ECOLOGY OF THE ASPEN PARKLAND

of Western Canada

CANADA DEPARTMENT OF AGRICULTURE

3.00

ECOLOGY OF THE ASPEN PARKLAND OF WESTERN CANADA

81314-7—1½

Aspen parkland under cultivation. Most of the grassland has been broken and the fields tilled up to the aspen and willow that surround the sloughs.

PUBLICATION 1066 FEBRUARY 1961

ECOLOGY OF THE ASPEN PARKLAND *of Western Canada*

IN RELATION TO LAND USE

by Ralph D. Bird
Entomological Laboratory
Research Station, Canada Department of Agriculture
P.O. Box 6200
Winnipeg, Manitoba

Contribution No. 27, Research Station
Canada Department of Agriculture
Winnipeg, Manitoba

RESEARCH BRANCH
CANADA DEPARTMENT OF AGRICULTURE
OTTAWA

HOW TO ORDER

Make cheques or money orders payable to the
Receiver-General of Canada, and send with your order to
THE QUEEN'S PRINTER
Ottawa, Canada

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1961

Price $3.00 Cat. No. A43-1066

4M—26161—2:61

PREFACE AND ACKNOWLEDGMENTS

Great changes have taken place in the ecology of the aspen parkland since it was invaded by the white man. Dominant animals and plants have been greatly reduced in numbers and many communities have been destroyed. Their places have been taken by the herds and crops of the settlers and their associated weeds and insect pests. Certain native species, however, have increased in numbers at the expense of those less adaptable. Conditions continue to change with the introduction of new farming methods. Oxen gave way to horses, which were in turn replaced by tractors. The swather and combine took the place of the binder and thresher; the plow was supplanted by the one-way disk. New methods and implements are continually being introduced. These man-made ecological changes are superimposed on changes that are taking place continuously without the intervention of man.

This is an account of the original ecological conditions and the changes that have taken place during settlement of the aspen parkland in Manitoba and eastern Saskatchewan. The descriptions of the early conditions were taken from the literature. Recent writers have described relatively undisturbed areas of prairie and woodland and old residents have reported changes since they settled in the country. The description of the changes is based on personal observations made during a lifetime of close association with the animal and plant life of the aspen parkland. Since early boyhood I have been keenly interested in all forms of life and have taken every opportunity to observe and photograph them.

The writing of this account was stimulated by association with many people. Help from all sources is gratefully acknowledged.

Early association with that great naturalist Norman Criddle, with whom I worked as an assistant for three summers while he was in charge of the Field Crop Insect Laboratory, Canada Department of Agriculture, at Treesbank, Manitoba, did much to stimulate my interest. He and his brothers Stuart and Evelyn contributed a great deal of information.

The nomenclature used is that of the following standard taxonomic works. When subspeciation is in doubt, binomials rather than trinomials are used. Standard common names are given when available, otherwise those in most general use in the area.

Mammals: Miller, S. G. and Kellogg, R. List of North American recent mammals. 1955.

Birds: American Ornithologists' Union. Check-list of North American birds. 5th edition. 1957.

Reptiles and amphibia: Logier, E. B. S., and G. C. Toner. Check list of amphibians and reptiles of Canada and Alaska. 1955.

Fish: Hinks, D. The fishes of Manitoba. 1943.

Insects: Common names of insects approved by the Entomological Society of America. 1955. Scientific names as recommended by systematists of the Entomology Research Institute, Dept. of Agriculture, Ottawa.

Plants: Fernald, M. L. Gray's manual of Botany. 8th edition. 1950.
Hitchcock, A. S., and A. Chase. Manual of the grasses of the United States. 1950. (for grasses)
Rydberg, P. A. Flora of the prairies and plains of central North America. 1932. (for plants not listed by Fernald)
Budd, A. C. Plants of the farming and ranching areas of the Canadian prairies. 1952. (for common names)

Technical help from the following people was most valuable: Prof. E. H. Moss, Department of Botany, University of Alberta; Prof. R. T. Coupland, Department of Plant Ecology, University of Saskatchewan; Dr. Doris Löve, Department of Botany, University of Manitoba (now at Botanical Garden, Montreal, Que.); Dr. B. Boivin, Plant Research Institute, Dept. of Agriculture, Ottawa; Earl Godfrey, National Museum of Canada; Dr. J. A. Elson, Department of Geology, McGill University; Dr. Alan Mozley, Union College, Schenectady, N. Y., and many others. My special gratitude is tendered to Dr. B. Boivin for assistance in mapping the southern boundary of the parkland. In his plant surveys in 1955 and 1956 he made a special project of checking this boundary and freely made his notes available. The provincial forestry departments of Manitoba, Saskatchewan, and Alberta assisted in mapping the northern boundary.

I acknowledge also the help received from my late wife, Lois Bird, who checked the manuscript and prepared the index.

CONTENTS

CONTENTS—Concluded

ILLUSTRATIONS

Abstract

The aspen parkland of the Prairie Provinces of Canada lies between the grassland of the great plains and the northern coniferous forest. The soil is of glacial origin. In many places the land is poorly drained and is covered by numerous small water bodies. There are also level beds of lakes of ancient times. Areas of grassland and forest are intermixed. The grassland has several communities, of which the following are typical: (1) *Festuca*, (2) *Agropyron-Stipa-Bouteloua*, (3) *Agropyron-Koeleria-Agrostis-Stipa*, (4) *Agropyron-Poa-Spartina*, and (5) *Stipa-Andropogon*. The forest is dominated by aspen poplar, which occurs in pure stands over much of the area. Lesser communities are formed by (1) on the flood plains: Manitoba maple, *Acer negundo;* elm, *Ulmus americana;* and ash, *Fraxinus pennsylvanicus;* (2) in eastern Manitoba: bur oak, *Quercus macrocarpa;* and (3) in the Spruce Woods Forest Reserve: isolated stands of white spruce, *Picea glauca*, larch, *Larix laricina*, and black spruce, *Picea mariana*. Original animal dominants were large herbivores: buffalo, *Bison bison;* prong-horned antelope, *Antilocapra americana;* elk, *Cervus canadensis;* and the wolf, *Canis lupus*.

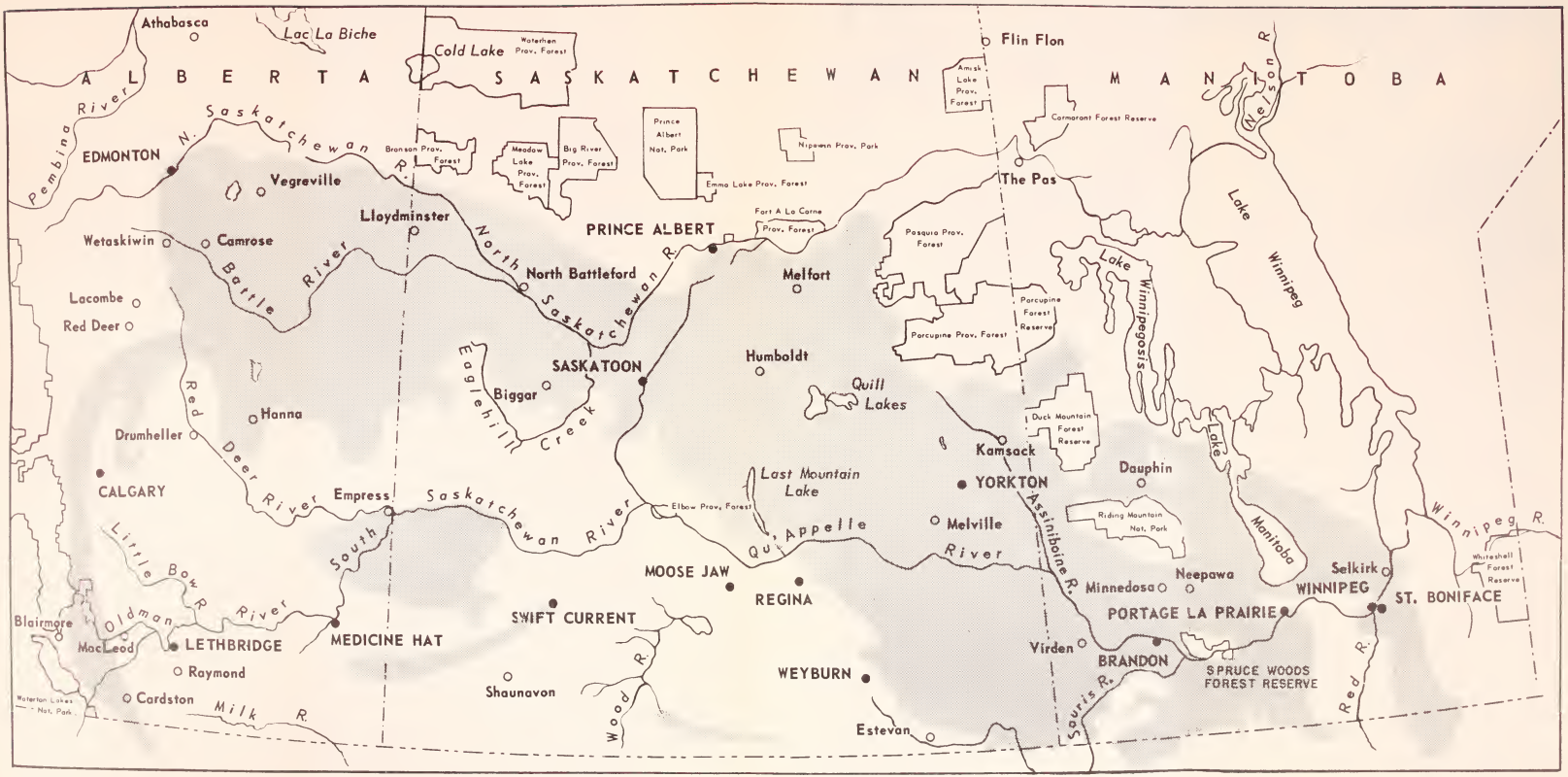
Deep waters in the lakes and rivers have little rooted vegetation but support appreciable populations of fish. The shallow water bodies have many submerged and emergent plants. They provide a habitat for large populations of birds, frogs, and insects. Plant succession takes place from open water through stages of submerged and emergent vegetation to willow (*Salix*) and aspen (*Populus tremuloides*) forest. Aspen seedlings can become established on grassland only through the agency of burrowing mammals, usually associated with western snowberry, *Symphoricarpos occidentalis*, seeds of which are often carried by sharp-tailed grouse, *Pedioecetes phasianellus*, who use the mounds of soil for dust baths. White spruce invades and replaces aspen on the northern edge of the parkland where the soil is not strongly alkaline.

Buffalo and elk overgrazed the grassland, browsed the shrubs, and destroyed trees by rubbing and trampling. They retarded the succession to forest. Fires set by Indians killed back the forest and reduced the area of the parkland. With settlement, fires were reduced and the forest advanced on the grassland to a considerable degree.

The parkland has been greatly changed by the invasion of white men. Little now remains undisturbed. From 1691 to 1870 the fur trade grew to a peak, and then declined as the fur-bearing animals were decimated. The buffalo were exterminated and the Indians reduced to a fraction of their former population by smallpox and tuberculosis. Settlers flocked to the vacant land and intensive agriculture commenced. With the checking of fires, aspen forest extended southward and occupied land formerly in grass. Grassland areas were first to be broken by the plow, their native plants and animals being destroyed. Only a limited amount of forest land was cleared until the bulldozer came into common use in 1945, when land clearing was greatly accelerated. Introduction of the automobile brought a demand for better roads. Grading of road allowances destroyed remnants of the native vegetation, which has been replaced by weeds and introduced grasses. Weeds from other countries have become well established in the fields. Land erosion by wind and water has become serious.

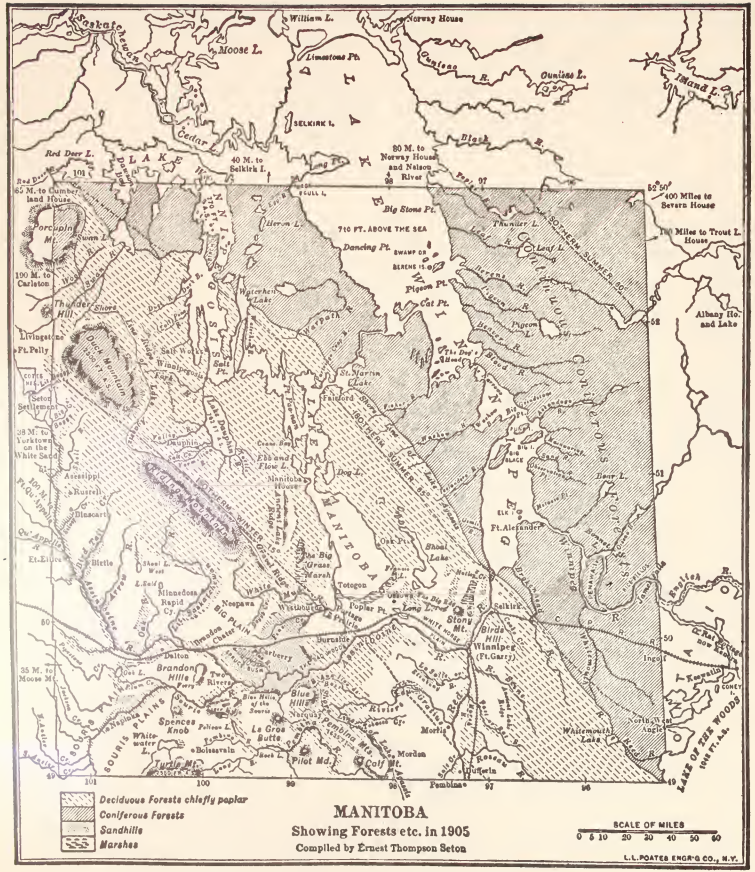
With the destruction of their habitat many animals were greatly reduced in numbers and a few species were exterminated in the area. Some fur bearers and game animals, after becoming scarce, have increased with proper management. The white-tailed deer, *Odocoileus virginianus*, and the jack rabbit, *Lepus townsendii*, have found improved habitats and have increased in numbers and extended their range. Some native insects have found crops preferable to their native food plants. The wheat stem sawfly, *Cephus cinctus*, the two-striped grasshopper, *Melanoplus bivittatus*, and other insects have become pests of crops. The Colorado potato beetle, *Leptinotarsa decemlineata*, which had turned from its native host to the potato, extended its range into the parkland with the introduction of the potato. Many foreign insects such as the imported cabbageworm, *Pieris rapae*, and the sweet-clover weevil, *Sitona cylindricollis*, have been introduced. Domestic animals and their associated insect parasites are now an established part of the fauna and compete with the native animals.

Independent of the man-made changes there are continuing changes, due to natural agencies, in the distribution and abundance of plants and animals.



Map 1. The aspen parkland in 1956 (Compare with Map 2, showing extent in Manitoba in 1905). The southern boundary was plotted by Dr. B. Boivin during surveys in 1955–56. The northern boundary, which is taken as the southern limits of spruce and jack pine, is based on information supplied by forestry officers of the three provinces. The isolated areas south of the main body of the parkland contain a more scattered growth of aspen. In the great sand hills area of Saskatchewan, in particular, trees are found only on the northerly and easterly slopes of the hills and ridges.

Halliday (1937) divided the aspen parkland into the western aspen grove section and the eastern aspen oak section. This is based on the occurrence of scattered stands of bur oak in Manitoba and in Saskatchewan south of the Qu'Appelle River.



Map 2. Map of southern Manitoba compiled by Ernest Thompson Seton in 1905. This map compared with Map 1, compiled in 1956, shows how the aspen parkland has expanded to the south during the last fifty years. Particularly noteworthy is the "Big Plain" stretching from Carberry to Russell, which is now covered by parkland.

Map 3. Surface geological deposits of southern Manitoba (modified from Ellis, 1938). The morainic areas constitute the uplands and contain many water-filled depressions. The Lake Agassiz Basin is a flat lowland area often referred to as the first prairie level. The higher land to the west is known as the second prairie level.

The Aspen Parkland in its Undisturbed Condition

General Character

During the eighteenth century fur traders from Europe ascended the St. Lawrence River, crossed the Great Lakes, and continued west. Others traveled south and west from the barren shores of Hudson Bay. Guided by Indians, they followed waterways for hundreds of miles in search of the rich trapping grounds from which the Indians had been bringing their loads of fur, and of the country where buffalo roamed in countless herds. After passing through a great area of rock and forest, they entered grassland with many groves of aspen poplars. Trees grew also along the watercourses and around many sloughs and lakes. The tall grass and many flowering herbs furnished luxuriant pasture for the herds of game. Waterfowl abounded. Best of all, from the point of view of the traders, fur was plentiful. Beaver were found along the streams; muskrats inhabited the marshes; mink, otter, fox, ermine, and other valuable furs were there for the taking. The Indians were friendly and with the encouragement of a little rum were ready and willing to bring in the fur. It was truly a paradise. This was the aspen parkland, later to become a rich agricultural land.

Geographical Limits

The aspen parkland (Map 1) is situated between the great plains of central North America and the coniferous forest of the Pre-Cambrian shield. Its southern boundary runs from northern Minnesota (Ewing, 1924) northwestward through southern Manitoba, central Saskatchewan, and Alberta. It is found also along the foothills of the Rocky Mountains in Alberta (Moss, 1955) and in Glacier County, Montana (Lynch, 1955).

Surface Geology[1]

The aspen parkland is a poorly drained region situated on relatively young glacial drift, comprising mostly ground moraine and end moraine, and on the beds of large glacial lakes with incomplete drainage systems.

The morainic areas constitute the uplands and the glacial lake bottoms the lowlands. Deep, flat-bottomed valleys were cut by streams in the uplands during deglaciation, and extensive deltas were deposited in the glacial lakes. The most important of these deltas was deposited in Lake Agassiz by the Assiniboine River. The sand that forms much of this delta has since been blown into dunes, which are now overgrown by vegetation. A section of this area has been set aside as the Spruce Woods Forest Reserve and is discussed in a following section. Farther out in the lakes the fine sediment brought in by the rivers was deposited as beds of clay. In addition to deltas, outwash plains of gravel and coarse sand were deposited in some areas.

[1]Prepared from information supplied by J. A. Elson, Department of Geology, McGill University, Montreal, Que.

The till, of which the moraines are formed, was deposited in most instances in a rolling topography consisting of low hills and undrained depressions, which may be from three to 15 feet deep and from a few hundred square feet to 20 or 30 acres in area. Some of these hollows were formed by blocks of ice becoming detached from the retreating glacier and covered with outwash sand and gravel. When the ice melted, depressions known as kettles were formed. These low spots now contain intermittent or permanent bodies of water. Locally these bodies of water are known as sloughs. Only a few of the larger ones attain the category of a lake. They may range in number from a few to 120 or more per square mile and when abundant form a prominent part of the landscape. Not all of the ground moraine, however, is of a rolling "knob and kettle" topography. Considerable areas are relatively flat and have few waterfilled depressions.

The glacial till varies in thickness and composition. It is important as the parent material of the soils that have developed on it. Highly alkaline areas are formed where the till is composed of rocks and shale containing gypsum and other salts. The salts are leached out from the surface and are carried down into the water table. When the water table rises the salts are brought up and deposited on the surface by evaporation. The surface of the water in a depression represents a local water table if the till is impervious. This condition is known as a "perched" water table.

As the ice sheet retreated, large glacial lakes were formed between the ice and heights of land. Lake Agassiz, the largest, occupied most of the eastern half of Manitoba. Lake Souris occurred in southwestern Manitoba and Lake Regina in southeastern Saskatchewan. These lakes drained when the ice melted, leaving lakes Winnipeg, Manitoba, Dauphin, and Winnipegosis in the Lake Agassiz bottom and Oak Lake in the Lake Souris basin. Sloughs and marshes occupy depressions in the glacial lake basins and occupy old drainage channels that are no longer free-flowing. As the glacial lakes retreated, a succession of beaches, or sand ridges, were thrown up by wave action. These beaches often dammed up marsh areas behind them. A large marsh formed at the south end of Lake Manitoba in this manner. At the south end of Lake Winnipeg large marshes formed by a combination of the delta of the Red River and lake beaches.

Rivers now follow the valleys eroded during the melting of the ice sheet or meander across glacial lake floors. They are characterized by abundant small meanders, oxbow lakes, and relatively broad flood plains. In several instances the river has been dammed by alluvial fans deposited by tributaries to form a lake or series of lakes, e.g., Pelican Lake and Rock Lake in Manitoba, and the Qu'Appelle Lakes in Saskatchewan.

Soils and Their Origins

The aspen parkland is situated on soils of the black soil zone, encroaching somewhat on degrading black earth and dark-brown zones adjacent to it (Moss, 1955; Ellis, 1938; Joel *et al.*, 1936).

Important factors that determine soil type are temperature and moisture within the soil, vegetation, parent material, and length of time the soil has been under the influence of its environment. Black soils are formed under a heavy grass and herbaceous vegetation whereas a gray type develops under forest. This suggests that the aspen parkland represents a recent invasion of aspen upon an area that had been in grass for a considerable period.

The parent material on which the soils were formed is boulder till or water-laid deposits on top of boulder till (Map 3).

The boulder till deposits vary markedly in character, depending on the geological origin of the materials of which they are composed. In Manitoba, Ellis (1938) stated that boulder till may be composed of limestome, of mixtures of limestone and shale or granite, or entirely of shale, and that soils developed on high-lime drift are shallow, whereas those of mixed origin are deeper.

The postglacial development of the flora of Manitoba was discussed by Löve (1959).

Major Plant Communities

The aspen parkland contains two major plant communities, forest and grassland, which are intermingled in a mosaic of irregular isolated patches and more or less solid stands, as well as numerous aquatic communities. According to the pressure of the dominant factors—weather, man, and fire—the grassland may advance on the forest when the trees are unable to survive during dry periods and when there are repeated fires, or it may retreat as conditions become more favorable for forest growth. These factors operated when the white man arrived. Since his appearance, man, by the introduction of agriculture and the checking of prairie fires, has taken an increasingly important part in changing the biota.

The records of early travelers and settlers, however, indicate that there were major fluctuations of the forest and grassland before the white man broke the land for agriculture. Hind (1859), in his account of an exploring trip in 1858 up the Assiniboine River to the Souris River, up the Souris to the boundary between Canada and the United States, across country to the mouth of the Qu'Appelle River, and up the Qu'Appelle to the elbow of the South Saskatchewan River, reported evidence of a greater extent of forest:

> An old Indian, born in this part of the country, told us that he remembered the time when the whole of the prairie through which we had passed since leaving Fort Ellice was one continuous forest, broken only by two or three narrow intervals of barren ground. The view from the Indian Head range is exceedingly beautiful; it embraces an extensive area of level prairie to the north, bounded by the Aspen Woods on the borders of the Qu'Appelle Valley. A portion of the old forest alluded to by the Indian still exists on this range. It consists of aspen of large growth and very thickly set.

On the other hand, Hind referred frequently to extensive tracts of prairie where many groves of trees now exist.

> The country west of the Souris [near the present town of Wawanesa], so far, is an open, treeless, undulating prairie. On the east side the Blue Hills [of Brandon] are very picturesque, with their flanks and summits wooded with aspen...
>
> The country west of the Souris is a treeless desert, in dry seasons destitute of water and without a shrub or bush thicker than a willow twig...
>
> Our half-breeds informed us that this great prairie west of the Souris continues treeless and arid for a distance of 60 miles, it is then crossed by a river, probably an arm of the Souris, connecting, as will afterwards be shown, with the Qu'Appelle River at Elbow Bone Creek; beyond the river the prairie continues for 80 miles further, without tree or shrub; and as this was the utmost westerly limit to which any of them had journeyed in their buffalo-hunting expeditions, they could afford us no further information respecting its extent.

Major wet and dry periods definitely affected the relative extent of forest and prairie. Wet periods checked fires and enabled the forest to advance.

81314–7—2

Fires raged during the dry periods and were particularly severe in the accumulated dead vegetation grown during the previous wet period. A major dry period occurred in the 1860's and '70's, when there was a prolonged outbreak of grasshoppers (Hind, 1859; Mitchener, 1954). A major wet period occurred during the period of settlement in the 1880's and '90's.

Homesteaders of the 1890's reported much of the land west of the present town of Souris and north to Birtle destitute of forest so that they had to go to the river valleys for firewood. By 1920 this country was extensively covered with groves of aspen. When settlers entered the sand plain southeast of Brandon in the 1880's they found scattered groves of aspen. The low spots were full of water, and dead trees of a previous dry period were standing in the water. By 1910 the ponds had dried up and a fresh growth of trees had replaced the old ones. In addition, many of the scattered groves had enlarged and joined to form extensive areas of forest.

In 1955 and 1956 record winter snowfall followed by heavy rains in the area northwest from Brandon to Birtle and Elkhorn raised the water levels in sloughs and lakes so that willows and aspen, which had been encroaching on them during the previous 15 to 20 dry years, were drowned out and killed. This was particularly noticeable in 1956, when rings of dead trees about the sloughs were common. Water levels in the sandhills near Brandon had not, however, risen above the ground.

In 1905 Ernest Thompson Seton compiled a map (Map 2) indicating the area then covered by the aspen parkland in Manitoba. A comparison with Map 1, compiled 50 years later, shows the extent to which the parkland has invaded the grassland and the closing in of several large areas. Particularly noticeable is the area northwest from Carberry to Russell and south and west to Saskatchewan. Part of this area, which is now parkland, is labeled by Seton as the "Big Plain".

The aspen parkland contains two principal biotic communities: (1) the grassland community and (2) the aspen poplar forest community, each of which may be divided into a number of lesser communities. In the northern part of the parkland the forest cover is broken by only occasional patches of grassland on the drier locations. As one approaches the great plains, the percentage of forest cover diminishes until it occupies only small, isolated groves and is finally restricted to depressions and north- and east-facing slopes, where there is more available moisture. The area has usually been considered an ecotone, or area of stress. Coupland and Brayshaw (1953), however, by their recent studies have shown that the ecotone exists only at the point of contact between the two communities:

> The aspen grove region has often been considered as an ecotone between the grassland formation to the south and the coniferous forest to the north. Critical examination of the vegetation, however, reveals that it consists of an intermingling of grassland and forest communities and that the ecotone occurs only around each grove of aspen within the zone. For this reason the authors consider the grassland community as distinct from the forest.

Moss (1932), speaking of the parkland in Alberta, considered that the groves of trees had been abundant for many years but not for many centuries, as the soil on which they are now growing is of the black grassland type rather than the gray wooded type.

Grassland Communities

Plant Components of Grassland Communities

The grassland portion of the parkland in Manitoba is considered a northern expression of the true prairie (*Stipa-Sporobolus* association) (Weaver and Fitzpatrick, 1934). In Alberta, Moss (1944) and Moss and Campbell (1947) have shown that the community is dominated by *Festuca scabrella*. This dominance is continued in the southern extremity of the aspen parkland in Glacier County, Montana (Lynch, 1955). Coupland and Brayshaw (1953) found the latter species dominant in the grassland of western Saskatchewan and named it the *Festuca scabrella* association (in the Clementsian sense). However, they indicate that the grassland to the east of Saskatoon represents a confused picture with intermixed communities of true prairie, fescue prairie, and mixed prairie (of the open grassland area).

The grassland of Manitoba and eastern Saskatchewan is made up of a number of associations, many of which intergrade with dominants varying with soil and available moisture. For the purpose of this publication examples are taken from five widely separated areas:

Festuca grassland near Saskatoon, Sask.;—
Agropyron-Stipa-Bouteloua grassland near Lyleton, Man.;—
Agropyron-Koeleria-Agrostis-Stipa grassland near Birtle, Man.;—
Agropyron-Poa-Spartina grassland near Arnaud, Man.; and
Stipa-Andropogon sand prairie near Shilo, Man.

Festuca Grassland near Saskatoon, Sask.—This association was studied by Coupland and Brayshaw (1953), who considered that it is the main constituent of the grassland in the aspen parkland from Saskatoon west to the grasslands of the black soils of Alberta. They stated that three species of grasses are the most abundant and compose 53 per cent of the basal cover: rough fescue, *Festuca scabrella* Torr.; porcupine grass, *Stipa spartea* Trin. var. *curtiseta* Hitchc.; and June grass, *Koeleria cristata* (L.) Pers. Sedges, notably *Carex stenophylla* Wahlenb. var. *enervis* (C. A. Mey.) Kukenth, *C. pensylvanica* Lam. var. *digyna* Boeckl., and *C. obtusata* Lilj., make up 25 per cent of the cover. Secondary grasses are northern wheat grass, *Agropyron dasystachyum* (Hook.) Scribn.; western wheat grass, *A. smithii* Rydb.; little bluestem, *Andropogon scoparius* Michx.; plains reed grass, *Calamagrostis montanensis* Scribn.; wild oat grass, *Danthonia intermedia* Vasey; sheep fescue, *Festuca ovina* L.; and blue grass, *Poa* spp. Together they furnish 3 per cent of the cover.

The nongrassy cover is composed principally of low goldenrod, *Solidago glaberrima* Martens; pasture sage, *Artemisia frigida* Willd.; pasque flower, or prairie crocus, *Anemone patens* L. var. *wolfgangiana* (Bess.) Koch; small everlasting, *Antennaria microphylla* Rydb.; moss phlox, *Phlox hoodii* Richardson and field chickweed, *Cerastium arvense* L. These species make up 68 per cent of the cover. Three per cent is composed of low prairie rose, *Rosa arkansana* Porter. The remaining 29 per cent is made up of 14 species of herbs and three

81314-7--2½

species of shrubs, of which western snowberry, *Symphoricarpos occidentalis* Hook., and wolf willow, *Elaeagnus commutata* Bernh., are the most important. There are three layers of vegetative cover: the tall grasses and herbs; the short grasses and sedges, *Carex* spp.; and a discontinuous surface layer of little club moss, *Selaginella densa* Rydb. "The Festuca community is postclimax to the *Stipa-Agropyron* fasciation of mixed prairie."

To the east *Festuca scabrella* loses its dominance and other species become more abundant. In southeastern Saskatchewan from the Canada—United States boundary to Yorkton, Coupland and Brayshaw (1953) stated, "Small areas dominated by *Stipa spartea* var. *curtiseta*, *Stipa comata* Trin. and Rupr., *Agropyron* spp. and *Bouteloua gracilis* (HBK.) Lag. alternate with communities in which *Festuca scabrella* and associates of the fescue community are abundant and with others in which species of the true prairie, notably *Andropogon scoparius*, are conspicuous."

Agropyron-Stipa-Bouteloua Grassland near Lyleton, Man.—This area is at the southernmost edge of the parkland in southwestern Manitoba. The soil, which when cultivated is subject to wind erosion in dry years, is formed on sediment that was deposited in glacial Lake Souris. The region is somewhat more arid than in the parkland to the north and east because of lower precipitation, higher temperature, and more permeable soils. Because of the abundance of grasshoppers during the drought period of the 1930's, an area for their ecological study was operated here from 1936 to 1938 by W. R. Allen (1939) of the Field Crop Insect Laboratory, Canada Department of Agriculture, Brandon, Man.

In July, 1938, Dr. S. E. Clarke and Dr. J. L. Bolton of the Experimental Farm, Canada Department of Agriculture, Swift Current, Sask., made a reconnaissance survey of the vegetation on relatively undisturbed road-sides. They distinguished three communities:

A highland community composed of *Bouteloua gracilis*, *Carex stenophylla* Wahlenb., and *Stipa comata*. Golden aster, *Chrysopsis villosa* (Pursh) Nutt., was an indicative herb species.

An intermediate grassland type composed of *Stipa viridula*, Trin. *Stipa comata*, *Bouteloua gracilis*, *Carex stenophylla*, and *Agropyron smithii*. *Stipa-Agropyron* and *Agropyron-Stipa* communities covered most of the area. In many places *A. smithii* was found in pure stands or mixed with forbs in various degrees. *A. smithii* and sand grass, *Calamovilfa longifolia* (Hook.) Scribn., formed communities, particularly where drifting soil was becoming stabilized.

A lowland grass type. Low meadow was dominated by fowl blue grass, *Poa palustris* L.; Canada blue grass, *Poa compressa* L.; and Kentucky blue grass, *Poa pratensis* L. Foxtail, or wild barley, *Hordeum jubatum* L., was dominant or subdominant. The following species were also common: slender wheat grass, *Agropyron pauciflorum* (Schwein.) Hitchc. (=*A. trachycaulum* (Link) Malte.); Macoun wild rye, *Elymus macounii* Vasey; *Calamagrostis* sp.; mat muhly, *Muhlenbergia squarrosa* (Trin.) Rydb.; and *Carex* spp.

Small sloughs along the roadsides contained communities composed of grasses, prairie cord grass, *Spartina pectinata* Link; *Poa palustris*; tall manna

grass, *Glyceria grandis* S. Wats.; and whitetop, *Scolochloa festucacea* (Willd.) Link; willow, *Salix* sp.; *Carex* spp.; and the herb, swamp persicaria, *Polygonum coccineum* Muhl.

The herbs mentioned as abundant in the fescue grassland were also important at Lyleton. Additional abundant species were hairy golden aster, *Chrysopsis villosa*; gumweed, *Grindelia squarrosa* (Pursh) Dunal; biennial wormwood, *Artemisia biennis* Willd.; many-flowered aster, *Aster ericoides* L.; long-headed cone flower, *Ratibida columnifera* (Nutt.) Wooton and Standl.; prairie goldenrod, *Solidago dumetorum* Lunell; and silver leaf psoralea, *Psoralea argophylla* Pursh. The shrubs *Symphoricarpos occidentalis* and *Elaeagnus commutata* formed extensive patches.

Agropyron-Koeleria-Agrostis-Stipa Grassland near Birtle, Man.— This area, situated about 90 miles north of the Canada—United States boundary and 15 miles east of Saskatchewan, is in the central portion of the parkland. It was studied by Bird (1930). The soil is black and overlies glacial drift. The grassland vegetation is taller and more luxuriant than at Lyleton and there are extensive aspen groves. The dominant grasses are *Agropyron trachycaulum*; *Koeleria cristata*; rough hair grass, *Agrostis scabra* Willd.; and *Stipa comata*. The first gives a characteristic aspect by means of its distinctive flower heads, which persist throughout the winter. In some areas big bluestem, *Andropogon gerardi* Vitman., may become locally dominant, and *Andropogon scoparius* in dry locations on sand prairie and hillsides.

The two shrubs *Symphoricarpos occidentalis* and *Elaeagnus commutata* are more abundant than at either Saskatoon or Lyleton and play an important part in advance of the forest on the grassland.

Important forbs arranged in their seasonal assocations are:

Spring: pasque flower, or prairie crocus, *Anemone patens* var. *wolfgangiana* (Fig. 6); Richards comandra, *Comandra richardsiana* Fern.; prairie buttercup, *Ranunculus rhomboideus* Goldie (Fig. 4); three-flowered avens, *Geum triflorum* Pursh; field chickweed, *Cerastium arvense* L.; long-leaved bluets, *Houstonia longifolia* Gaertn.; western ray-pimpernel, *Androsace occidentalis* Pursh; prairie everlasting, *Antennaria campestris* Rydb.; northern bedstraw, *Galium boreale* L.; hoary puccoon, *Lithospermum canescens* (Michx.) Lehm.

Summer: white prairie–clover, *Petalostemum candidum* (Willd.) Michx.; purple prairie–clover, *Petalostemum purpureum* (Vent.) Rydb.; rose, *Rosa* sp.; dotted blazing–star, *Liatris punctata* Hook.; black-eyed Susan, *Rudbeckia serotina* Nutt.; bluebell, *Campanula rotundifolia* L.; white beardtongue, *Penstemon albidus* Nutt. (Fig. 5); Indian turnip, or breadroot, *Psoralea esculenta* Pursh; silverleaf psoralea, *Psoralea argophylla*.

Autumn: rough false sunflower, *Heliopsis helianthoides* (L.) Sweet var. *scabra* (Dunal) Fern.; narrow-leaved sunflower, *Helianthus maximilianii* Schrad.; bergamot, *Monarda fistulosa* L.; stiff goldenrod, *Solidago rigida* L.; low goldenrod, *Solidago missouriensis* Nutt.; giant hyssop, *Agastache foeniculum* (Pursh) Ktze.; yarrow, *Achillea millefolium* L.; pasture sage, *Artemisia frigida* Willd.; white sage, *Artemisia ludoviciana* Nutt. var. *pabularis* (Nels.) Fern. (Fig. 3); many-flowered aster, *Aster ericoides*; smooth aster, *Aster laevis* L.

Agropyron-Poa-Spartina Grassland near Arnaud, Man.—This area is in the southern extremity of the parkland in eastern Manitoba. It lies just

east of the Red River, 20 miles north of the Canada—United States boundary in the tall-grass prairie region of Clarke *et al.* (1942). From 1935 to 1938 an eight-square-mile area was used for an ecological study of grasshoppers by Moore (1936). In July, 1939, Messrs. J. A. and J. B. Campbell of the Experimental Station, Canada Department of Agriculture, Swift Current, Sask., made a botanical survey of the area. Their report and Moore's unpublished thesis gave the following information.

The area comprises heavy clay soil developed on the level floor of glacial Lake Agassiz. Much of the land is low lying. It was frequently flooded until settlers drained it by deep roadside ditches. As a result the vegetation has changed from marsh grasses, notably cord grass (Fig. 7), to grasses and herbs favored by arid conditions, and aspen forest is invading the area. The land is very fertile, and at the time of the Campbell survey much of it was under cultivation. Hence their survey was confined to roadsides, railroad rights-of-way, native pastures, and small patches of unbroken land. Because of the disturbed conditions at the time of the survey it was difficult to distinguish natural communities and it is doubtful if any climax areas survived. However, three associations of single species or groups of species formed a series on soils ranging from poorly drained to well drained. On the poorly drained soils occurred cord grass, *Spartina pectinata* (Fig. 7), and big bluestem, *Andropogon gerardi*; on the intermediate sites the following species dominated: *Poa* (plains blue grass, *P. arida* Vasey; Kentucky blue grass, *P. pratensis*; Canada blue grass, *P. compressa*; inland blue grass, *P. interior* Rydb.; fowl blue grass, *P. palustris*) and the introduced timothy, *Phleum pratense* L.; and on the driest locations western wheat grass, *Agropyron smithii*, formed pure stands. Other common grasses were foxtail, *Hordeum jubatum* (Fig. 8); slender wheat grass, *Agropyron trachycaulum*; awnless brome grass, *Bromus inermis* Leyss (introduced). June grass, *Koeleria cristata*; porcupine grass, *Stipa spartea* Trin.; and spear grass, *Stipa comata*, were less common.

The shrub *Symphoricarpos occidentalis* had begun to invade the prairie in drier areas. Similarly, *Elaeagnus commutata* was found occasionally.

The important native herbs were prairie sage, *Artemisia gnaphalodes* Nutt.; smooth aster, *Aster laevis*; *Aster ericoides*; *Rosa* spp.; *Monarda fistulosa* (Fig. 9); tall smooth goldenrod, *Solidago serotina* Ait.; *Rudbeckia hirta*; *Galium boreale*. The yellow lady's-slipper, *Cypripedium calceolus* L. (Fig. 10), was found in moist prairie and woodland areas but is now becoming rare because of destruction of its habitat and excessive picking for floral bouquets.

Stipa-Andropogon Sand Prairie near Shilo, Man.—In the parkland of Manitoba, extensive areas of grassland are situated on level sand plains and anchored dunes. The soil is developed on medium-grained sand deposited as deltas in glacial lakes. Some species of plants found on sandy soils do not occur on the black soil areas or the heavy clay soils of the Lake Agassiz floor. Others exert a dominance, on sand, not found in other localities.

A large area of sand prairie is found in the Spruce Woods Forest Reserve and, although some of it is used for military manoeuvres, it is maintained in practically a virgin condition. The portion near Shilo military camp was studied by Criddle (1915) and by Bird (1927).

The dominant grasses over most of this prairie area are *Stipa comata*; *Stipa spartea*; sand dropseed, *Sporobolus cryptandrus* (Torr.) A. Gray; *An-*

dropogon scoparius; *Bouteloua gracilis*; *Koeleria cristata*; purple oat grass, *Schizachne purpurascens* (Torr.) Swallen; *Agrostis scabra* Willd.; and *Calamovilfa longifolia*. The dominant grasses encroaching on areas of drifting sand are: *Andropogon gerardi*; Indian rice grass, *Oryzopsis hymenoides* (Roem. & Schult.) Ricker; and *Calamovilfa longifolia*. Several species of *Carex* are common as well as *Selaginella densa*.

Extensive areas are dominated by creeping juniper, *Juniperus horizontalis* Moench. Patches of bearberry, or kinnikinnick, *Arctostaphylos uva-ursi* (L.) Spreng.; sand cherry, *Prunus besseyi* Bailey; and the lichens *Cladonia uncialis* (L.) Hoffm., *C. sylvatica* (L.) Hoffm., *C. alpestris* (L.) Rabenh., *Cetraria islandica* (L.) Ach., and *Parmelia molliuscula*, Ach. are common.

The shrub *Symphoricarpos occidentalis* is found particularly in the moister locations and about the edges of groves of trees. In areas of drifting sand *Elaeagnus commutata* is important in tying down the sand by means of its long rhizomes. Associated with it is the sandbar willow, *Salix interior* Rowlee, and the following herbs: *Petalostemum candidum*; silky prairie–clover, *P. villosum* Nutt.; skeletonweed, *Lygodesmia juncea* (Pursh) D. Don.; sand dock, *Rumex venosus* Pursh; and common horsetail, *Equisetum arvense* L.

The most important herbs in the prairie are: field chickweed, *Cerastium arvense*; prairie crocus, *Anemone patens* var. *wolfgangiana*; western wallflower, *Erysimum asperum* (Nutt.) DC.; alum root, *Heuchera richardsonii* R. Br.; white cinquefoil, *Potentilla arguta* Pursh; prairie cinquefoil, *Potentilla pensylvanica* L. var. *arida* Boivin; three-flowered avens, *Geum triflorum* Pursh; rose, *Rosa* sp.; silverleaf psoralea, *Psoralea argophylla*; white prairie–clover, *Petalostemum candidum*; ascending purple milk–vetch, *Astragalus striatus* Nutt.; locoweed, *Oxytropis lambertii* Pursh; shrubby evening primrose, *Oenothera serrulata* Nutt.; western ray-pimpernel, *Androsace occidentalis*; lilac-flowered beardtongue, *Penstemon gracelis* Nutt.; downy paintbrush, *Castilleja sessiliflora* Pursh; bluebell, *Campanula rotundifolia*; dotted blazing–star, *Liatris punctata*; rough fleabane, *Erigeron asper* Nutt.; daisy fleabane, *Erigeron strigosus* Muhl.; everlasting, *Antennaria* spp.; purple coneflower, *Echinacea angustifolia* DC.; gaillardia, or blanket flower, *Gaillardia pulchella* Foug.; yarrow, *Achillea millefolium* L.; linear-leaved wormwood, *Artemisia dracunculoides* Pursh; pasture sage, *Artemisia frigida*; prairie sage, *Artemisia gnaphalodes*; prairie ragwort, *Senecio plattensis* Nutt.

Animal Components of Grassland Communities

As the animal dominants for the most part range freely over the plant communities of the grassland, they are discussed for the grassland as a whole rather than for each plant community.

When the white man appeared on the scene the outstanding dominant was the buffalo, *Bison bison* (L.)(Fig. 11). Other dominants were: the pronghorned antelope, *Antilocapra americana* (Ord), which, though distinctly an animal of the open plains, ranged well into the parkland; and elk, *Cervus canadensis* (Erxl.)(Fig. 26), which grazed on the grassland around the edges of the aspen groves. These large game animals were preyed on by the buffalo wolf, *Canis lupus nubilus* Say.

The white-footed mouse, *Peromyscus maniculatus bairdii* (Hoy & Kennicott), and other subspecies, and voles, *Microtus pennsylvanicus* subspp. and *Microtus*

(*Pedomys*) *ochrogaster* (Wagner), are abundant in the matted vegetation of unburned and ungrazed grassland (Figs. 17 and 18). The thirteen-striped ground squirrel, *Citellus tridecemlineatus* (Mitchill), also inhabits the longer grass. In shorter grass on knolls, gravel ridges, and overgrazed areas, Richardson's ground squirrel, or flicker tail, *Citellus richardsonii* (Sabine)(Fig. 13), forms extensive colonies. The white-tailed jack rabbit, *Lepus townsendii* Bachman (Fig. 16), is the only hare inhabiting the grassland. The pocket gopher, *Thomomys talpoides* subspp., spends most of its life underground. Its mounds of dirt thrown up on the prairie are conspicuous features of the landscape (Fig. 33).

Associated with the herbivorous mammals are several predacious species. Coyotes, *Canis latrans* Say, and red foxes, *Vulpes fulva regalis* Merriam (Fig. 15), feed chiefly on rodents, birds, and insects. The principal food of the badger, *Taxidea taxus taxus* (Schreber), consists of ground squirrels, which it captures by digging. Weasels of three species, *Mustela* spp., feed chiefly on the mice and voles.

Characteristic birds of the grassland are the western meadowlark, *Sturnella neglecta* Audubon; the horned lark, *Eremophila alpestris* (L.); the upland plover, *Bartramia longicauda* (Bechstein); and the chestnut-collared longspur, *Calcarius ornatus* (Townsend). The vesper sparrow, *Poœcetes gramineus* (Gmelin); clay-colored sparrow, *Spizella pallida* (Swainson); chipping sparrow, *Spizella passerina* (Bechstein); and sharp-tailed grouse, *Pedioecetes phasianellus* (L.) (Fig. 12), are more abundant on prairie adjacent to woodland. The cowbird, *Molothrus ater* (Boddaert), followed the buffalo herds and fed on insects associated with them. All the above species of birds migrate to the south in the autumn, with the exception of the sharp-tailed grouse, which seeks winter shelter in the woodland and valleys. During migration great flocks of the Lapland longspur, *Calcarius lapponicus* (L.), stop over on the prairie. In the winter large flocks of the snow bunting, *Plectrophenax nivalis* (L.), and the redpoll, *Acanthis flammea* (L.), frequent the grassland and feed on the seeds of forbs and grasses exposed above the snow.

Associated birds of prey, which nest in the woodland and hunt over the grassland, are the red-tailed hawk, *Buteo jamaicensis* (Gmelin); Swainson's hawk, *Buteo swainsoni* Bonaparte; and the ferruginous rough-legged hawk, *Buteo regalis* (Gray). They feed mainly on ground squirrels and mice. The marsh hawk, *Circus cyaneus hudsonius* (L.), nests on the ground in patches of snowberry and long grass, and ceaselessly patrols the prairie in search of mice. The short-eared owl, *Asio flammeus* (*Potoppidan*), nests on the ground in long prairie grass; it also is a great mouser. The omnivorous crow, *Corvus brachyrhynchos* Brehm, nests in small aspen groves and feeds on the prairie. All these birds are summer residents only. The snowy owl, *Nyctea scandiaca* (L.), is an occasional winter visitor.

Reptiles are few. The commonest is the garter snake, *Thamnophis sirtalis parietalis* (Say). More rarely, the green snake, *Opheodrys vernalis* (Harlan), and the red-bellied snake, *Storeria occipitomaculata* (Stor), occur. In the sand hill areas the western hognose snake, *Heterodon nasicus* Baird and Girard, is occasionally found.

The common leopard frog, *Rana pipiens* Schreber, breeds in great numbers in the numerous sloughs and migrates on to the neighboring prairie, often to considerable distances from water, from the time the ice is gone in the spring

until freeze-up occurs in the fall. As many as 200 may be found to the acre and, being insectivorous, they exert a powerful influence on the community (Bird, 1930; Breckenridge, 1944).

There is little available information on the insects as they existed in early times; however, they must have occurred about as they occur today on patches of virgin prairie. Accounts are given by King (1926), Bird (1927, 1930), Moore (1936), and Allen (1939). Great swarms of the Rocky Mountain grasshopper, *Melanoplus spretus* (Walsh), were recorded by Henry (Coues, 1897), Hind (1859), and Macoun (1883).

King (1926) estimated the total insect population at 7,322,350 per acre. Of the total invertebrate animal population, insects formed 97 per cent.

> Spiders comprised 98% of the other animals. Ants were the most abundant insect group, forming 86.4% of the insect totals. The ant *Myrmica scabrinodis* (Nylander), which accounted for 80.6% of the insect population, must be considered the dominant species. A nest of the ant *Lasius brevicornis* Emery also occurred on the sample area. Other groups in order of importance were, Coleoptera 6.2%, Diptera 2.9% and Hemiptera 2.7%.

Bird (1930) found that the insect population fluctuated greatly, with spring and fall maxima. The peak population was over 6,000,000 per acre, the average about 3,000,000. He also found ants to be the most numerous insects, *Myrmica scabrinodis* being the most abundant and *Lasius brevicornis* second in importance. The leafhopper *Dikraneura mali* (Prov.), the bug *Laccocera vittipennis* (Van D.), and the beetle *Stilbus apicalis* (Melsh.) were also abundant. A great many other species of insects occurred as a few individuals in the collections and were listed by King (1926) and Bird (1930). Some of these insects became major pests because of the changes brought about by agriculture, for example, the wheat stem sawfly, *Cephus cinctus* Nort.; the prairie grain wireworm, *Ctenicera aeripennis destructor* (Brown); the red-backed cutworm, *Euxoa ochrogaster* (Guen.); the white cutworm, *Euxoa scandens* (Riley); the striped cutworm, *Euxoa tessellata* (Harr.); the two-striped grasshopper, *Melanoplus bivittatus* (Say); the red-legged grasshopper, *Melanoplus femur-rubrum* (Deg.); and the clear-winged grasshopper, *Camnula pellucida* (Scudd.).

Bird (1930) found a snail, *Succinea* sp., very abundant in the grassland at Birtle.

Forest Communities

Plant Communities of the Forest

The forest area of the parkland is made up predominantly of aspen poplar, *Populus tremuloides* Michx., with a number of lesser communities. The following are considered here: (a) aspen poplar community; (b) maple, ash, and elm flood-plain community; (c) bur oak community; (d) willow community; (e) white spruce sand hill community; and (f) tamarack-black spruce, swamp community.

Aspen Poplar Community.—The aspen poplar reaches its greatest abundance in the parkland. In the central and northern parts it forms a dense climax forest. In contact with the northern coniferous forest it is subclimax to white spruce, *Picea glauca* (Moench) Voss. In contact with the prairie communities it is considered climax, but succession from prairie to forest is often slowed to a standstill by climatic and edaphic conditions and may be reversed during drought periods.

In the southwestern extension of the aspen parkland into Glacier County, Montana, *Populus tremuloides* retains its dominance but the black cottonwood, *Populus trichocarpa* Torr. and Gray var. *hastata* (Dode) Henry, is associated with it (Lynch, 1955). In southern Alberta the balsam poplar, *Populus tacamahacca* Mill., is its associate but *P. trichocarpa* and the variety *hastata* are found north to the Oldman River (Moss, 1944).

The aspen is a soft-wooded, quick-growing tree that in this region rarely reaches an age of 60 years, or a height of 55 to 60 feet and a diameter of 16 inches. In mature stand the branches die on the lower two-thirds to three-quarters, leaving only the top with leafy branches. The south side of the tree trunk is covered with a white bloom. This may protect it from sun scald in late winter and early spring, when the side exposed to the sun may be well above freezing while the shady side is still frozen. The north side, being devoid of bloom, is dark green and covered with varying amounts of black spots and blotches. This characteristic is useful in determining one's direction when in the dense woods. It is much more reliable than observing a mossy growth found in varying amounts on the north side near the base of the tree. The mosses most commonly found, according to Prof. J. Ritchie, Department of Botany, University of Manitoba, are *Leskea polycarpa* Ehth., *Brachthecium salebrosum* (Hoffm.) B. and S., *B. oxycladon* J. and S., and *Mnium stellare* Reich.

The aspen poplar grows in pure stands except in poorly drained soil, where it may be associated with balsam poplar, *Populus balsamifera* L. In northern areas, on north-facing slopes, and at higher elevations in the Riding, Duck, and Porcupine mountains, there may be a considerable admixture of white birch, *Betula papyrifera* Marsh.

Aspen poplar is attacked by several fungus diseases, which cause the premature deaths of many trees. Fungus attack is favored by any disturbance or injury that weakens the trees: wind damage; borings by insects such as the

poplar borer, *Saperda calcarata* Say (Fig. 31); slash cutting by man; fire; and drought. Probably the most important fungus disease is white heart rot, caused by *Fomes igniarius* (L. ex Fr.) Gill., which weakens the tree tops and causes them to break off in high winds (Fig. 31). Large sections of forest are destroyed in this manner. A poplar canker, *Hynoxylon pruinatum* (Klotzsch.) Cooke, is of scarcely less importance than *F. igniarius*. It attacks the trunk, causing the bark to turn black and the leaves to die. Other important pathogenic organisms are *Radulum caesearium* (Morgan) Lloyd and *Corticium polygonium* Pers.

There are well-marked shrub and herb strata. The shrub stratum is composed principally of hazelnut, *Corylus americana* Walt. The beaked hazelnut, *Corylus cornuta* Marsh., is less common. The red osier dogwood, *Cornus stolonifera* Michx., is commonly scattered through the woods, particularly in the moister locations. Hazelnut grows in dense patches, particularly in the well-drained areas. The highbush cranberry, *Viburnum opulus* L. var. *americanum* Ait., is common in moist woods. Rose, *Rosa* sp.; choke cherry, *Prunus virginiana* L.; pin cherry, *Prunus pensylvanica* L.; saskatoon berry, *Amelanchier alnifolia* Nutt.; and snowberry, *Symphoricarpos occidentalis*, are sparse in the woods, but at the forest margin they grow in dense patches. The wild red raspberry, *Rubus idaeus* L. var. *strigosus* (Michx.) Maxim., is found occasionally throughout the climax forest and grows in profusion in disturbed areas, particularly after fire.

An upper herb stratum consists predominantly of wild sarsaparilla, *Aralia nudicaulis* L., and to a lesser extent red baneberry, *Actaea rubra* (Ait.) Willd.; Lindley's aster, *Aster lindleyanus* T. & G.; and sweet-scented bedstraw, *Galium triflorum* Michx. In areas of sandy soil these herbs may be largely replaced by poison ivy, *Rhus radicans* L. var. *rydbergii* (Small) Rehd.

Moss (1955) mentioned *Corylus cornuta* and *Aralia nudicaulis* as leading species in central Alberta but indicated that they are much less common in northwestern Alberta. Moss (1944) stated that *Corylus rostrata* (— *C. cornuta*), *Aralia nudicaulis*, *Cornus canadensis* L., and *Maianthemum canadense* var. *interius* are apparently absent from the aspen community in southwestern Alberta. Also, he stated that *Amelanchier alnifolia*, *Rosa acicularis* Lindl., *R. woodsii* Lindl., *Aster lindleyanus*, *Galium boreale*, and *Symphoricarpos albus* (L.) Blake are characteristic. *Cornus stolonifera*, *Prunus virginiana*, *P. pensylvanica*, *Rubus parviflorus* Nutt., *R. idaeus* L., *Spiraea lucida* Dougl., *Ribes oxyacanthoides* L., and *Lonicera glaucescens* Rydb. are less important. Lynch (1955) lists sweet cicely, *Osmorhiza occidentalis*, and aster, *Aster foliaceus* var. *parryi*, as dominants of the understory in Glacier County, Montana.

A lower herb stratum is composed of pink wintergreen, *Pyrola asarifolia* Michx.; dwarf dogwood, or bunchberry, *Cornus canadensis* L.; false lily-of-the-valley, *Maianthemum canadense* Desf. var. *interius* Fern.; star-flowered Solomon's-seal, *Smilacina stellata* (L.) Desf.; strawberry, *Fragaria* sp.; dewberry, *Rubus pubescens* Raf.; and blunt-leaved sandwort, *Arenaria lateriflora* L.

Maple, Elm and Ash Flood-Plain Community.—Flood plains along the Red, Assiniboine, Souris, and other rivers in the parkland are covered with a forest composed principally of Manitoba maple, or boxelder, *Acer negundo* L. var. *interius* (Britt.) Sarg. Next in abundance are lance-leaved ash, *Fraxinus*

pennsylvanica Marsh. var. *lanceolata* (Borkh.) Sarg., and American elm, *Ulmus americana* L. Less common is the cottonwood, *Populus sargentii* Dode. The basswood, *Tilia americana* L., is common only along the Red River and up the Assiniboine to Portage la Prairie. It becomes increasingly scarce westward and is not found at Brandon. On sand bars and low spots along the river bank are dense stands of the sand bar willow, *Salix interior*. The peach-leaved willow, *Salix amygdaloides* Anderss., a tree up to 30 feet high, is common close to the river. It grows in small clumps, or may be solitary.

Undergrowth is scanty in the flood plain forest. There may be patches of ostrich fern, *Pteretis pensylvanica* (Willd.) Fern. (Fig. 28), and along the Red River a heavy growth of wood nettle, *Loportea canadensis* (L.) Wedd. At the river edge there may be a marginal community composed of grasses; sedges; stinging nettle, *Urtica procera* Muhl.; marsh hedge nettle, *Stachys palustris* L. var. *pilosa* (Nutt.) Fern.; wild mint, *Mentha arvensis* L. var. *glabrata* (Benth.) Fern.; flat-topped goldenrod, *Solidago graminifolia* (L.) Salisb. var. *camporum* (Greene) Fern.; beggar-ticks, *Bidens glaucescens* Greene; flat-topped white aster, *Aster umbellatus* Mill.; New England aster, *Aster novae-angliae* L.; and silverweed, *Potentilla anserina* L. The American hop, *Humulus americanus* Nutt., is common. It climbs over the sandbar willow and marginal trees. The red osier dogwood occurs in a zone along the bank of the Red River.

Bur Oak Community.—The bur oak, *Quercus marcocarpa* Michx., reaches the limit of its northern distribution in southern Manitoba and southeastern Saskatchewan. It is found in greatest abundance along the Red River and in the vicinity of Winnipeg and Portage la Prairie. Here it may grow to a height of 50 feet and occur in pure stands. To the west of the Lake Agassiz basin the trees are much smaller and are generally scattered or in a fairly dense stand of scrubby growth. The oak grows on the south and west slopes of hills and valleys where there is greater warmth and is particularly abundant along the Pembina Valley, Tiger and Pembina hills, Turtle Mountain, and Assiniboine Valley. Scattered trees, usually very gnarled and twisted, occur in the Spruce Woods. Halliday (1937) delimits the eastern portion of the parkland, Manitoba and Saskatchewan south of the Qu'Appelle River, as the aspen–oak section because of the presence of oak. On account of the localized distribution of oak in the area, related to exposure and edaphic conditions, it is doubtful if this is justified. Oak is a favorite browse of deer, moose, and rabbits, and trees are often much dwarfed and club-shaped because of the repeated removal of leading shoots. Porcupines, *Erethizon dorsatum* (L.), feed almost entirely on oak in the Spruce Woods area but at Vermilion, Alta., where oak is absent, they consume mostly aspen. Extensive defoliation by larvae of the moths *Symmerista canicosta* Francl., *Anisota virginiensis* Dru., and *A. manitobensis* McD. often occurs. The bur oak comes into flower and leaf in late May but is often frozen back by early June frost.

Willow Communities.—Willow grows in great abundance in the parkland, and many stands of pure species are found. The sandbar willow, *Salix interior* Rowlee, grows in heavy stands along the sandbars and low banks of streams. It is also found in sand hills where subsoil water is available. It stabilizes the drifting sand by means of its long rootstock. It also occurs on sandy or gravelly beaches of lakes and in recently excavated ditches along roads. Apparently it is not the presence of running water that is necessary for the establishment

of this willow, but denuded soil with an abundant water supply. Its slender growth makes it ideally suited for basket weaving by the Indians.

The basket willow, *Salix petiolaris* Smith, grows from three to ten feet high. It is found in abundance about the margins of the numerous sloughs as a zone between the high and low water levels. In the spring and after heavy rains it often stands in one to two feet of water.

The pussy willow, *Salix discolor* Muhl., grows in low but better-drained ground than do the above two species. It is often found around sloughs in a zone just above the basket willow and between it and aspen forest or grassland. It also occurs in low spots in the aspen forest, where sloughs previously occurred, and on better-drained portions of flood plains.

There is little or no herbaceous growth under willows but often a heavy carpet of moss.

White Spruce Sand Hill Community.—The sand hill area of south-central Manitoba, part of which has been set aside as the Spruce Woods Forest Reserve, contains scattered stands of white spruce, *Picea glauca* (Fig. 22), intermixed with aspen. Here it appears that were it not for fire, to which spruce is very susceptible, and for the snowshoe rabbit, which prevents regeneration by feeding on the young trees, spruce would be dominant. Seedlings are found in abundance through the aspen forest, and mature trees are found in low ground and in stands of creeping juniper (Fig. 23) and bearberry, which protect them from ground fires. In the climax stands of spruce the mat of fallen needles, and dense shade, prevent the growth of herbaceous cover. In subclimax intermixture with aspen and in open stands where light is not excluded there is generally a dense mat of creeping juniper and bearberry. Poison ivy also occurs in abundance. Spruce is commonly the host of the dwarf mistletoe, *Arceuthobium pusillum* Peck, which forms characteristic witches'-brooms.

Tamarack–Black Spruce Swamp Community.—This community is not a part of the aspen parkland but of the northern coniferous forest. However, as relict stands occur in the parkland and the coniferous forest is adjacent to the parkland along its whole northern border, a brief description is given.

Tamarack, *Larix laricina* (DuRoi) K. Koch, occurs in swamps at the headwaters of Epinette Creek in the Spruce Woods Forest Reserve, along the Assiniboine River south of Shilo, and in numerous places along the Riding and Duck mountains and between lakes Winnipegosis and Winnipeg. It grows in the wetter parts of the swamps where there is often standing water. On slightly higher land there is a dense growth of black spruce, *Picea mariana* (Mill.) B.S.P. The tamarack, being deciduous and having less dense foliage than the spruce, permits a heavy growth of Labrador tea, *Ledum groenlandicum* Oeder, and dwarf birch, *Betula glandulosa* Michx. There is a heavy mat of sphagnum, *Sphagnum* spp., grading downward into peat. The black spruce, which replaces tamarack with a lowering of the water table, grows in such a dense stand that shrub and herbaceous growth is crowded out. The trees often grow so close together that it is scarcely possible to pass between them. Under such conditions they have a spindly growth with live branches only at the tops.

Animal Components of the Forest

The varying hare, or snowshoe rabbit, *Lepus americanus americanus* Erxleben (Fig. 27), is the dominant mammal of the forest. It is found chiefly in young

aspen and thickets of willow and hazel. Mule deer, *Odocoileus hemionus hemionus* (Rafinesque), and elk (Fig. 26) were common in early days, but now are nearly exterminated and are largely replaced by the Virginia white-tailed deer, *Odocoileus virginianus dacotensis* Goldman & Kellog (Fig. 28). Moose, *Alces americana andersoni* Peterson (Fig. 25), occurred in the swamps and willow thickets. Buffalo (Fig. 11) entered the woods for shelter in the winter and destroyed trees by rubbing and trampling. The beaver, *Castor canadensis canadensis* Kuhl (Figs. 29 and 30), through its damming of streams and cutting of aspen and willow, was a major influent. It was the principal fur bearer and the chief factor in the early exploration of the parkland. The red squirrel, *Tamiasciurus hudsonicus*, is plentiful in the vicinity of oak and hazel.

The red-backed mouse, *Clethrionomys gapperi loringi* (Bailey); the chipmunk, *Eutamias minimus borealis* (Allen); Franklin's ground squirrel, *Citellus ranklinii* (Sabine) (Fig. 14); and the skunk, *Mephitis mephitis hudsonica* (Richardson), are common mammals about the forest edge. The chief predators are the coyote, the fox, and before settlement the timber wolf, *Canis lupus griseoalbus* Anderson.

Birds are abundant, particularly at the forest edge. These include the goldfinch, *Spinus tristis* (L.); yellow warbler, *Dendroica petechia* (L.); brown thrasher, *Toxostoma rufum* (L.); catbird, *Dumetella carolinensis* (L.); crow; eastern kingbird, *Tyrannus tyrannus* (L.); yellow-shafted flicker, *Colaptes auratus;* mourning dove, *Zenaidura macroura margin'lla* (Woodhouse); robin, *Turdus migratorius* L.

These birds are all summer residents. In the early spring and late autumn, during migration, great flocks of the slate-colored junco, *Junco hyemalis* (L.); eastern tree sparrow, *Spizella arborea arborea* (Wilson); white-crowned sparrow, *Zonotrichia leucophrys* (Foster); white-throated sparrow, *Zonotrichia albicollis* (Gmelin); and Harris's sparrow, *Zonotrichia querula* (Nuttall), occur. In late spring a heavy migration of warblers passes through. There are many species, the myrtle warbler, *Dendroica coronata* (L.), being the commonest.

The red-tailed hawk and Swainson's hawk nest near the tops of large outstanding trees and hunt about the forest edge and over the prairie. The great horned owl, *Bubo virginianus* (Gmelin) (Fig. 31), occupies old crow and hawk nests in the dense woods. It is a permanent resident, feeding mainly on the snowshoe rabbit and mice. The long-eared owl, *Asio otus tuftsi* Godfrey, also occupies old crow nests but is a summer resident only. The Cooper's hawk, *Accipiter cooperi* (Bonaparte), nests in the dense woods and feeds on grouse and other birds in preference to mammals. The large and powerful goshawk, *Accipiter gentilis atricapillus* (Wilson), is a winter resident but occasionally remains to nest. In some winters this species is abundant and destroys many sharp-tailed and ruffed grouse as well as snowshoe rabbits.

Several birds are characteristic of the dense aspen forest. The red-eyed vireo, *Vireo olivaceus* (L.); warbling vireo, *Vireo gilvus* (Vieillot); least flycatcher, *Empidonax minimus* (Baird and Baird); and Baltimore oriole, *Icterus galbula* (L.), frequent the tree tops. The downy woodpecker, *Dendrocopos pubescens* (L.), and hairy woodpecker, *Dendrocopos villosus* (L.), two permanent residents, are common on the tree trunks, where they dig out beetle larvae and excavate their nesting holes. The black-capped chickadee, *Patus atricapillus* (L.), is also a permanent resident among the tree trunks and shrubs, where it feeds on insects

and their eggs. On the forest floor live the ruffed grouse, *Bonasa umbellus* (L.), and the willow thrush, or veery, *Hylocichla fuscescens salicicola* Ridgway. In the sandbar willow community the northern yellowthroat, *Geothlypis trichas* (Swainson), is a common summer resident. The basket willow communities have no characteristic bird but are used as nesting sites by many birds from the adjacent sloughs.

The invertebrate population of the forest is abundant, particularly in the willow and forest edge communities. Bird (1930) found that the population in the basket willow community fluctuated seasonally from one million to 9.5 million per acre, and in the sandbar willow community from 1.5 million to 6.75 million. There are many species but few of outstanding importance. The willows are covered by many distinctive insect galls. The sawfly *Pontania pomum* Walsh forms spherical leaf galls on the basket willow, and the cecidomyid *Phytophaga walshii* Felt makes rosette galls on the terminal twigs of the sandbar willow. The beetle *Galerucella decora* (Say) sometimes occurs in such abundance that, after completely defoliating its favorite food plant, *Salix discolor* Muhl., over large areas, it attacks other species of willow. A collembolan, *Nasosminthurus spinatus* (MacG.); leafhoppers, *Draeculacephala mollipes* (Say) and *D. noveboracensis* (Fitch); and snails, *Vertigo ovata* Say, *Succinea* sp., and *Lymnea* sp., are abundant. In the mature aspen, the invertebrate population may reach 4.5 million per acre, being highest among the leaf mold. The poplar borer, *Saperda calcarata*, is an abundant and influential insect attaching the aspen poplar. The adult lays its eggs beneath the bark and the larvae tunnel into the heart of the tree, seriously weakening it and providing entrance for the heart-rot fungus (Fig. 31). The trees are usually attacked on the upper third. The forest tent caterpillar, *Malacosoma distria* Hbn., whose favorite food is aspen, at times occurs in vast outbreaks, defoliating trees over hundreds of square miles. At other times, only the occasional individual is found. The fall cankerworm, *Alsophila pometaria* (Harr.), is a pest of boxelder. The oblique-banded leaf roller, *Choristoneura rosaceana* (Harr.), curls the leaves of saskatoon and choke cherry. The ugly-nest caterpillar, *Archips cerasivoranus* (Fitch), and the prairie tent caterpillar, *Malacosoma lutescens* (N. and D.), make their nests on choke cherry; the latter also occasionally attacks pin cherry and saskatoon. The long-horned beetle *Saperda bipunctata* Hopping attacks saskatoon, and *Ropalopus sanguinicollis* (Horn) choke cherry and pin cherry. The dermestid beetle *Byturus rubi* Barber feeds on the fruit of raspberry and has become a pest of cultivated raspberries. The lace bug *Corythucha pruni* O. & D. sometimes heavily infests choke cherry, and *Corythucha arcuata* (Say) oak. Two leaf rollers, *Pseudexentera oregonana* Wlshm. in early summer and *Choristoneura conflictana* (Wlkr.) in midsummer, heavily attack aspen and may defoliate considerable areas. The larch sawfly, *Pristiphora erichsonii* (Htg.), is a major pest of tamarack. Spruce is attacked by the balsam-fir sawfly, *Neodiprion abietis* (Harri.); the pine needle scale, *Phenacaspis pinifoliae* (Fitch); the spruce budworm, *Choristoneura fumiferana* (Clem.); and a spider mite, *Paratetranychus ununguis* (Jac.). Nests of the prairie tent caterpillar, *Malacosoma lutescens* (N. & D.), and the eastern tent caterpillar, *M. americanum* (F.), are commonly found on choke cherry. The boxelder is attacked by the boxelder leaf roller, *Gracillaria negundella* Chamb.; the fall cankerworm, *Alsophila pometaria* (Harr.); and the spotless fall webworm, *Hyphantria cunea* (Dru.).

Aquatic Communities

The poorly drained morainic region of the aspen parkland contains many bodies of water, ranging from depressions temporarily filled with snow water to large lakes. There are three large rivers in the eastern part of the parkland and a number of smaller streams. Aquatic communities contain many distinctive plants and animals.

Bodies of Water with Considerable Vegetation

Most bodies of water in the aspen parkland are small and shallow with much emergent vegetation about the margins. Open water often occurs in the central portion but this is usually choked with a heavy growth of submerged plants. The water accumulates from melting snow and rain running in from a shallow catch basin. These bodies of water are variously named. The names are often loosely applied and the distinction between one and another is not clear-cut because there are a number of intermediate types. Many of them dry up early in the summer. Others may persist throughout the year. Many of the larger waters, even if they are shallow and contain considerable vegetation, are called lakes (Metcalf, 1931). Whitewater Lake, Manitoba, is of this type (Bossenmaier *et al.*, 1954). Many biologists (Dzubin, 1955; Sowls, 1955; Evans *et al.*; and others) refer to small bodies of water with emergent vegetation as "potholes".[3] Some writers, e.g., (Macoun, 1883) call them "ponds". Locally, and in the literature (e.g., Metcalf, 1931), such bodies of water are referred to as "sloughs". This is the term I prefer to use. An area of wet or periodically inundated, treeless land with abundant grass, cattails, and rushes is usually called a "marsh". Marshes are usually of considerable size and contain permanent bodies of open water, as at the south end of Lake Manitoba.

There have been several attempts to classify sloughs. Metcalf (1931, p. 35) recognized three types: "Type A, cattail sloughs, with *Typha latifolia* dominant; type B, whitetop, or mallard, sloughs, characterized by a great abundance of *Fluminea festucacea*; type C, stagnant sloughs, usually characterized by an abundance of marsh plants, bulrush and common reed grass, *Phragmites communis* Trin. and the aquatics, algae, and common bladderwort."

Evans *et al.* (? 1952) classified potholes (sloughs) as: A, permanent; B, semipermanent; and C, temporary. In A and B the following types of vegetation were recognized: Sedge-whitetip, cattail, bulrush, and zones of emergents intermixed or denuded. This classification is now being followed by most of the wildlife workers in the parkland.

Sloughs may contain fresh water or water of various degrees of alkalinity. Highly alkaline sloughs do not have a marginal growth of willows but are surrounded by prairie. Aspen, if it does occur, grows some distance back from the slough on higher ground. Fresh-water sloughs are generally surrounded by a zone of willows, which are partly submerged at high water. Aspen grows next

[3]In geology the term *pothole* refers to a circular or subcircular hole cut in the rocky bed of rivers by the grinding action of stones whirled around by water in a particular spot (Webster, 1955; Rice, 1953). The biological use, however, is firmly established.

to the willows. If extended periods of high water occur, the willow and aspen will be killed by prolonged submergence and they will be replaced temporarily by cattail (Fig. 42).

Macoun (1883, pp. 288-289) observed the difference in vegetation in freshwater and alkaline sloughs and stated:

> A little experience only is necessary to detect brackish water by inspection of the vegetation. None of the salt lakes or ponds have a marshy or black muck border, or contain any sedges, except *Scirpus maritimus* and *pungens* [=*Scirpus paludosus* Nels.]. On the other hand, all the fresh water ponds have rich black soil around their margins, or are filled in every part with grass and various species of *Carex*, of which *Carex aristata* [=*Carex atherodes* Spreng.] is the most prominent, and the one constantly eaten by the horses in summer...many ponds of water that are good in summer are bad in October, owing to evaporation. Good water may always be known here, by the sedge in the ponds remaining green, close to and in the water; while, if the pool has become brackish, the sedges in the centre of it rot and apparently die.

Alkaline sloughs and marshes at low levels have shore lines heavily incrusted with white salts and usually bare of vegetation except for a few halophytic plants.

Whitewater Lake, a large, shallow, alkaline marsh in southwestern Manitoba, was described by Bossenmaier *et al.* (1954). It is typical of alkaline marshes and sloughs. Large areas of homogeneous aquatic vegetation occur. Emergent vegetation consists of prairie bulrush, *Scirpus paludosus;* whitetop, *Scolochloa festucacea;* cattail, *Typha latifolia* L.; and hard-stem bulrush, *Scirpus acutus* Muhl. Submerged vegetation is mostly sago, *Potamogeton pectinatus* L. The exposed shore line has a characteristic flora composed of the following species: seaside arrowgrass, *Triglochin maritima* L.; alkali grass, *Distichlis stricta* (Torr.) Rydb.; Nuttall alkali grass, *Puccinellia nuttalliana* (Schultes) Hitch. [= *Puccinellia airoides* (Nutt.) Wats. and Coult.]; creeping spike rush, *Eleocharis palustris* (L.) R. & S.; halberd-leaved atriplex, *Atriplex hastata* L.; red goosefoot, *Chenopodium rubrum* L.; samphire, *Salicornia rubra* Nels.; western sea blite, *Suaeda depressa* (Pursh) S. Wats.; and seaside crowfoot, *Halerpestes cymbalaria* (Pursh) Greene [= *Ranunculus cymbalaria* Pursh]. The pH of the lake varies from 6.8 to 8.5

In the deeper portion of the larger sloughs there is open water, which may become choked with a submerged growth of pondweed, *Potamogeton pectinatus* and *P. richardsonii* (Ar. Benn.) Rydb.; white water crowfoot, *Ranunculus subrigidus* W.B. Drew; and greater bladderwort, *Utricularia macrorhiza* (LeConte) R. Clausen. In July the surface of the water may be covered with the flowers of the last two species. Dr. D. Löve (Department of Botany, The University of Manitoba, Winnipeg, Man., in litt., 1955) has observed that the white-flowered crowfoot usually does not grow in association with the yellow-flowered bladderwort. Apparently they require somewhat different conditions.

Emergent vegetation consists of the soft-stem bulrush, *Scirpus validus* Vahl, which may grow in water up to 2 or 3 feet in depth. In shallower water several species of sedge, including *Carex lanuginosa* Michx. and *C. rostrata* Stokes; slough grass, *Beckmannia syzigachne* (Steud.) Fernald; and whitetop grow in a dense stand. The common reed grass, *Phragmites communis* Trin., is not generally distributed but grows in very dense patches in some sloughs, particularly in the marshes at the south end of lakes Manitoba and Winnipeg. This grass grows up to 12 feet in height and spreads from creeping rootstalks. Many ducks nest in whitetop but few in *P. communis.* Löve and Löve (1954) stated: "The

81314-7—3

Scolochloa (whitetop) patches, which sometimes cover some hectares of marsh, are the main habitats of nesting ducks, especially in places where the grass is sterile. It is thought that this preference may be based on the fact that *Scolochloa* rarely flowers unless its bases are flooded for some time in the early summer, and ducks may know that the sterile patches are comparatively safe against water." On mud flats covered with a few inches of water, and in roadside ditches, patches of the common cattail are found. It quickly populates exposed wet soil by its wind-blown seeds, but is later crowded out by the sedges. The sedges extend up on to land that is normally dry in late summer and are extensively cut for hay. Around the edges may also be found patches of persicaria, *Polygonum coccineum* and *P. natans* A. Eaton. The golden dock, *Rumex maritimus* L. var. *fueginus* (Phil.) Dusen, and *Juncus balticus* Willd. are common on alkaline shores. Foxtail (Fig. 8) grows in extensive patches on moist and saline flats.

The muskrat, *Ondatra zibethicus* (L.), is the dominant mammal of sloughs and marshes. It consumes quantities of roots and bulbs of aquatic plants, thus helping to keep the water open and more suitable for ducks. Ducks also use the muskrat houses for basking places.

Mozley (1938), who studied the abundant snail fauna, wrote: "Apart from certain molluscs, namely *Planorbis umbilicatellus* Cockerell and *Planorbula campestris* Dawson, the animals which are most characteristic of these situations [temporary sloughs] are phyllopod crustacea, tadpole shrimps, fairy shrimps and clam shrimps such as *Lepidurus*, *Branchipus*, *Limnetis* and *Estheria*." Of the more nearly permanent sloughs he stated, "The predominant molluscs are *Lymnea stagnalis jugularis* Say, *L. palustris* (Muller), *Planorbis trivolvis* Say and *Physa gyrina* Say."

The bird population about sloughs is large and impressive, being composed of many species and large numbers of individuals. Probably the most abundant bird in the parkland is the red-winged blackbird, *Agelaius phoeniceus arctolegus* Oberholser. Its nests are usually suspended over water in sedges, cattails, and willows, but they may be over dry land. The adults feed on insects and seeds about the sloughs and adjacent prairie. The yellow-headed blackbird, *Xanthocephalus xanthocephalus* (Bonaparte), is less abundant and more restricted in its habitat. It requires permanent sloughs with open water and patches of the giant bulrush or common reed grass, in which it nests in colonies.

At one time Canada geese, *Branta canadensis* L. (Fig. 40); sandhill cranes, *Grus canadensis tabida* (Peters); and the whooping crane, *Grus americana* (L.), nested around the larger sloughs. With the exception of a few Canada geese, these birds have now moved north of the parkland to less-disturbed areas.

Surface-feeding ducks were very abundant and still occur in considerable numbers: mallard, *Anas platyrhynchos platyrhynchos* L.; pintail, *Anas acuta* L.; gadwall, *Anas strepera* L.; baldpate, *Mareca americana* (Gmelin); blue-winged teal, *Anas discors* L.; shoveler, *Spatula clypeata* (L.); green-winged teal, *Anas carolinensis* (Gmelin). Among the diving ducks the following are found in considerable numbers in the deeper and more nearly permanent sloughs: redhead, *Aythya americana* (Eyton); canvasback, *Aythya valisineria* (Wilson); lesser scaup, *Aythya affinis* (Eyton); and ring-necked duck, *Aythya collaris* (Donovan). The ruddy duck, *Oxyura jamaicensis rubida* (Wilson), with its strikingly colored plumage and upturned tail, is a conspicuous inhabitant of even small sloughs, if the water is open and reasonably deep.

The American coot, *Fulica americana americana* Gmelin (Fig. 38), is very common. It may be seen at all times of the day feeding among the pondweed. The sora rail, *Porzana carolina* (L.), is seldom seen, as it is very secretive among the sedges and rarely flies, but its call is frequently heard. The bittern, *Botaurus lentiginosus* (Rackett), also is heard more often than seen. Three species of grebes are commonly seen on sloughs: the horned grebe, *Podiceps auritus* (L.); the eared grebe, *Podiceps caspicus* (Hablizl); and the pied-billed grebe, *Podilymbus podiceps* (L.).

Shore birds are well represented, particularly about sloughs with exposed mud or alkaline flats. The killdeer, *Charadrius vociferus* L., and willet, *Catoptrophorus semipalmatus inornatus* (Brewster), are common breeding birds; others are mostly migrants. The marbled godwit, *Limosa fedoa* (L.), is more rarely found about the grassy sloughs without tree and shrub growth. The black tern, *Chlidonias niger*, a very common summer resident, ceaselessly patrols bodies of water in search of insect life. The nests of floating debries are located in colonies among emergent vegetation.

The common leopard frog, *Rana pipiens*, Schreber, breeds in great numbers in the sloughs. The loud spring chorus of singing males is a characteristic sound. After the egg-laying period the adults gather around the edge of the slough and wander into the surrounding vegetation. They are later joined by the new generation until there may be a population of over a hundred per acre. The quantities of insects consumed by them are very great.

Insect life is characterized by the swarms of mosquitoes and midges and their chief predators, the dragonflies and damselflies. One of the commonest species of mosquito is *Aedes spencerii* (Theobald), which occurs early in the year and breeds in temporary snow water ponds. It is followed later in the season by *Aedes vexans* (Meigen), which prefers open meadows and pasture depressions about the edges of sloughs and temporary pools following heavy rains. It goes through very rapid development in warm weather. Other common mosquitoes are *Culiseta inornata* (Williston), *Culex tarsalis* Coquillett, *Aedes dorsalis* (Meigen), *A. campestris* Dyar & Knab, and *A. flavescens* (Müller).

Dragonflies and damselflies feed on mosquitoes both in the nymphal stage, when they attack the larvae, and as adults. Swarms of adult dragonflies hawk about the edges of ponds, on the sheltered side of tall vegetation, and wander far over the prairies and forest glades. The commonest are several species of *Sympetrum*—*S. corruptum* (Hagen), *S. decisum* (Hagen), *S. costiferum* (Hagen), and *S. danae* (Sulz.). At times these dragonflies are so abundant that they occur in swarms in the shelter of vegetation along prairie trails sufficient to clog the radiators of automobiles driven along these roads. When they and the species of *Aeschna* appear in abundance, mosquitoes begin to disappear. The species of *Aeschna* are large and strong-flying. They range farther afield and do not stay as close to vegetation as species of *Sympetrum* which are smaller. Literally clouds of them may be seen flying about on the lee side of bushes and trees and high in the air when the wind is not too strong. The commonest species are *Aeschna interrupta lineata* Wlk., *A. umbrosa* Wlk., and *A. canadensis* Wlk. Staying close to the open water and shelter of the sedges and rushes are the weak-flying damselflies. The conspicuous blue and black species of *Enallagma* hover over the water and settle in clusters on emergent pondweeds, where the females oviposit. The commonest species are *Enallagma cyathigerum* (Charp.),

81314-7—3½

E. hageni (Walsh), and *E. ebrium* Hagen. *Lestes disjunctus* Selys, *Lestes unguiculatus* Hagen, and *Ischnura verticalis* (Say) are frequently found wandering a short distance from shore and among the vegetation growing in water. Dragonflies and damselflies are preyed on heavily by kingbirds, purple martins, black terns, and Franklin's gulls. Roberts (1932), speaking of the latter species, stated, "The chief part of the food, however, and that on which the young are largely fed, consists of the nymphs of dragonflies which are commonly to be found in immense numbers at the time the young appear. The writer has counted no less than 327 of these insects in the stomach and gullet of a bird engaged in feeding young."

Alkaline sloughs and lakes with shallow edges where mud flats are exposed during hot weather are subject to outbreaks of botulism. The causative bacterium, *Clostridium botulinum* (van Ermengem) Holland, develops in the decaying vegetation. At such times great numbers of ducks, shore birds, and gulls perish from this virulent poison.

Lakes

Lakes in the parkland usually have firm sand or gravel bottoms and shores of the same material. They are fed by small streams, springs, and runoff water. Outlet streams usually join a river system. Patches of *Scirpus validus* may grow in the shallower bays. Where the water is 14 feet or more in depth over considerable areas, fish are present. If the water drops below this level, fish may be killed by suffocation in late winter when the oxygen supply is used up by the death and decay of vegetation. In many parkland lakes the depth approaches that critical for fish. When high water returns, fish may restock a lake by ascending the tributary streams. Minnows of the following species are common; the fathead minnow, *Pimephales promelas* Rafinesque; the spottail shiner, *Notropis hudsonius* (Clinton), and the brook stickleback, *Eucalia inconstans* (Kirtland). Of the sport fish, the pike, *Esox lucius* L., is the most abundant. A fierce predator, it consumes not only great quantities of other fish and frogs but also young ducks. When larger food is scarce, pike devour quantities of dragonfly nymphs and freshwater shrimps, *Gammarus* spp. The yellow walleye (incorrectly called pickerel over most of the parkland area), *Stizostedion vitreum* (Mitchell), is preferred to the pike by most fishermen; consequently it was introduced into many lakes although it occurred naturally in the larger lakes and rivers. The white sucker, *Catostomus commersonii* (Lacepede), occurs in large numbers but is not esteemed for human consumption. Its ability to withstand adverse conditions enables it to survive in shallow alkaline lakes when all other fish have been eliminated. Great numbers of suckers ascend small creeks in the spring to spawn and feed on many species of planktonic and bottom organisms, including chironomid larvae. Young suckers are consumed by pike and yellow walleye.

Many birds inhabit both sloughs and lakes, but fish-eating species are characteristic lake inhabitants. The common loon, *Gavia immer* (Brunnich), is a solitary nester, but many lake birds are colonial, including the white pelican, *Pelecanus erythrorhynchos* Gmelin, and the double-crested cormorant, *Phalacrocorax auritus auritus* (Lesson), which often jointly occupy low treeless islands. The great blue heron, *Ardea herodias herodias* L., prefers wooded islands and sometimes associates with the black-crowned night heron, *Nycticorax nycticorax hoactli* (Gmelin). The herring gull, *Larus argentatus smithsonianus* Coues, nests both in colonies and as isolated pairs on small rocky islands. The common tern,

Sterna hirundo hirundo L., selects islands with gravelly or sandy soil if available. Large colonies of Franklin's gull, *Larus pipixcan* Wagler, build floating nests out of the reeds in marshes attached to the larger lakes. They range far afield in their feeding forays and follow agricultural implements, picking up insects in the newly turned soil. They are attracted to grasshoppers, which they catch in the air as they fly or hop. Flocks systematically go over a field in leapfrog fashion; the gulls falling behind keep flying up ahead of those in front. In this manner they reduce high grasshopper populations to small numbers in fields where they feed.

Great numbers of mayflies, caddisflies, and midges breed in the lakes. The larvae are an important item of fish food. In the evening at certain times of the year dense swarms of adults hover over or near the water; the next day their dead bodies and exuviae may be washed up in windrows on the shore.

Rivers

The eastern portion of the parkland is drained by three major rivers: the Red, the Assiniboine, the Qu'Appelle, and their tributaries. These rivers flow slowly through meandering channels and have many oxbow lakes. The Qu'Appelle and upper Assiniboine flow in flat-bottomed valleys, one to two miles wide and 120 to 300 feet deep, eroded by glacial meltwater during the last deglaciation. The lower portions of the Assiniboine and the Red rivers are on the floor of the basin of glacial Lake Agassiz. The Assiniboine valley here is no larger than its channel, and the Red River fills its valley from wall to wall. In this area spring floods often spill over the river banks. This is particularly the case with the Red, which flows north. Its lower reaches are often icebound when the headwaters are subject to spring thaws. If the snow is deep and the thaw rapid, a major flood results and much of the surrounding land is inundated. For a few years before the railroads were built, river steamers up to 200 feet in length operated on the Red and ascended the Assiniboine as far as Brandon. A few trips were made up to Ft. Ellice and Ft. Pelly, Sask., on particularly high flood water. There are few rapids exposed except at low water; the tributaries entering the deep valley of the Assiniboine, however, are comparatively swift with many rapids.

Vegetation in running water is composed mostly of filamentous algae and diatoms, which attach themselves to the rocks on the bottom. In late summer great quantities of algae are detached and float downstream.

Common mammals are the beaver, muskrat, mink, and raccoon. In the smaller streams the beaver construct dams on almost every rapid, but on the larger streams dams are unnecessary and are not built. They burrow in the bank and gather large stocks of aspen and willow boughs for winter feed. Muskrats frequent the streams in large numbers. Here they give up their habit of house building, which they follow in sloughs and marshes, and excavate holes in the bank. They eat many clams, which they haul out on the bank and consume at some favorite spot, where piles of empty shells will accumulate. Mink, *Mustela vison lacustris* (Preble), feed on the muskrat, the abundant crayfish, fish, and frogs. The racoon, *Procyon lotor hirtus* Nelson & Goldman, is common but seldom seen because of its nocturnal habits.

Birds found along rivers are the belted kingfisher, *Megaceryle alcyon alcyon* (L.), which nests in outbanks and feeds on small fish and crayfish; bank swallow, *Riparia riparia riparia* (L.), which nests in colonies in cutbanks; and spotted

sandpiper, *Actitis macularia* (L.). In the autumn many mallard ducks congregate on the open water of the rivers when the sloughs freeze over. At such times they consume large numbers of water boatmen, *Corixa* spp., which may concentrate in such numbers as literally to cover the bottom.

The black fly *Simulium venustum* Say occurs in great numbers along some of the more rapid streams, notably the Souris River. Larvae cling to submerged stones, sticks, and vegetation, often in such numbers that they completely cover them. Stoneflies, caddisflies, and mayflies are numerous. Water striders, *Gerris remigis* Say and other species, are found in quiet waters.

Mollusca are common in the rivers. Mozley (1938) stated: "The commonest forms on the Prairie and Parkland are *Lymnea stagnalis jugularis*, *Planorbis trivolvis*, and *Lampsilis saliquoidea rosacea*. *Lasmigona complanata katherinae* is abundant in certain streams." In comparing two streams, the moderately rapid Birdtail with stony bottom, and the sluggish Red River with mud and clay bottom, he listed the following species:

> Birdtail Creek near Birtle, Man. (i) On bottom of stream, *Planorbis antrosus*, *Ferrissia rivularis*, *Physa integra*, *Lasmigona complanata katherinae*, *Lampsilis siliquoidea rosacea*, *Anodonta grandis footiana*, *Strophitus rugosus;* in small marshy areas along the banks of the stream, *Lymnea palustris*, *L. umbilicata*, *L. parva sterkii*.
>
> Red River, near Winnipeg, Man. *Lasmigona complanata katherinae*, *Lampsilis siliquoidea rosacea*, *L. ventricosa*, *Ligumia recta latissima*, *Proptera alata megaptera*, *Anodonta grandis footiana*, *Strophitis rugosus*, *Amblema costata*.

Many of the fish found in lakes also occur in the rivers, particularly pike, suckers, and some species of minnows. Minnows particularly partial to rivers are the common shiner, *Notropis cornutus* (Mitchill); the river shiner, *Notropis blennius* (Girard); and the flathead chub, *Platygobio gracilis* (Richardon). The rock bass, *Ambloplites rupestris* (Rafinesque), is common at rapids. Sturgeon, *Acipenser fulvescens* Rafinesque, which at one time were abundant in the larger rivers, are now very rare. The yellow walleye and the smaller sauger, *Stizostedion canadense* (Smith), are common in rivers and lakes.

Crayfish, *Cambarus* spp., are abundant in all permanent streams. They feed on many insect larvae and bottom organisms, and act as scavengers. Forming an important link in the food chain, they are preyed on heavily by fish, kingfishers, mink, and raccoon.

The western painted turtle, *Chrysemys picta belli* Gray, is a common inhabitant of sluggish backwaters and oxbows in the eastern parkland (Bird, 1958). It is largely vegetarian in its diet. The large predacious snapping turtle, *Chelydra serpentina*, is less abundant.

Successional Changes

An aerial view of the parkland (Fig. 41) shows willows and aspens surrounding water-filled depressions. They are separated by irregular patches of prairie. In some places they merge and the prairie is almost, if not entirely, crowded out.

Throughout the greater part of the parkland, vegetational succession is toward a forest climax. As sloughs dry up, the surrounding willows close in and in turn are crowded out by aspen. Succession is thus chiefly from water to aspen forest but may also proceed from prairie to forest. Intervening periods of drought and excessive moisture may temporarily reverse succession. During periods of drought the forest may recede from the prairie but at such times forest

invasion of the dried-up sloughs is hastened. When moisture again becomes abundant, the invading forest is drowned out, resulting in zones of dead willows and aspens about the sloughs (Fig. 42).

Succession has been studied by Ewing (1924), Bird (1930), Löve and Löve (1954), and Sowls (1955).

Succession from Slough to Forest

Succession in sloughs is initiated by a heavy growth of pondweeds, *Potamogeton* spp.; white water crowfoot; and greater bladderwort. As dead vegetation accumulates in the muck bottom the water becomes shallower and the open water is invaded by emergent vegetation, including bulrush, cattail, reed grass, whitetop, *Scolochloa festucacea* (Fig. 35), and several species of sedge. In sloughs that are slightly alkaline the sedges, on the land side, grade into prairie, often through a zone of foxtail grass (Figs. 33 and 8). In most sloughs which have fresh water, the vegetation between low and high water levels is a dense growth of basket willow. In a narrower zone at high water level the chief species is pussy willow. There may also be a few balsam poplar, but usually the willows adjoin aspen poplar, which forms a band around the depression. The next successional stage in invasion of the slough, before a complete coverage by willow and aspen, is a dense growth of sedge and often a few water parsnip, *Sium suave* Walt. (Fig. 43). Outside the aspen is prairie. The aspen encroaches on the prairie by sucker growth; hence taller and more mature trees are found next to the willows and the trees diminish in size toward the outer edge to suckers of only a year's growth. The prairie edge of the aspen grove often contains an undergrowth of snowberry, *Symphoricarpos occidentalis*, which helps to crowd out the grass as the forest advances on the prairie.

An account of succession from marsh to prairie, in the great alkaline marshes at the south end of Lake Manitoba, was given by Löve and Löve (1954). Their account applies to most of the highly alkaline sloughs except that reed grass is usually absent or occurs only in small patches. In the open water of the bays submerged vegetation occurs as large colonies of water milfoil, *Myriophyllum exalbescens* Fern., and small colonies of *M. verticillatum* L. In the deeper water pondweed, *Potamogeton richardsonii*, is found. Reed grass, *Phragmites communis*, is the predominating grass of the marsh. It grows in habitats ranging from soil that is moistened only by spring floods to water that is 18 inches deep. Although it has great powers of vegetative reproduction, it rarely sets seed before frost. Most of the humus of the marsh is formed from reed grass straw. Where the water level is low and does not rise much above the ground except in spring, there are extensive patches of whitetop. Where the water is deeper, soft-stem bulrush, *Scirpus validus*, may become dominant. Cattail, *Typha latifolia*, is not common but may be associated with the hard-stem bulrush, *Scirpus acutus*. There may be a narrow zone of alkaline vegetation between the reed grass and meadow vegetation or, if the whitetop is present, a gradual change into the prairie communities.

Succession in the same marsh was studied by Sowls (1955), who observed the effect of alternating periods of drought and flooding. In dry years willow and cottonwood invade the marsh, couch grass and wild barley (foxtail) thrive, whitetop and cord grass survive but do not bloom, reed grass survives, and cattail and hard-stem bulrush (*Scirpus acutus*) die out. In wet years reed grass,

cattail, hard-stem bulrush, wild barley, and whitetop thrive, cord grass blooms profusely, and willow and cottonwood survive. Under flooding hard-stem bulrush survives and all the other plants mentioned die out.

During periods of high water as in 1954-56, I observed that willows and aspen surrounding sloughs were killed by submersion and that this zone of dead vegetation was soon replaced by a dense stand of cattails (Fig. 42). It is possible that many cattail sloughs were created by changing water levels which killed other vegetation. Cattails quickly seed down shallow muddy areas, to be in turn crowded out by other vegetation.

Succession from Prairie to Aspen Forest

Aspen replaces prairie when there is sufficient moisture, and fires are not too frequent. Groves established about sloughs enlarge by underground stems and shoots, and occasionally aspen seedlings may become established directly on localized disturbed areas in prairie (Fig. 45), through the agency of birds and mammals and intervening shrub growth. It is difficult for aspen seedlings to become established on prairie because of the competition of grass but they may survive when the seed falls on bare ground. Such localized areas of bare soil are produced by burrowing mammals—Richardson's ground squirrels, pocket gophers, badgers, foxes, and coyotes. In the past buffalo produced bare areas by wallowing (Fig. 11) and trampling. These bare areas are used by sharp-tailed grouse for dusting places. Some seeds from snowberry fruit that they have consumed are passed in their droppings, and snowberry patches become established on the bare areas. Krefting and Roe (1949) stated that viable seeds have been found in sharp-tailed grouse droppings and that passage through the digestive tract probably aids in breaking dormancy. Pine grosbeaks, *Pinicola enucleator leucura* (Müller), which feed extensively on snowberry during the winter, may also aid in dispersal. Snowberry thus established spreads into the prairie, progress being accelerated by the reduction of grass through overgrazing, in the past by buffalo, now by domestic stock (Fig. 44). Coyotes and foxes utilize old holes within the patches of snowberry for denning sites.

On these mounds of earth, with the protection of the surrounding shrubs, seedlings from wind-blown aspen seed may take root. Only one seedling is necessary to establish a grove, as further reproduction takes place by rhizomes. Shading and crowding by aspen cause the snowberry to die out within the grove but it continues as a fringe around the edge. The enlarging groves coalesce to form forest areas. Since aspens are dioecious and there is individual variation, the single origin of groups of trees becomes evident in the spring by different dates of leafing.

Pelton (1953) stated that annual or very frequent fires are probably detrimental to the establishment of snowberry. This is further evidence of the importance of fires in limiting the extent of the parkland through the checking of forest succession. On the other hand, overgrazing and trampling by livestock (and probably by buffalo in the past) favor the increase of snowberry through the reduction of competition by grass (Fig. 44). Pelton's observations confirm my own.

Wolf willow (*Elaeagnus commutata*), in addition to snowberry, aids in the establishment of aspen. It forms extensive patches in the prairie and spreads by

long rhizomes (Fig. 36). Although it grows in a more open stand than snowberry it competes successfully with grass. Its shelter is attractive to coyotes for denning sites, the disturbed soil of which in turn provides seedbeds for snowberry and aspen. It is fed on by deer and cattle and probably was also eaten by buffalo. These mammals may have aided in the dispersal of the seeds, which have a very hard coat, but the main dispersal of seeds is probably by wind detaching the berries and rolling them across the top of crusted snow during the winter.

Succession from Aspen to Spruce

White spruce is dominant along the northern fringe of the parkland and in some sections of the Spruce Woods Forest Reserve. Here succession may proceed directly from aspen to spruce. Spruce seedlings become established in the forest floor, and when the aspen is crowded out or dies of old age a pure stand of spruce remains. This succession may be retarded by the feeding of rabbits, which, when abundant, nip off the leading shoots of young spruce. Deer select young spruce for rubbing their antlers and kill many of them by removing the bark. Single, widely scattered seedlings are generally killed before they are high enough to escape damage.

Fire kills spruce but aspen regenerates by sucker growth. Hence fires check the invasion of spruce into the parkland where conditions are otherwise favorable for its establishment, and may cause parkland conditions to extend into coniferous forest areas. The northern boundary of the parkland is hence not clearly defined (Map 1).

In the Spruce Woods Forest Reserve I have noted that isolated spruce growing in patches of juniper, *Juniperus horizontalis*, are often saved because juniper does not burn readily and helps to check fires. This is one of the reasons for the scattered growth of individual spruce trees in the area (Fig. 22).

Repeated fires kill not only the spruce but also the aspen.

Influence of Dominant Animals, Indians, and Fire

Before the coming of white men the parkland was heavily populated with large herbivores—buffalo, elk (wapiti), and to a lesser extent antelope. The nomadic population of Indians—Cree, Ojibwa or Saulteux, and Assiniboine—lived principally on buffalo. The large game animals and the Indians in their hunting and fighting disturbed the parkland and interfered with successional changes but kept it in a relatively stable subclimax condition.

The length of time that these conditions prevailed is unknown. MacNeish (1956) traced cultures in Manitoba from before 3000 B.C. to about A.D. 1750. The oldest culture he examined was the Whiteshell Focus, excavated in the Whiteshell Forest Reserve of southeastern Manitoba. Here he found the Indians had been living on buffalo and not forest game. Wettlaufer (1956) excavated a stratified site at Mortlach, Saskatchewan, near Moose Jaw not far south of the present boundary of the parkland. He found cultures dating back approximately 3400 years. The food of the Indians in this area was also buffalo.

Influence of Buffalo and Elk

The large herds of buffalo overgrazed sections of the prairie. Henry (Coues, 1897) wrote of the country west of the Red River: "The grass would be rather

long were it not for the buffalo . . . By rubbing and trampling they destroyed small groves of trees". Again quoting from Henry:

> Buffalo have ravaged this small island; nothing remains but the large elms and oaks, whose bark has been polished to the height of the buffalo by their perpetual rubbing. Brush and grass are not to be seen in this little wood, which on the whole is a delightful spot [See Fig. 46]. . . . Buffalo have destroyed all the grass and our horses are starving. . . . The ravages of buffaloes at this place [on Red River near Morris] are astonishing to a person unaccustomed to these meadows. The beach, once a soft black mud into which a man would sink knee-deep, is now made as hard as pavement by the numerous herds coming to drink. The willows are entirely trampled and torn to pieces; even the bark of the smaller trees is rubbed off in many places. The grass on the first bank of the river is entirely worn away. Numerous paths, some of which are a foot deep in the hard turf, come from the plains to the brink of the river, and the vast quantity of dung gives this place the appearance of a cattle yard.

By trampling and wallowing in numerous dust baths the buffalo created patches of bare ground. This together with overgrazing created conditions favorable for an increase of grasshoppers, particularly the Rocky Mountain grasshopper. Henry frequently mentioned flights of grasshoppers. By browsing, elk destroyed much young growth, and Henry stated, "Red deer were very numerous here not long ago, as the tops of the oaks along this little river are all broken and twisted."

Influence of Fire

Indians set many fires. Both Henry and Hind frequently referred to them. The following quotations from Hind (1859) are particularly illuminating:

> Putting out [setting] fire in the prairies is a telegraphic mode of communication frequently resorted to by Indians. Its consequences are seen in the destruction of the forest which once covered an immense area south of the Qu'Appelle and Assiniboine. The aridity of those vast prairies is partly due to this cause. The soil, though light, derives much of its apparent sterility from the annual fires. In low places and in shallow depressions where marshes are formed in spring, the soil is rich, much mixed with vegetable matter, and supports a very luxuriant growth of grass. If willows and aspens were permitted to grow over the prairies, they would soon be converted into humid tracts in which vegetable matter would accumulate, and a soil adapted to forest trees be formed. If a portion of prairie escapes fire for two or three years the result is seen in the growth of willows and aspens, first in patches, then in large areas, which in a short time become united and cover the country; thus retarding evaporation and permitting the accumulation of vegetable matter in the soil. A fire comes, destroys the young forest growth and establishes a prairie once more. The reclamation of immense areas is not beyond human power. The extension of the prairie is evidently due to fires, and the fires are caused by Indians, chiefly for the purpose of telegraphic communication, or to divert the buffalo from the course they may be taking. These operations will cease as the Indians and buffalo dimish, events which are taking place with great rapidity. . . .
>
> . . . From beyond the South Branch of the Saskatchewan to Red River all the prairies were burned last autumn, a vast conflagration extending for one thousand miles in length and several hundreds in breadth. The dry season had so withered the grass that the whole country of the Saskatchewan was in flames. The Rev. Henry Budd, a native Missionary at the Nepoween, on the North Branch of the Saskatchewan, told me that in whatever direction he turned in September last the country seemed in a blaze; we traced the fire from the 49th parallel to the 53rd, and from the 98th to the 107th degree of longitude. It extended, no doubt, to the Rocky Mountains. . . The prairie on the west of the Souris as well as on the east is treeless, the banks of Snake Creek [Plum Creek] support a thin belt of small forest trees, such as oak and ash, with a few ash-leaved maple. The annual fires prevent the willows and aspens from covering the country, which they undoubtedly would do until replaced by other species, if not destroyed to within a few inches of the root every time the fire sweeps over them. . .
>
> . . . He had not visited it [Pipestone Creek] for twenty years, and the timber, consisting of aspens and willows which then covered the country, had nearly all disappeared. The old man was correct, the face of the country had changed. the aspen forest had been burnt and no vestige remained. . .
>
> . . . Ponds and lakes are numerous on the Grand Coteau side, and it is probably on this account that the Buffalo cross the Qu'Appelle valley near the Moose Jaws Fork and

> west of Buffalo Pound Hill Lake; in the winter they keep towards the Touchwood Hills for the sake of shelter, and the excellent herbage which grows in the beautiful meadows between the aspen clumps. The prairies there too are not so often burned as south of the Qu'Appelle, the valley of that river serving as a great barrier to prevent the onward progress of the devastating fires.

In addition to destroying the forest and increasing the area of grassland, fires destroyed the nests and nesting sites of ground-nesting birds and voles and created arid, short-grass conditions favorable for the Richardson's ground squirrel.

Fires were set so frequently that they maintained a prairie subclimax that would, if left undisturbed, be invaded by aspen. The use of fire by primitive peoples to change the vegetation is universal. This practice was described by Stewart (1956), who summed it up in the following statement.

> The unrestricted burning of vegetation appears to be a universal culture trait among historic primitive peoples and therefore was probably employed by our remote ancestors. Archeology indicates that extensive areas of the Old and New Worlds were being burned over ten thousand years ago. It is logical to assume that some of the reasons which motivated historic and Neolithic men would also have motivated our remote ancestors to set vegetation on fire. One may conclude that fire has been used by man to influence his geographic environment during his entire career as a human. Furthermore, it is impossible to understand clearly the distribution and history of vegetation of the earth's land surfaces without careful consideration of fire as a universal factor influencing the plant geography of the world.

Influence of Animals in Seed Dispersal

The extent to which birds and mammals aid in seed dispersal and germination is not fully known. Krefting and Roe (1949) have done some preliminary experiments and quote references to show that the consumption of fruit by birds not only ensures dispersal of the seed but improves germination and increases the chances of seedling establishment. Many seeds have double dormancy, and passage through the digestive tract helps to break dormancy caused by an impervious seed coat. Poison ivy seeds taken from droppings of sharp-tailed grouse showed good germination. Rose and snowberry seeds showed some injury in the gizzard, but those that were not damaged showed improved germination. Choke cherry seeds, which do not have an impervious seed coat, were mostly destroyed in passing through pheasants. None of the seed passed through mammals was improved in germination by the digestive action as with birds. However, seeds do pass through uninjured and are dispersed. Bears eat quantities of sarsaparilla berries and are an important agent in their dissemination. Chipmunks and mice destroy many raspberry seeds by chewing but some pass through uninjured.

It is evident that in the above plant species, and doubtless in many others, birds and mammals are important factors in the dispersal of seeds. I have found choke cherry seeds abundant in the droppings of bears and coyotes. These mammals as well as foxes consume raspberries, strawberries, and other small fruits and pass their seeds relatively unharmed. Rodents, although they destroy many seeds by chewing, pass some uninjured and scatter many while collecting stores for winter use (S. Criddle, 1926, 1939, and 1950).

Horses pass many seeds of grains, grasses, and weeds unharmed, and since their introduction have been important in spreading seeds.

Burrs and awned grasses are carried by long-haired mammals. I have observed coyotes with many seeds of spear grass in their fur.

Jack rabbits aid in the dispersal of seeds of *Elaeagnus commutata.* The plants go into the winter with many fruits attached. As the snow drifts around the plants, jack rabbits reach up and pick off the fruit at successively higher levels. They eat only the outer portion, leaving the hard seeds. In addition to the fruits that are consumed, many others are knocked off. Both seeds and fruits blow along the hardpacked snow. Jack rabbits eat some of the smaller twigs but do not girdle the plants by removal of bark as do snowshoe rabbits, which are very partial to *E. commutata.*

Brief History of Settlement

The introduction of the horse into North America by the Spaniards was the first ecological change resulting from European invasion. Through escape, trade, and Indian capture, horses spread far ahead of the Europeans themselves. The destruction of the buffalo was accelerated. This reduced the amount of grazing and possibly brought about changes in the grassland cover before the build-up of the population of cattle (Clark 1956). The role of man in practical, accidental, and sentimental introduction of organisms was also stressed by Bates (1956).

The following brief review of the history of settlement in the parkland of Manitoba helps to trace the progressive effects of an increasing white population. This account is based on Morton and Martin (1938), who divided settlement into seven periods.

1668–1840: Settlement and Agriculture in Fur-trading Times

The invasion of Western Canada by white men began with the fur trade. It started when the Hudson's Bay Company ship *Nonsuch* reached Hudson Bay in 1668. The first trading posts were on the coast, but the competition of rival traders entering the "prairies" from the east via the Great Lakes caused the Hudson's Bay Company men to spread inland and build forts along the larger rivers. Henry Kelsey, in 1691, the first white man to reach the parkland, explored the area about the Touchwood Hills in Saskatchewan, met the Assiniboine Indians, and saw the buffalo. La Vérendrye passed through southern Manitoba and built several forts: Ft. Maurepas near Winnipeg in 1734, Ft. La Reine near Portage la Prairie in 1738, Ft. Dauphin on the Mossy River in 1741, and Ft. La Corne in Saskatchewan in 1753. As early as 1680 the Hudson's Bay Company ordered gardens and grain to be planted near their forts and attempted to establish livestock, Alexander Henry built a number of forts along the Red and Assiniboine rivers in 1800–1808 and planted gardens. The Selkirk Settlers arrived at the junction of the Red and Assiniboine rivers in 1812. After initial hardships, the settlement was thriving by 1825. By 1849 the population of Manitoba reached 5,291.

1840–1870: A Period of Transition

The fur trade declined with the increase in settlement and keen competition by rival traders. Buffalo were reduced. Floods and grasshoppers plagued the settlers. Because of the lack of communication with Eastern Canada, trade with the United States increased. This was a period of unrest resulting in the Riel Rebellion. The rival fur companies finally amalgamated with the Hudson's Bay Company, which surrendered its charter in 1870. The Province of Manitoba, with a population of 18,599, was formed in the same year.

Two explorers visited the country to determine its suitability for settlement, Palliser in 1857–60 and H. Y. Hind in 1857–58. They came at a time of drought and declared the open prairie nothing but a desert. Palliser drew a triangle

based on the Canada–United States boundary with its other boundaries approximately that of the south boundary of the aspen parkland. He declared the land within this area unsuitable for settlement.

1871–1881: Pre-railway Settlement of Lake Agassiz Basin

The Northwest Mounted Police were established and brought law and order. Treaties were made with the Indians and métis, who were placed on reservations. John Macoun explored the country in 1872, 1875, and 1879 under favorable weather conditions and reported it suitable for farming. As a result of his report, the Canadian Pacific Railway selected the southern route through the prairie. The Dawson Road from the Lake of the Woods was built, land was surveyed, free homesteads were given out, and the government promoted immigration. Foreign groups were brought in and placed on reservations. Mennonites were settled in the southern Red River Valley in 1873. Steam boats were put into service on the Red and Assiniboine rivers, and from 1876 to 1881 they did a huge business carrying settlers and their effects and establishing them along the rivers. Although most agricultural production was consumed locally, the first shipment of wheat was made to Toronto in 1876 and to Great Britain via the United States in 1877. Local lumber was sawn. The population increased to 65,954.

1881–1891: Coming of the Railways

This was a period of railway building. The transcontinental railroad from the east reached Brandon in 1881, Birtle, in 1886. The railroad brought a heavy influx of settlers and its building marked the end of the hunting and fur trading and the beginning of the era of agriculture. It also marked the end of the steamships on the Red and Assiniboine rivers.

The first Dominion experimental farms in Western Canada were established. The one at Brandon was started in 1888. Red Fife wheat, which was grown at that time, was subject to damage by frost. The population increased to 152,506.

1891–1901: Settlement Following the Railways

There was a continued influx of settlers of many nationalities. The practice of summer-fallowing was begun by Angus McKay of Indian Head in 1889. Railways were built into northern lumbering areas. The population increased to 285,664.

1901–1910: A Decade of Great Expansion

This was a period of great progress, prosperity, and continued immigration. Farmers began to organize to improve their marketing. The population increased to 455,614.

1911–1925: Rapid Increase of Production

A great increase in agricultural production arose out of the development of new wheats, new methods, and new machinery. An agricultural extension service was developed. Heavy debts for land and machinery put farmers in a poor position to cope with a general depression in the 1930's. The population increased to 700,139.

1926–present: Mechanization

The depression period of the 1930's was accompanied by a major drought and a severe outbreak of grasshoppers. As a result, much land was severely injured by wind erosion and was abandoned.

A period of prosperity followed the depression, due to a demand for food during the war of 1939-1945 and a period of abundant rainfall. New power machinery resulted in the breaking up of much abandoned and new land and clearing of forest.

The population increased to 809,000 in 1953.

Changes Brought About by Settlement

Periods in Establishment of White Man

Modification of the parkland due to the activities of the increasing white population may be divided into four periods: (1) Period of exploration and fur trade, 1691-1840; (2) transition period, 1840-1870; (3) period of settlement, 1870-1900; and (4) period of intensified agriculture, 1900-present. The last may be divided into two subperiods: (a) period of horses, 1900-1925; and (b) period of mechanization, 1925-present.

In each period a distinctive sequence of events affected the plant and animal life.

1691–1840: Period of Exploration and Fur Trade

Before 1700, no great changes had taken place in the life of the parkland for hundreds, perhaps thousands, of years. The first change of importance was the introduction of the horse, which was brought into southern North America by the Spaniards. It reached the parkland about 1750. By its use the Indians changed their hunting methods and became more mobile in their hunting and tribal wars. La Vérendrye stated that two horses were brought to Fort La Reine (Portage la Prairie) in 1741. The Assiniboine Indians had some horses before 1776 but still moved camp with dogs and hunted on foot (Burpee, 1927).

The white man was attracted by the abundant fur-bearing animals and the profitable sale of their skins on the European market. There was no thought of agriculture. In fact, the country was reported as uninhabitable. The first fur traders established peaceable relations with the Indians and, except for the encouraging of trapping and the introduction of a limited number of firearms, had little effect on the country. It was not until about 1800 that changes began to occur at an accelerating speed. The fur trade had become so lucrative that many traders of rival companies entered the field. Each vied with the other in debauching the Indians.

Henry (Coues, 1897) stated in 1803:

> The Indians totally neglect their ancient customs: and to what can this degeneracy be ascribed but to their intercourse with us, particularly as they are so unfortunate as to have a continual succession of opposition parties [In a footnote, Coues stated: "In the winter of 1794–95 no fewer than five mutually opposed trading-houses were located on the Assiniboine a short distance above the mouth of the Souris"] to teach them roguery and destroy mind and body with that pernicious article, rum? What a different set of people they would be, were there not a drop of liquor in the country!

In addition to the degrading effect of liquor the white man brought in many of his diseases, to which the Indian had little immunity. Sickness greatly reduced the population and undermined the physique of the remainder. The ravages of smallpox and other maladies were graphically described by Jenness (1934).

In 1800, Henry (Coues, 1897) camped at the present site of Winnipeg on August 19 and found evidence of smallpox. He stated:

> We are troubled by swarms of water-snakes, which even come into our tents at midday; every morning some are sure to be found in our beds; but they are harmless. They appear to lurk and breed in the old graves, of which there are many, this spot having been a place of great resort for the natives in 1781-82, and at the time the smallpox made such havoc many hundreds of men, women, and children were buried here.

Coues in a footnote to the above stated:

> Mr. Bell believes that he has determined the exact spot; viz., the Indian graveyard Henry speaks of: 'even as late as 1870, when I arrived at Fort Garry, the thicket of willows and brambles which stretched along what is now the east side of Main street, from near the entrance of Graham St., south to York St., covered the site of an extensive Indian graveyard, and was evidently the locality mentioned by Henry as the resort of the water-snakes'.

The "water snakes" were undoubtedly common garter snakes which were congregating in a favored area in preparation for hibernation.

Henry mentioned tuberculosis a number of times.:

> "Their complaint is a cough, spitting and pains in the breast: they linger for a long time, get very lean and seldom recover. This is the most common and fatal disease among them...all ages and sexes are attacked...Indians all sick with coughs and some at the point of death, which prevents all hunting."

Large numbers of firearms were brought in, and traded to the Indians. Fur bearers were trapped and game was shot in a very wasteful manner without any thought of conservation. Buffalo were shot in much greater numbers than could be consumed, and often for their tongues alone. Fires raged unchecked, often started from pure carelessness. Henry frequently mentioned fires raging in every direction in the spring and fall when the grass was dry. On October 4, 1803, he stated: "Fire raging at every point of the compass; thick clouds of smoke nearly deprive us of the sight of the sun and at night the view from the top of my house is awful indeed. In every direction are flames, some leaping to a prodigious height as the fire rushes through willows and long grass, or low places covered with reeds and rushes." On October 24: "The plains are burned almost everywhere: only a few spots have escaped the fury of the flames."

The fires often trapped and burned herds of buffalo. On November 25 1804 when on the plains near the foot of the Pembina Mountain, Henry wrote:

> Plains burned in every direction and blind buffalo seen every moment wandering about. The poor beasts have all the hair singed off: even the skin in many places is shrivelled up and terribly burnt. It was really pitiful to see them staggering about, sometimes running afoul of a large stone, at other times tumbling downhill and falling into creeks not yet frozen over. In one spot we found a whole herd lying dead. The fire having passed only yesterday, these animals were still good and fresh, and many of them exceedingly fat.

Agriculture began during this period but little land was broken for this purpose. Many trading posts had sizable garden plots.

Henry reported good yields from his garden at his Park River Post:

> Oct. 16th, 1803: I took my vegetables up—300 large heads of cabbage, 8 bushels of carrots, 16 bushels of onions, 10 bushels of turnips, some beets, parsnips, etc. 20th: I took up my potatoes—420 bushels, the produce of 7 bushels, exclusive of the quantity we have roasted since our arrival and what the Indians have stolen, which must have been at least 200 bushels more. I measured an onion, 22 inches in circumference, a carrot 18 inches long and at the thick end 14 inches in circumference, a turnip with its leaves weighed 25 pounds and the leaves alone weighed 15 pounds. The common weight is from 9 to 12 pounds without leaves.

In 1805 he raised a thousand bushels of potatoes, and as well as other standard crops, cucumbers, melons, and squash. The cucumbers he pickled in vinegar made from the sap of the boxelder (*Acer negundo*). Sugar was regularly prepared from the sap of the same tree by the Indians and traders.

The first real attempt at agriculture dates from the establishment of the Selkirk colony at the junction of the Red and Assiniboine rivers in 1812. They

broke up a considerable acreage of land and planted grain. They also had domestic stock. Undoubtedly many of the weeds common in the Prairie Provinces were introduced at this time.

1840–1870: Transition Period

This period ended the fur trade because of near extermination of the beaver and other important fur-bearers through overtrapping resulting from the keen competition of the rival traders. Buffalo, the main food supply of both Indians and white men, were greatly reduced and finally exterminated in Manitoba at the end of the period. Other large game was also greatly reduced in numbers. The Indians had not learned to hunt game birds, which were abundant. Macoun (1883) was struck by the inability of the Indians to turn from large game to small game for their subsistence. They had so degenerated that they preferred to get subsistence from the government.

> After the middle of September the sea ducks began to arrive, and it is no figure of speech to say that the ponds and lakelets were alive with them. For the following six weeks feathered game of every kind were so abundant that any person in a week could have shot enough ducks and geese to have lasted a family all winter. The abundance of waterfowl in the interior is of such importance at this time when Indians are being fed by the Government, that they should be compelled to lay in a stock of food for themselves during the winter. To see hunters perishing of hunger, or living on supplies furnished by the Government, and at the same time surrounded by millions of birds is a paradox· but these men carry rifles, and bird shooting to them is a small business after buffalo hunting. Within a day's journey of the Cree Reserve on the north side of the Cypress Hills, is a large lake named by me Gull Lake, which during the last days of August was literally alive with birds, and when one shot was enough to supply six of us with a dinner, yet these Indians were largely depending on the Government rations at this time, and Colonel McDonald could scarcely persuade some young men to go and kill a few ducks by liberal offers of powder and shot. At the Assiniboine Reserve it was just the same, plenty of birds in the neighborhood but scarcely any attempt made to shoot them, as the men preferred Government rations to independence. Rifles today are of little value to the plain Indians, and they should be required to exchange these for shot guns at an early day.

Fires continued to rage over the prairie and into the forest and prevented the successional advance of the forest community. Their effect was noted by Macoun (1883):

> It seems probable that at a period not very remote, a great part of this district was covered with forest trees. The humidity of the soil and climate is sufficient for their growth, and in some places little hummocks, resembling those formed in a forest, and known as "cradle hills", were observed. On approaching Turtle Mountain, the tendency of this part of the prairie to reclothe itself, is shown by the recurrence of thickets of seedling poplars on the sheltered sides of the undulations, wherever the fires have not passed for a few years.
>
> . . . Fire passes over the country every year, and, in 1879, in many places, burned the life so completely out of the roots of the various grasses which have a tendency to grow in clumps, that the following year, scarcely a blade was seen. Although the grass is short the rainfall is quite sufficient, as there is abundance of fresh water ponds, and yet not a shrub over six inches high exists in the country. I speak of the region east of the Qu'Appelle trail, which we crossed in lat. 50° 03′.
>
> . . . Aspen Poplar [*Populus tremuloides*] may be called the characteristic tree of the plains. Wherever there is dry soil, not too sandy, outside of alluvium, there is aspen. I have passed repeatedly from aspen "bluffs" on the prairies, not twenty feet high, and with the trees not thicker than a walking stick, to continuous forests of stately trees, with their white trunks towering to the skies. Each time I have noticed that the forest was only kept in check by the annual fires. Until the willow and aspen roots had lost their vitality, they persisted in sending up crop after crop of stems ever increasing in in number, until death by exhaustion took place and permanent prairie was formed. It has been frequently stated that aspen seeds remain in the soil, but this is not so. The reason it reclothes the ground so many times after being swept off by fire, is the fact that it throws up shoots from every root after a fire has killed the stem. It possesses this quality, in common with all members of the Willow family, which it is well-known grow indiscriminately from either roots or planted stems, and very seldom from seeds.

> . . . Indians in past time burnt the grass over wide areas every fall, so that the young and tender grass of the burnt districts might tempt the buffalo to migrate. On the dry southern plain few of the grasses bear seed the year after a fire, as the surface of the ground being bare of any covering to act as a mulch, the warm sun begins to change the grass to hay before seed has been formed. Where the rainfall is greater this is not noticed and heavy crops of grass loaded with seed may be seen every year. Hence certain grasses obtain local names. A grass may be cut for hay in one locality, in another it may bear no seed and be merely short pasture. By burning the grass, good pasture for the season is assured, but this should always be done in spring after the cattle have roamed over it all winter. Should the grass not be burned the young shoots grow up amongst the old grass, and cattle and horses wander off to where there is less of this mixture.

In some ways the transition period might be considered a partial vacuum. Buffalo and other big game had been nearly exterminated along with the important fur-bearers. Thus the people had been deprived of their main food supply and income. The Indians had been greatly reduced by the ravages of disease, and the remaining population, composed mainly of métis, was on the verge of starvation. Conditions were ripe for an influx of agriculturists with their livestock and crops.

1870–1900: Period of Settlement

On November 19, 1869, the Hudson's Bay Company surrendered to Great Britain rights over Rupert's Land that it had held since 1670. On July 15, 1870, Rupert's Land was transferred to the Dominion of Canada. This political event formally closed the period of fur trade and opened the land to agricultural development. At this time the population of the Red River area was 11,963, composed of 1,565 whites, 9,840 métis, and 558 Indians who were settled on the land. In March, 1871, formal provision was made for settlement on homesteads, and survey parties were sent in to lay out the land. For the first decade there was political unrest, and population growth was slow because of the lack of transportation. Then a great surge of settlers came in, first by steamships on the Red and Assiniboine rivers and after 1880 by the railroads.

With the coming of the settlers an increasing amount of virgin prairie was plowed by oxen and horses. Weeds were introduced with unclean seed and became such serious pests that in 1883 the Noxious Weeds Act was passed by the Government of Manitoba. Livestock was brought in and replaced the buffalo as grazing animals. Land was fenced and farm buildings were erected. Prairie fires were curtailed but it was still necessary to plow fire guards for protection of buildings and crops. Because of the greater labor involved, forested land was not broken, but an increasing amount of timber was cut for firewood. At first sod and log buildings were constructed, but later sawmills were set up and larger timber was cut for lumber to build more substantial dwellings. In spite of this utilization, forests spread out onto unbroken prairie because of the protection from fires.

Big game reached an all-time low in population, because of unregulated killing for food by settlers, who were often on the verge of starvation. In 1876 the first game act in Manitoba was passed. Its provisions were very liberal and gave the game little protection. It established closed seasons on prairie chicken, April 1-Aug. 15; ducks, May 25-Aug. 15; elk, moose, and deer, March 1-July 1; but no limit was placed on numbers taken. Poison was prohibited and most fur bearers were protected from May 1 to November 1. Revisions in the following years extended the closed season, but through lack of public support and shortage of enforcement officers they had little effect. Animals were killed at all times of

81314-7—4½

the year whenever opportunity offered. In 1883, for the first time in Manitoba, insectivorous birds were protected. By this time twenty-seven game guardians had been appointed (Manitoba Dept. Agr., Stat., and Health, 1884).

Wildfowl were not long in discovering a readily available food supply in the grain fields. Macoun (1883), reporting on his trip of 1880, stated:

> Geese, ducks, and prairie chickens are taking to the stubble fields in the fall, so that no difficulty will be found by incoming settlers to lay up a supply of fat fowl for the winter.

Fish received little protection. In 1881 some regulations to prevent pollution were passed but were not enforced (Manitoba Dept. Agr. and Stat., 1883).

Agriculture was of a primitive type. Oxen, used at first for power, were soon replaced by horses. Breaking was done with the single walking plow. Cultivators and seed drills with 12-foot sweep, however, were brought in by 1880 along with early binders and threshers.

1900–present: Period of Intensified Agriculture

After the turn of the century, pioneering and unsettled conditions had largely passed. Transportation had been provided by the railways. Rapid agricultural development of the country took place as more and more land was put under the plow.

1900–1925: Period of Horses

During the first half of the agricultural period, horses were the main source of power. They were supplemented by large steam engines and gang plows, on a custom basis, for breaking sod. Land breaking was confined mostly to prairie, relatively little forested land being cleared.

The method of land survey and assignment of certain sections to the Hudson's Bay Company and schools kept a considerable acreage in an undisturbed condition for some years after other land had been put under cultivation. The land was laid out in the cardinal directions into square townships six miles to the side. Each township thus contained 36 units, known as sections, of one square mile each. Generous road allowances of 99 feet were left around each section. Sections 11 and 29 in each township were set aside as school property, and the Hudson's Bay Company retained rights to sections 8 and 26 in townships whose numbers were divisible by 5 and to section 8 and to the S $\frac{1}{2}$ and NW $\frac{1}{4}$ of section 28 in all other townships. This land was not sold to settlers until after all homestead land had been taken up. The Hudson's Bay Company land was sold first, but most of the school land did not pass into private ownership until the next period. Road allowances were not disturbed except for a wagon trail or a narrow graded road on the main travelled routes. This left considerable land in its virgin state.

Increased agricultural activity for food production during and after the First World War, 1914-18, resulted in the breaking of some submarginal land which proved unprofitable and was later abandoned.

The great prairie fires that were common in the past century did not recur during this period. However, fires started by settlers for clearing land, and from carelessness, occasionally burned over patches of prairie and forest. These fires retarded the successional advance of the forest but were not so frequent as the previous conflagrations and the forest extended its range considerably.

Areas in the vicinity of Miniota, Virden, and Reston in Manitoba, and Redvers and Moosomin in Saskatchewan, for example, which were destitute of trees when settlers came in, were covered with aspen groves by 1920.

Agricultural methods are important because they had a direct effect on vertebrates, insects and weeds. After the land had been broken from sod, tillage was accomplished with gang plows, disk harrows, drag harrows, and cultivators. Wheat and oats, the main crops, were cut with the binder, stooked, and often stacked. Threshing was done on a custom basis or by a group of farmers jointly owning an outfit. Threshing outfits were large, consisting of a large separator and powerful self-propelled engines. The engines were at first steamers, which for operation required, in addition to an engineer, a fireman, a man and team to haul straw for fuel, and another man and team to haul water from a nearby slough or well. There was a gang of pitchers and stook teams if the grain was not stacked. Some of the straw was utilized for bedding of stabled livestock but the great majority was burned. The straw piles were usually fired in the evening at the end of the day's work. It was spectacular to have twenty or more burning straw piles in sight at one time.

This type of agriculture was beneficial to wild game because it provided food and shelter. People were becoming more conservation-minded. Better game laws were passed and hunting seasons were established. Laws were generally obeyed, but many people still felt it was their privilege to take game at any time. In 1916 the Migratory Bird Convention Act was passed in co-operation with the United States to give protection to all migrating birds. Ducks and geese fed in increasing numbers on grain fields and did appreciable damage to those adjacent to marshes. White-tailed deer found fields interspersed with woodland ideal habitat and increased accordingly, so that regular hunting seasons on bucks were established and several thousand were taken annually in addition to numerous illegal kills of both sexes. Mule deer and elk continued to decrease and remnants of the once plentiful herds retreated to the hills.

Sharp-tailed grouse and the greater prairie chicken, although subject to periodic cycles in abundance, generally benefited by this type of agriculture. They found waste grain about the sites of threshing outfits, stooks, stacks, and straw piles an abundant source of food for the winter months. Adjacent aspen groves furnished shelter and buds, rose hips, and snowberry fruit for food.

Weeds spread with agriculture and with disturbance of the native flora. Seeds were spread from one farm to another by the movement of unclean seed grain and implements, particularly by custom threshing outfits. Plants that had wind-blown seeds, such as the perennial sow thistle, *Sonchus uliginosus* Bieb., and dandelion, *Taraxacum officinale* Weber, rapidly spread over great areas during the first quarter of the 20th century. The harvesting methods of this period, however, when grain was cut and hauled to a central point for threshing, were not so effective in spreading weeds over the fields as the later methods of swathing and combine threshing.

During this period the wheat stem sawfly, *Cephus cinctus* Nort., and the prairie grain wireworm, *Ctenicera aeripennis destructor* (Brown), became major pests in the wheat growing areas. Both insects are native species whose numbers increased under farming conditions. The sawfly found the bread wheats a more favorable host plant than the native *Agropyron* grasses. It became a serious

pest in Manitoba in the period 1910–25, after which it became less important. The reduction in numbers was due to the introduction of soft durum wheats, which show a partial resistance to the sawfly (as opposed to hard spring wheat), and particularly to a rotation with barley, oats, and flax, which are resistant. Further reduction in sawfly numbers was caused by the replacement of native grasses on roadsides and headlands by brome grass, on which the larvae fail to reach maturity. The wireworm became a crop pest in areas of clay loam but is not numerous in heavy clay, sandy, or gray wooded soils. On account of its long larval stage, up to eight years, it does not fluctuate markedly in numbers annually, but it may be more destructive in dry seasons because of greater activity in loose soil.

Several species of grasshoppers occurred in outbreak numbers in the years 1898 to 1903, 1911 to 1912, and 1919 to 1923. These included the migratory grasshopper, *Melanoplus bilituratus* Walk. (=*mexicanus* Sauss.); Packard's grasshopper, *Melanoplus packardii* Scudd.; the red-legged grasshopper, *Melanoplus femur-rubrum;* and the clear-winged grasshopper, *Camnula pellucida. M. bilituratus* laid its eggs in the fields, and *C. pellucida* in sod adjacent to the fields and in pastures. The Rocky Mountain grasshopper, *Melanoplus spretus* (Walsh), a migratory, long-winged species that bred in enormous numbers in the dry, short-grass plains to the southwest in what is now Montana, Wyoming, and adjacent states, periodically migrated into the parkland from the time of the first explorers. The last flight into Manitoba occurred in 1901–02. The species is now believed to be extinct.

A number of other native insects became sufficiently abundant to be destructive to crops during this period. These include alfalfa caterpillars, *Colias philodice* Latr. and *C. eurytheme* Bdv.; the alfalfa plant bug, *Adelphocoris lineolatus* (Goeze), and the rapid plant bug, *A. rapidus* (Say); the armyworm, *Pseudaletia unipuncta* (Haw.), which attacks grains and grasses; the beet webworm, *Loxostege sticticalis* (L.), which attacks flax and a great variety of garden plants; cutworms, *Euxoa ochrogaster*, *E. tessellata*, and other species, which are general feeders; flea beetles, *Phyllotreta* spp., which attack beets, cabbages, radish, and rape; the six-spotted leafhopper, *Macrosteles fascifrons* (Stoal), which attacks a wide range of hosts and transmits the disease aster yellows; the plant bugs *Liocoris lineolaris* (Beauv.) and *L. borealis* Kelton, which feed on the developing seeds of alfalfa and on the foliage of a wide variety of garden plants; the peppergrass beetle, *Galeruca browni* Blake, which attacks turnips; the strawberry root weevil, *Brachyrhinus ovatus* (L.), which spreads from snowberry and other native plants to cultivated strawberries; the currant fruit fly, *Epochra canadensis* (Loew), which became a serious pest of cultivated currants and gooseberries.

The imported cabbageworm, *Pieris rapae* (L.), from Europe, and the Colorado potato beetle, *Leptinotarsa decemlineata* (Say), which spread from Colorado into the parkland with the introduction of the potato, became firmly established pests requiring annual control measures. The corn earworm, *Heliothis zea* (Boddie), migrates in annually from the United States and attacks corn but is unable to survive the winter. The imported currantworm, *Nematus ribesii* (Scop.), was introduced with the early shipments of nursery stock.

An efficient plant inspection service was set up by the Government of Canada under the Destructive Insect and Pest Act, passed in 1910, to prevent further importations of injurious insects.

1925–present: Period of Mechanization

The great increase in population during this period, accompanied by the development of the tractor and automobile, rural electrification, and almost complete mechanization of farms, produced great changes in the parkland. In many districts the native vegetation was completely destroyed, and in others only a few relatively undisturbed areas, generally on poor agricultural land, remain.

Horse power for farm work was gradually replaced by the tractor. Horses were still used to some extend as late as 1940. After that date they were retained only for odd jobs and winter use.

The development of farm machinery is important ecologically because changing methods of tillage affected the abundance and distribution of weeds, insects, and such animals as the jack rabbit and sharp-tailed grouse.

Tractors first appeared about 1909. At first they were large steam machines used mainly for threshing and pulling heavy breaking plows. Gasoline-powered engines, which appeared about 1914, were also large and cumbersome but smaller than steamers. After 1925 smaller engines suitable for pulling plows and other machinery were produced, but they did not come into general use until the late 1930's. The Manitoba Department of Agriculture (1939) reported only 195 tractors sold in 1932 and 3008 in 1938, after which there was a slight drop in annual sales as the supply saturated the market. The preference was for the smaller machine of 10-20 to 12-35 h.p., economically suitable for a single farm with the implements of that time. There was another upsurge in buying in the late 1940's as more modern machines were produced. In 1949, 7741 tractors were sold in Manitoba. Bigger machinery then called for larger tractors and the 22-31 to 27-39 h.p. class was favored.

Along with the development of the tractor was a corresponding development of tractor-drawn machinery, tillage practices, and harvesting methods. Four-furrowed gang plows were largely replaced by the oneway disk and duckfoot cultivator in the drought years of the 1930's, when it was necessary to produce a cloddy surface with trash cover to prevent wind erosion. Disk seeders became common in 1938 to 1940, and a flexible disk seeder, 16 feet in width, in four sections, was introduced in 1950. The high cost of labor and scarcity of help during the Second World War, 1939–45, which forced the farmer to attempt to work his land single-handed or with family help, stimulated the use of all possible labor-saving machinery. One of the most important was the combine thresher, either tractor-drawn or self-propelled, which eliminated the large gangs of men required for the stationary thresher. The grain was swathed in windrows. The combines picked up the grain from the swaths and threshed it as they moved over the field. The straw was either scattered with a spreader or left in long strips. In spite of recommendations to the contrary, many fields were burned to remove the straw. This type of harvesting aggravated the weed problem, particularly that of wild oats, by scattering the seeds. Ergot was similarly scattered over the fields and shallow tillage with the oneway disk was not effective in destroying the resting stage. Fires, which were started to burn the stubble, besides increasing the hazard of erosion, often escaped to the roadsides and into adjacent stands of trees. The burnt fields blew clear of snow in the winter, with the result that huge drifts piled up in water courses and windbreaks.

A great stimulus to land clearing was the introduction of the bulldozer in 1945-48. This powerful machine easily pushed over mature trees and piled them up for burning. Sometimes a blade was used to shear them off at ground level. This work was usually done in the winter, when the ground was frozen and young saplings easily snapped off with the frost. The bulldozed land was run over with a heavy disk the next spring and put into crop. From 1946 to 1952, 43,000 to 60,000 acres were broken annually, bringing the total cultivated acreage in Manitoba to about $8\frac{1}{2}$ million.

With the development of farm machinery a corresponding development in automobiles, road building, and highway transportation occurred. Automobiles became common after the First World War and roads were improved to handle this new traffic. Better roads were built as power machinery became available and traffic demanded them. At first, with only horses for power, only a few narrow grades were built. Graveled highways were being constructed in 1930, and a few years later concrete and asphalt roads. There is now a network of wide, paved trunk highways, gravelled secondary highways, and graded roads. Grades are built high so that they will blow snow-free. The result of this road building program has been an almost complete destruction of native roadside vegetation. The grade and accompanying borrow pits have taken most of the width of the road allowance, and for trunk highways additional footage has been used. Along the main highways this disturbed soil has been sown to brome grass to prevent erosion, but on lesser roads ditches have been allowed to grow up with weeds. Considerable shrub growth on the road allowances has been killed with herbicides. In many districts where the fields are not fenced they are cultivated right down into the ditch and there is no sod margin.

The removal of native vegetation, particularly from hilly land, increased the rate of water runoff with the result that low lands were subject to flooding. There were also areas of low-lying marsh or semi-marsh land that attracted the agriculturist. A drainage program was hence started. Roadside ditches were often utilized for drainage purposes. In the flat country on both sides of the Red River this was a common practice. These ditch banks made excellent egg-laying sites for the grasshopper M. *bivittatus*.

During this period aspen lost its value as fuel in competition with coal and oil. Farmers became well-to-to and found it less laborious and more efficient to equip their houses with stokers and oil burners than to cut wood. Comparatively little aspen is now used for heating purposes. It is now treated as a weed and in land clearing is piled up and burned. Wooded areas are fast disappearing.

In addition to the high value of grain crops and the ease of clearing with a bulldozer, further impetus to breaking new land has been the reduction in the number of horses and the lessened need for pastures. For dairy herds it has been found more profitable to break the land and sow it to brome grass and alfalfa rather than leave it in native sod. Native pastures remain only on marginal agricultural land—hilly, stony, or sandy. Here overgrazing has reduced the more nutritious grasses, and pasture sage and snowberry have increased. Except where there has been excessive trampling, aspen has increased in native pastures.

A direct effect of intensified agriculture has been a marked increase in wind and water erosion. Plant fiber and soil structure have been broken down. As an erosion preventive the retention of straw and trash cover is recommended. A large amount of straw, however, lowers the yield because of its capacity to

hold nitrifying bacteria, and fertilizers high in nitrogen are required to maintain yields. Many farmers still have the destructive habit of burning off the straw and stubble with little thought to the future condition of the soil. It is a general practice to summer-fallow every third year to conserve moisture and kill weeds. To kill the weeds, six or seven cultivations are necessary. This destroys all trash cover and so pulverizes the soil that it is easily eroded. Severe erosion takes place with high winds and heavy rains. It is estimated that soils that have been under cultivation for 22 years have lost a large percentage of organic matter, 20 per cent for prairie soils and 30 per cent for gray wooded soils.

Changes taking place during this period have affected game birds and mammals. People have generally become aware of the need for conservation and scientific wild life management. G. W. Malaher, Director of Game and Fisheries Branch, Manitoba Department of Mines and Natural Resources, summed this attitude up in the introduction to his report for 1953:

> One of the most encouraging aspects in the field of fish and wild life management during recent years has been the growing recognition of the place of research in management...It is becoming generally recognized that protection alone is insufficient in the maintenance or improvement of fish and wild life populations. Protection will not enable a species to survive if the right environment within which the species can thrive no longer exists. To determine the requirements of a particular species it is necessary to know something of the species itself, its life history, habits, food and other environmental needs.
>
> It is therefore gratifying to report that during the period under review research has taken, and it is hoped will continue to take, an increasingly important place in the management of our fish and wild life resources.

Game preserves and sanctuaries, hunting seasons and bag limits based on population, food, and habitat surveys, have been established. Men are being trained at universities in the technical aspects of game management and are being employed by provincial game departments. An outstanding research center for the study of wild fowl has been established at Delta, Man., by the North American Wildlife Institute. In spite of increased hunting pressure with the expanding human population, game has been able to hold its own or even increase under wise management when habitat destruction is not too great. Ducks Unlimited, an organization supported by contributions from sportsmen, has accomplished a great deal in habitat improvement for ducks by the construction of dams and the reflooding of marsh land that had been drained and found valueless for agricultural purposes. Muskrats benefited also from more stable water levels and increased so that local residents could obtain an income by trapping the surplus. In large marshlands methods of muskrat farming were developed. It was found that land could not be permanently flooded and continue to produce high populations of muskrats indefinitely. Natural succession of vegetation rendered these areas progressively less suitable as muskrat habitat. Periodic draining and reflooding produced more favorable conditions. For this purpose dams and dikes were built and maintained largely by Indians under white supervision. The Indians were also employed in trapping a carefully regulated annual take, thus stabilizing their economy. Outside the heavily populated areas, and hence outside the parkland proper, the provincial game departments have done much toward placing trapping on a stable basis and eliminating cutthroat competition that would result in serious overtrapping, by introduction of the registered trap line system. In this system a single individual is given sole rights of trapping in a certain area. He is encouraged to practise conservation and management and to leave sufficient breeding stock.

The beaver population has responded remarkably under management and has increased to a peak that has threatened its food supply. It has become necessary to extend the trapping season for the entire winter and remove quotas in order to try to reduce the population in both registered trap line districts and settled portions of the Province. In a trip by boat along 10 miles of the Assiniboine River east of Brandon in November, 1954, I counted 14 beaver lodges. This abundance must closely approach that at the height of the fur trade.

There is still considerable trapping of muskrat, weasel, mink, skunk, fox, coyote, and other fur animals in thickly settled areas of the parkland. To supplement the taking of wild fur animals and to produce pelts of high quality and improved types, fur ranching has become a big business. In 1952-53 the value of fur taken in the wild and that raised on farms in Manitoba was approximately equal at a little over two million dollars each. Mink and fox were the two species chiefly raised on the farms. It is tragic that fashion should change so rapidly that fur prices fluctuate violently and the production of fur cannot become a basic economy of a large group of the population.

The white-tailed deer extended its range into the parkland after 1900 and has increased greatly in settled areas under protection of short open seasons during which only one buck may be shot per license. Starting from an annual kill of only a few hundred (840 reported taken) in 1933, the take increased to an estimate of 30,950 taken by 45,986 hunters in 1951. It then became necessary to open the season on both sexes to reduce the population and try to prevent winter starvation. High populations endanger the winter food supply and heavy winter kills take place in seasons of heavy snowfall as in the winters of 1948-49 and 1955-56.

Although the population of waterfowl is definitely lower than at the beginning of the period of mechanization, sizeable populations still remain. In 1952 there was an estimated kill of 278,739 ducks by 24,283 licensed hunters in Manitoba. Farmers, who are not required to take out licenses, made no returns but took an additional number. Upland game birds, mostly sharp-tailed grouse, contributed an estimated 80,980 to the hunters' bag in 1952, the peak year of a cycle.

Hunting pressure on all species of game has increased tremendously through the use of the automobile, to which few areas of the parkland are now inaccessible. Improved firearms and ammunition have also increased the efficiency of the individual hunter. Fortunately for the game, however, the skill of the average hunter has decreased. The majority of hunters appear to have no idea of the range of a shotgun and shoot off boxes of ammunition at birds hopelessly out of range. This so alarms the birds that few venture within range of the careful hunter. Around many of the larger marshes, "firing lines" develop where hunters line up only a few yards apart. Each man is so anxious to get in a shot ahead of his neighbor that birds are shot at long before they come within range, causing them to fly so high that only a few are taken. The best way to hunt geese was to allow them to feed in a grain field for a few days, undisturbed, and then dig pits and set up decoys. It is now impossible to find an undisturbed flock. As soon as a flock leaves a marsh, cars of hunters follow it. If the flock alights in a field, a dozen cars converge on the surrounding road allowances within a few minutes. The birds get up well out of range and only occasionally come close to a lucky hunter.

Deer hunting, too, has developed much inefficiency. The majority of hunters prefer to drive around in cars and jump out to shoot at any they see out in the open. There is much wild shooting and the deer soon learn to stay in the thick willow swamps, where they dodge about like rabbits when hunters attempt to drive them out. Stalking has become a lost art, and hunters awaiting where deer are expected to appear make all kinds of noises and movements that alarm the deer.

Insect pests became of greater importance. Many of the destructive species were introduced from Europe and native species commenced to attack cultivated plants in preference to native hosts before the period of mechanization. There are, however, several that have become of economic importance more recently.

The sweetclover weevil, *Sitona cylindricollis* Fahr., of European origin, became a pest in Manitoba in 1939 and extended its range rapdily to the west and south. It does not attack any plants native to the parkland but is a major pest of sweet clover (Bird, 1947) and may also feed on alfalfa in the autumn. The European corn borer, *Ostrinia nubilalis* (Hbn.), first appeared in Manitoba in 1950, entering via Minnesota. After the introduction of commercial sunflower growing in Manitoba in 1942, three species of native insects became important pests and several others became pests of less importance. The banded sunflower moth, *Phalonia hospes* (Wlshm.), attacked the seeds (Westdal, 1950); the sunflower maggot, *Strauzia longipennis* (Wied.), mined in the pith (Westdal, 1951); and the sunflower beetle, *Zygogramma exclamationis* (F.), devoured the foliage (Westdal, 1952). Grasshoppers appeared in a major outbreak during the severe drought years of 1930-1942 (Mitchener, 1954). The severity of the outbreak of *Melanoplus bilituratus* at this time was increased by the large amount of cultivated land and ridges of wind-blown soil, both of which formed ideal egg-laying sites. *Melanoplus bivittatus* was favored by the abundance of sow thistle, *Sonchus uliginosus* Bieb., and succulent crops on the heavier clay soils of the Red River Valley. It first became a major pest in 1932 (Criddle, 1933). *Camnula pellucida*, which prefers sod for its oviposition sites, found overgrazed pastures and roadsides well suited to its needs.

Chemicals for weed control were introduced in 1946. At that time it was found possible to kill mustard and other broad-leaved weeds in crops of seedling grain by spraying with 2,4-D without injuring the grain. Since then considerable advances have been made in the use of selective weedicides, and thousands of acres are sprayed annually. Chemical weed control is not a cure-all. There has been some relaxation in necessary cultural practices, and immune weeds such as wild oats and wild millet have increased with the removal of broad-leaved competitors. Seeds persist in the soil for many years and annual treatments are necessary.

Since 1949 herbicides have been used extensively by municipalities for the elimination of willows and aspens in the roadside ditches. Powerful turbine sprayers blow the chemicals into adjacent property. Killing of willows where they cause snow to collect on the highway is necessary, but poison crews have systematically gone up and down road allowances spraying everything. They have killed many harmless shade trees and bushes and eliminated important cover for wildlife where the road allowance may contain the last cover for miles. The chemical 2,4-D drifts with the wind for several hundred yards and at that distance

kills or severely injures tender garden and native plants. Its general use has a profound effect on the parkland.

Chemicals for the control of insect pests were introduced about 1867. Probably the first was paris green, which was used for control of the Colorado potato beetle. It and other arsenicals were used as stomach poisons. Pyrethrum, derris, and nicotine sulphate were the main contact insecticides. Along with insecticides, sometimes in combination, fungicides have been used. Since 1945 many new insecticides, chlorinated hydrocarbons and organic phosphates, have been introduced and have largely replaced the arsenicals. Most of these are both contact and stomach insecticides. The first to come into general use was DDT. It was used for the control of house flies, mosquitoes, and many chewing and sucking insects. Chlordane came into general use for grasshopper control in 1948, to be replaced first by aldrin in 1950, then by dieldrin in 1952, and later by heptachlor. They, along with toxaphene, have also been used widely for the control of grasshoppers and other insects in the parkland.

The use of these insecticides and fungicides has produced other problems. Pickett (1949) and Bartlett (1956) have shown how the use of hydrocarbon insecticides has affected not only the species for which it was applied but also other species of insects and mites that might be present. Organic phosphates have produced the same results but to a lesser degree because of a shorter residual toxicity. Parasites and predators may even be more susceptible to the poison than the host, with the result that the surviving host insects reproduce rapidly without their natural enemies. Furthermore, they may have survived because of resistance to the chemical. They are left to reproduce, and by repeated application of poison over a number of generations a resistant strain is selected. This has happened with house flies following repeated use of DDT. Mites generally show a high degree of resistance and almost at once increase from low numbers to high populations when a hydrocarbon insecticide such as DDT, is applied to control an associated insect pest, because of the reduction of parasites and predators. Similar increases of mites have occurred with the application of sulphur fungicides. Pickett (1949) also demonstrated that the codling moth population in Nova Scotia increased through the repeated use of sulphur fungicides. The use of copper fungicides, on the other hand, had no effect on the parasites and predators and the population of codling moth decreased when they were used in place of sulphur.

The use of agricultural chemicals, both for the control of undesirable plants and for insect control, may have broad ecological effects. It is not safe to make generalizations, as effects vary locally and in different seasons or years. Much more research is needed.

According to Rudd and Genelly (1955), herbicides affect wildlife through the effect on plant cover and might be beneficial if they broke up dense cover and produced "edge" environment. On the other hand, they may remove protective cover plants that produce food in the form of berries or seeds. The effect of insecticides on food supply is very important. Insectivorous birds have been forced to leave areas of treated forest land because of reduced invertebrate food. Raccoons have been affected by the destruction of crayfish in waters treated with DDT. The resistance of vertebrates to insecticides varies with the species. In an area sprayed with half a pound of dieldrin per acre, ducks were unaffected; fish, herons, and egrets were killed; and pheasants showed sensitivity. Dieldrin

at $1\frac{1}{2}$ pounds per acre, applied to cover crops in an orchard, killed pheasants, mice, rabbits, and snakes. Toxaphene at two to three pounds per acre caused some pheasant mortality. Generally insecticides applied at recommended doses for insect control do not visibly affect vertebrates, but through carelessness stronger doses may be applied and concentrates may be spilled where they are accessible.

Martin (1955) pointed out that the necessity to protect domestic animals from dangerous chemicals also serves as a safeguard to wildlife but widespread harm could be done by the use of chemicals that have not been fully tested, and that tests cannot keep up to the rapid release of new chemicals. The significance of this lag in knowledge is demonstrated by the work of DeWitt (1955), who has shown that, although adult birds (bobwhite, quail) showed no ill effects from small doses of DDT, there was heavy mortality in young hatched from eggs laid by these birds. Only seven per cent survived for six weeks.

Changes in Plant Dominants and Succession

As indicated by Anderson (1956), disturbance of the native fauna and flora by human activities has produced changes in plant dominants and in succession of native plants. Many species have been introduced from abroad and have become established. They may be cultivated plants, weeds, or incidental species associated with man. Some have found niches among native plants and it is difficult, even for experts, to determine if they are native. Some hybridize with native species. They form new communities and new habitats for animals.

It is now difficult to find undisturbed areas in the parkland. Coupland (1954) stated that the importance of preserving areas of native vegetation for study purposes in as nearly as possible their natural state was recognized in 1917 when the Ecological Society of America set up a committee for the preservation of natural conditions. In 1931 the committee for the study of plant and animal communities was established, and in 1935 the Society appointed a committee for Saskatchewan. In 1941 the Saskatchewan group had five reserves set aside for the study of grassland, and is endeavouring to locate other representative areas. The greatest effort is being expended on setting up grassland preserves, as these areas are rapidly being cultivated and reserves, parks, and nature sanctuaries have not been created for them as they have for forested land.

It is not easy to manage an area and preserve it in an undisturbed, primitive, condition. Fires, grazing, and disturbance by dominant animals are a part of the environment. Removal of any of these factors upsets the natural balance. Grazing by domesticated stock may approach that of buffalo and other wildlife but differs because of food preferences and habits of the individual species. For instance, cattle do not make dust wallows or paw through snow to reach the grass, as did buffalo. Coupland (1954) stated:

> The management of grassland reserves requires careful consideration. Each reserve must be managed according to its own characteristics...
>
> . . . The role of fire, artificial clipping and other factors must also be considered in managing grassland reserves. . . The Saskatchewan committee has decided that the essential thing for the main reserves is to avoid overgrazing—either cumulative or during severe drought periods—which would appreciably alter the virgin character of the grassland. Fencing of the area is necessary in connection with this aim. The prime essential is considered to be that the arrangements should be made in such a way as to ensure that grassland reserves will not be upset or materially altered at any time in the future, and that no change in policy can be made except after due consideration. Once such reserves are destroyed or damaged they can probably never be restored and may not be replaced elsewhere.

Weaver and Fitzpatrick (1943) have experimental proof of the effect of fire on prairie:

> Experiments over a period of only 3-5 years have shown that the accumulation of debris greatly retards growth in spring. The soil warms more slowly since it does not receive the usual insolation. Not only is there an actual diminution of the basal cover, but also certain of the smaller and earlier species are greatly handicapped in growth and tend to disappear. Thus, occasional fires every two or three years renovate unmowed prairies and are distinctly beneficial if they occur in spring before growth is renewed.

Weaver's experiments, however, were conducted during favorable growing seasons in an area of heavier growth than that of the aspen parkland.

In forested areas it is now becoming recognized that fire is a factor that has always been present and that complete fire protection in managed areas does not necessarily produce the desired results. Sometimes controlled burning is necessary to promote regeneration of desired species and remove competitors. Spurr (1954) showed that complete protection from fire in Itasca Park, Minnesota, will result in the destruction of Norway pine, *Pinus resinosa* Ait., which the park was set up to preserve. He has shown that "they owe their establishment to the clearing of ground by these fires, and their continued existence to their ability to withstand the fires after they have reached sapling size." If fires are excluded they will be replaced by boreal or hardwood forest. Halliday (1935) traced the history of fires in the Riding Mountain of Manitoba and showed that repeated burning has suppressed white spruce in favor of aspen. In areas of jack pine, *Pinus banksiana* Lamb., fire promotes regeneration by stimulating the germination of dormant seeds.

Prairie

Very little, if any, prairie in the parkland of Manitoba and eastern Saskatchewan now remains in its virgin condition. It has been modified in varying degrees by human interference. The greatest factor has been overgrazing and trampling by domestic stock. Fires have been less frequent than formerly. Through fencing, a few areas have been excluded from domestic stock and lack the modifying effect of grazing as originally occurred.

Railroad rights-of-way and some ungraded road allowances have been considered representative. The former, however, have been modified by an appreciable deposit of soot and cinders, annual fires, and absence of grazing. The accumulation of soot on the snow along railroads absorbs the heat of the sun and causes the snow to melt earlier than on adjacent prairie, particularly on south-facing slopes. These early bare areas in the spring attract deer and grouse. At this time of the year numbers of both are killed by trains. The switch to diesel-oil engines from coal-burning locomotives, commenced in 1954, will remove the modifying effect of soot. Road allowances of native vegetation are so narrow that they are subject to deposition of wind-blown soil from adjacent fields and the invasion of weeds and other ruderals from both field and road. In pastures, horses spread many weed seeds by their droppings, whereas cattle, sheep, buffalo, and deer, which chew their cuds, destroy most of the seeds they consume.

Coupland (1950) stated: "Overgrazing results in favoring the less palatable and the low-growing species at the expense of palatable and tall-growing ones." The most conspicuous change brought about by overgrazing is a marked increase in the abundance of the pasture sage, *Artemisia frigida*. In some severely

overgrazed pastures on sandy land an almost pure stand of this species develops. On heavier soils the snowberry, *Symphoricarpos occidentalis* (Fig. 44), increases to the exclusion of grass from large patches. It also grows in profusion along headlands and fence rows where there is an accumulation of drift soil.

In sandy areas the blue grama grass, *Bouteloua gracilis*, and the sun-loving sedge, *Carex pensylvanica* Lam. var. *digyna* Boeckl., increase with overgrazing. Overgrazing aggravates drought conditions by removal of vegetative cover and exposure to excessive evaporation and runoff. This in turn favors certain plants. Weaver and Hansen (1941) recorded a great increase of western wheat grass, *Agropyron smithii*, under drought conditions in eastern Nebraska and stated that this early growing species further depletes moisture for later species and thus crowds them out. This grass is common in southwestern Manitoba and provides a favored food plant and egg-laying site for the clear-winged grasshopper, *Camnula pellucida*. Overgrazing and drought appear to favor an increase of *A. smithii* in this area, and hence promote an increase of *C. pellucida*. Many other species of grasshoppers are also favored by shortgrass conditions produced by overgrazing.

The blue grasses, *Poa pratensis*, *P. compressa*, *P. interior*, and *P. arida*, increase with drier conditions through drainage and grazing. They have spread in many pastures and in some cases form pure stands. This is particularly noticeable in the Red River Valley, where many pastures and roadsides now support pure *Poa* stands. Jackson (1924) forecast that *Poa* spp. will be the dominant vegetation in the Red River Valley area. *Poa* spp. are attractive to *Camnula pellucida*.

The introduced brome grass, *Bromus inermis*, has been planted in many cultivated pastures and on roadsides and headlands. It grows $2\frac{1}{2}$ to 3 feet in height and establishes pure stands, which spread and crowd out other species, particularly when the sod has been broken by wheeled vehicles, trampling, or other disturbance. After several years, however, it becomes root-bound through the lack of nitrogen and the stand is reduced in vigor. Under such conditions with grazing it may be replaced by *Poa* spp. Farmers increase the vigor of brome by planting it with alfalfa, which fixes nitrogen. Where forest cover is reduced by disturbance, brome grass often invades and eventually takes over. Brome on roadsides is regularly mown for hay. New growth after mowing is attractive to *Camnula pellucida* and is often used for egg beds, but *Poa* spp. are preferred. The rank, unmown growth is generally unattractive to grasshoppers except *Melanoplus bivittatus*, which feeds extensively on the foliage and causes a conspicuous blackened appearance to the stand.

In pastures of brome and *Poa* spp., tall green spots are noted where animal droppings have increased the nitrogen. The grasses in these patches, although appearing lush and attractive, for some reason are unpalatable and are avoided by livestock.

Some goldenrods, *Solidago rigida* L., *S. lepida* DC., and *S. canadensis* L.; coneflower, *Ratibida columnifera*; aster, *Aster ericoides*; gumweed, *Grindelia squarrosa*; and golden aster, *Chrysopsis villosa*, increase with disturbance and overgrazing in pastures. They are not palatable and are conspicuous when in flower.

Along headlands and fence rows, particularly where drift soil accumulates, *Solidago canadensis*, *Symphoricarpos occidentalis*, *Aster ericoides*, *A. laevis*, and

Monarda fistulosa grow along with *Bromus inermis, Calamovilfa longifolia,* and other grasses.

Where prairie is grazed to the extent that bare patches of ground appear, there is an invasion of annual weeds, such as ragweed, *Ambrosia artemisiifolia* L.; false ragweed, *Iva xanthifolia* Nutt.; peppergrass, *Lepidium* spp.; bluebur, *Lappula echinata* Gilib., and shepherd's-purse, *Capsella bursa-pastoris* (L.) Medic.

In low spots that are grazed, particularly alkaline ones, foxtail, *Hordeum jubatum,* becomes dominant and may develop a pure stand. It is palatable when young but the long-awned seeds are very irritating to grazing animals as they pierce the nose and mouth and cause festering sores on the gums and tongue.

Roadside prairie near Lyleton, Manitoba, where the original dominants were *Stipa viridula, S. comata,* and *Agropyron smithii,* was severely disturbed by drift soil and wind erosion in the 'thirties. Allen (1939) reported:

> In 1936 fully half of the road allowance area, severely damaged by erosion, fostered societies of false ragweed, Russian thistle, bind weed *Bilderdykia convolvulus* [=*Polygonum convolvulus* L.], lamb's quarters [*Chenopodium album* L.] and worm wood, *Artemisia biennis,* either in pure or mixed stands. Sweet clover seed blown from the fields also became established in many of the ditches. . . *Agropyron smithii* was the first grass to come back and in places it completely smothered the weeds. In other locations *Stipa viridula* came to its assistance. In sandy locations, *Calamovilfa longifolia* either assisted it or first became established. At a few points *Agropyron repens* competed with it for dominance. *Bromus inermis* (likely escaped from cultivation) and *Poa compressa* have joined with it in places to form a sod.

The Weed Problem on Cultivated Land

Cultivation is designed to kill all plant life and replace it with a pure stand of desirable species that will serve as food for man or domestic animals. This objective is never completely reached because a number of plants, including many introduced species, thrive under cultivation and invade the fields. These weeds have become a major problem of the agriculturist.

Groh (1949), in summarizing 25 years of weed survey work in Canada, lists about 1200 weed species, nearly one-quarter of all the flowering plants. His interpretation of a weed is very broad and includes:

> Not only undoubtedly noxious and nuisance plants but also any native plant persisting more or less regularly under the changed conditions of settlement, any alien plant establishing itself or spreading from cultivation to maintain itself unaided, and any poisonous or otherwise injurious plant.

Further, Groh did not survey fields and intentionally avoided them. He stated:

> Few weeds of farm land are absent from waysides, towns, railway and other yards, and many that go to make up the total weed nuisance scarcely appear in crops.

Groh lists the source of origin of all weeds recorded. His definition of a weed and method of survey would weight the list heavily with native species. In spite of this, the percentage of introduced species runs high. Of some 230 species listed for the area concerned in this publication, 79 are listed as of European origin and 26 of Eurasian origin.

The time when weeds first became a problem in the parkland is not known. Some were introduced with unclean seed by fur traders who cultivated gardens, and by early settlers. It is known that weeds plagued the Red River settlers and as early as 1883 the Manitoba Noxious Weeds Act was passed. At that time weeds were recognized to cause a serious loss to farmers and steps were taken to control them. Lamb's-quarters, *Chenopodium album* L.; peppergrass,

Lepidium sp.; wild buckwheat, *Polygonum convolvulus* L.; sunflowers, *Helianthus* spp.; thistles; and stinkweed, *Thlaspi arvense* L., were mentioned as being abundant. Canada thistle, *Cirsium arvense* (L.) Scop., was found growing about the sites of old Hudson's Bay Company forts near Brandon, Manitoba, by settlers in 1880. It has become a favorite food of the painted-lady butterfly, *Vanessa cardui* (L.), which in years of abundance severely defoliates it. Green foxtail, *Setaria viridis* (L.) Beauv., and wild oats, *Avena fatua* L., were brought in by early settlers. The 1895 report of the Manitoba Weeds Commission lists the following additional weeds as most injurious: tumbling mustard, *Sisymbrium altissimum* L.; wild mustard, *Sinapis arvensis* L. [*Brassica kaber* (DC.) L.C. Wheeler var. *pinnatifida* (Stokes) L.C. Wheeler]; hare's-ear mustard, *Conringia orientalis* (L.) Dumort.; ball mustard, *Neslia paniculata* (L.) Desv.; false flax, *Camelina sativa* (L.) Crantz; and cow cockle, *Saponaria vaccaria* L. Russian thistle, *Salsola pestifer* A. Nels., was mentioned as being found along the railroad near Wawanesa. The first perennial sow thistle, *Sonchus arvensis* L., a weed of European origin, was reported from Cartwright, Manitoba, in 1895, but it was not recognized as a serious pest until between 1900 and 1906, when patches were found all over the Red River Valley. It spread rapidly by its wind-blown seeds and by 1910 was considered the worst noxious weed. It thrives best on heavy soils with abundant moisture conditions. It also seeds rapidly into newly broken and disturbed forest land in northern areas. In the dry years of the 1930's it was given a severe setback by a combination of drought and grasshoppers. The two-striped grasshopper, *Melanoplus bivittatus*, is attracted by its milky juice and eats its leaves and stems so continuously that the plant dies of starvation. During the years of increased rainfall in 1945–54 sow thistle again became a serious weed.

Leafy spurge, *Euphorbia esula* L., was probably brought into Manitoba by the Mennonite settlers with a German wheat known as spelt. It was first noticed on a farm near Rounthwaite, Manitoba, in 1900. The farmer planted rye on the field and sold the infested seed to other farmers in the district. He also pulled a cultivator through the patch and spread roots over his farm. Norman Criddle reported the occurrence and indicated the danger of it becoming a noxious weed. It was not until 1923, however, when the weed became widespread in the Miami-Morden area, that steps were taken to eradicate it. It is found on clay soils but is well adapted to sandy soil where the necessary cultivation required to control it cannot be practiced on account of the danger of soil erosion. It is now widely established and thousands of dollars are being spent annually to keep it in check. It has also spread to uncultivated areas of sandy land through the agency of birds. This is particularly well demonstrated in the Spruce Woods Forest Reserve, where many hundreds of patches now occur. On a special survey of the Shilo area alone, by the Manitoba Weeds Commission in 1950, 1435 patches were counted. Stuart Criddle has observed mourning doves feeding in patches of leafy spurge and patches of the weed starting under trees where the birds stop to rest. From one seedling a patch develops by means of roots and chokes out other vegetation. Sheep are the only domestic animals that eat the foliage. They can be used to eradicate leafy spurge by close grazing.

Russian thistle, although mentioned in 1895, did not cause concern until the dry years about 1920, when it was becoming established in the Red River Valley. It is a weed of the lighter soils and of the drier years. In the great drought of the 1930's it constituted the major plant cover of many abandoned

81314–7—5

fields. Growing in a dense mat, it did much to prevent wind erosion. At such times, although rather laxative, it was eaten by livestock while young and tender, and some farmers even put it up as emergency hay. Smith *et al.* (1952), who carried out nutritional studies with the grasshopper *Melanoplus bilituratus*, found it of poor food value.

> A particularly interesting point is the apparent susceptibility to heat, of grasshoppers fed on Russian thistle as indicated by the severe mortality, on this food only, in 1945 at temperatures about 110° F.
>
> The fact that Russian thistle is also an unfavourable food, particularly with respect to egg production, is of significance on the western prairies, where in some areas and in some years this plant may form the major food supply.

On the return to years of higher rainfall, Russian thistle ceased to be a troublesome weed in Manitoba but persisted in the drier parts of Saskatchewan.

Sweet clover has been introduced and cultivated for forage and honey production, for which it is excellent. Its seeds have a hard coat and require scarification before planting to ensure rapid germinating. Because of this they may lie dormant in the soil for several years. Being small, the seeds are easily wind-blown. For these reasons the plant has become a weed. White sweet clover, *Melilotus alba* Desr., is the commonest species, but the yellow sweet clover, *M. officinalis* (L.) Lam., is also found in abundance. In fields where sweet clover has been allowed to go to seed, seedlings appear for several years after. When cut and threshed with wheat it imparts a flavor to the wheat known as melilot taint, which is objectionable to the milling industry. Sweet clover grows abundantly along roadsides, where it flourishes on high-lime soil that is exposed after the humus is removed by graders. It escapes from cultivation and spreads over adjacent prairie, disturbed land, and abandoned fields. It is attacked by the sweet-clover weevil, a species introduced from Europe.

Couch grass, *Agropyron repens* (L.) Beauv., which is thought to be of Eurasian origin, has taken over much disturbed sod land and has invaded fields, where it is difficult to eradicate. Abandoned fields are often invaded by this grass. It makes reasonably good pasture and prevents soil erosion by means of its creeping root stocks. Along with wild oats and wild millet it is not affected by the selective weed killer 2,4-D. The removal of the competitive broad-leaved weeds with chemical may have resulted in an increase in these three major weeds in crop land.

Field bindweed, *Convolvulus arvensis* L., a perennial of European origin, began to appear in patches in the Emerson and Morden areas in 1936. By 1942 it was considered one of the most common perennials.

Weeds of recent introduction are Russian knapweed, *Centaurea repens* L.; Loesel's mustard, *Sisymbrium loeselii* L.; hoary cress, *Cardaria draba* (L.) Desv.; bladder campion, *Silene cucubulus* Wibel. Since 1950, Tartary buckwheat, *Fagopyrum tataricum* (L.) Gaertn., and a biennial bladder campion, *Silene cserei* Baumg., have been found in a few localities along railroads.

The weed problem has changed with the change in farming methods. In the days of horses, these animals spread weed seeds through their droppings. Seeds were also spread with the fodder that was carried to feed the horses, and in their bedding straw. Furthermore, horses could not work fast enough to carry out timely operations for weed control. To offset these factors, harvesting methods of those days limited the spread of weeds since, grain was cut with a binder, stooked, and stacked or hauled to a central point for threshing.

With the change to mechanized farming the factors favoring the spread of weeds when horses were used were removed but others were introduced in their place. Ample power and better tillage implements permitted a more timely and better job of cultural control. The introduction of 2,4-D in 1946 revolutionized control of broad-leaved weeds. In 1949, 2,300,000 acres in Manitoba were treated with 2,4-D, mostly for the control of mustard. The extensive use of chemicals resulted in a tendency to depend too much on them and neglect complementary cultural practices. As 2,4-D is selective and kills only broad-leaved plants, the removal of these weeds as competitors resulted in an increase of wild oats, wild millet, and couch grass. Wild oats became the major weed problem, in fact, a greater problem than all other weeds together (Brown, D.A. Assistant Superintendent, Canada Experimental Farm, Brandon, Man. In litt. 1956). The ability of wild oat seeds to lie dormant for years makes it very difficult to control this weed. Delayed seeding and cultivation in the spring, in order to encourage germination and destroy as many wild oats as possible, is the approved method of control. This, however, increases the hazards of the crop and reduces yields. The switch to swathers and pick-up combine threshers has done much to spread weed seeds over the farms. Shallow cultivation with the oneway disk and the duckfoot cultivator, with the use of trash cover to check wind and water erosion, has increased the weed problem as compared with the older method of plowing. These methods scatter the seeds more widely and, particularly when used in the spring and in combination with a seeder attachment, put the weed seeds in the best condition for germination at the time the crop is coming up (Brown, D.A.). The use of trucks to haul loose grain to country elevators has done much to spread weed seeds. Often screenings are brought back to the farm for chicken and hog feed. The truck bodies are seldom covered with a tarpaulin, and the speed at which they travel blows much grain and weed seeds onto the road, where they are further dispersed by graders. Railroad cars have always been a means of spreading weed seeds, and new weeds are often found along railroads.

New weeds are continually being introduced and some native plants are becoming weeds. The native horsetails, *Equisetum* spp., are becoming a serious problem in heavy moist soils and the introduced hemp nettle, *Galeopsis tetrahit* L., which has been present for years, is now spreading at an alarming rate in some areas.

Abandoned Land

Under changing economic conditions, a considerable acreage of land that has been under cultivation may be abandoned. During war years when there was a great demand for food and when prices were high, farmers were encouraged to break up submarginal land that could not be profitably farmed under more stringent economic conditions. This was farmed for a few years and then abandoned. There is a "fly by night" type of farmer who with the aid of power machinery breaks up large acreages of sandy or gravelly prairie land and plants it to flax or rye for one or two years. He makes big profits and gets good yields while the grass fiber is still in the sod. The land is abandoned when the sod breaks down and low yields can be expected. During years of drought and economic depression considerable acreage of good farming land may also be abandoned.

81314-7—5½

These abandoned fields support a succession of annual and biennial plants before being invaded by perennial herbs and grasses, and, if left undisturbed, revert to the original prairie vegetation. Successional stages, except for some differences in species and usually a prairie rather than a forest climax, are similar to those described for Michigan by Beckwith (1954). Fields on the sand plain near Shilo, Manitoba, abandoned during the drought of 1900-03 were practically indistinguishable from the surrounding native prairie thirty years later.

Handford (1936) made the following observations on reversion on badly wind-blown and abandoned fields in the Lyleton, Manitoba, area:

> Reverted fields have been found with patches blown out by wind and entirely without vegetation. Where vegetation occurs it varies considerably and the species present do not always give the true indication of the years that have elapsed since the field was cropped. However, the impressions gained from the observations were that *Artemisia dracunculoides, Chenopodium album, Setaria viridis, Erigeron* spp. and the various pigweeds predominate, indicating a fairly recent reversion. In the next stage of reversion it appears that patches of *Solidago, Agropyron repens* or *Bromus inermis* (or both) creep in and continue to increase in size. Later, *Artemisia frigida* and *Artemisia ludoviciana* come in and the earlier plants, of the first stage of reversion, largely disappear and the grassy areas become larger. Then *Bouteloua gracilis, Agropyron smithii, Poa pratensis* begin to appear in patches, the *B. gracilis* appearing eventually to predominate.

The early stages of succession featuring rank growth of annual and biennial weeds, particularly sweet clover, false ragweed, sunflowers, and pigweed, form important food and shelter for wildlife. This was well illustrated in the Lyleton area during the drought period of the 1930's. At this time many abandoned fields formed ideal habitat for pheasants, which invaded the area from North Dakota and maintained a high population for several years. At the end of the drought period farmers again cultivated the land and the pheasant population was greatly reduced. Other animals maintaining a high population at this time were jack rabbits, foxes, Hungarian partridge, and sharp-tailed grouse. Grasshoppers occurred in outbreak numbers and were an important food supply for the pheasants, grouse, and foxes. White-tailed deer found that the tall growth of sweet clover provided excellent food and cover, invaded areas where this plant was abundant, bedded down in it, and stayed there for long periods.

Forest

Aspen groves and forests normally decrease in height at the margins. Here young trees only a foot or so in height are found because of the habit of spreading by underground shoots. This gives protection from wind, which is directed up and over the mature trees in the center. The progressive shading kills competitive plants and a normal understory of shrubs and herbs develops. When the forest margin is destroyed by land-clearing or road-building operations, the bare trunks of the mature trees are exposed to the elements and the lack of marginal shading permits the invasion of brome, *Poa* spp., and other grasses, often resulting in the death of the trees. The exposed trees are also more subject to wind damage and attack by fungus and insect pests, causing further die-back. Grazing by livestock on the invading grasses, trampling, and browsing on young aspen shoots prevent regeneration and extensive areas of forest may be killed out (Fig. 46).

Fire and the cutting of blocks of mature trees usually result in extensive suckering and a dense growth of young aspen. If this coincides with a peak of snowshoe rabbit abundance, a high percentage of aspen are girdled and killed. Usually only beneficial thinning results. If elk are abundant they may destroy

all sucker growth during their winter browsing. If this is repeated two years in succession, the trees are killed and grassland results. This has happened, on occasion, in the Riding Mountain. After fire there is usually a profuse growth of fireweed, *Epilobium angustifolium* L., and raspberry, *Rubus*, which in a few years is choked out by the regenerating forest. Choke cherry, pin cherry, and saskatoon also take advantage of disturbance to gain a foothold on disturbed areas. If the forest regenerates successfully, they are in turn choked out except at the forest edge.

Changes in Animal Abundance Since Settlement

Changes that have affected the abundance of animals to the detriment of some species and the benefit of others have been taking place since the beginning of life and will continue to take place as long as life exists. This is aptly summed up in a statement made in a report of a working party set up by the British Ministry of Agriculture to study the effect of toxic chemicals in agriculture on wildlife (Zuckerman, 1955):

> In approaching the problem, we were fully conscious of the fact that there is no such thing as a fixed balance of nature, and equally that every advance that has occurred in the evolution of plants and animals has meant a change in this so-called balance. Man's part in transforming the face of the earth is only the most recent contribution to a process which is as ancient as life itself. It is, however, probably a more rapidly acting and more far-reaching factor than any of those which have preceded it. As our species has multiplied, and as we have spread over the globe, forests have been laid low, and many animal species have disappeared, or their number been so considerably reduced that they now constitute little more than fragments of a previous picture of animal life. This process of change has intensified progressively over the past four centuries, and the essential question that we have had to ask ourselves is whether the chemicals now being used in farming constitute a more serious hazard to the fauna and flora of our land than did earlier innovations in farming and forestry practice.

By the establishment of an agricultural economy in the aspen parkland, white men brought about great changes in the abundance and habits of the fauna. Indians were much reduced by white men's diseases and forced to give up a nomadic hunting economy for agriculture and a sedentary existence. The dominant herbivore, bison, has been exterminated in the wild state, along with its chief predator, the buffalo wolf. Antelope, which ranged into the parkland, have retreated to the high plains. The passenger pigeon was extermined, and the trumpeter swan and whooping crane were reduced to very low numbers and driven from their former nesting grounds in the parkland. Elk, which occurred in great abundance, are represented by a few remaining herds that have retreated to the more heavily wooded and hilly country. Moose, which ranged all through the parkland, where there was an abundance of willow and forest growth associated with swamps, have retreated to national parks and inaccessible areas in the northern fringe of the parkland. Mule deer disappeared with settlement, except for a few in remote hilly sections, and were replaced by the white-tailed deer, which has flourished. The white-tail is well adapted to life near to settlement and has increased its range and numbers to the point where overpopulations occur in spite of heavy hunting.

The fur bearers were greatly reduced by intensive trapping and destruction of habitat. Grizzly bear and puma were exterminated in the parkland as were wolverine, marten, fisher, and otter. Beaver became scarce but are again common. Raccoons are holding their own and increasing in some localities. Mink are still common in spite of heavy trapping. Weasels are only a small fraction of

their former numbers. The long-haired fur animals, coyotes, foxes, badgers, and skunk, after being reduced by heavy trapping are now increasing as their fur has gone out of fashion. Muskrats are prolific, are under management, and produce great quantities of a currently popular fur.

Ground squirrels, particularly Richardson's, became an agricultural pest but have been much reduced by control campaigns and destruction of burrows by tillage. Mice fluctuate greatly in numbers as they have done from the days of the fur traders up to recent times. Native insects, especially the wheat stem sawfly, wireworms, and cutworms, have become pests of cultivated crops.

Snowshoe rabbits still occur in abundance in woodland areas and fluctuate in numbers regardless of man. Jack rabbits have been benefited by agriculture and have extended their range into the parkland with settlement. The prairie chicken at first increased but is now almost extinct. The robin has become semi-domestic. Insect pests, rats, mice, house sparrows, starlings, pheasants, and Hungarian partridges were introduced.

Before the coming of white men the Indians with their fires kept conditions in relative equilibrium and changes occurred mainly through natural phenomena. After the white men came, changes brought about by human agency were paramount but natural factors are still operating.

There are few continuous records of the changes in animal abundance in the parkland since settlement and much information reported here is gathered from scattered accounts and observations. The Criddle family of outstanding naturalists at Aweme (near Treesbank), Man., have resided on their farm and kept records continuously since 1883. They have reported many events orally and in publication.

Baines (1956) reported on changes at Crescent Lake, 16 miles south of Yorkton, Sask., since 1883. He noted that the lake went completely dry in 1897 and 1938 and that it was full to overflowing in 1919 and again in 1956, because of wet and dry cycles. In 1883 the prairie was covered with the bones of the recently abundant buffalo and the antlers of elk. Mule deer were fairly common in 1883, became scarce about 1911, and disappeared about 1928. The white-tailed deer appeared about 1910 and became abundant by 1920. Sharp-tailed grouse were common but have become scarce with more intensive agriculture. The prairie chicken appeared about 1900 and became as plentiful as the sharp-tailed from 1910 to 1920, when it commenced to thin out and finally disappeared. The Canada goose still nests about Crescent Lake as it has done for the past 70 years, but in reduced numbers. Migrating flocks are now bypassing the area. Crows were scarce in 1883 but gradually increased until about 1915, when they began to be less abundant. Magpies were not present until 1920. They were scarce until a few years ago but are now common.

Animals of the aspen parkland that showed marked changes in abundance in the historic period are discussed under the following groups: (1) animals that decreased because of man-made changes; (2) animals that increased because of man-made changes; (3) introduced animals that have become established; and (4) changes in animal abundance taking place without the agency of man.

Animals That Decreased because of Man-made Changes

The number of animals that decreased as a result of human interference is much larger than the number that increased as a result of the improvement

of conditions necessary for their survival. As the parkland was cleared and plowed for agricultural purposes, much cover and nesting habitat were destroyed. An example is given by Farley (1932). He counted the nesting birds in a half-section of typical parkland near Camrose, Alta., in June and found 256 birds of 41 species. Two years later this land was cleared and put under cultivation except for a few acres of coulee. He then found only a few pairs of vesper sparrows nesting in the area.

No discussion of the changes that have taken place in the aspen parkland would be complete without mention of the original human inhabitants. The Indians suffered by the invasion of a dominant race as much as many other species of animal.

According to Jenness (1934), about 15,000 to 20,000 Indians lived in the parkland in 1725. The large central portion was occupied by the Assiniboines. The Blackfeet were found in Alberta, and the Plains Crees in eastern and northern Manitoba. All were nomadic hunting tribes dependent on buffalo. Travel by means of travois drawn by dogs was slow. Along the borders of tribal territory there were occasional raids and fights but generally they lived a peaceful life.

The introduction of horses and firearms about the middle of the 18th century made the Indians much more mobile and lethal. Both buffalo hunting and warfare were stimulated. The Crees allied with the Assiniboines and attacked the Blackfeet to the west and the Sioux and Mandans to the south. They extended their area to the Rocky Mountains and the Peace River district of Alberta.

White men brought with them several diseases to which the Indians had little resistance. The most deadly was smallpox, which swept through the parkland in a series of outbreaks in the early part of the 19th century. A particularly severe outbreak in 1836 killed about half the population. Tuberculosis and other pulmonary diseases also took a heavy toll.

The Indians had no alcoholic beverage of their own and abandoned every restraint in their frenzy for white men's firewater. Alexander Henry (Coues, 1897) stated:

> Whiskey and brandy destroyed the self respect of the Indians, weakened every family and tribal tie, and made them, willing or unwilling, the slaves of the trading posts where liquor was dispensed to them by the keg. . . Disease and alcohol demoralized and destroyed the Indians just when they needed all their energy to cope with the new conditions that suddenly came into existence around them.

Once a tribe had adopted metal tools and firearms they were unable to hunt by their old methods and became entirely dependent on the traders, who, in turn, demanded more and more furs. For a few years the Indians were rich but they soon depleted their own hunting grounds and invaded territories of their neighbors. Firearms and horses converted the buffalo hunt into a slaughter. Tribes jostled each other in the buffalo chase, with ceaseless raids for horses, arms, and scalps. By the early 1800's fur-bearing animals were nearly exterminated over extensive areas. When the buffalo disappeared about 1870, the Indians became poor and could with difficulty procure the necessities of life.

One by one the bands and tribes signed treaties ceding their land and submitting to confinement on reserves. They are slow to adapt to agriculture and other occupations of the white man. As wards of the government they receive

technical assistance, schools, old age pensions, children's allowances, and medical care, and are beginning to increase but are still demoralized and lack initiative and thriftiness.

The bison, *Bison bison*, commonly called buffalo by residents of the area in which it occurred, was undoubtedly the dominant animal of the plains before the advent of white men. It wandered well up into the parkland and forested areas as far as Great Slave Lake, where the last wild herd exists in Wood Buffalo Park.

Alexander Henry (Coues, 1897) established a fort for the North West Fur Company on the Red River about 35 miles south of the Canada–United States boundary just above the entrance of Park River near the present town of Grafton, N.D., in 1801. He frequently referred to the abundance of buffalo and their effect on the vegetation in the vicinity of the fort and northward to the site of the city of Winnipeg.

> Langlois and myself proceeded along Rivière aux Marais [near Letellier]. Leaving the woods of that river, we crossed the plains to L'Isle du Passage through one continuous herd of buffalo, but had no time to chase them, At one o'clock we stopped at this island to rest our horses, and then proceeded to the foot of the Panbian river traverse, where we allowed our horses another half hour's rest and feed. Here I climbed a high tree, and, as far as the eye could reach, the plains were covered with buffalo in every direction...
>
> I saw more buffaloes than ever. They formed one body, commencing about half a mile from camp, whence the plain was covered on the W. side of the river [Red River] as far as the eye could reach. They were moving southward slowly, and the meadow seemed as if in motion...
>
> This afternoon I rode a few miles up Park river. The few spots of wood along it have been ravaged by buffaloes; none but the large trees are standing, the bark of which is rubbed perfectly smooth, and heaps of wool and hair lie at the foot of the trees. The small wood and brush are entirely destroyed, and even the grass is not permitted to grow in the points of wood. The bare ground is more trampled by these cattle than the gate of a farmyard...
>
> The country from Red River to this mountain [Pembina Hills near Canada—United States boundary] is one level plain, without a hill or stone. The grass would be rather long were it not for the buffalo.

Great numbers of buffalo were drowned when they attempted to cross the rivers on weak ice in the spring. Henry records drowned buffalo drifting down the Red River past his Park River post for the whole month of April, 1801.

> Apr. 1st. The river clear of ice, but drowned buffalo continue to drift by entire herds...
>
> . . . It is really astonishing what vast numbers have perished: they formed one continuous line in the current for two days and nights...Apr. 18th. Drowned buffalo still drifting down the river...Apr. 25th. Drowned buffalo drift down river day and night... May 1st. The stench from the vast numbers of drowned buffalo along the river was intolerable.

As further evidence, editor Coues appended the footnote:

> This account is not exaggerated. John McDonnell's Journal of May 18th, 1795, when he was descending Qu'Appelle R., stated: 'Observing a good many carcasses of buffaloes in the river and along its banks, I was taken up the whole day with counting them, and, to my surprise, found I had numbered when we put up at night, 7,360, drowned and mired along the river and in it. It is true, in one or two places, I went on shore and walked from one carcass to the other, where they lay from three to five files deep'. It is probable that the total number of buffalo killed by man in those days was insignificant in comparison with the destruction wrought by the warring of nature's elements against the poor brutes.

The above accounts are verified by the numbers of buffalo bones that may still be found as they erode out of the river banks.

The advent of firearms, which were traded to the Indians, marked the beginning of the end for the buffalo. Indians and whites alike had no idea of conservation and buffalo were slaughtered wholesale, often only for their tongues. Henry (Coues, 1897) frequently mentioned this and remarked:

> The stench about camp was great from the quantities of flesh and fat thrown away since our arrival...
>
> Although I killed enough provisions yesterday to last a month, today we are without a mouthful, so very improvident are people in this country.

Near Winnipeg, buffalo were last seen wild in 1819; the last great wild herd on the Souris was seen in 1867 and the last individual on the Souris in 1883 (Seton, 1909).

By 1900, buffalo were extinct in the wild state except in what is now Yellowstone Park and in the area south of Great Slave Lake. The latter was set aside as Wood Buffalo Park, for their protection. The buffalo of this northern area belonged to a larger, darker subspecies, the wood buffalo, *Bison bison athabascae* Rhoads. The plains buffalo was saved from extinction through the purchase by the Government of Canada in 1907 and 1909 of 709 animals from Don Michel Pablo of Montana. They were placed in a fenced area at Wainwright, Alta., where they increased sufficiently to supply nucleus herds for parks and zoological gardens and, in addition, surplus animals were butchered. In 1925–1928, 6,673 plains bison from the surplus herd at Wainwright, Alta., were shipped into the northern area and liberated. They hybridized extensively with the wood buffalo and the subspeciation is lost. In 1945 the herd numbered about 20,000 animals (Rand, 1948). Fuller (1950) made a resurvey by air in 1949 and reported that the population had been overestimated by ground parties. He estimated the population at between 10,000 and 12,500 and stated that the buffalo had been extending their range both inside and outside the park.

During World War II it was decided that the Wainwright reserve had served its purpose; some animals were moved to other areas but the great majority were butchered and the land was used for military training purposes.

Now all that remains in the parkland is mute evidence of the great herds of the past. Bones are frequently turned up by the plow or exposed in blown-out fields, particularly where there were Indian encampments. Skeletal remains are also exposed along river banks and lake shores. In a few patches of unbroken land, remains of their paths and wallows may still be seen. Another conspicuous sign, which is not generally understood, may often be noted. The prairies are dotted by large, erratic boulders surrounded by depressions (Fig. 47). These were the rubbing stones used by the buffalo to remove their winter hair. They still carry a considerable polish. The depressions were caused by trampling, and by blowing away of powdered soil.

The cowbird, *Molothrus ater*, formerly known as the "buffalo bird", followed the herds of buffalo, feeding on insects disturbed by their trampling. The extermination of the buffalo and their replacement by domestic cattle did not greatly affect its abundance. It now follows cattle in the same way as it did the buffalo and may be seen on the ground about their feet or sitting on their backs. Being entirely parasitic, never making a nest of its own, it is free to roam with the herds. It lays its eggs in the nests of birds of similar size or smaller. Changes in the abundance of their host probably affect the abundance of cowbirds more than the change from buffalo to cattle.

The pronghorn antelope, *Antilocapra americana,* is often mentioned in the literature as being associated with buffalo. Its main center of distribution is in the short-grass plains but it did range into the mixed grasslands of what is now parkland. Perhaps its presence here was due to the reduction of aspen by frequent fires and it did not enter the aspen groves. However, it is known at times to inhabit wooded areas, as reported by Sowls (Sowls, L. K. United States Fish and Wildlife Service, Tucson, Arizona, In litt. 1956) for Arizona.

Henry (Coues, 1897) did not often mention antelope but he did record a large "cabbri" shot near Pembina in 1801 and herds of "cabbrie" always in sight near the Brandon Hills. Hind mentioned some herds of "cabri" at Antler Creek and north to Two Creeks. Seton (1909) stated: "Formerly found in all the prairies of the South West. Recorded once or twice in early days very near Winnipeg and last seen on the Souris about 1881. Now extinct in the Province." The scarcity of early records may be partly due to the fact that, being at the northern extremity of their range, the antelope fluctuated greatly in abundance. They are delicate animals and cannot survive a severe winter. The present herds in southwestern Saskatchewan and southeastern Alberta have suffered considerable mortality in several winters in recent years (Rand, 1948).

Two large predators were associated with the buffalo and antelope, the buffalo wolf and the grizzly bear. They both followed the buffalo into extermination in the parkland.

Henry (Coues, 1897) frequently mentioned the abundance of the buffalo wolf, *Canis lupus nubilus.* He also called attention to behavior of wolves that indicated an outbreak of rabies, a disease that has been known to decimate their numbers:

> *Sunday Nov. 2d.* Last night the wolves were very troublesome; they kept up a terrible howling about the fort, and even attempted to enter Maymiutch's tent. A large white one came boldly into the door and was advancing toward a young child, when he was shot dead. Some of them are very audacious. I have known them to follow people for several days, attempt to seize a person or a dog, and to be kept off only by fire-arms. It does not appear that hunger makes them so ferocious, as they have been known to pass carcasses of animals, which they might have eaten to their fill, but they would not touch flesh; their object seeming to be that of biting. The Canadians swear that these are mad wolves, and are much afraid of them.

While excavating an Indian campsite near Brandon, Man., considered to be over 300 years old, I came across numerous wolf bones associated with great quantities of bones of buffalo killed in a pound. They may have been semidomesticated wolves or crosses with dogs. Mr. R. M. Anderson (in litt.) of the National Museum of Canada, who identified the jaws, indicated some were of pure *Canis nubilus* but others were of *Canis familiaris* or of a hybrid with *C. nubilus.*

With the decimation of the buffalo, wolves turned their attention to livestock, with the result that they were poisoned, shot, and trapped to the point of extinction. There may be the occasional individual still alive in part of their former range. On October 16, 1943, a specimen was taken by Mr. David Walters on Sec. 10, Twp. 4, Rge. 1E, near the town of Morris, Man. The skull is in the Manitoba Museum and was determined by Dr. Stanley P. Young of the United States National Museum in 1947 as of *C. l. nubilus.* Another wolf, possibly of this subspecies, was shot near Headingly, Man., on March 13, 1948.

Seton (1909) stated that the grizzly bear, *Ursus horribilis* Ord., has been extinct in Manitoba for perhaps 100 years. Henry (Coues, 1897) referred to their abundance about his Park River, North Dakota, fort in 1806:

> Grizzly bears are not numerous along Red river, but more abundant in the Hair hills [Pembina Hills, Manitoba]. At Lac du Diable [Devil's Lake], which is about 30 leagues W., they are very common—I am told as common as the black bear is here, and very malicious. Near that lake runs a principal branch of Schian [Cheyenne River], which is partially wooded. On the banks of this river I am informed they are also very numerous, and seldom molested by the hunters, it being the frontier of the Sioux, where none can hunt in safety; so there they breed and multiply in security.

While present in such abundance the grizzly was an important predator on buffalo and smaller mammals. It is now extinct over the whole parkland area.

The passenger pigeon, *Ectopistes migratorius* (L.), was a summer resident occuring in great abundance. Henry (Coues, 1897), when camping at the present site of Winnipeg on August 19, 1800, stated: "Pigeons were in great numbers: the trees were every moment covered with them and the continual firing of our people did not appear to diminish their numbers". Hind (1859), in reporting on his trip up the Assiniboine and Souris rivers in 1858, repeatedly referred to their abundance. At St. James Church in the suburbs of what is now Winnipeg he observed pigeon traps. Pigeons fed on acorns, wild berries, and, after settlement, grain in fields. They did extensive damage to the settlers' crops but were an important food item and many were trapped and shot for human consumption.

The pigeons nested in large colonies near plentiful supplies of oak and beech mast in Wisconsin and the northeastern United States (Schorger, 1955). As there was only a limited amount of oak in the eastern parkland and no beech, colonies were small in this area. Two nesting colonies were recorded in Manitoba by Macoun (1909): "Waterhan [Waterhen] River, lat. about 52° N., a colony of less than a dozen nests on June 23, 1881, and a colony in an aspen grove at the Northwest Angle, Lake of the Woods". Mitchell (1935) also recorded them nesting throughout the district north of the Lake of the Woods and Rainy Lake where cranberries and blueberries were abundant. Thompson (1891) recorded a few breeding at Portage la Prairie. The birds passed through Manitoba in large numbers during migration. They were plentiful over the whole of the parkland area in Manitoba and scattered flocks occurred over the northern part of the Province. Spring records date from April 8 to May 20 and fall records from August 30 to September 21 (Schorger, 1955). Seton (1909) reported that the last big flight came to Manitoba in 1878. Great reduction in numbers occurred after 1880 and the bird became extinct in the Province by the turn of the century. Schorger (1955) attributed the extinction of the passenger pigeon to wholesale market hunting in the northeastern United States and the destruction of nesting colonies to obtain squabs. Populations were reduced below the minimum required to maintain the species. Late records for Manitoba are: Riding Mountain, May 12, 1892, and Winnipegosis, April 10, 1898 (Fleming, 1907), and St. Boniface in the fall of 1893 (Atkinson, 1904).

The trumpeter swan, *Olor buccinator* Richardson (Fig. 50), bred across southern Canada and the northern United States from Manitoba westward, according to Roberts (1932) and Taverner (1926). However, it was not abundant as Coues (1874) saw it on only a few occasions. Taverner (1926) discussed a number of factors that caused its extermination in the parkland. It nested in an area that soon became settled. Although it was not as wary as the whistling

swan, *Olor columbianus* (Ord.), it did not tolerate disturbance. It was a favorite mark of hunters, particularly in the early days when its breast feathers had a market value with the Hudson's Bay Company. At this time its larger size and relative easiness of approach contibuted to a heavy kill. In 1959 a brood of 5 cygnets was successfully raised by captive parents at the Wildfowl Research Station, Delta, Man.

Bent (1925), recorded nesting in Manitoba at Shoal Lake in 1893 and 1894. Fred Bard, Saskatchewan Natural History Museum, Regina, reported (Shortt, A. H. Ducks Unlimited (Canada), Winnipeg, Man. In litt. 1956) that he has had annual reports of trumpeter swans nesting on Botley Lake and Adams Lake in the Cypress Hills, Saskatchewan, from 1949 to 1955.

The whooping crane, *Grus americana*, according to the monographic review of the species by Allen (1952), had its main breeding area in Canada in the aspen parkland. He reported that 47 per cent of the authentic nesting sites were in the parkland and 15 per cent in what he called transitional plains to parkland, most of which is now within the present boundaries of the parkland. He included in his aspen parkland habitat for the year 1864 two localities (Fort Resolution and Salt River, Mackenzie Territory) far removed from the aspen parkland as covered here but probably of a similar type of habitat. Allen's aspen parkland (and transitional) records include the following points:—*Alberta*—Killam, 1904–05; Whitford Lake; 1909; *Saskatchewan*—Moose Mountain area, 1881; near Yorkton, 1900; near Battleford, 1884; 20 mi. N. of Davidson, 1911; near Bradwell, 1912; near Baliol, 1922; Muddy Lake, 1922; *Manitoba*—near Winnipeg, 1871; Oak Lake, 1891. An unconfirmed record of a last nesting date for Whitewater Lake, Man., is given as 1879 (anonymous, 1956b). Allen quoted Raine (1892) as recording the whooping crane nesting in the Netley marshes at the mouth of the Red River in 1891. The disturbances accompanying settlement had driven it from its ancestral nesting grounds in the aspen parkland by 1922, after which there are no nesting records. The few remaining birds pass over during migration and stop briefly to feed and rest (anonymous, 1956a; Bard, 1956b; Bradshaw, 1956; Lahrman, 1957).

The dwindling numbers of the whooping crane have aroused much concern as to its possible extermination. Wildlife authorities have made every effort to protect it. Publicity has aroused the public to give it protection. Its wintering grounds are now restricted to one locality, the Aransas Refuge on the Gulf coast of Texas. Here it is closely guarded and annual counts are made. In 1954 there were 22 birds and no young of the year. In 1955 these birds left for northern nesting grounds and returned with six young. Although migrating birds are seen passing over Manitoba and Saskatchewan each year and attempts have been made to follow them with aircraft, no nesting sites were located until 1954. In this year nesting cranes were located by the Canadian Wildlife Service in a marsh in Wood Buffalo National Park near Fort Smith, Northwest Territories.

Fur-bearers, especially the beaver, prompted the first invasion of the parkland by white men, and the fur trade was the principal industry for about 150 years. During this time keen competition among the traders and resultant overtrapping greatly reduced the numbers of most of the fur-bearers.

The marten, *Martes americana abieticola* (Preble), which is generally considered an animal of the coniferous forest, probably at one time ranged in the parkland (Hagmeier, 1956). Henry (Coues, 1897) reported a take of 1207

marten from his Red River post in 1806–07, of which 908 came from Portage la Prairie, Man. Skins may have been brought into this post from a coniferous forest area in the Riding Mountain, but it is hardly likely, as Brandon House would have been closer. Swanson (1945) gave a number of records from northern Minnesota and mentioned that it was very easy to trap and hence became quite rare by 1900. According to Seton (1929) it was probably exterminated in the parkland of Manitoba a hundred years ago. It fed extensively on the snowshoe rabbit, mice, birds and their eggs, fish, and berries.

The fisher, *Martes pennanti* (Erxleben), now a rare animal of the coniferous forest, at one time ranged into the parkland (Hagmeier, 1956). Henry (Coues, 1897) recorded in his fur pack at Portage la Prairie 84 skins in 1804–05 and 48 in 1806-07. Swanson (1945) recorded it from northern Minnesota and mentioned that, unlike the marten, it was very difficult to trap. Hence returns were small and it is still present in the northeastern part of the State. Seton (1929) stated that it was the most arboreal of the weasel family and could easily catch a marten in pursuit among the trees. Marten in turn easily caught squirrels. The fisher was also very fast on the ground and could catch rabbits in chase. Rabbits formed an important part of its diet.

The wolverine, *Gulo luscus luscus* (L.), is now a rare animal of the coniferous forest and probably was never common. Before settlement it was apparently a resident of the parkland. Henry (Coues, 1897) recorded five in his fur pack from Portage la Prairie in 1806–07. Seton (1929) reported it as a principal predator on beaver and stated that it was usually found where beaver were abundant.

The otter, *Lutra canadensis* (Schreber), was at one time found along the rivers in the parkland. Henry (Coues, 1897) recorded it in his fur pack from Portage la Prairie, 45 in 1804–05 and 24 in 1806–07. Seton (1929) stated that in 1909 it was exceedingly rare. A few signs of its presence were seen in the Spruce Woods until about 1920 (Bird, 1927). Otters are now probably extinct over most of their former range in the parkland because of the value of their fur and persistent trapping.

The wapiti, *Cervus canadensis*, like the bison, is not commonly called by the correct name but is usually referred to as "elk". This was a characteristic large herbivore of the parkland, second only to the buffalo in abundance. The preferred habitat is a mixture of aspen and prairie. They seek shelter in the woodland during the day. In the evening they come out to graze on the prairie, where they consume grasses and herbs. In winter they paw through a considerable depth of snow to reach their food, but when the snow depth increases they consume large amounts of browse. Favorite browse plants are willow, saskatoon (*Amelanchier*), choke cherry, hazelnut (*Corylus*), aspen, oak, and dwarf birch (*Betula glandulosa*) (Banfield, 1949).

Alexander Henry (Coues, 1897) frequently referred to the abundance of elk, or red deer as he called them, in the years about 1800:

> Buffalo and red deer were everywhere in sight, passing to and fro...Red deer are seen continually in droves near the woods [country near the present town of Grafton, N.D.]...
>
> The land between these two rivers [Tongue River in North Dakota and Pembina River along the Canada—United States boundary] is partly wooded, forming a famous country for moose and red deer...
>
> Red deer were very numerous here not long ago, as the tops of oaks along this little river [Rivière aux Marais near the present town of Letellier, Manitoba] are all broken and twisted.

Elk were greatly reduced in numbers but were not exterminated in the wild state as were the buffalo. They were driven from the parkland and sought shelter in adjacent heavily wooded and hilly country. Elk do not get along well in settled areas even when given protection. They prefer wilderness areas and when forced by hunger to migrate to the edge of settlement, do extensive damage to haystacks, not only by feeding but also by tearing them apart with their horns and by trampling.

One of the largest remaining herds of elk in the parkland sought refuge in the Riding Mountain of Manitoba at the turn of the century. Their story is typical of elk herds and is recorded by Banfield (1949) and Green (1933). This area was set aside as a forest reserve by the Government of Manitoba and hunting was prohibited for a number of years. In 1914 the number of elk was estimated at 500, 2000 in 1925, and 3500 in 1933, when the area became a national park. With the protection of the park they continued to increase to 12,000 in 1946, when on overpopulation during the winter of 1946-47 destroyed their browse and a winter-kill of 20 per cent occurred. Banfield (1949) reported:

> The population dropped from an estimated 77.1 to 58.7 per square mile of concentration range. The rising yearling class had the heaviest loss of 64%. The senile class also suffered heavy loss...This high percentage caused extensive damage to the aspen stands. As high as 76% of all aspen under 10 ft. in height were killed in certain areas, while 69% of the aspen more than 10 ft. in height had part of the bark peeled by elk.

In addition, elk killed out saskatoon and choke cherry. Willows were so closely browsed that they were reduced to clumps of dead sticks with a few green shoots in the centers. Hazel, which formed a dominant understory, was browsed down to the snow line but was still alive and healthy as it appeared to be able to withstand heavy browsing: Aspen was denuded of branches to a height of about 10 feet, so that the forest had an open appearance with upper and lower browse lines and bare, often badly scored and blackened trunks in between. Grass and herbage in the open areas was eaten down like an overgrazed pasture. Elk developed a general rundown condition, and although starvation was the principal cause of death, according to Banfield (1949) there was also heavy parasitism by the hair lungworm (*Dictyocaulus viviparous*), lice resembling the horse biting louse [*Bovicola equi* (L.)], and the winter tick [*Dermacentor albipictus* (Pack.)]. Even when the park was under the pressure of overpopulation Banfield was able to divide it into areas he classified as (1) concentrated elk range, composed of prairie, parkland, and open aspen stands, (2) marginal elk range, consisting of moderately open aspen stands, and (3) transient elk range, covered by coniferous stands as well as mixed stands of sufficient density to yield 30 cords or more of wood to the acre, outside elk range and crossed by transient animals only. It is thus evident that preferred elk habitat is typical aspen parkland.

Since 1947 there has been very little winter starvation. Hunting seasons have been allowed in the area immediately surrounding the park and some surplus animals have been harvested. The population is now possibly half what it was at its peak and browse is slowly improving.

This increase from low numbers to an overpopulation under protection from hunting and reduction of predators is typical of the large herbivores in many parts of North America. The only predator of elk recorded by Green in 1933 was the coyote, which he observed killing young elk calves. He was unable to verify reports that black bears killed elk calves. However, in company with

Stuart Criddle and Dewey Soper, I observed a black bear kill an elk calf on the ranges in which Green carried out his studies.

Timber wolves have now invaded Riding Mountain National Park and several packs are established there. They have not appreciably reduced the elk herd. Coyotes are at present abundant. When flying over the park in winter one commonly sees 20 or 30 in packs of five to seven. They feed on carrion and small mammals, and on elk calves for about ten days after they are born and before they are able to follow their mother.

The mule deer, *Odocoileus hemionus* (Rafinesque), was present throughout the parkland at the time of the early settlers. Seton (1909) stated: "Formerly abundant in all the Alleghanian Region [prairies and aspen forest]; greatly reduced some twenty years ago, but now once more abundant in its proper region, wherever there is cover combined with open ground." After this peak in population, numbers were steadily reduced with the encroachment of settlement. The mule deer is now found only in small numbers in the northern part of the parkland, principally in the hilly sections. A few individuals may still be found in the Spruce Woods Forest Reserve and in Riding, Duck, and Porcupine mountains in Manitoba. Mule deer are unable to adapt themselves to life in settled areas as has the white-tail, which is now found over most of the former range of the mule deer in the aspen parkland.

The moose, *Alces americana* (Clinton), was abundant prior to settlement. Seton in 1909 stated:

> Abundant in all the forested areas of the Province [Manitoba]; apparently in no danger of extinction, since reasonable game laws have come into force. Several thousand are killed each year...The estimated total head of moose within our limits is between 20,000 and 30,000.

Since Seton wrote his statement, moose have steadily declined because of encroachment of settlement and hunting pressure. From 1933 to 1946 the annual kill by hunters was between 200 and 300. Since 1946 no hunting has been permitted in the parkland of Manitoba and the population has increased. An isolated band of some 30 to 40 moose is found in the Spruce Woods Game Preserve. A bull taken from this band was described by Peterson (1950) as a type of the subspecies found in Western Canada. Larger numbers are found in the Riding Mountain National Park, the Duck and Porcupine preserves, and east and north about lakes Winnipegosis and Winnipeg.

Moose are forest animals preferring low swampy areas where there is abundance of willow and red osier dogwood, upon which they browse. In the fly season of midsummer they spend much of their time in swamps and lakes, where they often lie partly submerged to escape the large bulldog and deer flies, *Tabanus* spp. and *Chrysops* spp. At this time they feed on aquatic vegetation and dive to obtain water lily roots. In the winter they scatter and wander considerable distances, singly or a cow and calf together. They then browse on oak, choke cherry, saskatoon, and aspen.

The black bear, *Ursus americanus* Pallas, was originally more numerous than the grizzly. It has been exterminated in most of the parkland but has persisted in the more isolated hilly and wooded areas. Adjacent to these areas it is a pest of farm stock and apiaries, with the result that a bounty has been placed on it in some sections of Manitoba, notably about the Duck and Porcupine Mountains. It is common in the Riding Mountain National Park. Until 1936 a few were

found in the Spruce Woods. It is omnivorous and feeds on wild fruits as well as small mammals, birds, and ants, whose nests it uproots. Occasionally it attacks larger game and the young of elk and deer. Henry (Coues, 1897) frequently mentioned their abundance along the Red River and their feeding activities on wild fruit and acorns:

> Bears make prodigious ravages in the brush and willows; and plum trees are torn to pieces, and every tree that bears fruit has shared the same fate; the tops of the oaks are also very roughly handled, broken, and torn down, to get the acorns, The havoc they commit is astonishing; their dung lies about in the woods as plentiful as that of the buffalo in the meadow.

Henry (Coues, 1897), on September 15, 1808, stated:

> Bears were uncommonly numerous in the Hair Hills [Pembina and Turtle Hills' Manitoba] owing perhaps to the quantity of water on the lowlands, which obliged them to resort to the rising grounds for winter quarters; they were excessively fat. One of my hunters killed 36 prime bears in the course of the season. Whatever the number of bears an Indian may kill in the summer or fall is considered of no consequence, as they are valueless and easy to hunt; but after they have taken up their winter quarters the Indians glory in killing them.

When the fur trading period was over the pressure was taken off wild furbearers and the raising of fur on ranches commenced. Trapping of wild fur animals, however, continued as a profitable sideline for many rural residents. A new factor, the vagaries of fashion, played an important part in selective trapping. For a number of years long-haired fur, wolf, coyote, fox, raccoon, skunk, and badger, has been out of fashion and prices have been so low that these animals are not worth trapping. Consequently, being well able to get along under settled conditions, they have increased in numbers. Marten, fisher, wolverine, and otter, however, cannot survive under settlement and have disappeared from the parkland. Beaver, the principal furbearer of the old days, made a remarkable comeback after being reduced to very low numbers. Muskrats have retained their popularity when made up in various forms for ladies' coats, but being prolific have been able to maintain high populations.

The badger, *Taxidea taxus* (Schreber), was found commonly in the prairie portion of the parkland, where it was the principal predator on the common "gopher", *Citellus richardsonii*. Its holes made in digging out gophers were a common sight. They were used by burrowing owls for nesting sites, by jack rabbits for shelter, and by skunks for shelter and dens, and enlarged by coyotes for dens. Bird (1930) reported that dirt thrown up by the badger in digging brings up the subsoil and forms a seedbed for successional changes. *Symphoricarpos occidentalis* often take root in this dirt and aid succession from prairie to forest. Unfortunately for the badger, its holes in pastures and fields were a source of annoyance to the farmer. Also, its coat was highly prized as fur, as well as being of value in the manufacture of shaving brushes. Hence, it was greatly reduced in numbers by trapping and shooting. Recently the value of its fur has declined and the badger has increased. It will never become abundant, however, as agriculture has destroyed the native prairie and greatly reduced the gopher.

Three species of weasel are found in the parkland of Manitoba: the long-tailed weasel, *Mustela frenata longicauda* Boneparte; the short-tailed weasel, *Mustela erminea* L.; and the least weasel, *Mustela rixosa rixosa* (Bangs). The first two species were once abundant. They feed principally on mice but also on ground squirrels, and the large, long-tailed species occasionally on snowshoe

rabbits. Weasel fur has always brought a good price, with the result that they are extensively trapped. They are easy to catch and provide pocket money for many a farm boy. The result is that the weasel population has been greatly reduced. In some places public sentiment is for protection of the weasel as a valuable mouser.

The mink, *Mustela vison lacustris* (Preble), has long been a staple item of the fur trade. It is found along streams and about the marshes of the parkland, where it feeds principally on muskrats, fish, and crayfish. In spite of heavy trapping mink are still common. The fur, being of the short-haired type, brings a good price and the animals are eagerly sought by the trapper.

The Canada lynx, *Lynx canadensis canadensis* Kerr, was at one time a common animal of the forested portion of the parkland, where it fed principally on the snowshoe rabbit and fluctuated in numbers with it. Up until the early part of this century it was commonly trapped in southern Manitoba. By 1915 it had become very rare, and except for the occasional wanderer is now extinct in the parkland. A straggler was shot near Margaret, Man., on December 7, 1950, and one near Kemnay, Man., in 1953.

The puma, *Felis concolor*, was never common and is not mentioned by Henry, but Seton (1929) recorded several from Manitoba, the last being killed in 1904. Swanson (1945) has several records from Minnesota. In recent years the puma has again been observed in both Manitoba and Saskatchewan. G. W. Malaher, Director of Game for Manitoba, gave the following record (letter of May 25, 1956):

> This animal was first seen on January 20, 1955, from a low-flying aircraft crossing Manigotogan River above Gem Lake, Township 21, Range 17E. On February 13, 1955, it was seen in the same area from the ground at close quarters. A plaster cast was taken of the foot pad and identified definitely as that of a mountain lion. In this identification Kenneth Racey, biologist from British Columbia, agreed.

F. G. Bard, Director, Saskatchewan Museum of Natural History, gave two records and a report from Saskatchewan (letter of May 16, 1956):

> Accession No. 4635. Cougar—male. Trapped and shot by Joe Fournier, March 20, 1948, at Connell Creek, Arborfield, Sask. 150 lbs. 7 ft. long.
>
> Accession No. 5342. Plaster cast of footprint of cougar. Vicinity of Yorkton. Submitted by Dr. Swallow, Yorkton, Sask. 1950.
>
> Report of cougar in Saskatchewan south south-east of Regina in the vicinity of Lajord-Riceton; however, we have nothing to substantiate this claim.

The Saskatchewan timber wolf, *Canis lupus griseoalbus* Baird, occurs in the forested area, where it feeds on moose, elk, deer, snowshoe rabbits, small mammals, and birds. Although it has been driven back into inaccessible areas by settlement it has not reached the point of extinction. In spite of bounties and control operations by aerial predator hunters and government control operators it has increased and migrated into settled areas during recent years. Here it preys on deer and domestic stock. It is now common in the Riding and Duck Mountain and Lake Winnipegosis areas, and a few are found in the Spruce Woods. In 1950–51, bounty was paid on 3410, a large number of them from unsettled areas north of the parkland, but at least 250 were taken in the southern portion of Manitoba.

The coyote, *Canis latrans*, inhabits both the prairie and wooded portions of the parkland. It was abundant prior to settlement and has continued to thrive under settled conditions in spite of determined attempts to destroy it.

81314–7—6

It feeds on a variety of small mammals, birds, and insects, including grasshoppers when they are abundant. In season, wild fruits (choke cherries, saskatoons, and strawberries) are consumed. At times it attacks big game. Green (1933) records it killing elk calves. It must also consume numerous fawn deer. During the winter when the snow is deep and crusted it is a major predator of adult deer. It consumes large quantities of carrion of both wild and domestic animals. It is particularly partial to sheep and makes sheep raising difficult in some districts. It also attacks poultry, particularly turkeys that wander from buildings. All hands are against the coyote and it is destroyed on every opportunity. Encouragement is given by a $5.00 bounty. The raiding of dens, which contain five or six pups on the average but may have as many as 10, is a lucrative occupation for Indians and farmers. The coyote held its own against this persecution and even increased when it had sufficient cover and wild land for protection and denning. In recent years the advent of hunting from airplanes and shooting them with shotguns as they run across open fields and frozen lakes has become popular and has decimated their numbers. One team of aerial hunters shot over 1000 in southwestern Manitoba in five years. The coyote, however, is an adaptable animal and is learning fast. It is safe from the aerial hunter if it stays in bush and forested areas. In 1955 and 1956 aerial hunting decreased in popularity and coyotes immediately increased. Although it has been necessary to control the numbers in order to protect game and livestock, it is evident that drastic reduction in numbers or extermination is not desirable. The coyote has a controlling influence on mice, gophers (*Citellus richardsonii* and *C. tridecemlineatus*), and rabbits, which are important agricultural pests.

The economic value of coyote fur has had a marked effect on trapping pressure. Thus the vagaries of milady's fashion influence the number of coyotes. At one time, about 1920, coyote skins were worth up to $25.00. Since 1950 they have not been worth skinning.

The red fox, *Vulpes fulva regalis* Merriam, fluctuates markedly in its abundance. Seton in 1909 stated that it was less numerous than formerly. It certainly was very scarce in following years up to about 1930. Then it began to increase as the commercial value of its fur decreased and trapping was reduced. It has been abundant for the past twenty years and has been classed as vermin with a bounty of $5.00. It is vulnerable to aerial predator control but has learned faster than the coyote to hide from airplanes. Where persistently hunted from planes it has become nocturnal and takes to dens during the day. On the Brandon, Man., municipal airport, which was being used by aerial hunters, three occupied fox dens were found but no foxes were seen from the aircraft.

Foxes inhabit both prairie and woodland, and where plentiful exert considerable influence on the abundance of rabbits, mice, ground squirrels, and pocket gophers. At times they feed heavily on grasshoppers. In the 1930's, when grasshoppers were in outbreak numbers, droppings were composed almost entirely of grasshopper remains, mostly *Melanoplus bilituratus*. Were it not for its fondness for poultry and game birds the fox would be a very desirable inhabitant of the settled community.

The striped skunk, *Mephitis mephitis hudsonica* Richardson, is a common animal of the parkland, being found particularly about the edges of woodland and sloughs. It is omnivorous and is an important influent of the community.

At times it feeds extensively on insects, digging up white grubs and grasshopper eggs. It eats many grasshoppers and is partial to the underground nests of wild bees and hornets, which it digs out at night, when the insects are numbed with cold, to feed on the brood. It also feeds on mice, eggs and young of ground-nesting birds, and poultry. Its fur, which at one time brought a good price on the market, is now practically valueless. No one wants the smelly job of trapping skunks, and they have increased greatly. They wander onto highways at night and many are killed by cars. Around some duck marshes skunk tracks are very plentiful and in some places form regular trails; here they feed on wounded birds and ducks lost by hunters.

Fur of the beaver, *Castor canadensis canadensis* Kuhl., was the most important item of the fur-trading days. Beaver abounded in the streams of the parkland, where they were important in controlling runoff and maintaining water levels. Henry (Coues, 1897), in his returns for the lower Red River Department for the winter of 1806-07, recorded 1184 beaver pelts weighing 1750 pounds. Seton in 1909 stated: "Formerly very abundant in all parts of Manitoba. Reduced to very few some years ago, but owing to fostering laws it has since increased and may once more become abundant." His forecast was correct, for they have continued to increase to a degree where they have become a nuisance. Numerous permits have been issued to farmers to reduce the number of beaver on their land and game department officials have live-trapped and moved beaver to other areas. When too abundant, beaver destroy the available food supply, aspen and willow, and flood areas of agricultural land. One of their most troublesome habits is the plugging of culverts under highways and railroads to make use of the man-made dam, with resultant washing out of the grade.

This increase in numbers is widespread. Minnesota opened a season on them in 1939 and took 11,048, and seasons were continued in the following years (Swanson, 1945). In North Dakota, beaver have increased to the point where they have become a problem and an open season was declared for the spring of 1953, after a permit trapping system had been practiced since 1931.

Nash (1951), in his studies in northern Manitoba, found the favored food of beaver was predominantly aspen followed by willow. Birch and alder were used for building material and occasionally food. Spruce was utilized only when there was no other food. Beaver can utilize aspen only within 500 to 600 feet of water and are hence limited to a narrow belt along streams. Fires are an important factor in providing beaver food since when spruce is killed by fire it is followed by a subclimax aspen forest.

In southern Manitoba, where flood-plain trees along the larger rivers are boxelder (*Acer negundo*), American elm, and green ash, I have observed beaver to utilize ash and only rarely the other trees.

The muskrat, *Ondatra zibethicus* (L.), is an abundant and prolific rodent of the streams and marshes of the parkland. It is extensively trapped and has become one of the most popular furs for ladies' coats. It is easily managed and if given protection stands a heavy harvest. It is preyed on by mink, great horned owls, and other predators, but probably its greatest natural enemy is drought. Frequently sloughs in which it builds its houses are so shallow that they freeze to the bottom, thus killing the muskrats, which do not store food or hibernate and must feed under the ice. Man has adversely affected the muskrat in agricultural areas by the drainage of sloughs and marshes. On the other hand, he

81314-7—6½

has reduced the numbers of predators and, in marsh areas unsuited for agricultural production, has put in dams to regulate water levels intentionally for the benefit of muskrats and wild fowl. Large areas in the delta of the Saskatchewan River are thus under management for muskrat production. Ducks Unlimited has done much in controlling water levels for ducks and enlarging muskrat habitat. Ducks and muskrats live in the same type of habitat. Muskrats improve conditions for ducks: ducks utilize the muskrat houses for basking places and the muskrats keep areas of water free from encroaching vegetation through their feeding activities on rushes, cattails, and sedges. In the early autumn, muskrats wander long distances from water and suffer heavy losses by predation. They are generally very active as freeze-up approaches and may be seen all day house-building and feeding, whereas at other times they are largely crepuscular or nocturnal. Muskrats inhabiting streams behave differently from those in marshes. They do not build houses but live in holes they excavate in the bank and they gather many clams, which they bring up to the shore or on to ice to consume. Piles of empty clam shells are conspicuous at their feeding places.

Richardson's ground squirrel, *Citellus richardsonii*, is the "common gopher" of the prairies. Its burrows have conspicuous piles of dirt on one side of the hole. It is particularly partial to dry uplands and gravel ridges, where it forms loose colonies, and is not found in the heavy soil of the lowlands. Closely grazed pastures on light soil are a favored habitat. It was thus associated with the buffalo as it now is with domestic stock. Sowls (1955) recorded a population persisting in a closely grazed pasture in the Delta marsh area. It is a grass feeder and soon learned to attack cereal crops. It invaded the crops from its burrows in the surrounding sod but also made some burrows in the fields. It not only fed on the young plants but also broke down many heads of ripe grain in obtaining seed for its winter stores. It was estimated that each gopher destroyed at least a bushel of grain. When the population about a field ran into the hundreds, losses were considerable. Hence it became a pest of prime importance. It was trapped, shot, and poisoned unmercifully. Competitions were organized among boys for the most gopher tails, and prizes and bounties were awarded. The greatest control measures were exerted from 1910 to 1925, after which the gopher became less of a problem. It is still common and troublesome in some spots but its numbers are greatly reduced, more by the destruction of habitat than by control measures. With increased acreage under the plow and the introduction of power machinery, waste land, pastures, and roadsides have been almost eliminated as breeding places.

During grasshopper outbreaks gophers eat large numbers of grasshoppers. They may do so in search for moisture when the vegetation is very dry as much as from desire for an insectivorous diet.

The thirteen-striped ground squirrel, *Citellus tridecemlineatus*, has the subspecies *tridecemlineatus* (Mitchill) in the southern part of the parkland and *hoodii* (Sabine) in the northern. The "striped gopher" is much more solitary and secretive than *C. richardsonii* and is found in longer and denser grass. Although *C. tridecemlineatus* invades gardens and crops it is seldom abundant enough to do much damage and is easily controlled. It is more nearly omnivorous than *C. richardsonii* and in addition to a predominantly vegetable diet consumes numerous insects and the flesh of mammals, as well as birds and their eggs.

Stuart Criddle (1939) studied winter homes and stores of the striped ground squirrel. He found nests and store chambers as deep as six feet. Dirt was scattered widely to leave no telltale mound and the original entrance hole was plugged with dirt from a side entrance joining the main tunnel at a sharp angle. This entrance was well hidden with a sharp angle making it difficult for a badger to follow in digging out the occupant. Winter stores were much smaller than those of field mice but might contain as much as $2\frac{1}{2}$ pounds of wheat or less of grass seeds. There were, however, several emergency stores in addition, small amounts hidden away under clumps of grass and in other places. After a rain these seeds sprout and can be easily located. Between a winter hole and a wheat field 140 yards away Criddle counted 173 of these sprouted stores containing from a few dozen up to 400 grains of wheat. The latter would be a full load for their cheek pouches. Since many of these small stores are never consumed they must be an important influence on the distribution of the food plants.

Agricultural practices have been detrimental to the striped ground squirrel, as the shallower summer burrows have been destroyed by the plow and grazing has removed protective vegetation. Populations are now considerably reduced.

Franklin's ground squirrel, *Citellus franklinii* (the shrub or bush gopher, as it is commonly called), is found about the edges of aspen groves, thickets of choke cherry, saskatoon, and willow, and in tall grass and rushes on dry land about the edges of sloughs and marshes. Sowls (1948) studied its life history and habits at the Delta marsh. Here he found that populations fluctuated markedly, with a peak in 1938 and lows in 1943 and 1946. He also found that animal food constituted about one-third of its diet and consisted of mice, young snowshoe rabbits, toads, frogs, young birds and birds' eggs, and insects, particularly grasshoppers. Vegetable food included sow thistle, stinging nettle, choke cherries, and clover. Many garden plants were eaten. At times of abundance at Delta they destroyed 19 per cent of vulnerable duck nests as compared with 21 per cent destroyed by crows. They were apparently reduced in numbers by disease, as predation by hawks, skunks, weasels, and mink was low. Land clearing operations have considerably reduced the habitat of Franklin's ground squirrel and the population in the aspen parkland.

Birds were not the primary concern of the early traders, as were mammals, and only a comparatively few were killed for food. It was not until an agricultural economy developed that game birds were hunted to any extent. All birds soon felt the effect of land clearing, cultivation, drainage, and the establishment of human habitation.

The aspen parkland with its many sloughs, potholes, and marshes is one of the best waterfowl breeding areas on the North American continent. As a group, ducks, geese, and swans have probably been subject to as great a pressure from settlement as any other group of birds in the parkland. They are excellent game birds and have been heavily shot each year. In 1952 an estimated 278,739 ducks were taken in Manitoba by 25,283 licensed hunters.

Many species of ducks return for nesting to the locality where they were raised (Sowls, 1955). Shooting too early in the autumn, before the birds have had a chance to scatter from their nesting areas, has resulted in the "burning out" of the breeding stock, particularly diving ducks, of some marshes. Stubble-fed mallards are preferred and are selectively shot by many Canadian hunters.

In spite of this terrific pressure, ducks are still holding their own in fair numbers, thanks to conservation measures. Seasons and bag limits have been set to regulate the take, marshes have been reclaimed, and preserves have been established.

In addition to the toll taken by hunters, ducks come into conflict with agriculture. Much nesting habitat has been destroyed by tillage, drainage, and grazing. However, some agricultural activities have benefited ducks. Two species, mallards and pintails, have taken to feeding in grain fields, where they pick up much waste grain. For a short period in the autumn heavy concentrations of these ducks may do considerable damage to unthreshed grain lying in swath. To combat this loss, permits have been issued to farmers to shoot the birds on their fields before the hunting season opens. This method has led to much abuse. Hochbaum *et al.* (1954) have shown, however, that it is not necessary to kill birds to drive them from the fields. This can be accomplished by the erection of scarecrows and the firing of blank shells from exposed positions near the scaring devices and by automatic exploding devices.

The habit of feeding in fields was developed almost as soon as fields were planted, for Macoun (1883), commenting on his trip of 1880, stated, "Geese, ducks and prairie chickens are taking to the stubble fields in the fall".

Sowls (1955) has shown that moderate grazing by livestock in the neighborhood of sloughs and marshes is beneficial to ducks. Trampling and grazing of reed grass, bulrushes, and cattails at the water margin exposes mud banks, which are important to ducks for loafing areas. The same relationship must also have existed with buffalo.

Sowls (1955) also noted that heavy grazing of a palatable grass, such as blue grass, renders the pastures useless for duck nesting sites but that patches of unpalatable vegetation, such as reed grass (*Phragmites communis*), wild barley (foxtail), and Canada thistle, make good nesting cover. Leitch (1951) found that snowberry, which increases with overgrazing, is used for nesting sites by blue-winged teal and shovelers when close to water. Sowls found that ungrazed meadows of whitetop are preferred nesting sites, and of secondary importance are reed grass, couch grass, goldenrod, aster, and annual weeds. The narrow strips of vegetation on roadside embankments were used by 10 per cent of the nesting ducks observed by Sowls. A few mallards nested close to the edges of heavy stands of red grass but these stands were impenetrable for any distance. Pintails and some mallards used stubble and fallow fields up to 500 or more yards from water. Most of these nests were destroyed by tillage.

Farmers adjacent to marshes cut wild hay as it becomes available when water levels retreat. If the area has not been cut for some years, because of high water, there is a dense mat of dead vegetation. To remove this, fires are set. These fires do a great deal of harm to nesting ducks unless they are timed and controlled to avoid the destruction of nests.

The relationship of predators to ducks is indirectly affected by human activities. The flushing of birds from their nests during agricultural and other activites exposes eggs to crows. Crows often closely follow agricultural implements to feed on insects and mice that are disturbed. If a duck is flushed from her nest they invariably take the eggs, even if the farmer is careful to leave a

patch of untilled land to shelter the nest or moves the nest to another site close by. Kalmbach (1937, p. 7) stated:

> It cannot be emphasized too strongly, however, that careless intrusion of human beings into duck-nesting areas creates a hazard of utmost importance, for incubating ducks may then be flushed in the presence of crows and the suddenly uncovered eggs left exposed to view. It is for this reason that the breeding grounds of ducks should be carefully guarded against trespass during the nesting season.

There is abundant evidence that the crow increased with agriculture (Phillips, 1928; Farley, 1932; Kalmbach, 1937; Hochbaum, 1944; and Sowls, 1955), although there is now some evidence that its population is declining. Kalmbach (1937) found that crows destroyed 33 per cent of the duck nests at Waterhen Lake, Saskatchewan.

Sowls (1955) lists the skunk, along with the crow and Franklin's ground squirrel, as a principal predator of duck nests at Delta. In the Lower Souris Refuge, North Dakota, Kalmbach (1938) found that the skunk took 30 per cent of the duck nests. The skunk, when it was an important fur-bearer, was trapped heavily and its numbers kept at a minimum. Now this check on its numbers has been removed, as its fur is valueless.

The effectiveness of localized programs of crow reduction to protect duck nests is questioned by Sowls (1955). He points out that the destruction of crow nests produces more wandering crows, which are more persistent hunters of duck nests than breeding birds. Also, if adult crows are reduced, more nests are available for skunks and the end result may be the same. Kalmbach (1938) concludes that the control of predators is so involved that it should be undertaken only by wildlife managers. The intrusion of predator hunters on waterfowl nesting areas disturbs the ducks. In other areas hunters may shoot predators that are taking food to the detriment of agricultural interests.

The American coot, *Fulica americana* Gmelin, is a very common bird that may be seen about the open water of sloughs in association with ducks. It nests in the rushes and raises large broods, which soon scatter, and young of all ages may be seen swimming over the marsh. Sowls (1955) has shown that young coots are fed on extensively by mink and that they are an important buffer between the mink and ducklings.

The Canada goose, *Branta canadensis* (L.), is the only goose that nested in the parkland. It apparently nested generally throughout the area but there is little exact information on its nesting locations. Stuart Criddle (naturalist and old-time resident, Treesbank, Man. In litt. 1955) stated that a few pairs nested along the Assiniboine River near Treesbank, Manitoba, in the 1880's and that some nested in the Douglas marsh, ten miles to the north, until the early part of this century. Hales (1927) stated that he shot a Canada goose out of a flock nesting in Oak Lake, Manitoba, in 1901, and that geese were then nesting in only a few scattered localities. According to Lawrence (1925), A. G. Vidal of West Shoal Lake, Manitoba, reported that 20 Canada geese had nested there in 1925 and that these were the first geese nesting there for about 30 years. This was just a year following the creation of the Shoal Lake sanctuary in February, 1924. Farley (1932) recorded five pairs of Canada geese nesting in a lake near Camrose, Alberta, in 1931, and that geese have nested there annually since he first observed them in 1907. A few pairs still nest in more isolated marshes, e.g., Dog Lake near Ashern, Manitoba, where a sizeable colony is still found; but the goose has been practically exterminated as a breeding bird in the aspen

parkland. It is easily raised in captivity, and some captive birds have been released and are once again nesting in the old haunts in a few protected marshes. A breeding colony has been re-established at Delta on the south end of Lake Manitoba through the activity of the Delta Waterfowl Research Station. Sizeable flocks pass through on migration. In 1950 the reported hunter kill of Canada geese in Manitoba was 4,668, over twice the number taken in 1948 and 1949.

The white-fronted goose, *Anser albifrons frontalis* Baird; the lesser snow goose, *Chen hyperborea* (Pallas); and the blue goose, *Chen caerulescens* (L.), are common migrant geese. The last two species, however, pass through in numbers only in the spring migration and most return via the Niagara peninsula in autumn. Southern Manitoba is a main stopping place on the way to Hudson Bay. As spring shooting has been stopped for the last forty years, the geese are exposed to very little hunting in the parkland. Unfortunately they have never become accustomed to aircraft. Training planes during the Second World War disturbed them on their resting grounds near Marquette and Warren, a few miles northwest of Winnipeg, and the migration has become disorganized.

The whistling swan, *Olor columbianus* (Ord), never nested in the area but passes through regularly on migration to and from its nesting grounds in the Arctic. It, as well as the trumpeter swan, was shot for down and skins and decreased in numbers, but with protection in recent years it has increased. Large numbers now stop over, particularly in the fall migration, and gather on the larger marshes. Thousands may be seen on Whitewater Lake in southwestern Manitoba in October. Seton (1909) described it as a rare migrant.

The hawks and owls, like wolves, have been persecuted by man on account of their habit of preying on domestic and game birds. Unfortunately, however, most men do not distinguish between the hawks that feed primarily on rodents and those that take birds, and many hawks helpful to human interests are destroyed. The only hawks of the parkland that feed primarily on birds are the sharp-shinned hawk, *Accipiter striatus*; Cooper's hawk, *Accipiter cooperi*; and the goshawk, *Accipiter gentilis atricapillus*. The last is the largest and most destructive of the three; however, it is only a winter resident. During this period it takes considerable numbers of sharptailed and ruffed grouse and snowshoe rabbits. If game is scarce it raids flocks of domestic fowl. It lives and hunts close to woodland, and its habitat is being reduced with land clearing. The other two species, which are summer residents, are also woodland dwellers. The sharp-shinned hawk is too small to attack birds larger than pigeons and songbirds. It does not often molest poultry. Cooper's hawk will feed on ruffed grouse and poultry and is primarily responsible for putting hawks in disrepute. It has increased during the past fifty years. Seton (1909) reported it as rare and that he did not know of a specimen being taken in the Province.

The red-tailed hawk, *Buteo jamaicensis borealis*, and Swainson's hawk, *Buteo swainsoni*, are two common and conspicuous hawks that have unjustly been subject to severe persecution. Their habit of sitting on telephone poles and building conspicuous nests in outstanding trees makes them very vulnerable. They only rarely attack poultry but feed chiefly on mice and ground squirrels. Swainson's hawk, which hunts mostly over the prairie, also consumes large numbers of grasshoppers. Both hawks have been considerably reduced in numbers by shooting and destruction of nesting sites.

The marsh hawk, *Circuls dyaneus hudsonius*, is the most abundant hawk of the parkland. The Manitoba parkland is probably the finest marsh hawk breeding range in North America (Hochbaum, A. Director, Waterfowl Research Station, Delta, Man. In litt. 1956). Coues (1874) stated that in North Dakota it was the most abundant and widely distributed of all the rapacious birds. With the expansion of farming, draining, pasturing, and breaking of prairie sod, however, it is considerably less abundant than in earlier times. As with ducks (Leitch, 1951), some compensation for loss of habitat has arisen through the increase of snowberry in overgrazed pastures. It rarely settles on a high object such as a telephone pole and is hence not vulnerable to the rifle and it rarely approaches within shotgun range. Its wariness has developed on association with settlement, for Coues (1874) stated that it showed little of the wariness most hawks display. Sowls (1955), who studied the food habits of marsh hawks at Delta, Manitoba, found that ducklings and adult and juvenile coots were occasionally taken but that juvenile passerine birds, mice, insects, and amphibians comprised the principal food items. In the hunting season it captures many wounded ducks. I have observed them carry off blue-winged teal shot and dropped in the water, before they could be retrieved by the hunter. Its nests are on the ground, well hidden in tall grass or low shrubs. Criddle (1912) noticed that young marsh hawks when they start to hunt for themselves will take young sharp-tailed grouse. The grouse soon get too large for them to handle and they learn to leave them alone. The following year when young grouse are about, they do not molest them.

The sparrow hawk, *Falco sparverius* L., is a common bird of the parkland. It is restricted in its nesting distribution as it requires some sort of a cavity, usually an old flicker's hole, in which it builds a very scanty nest. The destruction of nesting sites through land clearing has only partially been compensated for by the habit flickers have of excavating holes in telephone poles, which are later utilized by the hawks. It is not shot as much as the larger hawks and is still common. Its food is chiefly grasshoppers, dragonflies and other large insects, mice, and occasionally small birds.

The great horned owl, *Bubo virginianus*, is resident throughout the year. This powerful predator is still common about wooded areas and groves of trees in spite of persecution by farmers and sportsmen. At times it captures grouse and ducks and feeds on domestic fowl, but such attacks are made mostly by a few individuals that have found an abundant food supply or have experienced a scarcity of other food. It consumes large numbers of snowshoe rabbits, mice, pocket gophers, and rats, and occasionally takes skunks and crows. I (Bird, 1929) kept six nests under observation while the young were being fed and found the principal food to be rabbits and mice, only the occasional duck and domestic fowl being taken during the period of observation.

The ruffed grouse, *Bonasa umbellus*, is the grouse of the denser woods and willow swamps of the parkland. Like other grouse and snowshoe rabbits, it is subject to periodic highs and lows of population, averaging about ten years between peaks. Since settlement the peaks of population have been progressively lower. The birds are easy to shoot on account of their tameness, and much habitat has been destroyed by land clearing. They eat the fruit of the poison ivy, which is not toxic to them, but sportsmen sensitive to the ivy have reported symptoms after cleaning ruffed grouse and touching the berries in the crop.

The sharp-tailed grouse, *Pedioecetes phasianellus*, is the most abundant grouse of the parkland. The groves of aspen interspersed with grassland or grain fields make an ideal habitat. The birds resort to the woods for protection in the winter and a noon-day siesta in the summer. They are well adapted to withstand the rigors of winter. On the approach of winter, scales on the sides of the toes grow out to enable them to walk on crusted snow. They feed on rose hips, snowberries, and buds of trees and shrubs projecting above the snow, and for protection from the cold they dive into soft snow and make their beds several inches below the surface. Changes in farming practices first benefited the sharp-tail. Food was abundant in gleanings about straw piles, and sheaves in stooks or stacks were often available for several weeks before they were threshed. The change to mechanized farming reduced the available grain. Grain was threshed from the swath, eliminating straw piles, and the stubble was generally worked with a oneway disk or cultivated shortly afterward, thus burying most of the waste grain. The most unfavorable effect of agriculture on this grouse has been the destruction of nesting sites and land clearing. The reduction in numbers of horses with resultant breaking up of native pastures has further reduced their habitat. Intensively cultivated areas are now nearly devoid of sharp-tails.

The sandhill crane, *Grus canadensis tabida*, and the little brown crane, *Grus canadensis canadensis* (L.), were always much more abundant than the whooping crane. They feed considerably on the uplands although they return to a marsh for resting. The little brown crane, which is the more abundant, did not nest in the parkland. It soon learned to feed on waste grain in the stubble fields, and since swathing of grain has been practiced may do considerable damage by trampling. It was shot for food by the settlers and reduced in numbers, but since protection has been enforced it has increased and is commonly seen during migration. It gathers in large numbers about favorite marshes in the spring and fall. The Big Grass Marsh west of Lake Manitoba is one such area. Flocks of hundreds may be seen feeding on adjacent fields.

Norman Criddle (Entomologist in Charge of the Dominion Entomological Laboratory at Treesbank, Man. In litt. 1925) recorded the sandhill crane nesting in the area east of Brandon, Man., along the Assiniboine River in the 1880's. Pittman (1956) mentioned sandhill cranes as plentiful and nesting near Wauchope in southeastern Saskatchewan in the early days of settlement. They nested on low but not wet ground. Destruction of nesting habitat drove them away.

Shore birds were heavily shot during the days of market hunting and have not regained their former numbers (Roberts, 1932). The upland plover, which inhabits the prairie, was most vulnerable to destruction of nesting habitat by agricultural activity. It is greatly reduced in numbers.

The following are breeding species of shore birds: the killdeer, *Charadrius vociferus* L.; Wilson's snipe, *Capella gallinago delicata* (Ord); the upland plover, *Bartramia longicauda*; the spotted sandpiper, *Actitis macularia*; the willet, *Catoptrophurus semipalmatus inornatus*; the marbled godwit, *Limosa fedoa*; and Wilson's phalarope, *Steganopus tricolor* Vieillot. Many other species pass through during migration.

The white pelican, *Pelecanus erythrorhynchos*, and the doublecrested cormorant, *Phalacrocorax auritus*, are largely fish eaters. They nest together in

colonies on islands in the larger lakes. McLeod and Bondar (1953), who investigated the status of the cormorant in southern Manitoba, reported colonies confined to Lake Manitoba and that the estimated number of nests was reduced from 39,448 in 1945 to 18,624 in 1951. This reduction resulted from the repeated raiding of colonies and smashing of eggs by commercial fishermen. In one case a mink rancher harvested the young each year for mink food.

The Saskatchewan horned lark, *Eremophila alpestris enthymia* Oberholser, is the only true lark in the parkland. It is a common and abundant bird of the grassland and open cultivated fields, to which it readily adapted itself. It stays late in the fall and is the first bird to return in the spring. Its food consists of about 20 per cent insects and the remainder seeds, mostly weeds. With the development of intensive agriculture its numbers have been reduced by destruction of nests by tillage operations and the planting of crops. Roberts (1932) estimated that in southeastern Minnesota only one pair is now found where there used to be fifty.

The bobolink, *Dolichonyx oryzivorus* (L.), was an abundant summer resident in moist meadows (Seton, 1909). In recent years it has become much less abundant because of the draining and breaking of land. Roberts (1932) reported a decrease in numbers in Minnesota. He believed that Brewer's blackbird, which has been extending its range to the eastward, has been driving it from its former range. Hales (1927) considered Brewer's blackbird, *Euphagus cyanocephalus* (Wagler), the most abundant blackbird. Since that time it has steadily decreased in numbers through destruction of its nesting habitat in the fast-disappearing native prairie. The western meadowlark, *Sturnella neglecta*, is a common and delightful bird of the prairies. Roberts (1932) considered that it adapted itself well to settlement and even increased, as it preferred pastures to wilder places. In recent years with mechanized farming and the destruction of pastures this is no longer true and populations have declined.

The chestnut-collared longspur, *Calcarius ornatus*, was common on dry upland sand prairie. Some of this land is unfit for agriculture and appreciable populations remain in these locations. In Minnesota, Roberts (1932) reported that the bird has been driven from the western part of the State, where it was once common, by cultivation of its habitat.

Prior to settlement the rivers and lakes of the parkland teemed with fish. Since settlement there has been a steady decline in the fish population as a result of overfishing and pollution. Alexander Henry (Coues, 1897), in his travels along the Red River from 1799 to 1808, made frequent references to the abundance of fish. Unfortunately the names he used are often misspelt Indian and French names and it is not possible to identify the species. He frequently used the words "picaneau" and "piccanan", which are apparently different spellings of the same word and to which there is no clue. Similarly the words "pois d'oile" and "pois d'ouce" are used. The term "lacaishe" may refer to the goldeye, *Amphiodon alosoides* Rafinesque, or pike, *Esox lucius*, and "achegan" to the yellow walleye, *Stizostedion vitreum*. The following quotations give some idea of the abundance of fish and their ease of capture:

> My men as usual betook themselves to fishing, and in a short time caught upwards of 300 Lacaishe...
>
> We take plenty of catfish and lacaishe...
>
> Men fishing with hook and line, and others with the seine: all were successful, taking plenty of catfish, sturgeon, lacaishe, and other kinds...

> We take plenty of catfish with a night-line of 60 hooks, and 20 to 30 sturgeon a day...
>
> My people are all unwell: as usual every spring, on the sudden change of diet from flesh to fat sturgeon, they are very troubled with dysentry that reduces them very much: they are extraordinary gormandizers, and the sturgeon oil is too much for them. We take large fat picaneau in our sturgeon nets; they are excellent eating, but too oily, and tend to increase the disease...
>
> He takes daily a number of fine large whitefish in his nets [in Lake Manitoba]. This fishing is abundant the whole year, but more particularly in the autumn, when almost any number may be caught; they generally weigh from 12 to 20 pounds...
>
> We caught great abundance of sturgeon and all other kinds of fish peculiar to this river [Red River]—much more than my people could consume.

With settlement we immediately find a pollution problem. The report of the Manitoba Department of Agriculture for 1882 included mention of the first efforts at trying to impose regulations to prevent pollution, without success. "The prohibition of placing saw dust in streams is a dead letter. The Winnipeg Gas Company is doing great injury by polluting Red River with its refuse and killing the fish." It is also interesting to note in the same report that an attempt to introduce carp was considered.

The cities dump raw sewage, waste oils, and chemicals into the rivers. Pollution, together with overfishing, has sadly reduced the fish population. The once-abundant sturgeon and catfish are now practically exterminated. Goldeye are much reduced. Pike hold their own in reasonable numbers in suitable water but are very scarce in the Red River.

Erosion and silting are particularly acute on the east slopes of the Riding and Duck mountains. As land has been cleared, erosion has been accelerated and drainage systems have dumped much silt into the rivers. Lake Dauphin at one time was a particularly productive lake. It is now silting up rapidly and fishing has declined. Tributary rivers, which were crystal clear and formed ideal spawning grounds for pike and walleyes, are now scoured by spring floods, and gravel beds are loaded with silt so that fish reproduction is much reduced.

Attempts are being made to restock depleted waters but with the spoilage of habitat the attempts are often futile.

Lastly, sport fishing has become extremely popular, and with more leisure, cars, and outboard-motor boats, the fishing pressure at favorite spots is very heavy. On holidays and weekends hundreds of people gather at such places. Fishing camps with modern conveniences have sprung up and the market has been flooded by every imaginable lure and accessory. New lakes are soon fished out as roads are built to them and the fishing frontier is pushed farther and farther north.

Of all animals, insects as a group are the most adaptable to changes in the environment. Changes in the parkland, however, have been so great that a number of insects have been reduced in abundance.

The only serious attempt at comparative studies of insects in disturbed and undisturbed areas of the parkland has been made by King (1926) at Saskatoon, Sask. In comparison of grazed and ungrazed prairie he said that there was no evidence that insects indigenous to the *Symphoricarpos* and *Elaeagnus* thickets were particularly affected by grazing except by partial destruction of the habitat. Because of the importance of migrant forms, however, the population was considerably affected indirectly by changes in the prairie and proximity of ruderal associations. I have noted that although livestock do not feed to any extent on

Symphoricarpos occidentalis, except for some browsing on the fruit and dried leaves in winter, they cause it to spread by removal of competition of grasses through close grazing. Pastures become overrun with the shrub and their carrying capacity is greatly reduced. On the other hand, *Elaeagnus commutata* is heavily browsed by cattle, and patches are killed by a combination of browsing and trampling. The killing of patches of *E. commutata* by pasturing was noted by King, but he did not report an increase of *S. occidentalis* as a sign of overgrazing, as noted by Leitch (1951) and observed by myself.

King (1926) stated that grazing of grassland reduced the taller herbs and grasses and the animals associated with them, including thrips, spiders and the ambush bug, *Phymata erosa wolffii* Stål. Insects requiring specific food plants were most affected. These included the wheat stem sawfly, *Cephus cinctus,* which requires large grass stems for larval development; the fly *Eurosta solidaginis fascipennis,* which makes galls on goldenrod; the bugs *Lopidea minor* Kngt. and *L. dakota* Kngt., which feed on certain Leguminosae; and the katydid *Scudderia pistillata* Brunn, which is not a general feeder. The abundance of animal droppings resulted in an increase of insects associated with them, including the fly *Forcipomyia specularis* Coquillett. Closely grazed grass with exposed soil favored the increase of certain grasshoppers. *Melanoplus infantilis* Scudd. was the most abundant. Other species that increased with this condition were: *Psoloessa delicatula* (Scudd.), *Xanthippus corallipes* (Hald.), *Arphia conspersa* Scudd., and *Spharagemon collare* Scudd. Grasshoppers characteristic of undisturbed grassland such as *Aeropedellus clavatus* (Thom.) decreased. The increase of sunlight and evaporation associated with overgrazing benefited the lygaeid bug *Geocoris discopterus* Stal, and the cutworms *Euxoa flavicollis* (Sm.), *Euxoa divergens* (Wlk.), *Feltia ducens* (Wlk.), *Spaelotis clandestina* (Harr.), and *Lacinipolia meditata columbia* (Sm.). Other cutworms, *Leucania commoides* Gn., *Nephelodes emmedonia tertialis* Sm., *Faronta diffusa* (Wlk.), *Hyphilare oxygala* (Grt.), and *Paradiarsia littoralis* (Pack.), were more abundant in areas of long grass. Among the ants, *Myrmica scabrinodis* increased in grazed areas whereas *Lasius brevicornis* was reduced. Three weevils, *Trichalophus simplex* Lec., *Lepyrus palustris* (Scop.), and *Hyperodes ulkei* (Dietz), decreased with grazing as did crane flies, *Pachyrrhina* spp.

King found that the total insect population of all strata in cultivated fields was less than that of pasture. Ants were practically eliminated by cultivation and spiders, Heteroptera, and Homoptera were greatly reduced. During outbreaks certain Orthoptera were more abundant in crop land. Diptera and Coleoptera were appreciably more abundant in the cultivated fields, particularly in the families Elateridae, Carabidae, and Staphylinidae although there was a reduction in Curculionidae and Chrysomelidae. He also found that although the upper strata of soil in cultivated fields contained low populations, the levels below seven inches contained high populations. In sandy loam the insect population averaged over 40,000 per acre between 7 and 10 inches and 20,000 per acre between 10 and 13 inches. "The most important natural enemies of wireworms (Elateridae) appeared to be birds, especially the Franklin Gull, and the larvae and adults of Carabidae. . . The mortality, in actual numbers, from both these agencies is very much greater in cultivated fields than in native sod." Carabids were more abundant although cultivation exposed them and other insects to be picked up by birds. Soil moisture was important to both carabids and elaterids.

In dry years there was considerable mortality of both groups but proportionately less of the wireworms, which were able to burrow to greater depths. Cultivation may thus be more injurious to the predaceous carabids than to the wireworms, which were often below plow depth.

Grasshoppers with restricted food habits have been adversely affected by destruction of the native prairie. A number of those that are more general feeders, however, have benefited by human activity and have become pests. One exception is the Rocky Mountain grasshopper, *Melanoplus spretus*, a species to which all grasshopper outbreaks in the parkland prior to 1903 are referred. These outbreaks have undoubtedly occurred periodically for centuries. Layers of grasshoppers are found frozen in glaciers on the east slopes of the Rocky Mountains—remnants of ancient flights from the plains (Gurney, 1953). The first outbreak of which we have any record occurred in 1799–1800. There was another in 1808, and a large one in 1818, which wiped out the crops of the Selkirk Settlers near Winnipeg. A great outbreak continued from 1857 to 1876 (Mitchener, 1954). *M. spretus* was last seen in a small outbreak that occurred in Manitoba in 1902–03.

The early outbreaks of the Rocky Mountain grasshopper originated in the short-grass plains to the southwest and the grasshoppers invaded the parkland, where they laid great quantities of eggs. One or more generations developed before they died out. The grasshoppers in migration sometimes flew north and east beyond the parkland to the large lakes and heavily forested country, where they perished by drowning or from unfavorable habitat.

On August 17, 1800, Alexander Henry (Coues, 1897), on the south shore of Lake Winnipeg, a few miles east of the mouth of the Red River, recorded:

> The beach was covered with grasshoppers which had been thrown up by the waves and formed on continuous line as far as the eye could reach; in places they lay from 6 to 9 inches deep and in a state of putrefaction which occasioned a horrid stench.
>
> Again on July 25, 1808, at the mouth of the Pembina River: Swarms of grasshoppers have destroyed the greater part of the vegetables in my kitchen garden...
>
> The swarms appear about the 15th of June generally in clouds from the south and spread destruction, the very trees are stripped of their leaves.
>
> . . . They do not make such a formidable appearance every year.

The most graphic account of a grasshopper flight, which occurred in 1858 in the country west of the present town of Souris, Man., was given by Hind (1859, p. 44):

> On the second of July we observed the grasshoppers in full flight towards the north, the air as far as the eye could penetrate appeared to be filled with them. They commenced their flight about nine in the morning, and continued until half-past three or four o'clock in the afternoon. About that hour they settled around us in countless multitudes, and immediately clung to the leaves of grass and rested after their journey. On subsequent days when crossing the great prairie from Red Deer's Head River [now Antler River] to Fort Ellice, the hosts of grasshoppers were beyond all calculation; they appeared to be infinite in number. Early in the morning they fed upon the prairie grass, being always found most numerous in low, wet places where the grass was long. As soon as the sun had evaporated the dew, they took short flights, and as the hour of nine approached, cloud after cloud would rise from the prairie and pursue their flight in the direction of the wind, which was generally S.S.W. The number in the air seemed to be greatest about noon, and at times they appeared in such infinite swarms as to lessen perceptibly the light of the sun. The whole horizon wore an unearthly ashen hue from the light reflected by their transparent wings. The air was filled as with flakes of snow, and time after time clouds of these insects forming a dense body casting a glimmering silvery light, flew swiftly towards the north north east, at altitudes varying from 500 to perhaps 1000 feet...

> Lying on my back and looking upwards as near to the sun as the light would permit, I saw the sky continually changing colour from blue to silver white, ash grey and lead colour, according to the numbers in the passing clouds of insects. Opposite to the sun the prevailing hue was a silver white, perceptibly flashing. On one occasion the whole heavens, towards the south-east and west appeared to radiate a soft grey-tinted light with a quivering motion, and the day being calm, the hum produced by the vibration of so many millions of wings was quite indescribable, and more resembled the noise popularly termed 'a ringing in one's ears', than any other sound. The aspect of the heavens during the greatest flight we observed was singularly striking. It produced a feeling of uneasiness, amazement and awe in our minds, as if some terrible, unforeseen calamity were about to happen. It recalled more vividly than words could express the devastating ravages of the Egyptian scourges, as it seemed to bring us face to face with one of the most striking and wonderful exhibitions of Almighty power in the creation and sustenance of this infinite army of insects...
>
> In the evening, when the grasshoppers were resting from their long journeys, or in the morning, when feeding on the grass leaves, they rose in clouds around us as we marched through the prairie—if a strong wind blew they became very troublesome, flying with force against our faces, in the nostrils and eyes of the horses, and filling every crevice in the carts. But fortunately, comparatively few flew on a windy day, otherwise it would have been almost impossible to make headway against such an infinite host in rapid motion before the wind, although composed individually of such insignificant members...
>
> Those portions of the prairie which had been visited by the grasshoppers wore a curious appearance; the grass was cut uniformly to one inch from the ground, and the whole surface was covered with the small, round, green exuviae [feces] of these destructive invaders.

When grasshoppers occurred in outbreak numbers they formed an important food supply for many birds and mammals that do not normally feed on them. Coues (1874, p. 359) stated:

> Those [Swainson's hawk] that I shot after midsummer all had their craws stuffed with grasshoppers. These insects, which appear sometimes in almost inconceivable numbers, seem to be the natural source of supply for a variety of animals. Wolves, foxes, badgers, and even rodents, like gophers, supposed vegetarians, come down to them. Sand-hill Cranes stalk over the plains to spear them by thousands. Wild fowl waddle out of the reedy sloughs to scoop them up. We may kill scores of Sharp-tailed Grouse, in September, to find in every one of them a mass of grasshoppers.

Norman Criddle (unpublished manuscript) pointed out the importance of grasshoppers in maintaining other forms of life. Grasshoppers are eaten by many birds and mammals, which do much to control the numbers of grasshoppers, but it is not generally realized that these predators would perish without grasshoppers for food or would have to feed on other forms of life. The upland plover and to a lesser extent the western meadowlark and horned lark depend on grasshoppers for food for their young. The sharp-tailed grouse flourishes in dry years when there are plenty of young grasshoppers for their chicks. Crows and such hawks as the Swainson and sparrow hawks eat large numbers of grasshoppers and when this food is not present turn to small birds, their young, and rodents for food. Grasshoppers thus act as buffers in the food chain.

Grasshopper flights such as described by Hind have not occurred since the great outbreak of 1857-76 and *Melanoplus spretus* has not been recorded since 1902. Parker (1930) and Norman Criddle considered it was a long-winged form of *M. bilituratus* produced by a dry diet and by overcrowding. Gurney and Brooks (1959), however, consider that it is a distinct species that is now extinct. Conditions in the short-grass prairie region, which Parker and Criddle considered necessary for production of a long-winged form of *M. bilituratus*, apparently were required by *M. spretus*. Their elimination by settlement contributed to the extinction of the species. Before settlement, buffalo by grazing, trampling, and making dust wallows created favorable egg-laying sites and the dry prairie

grass provided the principal food. With settlement buffalo were replaced by cattle, which do not make dust wallows. The prairie was more closely grazed with the resultant reduction of various grass species and the introduction of weeds, but the most important change in food supply was the breaking of land and the planting of crops, which provided green food in place of the dry prairie grass.

Cole (1956) indicated that the bumble bee *Bombus terricola* Kirby and the leaf-cutter bees *Megachile frigida* Smith and *M. inermis* Prov. are finding alfalfa a good source of pollen and have become efficient cross pollinators by tripping the blossoms. Thus the introduction of this crop has favored their increase. Land clearing by burning provided nesting sites for the leaf-cutters, in dead logs, but as the fields were enlarged logs were destroyed and nesting habitat for leaf-cutters and bumble bees was destroyed. This has resulted in such a reduction in the bee population that alfalfa seed production has become unprofitable in many areas.

Animals That Increased because of Man-made Changes

Although many animals were reduced in numbers by changes brought about by the white man, others found these changes beneficial. Because of improved habitat and the introduction of new food plants, species such as the white-tailed deer, the jack rabbit, the pinnated grouse, and the Colorado potato beetle extended their ranges into the parkland; and native species of grasshoppers, wire worms, cutworms, and the wheat stem sawfly increased to become pests of agricultural crops.

The white-tailed deer, *Odocoileus virginianus* (Fig. 28), did not occur in the aspen parkland at the time of the first white traders, except possibly at its southern tip in Minnesota. Henry (Coues, 1897) in his travels, in 1801, in Marshall County, Minnesota, near the present town of Warren, stated:

> Red deer were very numerous, and for the first time we saw numerous tracks and roads of the fallow deer or chevreuil (*Cariacus virginianus*), which we soon perceived jumping in every direction. . . Red and fallow deer are very numerous. They have beaten paths in the woods like those of the buffalo on the banks of Red River.

He was probably referring to the white-tailed deer, though he may have confused it with the mule deer, *Odocoileus hemionus*, a race of which is believed to have inhabited this area at that time.

Seton (1909), speaking of white-tailed deer, stated: "Unknown in the province [Manitoba] until about 30 years ago, since then it has greatly increased, following the settlers; now found wherever there are settlements adjoining woods." In the district about Brandon, Manitoba, the white-tailed deer was unknown at the time of settlement in 1880-1900, but scattered individuals were seen a few years later. The mule deer was the common deer at that time. In the Tiger Hills, 40 miles south of Brandon, settlers reported that in the 1880's half the deer were white-tail and half mule. The white-tail flourished under settlement, where it had protection from wolves and hunting was restricted to the shooting of bucks only during a short season. Aspen groves interspersed with cultivated fields provided an ideal habitat. It extended its range to the limits of settlement and had replaced the mule deer, except on a few isolated ranges of wooded hills, by 1925. Once firmly established the white-tail continued to increase to the point of overpopulation, as it had done in other parts of its range. This became evident in the winters of 1948-49 and 1955-56, when there was deep

snow. Deer gathered in groups in river valleys and other favored wintering areas, browse was depleted, and starvation occurred. The winter following 1948-49 was mild with light snowfall and the population quickly recovered. A hunting season for both sexes was declared in 1951, but in spite of a heavy kill another good winter and fawn crop brought their numbers back almost to those of 1948. Recovery from the severe winter in 1955-56 was also rapid.

White-tailed deer are very specialized feeders, much more so than elk. When they occupy a range with elk they are unable to compete with the elk and populations are much smaller than where only deer are found. Deer prefer broad-leaved plants in summer. In winter they browse on choke cherries, pin cherries, and saskatoon. In districts where *Juniperus horizontalis* is found in abundance they paw through a considerable depth of snow to reach it. They also feed on oak mast wherever it occurs and browse on oak twigs in winter. In the spring they graze on fields of fall rye, as it is often the only green forage available at that time. They feed on the ripened heads of grains and flax. In fields adjacent to good deer habitat, they may damage standing, swathed, and stooked grain.

White-tailed deer feed on sweet clover, and where areas of abandoned land support a heavy growth they bed down in it and remain there for long periods. They have invaded the heavy stands of *Phragmites communis* about the south end of Lake Manitoba and in the Big Grass Marsh. This grass provides shelter, and nettles and sow thistle provide the principal food. Under such conditions the deer become semi-aquatic, wade belly deep in water, and swim without hesitation.

Intensive mechanized agriculture is rapidly depleting deer habitat, particularly with the use of the bulldozer in land clearing. Many aspen groves that had been allowed to remain in and about fields are now being bulldozed out and deer are being forced to seek shelter in woodlands along river valleys and in nonarable districts.

The future for the white-tailed deer in southern Manitoba appears to be a reduced population due to reduced habitat. It would be advantageous to leave groves of aspen for protection from wind and water erosion and to provide deer habitat, but the pressure for more land under the plow is too great. In the remaining habitat, good management practices must be carried out to conserve the deer and at the same time prevent overpopulation and the depletion of browse and resultant starvation. It may be that as settlement is pushed farther north to the edges of the Pre-Cambrian shield the deer range will continue to expand and more habitat will be made available on nonarable land adjacent to settlement. Deer will occupy the mixed deciduous-coniferous forest in the Pre-Cambrian shield if given protection from wolves, as is evidenced in the Whiteshell country of southeastern Manitoba.

Harold Wells (Conservation Officer, Game Branch, Manitoba Department of Mines and Natural Resources, The Pas. In litt. 1948) reported on the invasion of mule and white-tailed deer into The Pas area in northern Manitoba and replacement of the mule deer by the white-tail:

> 1914. First deer killed in The Pas area. These deer were all mule deer and came from the Pasquia Hills.
>
> 1920. Mule deer common and white-tails first appearing. These latter came from the Pasquia Hills to the west and also from the south, following the two streams which point to The Pas, the Carrot River and Pasquia River.

81314–7—7

1925. Mule deer scarce. White-tails abundant and trying the country to the north.

1930. Mule deer replaced by white-tails. White-tails reach highest point of abundance.

1948. White-tails static, limited by wolves and hunters. Floods drive the white-tails out of the Saskatchewan River Valley to higher ground. Flood damage to browse plants severe.

We might add that the population of white-tails in The Pas area is nothing like as large per acre of habitat as that in the Swan River and Birch River areas, just to the south of the reported area.

To the east of The Pas about Cedar Lake I saw a recently killed mule deer in 1950, and Indians reported them as more numerous than the white-tail but not common. The white-tail may continue its spread and replace the mule deer here also. At Wanless, 30 miles north of The Pas, white-tailed deer became common when some of the forest was cleared in 1954, and the land was planted to alfalfa.

The white-tailed jack rabbit, *Lepus townsendii campanius* (Fig. 16), which is a hare, increased with agriculture and extended its range. Seton (1929) gave a history of its invasion into Manitoba from farther south and west. In travels throughout southwestern Manitoba in 1883, Seton did not see a single jack rabbit. One was reported from Boissevain in 1881 and another at Fort Ellice in 1885. Since then they increased and extended their range. At Carberry the first one was shot in 1892, and by 1897 they were so plentiful one could see 15 to 20 in a mile. Near Winnipeg the first one was seen in 1896 and at Stony Mountain in 1898.

The jack rabbit feeds, makes its bed, and raises its young in cultivated fields as readily as in its native prairie. Its range has continued to increase and it is now found as far north as Swan River. When snow covers its normal hiding places in winter, it seeks the shelter of isolated patches of willow or aspen, where it makes its bed on hard-packed drifts of snow from which it can readily escape by running out into the open. Well-packed trails lead from resting to feeding areas. It digs burrows in snow banks and takes refuge in badger holes when escaping from winged predators, goshawks, and eagles, but prefers to run from four-footed and human enemies. It fluctuates considerably in numbers, but not in the same rhythm as the snowshoe rabbit. During the early 1930's it occurred in great abundance and it was common to see as many as 50 at one time. For the past 20 years numbers have been much lower. One reason for their present low numbers is the value of their skins. Prices of from 50 to 75 cents are worth while to farm boys. They are also used as human food and are fed in fox ranches. They, as well as the snowshoe rabbit, are the alternate hosts of the bladder tapeworm found in dogs, coyotes, and foxes.

The raccoon, *Procyon lotor* (L.), is found along the wooded streams of the parkland. Henry (Coues, 1897) recorded 14 to 25 skins yearly from the returns of Portage la Prairie and as many as 63 (1805-06) at Pembina. During recent years it has increased. Tracks are common along the Assiniboine and Souris rivers in western Manitoba. Its fur is at present of little value, and it is seldom killed except when it raids chicken houses. Its increase is limited by the availability of hollow trees for denning sites.

The greater prairie chicken, *Tympanuchus cupido pinnatus* (Brewster), entered the parkland with settlement. There were no prairie chickens in Manitoba or Minnesota in the days of the early explorers. They were favored by the

presence of grain fields and advanced westward and northward with settlement (Roberts, 1932). Near Winnipeg the first specimen was taken in 1881. By 1884 it was common at Winnipeg and Portage la Prairie. In 1886 it reached Carberry (Seton, 1909; Cooke, 1888). After an initial increase the prairie chicken declined in numbers because of over-shooting and destruction of nesting sites by intensified agriculture. It is now a very rare bird.

The crow, *Corvus brachyrhynchos brachyrhynchos* Brehm, is a very common summer resident of the parkland, which with its groves of aspen and willow makes a favorable nesting area. It ranges over prairie, cultivated fields, and sloughs to feed. When the young leave the nest they go off with their parents in family groups. Soon families join company and by August small flocks have grown to big flocks in preparation for migration. These large flocks remain for some time before departing. At such times they consume large quantities of grasshoppers when these insects are abundant. Norman Criddle (1925) considered the crow, because of its insectivorous diet, highly beneficial to the farmers. Before settlement, when tree growth on the uplands was kept at a minimum by repeated fires, crows resorted to wooded river bottoms. This was noted by Coues (1874).

Many authors—Taverner (1926), Roberts (1932), Phillips (1928), Hales (1927), Farley (1932), Kalmbach (1937), Hochbaum (1944), Sowls (1955), and others—recorded the spread of crows with agriculture and the increase in their numbers in the aspen parkland. This increase was brought about by an increase in food supply and nesting sites. Cultivated fields and pastures provided an abundant supply of grain, weed seeds, and insects. Dead livestock, birds and animals killed on highways, and refuse in garbage dumps provided readily available food. Nesting sites increased with settlement because of the checking of prairie fires and the spread of aspen groves. Schorger (1941, p. 105), speaking of areas adjacent to the prairie but south of the parkland stated:

> There is general agreement that the crow, in both Wisconsin and Illinois, was a comparatively rare bird in the prairie regions until the latter were brought under cultivation. Agriculture not only provided more food but permitted the growth of forests previously prohibited by prairie fires.

As settlement moved north into the continuous forest stands at the northern portion of the aspen parkland, clearings were made which provided the forest edge environment important to crows. The crow population probably reached a peak in Manitoba in the 1930's and '40's, since when there has been a gradual decline. There are few statistical data on comparative populations in recent years but it is the impression of reliable observers and old timers, such as Stuart Criddle (1956), that crows are definitely less numerous. A. H. Shortt (Ducks Unlimited (Canada), Winnipeg, Man. In litt. 1956) also has observed a decrease in recent years and agrees with me that intensive crow control campaigns in Canada and the United States might have had effect on the overall population, but opinions among authorities differ widely and there is no proof that this has actually taken place. He stated that Ducks Unlimited questionnaire returns indicated a slight decrease of crow populations.

Phillips (1928, p. 147) stated:

> The crow has increased rapidly during the past few years in the newer agricultural districts [near Edmonton, Alberta]. It may already have reached its maximum. It does not appear to be a problem in the older settled districts.

Land clearing, in recent years, has eliminated many small groves of trees and has reduced crow nesting sites over considerable areas of the parkland. This

81314–7—7½

may have been partly compensated for by the opening up of forested land by land clearing in more northern areas.

Swallows—the cliff swallow *Petrochelidon pyrrhoonta* (Vieillot); the barn swallow, *Hirundo rustica erythrogaster* Boddaert; the bank swallow *Riparia riparia;* and the tree swallow, *Iridoprocne bicolor* (Vieillot) are common insectivorous birds of the parkland whose nesting activities have been greatly influenced by settlement.

The cliff swallow nests in colonies on cliffs where the mud nests are protected from rain. Natural sites are not plentiful in the parkland. Buildings and bridges, however, provide ideal locations and have been freely utilized by the swallows. Emlen (1954), who conducted studies in the Jackson Hole area in Wyoming, had 18 colonies under observation. Of these, eight were under the eaves of buildings, four under concrete culverts, three under ledges on large concrete bridges or dams, one on steel girders under a steel-wood bridge, one in a natural limestone bank, and one in a sand bank. About the same ratio would be expected in Manitoba.

Roberts (1932) reported a change in cliff swallow abundance in Minnesota associated with human activity. Before settlement the swallows nested in colonies on cliffs. Large wooden frame barns and buildings erected by settlers were quickly adopted for nesting sites and the population increased. This was followed by a reduction in numbers for two reasons. First, as farmers became more prosperous they painted their barns and destroyed the nests, which they considered unsightly. Secondly, the introduced house sparrow usurped the nests for its own, and the swallows were not able to defend themselves. They were hence forced to return to their original nesting sites. In more recent years they have found concrete bridges and girders to their liking and have begun to increase. Many bridges in Manitoba now have nesting colonies.

The bank swallow has had somewhat the same history as the cliff swallow in relation to man. In primitive times their only nesting sites were clay or sand banks along streams where they could excavate their nesting tunnels. As man commenced road building, vertical banks were formed in road cuts and gravel pits. Many of these were quickly adopted by swallows, resulting in a considerable increase in population. In recent years road cuts along main highways have been cut back to a gradual slope and planted to brome grass, thus destroying the nesting sites. Gravel pits are still used when the birds are not disturbed by further excavating. When colonies are near buildings some nests have been usurped by house sparrows.

The barn swallow in the parkland is entirely dependent on man for nesting sites. According to Roberts (1932) it did not nest in northern Minnesota before settlement. Seton (1909) recorded it as a rare bird that was then just beginning to increase. It does not nest in colonies but constructs single, cup-shaped nests on the rafters and walls inside outhouses and buildings where the birds can gain entrance. They are also very partial to bridges and large culverts. It has become so closely associated with man that it might be considered semidomesticated. It does a great deal of good by destroying many destructive and annoying insects, including house flies, horse flies, and mosquitoes.

The tree swallow nests in holes in trees, such as old woodpecker holes, and takes readily to bird boxes. Man has increased its abundance indirectly through use of cedar telephone poles, which are excavated by the flicker for nesting sites;

the deserted holes are in turn used by tree swallows. Many bird lovers also erect bird boxes. Roberts (1932) reported it as consuming about 20 per cent vegetable matter, made up of berries of Virginia creeper and other plants and a small quantity of seeds.

The purple martin, *Progone subis* (L.), is commonest in eastern Manitoba. It occasionally nests in old woodpecker holes away from dwellings but is almost entirely dependent on apartment-type nesting boxes erected by man. It consumes a great variety of insects, particularly ants. I once observed winged ants taking off from a colony on a lawn near a martin house. As fast as the ants took to the air they were caught by the martins.

Swallows, except the purple martin, form enormous mixed flocks in preparation for migration. At such times they assemble near marshes where insect food is abundant. They rest in trees or rushes but prefer telephone and power lines when available. The wires may be covered with swallows as close as they can sit for several hundred yards. Such concentrations are common at the south end of Lake Manitoba.

The Colorado potato beetle, *Leptinotarsa decemlineata* (Say), extended its range into the parkland after the introduction of the potato. Chittenden (1907) stated that its original food plant was the buffalo bur, *Solanum rostratum* Dunal, and the center of its distribution Colorado. When the potato was introduced by settlers, the beetle fed on it in preference to the buffalo bur and became a serious pest. In 1859 it was recorded from Nebraska and by 1874 it had spread eastward through the northern states and southern Canada to the Atlantic coast. Gibson *et al.* (1925) recorded its first appearance in Ontario in 1870, in Nova Scotia in 1881, in Manitoba in 1887, in Alberta in 1900, and in British Columbia in 1919. In Manitoba the beetle has encountered climatic conditions that may limit its abundance. It is here limited to only one generation a year, whereas in other localities it may have two generations. In Manitoba adults over-winter, emerge in the spring, and lay eggs. The resulting larvae mature and produce adults, most of which hibernate. A few may lay eggs but the resulting larvae are killed by frost. In the average winter there is sufficient snowfall to protect the hibernating adults, but if there are severe frosts before there is sufficient snow to give protection there may be heavy mortality. Norman Criddle (1917) recorded that in the winter of 1914-15 there was very little snow. In districts with less than three inches of snow all hibernating beetles died from frost. In districts where there was more snow many survived and where there was over a foot of snow none died from frost. Districts where the beetle was eliminated were slowly repopulated from the surrounding areas. At Treesbank, Manitoba, however, Criddle reported they were still scarce in 1916. In isolated areas the beetles may be introduced and breed for a number of years. If they are killed by frost, it may be many years before they are again introduced. Severe infestations were reported in the area about The Pas, Manitoba, in 1942 but they have not been found there since.

The Colorado potato beetle is noteworthy in that it became a pest before chemical control measures had been developed. The first chemical to be used for insect control in North America, paris green, was demonstrated as being effective against the beetle in 1869 but it was some years before methods of application were developed.

As new crops are introduced, native insects feeding on closely related plants may find them attractive and become pests of importance. Since 1940, sunflowers have been grown on considerable acreages in southern Manitoba and two native insects have become pests (Westdal and Barrett, 1955). The banded sunflower moth, *Phalonia hospes* (Wlshm.), feeds on sunflower pollen and seeds in its larval stages, and the larva of a fly, the sunflower maggot, *Strauzia longipennis* (Wied.), mines in the pith. The native hosts of both these insects are wild sunflowers; the common sunflower, *Helianthus annuus* L.; the narrow-leaved sunflower, *H. maximilianii;* and the tuberous-rooted sunflower, *H. subtuberosus* Bourgeau.

The wheat stem sawfly, *Cephus cinctus* Nort., is a native insect that has become a major pest of wheat. It was first collected from wheat at Indian Head, Sask., in 1895 by Dr. James Fletcher. Fletcher (1897) reported that it caused injury to wheat at Indian Head in 1897 and at Souris, Man., in 1896. Norman Criddle studied it in its early adoption of its new host. He (1911) stated:

> This is an insect that usually confines itself to native grasses upon which it subsisted entirely before the introduction of grain; its food plants being species of the genus *Agropyron*—especially [awned wheat grass] *A. caninum* [=*subsecundum* (Link) Hitchc.]. Happily *A. tenerum* [western rye grass], which is now so extensively grown in western Canada, has proved almost immune, due, no doubt, to its more slender stems. This sawfly, however, readily adapts itself to new conditions and having once become established, seems to have a preference for the plants that it fed upon in its early stages. In 1906 owing to a failure of its native food plant to produce heads, it swarmed to the wheat fields, where it soon became established and, in some cases, where proper precautions were not taken, remained ever since.

This is a very important observation. One wonders how often the failure of a native food plant to mature properly in one year may have influenced an insect to move into a cultivated crop, which it then preferred.

Criddle (1915) continued his studies and showed how dependent the sawfly, when on its native hosts, was on stem size and how this size was in turn dependent on abundant moisture. The sawfly hence fluctuated in abundance with weather. After grain fields were available for alternate oviposition sites stems of sufficient size were always available but weather changes also affected the grain. In 1914 during a severe drought, wheat ripened prematurely, resulting in the killing of a number of larvae, and the stunting of many more. He also noted that sunshine was necessary for ovipositing and that activities were much retarded at temperatures below 60°F. A cold cloudy period at the time of oviposition might prove as disastrous as a very dry one. The years 1906 and 1907 were the turning point in its development as a pest. In these years there was a high population of sawflies with the result that practically every stem of *Agropyron* spp. and *Elymus canadensis* L. was infested. There were more sawflies than the native grasses could accommodate. Consequently they invaded fields of wheat and rye, which suffered severely. After this original heavy infestation the sawflies changed their habits and selected wheat and rye in preference to the wild grasses.

Of cultivated plants, hard spring wheat, winter wheat, and spring rye are the most susceptible to the sawfly. Durum wheat is resistant. Barley, owing to its quicker growth and late date of planting, usually escapes the main attack but is not immune. Similarly, fall rye and oats are often heavily attacked but are resistant to damage. Speltz is also a suitable host, but oats are not attacked.

Timothy is sometimes attacked. Although *Agropyron richardsonii* (=*subsecundum*) and *A. smithii* are the favored wild hosts, species of *Elymus* and *Calamagrostis*, *Deschampsia caespitosa*, and *Hordeum jubatum* are also attacked. Criddle (1917) pointed out that *A. richardsonii* is the most important host in the eastern districts, but that *A. smithii* is the more important farther west. The latter is much influenced by rainfall in the size of stems it produces. At times of drought they are seldom large enough to accommodate sawfly larvae, under normal rainfall a third of the stems are suitable, and at times of heavy rainfall as many as 90 per cent may be satisfactory. Criddle also made an observation on the importance of couch grass in the spread and establishment of the sawfly. Even in 1917, ten years after the sawfly had become a major pest of grains, it still did not appear to be fully adapted to cultivated hosts. Its population dropped to low numbers because its native hosts had been reduced by increased acreage under the plow. It was saved and propagated by couch grass, whose stems were suitable. This plant, which is difficult to eradicate and is spread over the fields by tillage implements dragging the living rhizomes, had now become widespread over many fields. It was probably a greater menace as a breeder of sawflies than any other grass.

By 1920 another grass appeared that had an important influence on the future of the sawfly in Manitoba, namely, brome grass, *Bromus inermis*, of Hungarian origin, which was introduced into North America in 1880 (Dolan, 1956). It was planted extensively as a pasture and forage grass and escaped to populate headlands and roadsides. Criddle (1922) stated:

> There are three important grasses being grown by farmers on the prairies at the present time; they are timothy, western rye-grass, and awnless brome. All of these are severely attacked by the sawfly but only two are of much importance as sawfly carriers, timothy being cultivated chiefly outside the insect's present range. Of the two remaining, both of which are heavily attacked, only rye-grass has been found to mature the sawflies in large numbers. Our studies in 1921 showed that about 42% of the insects matured in western rye-grass in comparison with only 7% in brome grass. Secondly, that rye-grass reared parasites to the extent of 38% as against 54% in brome grass. It will be noted that brome grass appears to be of particular value in controlling the sawfly because it induces large numbers to lay their eggs in it instead of flying to the growing grain, while of the larvae thus started in their career only a very small percentage survive. Thus the evidence indicates that brome grass is not only a valuable fodder plant but also an important one in assisting to control the western wheat stem sawfly.

Criddle's predictions proved correct. After peak populations in the 1920's the sawfly ceased to be a major pest in Manitoba. In the short-grass plains of Saskatchewan and Alberta, it had previously occurred in very low numbers on account of the scarcity of native grasses with sufficiently large stems. Here, when wheat was grown without rotation it became and still is a major pest. In Manitoba, crop rotations of hard spring wheat with durum wheat, barley, oats, flax, sweet clover, and brome-alfalfa mixtures reduced the sawfly to small numbers. Brome grass has become a weed and has spread extensively over field margins, roadsides, and disturbed prairie and woodland. It is planted by highways and municipalities for erosion control. The abundance of brome grass helped to reduce the sawfly. Also, with improved implements and knowledge, farmers are better able to control couch grass and thus reduce its importance as an alternate host in grain fields.

Grasshoppers, *Melanoplus bilituratus*, *M. bivittatus* (Fig. 51), and *Camnula pellucida*, and to a lesser extent *M. packardii* and *M. femur-rubrum*, have become pests as a result of agricultural practices.

To gather detailed information on the ecology of grasshoppers and how they increase under conditions of intensive cultivation, two study centers with resident observers were operated by the Canada Field Crop Insect Laboratory, Brandon, Man. One was established in 1935 at Arnaud on heavy clay soils of the Red River Valley, where *M. bivittatus* and *C. pellucida* were abundant. A second center was established in 1936 at Lyleton in southwestern Manitoba, where *M. bilituratus* associated with *C. pellucida*, *M. bivittatus*, and *M. packardii* were the principal species. The Lyleton center was located on the light and sandy loam of glacial Lake Souris at a period of extreme drought and wind erosion and during a major grasshopper outbreak.

Allen (1939) reported that the main concentrations of *Melanoplus* nymphs at Lyleton were found in abandoned, weedy fields, in weedy stubble fields, and on drift ridges and road allowances covered with drift soil. Russian thistle, *Salsola pestifer*; false ragweed, *Iva xanthifolia*; Canada fleabane, *Erigeron canadensis* L.; wild buckwheat, *Bilderdykia* (= *Polygonum*) *convolvulus*; and biennial wormwood, *Artemisia biennis*, provided early spring food and shelter for the nymphs. As the grasshoppers matured and began to fly, about the middle of July, they spread widely and fed on cultivated crops as well as weeds. With the maturing of vegetation they again became more localized. Concentrations were first found in late crops of wheat, oats, or barley; and, as these crops were cut, in weedy stubble fields, corn, and weedy sweet clover fields. Russian thistle was favored by the adults because it matured late and irregularly and provided succulent food until early September, when the population declined. For this reason stubble fields with a heavy growth of Russian thistle supported a heavy late-season population of the migratory grasshopper.

Lactiferous plants, such as blue lettuce, *Lactuca pulchella*; ridge-seeded spurge, *Euphorbia glyptosperma* Engelm.; and also skeletonweed, *Lygodesmia juncea*, were important grasshopper food plants in August. The last two plant species were attacked chiefly by *M. bilituratus* and *M. packardii*, whereas *M. bivittatus* favored the blue lettuce. In all cases observed more than half the individuals were females. Swarms of grasshoppers concentrated on individual plants and destroyed them.

Abandoned fields reverting to couch grass, *Agropyron repens*, had low nymphal populations but were flooded by a general population spread as the season advanced. Couch grass was apparently attractive to *M. bilituratus* because of its succulence. It remains more succulent than other grasses during drought but eventually desiccates during long periods of extreme drought. It revives quickly with light rains and again becomes attractive.

Brome grass, *Bromus inermis*, is attractive to grasshoppers when mowing promotes an autumn growth. There was a noticeable movement of grasshoppers to road allowances in August because mown brome provided succulent food.

Grasshoppers retreated to dense patches of snowberry, *Symphoricarpos occidentalis*, when other vegetation desiccated with drought. They fed on snowberry to some extent but preferred grasses growing among it. S. E. Clarke, Canada Experimental Farm, Swift Current, Saskatchewan, who made a plant survey of the area, pointed out a definite plant association that provided a late-season habitat. Among the patches of snowberry the grasses *Agropyron smithii*

and *A. repens* grow more lush, and *Poa pratensis*, *P. palustris*, and *Agropyron trachycaulum*, which require more humid conditions, are found. Clarke considered that, by holding more snow in winter, snowberry provides more soil moisture and a cooler and moister habitat.

In the Lyleton area, fields were badly wind-blown, creating high ridges of drift soil among the vegetation along the fences and headlands. These drift ridges made ideal sites for grasshopper egg laying. Allen reported them as being favored by *M. bilituratus* because they were composed of coarse-to-fine sand intermixed with silty clay and were markedly different in texture from the soil type of the area. He found an average of 1.56 egg pods per square foot on drift ridges as compared with 0.88 per square foot on road allowances, covered with varying amounts of drift soil, and 0.5 in fields. The south-facing slopes of the drift ridges were more favored, having an average of 2.42 egg pods per square foot as compared with 1.29 and 1.26 for east and west slopes and 0.96 for north slopes. The grasshoppers sought the warmer slopes, where on warm sunny spots sheltered from the cool northerly winds they could oviposit on cooler days. Allen pointed out, however, that newly formed drift ridges with loose soil are not so attractive for egg laying sites as older ones that have become firm. In a year or so, they become covered with vegetation and are less attractive. The same soil condition applies to cultivated fields. Fields that are well worked and have loose soil contain fewer grasshopper eggs than fields that have firm soil. Plowing or cultivation with the oneway disk or the duck-foot cultivator sufficient to kill all weed growth loosens the soil, reduces the grasshopper population, and kills nymphs by starvation and exposure to heat and desiccation.

The Arnaud study center was established on the heavy clay soils of glacial Lake Agassiz, on land that had only recently been drained from a wet meadow and put into cultivation. As in the Lyleton area, a grasshopper outbreak was present. Moore (1936), who was resident observer, reported that according to farmers resident in the area since 1899 grasshoppers were not troublesome until 1930. Grasshoppers became pests as a result of man-made changes, drainage, drying up of the soil, and change in plant dominants. The vegetation on the better drained areas consisted of *Agropyron smithii* and *Poa* spp. sod, whereas that on wetter areas was mostly *Spartina pectinata* (=*michauxiana* Hitchc.). The former supported the heaviest populations of *Camnula pellucida*. Timothy and brome that had become abundant on roadsides supported both *C. pellucida* and *M. bivittatus*. *M. bivittatus* was found over the whole area except in pure stands of *Spartina pectinata*, which it only entered for shelter from high winds. *M. bivittatus* was found in disturbed areas such as roadsides and ditch banks, with the greatest concentrations among areas of brome, false ragweed, ragweed, lamb's-quarters, *Poa*, spp. timothy, snowberry, and mixed grasses.

M. bivittatus fed on sow thistle, dandelion, false ragweed, giant ragweed, lamb's-quarters, timothy, brome, *Poa* spp., dock, willow, rushes, and slough grass (*Beckmannia syzigachne* (Steud.)). Snowberry was stripped of its leaves by adults when other food was scarce. *Spartina pectinata*, couch grass, asters, goldenrod, and barnyard grass, *Echinocloa crusgalli* (L.) Beauv., were hardly touched. False ragweed was preferred to lamb's-quarters and stinkweed, *Thlaspi arvense*.

Smith (1938) also reported on the food preference of *M. bivittatus* for mustard and considered its abundance important as a nymphal food. He observed that

this food preference was more noticeable in the spring but continued throughout the year and that concentrations of nymphs were associated with mustard about the borders of crops. In a sweet clover field concentrations up to 30 per square yard were found in August in patches of mustard growing where stocks had stood the previous year. Young millet associated with the mustard was practically untouched. Wild buckwheat, *Bilderdykia convolvulus*, was a favored food when abundant.

In contrast to the wide range of food plants eaten by *M. bivittatus*, *C. pellucida* fed only on grasses. Both species invaded grain fields and did extensive damage to these crops.

Concentrations of *M. bivittatus* on blue lettuce, *Lactuca pulchella*, were recorded by Smith (1938). A number of individuals would attack a plant, eating first the flowers, then the leaves and stem, and finally follow the stem right into the ground. They would fight for a place on one plant while another plant alongside would be untouched. Blue lettuce carries a large supply of latex and possibly served as a moisture reservoir at the time of the year when other plants were becoming dry and before seedlings of winter-annual weeds appeared in the stubble fields.

In gardens, Moore (1936) reported *M. bivittatus* feeding on potatoes, beans, cabbage, corn, and black currant. Squash, tomatoes, and plum were not attacked.

For oviposition sites *M. bivittatus* prefers south-facing ditch banks, where during cool days they are active in sheltered sunny spots.

Wireworms and cutworms are native, soil-inhabiting insects that have become major pests. Breaking of the native sod and cultivation has made conditions more favorable to them than to their enemies, as they are able to move freely below the surface in loose soil. Some idea of the importance of these insects as pests is given by McDonald (1954).

> These soil-inhabiting spring pests destroyed 4.30% of the crop. This was slightly more than in 1952, but less than in 1950 or 1951...The value of the crop destroyed [in Saskatchewan] by wireworms and cutworms in 1953 was almost 27 million dollars, as compared with 38 3/4 and 35 1/2 million dollars in 1951 and 1952, respectively.

Even though a great deal of this damage occurred in the true prairie rather than the parkland, losses in the parkland were large. The prairie grain wireworm, *Ctenicera aeripennis destructor* (Brown) (Fig. 52), is the principal species. Its native habitat is a bunch-grass formation in friable soil. It is able to increase in land that is continually cropped and grass is not necessary for its increase. It is usually found in medium-textured soils, not in sandy land, and only in heavy soil when it is kept loose by cultivation. The second most important species of wireworm, *Cryptohypnus nocturnus* (Eschscholtz), is favored by the abundance of the introduced *Agropyron repens*, which has invaded many fields, also by *Hordeum jubatum*, and increases in land which has temporarily been abandoned (King, 1926).

The red-backed cutworm, *Euxoa ochrogaster* (Guen.); the striped cutworm, *Euxoa tessellata* (Harr.); the white cutworm, *Euxoa scandens* (Riley); the armyworm, *Pseudaletia unipuncta* (Haw.); and the bertha armyworm, *Mamestra configurata* Wlk., are all cutworms that have invaded cultivated fields in sufficient numbers to do extensive damage to a variety of crops.

The beet webworm, *Loxostege sticticalis* (L.), similarly is favored by agriculture. It feeds on many of the broad-leaved weeds, particularly lamb's-quarters, but also attacks flax, sugar beets, sunflowers, and many garden plants. It passes the winter as larvae spun up in silk-lined cells in the loose soil of the fields.

Changes in harvesting methods have resulted in grain going into storage at a higher moisture content. This has led to an increase in infestations of the rusty grain beetle, *Laemophloeus ferrugineus* (Steph.), the so-called fungus beetles *Cryptophagus* spp. and *Lathridius* spp., and mites that feed on grain in storage. F. L. Watters (In Charge, Canada Stored Product Insect Laboratory, Winnipeg, Man. In litt. 1957) stated:

> The combine harvester is used almost exclusively now compared with the threshing machine of 15-20 years ago. One result of this change in farming methods is that wheat, formerly stored at 12 to 13 per cent moisture content, is now being harvested and stored at between 13 and 15 per cent moisture content. The fear of crop losses through early frosts in autumn has led many farmers to cut their crops before they are fully mature. This, together with the use of combines during wet weather, has intensified insect problems concerning stored grain.

Several species of insects invade the parkland from the south from time to time, but although they reproduce during the summer they are unable to survive the winter. The corn earworm, *Heliothis zea* (Fig. 53), appears practically every year and attacks sweet and field corn. Three species of aphids—the greenbug, *Toxoptera graminum* (Rond.); the corn leaf aphid, *Rhopalosiphum maidis* (Fitch); and the English grain aphid, *Macrosiphum avenae* (F.)—overwinter in the winter wheat area of the southern United States but occasionally, when conditions are favorable, migrate into the parkland in sufficient numbers to cause severe damage to grain crops. The painted-lady butterfly, *Vanessa cardui* (L.), emigrates to wintering grounds in the southern United States and immigrants return in the spring. It fluctuates greatly both in abundance and in extent of its summer range. Canada thistle, *Cirsium arvense*, a common introduced weed, is its favorite host but it also feeds on hollyhocks and commercial plantings of sunflowers (Bird, 1956).

Several species of birds adapted themselves to changes brought about by settlement and have increased for various reasons.

Two common gulls are nesters in the parkland: the herring gull, *Larus argentatus* Coues, and Franklin's gull, *Larus pipixcan* Wagler. The former nests on rocky islands in the larger lakes. It feeds on garbage dumped by boats, dead animal matter washed up on the shore, and some insects and rodents. It ranges inland during migration and sparingly at other times. At such times it picks up food in the fields and flocks around city garbage dumps. Franklin's gull is a common bird of the parkland. It nests in colonies in rushes about the larger lakes and flocks range out to feed over cultivated land. It has adapted itself well to agriculture, which has greatly increased its food supply. It is common to see flocks of birds closely following plows and other agricultural implements to pick up insects brought to the surface. When grasshoppers are abundant, flocks systematically work fields and consume enormous quantities of these insects, When the young take to the wing, the flocks do not return to the larger lakes at night but water at small sloughs and ponds. They are important destroyers of agricultural pests and have no harmful habits other than possibly the destruction of dragonfly nymphs, which feed on mosquito larvae.

They have probably increased in numbers because of their close association with agriculture. Their chief enemy is apparently botulism, to which they are more sensitive than ducks. In 1954 I investigated an outbreak of botulism in a colony at the south end of Lake Manitoba. At that time large numbers of young and a few adults died. Another outbreak of botulism occurred in 1958.

The mourning dove, *Zenaidura macroura*, has found an abundant supply of food made available by agriculture. It is tame and confiding and readily enters towns and villages, where it nests in shade trees. In the country, where there is not the menace of cats and dogs, it often nests on the ground. Several broods may be raised in a year.

The western house wren, *Troglodytes aëdon parkmani* Audubon, is the common wren of the parkland, and like many other birds it has adopted man and nests in many places about outbuildings, machinery (the twine box on most binders has a wren's nest), tin cans, boxes, etc. It takes readily to bird houses but still nests in the wild state in old woodpecker nests and other cavities.

The catbird, *Dumetella carolinensis*, and the brown thrasher, *Toxostoma rufum*, are two beautiful song birds that nest near human dwellings as well as in the wild state about the forest edge. They nest regularly in windbreaks planted about farm homes and in hedges and shrubbery about urban dwellings. Both eat a large number of insects and some small fruits. Of the two the catbird eats the most fruit and sometimes can be destructive. It regularly consumes all the berries of honeysuckle bushes, which are commonly planted for ornamental purposes. By so doing it sometimes drops seeds and starts honeysuckle in the wild.

The robin, *Turdus migratorius*, prefers to nest close to man in shade trees and about dwellings and machinery. It is attracted by the abundance of earthworms in lawns and gardens as well as cutworms and other insects. Several broods of young are raised in a season and the amount of earthworms and insects destroyed is large. In the fall before flocking for migration they may destroy some small fruits. Huge flocks may be seen feeding in pastures, prairies, and about the edges of woodland areas during migration. Choke-cherry fruit dries and stays on the bushes all winter. It is a favorite food of robins and a few birds may stay well into the winter when this fruit is abundant.

Two bluebirds, the eastern bluebird *Sialia sialis* (L.), and the mountain bluebird, *Sialia currucoides* (Bechstein), are common in the parkland. They are both highly insectivorous and delightful birds that take readily to nesting boxes close to dwellings. They also nest regularly in the wild, and frequent old flicker holes in telephone poles and fence posts. Roberts (1932) quoted from observations published in 1871 by T. M. Trippe that at that time both the robin and the eastern bluebird nested in the pine barrens, aspen poplar, and tamarack of northern Minnesota and were then just beginning to associate themselves with man.

The red-winged blackbird, *Agelaius phoeniceus arctolegus* Oberholser, is probably the most abundant bird of the parkland and has adapted itself well to settlement. It prefers to nest in vegetation over water but also constructs its nest over dry land in tall grass, herbage, willows, snowberry, and rose. Roadside ditches where temporary water promotes rank vegetation are favored locations. Red-winged blackbirds consume great quantities of insects and

follow agricultural implements, but as the nesting season terminates enormous flocks form and range out into the fields, where they destroy grain by picking the kernels from the heads or crushing them in the milk stage. They prefer oats, corn, and sunflowers. They are so destructive that measures have to be undertaken to control them. Feeding on grain is not a recent adaptation. Roberts (1932) published an old photograph of Indians attempting to frighten blackbirds from their corn fields. The Manitoba Department of Agriculture (1884) also reported on their destructiveness: "The grain crops have suffered very severely from the incursions of these pests; from 5 to 25 per cent of some crops in some places being destroyed by them." Associated with the flocks of red-wings there is often a considerable percentage of the rusty blackbird, Brewer's blackbird, the yellow-headed blackbird and grackle. The bronzed grackle, *Quiscalus quiscula versicolor* Vieillot, is the most crowlike of the blackbirds and like that bird it destroys eggs and young of other birds. It often nests in a loose colony close to farmsteads and urban dwellings, where on account of its nest-robbing habit it is unpopular. It will even carry off the newly hatched young of domestic chicken. At other times it is a grain and fruit eater but will consume large numbers of insects. Roberts (1932) recorded a great increase in its numbers in recent years with a corresponding decrease of song birds in the vicinity of their nests. In the wild it nests in trees and willows adjacent to sloughs.

The nighthawk, *Chordeiles minor* (Forster), has maintained its earlier abundance. It is not afraid of man and may lay its eggs on the flat roof of city buildings. Its food is composed entirely of insects and includes many injurious species such as June bugs, potato beetles, mosquitoes, and winged ants. Remarkably, its stomach has been found to contain numerous grasshoppers (Roberts, 1932).

The chimney swift, *Chaetura pelagica* (L.), nested sparingly in hollow trees until settlement. It then took to nesting in unused chimneys and is now fairly common about towns and villages.

The yellow-shafted flicker, *Colaptes auratus luteus* Bangs, is the commonest woodpecker but is only a summer resident. It feeds on the ground more extensively than any other woodpecker and at such times consumes large quantities of ants. It may often be seen on urban lawns, sitting with its beak close to the ground and "licking up" ants as they come out of their nest. It nests in dead limbs of shade trees in towns and in telephone poles in the country as well as throughout the aspen forest. To prevent flicker damage, electricity poles are sometimes creosoted for their entire lengths.

The eastern phoebe, *Sayornis phoebe* (Latham), is often found nesting in old buildings, under bridges, and in other man-made structures, particularly if near water.

The Baltimore oriole, *Icterus galbula*, is common about well-treed urban areas, farmers' shelterbelts, and aspen groves. It has adapted itself well to settlement. Its habitat has been considerably enlarged through the spread of aspen on to prairie after the checking of prairie fires by settlement. Its food is mostly insects but at times it eats raspberries and other small fruit and is very fond of garden peas.

The Lapland longspur, *Calcarius lapponicus*, is found in immense flocks over the open fields in late fall and early spring. Agriculture has provided abundant weed seeds, which it consumes in large quantities.

The snow bunting, *Plectrophenax nivalis*, has probably increased with settlement, as the abundance of weed seeds provides plenty of food during its winter sojourn. Very large flocks may commonly be seen on open fields and along the highways that are blown bare of snow. Stomachs have been found to contain up to 1500 pigweed seeds (Roberts, 1932).

Introduced Animals That Have Become Established

A number of animals have been associated with the invasion of Europeans into the parkland. Domestic animals, cattle, horses, sheep, hogs, dogs, and cats; carp; game birds, pheasants and Hungarian partridge; rats and mice; insect pests of crops, stored food, and man, have become established, purposely or accidentally. They compete with the native fauna and flora. Cattle, sheep, and hogs cannot survive without human care and feeding in the winter months. During the summer they may cause serious overgrazing of pastures with resultant destruction of native plants and the invasion of weeds. Dogs generally stay close to habitation but sometimes form hunting packs and attack deer and other wild animals. They are then more destructive than coyotes, with which they sometimes interbreed. Cats frequently run wild all summer and feed on native birds and rodents.

Carp, *Cyprinus carpio* L., were unknown in Manitoba until 1938, when, according to Hinks (1943), they were taken in the Red River. They may have spread northward in that river from the United States or have been introduced accidentally by fishermen who released unused live bait (minnows) containing young carp. Dymond (1955) stated:

> Since that time they have extended northward into Lake Winnipeg where they are now known as far north as Sturgeon Bay (Lat. 52°). This represents a northward spread of 200 miles in 15 years...In Canada they are largely confined to the warmer, preferably weedy, rivers and lakes. They are accused of driving out other more valuable species but the success of the carp and the disappearance of other species is probably to be attributed to change ecological conditions incident to the clearing of the land...Two of the conditions favorable to carp and detrimental to other species, are the higher temperatures of streams and the silting of lakes and streams. The warmer summer temperatures are due to the removal of the forest cover and the reduced flow in summer; silting results from the erosion of agricultural lands.

The European or "Hungarian" partridge, *Perdix perdix* (L.), was introduced into Western Canada in 1908-09, when 207 pairs were released at Calgary, Alta. They increased so rapidly that an open season was declared in 1915. In 1921 they were released in Saskatchewan and an open season was declared in 1927. In 1924, 17 pairs from Czechoslovakia were released at Warren, Man., and a further 26 pairs in 1925. In the same year 17 pairs were released at Neepawa, Man. (Lawrence, 1930). The bird became established and large populations built up in the parkland of Manitoba in the early 1930's. During the drought period of 1931 to 1938 it reached a peak population but since has declined in numbers. It is a bird of the open stubble, grain fields, and weedy headlands. Besides eating a large quantity of waste grain and weed seeds it also consumes insects, particularly ants, which make up a large part of its summer diet (Roberts, 1932). The birds stay in flocks and huddle close together on the ground at night. This habit is sometimes the cause of mortality. During the late winter many

feed along the railroads picking up spilt grain, and bed down between the rails. They fly up at the last minute in front of oncoming trains and are killed. Some are also killed along highways.

The ring-necked pheasant, *Phasianus colchicus*, has been repeatedly introduced into North America, chiefly from England, where it has been "farmed" for centuries. The birds are a mixture of Chinese, Mongolian, and Japanese strains. They thrived in parts of Eastern Canada, British Columbia, Alberta, and Saskatchewan, and in the United States. In the parkland its status is doubtful. During periods of drought and light snowfall it does well but it cannot survive long winters with deep snow unless it has adequate shelter and food. It has not learned to shelter in forms under the snow as do the native grouse, or to subsist on buds and berries on trees and shrubs above the snow. It requires a high seed diet and prefers to scratch for its food. In the drought period of the 1930's it increased sufficiently for short open seasons in southern and southwestern Manitoba. On the return to more average seasons the numbers declined and only a small population maintains itself in a few sheltered localities.

The starling, *Sturnus vulgaris* L., was first successfully introduced into North America at New York in 1890 and 1891 by Europeans who sought the companionship of this bird from their homeland. Since that time it has spread rapidly across the continent, reaching Fort William on Lake Superior in 1931 (Roberts, 1932). Shortt (1956) stated that it was first recorded in Manitoba in June, 1925, at Somerset and was first reported nesting at Fort Whyte, near Winnipeg, in 1935. It was reported as resident at Lethbridge, Alta., in 1954 by Bird (1956). Small flocks are now commonly seen and there are a number of nesting records, but it has not become excessively abundant in the parkland as it has in the northeastern United States. It prefers to live close to human dwellings and cultivated areas where by its aggressive nature it drives out more desirable native birds. Its diet is largely insects.

The English sparrow, or house sparrow, *Passer domesticus* (L.), is not a sparrow but a weaver bird that was introduced from Europe into over a hundred cities in the United States and Canada. In Manitoba it was first seen at Carberry in 1892 and by 1909 it was found in every town and farmstead as far northwest as Athabaska Landing, Alta. (Seton, 1909). It is a domestic bird, rarely nesting away from buildings but is undesirable, as it is noisy and dirty and by its aggressive nature drives off more desirable native birds. It eats considerable vegetable matter and is destructive about gardens but consumes numbers of insects. In the summer of 1954 in Brandon it ate many cankerworms and did much to reduce an outbreak. The house sparrow reached a peak of its abundance in the horse and buggy days. The sparrow fed on grain passed in the horse droppings. This was one time when it could be said "Two can live as cheaply as one"—the horse and the sparrow. With the decline in the use of the horse in cities the sparrow population declined.

The hessian fly, *Phytophaga destructor* (Say), which was accidentally introduced into North America from Europe, reportedly in straw bedding for horses used by Hessian soldiers at the time of the American revolution, was first recorded at Long Island, New York, in 1776. From here and possibly by other introductions it spread over the wheat growing area of the continent by the shipment of infested straw and by flight. It was first recorded from Manitoba and as far west as Moose Jaw, Saskatchewan, in 1899, when it damaged 10 to 30 per cent

of the wheat crop. Criddle (1915) related its spasmodic outbreaks to climate and pointed out that they are much worse in wet years than in dry ones. The insect has two broods, a spring brood that attacks seedling grain, and a summer brood derived from 20 per cent of the puparia of the spring brood. The remaining puparia of the spring brood and those of the summer brood overwinter. If dry weather occurs, many of the summer brood perish. Earlier-maturing varieties of wheat similarly limit the survival of the summer brood. This may be the reason why no outbreaks of importance have occurred for the past 35 to 40 years and the hessian fly has ceased to be a major pest. Red Fife and other early wheat varieties had a time of maturity of 114 to 124 days. Marquis shortened the season to 106 to 112 days, and Reward to 103 to 105 days. Later rust-resistant wheats have lengthened the season to 107 to 108 days. The hessian fly attacks wheat, barley, and rye. It has also spread from cultivated grains to wild grasses in the reverse direction to the wheat stem sawfly. Criddle (1915) found light infestations in *Agropyron trachycaulum* and a few other species of this genus. He expected, but did not actually record, it to breed in *Hordeum jubatum.*

The imported cabbageworm, *Pieris rapae* (L.) (Fig. 55), a native of Europe, was first recorded in North America in Quebec in 1860. Within 20 years it had spread over Eastern Canada and the United States east of the Mississippi River (Metcalf *et al.*, 1951). It has spread through Western Canada and has become a serious pest of cabbages, turnips, rape, and other cruciferous plants. It is, however, unable to overwinter in the parkland except in particularly favorable locations. Heavy migrations occur annually into the area from the south. Stephen and Bird (1949) have shown that these migrations take place during periods of atmospheric highs. During periods of low pressure the butterflies settle down and commence egg-laying.

The imported currantworm, *Nematus ribesii* (Fig. 54), was imported from Europe and was first recorded as a pest in North America about 1857. The currant aphid, *Capitophorus ribis* (L.), and the currant borer, *Ramosia tipuliformis* (Clerck), are also of European origin. They are now common pests of currants and gooseberries (Metcalf *et al.*, 1951).

Two introduced insects that have recently become important crop pests are the sweetclover weevil, *Sitona cylindricollis* Fahr., and the European corn borer, *Ostrina nubilalis* (Hbn.) (Fig. 56 and 57). The sweetclover weevil was first found in Canada near Montreal, Quebec, in 1927. It was first recorded from Manitoba in 1939. In 1940 it completely defoliated sweet clover at Waldeck, Saskatchewan, and in 1943 was abundant at Medicine Hat, Alberta. In North America it feeds on sweet clover, attacking alfalfa only occasionally. In Europe, where little sweet clover is grown, it regularly feeds on alfalfa (Bird, 1947).

The European corn borer first reached Manitoba via Minnesota in 1949. It quickly spread throughout the sweet corn growing area of Manitoba and entered Saskatchewan. In Saskatchewan its spread has been slow and as recently as 1955 it was still expanding its range. It appears as though the corn borer will not become a serious pest in the parkland, for since its first appearance it has done only a limited amount of damage to early sweet corn and in the majority of years is of rare occurrence. Apparently the chief limiting factor is the lack of warm nights at the time of oviposition (Bird and Stewart, 1958).

Many insect pests of man and domestic animals, households, and stored foods entered the parkland with the establishment of agriculture. Hearle (1938)

stated that the cattle grubs, *Hypoderma bovis* (L.) and *H. lineatum* (De Vill.); the sheep ked, *Melophagus ovinus* (L.); the sheep bot fly, *Oestrus ovis* L.; the horse bot flies, *Gasterophilus haemorrhoidalis* (L.), *G. nasalis* (L.), and *G. intestinalis* (DeG.); the cat flea, *Ctenocephalides felis* (Bouche); the dog flea, *Ctenocephalides canis* (Curt.); and the human flea, *Pulex irritans* L., are of world wide distribution. They became established in the parkland with the introduction of domestic stock. Percy Criddle (diary, 1883), who homesteaded at Aweme, Manitoba, reported warbles on oxen in 1883. The human flea attacks cats and dogs and has spread to foxes and coyotes and to jack rabbits, which sometimes enter vacant fox dens. The horn fly, *Siphona irritans* (L.), according to Hearle was first noted in Canada in 1892 and in the succeeding eleven years spread across the continent.

The wheat midge, *Sitodiplosis mosellana* (Gehin), appeared as a pest of wheat in 1955. It is most abundant in the Red River valley south and west of Winnipeg and is only rarely encountered west of Portage la Prairie.

Changes in Animal Abundance Taking Place Without the Agency of Man

Although changes brought about by man are very great, in some cases catastrophic, animals continue to vary in abundance and distribution regardless of man's activities (Urquhart, 1957). In many cases the reasons are unknown. Some may be due to climatic and other changes slowly taking place after the retreat of glacial ice, beginning about 11,000 years ago. It was followed by a thermal maximum 5,000 to 6,000 years ago (Elson, 1954). At the present time there is a warming trend, glaciers are retreating, and some animals are showing signs of a northward advance (Bird, 1956). Major as well as minor climatic cycles continue to take place. Norman Criddle (1930) has shown how these affect the abundance of grouse, grasshoppers, and some insectivorous birds. He concluded that the abundance of insects, which fluctuates with weather cycles, in turn affects the abundance of birds. Periods during which large bodies of water dry up cause their abandonment by waterfowl, but they are reoccupied on the return of wet seasons. This has happened at Whitewater Lake in Manitoba and is recorded for Crescent Lake near Yorkton, Saskatchewan, by Baines (1956). A ten-year cycle is very pronounced in the abundance of the snowshoe rabbit, mice, and sharp-tailed and ruffed grouse. Hawks, owls, lynx, and other predators that depend on these animals for food fluctuate in the same rhythm because of alternate periods of plenty and starvation (Rowan, 1948). Elton (1936) has indicated that the marten, which used to show a conspicuous ten-year cycle, now has no cycle. "After about 1900 the cycle gradually broke down and this is probably connected with overtrapping". This is the only reference to the possibility of periodicity being broken by human interference.

Cartwright (1944) has shown that an abrupt decline in the population of a short-lived species such as the sharp-tailed grouse can be produced by a short period of inclement weather at hatching time and that heavy destruction of nests by predators, not less than 50 per cent, may be beneficial by causing renesting and thus staggering the hatch to avoid such periods. As three years is the normal life expectancy of sharp-tails, one adverse breeding season might reduce the population by 70 to 80 per cent, two adverse seasons would cause a "crash decline", and three adverse seasons would exterminate the species if it were not saved by renesting.

81314-7—8

Of particular interest is the remarkable extension of range of the Arkansas kingbird and the magpie in recent years. This may be partly due to their association with settlement but the reason for this increase is unknown.

The Arkansas kingbird, *Tyrannus verticalis* Say, during the past 50 years has extended its range eastward into Manitoba, where it is now common over the parkland. Lawrence (1952, 1953) gave an account of its range extension into Manitoba from Saskatchewan but recorded a reduction in numbers over the last few years. In Manitoba it was first recorded at Oak Lake in 1907 and at Pilot Mound in 1909, after which its spread was rapid to as far east as Victoria Beach and Whitemouth. It often nests in windbreaks planted close to occupied buildings and has invaded villages and towns, where it builds in shade trees or on the crossarms of telephone poles.

The American magpie, *Pica pica hudsonia* (Sabine), has extended its range to the north and east. Before 1910 it was a rare casual visitor to Manitoba. In 1910 more than the usual number of birds came to Manitoba and a few remained to nest (Hales, 1927). G. W. Malaher (Director, Game Branch, Manitoba Department of Mines and Natural Resources, Winnipeg. In litt. 1956) reported that it appeared at The Pas and Moose Lake in 1950 and has now been recorded from Fort Churchill on Hudson Bay. Extension of its range in Alberta was recorded by Farley (1932, p. 73). He stated:

> Until 1911 it was unknown north of the Red Deer River. In October of that year, the writer observed two about seven miles north of Lacombe, the following year magpies were reported from the vicinity of Bittern Lake, and from that time on they have gradually become more numerous until they are now very plentiful at all times of the year.

Its appearance is not welcomed by the farmer and sportsman, and attempts have been made to control it through the payment of bounties, without success. It feeds on carrion and is not averse to attacking open wounds on living animals, particularly in the winter when other food is scarce. It will alight on the backs of cattle and peck at warbles and sores. It eats into the living flesh and enlarges the opening so that frost enters the wound and the animal dies. One rancher (Criddle, S. In litt. 1949) lost eight animals by magpies out of a herd of 200 in one winter. The cattle make no attempt to defend themselves. This bird probably attacked buffalo in the same way. It consumes many birds' eggs and young and is considered one of the most important predators of game birds.

The burrowing owl, *Speotyto cunicularia hypugeaa* (Bonaparte), may be found occasionally in western Manitoba, where it nests in the burrows of badgers made in digging out Richardson's ground squirrel. Seton (1909) reported it as having appeared only recently in Manitoba and that it was unknown in the eighties. Its food consists mostly of insects, particularly grasshoppers, but may include mice and young ground squirrels. With the breaking up of prairie sod and pastures and the destruction of ground squirrels and badgers, populations of the owl have been reduced because of the scarcity of nesting sites in most areas. In a few areas it may still be on the increase. A. Hochbaum (Director, Waterfowl Research Station, Delta, Man. In litt. 1955) stated that it is on the increase in the Portage la Prairie plains.

Brewer's blackbird, *Euphagus cyanocephalus*, according to Roberts (1932) increased in Minnesota and spread eastward, replacing the bobolink. Hales (1927) stated that it was the most abundant blackbird in Manitoba. It has

since been considerably reduced in numbers through destruction of its nesting habitat and is now far exceeded in numbers by the red-winged blackbird.

The snowshoe rabbit, *Lepus americanus americanus* Erxleben (Fig. 27), occurs in Alberta, Saskatchewan, and northern Manitoba, and *L. a. phaeonotus* Allen, the Minnesota snowshoe rabbit, is found in the southern portion of Manitoba. Their habits, however, are very similar. The former stays more in the mixed coniferous forest whereas the latter is found mostly in the true parkland.

The snowshoe rabbit is a woodland species and seldom ventures far from trees. It is found in greatest abundance in dense stands of young aspen, willow, hazel, and cherry thickets, which provide cover and food. It is predominant and a major influent not only on its food plants but on its predators, which fluctuate in numbers with the food supply made available by cycles of abundance of rabbits. These cycles, of roughly ten years between peaks (Elton, 1936), have not been affected by human interference. Man has eliminated rabbits in places where cultivation has destroyed forests, and reduced them where woodland has been heavily pastured, but has helped them by reduction of predators and by cutting and burning forest where the resultant second growth makes abundant food and shelter.

Stuart Criddle (1938) made a careful study of the rabbit about his home at Treesbank, Man. He reported on the importance of well-kept runways to the rabbits in escaping predators and for travel, and the labor they go to in maintaining them. In the summer all vegetation is carefully trimmed back and in the winter the snow is kept hard-packed. He proved by a large number of records over a period of years that the size and number of broods do not vary with the period in the cycle of abundance. Numbers are determined by deaths rather than births. There are at least three, often four, and occasionally five litters a year, with an average of 3.4 per litter. The snowshoe rabbit shows a preference for certain trees and shrubs particularly aspen, oak, hazelnut, willow, wolf willow (*Elaeagnus commutata*), and cherry. Maple, saskatoon, and snowberry are rarely eaten. The bur oak would be much more abundant were it not for rabbits. Growing shoots of young trees are eaten back year after year so that the trees are reduced to stunted clubs and finally die.

The white-footed mouse, *Peromyscus maniculatus* and subspecies, is one of our commonest mice. Its numbers show a marked periodicity, and early records show that it occurred in great numbers before settlement and before its predators had been depleted. This would indicate that it fluctuates in spite of predators and that human interference may not greatly affect its abundance. It is particularly abundant near woods and frequently enters houses. Henry in 1808 (Coues, 1897) recorded their abundance at his Park River, North Dakota, fort:

> We are plagued by great numbers of mice, which destroy almost everything but metals; our strouds and blankets are nearly all damaged, and they even carry off our beads. At night we see them running in droves over the floor; they are not shy in the least. They often awake us by scampering over our faces and playing on our beds...The mice destroy everything; they eat my skins and peltries—indeed, anything that is not iron or steel goes down with them.

Stuart Criddle (1950) stated that these mice were as abundant in pre-agricultural days as at the present and quotes from his father's diary of 1882:

> This little pest pervades the prairie in thousands and destroys everything...No place is safe from him, and for the construction of his nest, wherein lies his greatest destructiveness, he is not contented with gnawing up and destroying any one garment, but loving variety, he will take a bit of fur here, some wool there, the heel of a sock, the seat of a pair of breeches.

Criddle also gave an account of the food and stores of this mouse. During the warmer months it feeds extensively on insects, grasshoppers and their eggs, cutworms, June beetles, and others. As fruits and seeds ripen it feeds on them and stores great quantities of seed for winter use, including many weeds, grains, grasses, acorns, and cherry stones. In this activity it is an important influent in the community both in dispersal and in consumption of seeds.

Voles or meadow mice, *Microtus pennsylvanicus* (Fig. 17) and *Pedomys* (*Microtus*) *minor*, are very common mammals of the prairie. They inhabit the matted dead grass, where their runways and nests are conspicuous. Bird (1930) mentioned the abundance in virgin prairie of *Microtus pennsylvanicus drummondii* (Audubon & Bachman), and Stuart Criddle (1956) made observations for 22 years. He recorded their abundance, a periodic fluctuation of about 10 years, their food preference for grain crops, for *Poa* and *Bromus inermis* and other introduced grasses. In the wild they eat *Geum triflorum*, fruit, insects, and fungi. They eat bark when other food is scarce. Stuart Criddle (1926) discussed the habits and food of *Microtus* (*Pedomys*) *ochrogester*. They store large quantities of seeds and roots. Criddle weighed a number of these stores and found a total weight of food material of 17 pounds 5 ounces to 24 pounds 6 ounces. Such stores were used by several mice. They store a certain amount of wheat, oats, and rye from gleanings about the edges of fields, but their food consists chiefly of *Liatris punctata*, *Allium stellatum* Fraser, *Psoralea esculenta*, *Helianthus* spp., *Geum triflorum*, *Taraxacum erythrospermum* Andrz., and *Juniperus horizontalis*. Bailey (1924) refers in general terms to the genus *Microtus*, and in particular to *Microtus pennsylvanicus*. He mentioned the serious agricultural losses they cause by the destruction of grass and clover and the barking of trees below the snow line in the winter. Criddle, however, stated that *Pedomys minor*, unlike the red-backed mouse, *Clethrionomys gapperi loringi*, does not feed on the bark of trees. Bailey also referred to the huge stores of seeds and roots and mentioned that at one time their stores formed an important food item for Indians, who systematically searched for them.

Agriculture with its accompanying cultivation and overgrazing has destroyed the native prairie and much vole habitat and consequently reduced the population; however, they are still abundant and continue to fluctuate in a marked periodicity unaffected by man.

Among insects, grasshoppers have shown the most marked periodicity. The history of grasshopper outbreaks in Manitoba has been compiled by Mitchener (1954). He recorded outbreaks in 1799-1800, 1808, 1818-1821, 1857-58, 1864-74, 1898-1902, 1919-22, 1929-35, 1937-42, and 1949-52.

The early grasshopper outbreaks up to and including 1902 were probably largely of the Rocky Mountain grasshopper, *Melanoplus spretus*. The species *Melanoplus bilituratus*, *M. bivitatus*, and *Camnula pellucida*, which have been most abundant in the later outbreaks, show similar periodicity associated with periods of low rainfall.

Insects of the forests have been less affected by man-made changes than those of areas brought under agriculture. Many of them show marked fluctuations in abundance arising from natural causes. Mr. W. A. Reeks (Chief, Forest Biology Laboratory, Winnipeg, Man. In litt. 1959) has supplied data on peaks of abundance of the following forest insects found in southwestern Manitoba: Larch sawfly, *Pristiphora erichsonii* (Htg.), 1913-1920, 1925-1926,

1938-1949; forest tent caterpillar, *Malacosoma disstria* Hbn., 1923-1924, 1937-1938, 1952-1953; large aspen tortrix, *Choristoneura conflictana* (Wlk.), 1916-1917, 1957; willow leaf beetle, *Galerucella decora* Say, 1932-1934, 1948-1950, 1956-1957. These outbreaks, which resulted is repeated defoliation of the host trees over a period of years, retarded growth, weakened the trees, and in some cases killed out sections of the forest (Hodson and Duncan, 1956).

References

Allen, R. P. The whooping crane. Res. Rept. No. 3, Natl. Audubon Soc., New York. 1952.

Allen, W. R. An ecological study of *Melanoplus mexicanus mexicanus* (Saussure). M. Sc. thesis. University of Manitoba. 1939. (Unpublished)

American Ornithologists' Union. Check-list of North American birds. 5th ed. Baltimore, Md. 1957.

Anderson, E. Man as a maker of new plants and new plant communities. *In* Man's role in changing the face of the earth, ed. by W. L. Thomas, Jr., pp. 763-777. Univ. Chicago Press, Chicago. 1956.

Anderson, R. M. Catalogue of Canadian recent mammals. Canada Dept. Mines and Res., Mines and Geol. Br., Natl. Mus. Canada Bull. No. 102. 1946.

Anonymous. Those pesky beaver. North Dakota Outdoors 14(7) : 6-7, 15. 1952a.

Anonymous. Waterfowl populations and breeding conditions, summer 1952. U.S. Dept. Interior, Fish and Wildlife Serv., and Canada Dept. Res. and Development, Canadian Wildlife Serv., Special Sci. Rept. No. 21. 1952b.

Anonymous. The whooping crane problem. The Blue Jay 14 : 111-112. 1956a.

Anonymous. Beckoning hills. Pioneer settlement Turtle Mountain Souris-Basin areas. Boissevain's 75th Jubilee Book. Boissevain, Manitoba. 1956b.

Atkinson, G. E. Rare bird records of Manitoba. Trans. Hist. Sci. Soc. Manitoba, No. 65. Winnipeg. 1904.

Bailey, V. Breeding, feeding, and other life habits of meadow mice (*Microtus*). J. Agr. Res. 27:523–536. 1924.

Baines, K. E. The ups and downs of game at Crescent Lake. The Blue Jay 14:65–66. 1956.

Banfield, A. W. F. An irruption of elk in Riding Mountain National Park, Manitoba. J. Wild Life Mgnt. 13:127–134. 1949.

Bard, F. G. Whooping cranes in migration, 1956. The Blue Jay 14:39–42. 1956a.

Bard, F. G. Whooping cranes in southern Saskatchewan in 1956. The Blue Jay 14:81. 1956b.

Bartlett, B. R. Natural predators. Can selective insecticides help to preserve biotic control? Agr. Chem. 11(2):42–44,107,109. 1956.

Bates, M. Man as an agent in the spread of organisms. *In* Man's role in changing the face of the earth, ed. by W. L. Thomas, Jr., pp. 788–804. Univ. Chicago Press, Chicago. 1956.

Beckwith, S. L. Ecological succession on abandoned farm lands and its relation to wildlife management. Ecol. Monogr. 24:349–376. 1954.

Bent, A. C. Life histories of North American wild fowl. Order Anseres. U.S. Natl. Mus. Bull. 130. 1925.

Bird, C. D. The distribution of the western painted turtle in Manitoba. Canadian Field-Nat. 72:28–31. 1958.

Bird, R. D. A preliminary ecological survey of the district surrounding the entomological laboratory at Treesbank, Manitoba. Ecology 7:207–220. 1927.

Bird, R. D. The great horned owl in Manitoba. Canadian Field-Nat. 43:79–83. 1929.

Bird, R. D. Biotic communities of the aspen parkland of central Canada. Ecology 11:356–442. 1930.

Bird, R. D. The sweetclover weevil, *Sitona cylindricollis* Fahr. Canadian Ent. 79:5–11. 1947.

Bird, R. D. Extensions of faunal ranges in the Prairie Provinces. Ann. Rept. Ent. Soc. Ontario 86(1955):33–37. [1956]

Bird, R. D., and W. W. A. Stewart. The European corn borer in Manitoba and Saskatchewan. The Prairie Garden, Winnipeg. 1958.

Bossenmaier, E. F., T. A. Olson, M. E. Rueger, and W. H. Marshall. Some field and laboratory aspects of duck sickness at Whitewater Lake, Manitoba. Trans. 19th North American Wildlife Conf., pp. 163–175. 1954.

Bradshaw, F. The home of the whooping crane. The Blue Jay 14:76–78. 1956.

Breckenridge, W. J. Reptiles and amphibians of Minnesota. Univ. Minn. Press, Minneapolis. 1944.

Brooks, A. R. Acridoidea of southern Alberta, Saskatchewan, and Manitoba (Orthoptera). Canadian Ent. 90, Suppl. 9. 1958.

Budd, A. C. A key to plants of the farming and ranching areas of the Canadian prairies. Canada Dept. Agr., Expt. Farms Serv., Ottawa. 1952.

Burpee, L. J., editor. Journal of La Verendrye. Publications the Champlain Society, Toronto. 1927.

Cartwright, B. W. The "crash" decline in sharp-tailed grouse and Hungarian partridge in Western Canada and the role of the predator. Trans. 9th North American Wildlife Conf., 1944, pp. 324–330.

Chapman, F. M. Handbook of birds of eastern North America. 2nd ed. D. Appleton-Century Co. Inc., New York-London. 1934.

Chittenden, F. H. The Colorado potato beetle. U.S. Dept. Agr., Bur. Ent. Circ. 87:1–15. 1907.

Clark, A. H. The impact of exotic invasion on the remaining New World mid-latitude grasslands. *In* Man's role in changing the face of the earth, ed. by W. L. Thomas, Jr., pp. 737–762. Univ. Chicago Press, Chicago, Ill. 1956.

Clark, S. E., J. A. Campbell, and J. B. Campbell. An ecological and grazing capacity study of the native grass pastures in southern Alberta, Saskatchewan and Manitoba. Canada Dept. Agr., Pub. No. 738, Tech. Bull. 44. 1942.

Cole, T. V. Alfalfa pollination in Manitoba. Ann. Conf. Manitoba Agronomists, Dec. 18 and 19 1956, pp. 29–30. (mimeographed) 1956.

Colls, D. G. The conflict between waterfowl and agriculture. Trans. 16th North American Wildlife Conf., 1951, pp. 89–93. 1951.

Cooke, W. W. Report on bird migration in the Mississippi Valley in the years 1884 and 1885. U.S. Dept. Agr., Div. Econ. Ornithology Bull. No. 2. 1888.

Coues, E. Birds of the northwest. A hand-book of the ornithology of the region drained by the Missouri River and its tributaries. U.S. Dept. Interior, Geol. Surv. of the Territories Misc. Pub. No. 3. 1874.

Coues, E. The manuscript journals of Alexander Henry, 1799–1814. Vol. 1. The Red River of the north. Francis P. Harper, New York. 1897.

Coupland, R. T. Ecology of mixed prairie in Canada. Ecol. Monogr. 20:271–315. 1950.

Coupland, R. T., and T. C. Brayshaw. The fescue grassland in Saskatchewan. Ecology 34: 386–405. 1953.

Coupland, R. T. The role of natural grassland areas in research. *In* Addresses and Proceedings of Farm Week, University of Saskatchewan, 1954.

Criddle, N. Injurious insects of 1910 at Treesbank, Manitoba. J. Econ. Ent. 4:236–241. 1911.

Criddle, N. The marsh hawk. Ottawa Nat. 25(10):147–151. 1912.

Criddle, N. Some inhabitants of a sand plain in June. Canadian Ent. 47:24–30. 1915.

Criddle, N. The hessian-fly and the western wheat-stem saw-fly in Manitoba, Saskatchewan and Alberta. Canada Dept. Agr., Ent. Br. Bull. No. 11. 1915.

Criddle, N. Further observations upon the habits of the western wheat stem sawfly in Manitoba and Saskatchewan. Agr. Gaz. Canada 4(3):176–177. 1917.

Criddle, N. Precipitation in relation to insect prevalence and distribution. Canadian Ent. 49:77–80. 1917.

Criddle, N. The western wheat-stem sawfly and its control. Canada Dept. Agr., Ent. Br. Pam. No. 6, New Ser. 1922.

Criddle, N. The life habits of *Cephus cinctus* Nort. in Manitoba. Canadian Ent. 55:1–4. 1923.

Criddle, N. The habits and economic importance of wolves in Canada. Canada Dept. Agr., Bull. No. 13, New Ser. 1925.

Criddle, N. Some natural factors governing the fluctuations of grouse in Manitoba. Canadian Field-Nat. 44:77–80. 1930.

Criddle, N. Notes on the habits of injurious grasshoppers in Manitoba. Canadian Ent. 65:97–102. 1933.

Criddle, S. The habits of *Microtus minor* in Manitoba. J. Mammalogy 7:193–200. 1926.

Criddle, S. A study of the snowshoe rabbit. Canadian Field-Nat. 52:31–40. 1938.

Criddle, S. The thirteen-striped ground squirrel in Manitoba. Canadian Field-Nat. 53:1–6. 1939.

Criddle, S. The *Peromyscus maniculatus bairdii* complex in Manitoba. Canadian Field-Nat. 64:169–177. 1950.

Criddle, S. Drummond's vole in Manitoba. Canadian Field-Nat. 70:78–84. 1956.

Dewey, L. H. The Russian thistle and other troublesome weeds in the wheat region of Minnesota and North and South Dakota. U.S. Dept. Agr. Farmers' Bull. 10. 1893.

DeWitt, J. B. Effects of chlorinated hydrocarbon insecticides upon quail and pheasants. Agr. and Food Chem. 3:672–676. 1955.

Dice, L. R. Natural communities. University of Michigan Press, Ann Arbor. 1952.

Dolan, D. D. Better bromegrasses for the northeast? Farm Res. 22(4):4–5. 1956.

Dymond, J. R. The introduction of foreign fishes in Canada. Proc. Int. Assoc. theoretical and applied Limnology. 12:543–553. 1955.

Dzubin, A. Some evidences of home range in waterfowl. Trans. 20th North American Wildlife Conf., March 14, 15 and 16, 1955, pp. 278–298.

Ellis, J. H. The soils of Manitoba. Manitoba Economic Survey Board. 1938.

Elson, J. A. Guide book. Pleistocene geology of south-western Manitoba. Field excursion, Oct. 2–3, 1954. Geol. Surv. Canada, Dept. Mines and Tech. Surv. (processed)

Elton, C., and G. Swynnerton. The Canadian snowshoe rabbit inquiry, 1934–35. Canadian Field-Nat. 50:71–81. 1936.

Emlen, J. T., Jr. Territory, nest building, and pair formation in the cliff swallow. The Auk 71:16–35. 1954.

Evans, C. D., A. S. Hawkins, and W. H. Marshall. Movements of waterfowl broods in Manitoba. U.S. Dept. Interior, Fish and Wildlife Serv. Spec. Sci. Rept.: Wildlife No. 16. 1952.

Ewing, J. Plant successions of the brush-prairie in north-western Minnesota. J. Ecol. 12:238–266. 1924.

Farley, F. L. Birds of the Battle River region of central Alberta. 1st ed. Inst. Applied Art Limited, Edmonton, Alta. 1932.

Fernald, M. L. Gray's manual of botany. 8th ed. American Book Co., New York. 1950.

Fitzpatrick, F. L. The ecology and economic status of *Citellus tridecemlineatus*. Univ. Iowa Stud. in Nat. Hist., New Ser. No. 86, Vol. 11, No. 1. 1925.

Fleming, J. H. The disappearance of the passenger pigeon. Ottawa Nat. 20:236–237. 1907.

Fletcher, J. Report of the Entomologist and Botanist. *In* Ann. Rept. Expt. Farms. Canada Dept. Agr. 1897.

Fuller, W. A. Aerial census of northern bison in Wood Buffalo Park and vicinity. J. Wildlife Mgnt. 14:445–451. 1950.

Gibson, A., R. P. Gorham, H. H. Hudson, and J. A. Flock. The Colorado potato beetle in Canada. Canada Dept. Agr., Div. Ent. Bull. 52. 1925.

Glen, R. Insects and agriculture. Agr. Inst. Rev. 8(1):11–13, 36. 1953.

Godfrey, W. E. Notes on birds of the area of intergradation between eastern prairie and forest in Canada. Canada Dept. Res. and Development, Natl. Mus. Canada Bull. No. 128 (Ann. Rept. Natl. Mus. Canada, 1951–52):189–240. 1953.

Green, H. V. The wapiti of the Riding Mountain, Manitoba. Canadian Field-Nat. 47:105–111, 122–132, 150–157, 171–174. 1933.

Groh, H., and C. Frankton. Canadian weed survey seventh report 1948, pp. 1–144. Canada Dept. Agr., Sci. Serv., Div. Bot. and Pl. Path. (mimeographed) 1949.

Gurney, A. B. Grasshopper glacier of Montana and its relation to long-distance flights of grasshoppers. Smithsonian Inst. Pub. No. 4121. 1953.

Gurney, A. B., and A. R. Brooks. Grasshoppers of the *mexicanus* group, genus *Melanoplus* (Orthoptera: Acrididae). Proc. U.S. Nat. Mus. 110:1–93. 1959.

Hagmeier, E. M. Distribution of marten and fisher in North America. Canadian Field-Nat. 70:149–168. 1956.

Hales, B. J. Prairie birds. Macmillan Company of Canada Ltd., Toronto. 1927.

Halliday, W. E. D. Report on vegetation and site studies, Clear Lake, Riding Mountain National Park, Manitoba, 1932. Canada Dept. Interior, For. Ser., Res. Note No. 42. Ottawa. (mimeographed) 1935.

Halliday, W. E. D. A forest classification for Canada. Canada Dept. Mines and Res., For. Serv. Bull. 89. 1937.

Hambley, G. H. Historical records and accounts of the early pioneers of the district of Swan Lake, Manitoba from its early settlement, 1873–1950. D. W. Friesen and Sons, Altona. (no date)

Handford, R. H., R. H. Painter, and H. W. Moore. Manitoba grasshopper surveys in 1936. Technical report for 1936, Entomological Laboratory, Brandon, Manitoba. (Unpublished)

Hawkins, A. S. Waterfowl breeding conditions in Manitoba, 1947. U.S. Dept. Interior, Fish and Wildlife Serv., Special Sci. Rept. No. 45:39–57. 1948.

Hearle, E. Insects and allied parasites injurious to livestock and poultry in Canada. Canada Dept. Agr., Ent. Br. Pub. 604 (Farmers' Bull. 53). 1938.

Hind, H. Y. A preliminary and general report on the Assiniboine and Saskatchewan exploring expedition. Queen's Printer, Toronto. 1859.

Hinks, D. The fishes of Manitoba. Manitoba Dept. Mines and Nat. Res. 1943.

Hitchcock, A. S. (Revised by Agnes Chase) Manual of the grasses of the United States. 2nd ed. U.S. Dept. Agr., Misc. Pub. 200. 1950.

Hochbaum, H. A. The canvasback on a prairie marsh. American Wildlife Inst., Washington, D.C. 1944.

Hochbaum, H. A., S. T. Dillon, and J. L. Howard. An experiment in the control of waterfowl depredations. Trans. 19th North American Wildlife Conf., March 8, 9, and 10, 1954, pp. 176–185.

Hodson, A. C., and D. P. Duncan. Effects of defoliation by the forest tent caterpillar. Minnesota Farm and Home Science 14(1):3, 8. 1956.

Jackson, V. W. Vegetational succession in the Red River basin. Sci. Agr. 4:301–307. 1924.

Jenness, D. The Indians of Canada. 2nd ed. Canada Dept. Mines, Natl. Mus. Canada Bull. 65. (Anthrop. Ser. No. 15). 1934.

Joel, A. H., J. Mitchell, F. H. Edmunds, and H. C. Moss. Reconnaissance soil survey of Saskatchewan from the International Boundary on the south to the top of township 48 on the north. Univ. Saskatchewan, Coll. Agr., Dept. Soils, Soil Surv. Rept. No. 10. Saskatoon, Sask. 1936.

Kalmbach, E. R. Crow-waterfowl relationships based on preliminary studies on Canadian breeding grounds. U.S. Dept. Agr. Circ. No. 433. 1937.

Kalmbach, E. R. A comparative study of nesting waterfowl on the Lower Souris Refuge: 1936-1937. Trans. 3rd North American Wildlife Conf., Feb. 14, 15, 16, 17, 1938, pp. 610–623. 1938.

Kavanagh, M. The Assiniboine basin. The Public Press, Winnipeg. 1946.

King, K. M. A quantitative comparative investigation of the fauna of natural and ruderal associations at Saskatoon, with special reference to climatic conditions. M.Sc. thesis. Univ. Saskatchewan. 1926. (Unpublished)

King, K. M. A quantitative investigation of the fauna of native and ruderal associations at Saskatoon, Saskatchewan, with special reference to the climatic influence (abstract). Bull. Ecol. Soc. America 8(4):5. 1927.

Krefting, L. W., and E. I. Roe. The role of some birds and mammals in seed germination. Ecol. Mongr. 19:269–286. 1949.

Lahrman, F. W. Aggressive behaviour of a whooping crane. The Blue Jay 15:14–15. 1957.

Lawrence, A. G. *In* Chickadee Notes, No. 153. Manitoba Free Press. February 28, 1924.

Lawrence, A. G. *In* Chickadee Notes, No. 234. Manitoba Free Press. September 17, 1925.

Lawrence, A. G *In* Chickadee Notes, No. 465. Manitoba Free Press. February 19. 1930.

Lawrence, A. G *In* Chickadee Notes, No. 1619. Manitoba Free Press. May 30, 1952.

Lawrence, A. G. *In* Chickadee Notes, No. 1671. Manitoba Free Press. February 28, 1953.

Leitch, W. G. Saving, maintaining, and developing waterfowl habitat in Western Canada. Trans. 16th North American Wildlife Conf., 1951, pp. 94–99. 1951.

Logier, E. B. S., and G. C. Toner. Check-list of the amphibians and reptiles of Canada and Alaska. Contrib. Roy. Ontario Mus. Zool. and Paleont. No. 41. 1955.

Löve, A., and D. Löve. Vegetation of a prairie marsh. Bull. Torrey Bot. Club 81(1):16–34. 1954.

Löve, D. The postglacial development of the flora of Manitoba: a discussion. Canadian J. Bot. 37:547–585. 1959.

Lynch, D. Ecology of the aspen groveland in Glacier County, Montana. Ecol. Monogr. 25:321–344. 1955.

Macan, T. T., and E. B. Worthington. Life in lakes and rivers. Collins, London. 1951.

MacNeish, R. S. Summary of archaeological investigations in southeastern Manitoba. Canada Dept. Northern Affairs Natl. Res., Natl. Mus. Canada No. 142 (Ann. Rept., 1954–55):25–45. 1956.

Macoun, John. Manitoba and the great north-west. Thomas C. Jack, London. 1883.

Macoun, John, and James H. Macoun. Catalogue of Canadian birds. Ottawa. 1909.

Malaher, G. W. Game and fisheries. *In* Annual report of the Department of Mines and Natural Resources, Manitoba, for period ending March 31, 1951, pp. 61–90

Malaher, G. W. Game and fisheries. *In* Annual report of the Department of Mines and Natural Resources, Manitoba, for period ending March 31, 1953, pp 49–66

Manitoba Department of Agriculture and Immigration Report on crops livestock, etc., produced in Manitoba in 1939. Crop Bull. No. 118. Winnipeg. 1939.

Manitoba Department of Agriculture and Immigration. Report on crops livestock, etc. produced in Manitoba in 1949. Crop Bull. No. 128. Winnipeg. 1949.

Manitoba Department of Agriculture and Statistics. Report for the year 1882. Winnipeg. 1883.

Manitoba Department of Agriculture, Statistics, and Health. Report for the year 1883. Winnipeg. 1884.

Martin, A. C. Can insecticides and wildlife co-exist? Agr. Chem. 10(12):51, 103. 1955.

McDonald, H. Insects and pests. Estimates of damage by the major field crop pests: 1953. Saskatchewan Dept. Agr., 3rd Ann. Rept. Plant Ind. Br., pp. 189–193. 1954.

McLeod, J. A., and G. F Bondar A brief study of the double-crested cormorant on Lake Winnipegosis. Canadian Field-Nat. 67:1–11. 1953.

Metcalf, C. L., W. P. Flint, and R. L. Metcalf. Destructive and useful insects. 3rd. ed. McGraw-Hill Book Co. Inc., New York. 1951.

Metcalf, F. P. Wild-duck foods of North Dakota lakes. United States Dept. Agr. Tech. Bull. No. 221. 1931.

Miller, G. S., and R. Kellogg. List of North American recent mammals. Smithsonian Inst. Bull. No. 205. 1955.

Mitchell, M. H. The passenger pigeon in Ontario. Roy. Ontario Mus. Zool. Contrib. No. 7. Univ. Toronto Press. 1935.

Mitchener, A. V. A history of grasshopper outbreaks and their control in Manitoba, 1799–1953. 84th Ann. Rept. Ent. Soc. Ontario, 1953, pp. 27–35. 1954.

Moore, H. W. An intensive study of seasonal fluctuations in grasshopper abundance in a restricted area. M.Sc. thesis. University of Manitoba. 1936. (Unpublished)

Morton, A. S., and C. Martin. History of prairie settlement and "Dominion Lands" policy. Macmillan Company of Canada Limited, Toronto. 1938.

Moss, E. H. The vegetation of Alberta. IV. The poplar association and related vegetation of central Alberta. J. Ecol. 20:380-415. 1932.

Moss, E. H. The prairie and associated vegetation of southwestern Alberta. Canadian J. Res., C, 22:11–31. 1944.

Moss, E. H., and J. A. Campbell. The fescue grassland of Alberta. Canadian J. Res., C, 25:209–227 1947.

Moss, E. H. The vegetation of Alberta. Bot. Rev. 21:493–567. 1955.

Mozley, A. The fresh-water Mollusca of subarctic Canada. Canadian J. Res., D, 16:93–138. 1938.

Nash, J. B. An investigation of some problems of ecology of the beaver, *Castor canadensis canadensis* Kuhl, in northern Manitoba. Manitoba Dept. Mines and Nat. Res. (mimeographed thesis) 1951.

Parker, J. R. Some effects of temperature and moisture upon *Melanoplus mexicanus mexicanus* Saussure and *Camnula pellucida* Scudder (Orthoptera). Univ. Montana Agr. Expt. Sta. Bull. 223. 1930.

Pelton, J. Studies on the life-history of *Symphoricarpos occidentalis* Hook in Minnesota. Ecol. Monogr. 23:17–39. 1953.

Peterson, R. L. A new subspecies of moose from North America. Occasional Pap. Roy. Ontario Mus. Zool. No. 9. 1950.

Phillips, J. C. The crow in Alberta and the work of the American Wild Fowlers. Trans. 15th Int. Game Conf., New York City, Dec. 3 and 4, 1928, pp. 146–155.

Pickett, A. D. A critique on insect chemical control methods. Canadian Ent. 81:67–76. 1949.

Pittman, H. H. Sandhill cranes—in retrospect. Nat. Mag. 49:237–239. 1956.

Pritchett, J. P. The Red River Valley 1811–1849. Ryerson Press, Toronto 1942.

Urquhart, F. A., ed. Changes in the Fauna of Ontario. Univ. Toronto Press. 1957.

Raine, W. Bird-nesting in north west Canada. Hunter, Rose and Co., Toronto. 1892.

Rand, A. L. The 1945 status of the pronghorn antelope, *Antilocapra americana* (Ord), in Canada. Canada Dept. Mines and Res., Mines and Geol. Br., Natl. Mus. Canada Bull. No. 106 1947.

Rand, A. L. Mammals of the eastern Rockies and western plains of Canada. Natl. Mus. Canada Bull. 108. 1948.

Rice, C. M. Dictionary of geologic terms. Edwards Bros., Ann Arbor, Michigan. 1953.

Rice, E. E., ed. Isham's observations and notes 1743–49. The Champlain Society for the Hudson's Bay Record Society, 1949.

Roberts, T. S. The birds of Minnesota. Univ. Minnesota Press. 1932.

Rowan, W. The ten-year cycle, outstanding problems of Canadian conservation. Second printing. Univ. Alberta Dept. Extension pamphlet. Edmonton, Alta. August, 1948.

Rowan, W. Some effects of settlement on wildlife in Alberta Trans. Canadian Conser. Assoc. 1952, pp. 31–39. 1952

Rudd, R. L., and R. E. Genelly. Chemicals and wildlife—an analysis of research needs. Trans. 20th North American Wildlife Conf., pp. 189–198. 1955.

Rydberg, P. A. Flora of the prairies and plains of central North America. New York Botanical Garden, New York. 1932.

Sailer, R. I. Common names of insects approved by the Entomological Society of America. Bull. Ent. Soc. America 1(4):1–34. 1955.

Schorger, A. W. The crow and the raven in early Wisconsin. Wilson Bull. 53:103–106. 1941.

Schorger, A. W. The passenger pigeon, its natural history and extinction. University of Wisconsin Press, Madison. 1955.

Scoggan, H. J. Botanical investigations in Manitoba in 1950. Canada Dept. Res. and Development, Natl. Mus. Canada Bull. No. 126 (Ann. Rept. Natl. Mus. Canada, 1950–51):pp. 208–227. 1952.

Scoggan, H. J. Botanical investigations in the glacial lakes Agassiz-Souris basins. Canada Dept. Res. and Development, Natl. Mus. Canada Bull. No. 128 (Ann. Rept. Natl. Mus. Canada, 1951–52):103–109. 1953.

Scoggan, H. J. Flora of Manitoba. Canada Dept. Northern Affairs and National Resources, Natl. Mus. Canada Bull. No. 140. 1957.

Seton, E. T. Fauna of Manitoba. *In* A handbook to Winnipeg and the Province of Manitoba, pp 1–47. British Association for the Advancement of Science, Winnipeg. 1909.

Seton, E. T. Lives of game animals. 4 vols. Doubleday, New York. 1929.

Shelford, V. E. Biological control of rodents and predators. Sci. Mon. 55:331–341. 1942.

Smith, D. S. An intensive study of the grasshoppers of economic importance at Arnaud, Manitoba, 1938. Technical report for 1938, Entomological Laboratory, Brandon, Manitoba. (Unpublished)

Smith, D. S., R. H. Handford, and W. Chefurka. Some effects of various food plants on *Melanoplus mexicanus mexicanus* (Sauss.) (Orthoptera: Acrididae). Canadian Ent. 84:113–117. 1952.

Soper, J. D. History, range, and home life of the northern bison. Ecol. Monogr. 11:347–412. 1941.

Sowls, L. K. The Franklin ground squirrel, *Citellus franklinii* (Sabine), and its relationship to nesting ducks. J. Mammalogy 29:113–137. 1948.

Sowls, L. K. Prairie ducks. A study of their behaviour, ecology and management. The Stackpole Co., Harrisburg, Pa., and Wildlife Management Institute, Washington, D.C. 1955.

Spurr, S. H. The forest of Itasca in the nineteenth century as related to fire. Ecology 35:21–25. 1954.

Stephen, W. P., and R. D. Bird. The effect of barometric pressure upon oviposition of the imported cabbageworm, *Pieris rapae* (L.). Canadian Ent. 81:132. 1949.

Stewart, O. C. Fire as the first great force employed by man. *In* Man's role in changing the face of the earth, ed. by W. L. Thomas, Jr., pp. 115–133. Univ. Chicago Press, Chicago, Ill. 1956.

Strange, H. G. L. A short history of prairie agriculture. Searle Grain Co. Ltd., Winnipeg. 1954.

Swanson, G., T. Surber, and T. S. Roberts. The mammals of Minnesota. Minnesota Dept. Conser. Tech. Bull. No. 2. 1945.

Taverner, P. A. Birds of Western Canada. Canada Dept. Mines, Victoria Memorial Mus., Mus. Bull. 41 (Biol. Ser. No. 10). 1926.

Thomas, R. W. Forest disease survey, Manitoba and Saskatchewan. *In* Annual report of the Forest Insect and Disease Survey, 1953, pp. 104–111. Canada Dept. Agr., For. Biol. Div., Ottawa. 1954.

Thomas, W. L., Jr., ed. Man's role in changing the face of the earth. Univ. Chicago Press, Chicago, Ill. 1956.

Thompson, E. S. The birds of Manitoba. Proc. U.S. Natl. Mus. 13:457–643; plate 38. Washington. 1891.

Urquhart, F. A., ed. Changes in the fauna of Ontario. IV+75 pp. Maps. University of Toronto Press, Toronto. 1957.

Vickers, C., and R. D. Bird. A copper trade object from the headwaters lakes aspect in Manitoba. Amer. Antiquity 15:157–160. 1949.

Walker, E. M. The Odonata of Canada and Alaska, Vol. 1 and Vol. 2. University of Toronto Press, Toronto. 1953 and 1958.

Weaver, J. E., and T. J. Fitzpatrick. The prairie. Ecol. Monogr. 4:113–295. 1934.

Weaver, J. E., and W. W. Hansen. Native midwestern pastures; their origin, composition, and degeneration. Nebraska Univ., Conser. and Surv. Div., Conser. Bull. No. 22. Lincoln, Nebraska. 1941.

Weaver, J. E., and F. W. Albertson. Grasslands of the Great Plains, their nature and use. Johnssen Publishing Company, Lincoln, Nebraska. 1956.

Webster's New International Dictionary of the English Language. 2nd ed. Unabridged. G. & C. Merriam Company, Springfield, Mass. 1955.

Westdal, P. H. A preliminary report on the biology of *Phalonia hospes* Wlshm. (Lepidoptera: Phaloniidae), a new pest of sunflowers in Manitoba. 80th Ann. Rept. Ent. Soc. Ontario, 1949, pp. 36–38. 1950.

Westdal, P. H. Two important insect pests of sunflowers. Ann. Conf. Manitoba Agronomists, Dec. 18, 19, and 20, 1951, pp. 22–23. (mimeographed) 1951.

Westdal, P. H. Insect pests of sunflowers. Ann Conf. Manitoba Agronomists, Dec. 17, 18, and 19, 1952, pp. 27–28. (mimeographed) 1952.

Westdal, P. H., and C. F. Barrett. Insect pests of sunflowers in Manitoba. Canada Dept. Agr., Ent. Div. Pub. 944. 1955.

Wettlaufer, B. The Mortlach site. Saskatchewan Dept. Nat. Res., Anthrop. Ser. No. 1. 1956.

Wood, H. E. Facts about Manitoba. Manitoba Dept. Agr., Winnipeg. 1952.

Zuckerman, S. (Chairman of Working Party). Toxic chemicals in agriculture, risks to wild life. Report to the Minister of Agriculture, Fisheries and Food, and to the Secretary of State for Scotland, of the Working Party on Precautionary Measures against Toxic Chemicals used in Agriculture. H. M. Stationery Office, London. 1955.

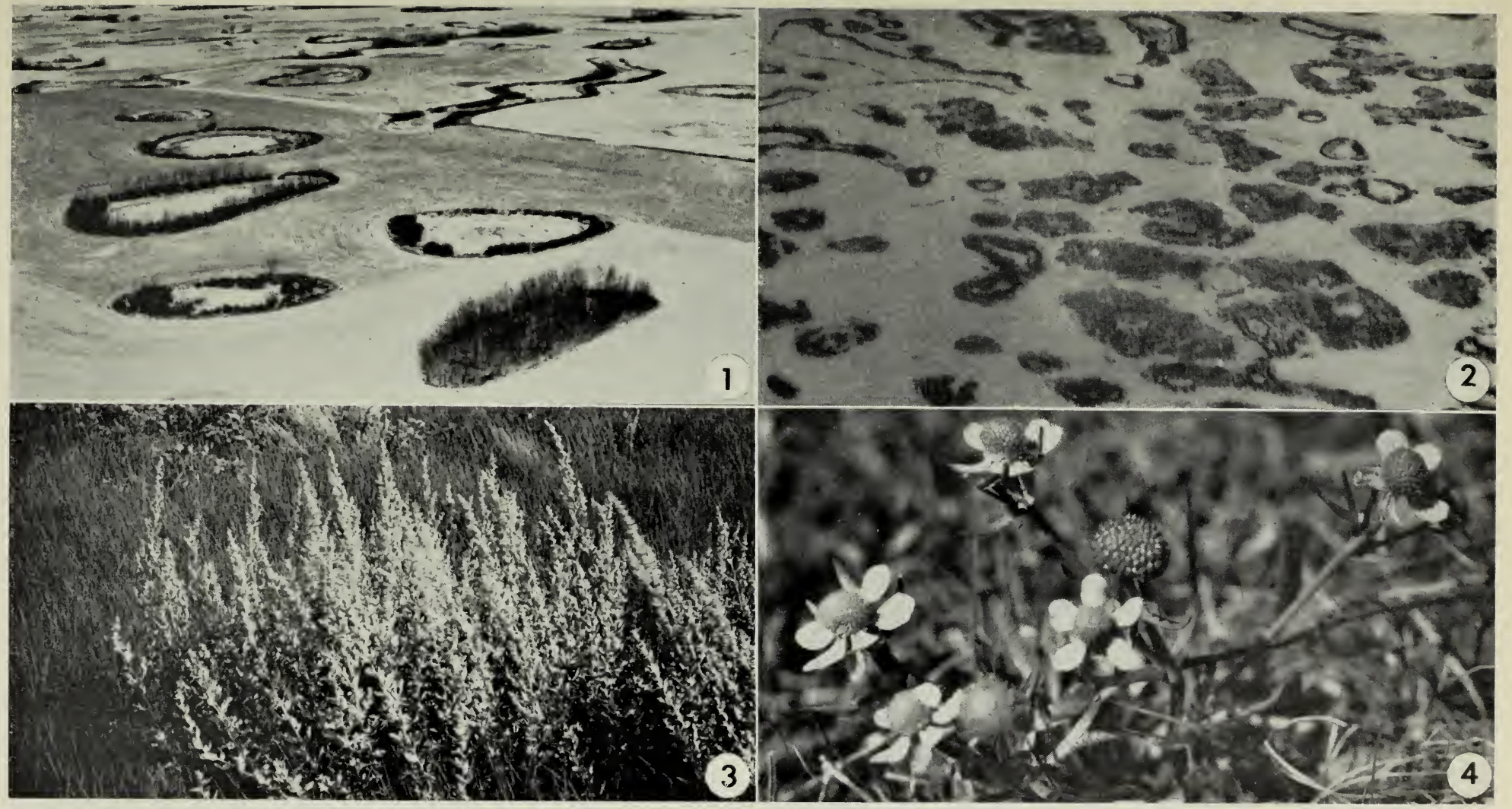


FIGURE 1 Cultivated aspen parkland in winter. Sloughs (potholes) bordered by willow and aspen are very prominent. In the foreground a depression that holds water for only a short time in spring has been overgrown by aspen. FIGURE. 2. Aerial view of aspen parkland from 5,000 feet in winter, showing clearly as rings the mosaic of sloughs bordered by willow and aspen with a few larger groves of aspen in the foreground. FIGURE 3. White sage, *Artemisia ludoviciana*, a common autumn herb, particularly in the tall-grass areas of the parkland. FIGURE 4. Prairie buttercup, *Ranunculus rhomboideus*, a common early spring flower in moist prairie.

FIGURE 5. White beardtongue, *Penstemon albidus*, a common summer herb on drier patches of prairie. FIGURE 6. Pasque flower, prairie crocus,or anemone, *Anemone patens*. This is the first spring flower. It grows in great abundance on gravelly and sandy prairie soils. FIGURE 7. Cord grass, *Spartina pectinata*, a common grass in wet prairie and near sloughs. FIGURE 8. Foxtail, *Hordeum jubatum*, a common grass in low alkaline areas, often forming a zone about alkaline sloughs. FIGURE 9. Bergamot, *Monarda fistulosa*. This member of the mint family grows abundantly about the edges of aspen groves and in rich prairie.

FIGURE 10. Yellow lady's-slipper, *Cypripedium calceolus*. Found in moist prairie and woodland areas. FIGURE 11. The buffalo, *Bison bison*, overgrazed the prairie and by its dust wallows created conditions favorable for the increase of the Rocky Mountain grasshopper. Here a buffalo is seen wallowing. FIGURE 12. The sharp-tailed grouse, *Pedioecetes phasianellus*, is the most abundant grouse of the parkland. Here a group is seen dancing on a hill in a plowed field. These grouse have favorite knolls, where they gather annually for their dances.

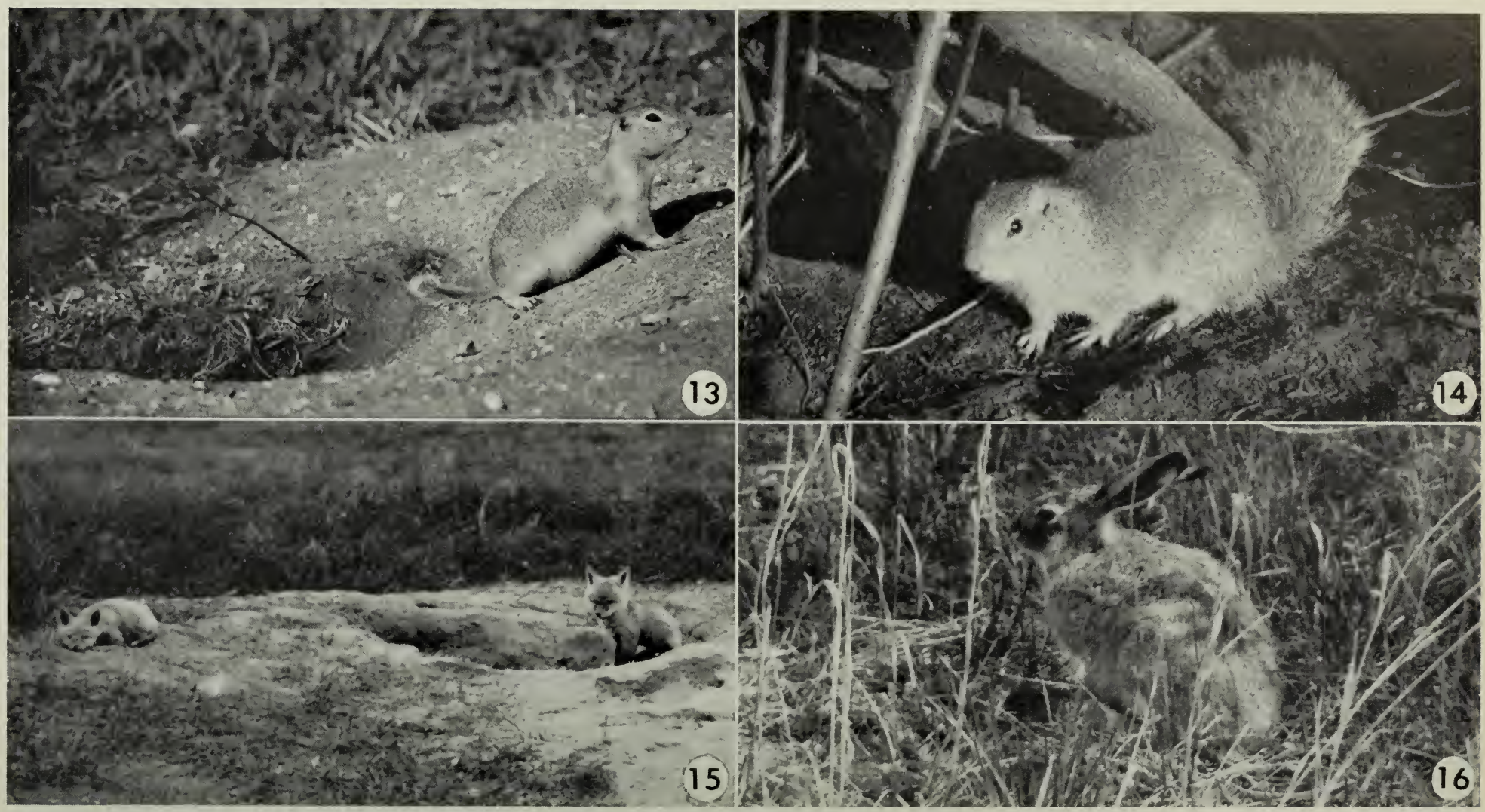


FIGURE 13. Richardson's ground squirrel, or prairie gopher, *Citellus richardsonii*. This was a very common rodent of short-grass and overgrazed areas. FIGURE 14. Franklin's ground squirrel, or scrub gopher, *Citellus franklinii*. This ground squirrel was never so abundant as Richardson's. It is commonly found about scrub land, the edges of groves, and marsh land. FIGURE 15. The red fox, *Vulpes fulva regalis*, a common predator of the prairie and woodland areas. Here two young foxes are seen at a den on the prairie. Photo by R. H. Painter. FIGURE 16. The white-tailed jack rabbit, *Lepus townsendii*, in summer pelage among a stand of big blue-stem grass.

FIGURE 17. Drummond's vole, *Microtus pennsylvanicus drummondii*, is probably the commonest small mammal in the parkland. FIGURE 18. A patch of silverberry, *Elaeagnus commutata*, that was destroyed by the feeding of voles, probably the red-backed vole, *Clethrionomys gapperi loringi* (Bailey). FIGURE 19. The rose curculio, *Rhynchites bicolor*. An adult is here seen feeding on the petals of the prairie rose. It has become a pest of cultivated roses. FIGURE 20. The Nuttall blister beetle, *Lytta nuttallii*, feeding on vetch, *Vicia* sp. This brilliant, metallic blue-green beetle attacks cultivated legumes—caragana, sweet clover, beans. FIGURE 21. Mature aspen forest near Treesbank, Man., with well-marked shrub stratum composed mostly of hazel. Photo by Norman Criddle

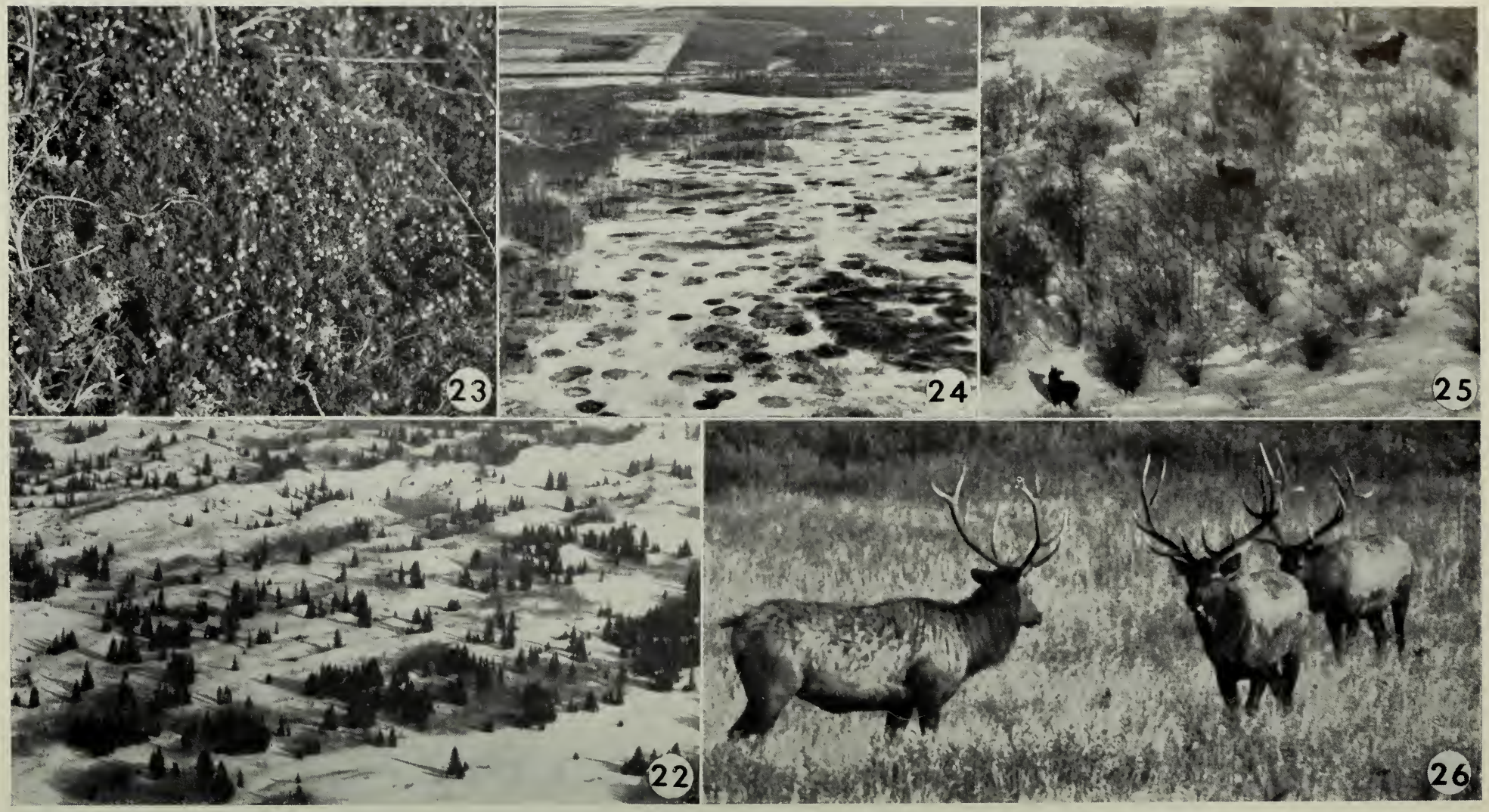


FIGURE 22. The Spruce Woods sand hill area of Manitoba in winter. The sand hills are overgrown. Scattered spruce grow singly and among groves of aspen mostly in the hollows, where the water table is close to the surface, and on north-facing slopes. FIGURE 23. Creeping juniper, *Juniperus horizontalis*, grows abundantly in sand hill areas. Sharp-tailed grouse feed on the berries and white-tailed deer browse extensively on the foliage. FIGURE 24. The sand hill area near Hartney, Man. A light snow cover outlines the circular patches of juniper. FIGURE 25. Moose, *Alces americana*, seen in a typical habitat of willow and aspen. FIGURE 26. Elk, *Cervus canadensis*. Three bulls on a patch of prairie in the Riding Mountain.

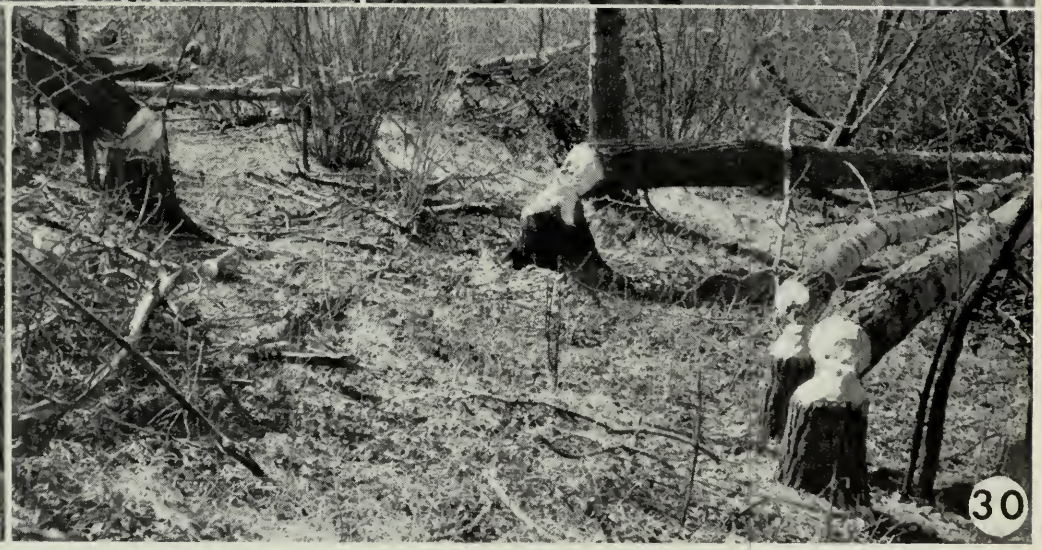


FIGURE 27. The snowshoe rabbit, *Lepus americanus*, in winter. FIGURE 28. White-tailed deer, *Odocoileus virginianus*. A doe among ostrich ferns of the floodplain forest. FIGURE 29. Hut and winter store of beaver, *Castor canadensis*. In the autumn, beaver repair and build houses and store up willow and aspen near their houses for winter feed. FIGURE 30. Beaver cuttings. Aspen trees are felled and the tops and branches carried off for winter stores. FIGURE 31. The great horned owl, *Bubo virginianus*, nesting in an old crow nest. The prominent black spots on the aspen are the scars produced by the poplar borer, *Saperda calcarata*.

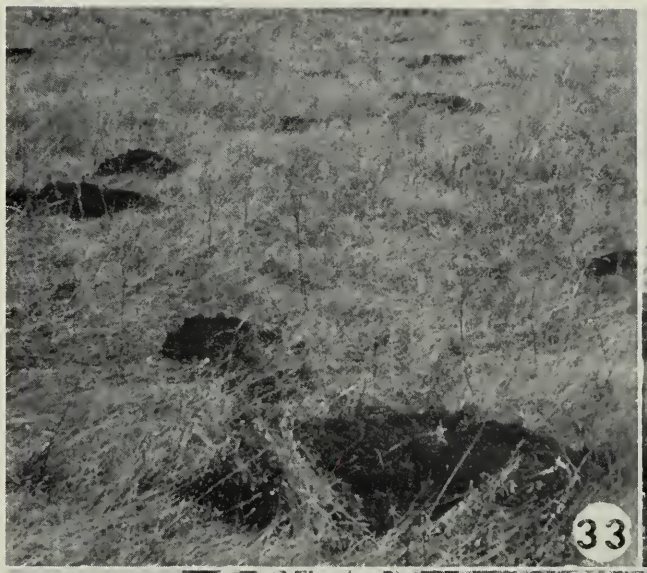


FIGURE 32. An alkaline slough. Note the lack of emergent vegetation and the white zone of incrusted salts along the shore. Prairie borders the shore but on higher ground, where the alkali is not concentrated, groves of aspen occur. FIGURE 33. Hills of soil thrown up by the pocket gopher, *Thomomys talpoides*, in its feeding activities. FIGURE 34. A willow slough. *Salix petiolaris* grow in the shallow water. Sedge, *Carex* spp., is emergent. FIGURE 35. A whitetop slough with willow and aspen in the background. FIGURE 36. *Scirpus* slough with zones of whitetop and prairie. *Elaeagnus commutata* and aspen groves are invading the prairie.

FIGURE 37. A house of the muskrat, *Ondatra zibethica*, built of *Scirpus* spp. Muskrats use rushes, sedges, cattails, and any other convenient material for house building. FIGURE 38. The coot, *Fulica americana*. This is a young bird that has not yet assumed the black plumage and white bill of the adult. FIGURE 39. A flight of blue geese, *Chen caerulescens*, and snow geese, *Chen hyperborea*, migrating near Rosser, Man., in 1936. FIGURE 40. Canada geese, *Branta canadensis*, have deserted most of their nesting grounds in the parkland.

FIGURE 41. An aerial view in spring of aspen parkland, illustrating advanced succession. Across the foreground is a strip where the groves of aspen have started to coalesce and the grass (light color) is almost crowded out. The central groves surround sloughs with heavy border growths of willow but still with some open water, whereas the groves to the right have overgrown sloughs that have dried up. The grassland is being invaded by patches of snowberry (dark) and sucker growth from the aspens. In the mid-distance two prominent sloughs show bands of willow. These have deep water, which extends beyond the willow and prevents the establishment of aspen.

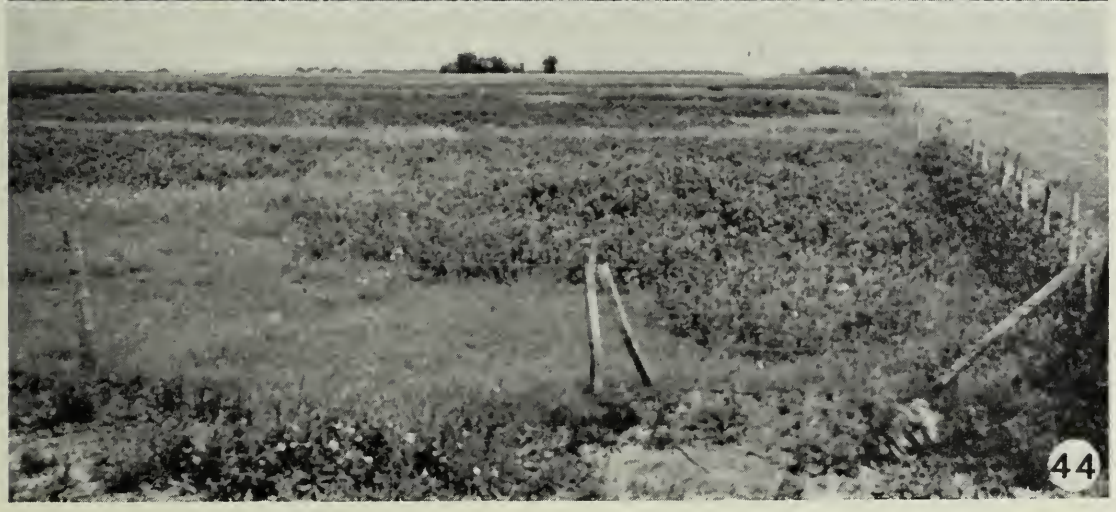


FIGURE 42. A slough full of water after being dry for a number of years, with a resultant invasion of willow and aspen. The invading plants have been killed by flooding, and cattails have commenced to seed into denuded areas.

FIGURE 43. A slough in an advanced stage of succession. Surface water has been practically eliminated through filling by accumulated vegetative debris. Willow and aspen have closed in so that only a small area supporting a dense stand of sedge, *Carex* spp., and a few water parsnip, *Sium suave*, remains.

FIGURE 44. Overgrazed pasture invaded by snowberry.

FIGURE 45. An aspen seedling in *Stipa* prairie. This seedling probably became established on bare ground created by a burrowing mammal.

FIGURE 46. Aspen grove rubbed and trampled by cattle in the manner described by Henry for buffalo.

FIGURE 47. Buffalo rubbing stone. Large, erratic boulders scattered over the prairie were used by buffalo as rubbing stones. They are still evident today, often have a distinct polish, and are characteristically surrounded by a depression from which soil loosened by trampling has blown away.

FIGURE 48. Grassland destroyed along road allowance has resulted in erosion. FIGURE 49. Road built several years ago in Lake Agassiz basin. Native vegetation has been destroyed except for some *Rosa*. Cattail and water plantain have invaded the ditch. Vegetation on the road shoulder is mostly brome and sow thistle; on the portion between ditch and field, brome, rose, ragweed, and sow thistle. FIGURE 50. The trumpeter swan, *Olor buccinator*, at one time nested throughout the parkland. FIGURE 51. Two-striped grasshopper, *Melanoplus bivittatus*. This species has increased with the increase of weeds.

FIGURE 52. Adult of the prairie grain wireworm, *Ctenicera aeripennis destructor*.

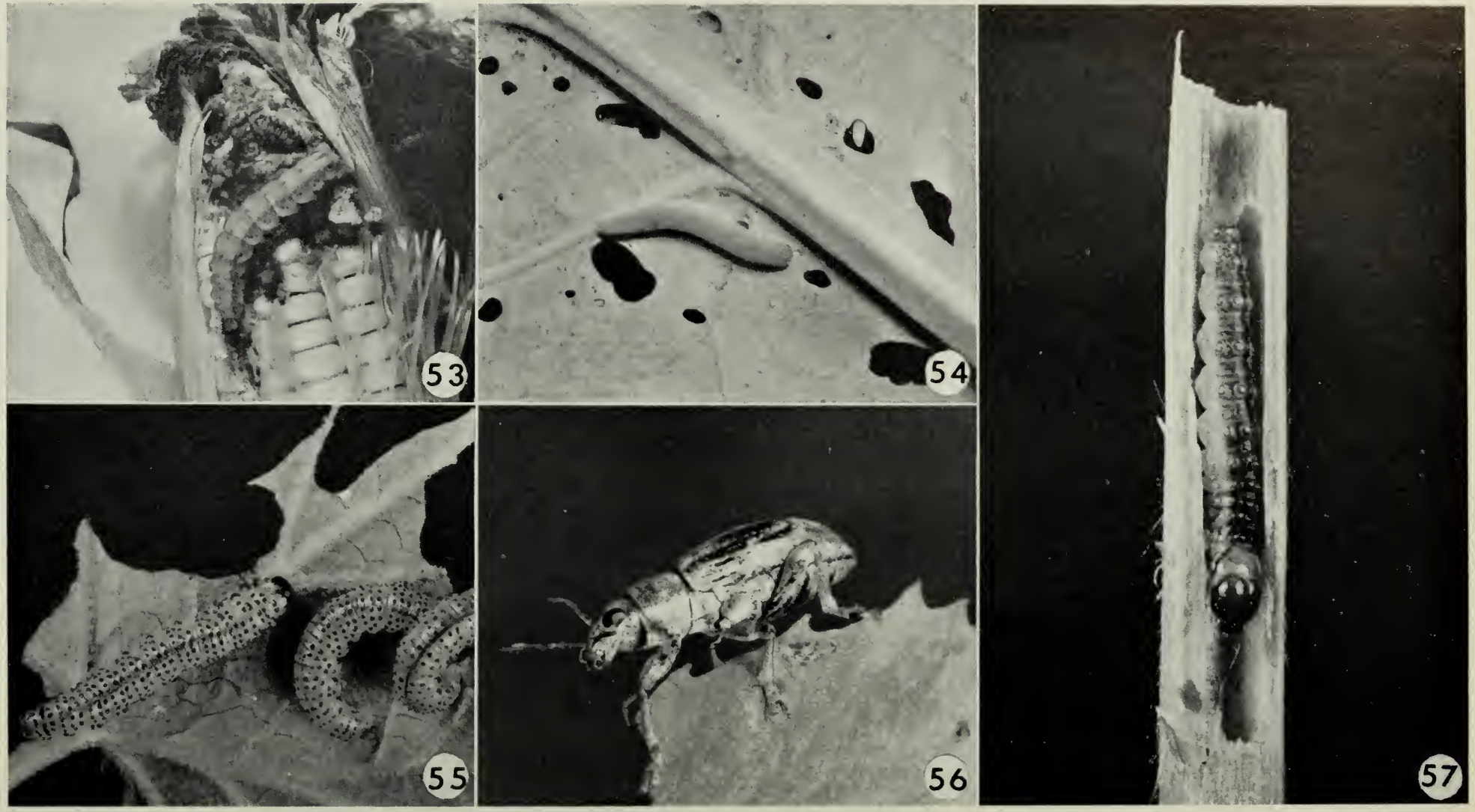


FIGURE 53. A larva of the corn earworm, *Heliothis zea*, attacking an ear of corn. FIGURE 54. The imported currantworm, *Nematus ribesii*, which has become a pest of currants and gooseberries. FIGURE 55. The imported cabbageworm, *Pieris rapae*, a pest of a number of species of Cruciferae. FIGURE 56. Adult of the sweet-clover weevil, *Sitona cylindricollis*, and characteristic feeding notch on leaf of sweet clover. FIGURE 57. A larva of the European corn borer, *Ostrinia nubilalis*, boring in a stem of millet.

INDEX

INDEX

81314-7—10

B

81314-7—10½

D

F

G

M

81314–7—11

N

O

P

81314–7—11½

Q

S

T