Denis Research Area is 960 acres (1½ sections) of land bought in 1968 for wetland research. The only permanent site for CWS research, it is used by biologists of the Prairie Migratory Bird Research Centre in Saskatoon.

The wildlife area is 26 miles east of Saskatoon and 3 miles north of the hamlet of St. Denis in Minichinas Hills, a region of moderately rolling upland. This region has a pond density ranging from 30 to 153 per square mile. Soils are Weyburn loam and a medium-textured dark brown soil occurring on undifferentiated glacial till deposits (boulder clay). Cereal crops predominate here, but tracts of native pasture are still quite common in more steeply rolling and stony locations.

Two hundred and twenty depressions capable of holding water range in size from 0.10 acre to 21.4 acres. Of these, 86 were in their natural state when the site was bought, the balance were being cultivated or had been recently cultivated. Six of the wetlands, excluding three dugouts, were classed as semi-permanent to permanent. Approximately 118 acres of uncultivated upland were either native prairie or aspen groves.

Development began in May 1968 when steel water level markers were installed in 150 basins and five rain gauge sites established. Records of water level, rainfall and waterfowl use were collected weekly from May to November. A legal survey was conducted by personnel of the Department of Transport and perimeter fences were erected. Six permanent bench marks (24-foot high steel and concrete columns) provide accurate reference points for future water level and contour surveys.

The high water levels in spring 1969, highest in several years, gave us an opportunity to determine capacity and maximum size of many basins. The diameter of 65 wetlands was measured as water levels dropped and the data were used to calculate the area and shoreline of wetlands at various water levels. Water level was measured biweekly, and rainfall weekly. In addition, three types of rain gauges were compared. During the year water level gauges were removed from several cultivated depressions which could not hold enough water to be of any consequence. Twenty cultivated basins were selected for reversion to their natural condition.

Water level records from the study area will be compared for rates of water loss from wetlands on glacial till and sandy lacustrine

material. We will continue to collect these records to obtain reference material for future studies.
John B. Millar

Ecological evaluation in Saskatchewan and Alberta

The Saskatchewan River Delta

Development of an integrated land-use plan to increase economic opportunities for 1,000 Indians and Metis living on the western part of the Saskatchewan River Delta called for information on the area's capability for agriculture, fisheries, forestry, wildlife and recreation. The Saskatchewan Government therefore initiated study of the 1,100-square-mile region by a number of agencies between 1964 and 1967. CWS cooperated with the Saskatchewan Wildlife Branch and Ducks Unlimited (Canada) to evaluate the delta's potential for producing and utilizing big game, furbearers and waterfowl, and to determine how conservation of its wildlife and aesthetic resources could best be harmonized with land-use development.

A vegetation map at a scale of one inch to one mile (1:50,000) was prepared through interpretation of stereo-pairs of aerial photographs and about 190 ground checks by helicopter and airboat. The map was then used as the sampling universe for census work to establish wildlife population levels and potential. Subsequently, three maps illustrating production capabilities for waterfowl, muskrat and moose were assembled. A comprehensive report to the Saskatchewan River Delta Development Committee recommended restriction of agriculture to the higher lands along the banks of the Saskatchewan River, and development of 400,000 acres of low-lying marsh habitat for wildlife management. To carry out the second recommendation, a series of interconnected compartments would be built to allow manipulation of water level which would create habitat conditions best suited to production of waterfowl and muskrats; access to the management area would be improved; and out-camps for hunters, fishermen and other visitors would be set up. The area would benefit economically from the wildlife scheme through increased work opportunities for residents and purchases by visitors, and it would help meet increasing demands for various forms of outdoor activities. The committee largely accepted the wildlife report and the Government of Saskatchewan is considering it.

CWS field research into the dynamic relationships between major vegetation types and principal environmental gradients, such as water regime and soil nutrient status, ended in autumn 1968. This knowledge is needed for fuller understanding of how the delta and similar ecosystems are functioning. From this can be predicted how potential environmental changes induced by man will affect the wildlife habitat.

Composition and structure of the vegetation were investigated in selected representative areas; seasonal fluctuations and depth of the water table and soil temperature were monitored during three growing seasons. Soil and water samples were analysed in the laboratory.

The data were classified by association analysis using computer programs written by the Division of Computing Research of the Commonwealth Scientific and Industrial Research Organization at Canberra, Australia. Vegetational categories occupying certain distinct positions in the landscapes have been recognized. The distribution of major plant species and species-groups related to specific environmental factors will be examined in detail through principal component ordination techniques.

Peace–Athabasca Delta

Filling of the reservoir behind the W.A.C. Bennet Dam on the Peace River at Hudson Hope, B.C., began in spring 1968. Until the reservoir is filled in 1971, the mean annual flow of the Peace River will remain drastically reduced. Although flows will increase when the hydro-electric generating plant is operating to capacity, the natural periodicity of high and low water levels on the river will probably never recur. One major effect of this change in flow pattern will probably be a lowering of the mean level of Lake Athabasca and the adjoining numerous lakes and marshes of the 2,000-square-mile Peace–Athabasca Delta in northeastern Alberta. This delta is very important in the life cycle of a large number of North American waterfowl for breeding and moulting, as a congregating area during spring and fall migrations, and as a refuge for prairie ducks displaced by drought. In addition, the delta has produced large muskrat harvests and its major water body, Lake Claire, has supported a large goldeye fishery. Reduction in seasonal water levels in the delta will probably cause major changes in the vegetation patterns of the delta and consequently in the extent and quality of wildlife habitat.

The Canadian Wildlife Service has undertaken a five-year study of the Peace–Athabasca Delta, with the following objectives:

1. To determine the relationship between vegetational patterns and principal environmental features, and develop a vegetation/site classification of the landscape;
2. To evaluate waterfowl use of various habitat types for breeding, nesting, brood rearing, moulting, and spring and fall staging;
3. To predict the long-term effect of the Bennett Dam on landscape and waterfowl capability, and recommend remedial action to maintain waterfowl populations at a desired level.

Owing to the extensive and relatively inaccessible terrain, interpretation of aerial photographs is a major technique in the study. Several representative areas have been selected within the delta for intensive examination. For each study block, a map outlining major landscape units was prepared from mosaics of recent, small-scale aerial photographs. These reconnaissance maps form the basis for all phases of the field research.

To evaluate the relationship of major vegetation and site types and to monitor changes in their pattern of distribution resulting from the altered water regime, permanent transects were marked within each study block. CWS personnel photographed the transects on three occasions during the 1969 growing season. True colour, infrared colour and black and white photos were taken from an altitude of 1,500 feet with a 70 mm Hasselblad 500 EL camera. This combination of film types, in conjunction with the seasonal difference in the vegetation, will permit far greater detail and accuracy for interpretation of the aerial photographs than is possible with conventional black and white coverage alone.

In addition, selected segments of the transects were sampled on the ground to relate actual vegetation and site conditions to the aerial photographs.

Infrared colour film is particularly valuable in distinguishing various types of wetland vegetation types. Sedge meadow vegetation is apparently reacting quickly to reduced water levels, invading the newly exposed silty deltaic deposits very rapidly. It will probably take the wide variety of species in these new communities several years of competitive interaction to sort themselves into uniform community types. Detailed study of the changes in density, structure and composition of fen communities will aid in predicting types and quality of lakeshore habitats.

Waterfowl populations and distribution are determined along selected transects, shorelines, and sections of rivers and streams. Spring populations, breeding populations, broods, moulting populations and fall populations are counted repeatedly from airboats and slow-flying aircraft. Counts are then related to the distribution of certain habitat types.

Air photo monitoring of vegetation changes over a period of years will aid in predicting permanent changes in the landscape of the delta, likely a result from the altered water regime. This information can be correlated with the results of the waterflow study to forecast the future waterfowl capability of the delta and decide what steps are required to prevent habitat loss or deterioration.

H. J. Dirschl

Alberta watershed research program

The Alberta Watershed Research Program, sponsored by several government agencies, investigates water yield from the east slopes of the Rocky Mountains, and the effects of logging, mining, grazing and land management on quantity and quality of water yield.

The Canadian Wildlife Service has been participating in this program for several years. Our investigations into the relationships of big game and rodents to vegetation, and their possible effects on the water regime, will help us to predict the effect of land management practices on wildlife and will provide basic information on the ecology of the foothills region of Alberta.

The foothills support a wide variety of large mammals: domestic cattle, moose, wapiti, white-tail deer, mule deer, black bear, grizzly bear and feral horses. The research watersheds contain these animals in various combinations. The research areas also have varied populations of rodents: prairie burrowers, such as pocket gophers and ground squirrels; forest rodents, such as beavers and chipmunks; and alpine species, such as marmots and pikas.

CWS studies have centred on the Streeter Basin Research Watershed in the Porcupine Hills to evaluate the primary production of browse and herbage and its relation to weights eaten by ground squirrels, big game and cattle. We are monitoring populations of these mammals by live trapping and pellet counting, and investigating forage use by remeasuring sample shrubs and by wire-cone exclosures.

The rodent that most greatly influences the water regime is, of course, the beaver. Beaver dams hold water, slowing spring runoff. They provide watering places for livestock and big game, and habitat for waterfowl, shore birds, small fur-bearers and fish. Beaver do not remain forever in the same place, although certain desirable colony sites may be occupied quite regularly for decades. Beaver usually occupy a site for several years. During these years they use up the available food supply, then move on. Alternatively, if the beavers are trapped out, or die from some other cause, the site will not be reoccupied. A site with a good food supply is almost always reoccupied in the same year. Once a colony site is abandoned the dams deteriorate and eventually give way; the rushing water may seriously erode stream banks and also increase the rate at which sediments trapped behind the dam are washed downstream.

To determine the geomorphological and vegetational characteristics that make a site suitable for year-round beaver occupation CWS is studying beaver ecology in the Porcupine Hills of southern Alberta. It is also comparing abandoned colony sites with sites still being used, and with stretches of stream never used by beavers, to pinpoint the factors that render a site desirable. In addition, the ecology of beavers in the Porcupine Hills is being compared with the ecology of those in the boreal forest of the Spring Creek research watershed near Valleyview.

Logging practices will be tested on some experimental watersheds and their effects on wildlife monitored.

E. S. Telfer

Pathology

Moose. The Pathology Section's studies of moose in southern national parks have shown they are generally healthy.
Photo by Don Dabbs.

Wild animals die from a number of causes. Those of us who drive along the highways are only too familiar with the sight of dead animals lying there. Very likely just as many are injured by vehicles and go off to die in some quiet spot. Poisoning of wildlife by chemical agents in the environment is also common. How certain pesticides have caused the decline of some bird populations has been well established. Disease is another cause of death in wildlife.

Parasitic organisms cause many diseases in wildlife just as they do in humans and domestic animals. Some of these parasites, such as viruses, bacteria, fungi and protozoa, are microscopic; others, such as worms and arthropods, are larger and visible to the naked eye. Diseases may be a cause of conditions which kill animals or lower their commercial or recreational value. Diseases may also result from nutritional deficiencies, arising from overpopulation or environmental change, which reduce the animals' resistance to infection.

Disease is one of nature's ways of regulating wildlife populations, bringing them to levels at which their habitat can support them in good health. It thus achieves results comparable to those attained through management practices, though the latter are less wasteful of animals and habitat. Disease also continually threatens rare species with extinction. In addition, many wildlife species are reservoirs of diseases transmissible to man and/or domestic animals.

We have been studying parasitic worms to determine what species occur in fur-bearing carnivores in the Yukon and Northwest Territories, such as grizzly and black bears, wolves, wolverines, foxes and lynx; in colonial sea-birds on the Atlantic coast, such as gannets; and in waterfowl on the prairies of British Columbia.

From information gathered over a number of years we have reached the following conclusions about the health of wildlife species in national parks and in the territories, and the distribution, prevalence and significance of parasites and diseases affecting them.

Bison, moose, deer and elk in southern national parks and reindeer in the Canadian north are in generally good health, whereas bighorn sheep in some areas of western Canada are not. The Kaminuriak barren-

Siberian reindeer, bought in Alaska in 1935, formed the nucleus of the Canadian herd in the Reindeer Preserve, NWT.
Photo by Terry Pearce.

ground caribou in the District of Keewatin, Northwest Territories, and in northern Manitoba have undergone a two-year study. This population is generally healthy, but further investigations are warranted to assess the significance of a number of conditions that were noted.

Such information is useful to the biologist studying a species, to the manager managing it and, for those diseases which may be transmitted to man or domestic livestock, it is also important for protection of health.

The Pathology Section investigates disease problems in wildlife, except for marine species, in the Yukon and Northwest Territories and in national parks; and in migratory birds throughout Canada. In addition, it assesses the nature and cause, the occurrence, extent and significance of diseases in wild animals; and, working with other CWS sections and other wildlife agencies, develops and often implements measures for their prevention or control. In the Pathology Section's laboratory material collected by CWS staff, other agencies or individuals is examined.

Assessment of disease

Conservation of animals requires more knowledge about the health of wildlife populations. This information is obtained by investigations of disease outbreaks and die-offs, and by systematic study of wild animals to determine the incidence and significance of the diseases which affect them.

Blood, faeces and tissues are examined in the laboratory. Of equal interest are anomalies. CWS pathologists and biologists collect material at every opportunity from animals taken for biological studies or for wildlife reduction programs. Trappers and sportsmen occasionally submit specimens for examination.

Trichinosis

The trichina worm, widely prevalent in northern carnivores, is essentially a parasite of flesh-eating mammals. Raw and rare meat containing the larvae can cause trichinosis. In man, it is a serious and often fatal disease and it can be detected by skin tests. Surveys of human populations in northern Canada have shown that the disease is common in aborigines. And it is likely that the "food poisoning" on which the deaths of entire Eskimo families had been blamed, until the 1930's, was trichinosis. Outbreaks of trichinosis in the Canadian north have been traced to the consumption of the meat of bears, walruses and arctic foxes. The polar bear is probably the greatest potential source of human infection. But spread of the disease by the walrus can be more extensive since several families may share an infected carcass.

Hydatid disease

Hydatid disease is a parasitic disease resulting from the development of the larvae of tapeworms of the genus *Echinococcus*. The life cycle of one tapeworm species (*E. granulosis*) is outlined here. Two hosts are required to complete the life cycle. The final host harbours the adult worm, and the intermediate host harbours the larva which is in the form of a vesicle or cyst known as a hydatid. In northern areas, the tapeworm develops in the dog, the wolf and, occasionally, the coyote; its larva or hydatid develops in ungulates and man.

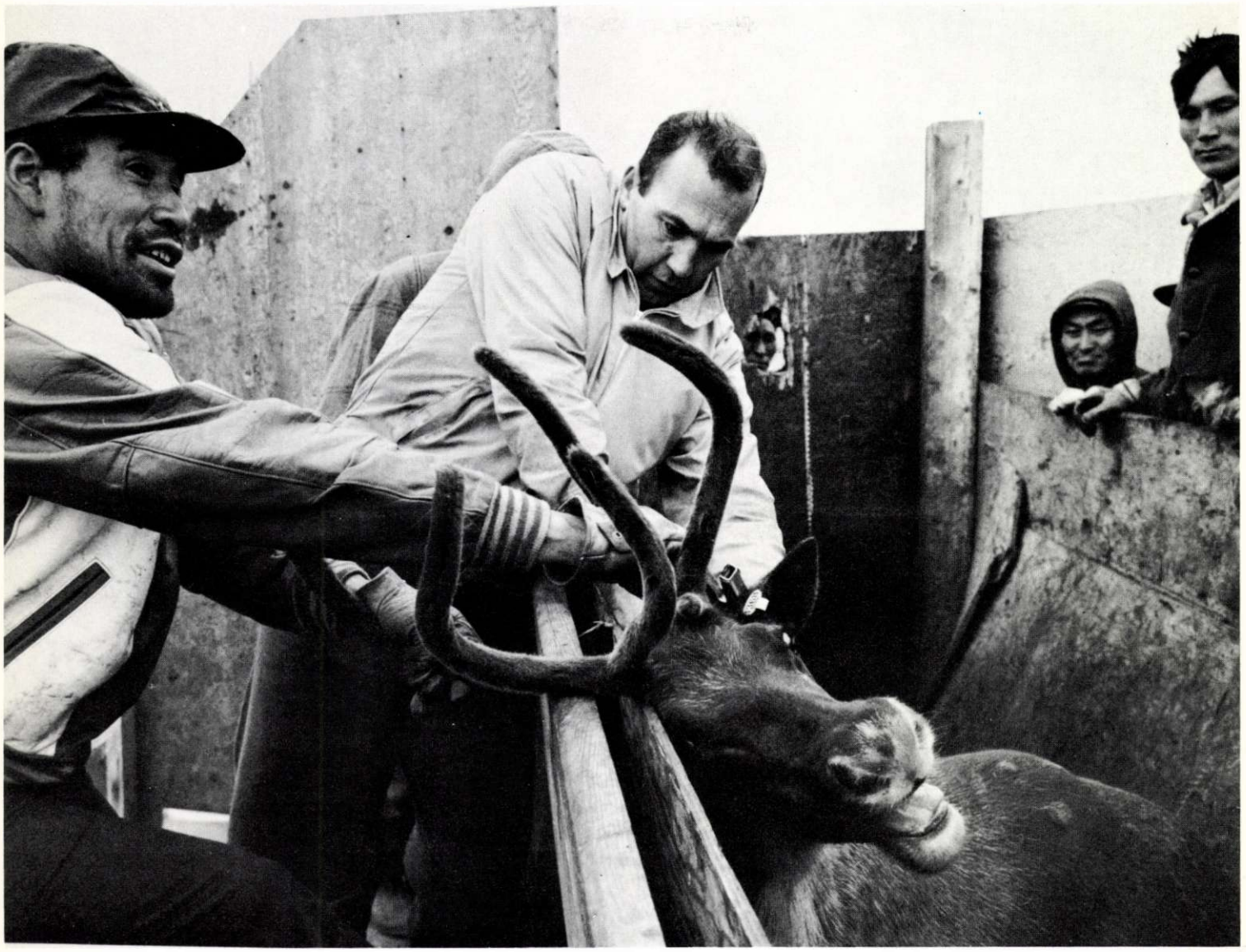
Hydatid cysts are frequently found in the lungs of moose and caribou. The hydatid can be as small as a marble or bigger than a grapefruit. It contains many tapeworm heads which develop into adult worms when it is taken into a suitable host, for example wolf. The adult tapeworm then produces eggs in the intestine of the wolf which evacuates them in its faeces. An ungulate, for example caribou, may eat these eggs on contaminated vegetation and in this host they are slowly transformed into hydatid cysts.

Several large cysts in the lungs may debilitate a moose or caribou but they cause a much more serious condition in man. There are several records of hydatid disease in northern Canadians who have been infected mainly by dogs feeding on the contaminated viscera of game animals like moose and barren-ground caribou.

Besnoitiosis

Besnoitiosis is caused by the spore-forming protozoa *Besnoitia tarandi*. The spores are formed within pseudocysts in the connective tissue (skin, tendon and the fibrous membrane surrounding a bone). Besnoitiosis is common in countries of the Middle East and Africa where it causes chronic debilitation and occasionally death in cattle. The disease affects the skin and occasionally the reproductive system. Cutaneous lesions appear as rugose, thickened, hairless areas particularly on the legs and scrotum. Sterility, as a result of the invasion of the testicles has been reported in cattle

E. Broughton, CWS pathologist, applies an ear tag to this reindeer. The Pathology Section is also investigating disease in reindeer.
Photo by Terry Pearce.



in South Africa and reindeer in Russia.

Lesions observed in caribou consisted in a slight thickening of the skin and were not extensive. The animals showed no sign of debilitation and the genital organs of the infected males were not affected. Records indicate that besnoitiosis is common in barren-ground caribou, but its significance in this species is not very well known. Seriousness of the disease in cattle and, occasionally, in reindeer calls for further study to assess its effects on barren-ground caribou.

Brucellosis

Brucellosis afflicts humans and animals exposed to bacteria of the *Brucella* genus. The clinical disease or evidence of exposure has been reported in domesticated, semi-domesticated and wild animals in many parts of the world. *Brucella* organisms cause abortion, retention of the placental membranes, inflammation of the testicles or uterus, sterility or infertility, arthritis and bursitis in such animals as cattle and bison, reindeer in Russia and caribou in Alaska.

Brucellosis has been diagnosed in bison, moose and elk in some of Canada's national parks. It is no longer a problem in wild animals in the southern parks but it is a problem in the 10,000 to 12,000 bison in Wood Buffalo National Park which straddles the Alberta–Northwest Territories border. The disease was probably introduced there by bison transferred from Wainwright, Alberta, in the mid-1920's. Brucellosis has also been diagnosed in reindeer in the lower Mackenzie District but it is not widespread in these animals. It exists in the Kaminuriak barren-ground caribou herd in the District of Keewatin and northern Manitoba but we do not have enough information to assess the incidence or significance of the disease in this population.

Humans who come in contact with meat, blood and placental membranes of animals with brucellosis, or eat their raw meat or

bone marrow, may become infected. Seven clinical cases of brucellosis in Canadian and Alaskan Eskimos, probably infected by caribou and/or reindeer, were recorded between 1953 and 1966. Five of the Eskimos had never been out of the Arctic. Subsequent studies in Alaska have shown that caribou are an important source of human infection. We do not know whether brucellosis is present in Canadians who utilize the Kaminuriak barren-ground caribou.

While brucellosis does not seem a serious threat to the welfare of that caribou population, we should certainly try to determine its significance to the health of animals and people.

Enzootic diseases

Enzootic diseases are those of low incidence, constantly present in a specific locality. They do not reveal their presence by high mortality rates and rapid spread, as do the epizootic (epidemic) diseases. It is therefore difficult to recognize their occurrence and assess their significance in wildlife populations. This can be correctly assessed only through the accumulation of information on health status, population dynamics and the total number of animals in a specific area.

The growing impact of recreation, agricultural development and mineral exploitation on wilderness and wildlife will certainly call for changes in wildlife management and conservation practices. Pathologists will have to pay closer and continued attention to enzootic diseases in wildlife populations, and will have to regard, with utmost importance, their prevention and control.

Prevention and control of disease in wildlife populations

Faced with outbreaks of disease or die-offs in wildlife populations one is often left with a sense of helplessness. But many of these problems can, to some extent, be solved by a positive and rational approach. The nature and behaviour patterns of free-living animals, the features of their habitat, the condition or disease to be controlled or eradicated all pose problems. But these are not necessarily insurmountable if logical and sensible use is made of information about the species and the disease afflicting it. Measures to control anthrax in free-roaming bison in northern Canada are an example.

Anthrax is an infectious disease caused by a bacterium, *Bacillus anthracis*. The disease is usually characterized by its sudden onset and rapidly fatal course. This bacterium can produce spores highly resistant to heat, cold and environmental change, and may remain viable for many years in the soil, water or such animal matter as hide and hair. The spores' ability to survive for an indefinite period in some types of soil means that animals utilizing meadows where anthrax has previously occurred are in danger unless they are vaccinated.

Few parts of the world are free of anthrax. In Canada, the disease occasionally occurs in livestock; it can be transmitted to man; and it has been reported in various wild animals, particularly herbivores. Bison was the first Canadian wildlife species in which anthrax was diagnosed. The disease was found in bison in the Northwest Territories in summer 1962 and has recurred in subsequent years. It has killed almost 1,000 bison, but how it was introduced into northern Canada is not known.

A control programme initiated in 1965 entails continued surveillance, mostly by helicopter, of bison herds during summer and an anti-anthrax vaccination program. All dead bison are considered to have died of anthrax and are destroyed by fire in a pit. The area where the dead animal was lying is burned off, the pit is filled in and the site and immediate vicinity are covered with lime to discourage grazing and wallowing by other bison.

Because bison are gregarious, it is fairly easy to herd them by helicopter and drive them into corrals where they are vaccinated. The corners of the corrals are rounded to prevent animals from piling up, and the chute leading from the corral can be partitioned off with sliding gates to isolate one animal in each compartment. The inoculator can then inject the bison from a catwalk alongside the chute.

In 1965, 1966, 1968, 1969 and 1970 respectively 4,291, 4,161, 940, 3,020 and 3,452 bison were vaccinated. Only one death attributable to anthrax was recorded in 1968, and none in the other four years. In 1967, when no animals were vaccinated, 120 died from the disease.

Our use of vaccine on bison in 1965 was the first attempt ever to control anthrax in a wild population. Evaluation of the success of the vaccination program is very difficult. In 1965, 1966, 1969 and 1970, when almost half the bison in the high risk areas were vaccinated, no deaths of non-vaccinated bison were attributed to anthrax. The vaccination program on its present scale is unlikely to eliminate occurrence of the disease completely but it will, undoubtedly, prevent large explosive outbreaks.

Diseases are not the only causes of die-offs. Over-population or increased competition for food may weaken animals thus making them susceptible to disease. Such situations can often be corrected, or avoided, through management of habitat and animal populations. Where over-utilization, pollution or other human activity cause changes in the environment detrimental to the health of wildlife populations, the solution rests with removal of the primary cause. In some cases, however, the environment has been so badly damaged that there is little chance of rehabilitation.

L. P. E. Choquette

CWS took over management of the reindeer herd in 1966. It is also studying the value of the range to the herd.
Photo by Terry Pearce.

Male peregrine falcon. This predatory bird species is affected by some pesticides.
Photo by R. W. Fyfe.

Toxic chemicals

Introduction

Continued federal research into pesticide effects on wildlife in Canada has been conducted only since 1963, in contrast to the United States federal program dating back to the 1940s. This is because the few Canadian studies done in the 1940s and '50s showed no serious effects on wildlife, and the large-scale use of pesticides in the United States that were clearly destructive of wildlife had no counterparts in Canada. During this early period, the Canadian Wildlife Service studied DDT used to control spruce budworm in forests, and DDT and parathion used in orchards. None of these studies showed important effects within the treated areas on birds, the principal wildlife group studied.

These encouraging research results, and the continuing absence of widely noticed wildlife casualties due to pesticides, meant that Canadian federal wildlife research priorities lay elsewhere during the next ten years. In the early '60s, however, research in Europe and the United States clearly showed that immediate wildlife kills caused by pesticides were not the whole story. The magnification of persistent residues along food chains could produce either direct mortality or reduced productivity in populations of birds distant in time or space from the actual pesticide use. These effects were by no means obviously pesticide effects and to uncover them required both long term biological field work and elaborate chemical analysis of residues.

At this point CWS started a continuous research program.

Effects of forest spraying

The aerial-spraying of New Brunswick forests to control spruce budworm began in the early '50s and is still continuing. While DDT, the initial material used, had produced no obvious effects on wildlife, the substitution of an organophosphate prompted CWS to renew its attention. Initial studies done for the service by C. D. Fowle showed severe bird mortality caused by the first organophosphate used. From this, Peter Pearce has developed a long-range CWS program to measure side effects of materials used in forest spraying and to work co-operatively with agencies, such as the federal Department of Fisheries and Forestry, to identify what wildlife damage could

be expected from different pesticides or application rates proposed for operational use. The emphasis is on experiments to define wildlife hazard before large-scale operational use.

The CWS project is continuing for several reasons. First, millions of acres of wildlife habitat are treated each year, and it is obviously desirable to avoid wildlife damage on this scale. Second, Canadian forests are likely to become more intensively managed in the future and pesticides are likely to remain important management tools, therefore, we need to learn how to measure wildlife damage from forest spraying. The New Brunswick experience is clearly showing that present wildlife techniques for measuring anything less than a biological disaster are embarrassingly inadequate. We have a few techniques for measuring changes in breeding songbird populations and we are trying out ways of measuring changes in numbers of forest mice and amphibians.

These techniques are, of course, a long way from a decent ecological assessment and their inadequacy is an index of both the complexity of ecological systems and of the primitive state of contemporary ecological measuring. A legacy of the large-scale spraying of forests with DDT came to light in 1970, when we found DDT levels averaging 56 parts per million (ppm) in woodcock from heavily sprayed areas of New Brunswick. Samples of woodcock were taken throughout the province with the co-operation of the New Brunswick Fish and Wildlife Branch, before the 1970-71 hunting season opened. The discovery of such high DDT residues led to cancellation of the hunting season on these birds. This step was taken after consultation with the Department of National Health and Welfare, whose highest tolerance for human food is 7 ppm DDT.

Persistent chemicals in food chains

Evidence, from abroad, that certain bird species at the ends of food chains were accumulating damaging levels of pesticide residues led CWS to examine similar species in Canada. But instead of looking at a particular use of a pesticide and defining its side effects we look at a particular species population and try to assess what role pesticides might play amongst the whole complex of population regulating factors.

Long-term projects are now underway on the prairies. Richard Fyfe is studying populations of falcons and hawks at the end of terrestrial food chains and Kees Vermeer is studying populations of fish-eating birds at the ends of aquatic food chains. Early results suggest that recent declines in breeding populations of some falcons are indeed related to accumulating residues of toxic chemicals in Canada. Such agricultural pesticides as DDT, heptachlor and mercurial fungicides are playing a part in abnormally reduced survival of eggs or young. Also present are PCB residues of industrial origin; and while their relationship to decreased survival does not now seem as close as the pesticide relationship, neither their chemical detection nor their biological activity is well worked out. First results suggest that some populations of fish-eating birds, such as white pelicans, are now not at risk from organochlorine compounds, but in some other species, such as Great Lakes bald eagles, the association between high organochlorine residues and abnormally low reproductive success is uncomfortably close.

These studies on birds at the end of food chains are likely to continue for some years, partly because we need to know more than we do of their population biology, but particularly because such birds are valuable indicators of those persistent environmental toxicants that are magnified along food chains. If prairie falcons in southern Alberta reach the point of having trace quantities of mercury and the organochlorines, we can reliably predict that in that area terrestrial animals and their food are generally free of these chemicals.

Colonial-breeding fish-eating birds are particularly useful indicators of contamination in the aquatic environment because the colonies themselves are very stable, lasting for tens or even hundreds of years, and so really long term trends in residues can be traced against an extremely constant genetic and ecological background. CWS is now following residue levels in the huge gannet colony on Bonaventure Island off the Gaspé with this in mind. These birds spend the summer catching fish, mostly herring and mackerel in the Gulf of St. Lawrence. Thus, trends in the gannets' residue loads will reflect trends in residues entering the gulf, primarily those coming down the St. Lawrence itself.

All these studies of persistent chemicals in food chains were started with pesticides in mind, but results now show that for persistent materials whose residues move away from their source, the separation of pesticides from other toxic chemicals is misleading.

Residues both of pesticides and of industrial-origin PCB and mercury are now commonly found together in Canadian wildlife, and their combined effects have to be worked out. What used to be the pesticide-wildlife area of research has lost its traditional boundaries, and some general term, such as "toxic chemical", should be substituted for "pesticide".

Mercury project

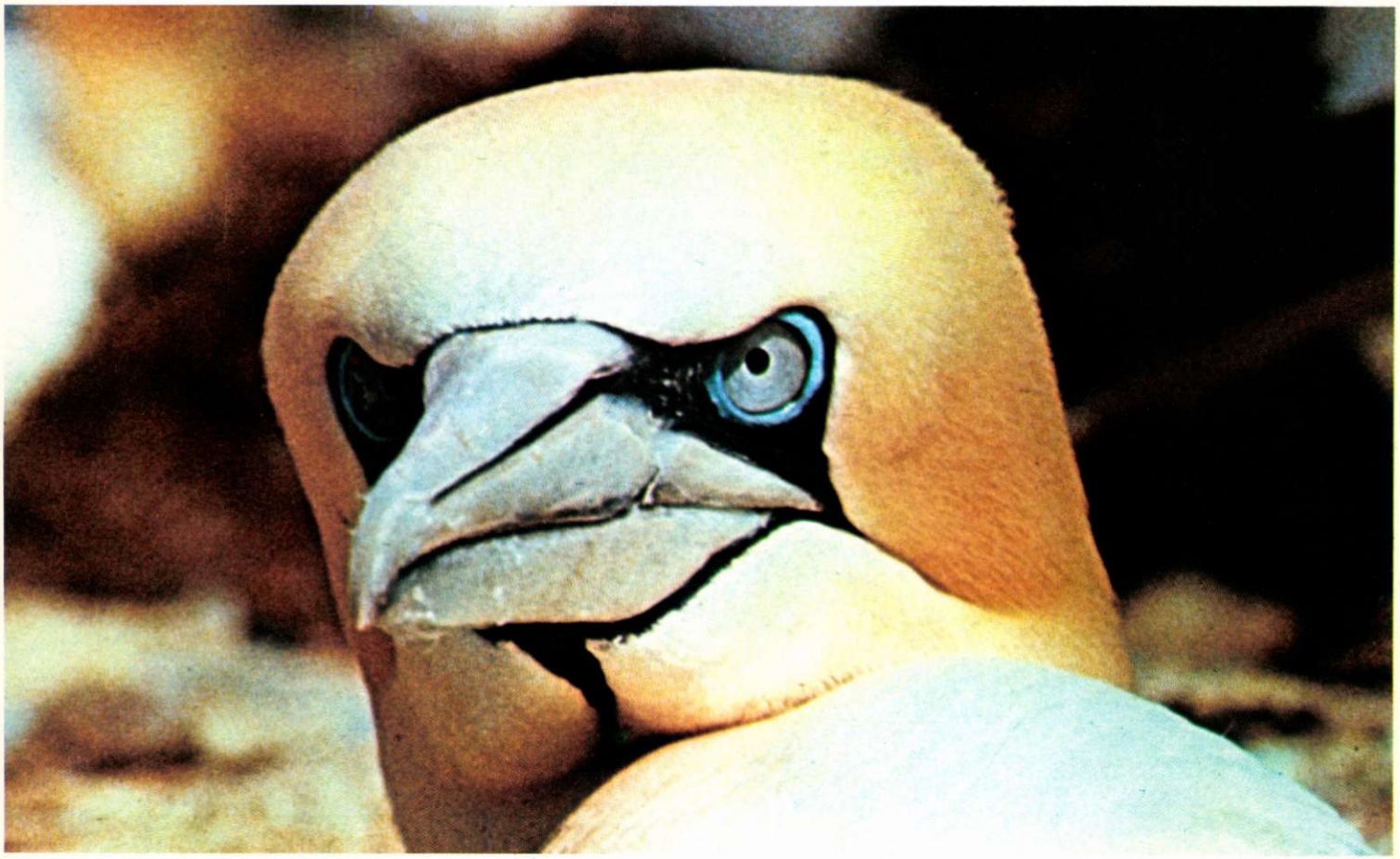
An example of this shift in emphasis is the CWS mercury project, begun in early 1968 with a contract Ph.D. study by Norvald Fimreite at the University of Western Ontario and since integrated into staff programs. This project, perhaps the first look at mercury as a widespread biological contaminant in North America, set out from the beginning to measure the total use of mercury in Canada and to assess residues of mercury originating from both agricultural pesticide and industrial uses. Both agricultural and industrial uses of mercury prove to be important sources of food-chain contamination. From the agricultural source come the terrestrial system residues in seed-eating animals and their predators, and from the industrial sources come aquatic system residues in fish and fish-eating animals.

CWS 1968 and 1969 field data of mercury levels in birds and fish caused other agencies to make their own surveys. Our data on mercury and seed-eating prairie birds led Alberta to survey pheasants and partridges and close the hunting seasons in 1969. Our data on Lake St. Clair fish led fishery agencies to conduct their own extensive surveys and close many commercial fisheries.

Review of pesticides before use

In the mid '60s the CWS role in the Department of Agriculture's review of pesticide registrations was relatively minor, with the work done part time by the one Pesticide Section staff biologist. Its role gradually developed until by 1969 it had a major part in the interdepartmental review resulting

An adult gannet. Preliminary studies show that DDT levels of gannets on Bonaventure Island are high enough to be linked with their unusually low hatching rate.
Photo by R. W. Fyfe.



in elimination of most of the registered DDT uses. This review function of the Toxic Chemicals Section has now expanded to the point where a staff member works entirely on review of agricultural chemicals and on improvement of techniques for spotting potential environmental pollutants among proposed new products.

New directions

For the immediate future, we must pay close attention to wildlife contamination attributed to those DDT and mercury uses now being restricted. In this way, our causal hypotheses can best be tested. Given wild populations subject to a variety of chemical and non-chemical stresses, CWS research has indicated that just a few chemicals are much more important as stresses than anything else. If these chemicals are sharply reduced, and other factors stay roughly the same, a resurgence of the wild populations would confirm the original hypotheses.

The next research priority would be the PCB question. Something has been learned of PCB distribution in wildlife populations, and if present methods are any good, concentrations of PCB's are now similar in many places to the traditional benefactor DDT. PCB residues from industrial compounds show the same flair for widespread distribution and food-chain concentration as DDT and CWS is now investigating their possibly similar role in interference with bird reproduction. The key question is biological significance. The research has, so far, come up with conflicting results. Some research suggests that PCB's, like DDT, are active enzyme inhibiters causing abnormal eggshell thinning; other research fails to show that PCB's are a significant cause of eggshell thinning or lower hatchability. But it is definitely possible that PCB's are as ecologically damaging as the DDT group.

Some research has been done on the main problems caused by insecticides whenever these problems have come to light. Herbicides form another particular group and their use has increased enormously in recent years. Herbicides have altered widespread plant communities in favour of a particular crop or human rights-of-way, and spray drift has altered adjacent areas. Wildlife species usually depend on certain kinds of plant communities rather than on others, so the widespread use of herbicides in Canada may strongly affect wildlife by altering its habitat. As suprisingly little is known about this, CWS is starting a long-term project on the ecological effects of herbicides.

Obviously, research into the effects of toxic chemicals has been oriented towards problems of contaminants already at large in the environment. This work will continue. But it is equally vital to try to intercept potential environmental contaminants before they are generally used. To predict how new products will behave in the environment, CWS has embarked on long term research to devise the appropriate ecological tests.

J. A. Keith

Biometry

When we speak of biometry, we are speaking of the application of mathematics to biology. Every biologist who can count is to some degree a biometrician. When he scans a water body through binoculars and reports ten broods of mallard ducks with an average of six young per brood, he is practising biometry. When the Biometrics Section completes a statistically designed, Canada-wide, mail questionnaire survey of waterfowl hunters and reports that 389,000 persons bought permits in 1969 and harvested 2,716,000 upland game ducks of which over a million, or 38 per cent, were mallards, that too is biometry.

At one time, the naturalist was satisfied to describe things rather than to count them; he looked for unknown species to name and describe; he preserved specimens in museums to record their existence. He was a qualitative biologist. Today, the naturalist goes far beyond that. More and more, he studies populations rather than individuals. He measures individual animals, populations and the environment; he maintains continuous inventories of populations. He is a quantitative biologist.

Since 1966 biometry in the Canadian Wildlife Service has expanded in many directions. Denis Benson is section head and Harold Delcorde is co-ordinator of surveys. Positions for biometricians were established and we are now assisted by Amode R. Sen and Donald Crober. Dr. Sen carries on research on the permit and survey system to improve statistical design and analyses. Mr. Crober advises field researchers. In addition three or four computer scientists of the Computer Division handle our data processing requirements.

Advisory services

We have all felt the impact of the computer. No longer are we intrigued by the little rectangular holes found in so many cheques, subscription statements, bills and so on. If we notice them at all, it is only after we have examined the dollar amount. This is one of the simple jobs for which the computer is used. In biology, as in other fields, the computer makes it possible to pursue complex numerical studies not practical by manual methods. The biometrician is the middleman between the biologist and the computer.

Studies of fish, particularly sturgeon; methods of census for many species; feeding habits and distribution of waterfowl; body measurements of elk; population dynamics of caribou; and the rate of growth of arctic lichens are some CWS projects which the Biometrics Section has assisted.

Canada migratory game bird hunting permit and survey system

Canada migratory game bird hunting permits were first sold in 1966 and sales records processed and analysed by computer. In 1967, we began a waterfowl harvest survey of hunters selected from records of permit sales. Questionnaires were mailed toward the end of the hunting season, with follow up questionnaires later on to those who did not reply, and the information processed by computer.

The species composition survey began in 1967. We asked each hunter in the sample to send us one wing of each duck and the tail feathers of each goose shot, each item in one of 10 large envelopes supplied. More envelopes were available on request. Such a survey is necessary because hunters are often unable to identify the birds they take. However, biologists can identify the species, general age group and sex from the wing or tail feathers.

From our estimate of the total number of birds killed, we can work out the species composition of the harvest. This explains the name *species composition survey*, Such a survey is also known as a *parts*, or a *wing and tail*, survey. We analysed the 1967 species composition survey by hand, but have since used a computer.

The Canada migratory game bird hunting permit and survey system has developed into an effective working system for gathering data on waterfowl management. It will, of course, need improvement and change as we learn more and as waterfowl managers require different kinds of information.

Survey results are analysed as soon as possible, and published in detail in the CWS Progress Note series. They are also summarized in our "Report to Hunters" sent each August to all permits holders of the previous season. In this way, we complete the annual co-operative cycle. We return to the hunter information he has provided to assist us in managing the resource upon which he depends for his sport.

Denis A. Benson

Interpretation

A guide at Wye Marsh Wildlife Centre discusses a painted turtle with this young student.

A visiting student listens to a recording of bird songs. Audio-visual methods used inside the building can lead visitors to a greater understanding of what they see and hear outside.

Visitors to Wye Marsh Wildlife Centre can learn about life in the water.
CWS photos by Harold Whyte.

There are men still alive who can remember when the passenger pigeons filled the skies, the roar of their wings drowning out all other sounds. The flocks of swiftly flying birds, their numbers too large to imagine, sometimes took a full day to pass overhead. Today not one passenger pigeon remains alive. The last one seen in Ontario, in 1902, was just six miles from Wye Marsh Wildlife Centre.

The hardwood forest of eastern Canada is a rich, distinctive and heavily-populated part of the country and it is here that the Canadian Wildlife Service has begun its interpretation program. Opened officially in 1970, Wye Marsh Centre is four miles east of Midland, ninety miles north of Toronto and within a one-day drive of 50 million people. It is the first of a series of wildlife centres that will inform Canadians about the natural forces which shaped the face of Canada; about man and his environment and how one changes the other. If these wildlife centres achieve their purpose they may prevent tragedies like the vanishing of the passenger pigeon.

Man's technological progress gives him an enormous and increasing ability to destroy the productive surface of earth and puts him in danger of destroying all life, including his own. His green world shrinks while he crowds into great cities where he loses touch with the very countryside that makes life in the city possible. He loses his understanding of his natural environment and thus his capacity to destroy it grows.

Fascinating stories are contained in the landscape. Wildlife centres will interpret these stories using techniques perfected over 50 years in park interpretation programs throughout North America. These programs are highly successful in involving people with their environments and their success lies in using nature to tell its own story. For example, park visitors are taken right out on the land where they can feel the soil that makes all life possible; examine the plants that grow out of it while learning that the green leaf is ultimately the world's only maker of food for animals; and glimpse the wildlife that, like man, is supported by chlorophyll.

Wye Marsh Wildlife Centre is a low building surrounded by 2,500 acres of marsh, forest and old fields owned by the Province of Ontario. The building offers a theatre with shows many times daily, an exhibit hall, an information and sales desk, and a helpful staff of biologists and naturalists who conduct informal talks, daily walks, and special programs for classes of school children or groups of adults.

The building is not the focal point of activity—that lies outside. Within, exhibits and a wide range of literature are set up to arouse the visitor's curiosity and give him a brief lesson on how to look and where to look outside; closed circuit television brings live action from outdoors and encourages the viewer to explore the facinating landscape just beyond the door. There are paths, trails and boardwalks, blinds in which to hide and watch for wildlife, a viewing window into the underwater world of the marsh, and self-guiding nature trails with informative signs.

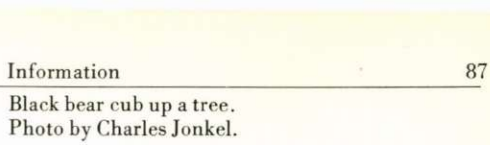
Management of Wye Marsh, by the Ontario Department of Lands and Forests, will enable people to see for themselves that improved habitats produce more and better wildlife. The primary purpose of the provincial lands in and around the marsh is wildlife management and public hunting. At the same time the area is open to other compatible public uses, such as hiking, nature study and photography.

The fee for entrance to the building is nominal: adults, 50 cents a day or $1.50 a year; children, 25 cents a day or 50 cents a year. There is no charge for entry to the surrounding land. The building is open daily from Victoria Day to Thanksgiving, but groups may visit, by appointment only, the rest of the year.

Ten centres are planned, mostly in the highly populated south, in the ecologically distinctive parts of Canada—the prairies, the north woods, the Atlantic shores, the desert-like valleys of the western mountains.

If man's survival is in doubt, it is because he is out of touch with the basic realities of his life. He has forgotten that he is part of his natural environment and is dependent on it. He must once again learn that destruction of his own landscape will lead to his own destruction. The road to renewed understanding must begin with renewed interest. Wildlife centres will capture this interest by showing how people, and wildlife, prosper in a healthy environment.
R. Y. Edwards

Information



Black bear cub up a tree.
Photo by Charles Jonkel.

The Canadian Wildlife Service communicates with many different publics through publications, television, radio and films. These publics range from scientists in a particular research field, to game managers, to Canadians who enjoy seeing or hunting wildlife and who are concerned about the future of this resource.

Communication with scientists and game management agencies is through scientific papers published in independent scientific journals, or one of four CWS series; Progress Notes, Occasional Papers Series, Report Series and Monograph Series. CWS has twice won the coveted Wildlife Society Award for two of its monographs: *The Murres* by Leslie Tuck and *The Barren-ground Caribou* by John Kelsall. Although these works are intended primarily for a scientific audience, they are written in a manner that makes them understandable to the interested layman and amateur naturalist. Even highly technical publications in the Report Series contain a "Perspective" that provides a popular explanation for the study.

As the agency responsible for administration of the Migratory Birds Convention Act, CWS publishes the regulations for hunting migratory game birds. These appear on posters and in pocket-sized abstracts as well as in a more complete booklet most often used by enforcement officers. CWS also publishes *Questions and Answers on Canada's Migratory Birds Regulations*, which answers more common queries on hunting these birds.

The ability of hunters to identify migratory game birds, under field conditions, is important to the management of individual species. Unless more hunters can discriminate accurately, selective management techniques will be most difficult to apply. To assist enforcement agencies and outdoor clubs in conducting duck identification courses for hunters, CWS supplies a booklet, *Ducks at a Distance*. In addition, it has sponsored a series of three-minute Super 8 film loops and a film, *Ducks of Course*, designed for intensive training in identification.

Informing the general public about wildlife is so vast an undertaking that no one agency could possibly carry it out. Most public libraries have a well stocked natural history section and some communities are also fortunate in having a good natural history museum. Joining the local natural history club, and the Canadian Audubon Society, are excellent ways to make contact with knowledgeable people and these organizations well deserve more public support. CWS assists in these grassroots efforts in every way it can but, because its scientific staff are fully occupied with research and management projects, most of its assistance must take the form of sponsorship of films and the publication of popular pamphlets about wildlife. Periodic reports to the public, such as this publication, are an important part of the effort to keep Canadians informed about CWS and its work.

The Hinterland Who's Who series is designed to provide authoritative readable information about wildlife species. The species selected are quite closely related to popular demand. CWS has been receiving an average of 4,000 letters a month, many of which ask for information about particular animals or birds, like the chipmunk or whooping crane; others are in response to one-minute films on wildlife that CWS supplies to television stations. Recently, a radio tape counterpart of the successful television film clips was inaugurated. The theme of the first series of five tapes featured the chickadee, downy woodpecker, red-breasted nuthatch, evening grosbeak and blue jay, all birds wintering in Canada.

Film and television are tremendously important media for communicating about wildlife, because their impact is so direct and powerful and because they can show us wildlife found only in remote places where few of us can go.

This year two feature films sponsored by CWS were produced by the National Film Board. *Atonement*, the first film, portrays selected CWS research and management projects organized around a theme of wildlife and the environment. The second, in which the timber wolf plays a leading role, portrays wildlife in our history and culture. It also demonstrates that research and management are vital to wildlife's survival, because of changes made by man to the environment.

Coverage of wildlife news in mass media has advanced in sophistication and depth and reflects greater public concern for deteriorating environment and vanishing species. A decline in number of some species is often an indication of important environmental changes. Wildlife is the theme of several regular television shows and some excellent popular books. If all this leads more people to direct experience of the wilderness and greater enjoyment in observing wildlife, the future will be much more encouraging for these natural resources and for man.

J. F. Cameron

Canadian Wildlife Service
Department of the Environment

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