BIOTIC COMMUNITIES OF THE ASPEN PARKLAND OF CENTRAL CANADA [1] †

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A scene in the Birdtail river valley near Birtle, Manitoba, illustrating a typical landscape of the aspen parkland. A dense aspen forest is seen on the east and south slopes of the valley and close to the river. That on the far side of the river has been partly cut away by beaver which have a hut on the river bank close to the center of the picture. The gravelly, west-facing terrace across the river shows young aspen groves interspaced with the lighter colored prairie. The small dark patches in the prairie are due to *Symphoricarpos* starting up about badger holes. These will eventually be replaced by aspen.

I. Introduction

Since plant and animal communities in many cases are in full agreement, we may speak of biotic communities. Vestal ('13*a*, p. 13) was impressed by the relation of animals to plants through a field study and says: "The writer's training had led him to the hypothesis that animals and plants in a given terrestrial environment are very intimately related; that animal and plant associations (communities) [2] are coextensive and to a large extent interdependent, the animals being entirely dependent upon the plants, speaking broadly, and the plants being partly dependent upon the animals. If this be true the boundaries of an animal association (community) are those of the plant association (community); in fact both may be spoken of as a single *biotic* association (community), composed of plant and animal *assemblages*. Once this relation were established, certain of the problems of animal ecology would be greatly simplified; for although the animal assemblage is at first very obscure, the plant assemblage is evident, giving the characteristic appearance to the area. This physiognomy, lent by the plants, would thus serve as an index to the animals of the association (community), as regards ecological type, distribution, etc. Then, too, many of the methods of plant ecology, now an organized science, might be used in studying the animals of the association (community)." He concluded that his theory was supported by his study of the Illinois sand prairie.

Shelford ('13) indicated, from a physiological and experimental viewpoint as a result of the general field study involved in the production of his book ('13), that "plant and animal communities may be said to be in full agreement when the growth form of each stratum of the plant community is correlated with the conditions selected by the animals of that stratum." He then pointed out a few cases of disagreement, but showed that in the great majority of cases the communities are only temporarily out of adjustment, and summed up the discussion by the statement (p. 308): "The exceptions are often apparent only and due to the emphasis of species instead of mores and growth form. From this viewpoint and with such exceptions as are noted, plant and animal communities are probably in agreement the world over."

Since these papers were written more interest has been taken in bio-ecology, particularly among zoologists. Weese ('24), Blake ('26), Shackleford ('29), Smith ('28) and King ('27) in North America, and Cameron ('17) and Watt ('23) in Europe, have shown the close relationship of animal and plant communities. Botanists, in general, have been slower in realizing the importance of animals to plant communities. Clements, however, has long realized this relationship ('05, '16, '20) and together with Shelford ('27) has published a notice of a forthcoming work on "Bio-ecology." In this paper Clements and Shelford make the statement that, "On land, plants

[2] Vestal used association in the sense of community: the parentheses are the writer's.

are the universal dominants, though not to the entire exclusion of the animals, while in the ocean and all major water-bodies animals constitute the dominants and plants are secondary." Hence Shelford, in naming terrestrial biotic communities is discussing the adoption of a trinomial system, though four are used here, two names of which represent the plant dominants and one an animal predominant. Also, since animals are rarely dominant on land but form a group of predominants in a biotic community, he has applied to such a group the term *presociety*.

In this paper the terms and concepts of Shelford ('26) have been used essentially as expressed by Smith ('28). By oversight she omitted the words "outstanding abundance or conspicuous influence" from her definition of "predominants," thus making it necessary to redefine them.

A general term, predominant, like community, should be used, for those animals of outstanding abundance or conspicuous influence in the community which are present throughout the year, or entire active or open season, and whose exact importance is not known.

In countries of such northern latitude as Manitoba, we find many animals which are present during the active period of the community, from early spring to late fall, but which hibernate or migrate to the south in the winter. These, if of sufficient importance, may rightly be classed as predominants. In addition, there are a few mammals and birds which remain active all winter. Thus, through their longer period of activity, they are obviously of more importance than forms of equal abundance which are present only for the active period of the community. It does not seem necess ry to coin a new term for them, but rather to designate them by such qualifications as "permanent residents" for the birds or "active in the winter" for the mammals. Those forms which only winter in the community can be designated as "winter residents." Seasonals are those abundant or conspicuous animals which are present or active for only part of the year. This term may be used as a noun, or as an adjective to modify the preceding or following terms:

Influents. These are common animals which have important relations in the biotic balance and in the community. This term may also be used as a noun or as an adjective.

Sub-influents. Those animals which affect the life of the community but which are not as important as the influents.

The terms presociety and presocies have been used as employed by Smith ('28) to designate the animals of a climax or subclimax community respectively. The somewhat similar communities of plants within the larger units constituted by dominants are respectively termed society and socies (Clements, personal communication).

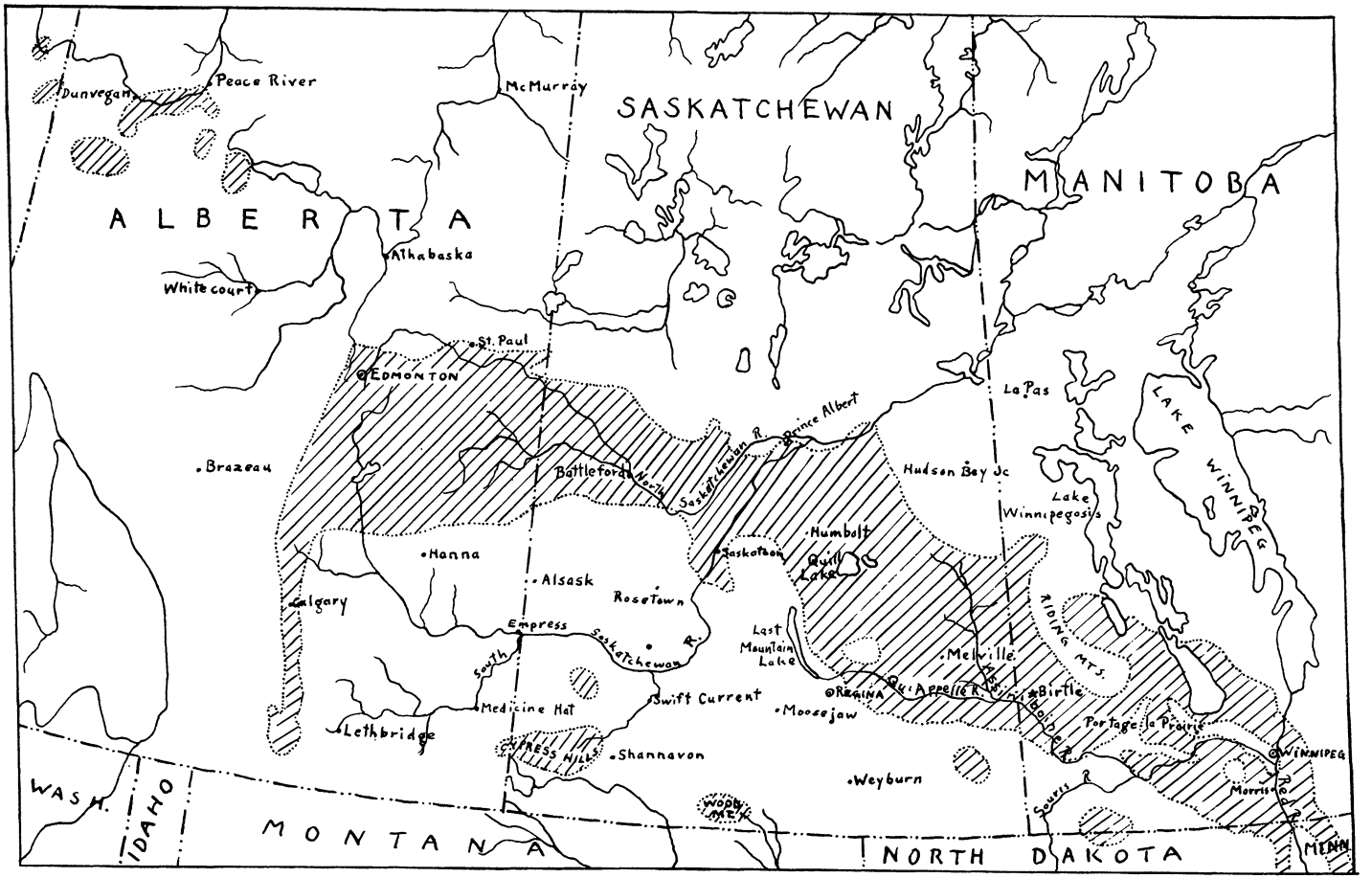


FIG. 1. The distribution of the aspen parkland (shaded). To the north is the northern coniferous forest and to the south the great plains. Birtle, where the study was made, is starred.

II. The Parkland of Central North America

The Great Plains region of central North America is separated from the deciduous forest on the east and from the coniferous forest on the north by a narrow belt of country, in which forest and prairie intermingle. This is characterized by forest stretching far into the prairie along the rivers, and by groves of trees interspaced by prairie which is found to be gradually crowded out as one approaches the forest. Such a country is called by some biologists savanna, but more generally parkland (Fig. 1).

Two types of parkland may be recognized in central North America, one between the eastern deciduous forest and the true prairie, which is characterized by oak and hickory groves, and one between the northern coniferous forest and the true prairie, which is characterized by aspen groves. Each represents an ecotone or area of stress between a forest and grassland formation, and generally may be considered as a subclimax community or associes of the former. In extensive areas, however, the dominant trees of the forested parts of the parkland may form a false climax (Clements' personal communication proposes proclimax) community or separate association of the forest formation. This is possibly the condition of the aspen over the greater part of the aspen parkland.

The Aspen Parkland (Fig. 1 and Plates XII–XVIII)

The aspen parkland, except for small areas in northern North Dakota and northwestern Minnesota, is confined to Canada. It extends from a short distance south of the Manitoba-Minnesota boundary north-westward in a line varying in width from 50 to 150 miles to a point near Edmonton, Alberta, and from there southward in a narrow strip some 25 miles in width along the foot hills of the Rocky Mountains to the Old Man River (see Fig. 1). In addition, it is found in isolated areas in the Turtle Mountains in Manitoba; Moose Mountains, Wood Mountains, Cypress Hills and the Great Sand Hills in Saskatchewan; and in several small areas along the tributaries of the Peace River in Alberta.

Throughout this region the dominant tree of the woodland is the aspen *Populus tremuloides Michx.* In places there are fair stands of other trees, Manitoba maple or box elder *Acer negundo* L., elm *Ulmus americana* L., bur oak *Quercus macrocarpa* Michx., and balsam poplar *Populus balsamifera* L.; but in all cases the succession is toward aspen. The forests of this region may be considered as consisting of an aspen association and of associes of the other trees mentioned. The relationship of these communities is discussed under the section on biotic succession.

On the north the aspen is in some places being replaced by white spruce *Picea canadensis* (Mill.) BSP. (Pl. XV, A). This replacement is slow, and, in the opinion of the writer, is largely controlled by edaphic conditions, for the spruce seems to be very partial to rocky and sandy soils. It is found to

the south in soils of this nature, e.g. the sand hills near Carberry, Manitoba, indicating that spruce was scattered over the whole area and that the trees have died or that they never gained a foothold in the intervening land. These isolated areas may be explained by spruce following close behind the ice as it receded at the end of the glacial period and remaining wherever conditions are favorable.

The aspen parkland thus forms an ecotone between the prairie and the coniferous forest. It is replacing the prairie over practically all its southern front, and to the north in some localities, at least, is in turn being replaced by spruce.

In this study of the parkland region the writer selected stations for intensive study and made headquarters at Birtle, Manitoba, situated on the Winnipeg, Saskatoon, Edmonton branch of the Canadian Pacific Railway within 15 miles of the Saskatchewan boundary. This region is particularly favorable as it is in the heart of the parkland and presents many seral stages in a state as yet relatively undisturbed. In addition, trips were made to other points for the purpose of comparison and the study of succession. Districts about Winnipeg, Treesbank, Molson, and Mafeking in Manitoba; and Saskatoon and Quill Lake in Saskatchewan were visited.

III. The Physical Environment

1. Geology of Southern Manitoba

"There are four main time intervals in the geological history of Manitoba during which contributions have been made to the rocks now to be found in the province" (Wallace '25). These are the pre-Cambrian, the Palaeozoic (Ordovician, Silurian and Devonian), the upper Cretaceaous and the Pleistocene. In the latter period deposition was the result of the southward progress of the ice sheets. "As a result of their erosive activity, there have been deposited on the surface of the older rocks, boulders and eskers, moraines, drumlins and glacial till; while in the great glacial lake (Lake Agassiz) which formed on the southward margin of the retreating ice sheet bedded clays were deposited; and beaches were formed along the margin of the lake during the successive halts in the lowering of the lake surface. In recent times rivers have cut their way through the glacial clays, lakes have to some extent been silted up, and extensive peat bogs have been formed on the surface of the glacial deposits. The topography of the country has on the whole been only slightly modified since glacial times" (Wallace '25).

Throughout the territory now occupied by the aspen parkland the surface material consists of these Pleistocene deposits, and it is with them and their local variations that we are now concerned. The glacial till, consisting of clays, sand and gravel, varies in depth from a few inches to over 200 feet. In the areas occupied by the glacial lakes Agassiz and Souris this material

was sorted out and deposited as fine silts and clays in the deeper parts of the lakes. Near the shore, and where rivers entered, deltas of coarser material were formed. The largest and most influential (ecologically) of these deltas was formed where the Assiniboine river entered Lake Agassiz. "It extended eastwards from Brandon 75 miles to Portage la Prairie, northeastwards 50 miles to Gladstone, and east-southeastwards 80 miles into the Boyne river valley. The sand deposited in this delta has since been to a large extent reassorted as sand dunes" (Wallace '25). It is on these dunes, in an area situated between Carberry and Glenbro, that we find an isolated area of white spruce.

2. Topography of Southern Manitoba

The topography of southern Manitoba is essentially that of Pleistocene times, and is largely due to the glacial action of that age. By far the greater part of the country was, at the close of this period, covered by three glacial lakes which, as they successively drained to the northward with the retreat of the ice, left behind them bottoms which now appear as level plains. Lake Souris, the oldest of the three, covered country in the southwestern corner of the province now known as the Souris Plains (Fig. 1) and extended up the valley of the Assiniboine River a little way into Saskatchewan. Its basin lies at a level of 1450–1550 feet. To the west the country rises to a height of 2,000 feet. The lake was bounded on the east by a group of hills known as the Turtle Mountains, Tiger Hills and Pembina Mountains, which in some places rise to a height of 1800 feet. The northern boundary was formed by the Riding Mountains which rise to 1,950–2,000 feet. At first the drainage was to the south, but on the retreat of the ice a passage, known as Lang's Valley, was formed to the north of the Tiger Hills, and the lake drained dry into Lake Brandon which lay at an elevation of 1,300 feet between the Pembina and Riding Mountains.

The remainder of the southern part of the province was covered by Lake Agassiz, the youngest and largest of the lakes. Its western boundary is roughly marked by a line drawn from the eastern side of the Pembina Mountains, longitude 98 on the international boundary, in a north-westerly direction to the eastern slopes of the Riding, Duck and Porcupine Mountains. As Lake Agassiz gradually drained out into Hudson Bay it left behind it a plain of 1,300 feet elevation on its western shore-line and sloping to the eastward to an elevation of 750 feet at Winnipeg. Even now it is relatively poorly drained. Much is low and marshy, and to the north it is covered by large shallow lakes—Winnipeg, Manitoba and Winnipegosis.

The present drainage is, as it was at the end of the Pleistocene age, northward into Hudson Bay. It is made up of two river systems, the Red River which rises in northern Minnesota and runs north into Lake Winnipeg, and the Assiniboine River which rises in Saskatchewan and flows eastward to join the Red at Winnipeg.

In parts of the Province above the level of the glacial lakes, and in the Souris Plains, the river valleys are deep, 200–300 feet. In Big Plains, which was covered by Lake Brandon, they are shallow, and in the Lake Agassiz bottoms, which have only recently been subject to erosive action, there is little or no valley.

Birtle, the headquarters for this study, is situated at an elevation of 1,700 feet, five miles to the north of Lake Souris bottoms and on the slope which gradually rises to the north to terminate in the Riding Mountains.

The topography of the Province, and the geological history associated with it, is of great interest to the ecologist because it gives rise to local variations in soil and climate which influence the distribution of the communities. The bottom lands of Lake Souris are high and dry, and have been covered for years by prairie which is even now only slowly giving way to the advancing aspen forest. On the other hand, the country which was covered by Lake Agassiz is low and marshy. Here, in contrast to the xerarc succession of the Souris Plains, we find a hydrarc succession. The highlands of the Province, not being subject to the inundations of the lowlands, have been forested for a long time.

3. Climate of Southern Manitoba

The climate of southern Manitoba becomes slightly more severe as we proceed from the lowlands about Winnipeg in a north-westerly direction to Birtle, which is 1,000 feet higher. At Winnipeg, the precipitation is on the average one inch greater, the expectation of a frost free season is considerably longer, and the extremes of temperature are not so great. The periods of precipitation and drought are, however, approximately the same.

Meteorological data for the area under discussion is woefully incomplete. Connor ('20) has brought all available data together; but, although some stations have kept complete records for many years, others have kept them for only a few years at a time. Hence it is difficult to compare the climate over the same period. In the decade 1885–1894 Connor gives complete records of precipitation at Fort Ellice (10 miles west of Birtle), at Winnipeg and at St. Albans (Aweme) approximately midway between the two former stations. Table I presents a summary of these records.

Over the same period the temperature records for Minnedosa (60 miles east of Birtle), St. Albans (Aweme) and Winnipeg as given by Connor are presented in Table II.

Although the total precipitation is not great, most of it comes in June when it is most needed, and decreases towards autumn. May, however, is often subject to drought (only .10 of an inch falling in the dry year of 1917) which, coupled with a temperature running as high as 90 degrees, i detrimental to young seedlings and prevents many seeds from germinatin .

At St. Albans (Aweme) complete records have been kept since 1887. Since this station, on account of its situation at an elevation of 1,200 feet,

might be considered as having an average climate for the southern part of the Province, it has been thought advisable to quote the following (Bird '27):

"The average yearly precipitation for 38 years, from 1887 to 1924 was 18.45 inches. The greatest for any one year was 25.52 inches in 1924,

TABLE I. *Precipitation means and extremes at Fort Ellice, Manitoba, 1885–1894*

Month	Precipitation in inches				Snow in inches	
	Average per month	Greatest in one month	Amount in driest year	Amount in wettest year	Average per month	Greatest in one month
			1889	1890		
Dec.	0.59	1.15	1.15	0.26	5.9	11.5
Jan.	0.88	3.00	0.70	0.24	8.8	30.0
Feb.	0.94	2.12	0.70	2.12	9.4	21.2
Winter	2.41		2.55	2.62	24.1	
March	0.82	1.45	0.23	0.35	7.8	14.5
April	1.06	1.67	0.42	1.18	4.3	11.0
May	1.77	2.97	0.83	2.33	0.6	5.0
Spring	3.65		1.46	3.86	12.7	
June	3.61	6.58	2.95	3.86		
July	3.09	6.80	1.65	2.90		
Aug.	1.60	3.48	0.57	3.48		
Summer	8.30		5.17	10.24		
Sept.	1.05	3.67	0.94	3.67		
Oct.	1.04	2.00	0.06	2.00	1.6	5.0
Nov.	0.93	2.57	0.30	2.54	6.5	14.0
YEAR	17.38		10.48	24.93	44.9	
Year at Winnipeg	18.80		14.38	24.91	52.2	
Year at Aweme	17.14		13.58	22.30	41.9	

and the least 12.6 inches in 1917. The average monthly precipitation for 33 years, from 1885 to 1917, was: Jan. 0.78, Feb. 0.58, March 0.95, April 1.05, May 1.81, June 3.09, July 2.17, Oct. 1.08, Nov. 0.81, Dec. 0.66.

TABLE II. *Temperatures, degrees F., at Aweme, Winnipeg and Minnedosa, Manitoba, 1885–1894*

	Mean	Mean Maximum	Mean Minimum	Extreme Highest	Extreme Lowest
Aweme	34.5	47.4	21.6	108	−48
Winnipeg	33.0	44.7	21.4	103	−46
Minnedosa	32.2	44.9	19.5	103	−52

"The temperatures for 30 years, from 1885–1914, in degrees F. are mean 35.4, mean maximum 48, mean minimum 22.9, extreme highest 108

and extreme lowest –48. The last spring frost occurs on the average between June 19 and 21 and the first fall frost between August 24 and Sept. 2."

Connor's data for the frost free season at Birtle, which is slightly shorter than at Aweme, are presented in Table III. The same period at Winnipeg is correspondingly longer.

TABLE III. *Frost free season at Aweme, Manitoba*

Year	Late Frost		Early Frost	
	Date	Temp. ° F.	Date	Temp. ° F.
1904	June 27	30	Sept.	29
1905	June 21	33	Sept. 12	26
1906	May 28	26	Sept. 12	31
1907	June 2	33	Aug. 11	33
1908			Sept. 2	31
1909	May 19	33	Sept. 18	33
1915			Aug. 4	33
1916	June 19	32	Aug. 24	33
1917	June 21	30.5	July 12	31

During the summer of 1928, observations were made on the weather conditions at Birtle. The last spring frost was on June 14, with a temperature of 32° at 6.00 A.M., and the first fall frost was on August 21, also with a temperature of 32° at 6.00 A.M. The precipitation, in inches, was as follows: April 0.02, May 0.93, June 5.15, July 1.38, August 1.01, September 0.57, October 0.38. The first snow flurry was on October 11th. The above precipitation is average, the greatest amount falling in June, after which there is a gradual decrease until October. From then on the precipitation is mainly snow. In some autumns, however, there is considerably more rain in late September and October.

IV. Methods Used in Investigation

In this study, the writer followed the method of random quantitative sampling, supplemented by observation and cruising.

Succession was studied mainly by the last two methods. These investigations were carried out intensively in the spring of the year in which the study was undertaken, so that as thorough a understanding as possible of the major stages in succession could be grasped. This procedure also aided in the selection of stations for the quantitative sampling. Careful observations were taken of the zonation of plants from wet to dry areas and vice versa. The dominants of each stage were noted; also, the process of replacement of one dominant by another as the nature of the soil and water content changed; and how certain dominants would create conditions unfavorable for their reproduction, but favorable for other species which would replace them, until a more or less stable or climax condition was reached.

When a sufficient knowledge of succession had been gained, certain stations, or typical areas, in important successional stages were selected for quantitative sampling throughout the year. The actual method of sampling in these areas was a random one and essentially the same as that used by King ('27) in his study of the prairie and early successional stages toward the aspen forest at Saskatoon, Saskatchewan.[3]

Collections of the invertebrate population were made early in the morning, so as to be at a period of minimum activity, and thus insure as accurate samples as possible. At this time the nocturnal forms had come to rest and the diurnal species had not yet become active. The great majority of animals which, when active, inhabited the herb, shrub and tree top strata remained there when at rest and were taken *in situ*. The collections from these strata were taken by means of an ordinary sweep net, from 3 to 5 sweeps, according to the density of the population, being found to give the best results. At the same time a sample was taken from the herb and surface strata by means of a metal cylinder which measured 30 inches in height by 14.13 inches in diameter. It was open at one end and closed at the other save for a small hole into which a cork was inserted. For convenience, handles were attached to the sides. In addition, a band of metal 8 inches deep and of the same diameter as the outside of the cylinder, and working closely but freely over it, was used. When a collection was to be made the area was approached quietly and the cylinder dropped open end downwards on the ground. The metal band was then forced a short distance into the earth and ether poured in through the hole at the top.

After the ether had time to act (the sweepings were made while waiting), the cylinder was removed, leaving the band in the ground. The surface vegetation and debris inside the band were then gathered up and placed in a canvas bag for transportation to and examination at the laboratory. From the denuded area, with the band still in place, the soil was taken with a trowel and also placed in canvas bags. For convenience it was divided into 0–2, 2–4, 4–7 and 7–10 inch depths. Since, however, it was found that few or no animals descended below the 2 inch level, the majority of collections did not extend beyond that depth.

The soil was washed with strained river water through two sets of sieves, the first of ordinary mosquito netting to remove the coarser material, the second of wire gauze of 50 meshes to the inch.

Since the cylinder covered a circle 14.13 inches in diameter which is 1/40,000 of an acre, or 1/100,000 of a hectare, and one sweep of the net corresponded roughly to five samples with the cylinder, it was a simple matter to estimate the population for any area.

It was found that collections made once every two weeks were sufficient to trace the seasonal changes of the population. Owing to the mechanical

[3] The writer is very greatly indebted to Mr. K. M. King for advice in selecting stations and personal demonstrations of the methods involved in his study.

difficulties of washing without running water, soil samples were taken only once a month, but from the results this was judged sufficient.

The vertebrate population was studied by general observations and cruising, supplemented by trapping the smaller mammals and shooting some of the larger species and birds when an examination of stomach contents or other information was desired.

A fair estimate of the numbers of some of the more important birds was gained by counting the singing males and searching for the nests. The actual numbers of the mammals were harder to judge and became successively more difficult from the larger to smaller species, so that in many cases it became necessary to resort to the indefinite terms of relative abundance.

V. Major Biotic Communities of the Aspen Parkland

Certain stations in important successional stages were selected at Birtle, Manitoba, for the intensive study by means of quantitative collecting in the most important biotic communities of the aspen parkland. These studies were carried on in the spring and summer of 1928, and collections were made in the following communities: 1. Prairie Community. 2. Willow Community, (a) *Salix petiolaris* consocies, (b) *Salix longifolia* consocies. 3. Aspen Community, (a) Forest-edge associes, (b) Mature aspen association (see Fig. I and Pls. XII–XVIII).

These communities are of wide range and of major importance as is shown by their successional significance, and it was thought that in the limited time available for study they would give as good an understanding as possible of the general biological conditions prevailing throughout the parkland.

A. Prairie Community (Plates XIII, XIV, and Fig. 4)

Agropyron-Microtus Associes

The prairie of the aspen parkland is an association of the tall grass of the eastern Great Plains, as described by Shantz ('23), and extends by finger-like projections and isolated areas throughout the parkland. It is characterized by the persistent heads of wheat grass, *Agropyron,* reaching to a height of some 2.5 feet, and by a dense mat, 1 to 3 inches in depth, of grass leaves. There are also a great many subdominant herbs which in their respective season of flowering (see Norman Criddle '27) turn the prairie into a veritable flower garden.

The station selected for study was an area of virgin prairie of about 2.5 acres in extent situated a little north of the center of the north-west quarter of section I, township 17, range 27 west of the principal meridian, at about one mile northwest of the town of Birtle. It was roughly triangular in outline. The east side was bordered by a young aspen grove, and the southern and western by gullies in which there was a growth of willows

and native grass and sedge. A hundred yards to the north was a field of oats, and across the gulley to the northwest a fallow field. The whole, except for a narrow strip bordering the water course to the west, sloped gently to the south. Three small aspen groves and several patches of *Symphoricarpos* and *Elaeagnus* were scattered over the prairie. As far as was known it had not been burnt over for many years or disturbed in any way, and represented a typical portion of parkland prairie.

1. Plants

The dominant plants are the four grasses, *Agropyron Richardsoni* Schrad., *Koeleria cristata* (L.) Pers., *Agrostis hyemalis* (Walt.) BSP. and *Stipa comata* Trin. and Rupr.; but it is the first, by means of its flower heads which persist throughout the winter, that gives the characteristic aspect to the prairie.

At Birtle, on dry hillsides *Andropogon furcatus* Muhl. and *A. scoparius* Michx. may become dominant, while further west, under more generally xeric conditions at Saskatoon, Saskatchewan, King ('27) recognizes an *Agropyron-Festuca-Stipa-Bouteloua* prairie associes.

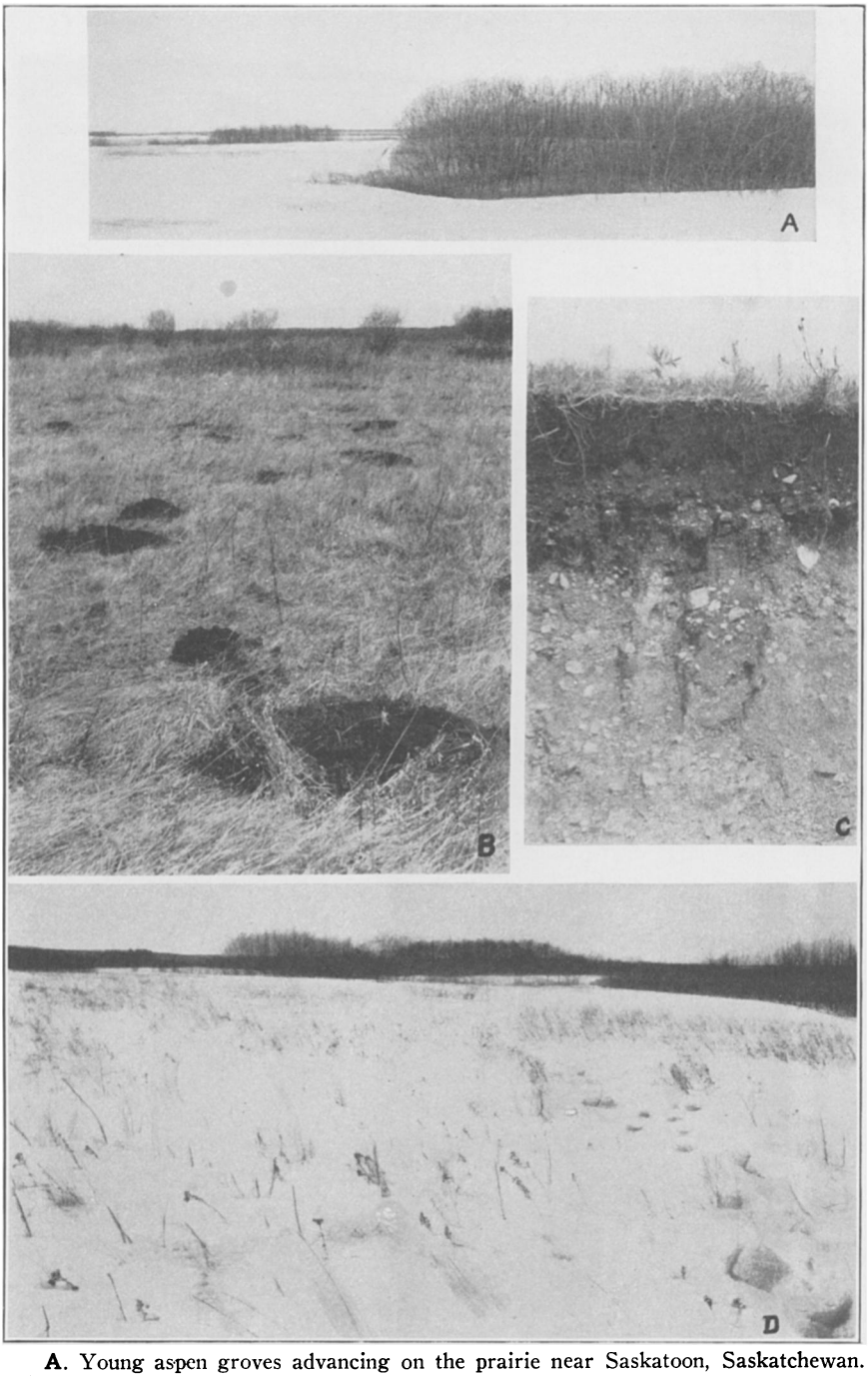
The subdominant plants arranged in the seasonal socies in which they occur are:

Spring	Summer	Autumn
Anemone patens wolfgangiana (Bess.) Koch.	*Erigeron borealis* Nutt.	*Helianthus scaberrimus* Ell.
Comandra Richardsiana Fernald.	*Rosa pratincola* Green.	*Monarda mollis* L.
Geum triflorum Pursh.	*Liatris punctata* Hook.	*Solidago rigida* L.
Cerastium arvense L.	*Rudbeckia hirta* L.	*Solidago missouriensis* Nutt.
Houstonia longifolia Gaertn.	*Campanula rotundifolia* L.	*Glycyrrhiza lepidota* (Nutt.) Pursh.
Androsace occidentalis Pursh.	*Pentstemon gracilis* Nutt.	*Achillea millefolium* L.
Antennaria neodioica Greene.	*Psoralea esculenta* Pursh.	*Artemisia frigida* Willd.
Galium boreale L.		*Artemisia ludoviciana* Nutt.
Lithospermum canescens (Michx.) Lehm.		*Aster multiflorus* Ait.

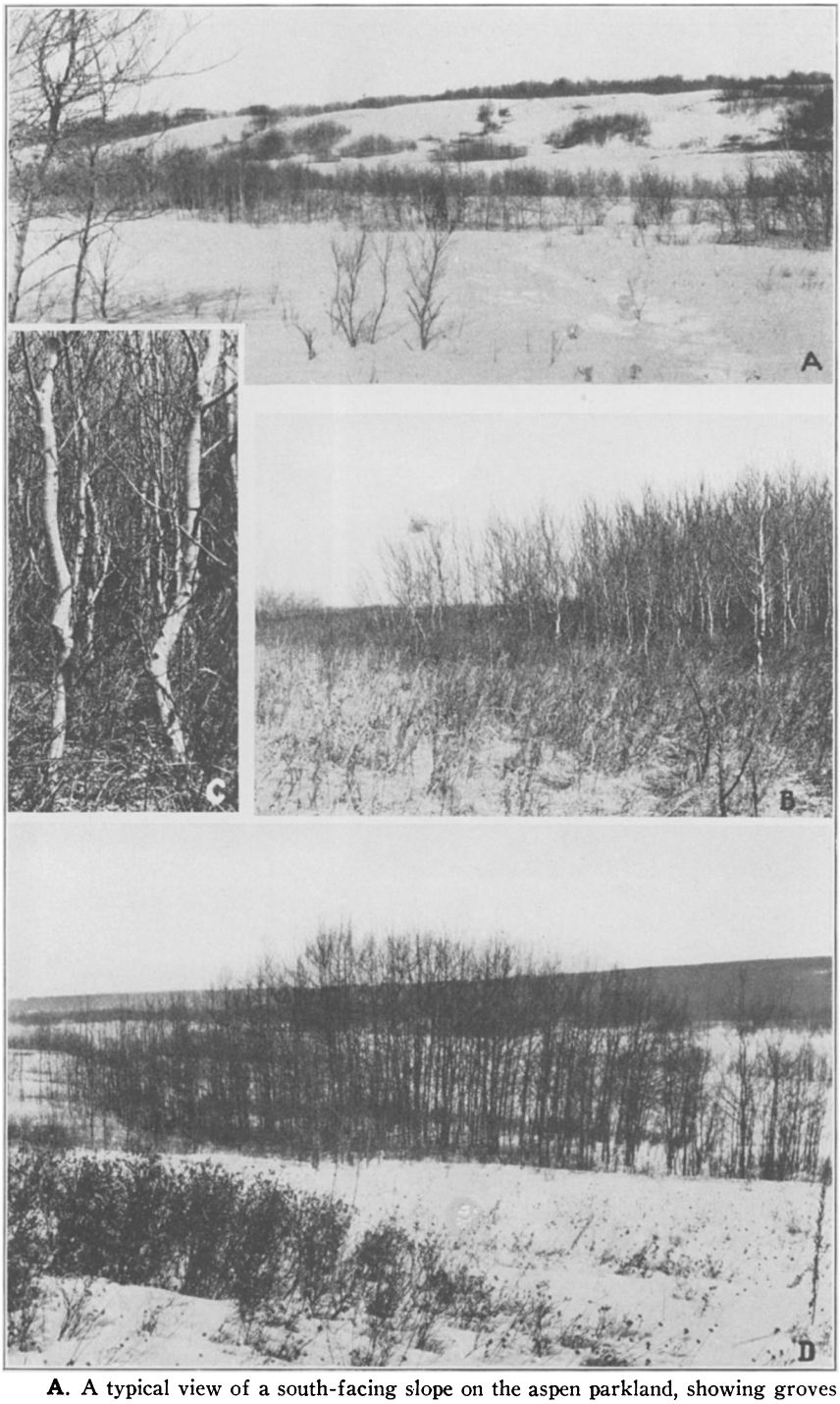
In the sandy soil about Treesbank, Manitoba, the following plants occur as subdominants in addition to the above (Bird '27), but are absent from the rich soil about Birtle: *Prunus pumila* L., *Senecio plattensis* Nutt., *Brauneria angustifolia* (DC.) Britton, and *Juniperus horizontalis* Moench.

2. Animals (Presocies)

The area of study is on the border of the *Stipa-Bouteloua-Antilocapra-Bison* formation of the Great Plains, and represents an associes related to it. Into this associes the larger pedominants of the former ranged and formerly played an important role. They disappeared or were greatly reduced in



A. Young aspen groves advancing on the prairie near Saskatoon, Saskatchewan. They are situated in the hollows where there is an accumulation of water in the spring, and are preceded by *Symphoricarpos*. **B**. Pocket gopher mounds on the part of the prairie under intensive study. **C**. A typical soil profile. About 10 inches of humus overlie glacial till. **D**. The prairie "station" in winter. The heads of *Agropyron, Solidago* and *Artemesia* may be seen above the snow.



A. A typical view of a south-facing slope on the aspen parkland, showing groves in the gullies and damp places. **B.** The edge of a young aspen grove advancing on the prairie. The dark colored shrub is *Symphoricarpos*. **C.** A close view of **A**. **D.** A typical young aspen grove replacing a patch of *Symphoricarpos* which shows as a dark ring about its edge. A younger patch is shown in the left foreground. The old flower heads showing above the snow are of *Monarda mollis*.

numbers before the advance of the settlers. At present only the smaller ones remain.

a. Formation Influents. The prong-horned antelope, *Antilocapra americana* (Ord.), although more of an animal of the arid plains, nevertheless wandered into the parkland and was "Recorded once or twice in the early days very near Winnipeg; last seen on the Souris about 1881." (Seton '09*a*). It was recorded by Alexander Henry as abundant on the Souris plains in 1806 and by Seton as plentiful at White Water in 1879.

The immense herds of buffalo, *Bison bison* L., of the Great Plains extended well into this region, and it was undoubtedly the most influential prairie animal of those times. They were "last seen wild near Winnipeg in 1819. Last great wild herd on the Souris 1867; the last wild individual on the Souris 1883" (Seton '09*a*). Although shortly after the extermination of the buffalo large quantities of the bones were gathered and sold for fertilizer, many broken bones and parts of skulls may still be seen. Alexander Henry ('97, p. 118) gives an idea of the influence on the vegetation exercised by the buffalo: "The grass would be rather long were it not for the buffalo."

Associated with the change from buffalo to cattle as the predominant grazing animal it is interesting to note how the cowbird, *Molothrus ater* L., which once accompanied the buffalo herds and fed on the insects associated with them, has been little disturbed by the change, and follows the cattle in a similar manner.

The most abundant of the deer family and the first to disappear before the advance of the white man, was the elk or wapiti.

The only animal which seems to have been really benefited by settlement, and is not only holding its own but increasing its range, is the jack rabbit, *Lepus townsendii campanius* Hollister. "It was formerly found only in the extreme south-west of the Province (Manitoba), and exceedingly rare; now abundant in all the prairie regions, especially in the vicinity of cultivated fields" (Seton '09*a*). It is well adapted to life in such situations, and with the reduction in numbers of its chief enemy, the coyote, increases sufficiently to keep pace with those that are killed by human agency.

The chief carnivore associated with the herds of buffalo and antelope was the buffalo-wolf, *Canis mexicanus nubilis* Say. Bailey ('26) records them as being very numerous in North Dakota in the early part of the 19th century and they were probably only slightly less abundant in Manitoba.

The larger animals of the prairie in the aspen parkland were thus early exterminated by the hunters which preceded the early settlers. The buffalo-wolves, after a diminution in numbers with the loss of their chief food supply, began to increase with the introduction of range cattle, and it was only with systematic trapping and poisoning that their numbers were finally reduced so that it is doubtful if a single individual may now be found alive in central Manitoba.

b. Influents of narrower range. At one time foxes, *Vulpes regalis*

Merriam, were plentiful, and as late as 1890 there were as many as two pairs to a township (Seton '09*a*). Since then they have decreased rapidly until now they have been driven back to the coniferous forest and are practically extinct in the parkland. In contrast, the coyote, *Canis latrans* Say., increased with settlement as the foxes decreased, and in 1904 numbered as many as 10 to a township (Seton '09*a*). Today, after the introduction of a bounty system and intensive trapping for fur, they have been reduced to less than half that number.

Some of the smaller mammals, at first, also greatly increased in numbers with the advance of the settlers, only to be later destroyed. The most important of these is the Richardson's ground squirrel, *Citellus richardsoni* (prairie-dog equivalent) and its chief predator, the badger, *Taxidea taxus*. This rodent lived in scattered colonies on the dryer knolls of the prairie and waxed fat on the wheat fields of the farmer. Its burrows were deep enough to escape injury by plowing, and those whose holes were in the surrounding prairie came long distances to feed on the grain and carry it back for their winter store. With this abundant food supply they increased and multiplied until about 1915, when their peak was reached and they numbered as high as 30 to 40 per acre. The damage to the crops was so great that bounties and competitions of various kinds were organized to destroy them. This, together with systematic poisoning by the farmers, reduced their numbers to a minimum, so that now only a few may be seen where once they were abundant.

The curve of abundance of the badger followed close behind the Richardson's ground squirrel, or gopher, as it is locally called, and now that its fur has gained favor it is rapidly nearing the point of extermination.

The striped ground squirrel, *Citellus 13-lineatus,* another common prairie rodent which was never as abundant as Richardson's ground squirrel, lived in scattered holes well hidden in the grass rather than in colonies. Its burrows were shallow and easily destroyed by plowing, so that it rapidly decreased with cultivation, and competitions were not needed to destroy it.

Originally two large birds were important in the tall grass prairie. One, whose fluctuations in abundance are of rather unusual interest, is the prairie chicken, *Tympanuchus americanus* L., which was unknown in the Province until 1882. Seton ('09*a*) writes: "In 1883, W. R. Hine informs me, it began to be common at Pembina. In 1884 it was not only common at Winnipeg, but had also for the first time made its appearance at Portage la Prairie, on the Assiniboine. In 1886 I first saw it at Carberry. Since then it has spread with cultivation, and is now abundant in all settled parts." It remained abundant until 1916 in the Birtle district, when, together with the sharp-tailed grouse, *Pedioecetes phasinellus campestris* L., its numbers began to decline rapidly until now both are comparatively scarce. In habit it was more a bird of the open than the sharp-tail, which preferred a parkland type of country, and hence was more benefited by civilization.

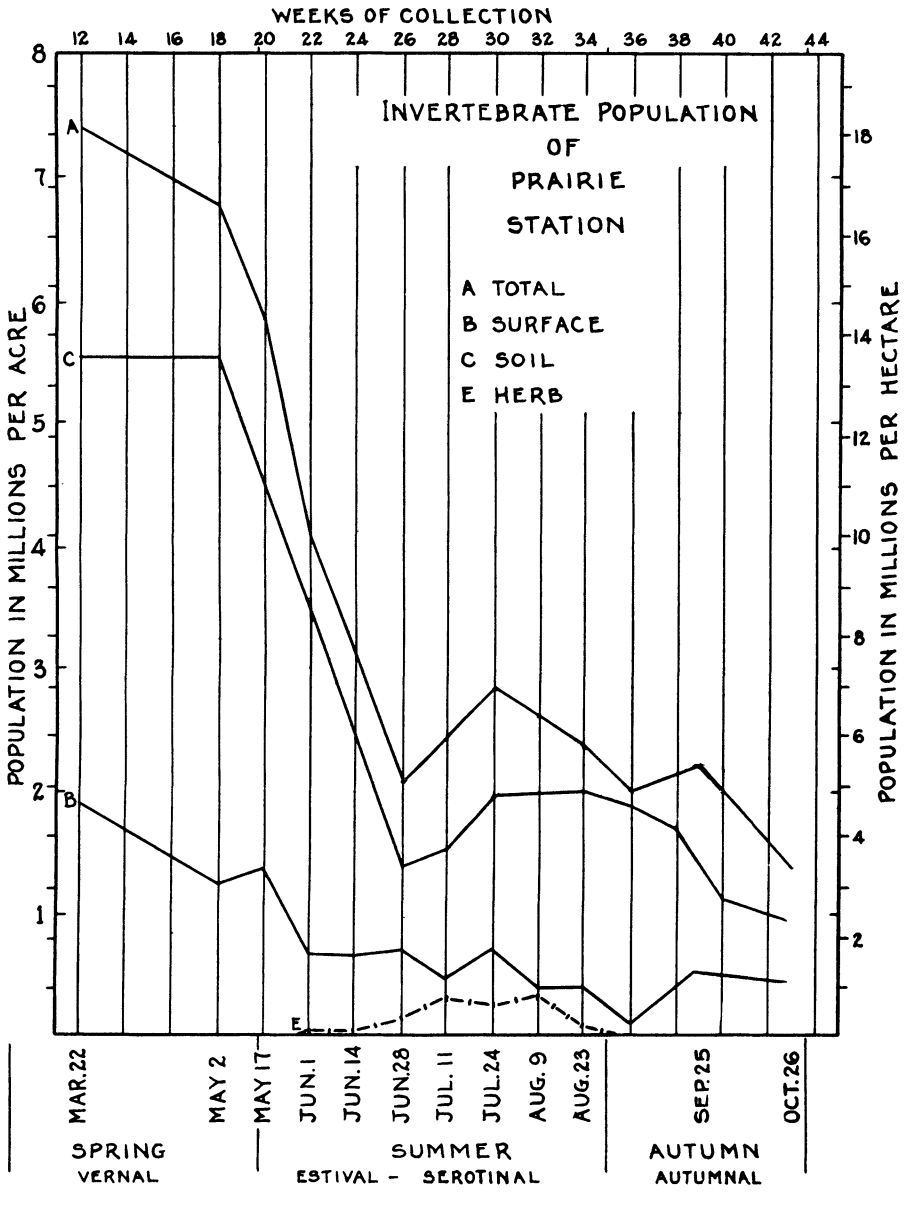


FIG. 2. Graph showing invertebrate population of the "prairie station" as indicated by the quantitative collections in 1928. Both the surface and soil populations (curves *B* and *C*) show a high spring maximum and fall to a minimum in late June and early July, from which they show a tendency to climb toward a similar fall maximum. This was prevented by the onset of a drought and they fall to a still lower minimum. The population of the herbage (curve *E*) is present for a brief period from June to September. It may thus be considered as estival-serotinal.

In addition to the domestic animals several semi-wild species have been introduced. One of these, the Hungarian partridge, *Perdix perdix* L., was introduced near Calgary, Alberta, in 1908 (Taverner, '26) and has since spread eastward to western Manitoba. It is abundant throughout the prairie and neighboring parkland of Alberta and Saskatchewan.

The Drummond's vole, *Microtus drummondii* (Audubon and Bachman), is extremely abundant and the most influential animal found on the prairie at the time of study. All specimens taken were of a small form, measuring only 110 mm. in average length, while Bailey ('26) gives 145 mm. as the total length. Other specimens of this small form were taken at Treesbank by Stuart Criddle, and sent to Bailey who did not recognize them as a distinct variety. It was not possible to estimate the number present on an acre of ground, but it must be very great, for it was scarcely possible to find a square foot of ground that was not crossed by several runways. Bailey ('26) reports an even greater abundance on the prairie of North Dakota, and, in an earlier paper ('24) gives a full account of their habits. Their food is apparently entirely vegetable, and consists of seeds and the tender shoots of grasses. They are active all winter, and have many runways through the snow. In the summer the nests are underground, but in the winter they are above ground, and consist of fine grasses woven into a spherical shape some 10 inches in diameter. They have many enemies, hawks, owls, and weasels, which, in spite of their great fecundity, keep their numbers in check.

Probably the next most important mammal at present is the pocket gopher, *Thomomys talpoides rufescens* (Wied), which is an important influential rodent throughout the parkland prairie, and is found in all types of soils from almost pure sand to the heavy silt of river flats. The mounds of dirt thrown up from its burrows in search of food are a common sight (Pl. XIII, B). The numbers are very variable. About Treesbank, Stuart Criddle finds that there are not more than one to every 20 or 30 acres, while in parts of the Birtle district and in North Dakota (Bailey '26) there are as many as one or more to every acre. At one time there were two active burrows in the study area, but activity ceased in May. The occupants were probably taken by the great horned owl which was seen hunting over the area, and in whose pellets gopher remains were found. At this time of the year gophers spend much of the night above ground in search of their mates, and many are taken by owls and other predators. At other times they are entirely fossorial, and are practically free from enemies. Their food is entirely vegetable, and consists of roots and tubers (Bailey '26). They are thus an important influent in the prairie community, not only on account of the vegetation they eat, but also that which they cover with their mounds. As with the earth from the badger holes, the mounds form starting places for patches of *Symphoricarpos*.

c. Sub-influents of the Prairie. The crow, leopard, frog, meadow

lark, ants, the insects and invertebrates generally taken as a group may be considered important in the prairie. They are divided into several classes, (1) local visitants which breed in some other community and feed in the prairie adjacent, and (2) open season birds, characteristic of the prairie, which leave during the cold winter, (3) mammals reduced in number or of small influe ce, and (4) invertebrates, especially insects of the more important orders, particularly ants.

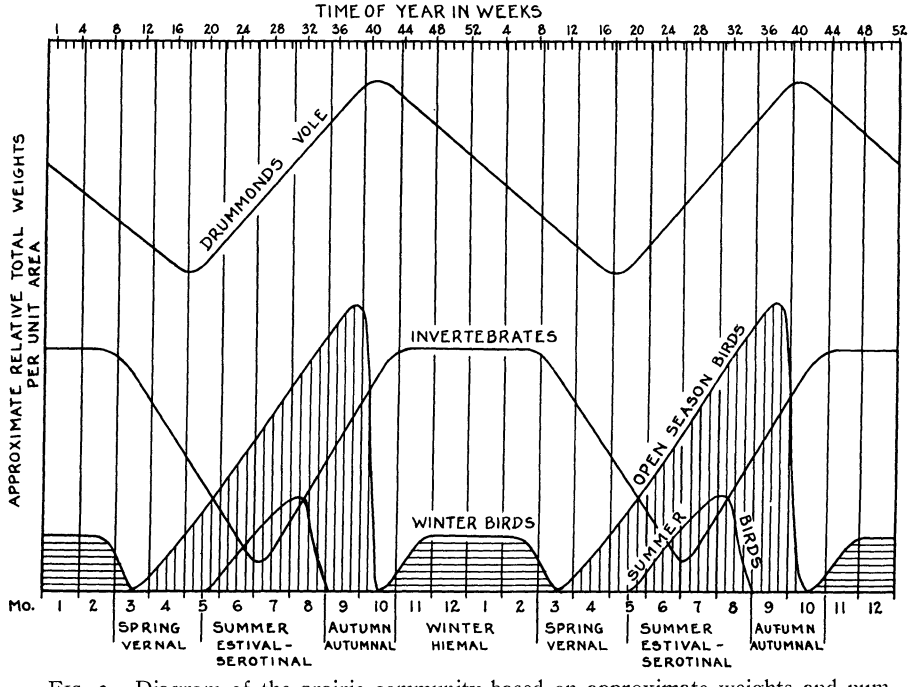


FIG. 3. Diagram of the prairie community based on approximate weights and numbers to show the relative abundance and importance of the components at different times of the average year. The curves are based on weight, number of individuals and estimated influence. Drummond's Vole, an outstanding predominant, is taken as a standard upon which the other curves are based. During the winter the invertebrate population is present but hibernating. It is indicated by a straight line. The curves are apparently in disagreement with those of figure 2 in which a fall minimum of the invertebrate population was due to a drought. Normally there would have been a maximum nearly equal to that of the spring, bringing it up to that of the preceding fall. The basis for these data was the 1928 observations (pp. 367–368) but the curves were adjusted to agree with the writer's fifteen years' experience in the area and his work at Treesbank, Manitoba, 1924–1926 (Bird '27). It also agrees with the findings of King ('27). There is a fall invertebrate maximum which is low when the fall is dry and high when wet.

The curve for the "open season birds" includes the "summer birds" which are shown as a separate curve within the latter. One really grades into the other. Birds begin arriving in March but there are a few species, such as the upland plover and chipping sparrow, which are present only from May to September and may be properly called "summer birds." Spring and fall migrant birds do not affect the prairie community, as they are found about the forest edge.

(1) Local Visitant Vertebrates. The common crow, *Corvus brachyrhynchos* L., is not a bird of the open prairie, but of the parkland where there are frequent groves of trees which form its nesting sites. It was very abundant, and 32 nesting pairs were estimated to the square mile in the Birtle district. Two pairs nested close to the study area. It is a bird of omniverous tastes and disputed economic value (Taverner '26, Kalmbach '25) which feeds mainly in the open, on the prairie, cultivated fields and about the edges of the aspen groves.

From the stomach analyses made by the author it was found that the crow takes whatever is abundant, or whatever it happens to find. In the spring, April and May, it feeds on waste grain picked up in the fields and such insects as it finds in so doing. At this time of the year the adults of the click beetle, *Ludius aeripennis* (Kby.), an injurious (predominant) insect of cultivated fields, are about and many are eaten. In August the fruit of many forest and forest-edge shrubs, particularly *Cornus* and *Amelanchier,* are ripe and are largely fed upon. One crow examined at this time picked up 20 Bertha armyworms which occurred in outbreak form in a local cultivated field, 2 larvae of *Ludius aeripennis* from the same place, and one each of *Gryllus sp., Melanoplus sp.,* and a carabid beetle.

The common leopard frog, *Rana pipiens* (Shreber), breeds in immense numbers in the numerous sloughs, and is present as a sub-influent on the neighboring prairie, often at considerable distance from water, from the time the ice has gone in the spring until freezing occurs in the fall. On June 27, in an attempt to make an estimate of this frog's abundance in the study area, about 194 were found to an acre. In some places where it is moist, or near a slough, the population would be greater, and in drier places not so great. Its food is chiefly insects and hence it is a powerful influence in the community. Several frogs were collected on the study area, and their stomachs examined in order to gain some idea of their food. They contained the following:

May 26

Stomach No. 1: 1 Arctiid larva; 1 Syrphid fly; 1 Tachinid; 1 Nabid bug.

August 3

Stomach No. 2: 1 burying beetle, *Necophorous marginatus;* 1 weevil, *Rhynchitis bicolor* (from prairie rose); 1 Membracid, *Ceresa* sp.; 1 Bibionid larva; 1 Carabid (parts).

Stomach No. 3: 2 spiders; 1 Carabid, *Harpalus pleuriticus* ?; 1 Elaterid beetle; 1 grasshopper nymph, *Melanoplus* sp.; 1 Andraena bee; 1 robber fly (Asilidae); 1 Staphylinid beetle; 3 lepidopterous larvae.

Stomach No. 4: 1 Carabid, *Agonium cuprinus* ?; 1 lepidopterous larva.

Stomach No. 5: 3 Noctuid larvae ?; 1 grasshopper nymph, *Melanoplus* sp.; 1 fly, Fabriciella sp.

Stomach No. 6: 2 Noctuid larvae ?; 1 dragonfly; 1 Harvestman (Araneida); 1 sphinx larva (large); 1 Muscid fly; 1 *Melanoplus* nymph.

Stomach No. 7: 3 Carabids, *Harpalus pleuriticus* ?; 1 Carabid, *Agonium cuprinus* ?; 1 ant; 1 cicadellid; 1 Andraena bee; 1 lepidopterous larva.

The frog is thus an entirely carnivorous feeder, but o e that will eat anything that moves, for it will quickly snap at small pieces of earth thrown in front of it. Besides the animals listed above, it was observed to eat snails and even small individuals of its own species. It never seems to know when it has had enough. One individual (Stomach No. 6) after already having had a pretty fair sized meal swallowed a sphinx larva which was as long as its own body. The animals found in the above stomach analyses were all common species of the prairie community.

The chipping and clay-colored sparrows, *Spizella passerina* L. and *S. pallida* L., are characteristic birds of the parkland prairie, with almost identical habits and song. Like the vesper sparrow, they are found near patches of shrub, *Symphoricarpos* being their favorite haunt. Judging from the singing males, 4 pairs were nesting on the study area, but owing to the similarity of the notes the species was not determined.

The marsh hawk, *Circus hudsonius* L., is a bird of low marshy ground, but also hunts over prairies and along the edges of fields. It was estimated that there was one pair of nesting birds per square mile in the Birtle district. Ever since their return on March 22 a pair of these birds hunted constantly over and about the study area, and, as their food is chiefly mice, they probably were the greatest natural check on the population of Drummond's voles. They nested within a half mile of the area and reared 5 young which also hunted over it. Norman Criddle ('12*a*) gives an interesting discussion of the habits of this bird.

The red-tailed hawk, *Buteo borealis borealis* L. is a characteristic bird of the parkland and nests in the smaller aspen groves. It was estimated that on the average there were 2 nesting pairs per square mile. Their food is chiefly ground squirrels and voles, the remains of which were found about their nests.

The elk and mule deer (see pp. 400–401) were formerly important visitants on the prairie.

(2) Open Season Birds. The western meadow lark, *Sturnella neglecta* L., although not actually nesting on the study area, was frequently seen flying over the prairie and perching on the neighboring trees. It is one of the most abundant and characteristic birds of the prairie. Its food is 75 per cent insectiverous (Taverner '26). In 1928 it returned from the south on March 31.

The western vesper sparrow, *Poecetes gramineus confinis* L., is a very characteristic bird of the parkland prairie. Although not strictly of the

prairie, this bird ranges over it and feeds on many prairie insects. No nests were found in the study area, but the bird itself was frequently seen there. It returned on April 28.

The chestnut-collared longspur, *Calarius ornatus* L., is a bird of the open prairie, but is commonly found on the larger and drier portions within the parkland. Many were observed nesting near Birtle on the dry prairie which forms the bottom of glacial Lake Souris, and on the sand plains near Treesbank. Henderson ('27) gives 68 per cent of the food as vegetable matter, and 31 per cent as animal, chiefly insects.

The upland plover, *Bartramia longicauda* L., was at one time an extremely abundant summer resident on all the prairies of the Province (Seton '09*a*). It is now comparatively rare, but is nevertheless still a characteristic bird of the prairie. Its food consists almost entirely of grasshoppers (Norman Criddle '12*b*), and for this reason it is an inhabitant of the dryer portions where Orthoptera are abundant.

The prairie horned lark, *Otocoris alpestris pratincola* Hensh., is a common bird of the prairies, returning from the south in the last week of February, long before the snow is gone, and remaining until late in the fall. It is particularly partial to dry knolls which are swept bare of snow by the wind. At such time its food is largely weed seeds, but in the summer many insects are eaten. Norman Criddle ('20) estimated that 3 young a week old consumed 400 cutworms a day. Two broods are reared in a season.

(3) MAMMALS OF LESSER INFLUENCE. The prairie-wolf or coyote, *Canis latrans* Say., is still abundant, and, although none were actually seen on the study area, they probably ranged over it. One was seen within a half mile, and an Indian found a den with 10 young not far away. They may be heard howling practically every night. Besides feeding on birds, rabbits, and ground-squirrels, they take many mice (for further details see Norman Criddle '25).

The badger, *Taxidea taxus taxus* (Sch.), is common wherever ground squirrels, which form its chief food, are abundant. The holes that it digs in search of these rodents dot the prairie, and the loose dirt thrown out of them forms in many cases the starting place of a patch of *Symphoricarpos*, and hence materially aids succession. Although not realizing the successional importance of this shrub, the settlers have recognized the fact that it is frequently found about badger holes, and have given it the local name of "badger-willow." The badger is largely nocturnal in its habits and is seldom seen.

The jack rabbit, *Lepus townsendii campanius* Holl., is distinctly an animal of the open, never entering the woods. It is found abundantly on all the larger patches of prairie and many cultivated fields.

The striped ground squirrel, *Citellus tridecemlineatus tridecemlineatus* (Mit.), is a common prairie species. It never reached the peak of abundance of the Richardson ground squirrel, and is quickly driven out of cultivated

areas because its burrows are shallow and destroyed by plowing. In natural areas runways extend in all directions from the burrows. In many cases these runways are arched over by the tall grass which forms excellent cover, and into which the squirrel's striped coat blends so well that it is seldom seen, so that only the trill of its call-notes reveals its presence. Its food consists of insects and sometimes mice as well as vegetable matter. The food and habits are fully dealt with by Fitzpatrick ('25) and Bailey ('26).

d. Sub-influents of minor importance. (1) SMALL VERTEBRATES. Other mammals which occurred on the prairie were: The white-footed deer mouse, *Peromyscus maniculatus bairdii* (H. & K.), the little upland mouse, *Microtus minor* Merriam, the skunk, *Mephitis hudsonica* Rich., the weasel , *Mustela c. cicognanii* Bon., *M. r. rixosa* (Bangs) and *M. l. longicauda* Bon. (Criddle, Norman and Stuart '25). They were few in numbers, but nevertheless important members of the community. The weasels in particular, although only occasional visitors, on account of their blood-thirsty habits kill many voles in both winter and summer. The snowshoe rabbit, *Lepus americanus phaeonotus* Allen, frequently crossed the prairie and had well beaten paths over it from one aspen grove to another.

The reptiles of the aspen parkland are few in number and species (Seton '18) and only one form is worthy of mention as a sub-influent in the prairie community. This is the garter snake, *Eutaenia sirtalis parietalis* (Say), which is occasionally seen and feeds on frogs, mice and insects.

(2) INVERTEBRATES. The invertebrate population was studied quantitatively by random sampling as discussed under IV, "Methods Used in Investigation," and the results were tabulated graphically in figure 2. The total population averaged around 3,000,000 per acre and showed some interesting seasonal fluctuations. In March, while the larger animals were still hibernating, it ran well over 6,000,000, from which it showed a gradual decrease until June 28 when it reached a minimum of 1,000,000. Then it started to climb toward a fall maximum until August 9 when the onset of a drought caused it to fall off again. After the ground had frozen in late October, it had reached a second minimum of 1,000,000. Throughout the season, except for a brief period in July, the soil population was well above that of the surface. The population of the herbage is small compared with that of the surface and soil, and is present only for a brief period during the warmest part of the year. It does not markedly affect the total population but may be considered as a stratal associes.

The most important of the invertebrate predominants are, *Succinea* sp. (snail), *Laccocera vittipennis* (Van Duz.) (bug), *Dikraneura moli* (Prov.) (leaf-hopper), *Eustilbus apicolis* Melsh (beetle), *Lasius brevicornis* (ant), and *Myrmica scabrinodis* Nylander (ant).

e. Subordinate Communities. Both stratal and seasonal communities may ordinarily be recognized. These are usually composed, in considerable part, of animals which rank as sub-influents of minor importance and

animals too small in numbers or too insignificant to receive much attention. Animals occurring throughout the year are necessarily not included in a list of seasonals, while animals of considerable influence in communities are merely mentioned but not properly included in the stratal societies or socies where they are confined to a particular layer.

(1) STRATAL OR LAYER COMMUNITIES. (*a*) *Soil stratal or layer socies.* The various small influent mammals modify soil conditions by moving portions of it, opening it to air and water and bringing portions to the surface. The ungulates render the surface rough by tramping it. The invertebrates have a very important similar influence which is more uniformly distributed over the surface and through the shallower parts of the soil.

The pocket gopher needs mention in soil socies because it is essentially confined there. Drummond's vole is probably among the most important of the soil influents, at present. The predominant ants also exercise an important influence.

The subterranean socies proper, however, is made up chiefly of larvae of insects. The dipterous larvae are of most conspicuous but of varying abundance and different species. The majority belong to the family Mycetophilidae. The wire worms (including *Ludius aeripennis* Kby.) and white grubs (*Apodius* sp.) are the most abundant beetle larvae.

b. Surface and herb socies. Leaving the larger anima s out of consideration, this group consists chiefly of insects and spiders. Most of those listed as predominants on p. 381 and the seasonals listed on p. 384 are included. A strictly herb community is purely seasonal, being confined to the summer.

(2) SEASONAL COMMUNITIES. This type of subordinate community is usually more important than the stratal or layer communities as it includes the animals which often fluctuate most in numbers from year to year.

One striking difference between the seasonal communities of Manitoba is the absence of well marked seasonal socies such as were found by Smith ('28) working on the Illinois forest and Shackleford ('29) working on the Illinois subclimax prairie. Compared with Shackleford, so far as invertebrates are concerned, the vernal socies is poorly developed, being suggested only by one species of vernal beetle and a number of subterranean dipterous larvae. For the period recognized as summer in figure 2 a different condition obtains. In the parkland there is generally what may be termed a group of species beginning on the herbs and grasses at the opening of summer and declining in the early autumn. This corresponds to the estival socies of Shackleford. Neither the present writer nor Shackleford found anything comparable to the serotinal socies of Smith; because of its extension into the early part of the autumnal season it is best called the estival-serotinal socies.

a. Estival-serotinal socies. This occurs in the season designated as summer in figures 2 and 3. It consists of the strictly summer birds: upland

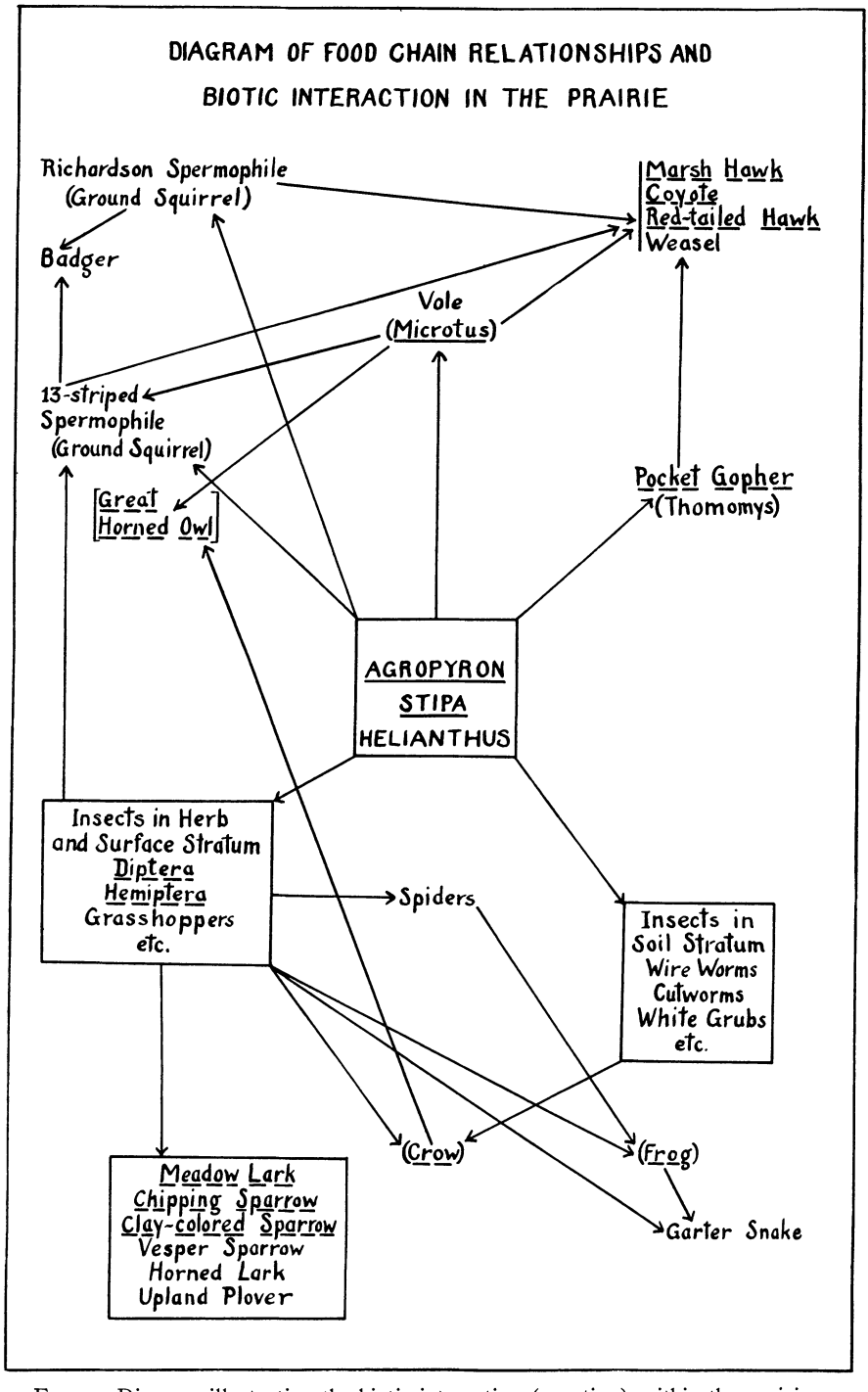


FIG. 4. Diagram illustrating the biotic interaction (coaction) within the prairie communities. Arrows point from the animals or plants eaten to those that eat them. Dominants are in capitals underlined, subdominants in capitals, predominants with every second letter underlined, and influents in small letters.

plover (*Bartramia longicauda* L.), chipping sparrow (*Spizella passerina* L.) and clay-colored sparrow (*Spizella pallida* L.) and the invertebrates of the herbs, *Melanoplus dawsoni* (Scud.) (grasshopper), *Homaenus aerrifrons* Say (bug), *Deltocephalus configuratus* Uhler (leafhopper), *Tachyporus jocosus* Say (beetle), *Coenosia* sp. (fly); *Hylemyia clicrura* Rond. (fly); and *Melanochila surda* Zett. (fly). The less abundant species are Hemiptera and Diptera.

The general relations of seasonal groups are shown in figures 2 and 3. The rise and decline of the estival-serotinal invertebrates is shown in figure 2, curve E, while the birds are indicated as a lower part of the open season total of figure 3.

f. Biotic Interaction (Coaction) and Food Chain Relationships. The dominant grasses and subdominant herbs of the prairie support a large population of insects and voles and a smaller one of gophers and ground squirrels. These animals feed directly on the plants and in turn support insectiverous birds, frogs, and such carnivores as the badger, coyote, and red-tailed hawk. The badger, in digging out ground squirrels, its favorite food, throws up mounds of earth which kill the grass and form starting places for patches of *Symphoricarpos* which in turn may enable aspen seedlings to take root and thus hasten the advance of the forest on the prairie. On the other hand, the work of snowshoe rabbits on the forest-edge is tending to check this spread.

Certain sub-influent species which breed in other communities wander onto the prairie and feed there extensively. Such forms are the crow and great horned owl from the forest and the frog from the sloughs.

The biotic interaction may be best understood by referring to figure 4. The crow, frog, and great horned owl, although local sub-influents, are visitors from other communities and are put in parentheses.

g. Comparison With Other Communities. Sampson ('21) covered the plants of the Illinois prairies. Shackleford ('29) made a study similar to the writer's. A comparison with the invertebrate predominants listed for her *Andropogon-Lygus-Microtus* associes, shows no species in common with our *Agropyrum-Microtus* associes. *Lygus pratensis,* a predominant in the Illinois prairie, was found only twice in my collections as a single specimen in the *Salix longifolia* station and a single specimen in the mature poplar station, in winter.

However, the striped ground squirrel is common in both areas. The coyote (*Canis latrans*) and the prairie chicken were formerly found in both the aspen parkland and the northern half of the oak parkland.

B. Willow Communities

Salix-Chrysomellidae Associes

In the course of succession leading to forest, willows form important dominants, as will be seen by studying the diagram of successional stages,

figure 15. They are wide-spread, cover large areas, and are found in numerous habitats which, at first, were believed to be distinct biotic communities. For this reason stations for quantitative sampling were selected in *Salix petiolaris* and *Salix longifolia* consocies which are discussed separately. Further study, however, indicated that they really formed parts of one associes, and that the animal life of the two differed but slightly. The animal presocies of the two is hence discussed under one head.

1. *Salix petiolaris* Consocies

A large part of the area occupied by the aspen parkland is covered by sloughs, the great majority of which are surrounded by a consocies of willow, *Salix petiolaris* Sm. It is absent only when there is a high perceutage of alkaline salts, in which case succession is direct to prairie. It is a community not only of wide distribution, but of great successional importance, as it may pave the way to aspen forest if conditions are hydric, or to prairie if xeric (see section VI, Coaction, Seasonal Phenomena, etc.).

The slough selected for study was situated near the northeast corner of the southeast quarter of section 12, township 17, range 27 west of the principal meridian. It was completely surrounded by a zone of *Salix petiolaris* which gave place through *Salix discolor* to aspen along the southwest side. The other sides were surrounded by prairie. On May 2 the prairie was superficially burnt over, but as the ground was still wet from the freshly melted snow, and the fire did not penetrate to the bases of the grasses, it had only a very slight effect on the fauna. The area remained undisturbed until July when a herd of cattle was pastured in the vicinity an heavily grazed the surrounding grassland. The cattle also drank from the slough and lightly cropped the sedges growing in it. The willows, however, were not touched and by taking the quantitative samples close to them, it was found that the fauna had been very slightly disturbed. Throughout the summer the slough was full of water which covered the bases of the willows growing further out.

The one dominant of this community is the willow, *Salix petiolaris* Sm., which grows in a close bush-like formation from just above the average high water level to about 6 inches below the average low water found in the fall of the year. The soil below the willow, which is a rich black humus, is thus permanently saturated, if not actually flooded.

There is one subdominant, a sedge, *Carex vesicaria* L. The other plants are of less importance and are, in order of their abundance, *Fragaria virginiana* Duch., *Aster* sp., *Scirpus* sp., *Pyrola* sp., *Spiraea salicifolia* L. and *Potentilla Anserina* L. There is a dense growth of moss which in some places covers the surface to a depth of almost an inch.

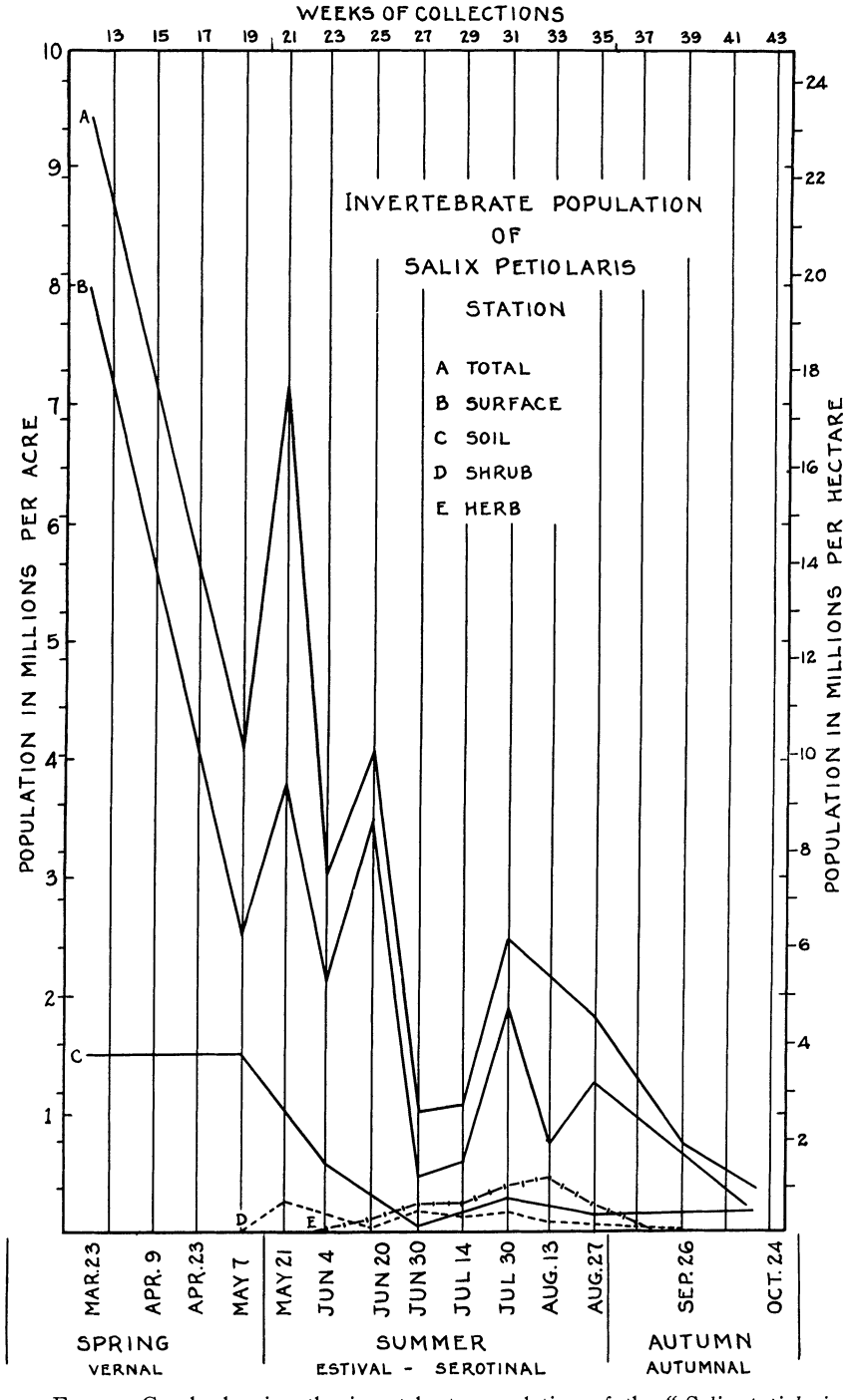


FIG. 5. Graph showing the invertebrate population of the "*Salix petiolaris* station" as indicated by the quantitative collections in 1928. There is a steady decline from the spring maximum to an early July minimum from which the population increases to the end of July and then falls to a still lower minimum in October. This is similar to the curve for the invertebrate population of the prairie (Fig. 2) and is correlated with a dry fall. The herb and shrub strata both have a population present during the estival-serotinal season at a time when there is green vegetation.

2. *Salix longifolia* Consocies

The *salix longifolia* consocies is of wide distribution throughout the parkland, and represents the first successional stage of woody plants after running water. It is found on the mud banks and sand bars of all the rivers, and, where there is a rapid deposition of sediment, represents the first community. When the rivers are sluggish it may be preceded by a grass, *Glyceria grandis* Wats. It may also be found on sandy or gravelly beaches of lakes, sand dunes and in recently excavated ditches along roads. Apparently it is not the presence of running water that is necessary for the successful establishment of this willow, but denuded s il with an abundant water supply. In such situations it spreads rapidly by seeds and by means of long roots parallel to the surface of the ground from which frequent shoots are sent up.

The area selected for intensive study was on a mud bank on the east side of the Birdtail river, just above the town of Birtle, and at a distance of 300 yards from the railroad pumphouse. It covered about half an acre of ground and was backed by a terrace 2 feet higher on which was a thick growth of *Salix discolor,* some senescent *Salix longifolia* and a few maples, *Acer negundo.* Between it and the river was a dense growth of *Glyceria grandis* for about 4 feet. The soil to a depth of 10 inches was composed of 5 layers of mud, each 2 inches in thickness, separated y a thin layer of rotting willow leaves. These represented the deposits of 5 spring floods. Below the 10 inch level there was a deposit of fine sand to a considerable depth. Throughout the period of study the soil was very wet.

The sole dominant is the willow, *Salix longifolia* Muhl. according to Robinson and Fernald ('08) or *Salix interior* Roulee in the recent revision of this group of willows by Ball ('26). It is a grey-barked species growing in a close stand after the manner of a forest of small trees, rather than in a clump or bush-like formation characteristic of most willows. It reaches a height of 8–10 feet and a diameter of scarcely more than an inch. The top has leafy branches and the stem is bare.

There was nothing that might correspond to a shrub stratum, and only a scattered growth of herbage consisting of the following plants in order of their abundance: *Ranunculus Cymbalaria* Pursh., *Carex* spp., *Mentha canadensis* (L)., *Potentilla Anserina* L., *Scirpus* sp., *Agrostis* sp., and *Plantago major* L. There is a scattered growth of moss which does not cover the surface.

3. Animal Presocies of the Willow Community

The predominating animals of the willow community are insects of the orders *Diptera, Coleoptera, Homoptera,* and *Collembola.* Spiders also are rather numerous. Frogs breed in the sloughs in great numbers, and spread from them into the neighboring woods as local influents as well as onto the prairie.

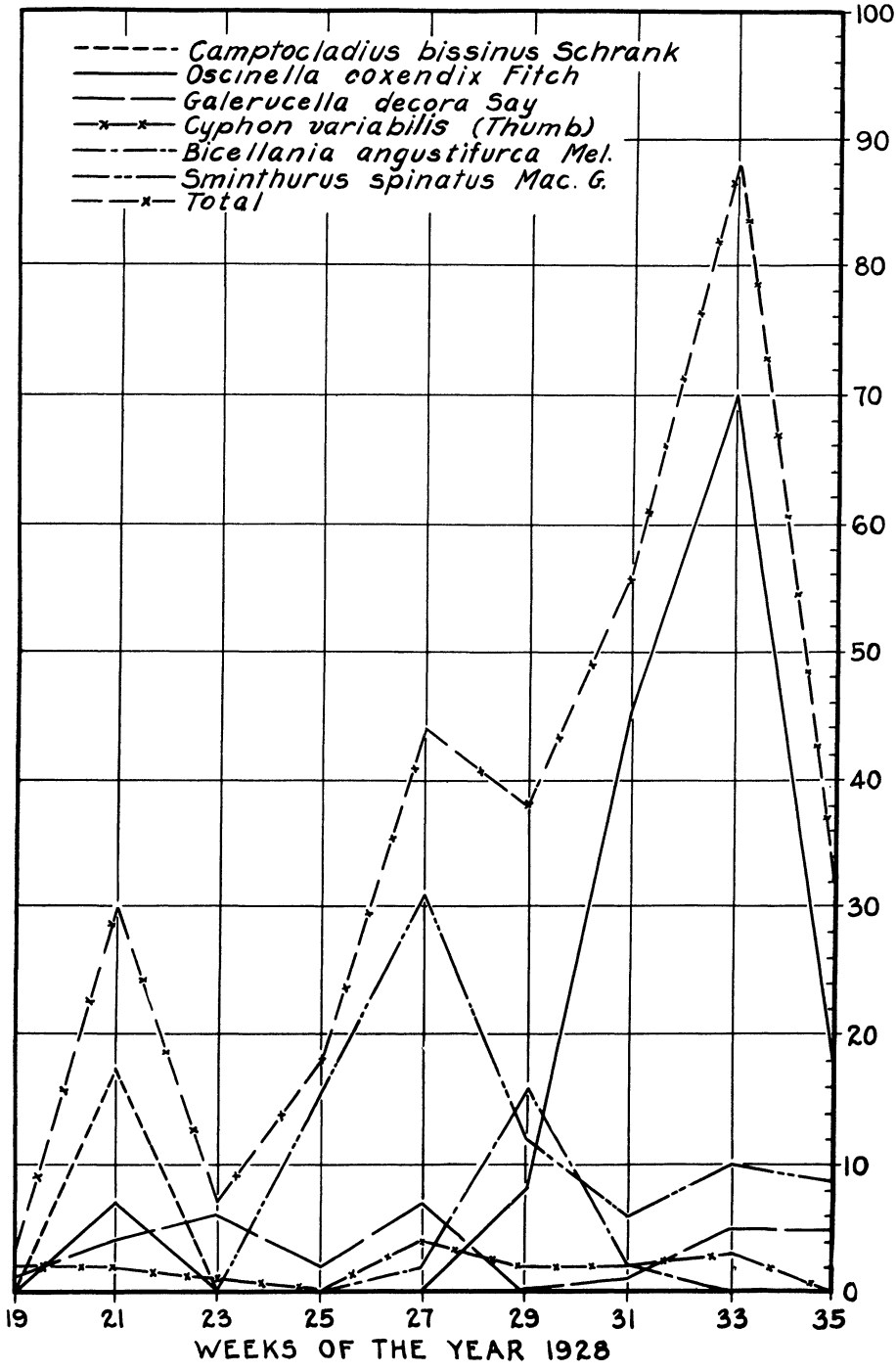


FIG. 6. Diagram (vertical scale is number of individuals per 1/10 m^2) showing how the population of the herb and shrub strata of the *Salix petiolaris* community reaches a maximum in the 35th week of the year due to the adding of different species which reach a peak at successively later dates. Only a few predominants are used to illustrate. The total population of the species used is indicated.

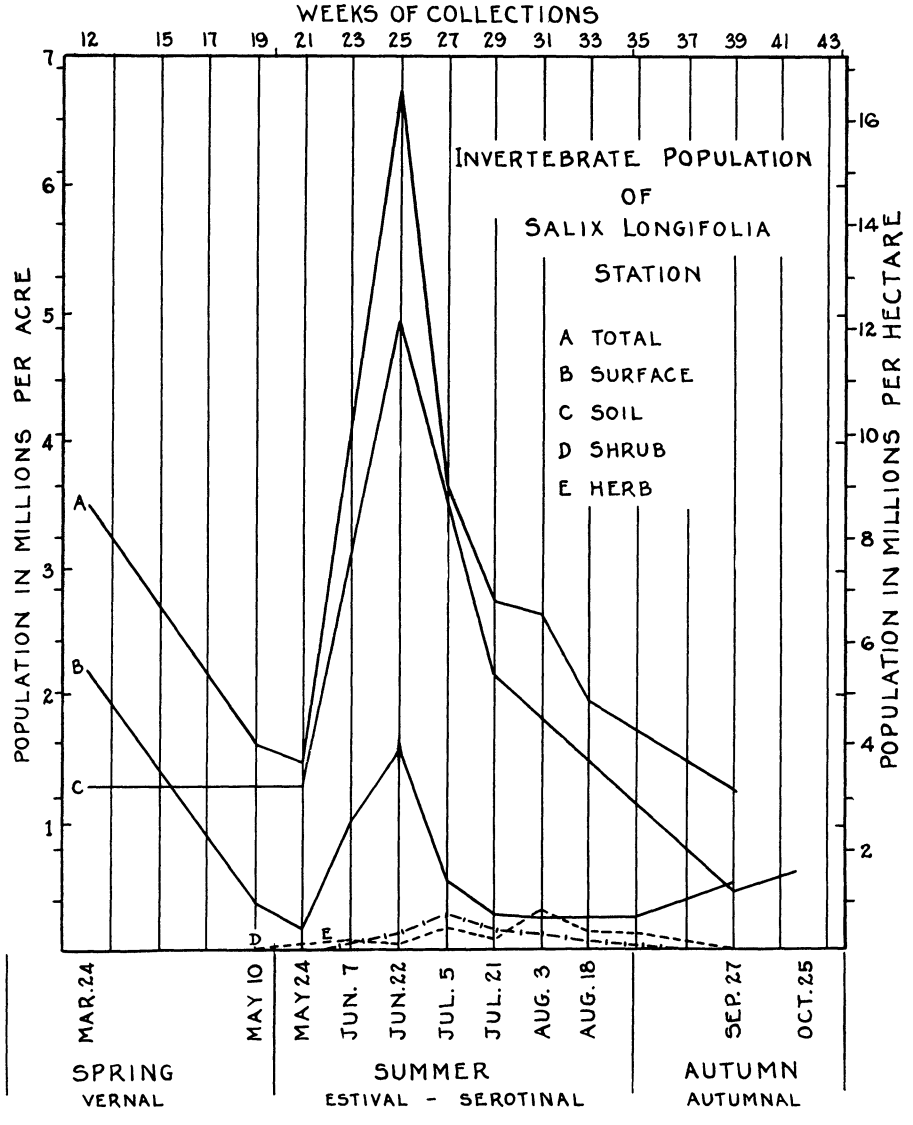


FIG. 7. Graph showing invertebrate population of the "*Salix longifolia* station" as indicated by the quantitative collections in 1928. Starting from a spring maximum the population falls to a minimum at the end of May, a month earlier than in the "*Salix petiolaris* station." It rises rapidly till June 22 when it reaches a maximum due to the presence of large numbers of the larvae of a minute orthoraphous Dipteron (unidentified) in the soil and two Collembolans (*Sminthurus arvalis* and *S. hortensis*) on the surface. It then falls rapidly to a minimum in September lower than that of May due to the dry fall. Normally it would have risen to a maximum equal to that of March. Although there was a maximum of individuals in June, the total weight of the population was at its minimum because the majority of the species were minute and their influence can be minimized. Disregarding these species the curves would correspond to those of the "prairie" and "*petiolaris*" stations. The estival minimum is earlier than that of the "*petiolaris*" station, probably because of the lower water content of the soil, since, being on a river bank, the drainage was better than that about a slough.

The willows and sedges also give shelter and form breeding places for large numbers of coots, ducks and other aquatic birds. Other birds are characteristic sub-influents of the willow community but are not confined to any particular stratal socies. They are, in order of their abundance: red-winged blackbird, *Agelaius phoeniceus* L., and the bronzed grackle, *Quiscalus quiscula* L., 3 or 4 pairs of which nested in the *Salix petiolaris* study area. They feed on both animal and vegetable matter, and often wander some distance from the sloughs in search of food.

The Maryland yellowthroat, *Geothlypis trichas* L., might be classed as a sub-influent in the *Salix longifolia* consocies. One pair was frequently seen and probably nested on the area. It is a bird whose food is 99 per cent insects (Henderson '27). The yellow warbler, *Dendroica aestiva* L., ranks close to the yellowthroat in numbers and importance. It also might be classed as a sub-influent of the *Salix longifolia* consocies, and was frequently seen on the study area, probably nesting there. The song sparrow, *Melospiza melodia* L., is a common bird of the willow community, but its numbers are hard to estimate and it probably ranks only as a minor sub-influent.

Muskrats, *Ondatra zibethica* L., were sometimes seen about both willow consocies, and a pair built a nest in the *Salix petiolaris* study area. Field mice, *Microtus,* were also seen in both places, particularly about the *Salix petiolaris,* after the surrounding prairie had been burnt. They made numerous runways and nests in the moss at the base of the willows, but left them as soon as an abundant supply of grass was found in the prairies.

The invertebrate population of both willow consocies was studied quantitatively, and the results were plotted in graphical form in figures 5, 6 and 7. The population of the *Salix petiolaris* (Figs. 5, 6) was found to be much higher than the *Salix longifolia* station (Fig. 7), or study area. This is due to the much larger surface population of the former on account of the accumulation of moss and surface debris which affords food and shelter. This accumulation is prevented in the latter on account of the seasonal flooding from the river and deposition of sediment.

The relationships of the population of the two consocies in 1928 may best be understood by referring to the comparison in Table IV.

a. Stratal Socies. The invertebrates of the animal presocies may be divided into four well-marked stratal socies:

(1) *The Shrub Socies* is characterized by influents which are leaf-feeding beetles belonging to the family Chrysomelidae, *Galerucella decora* (Say), *G. tuberculata* (Say), *Chalcoides helxenes* (L.), and *Disonycha quinquivittata* (Say). These species vary in number from season to season and from locality to locality. Where they occur in any abundance they completely strip the willows of their leaves.

Another influent insect is an unidentified fly belonging to the family Cecidomyidae, the larvae of which bore in *Salix petiolaris* stems just beneath the bark, often in such numbers as to kill the stem.

TABLE IV. *Comparison of the invertebrate population in the two willow communities*

Salix petiolaris Station	*Salix longifolia* Station
Total population closely follows that of the surface, which is the greatest.	Total population closely follows that of the soil, which is greatest.
Total population in March, before the break of hibernation, was over 9.5 million per acre and steadily decreased to a minimum of 1 million at the end of June after which it rose to a maximum of 2.5 million at the end of July and fell steadily off to an autumn minimum of 0.5 million.	Total population in March before the break of hibernation was 3.5 million per acre. It fell to a minimum of 1.5 million at the end of May, but suddenly rose to a peak of 6.75 million on June 22, due to a large number of larvae and pupae of some minute Dipteron which was apparently of little ecological importance. It then fell off to a autumn minimum of 1.0 million.
The soil population was less than one-half that of the surface.	The surface population was less than one-half that of the soil, except in September and October when they were approximately equal.
The population of the shrub and herb strata was a very small part of the total, and reached a maximum of only one-fourth million and one-half million per acre respectively during the warmer part of the year.	The population of the shrub and herb strata were both about one-fourth million in the warmest part of the year.
The shrub stratum reached a maximum population in early June, and the herb stratum in the middle of August.	The shrub stratum reached a maximum population in early July and the herb stratum in the middle of August.

Sub-influents which are conspicuous by the galls they cause are the sawfly, *Potania petiolaridis,* which makes large round galls on the leaf of the willow from which it takes its name, and a Cecidomyid, *Phytophaga walshii* ?, which makes rosette galls on the terminal twigs of *Salix longifolia.* In some cases there may be as many as fifteen to twenty galls of either species on a single stem, but they appear to have but slight effect on the health of the willow.

During the winter, snowshoe rabbits, *Lepus americanus,* wander into the willow community from neighboring aspen groves, and eat large numbers of the willow shoots.

During the brief period when the willows are in flower they are visited during the warm part of the day by many small Diptera (Cecidomyids, Chironomids, etc.) and Andraenid bees which assist in pollination.

(2) *The Herb Socies* is almost entirely invertebrate. It contains no influents of the community as a whole, but several seasonal sub-influents which are: a Collembolan, *Sminthurus spinatus* Heb., leafhoppers, *Deltocephalus mollipes* (Say) and *D. noveboracensis* (Fitch), and snails, *Vertigo ovata* Say, *Succinea* sp. and *Lymnea* sp.

(3) *The Surface Socies* has no outstanding influent. The population is composed chiefly of snails and many insects, mostly Coleoptera belonging to the families Staphylinidae and Carabidae. Frogs, more abundantly *Rana*

pipiens and less abundantly *Rana cantabrigiensis,* are abundant and may be classed as sub-influents of the community. They feed on insects and snails.

(4) *The Soil Socies* is lacking in influents and sub-influents of the community. The population is entirely invertebrate and is made up of earthworms of the family Enchytraeidae and of the larvae of insects.

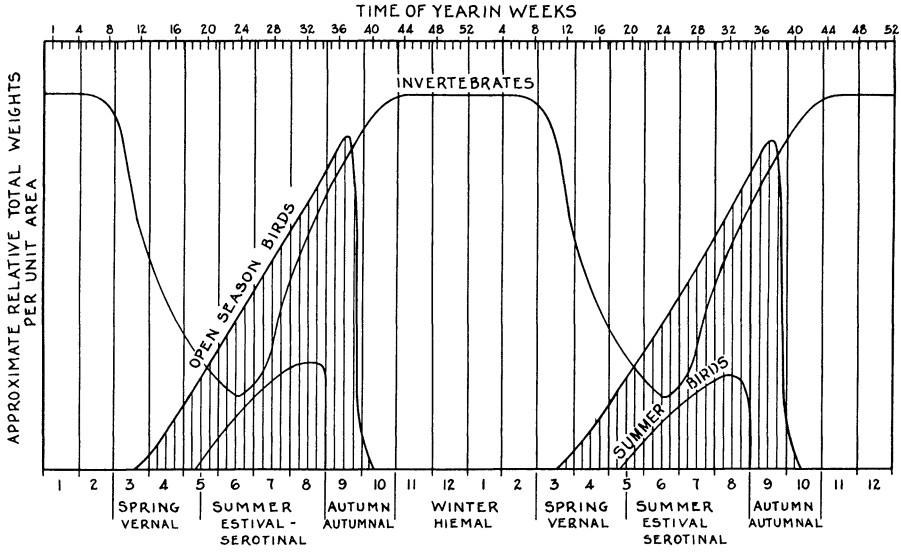


FIG. 8. Diagram of the willow community based on the approximate weights and numbers of the animals to show the relative abundance and importance of the components at different seasons of the year. For further details see description of figure 3. The invertebrate minimum is indicated at the middle of June, halfway between that of the *Salix petiolaris* and *S. longifolia* communities. This is slightly earlier than in the prairie, and is probably correlated with differences in the water content of the soil. There are no important winter birds, spring or fall migrants or resident mammals.

b. Seasonal Socies. Seasonal socies are essentially absent, except for an *estival-serotinal* group in the shrubs and herbs, and the birds: northern yellowthroat and sora rail. The open season birds come to the area gradually, one species after another, from late March to early June, and drop out again in a similar way. The invertebrates appear in a similar manner, many of them disappearing after reaching a maximum (see Fig. 6). The seasonal fluctuation in abundance of animals is shown in figure 8.

c. Biotic Interaction (Coaction) and Food Chain Relationships. The biotic interaction and food chain relationships of the willow community is intimately interwoven with those of surrounding communitie , particularly that of the *Salix discolor* consocies. The predominant of the latter, *Galeruccella decora,* which in 1928 occurred in such abundance as to completely skeletonize its leaves, spreads from this food plant to *Salix petiolaris, S. longifolia* and, in years of extreme abundance, to *Populus tremuloides* (Crid-

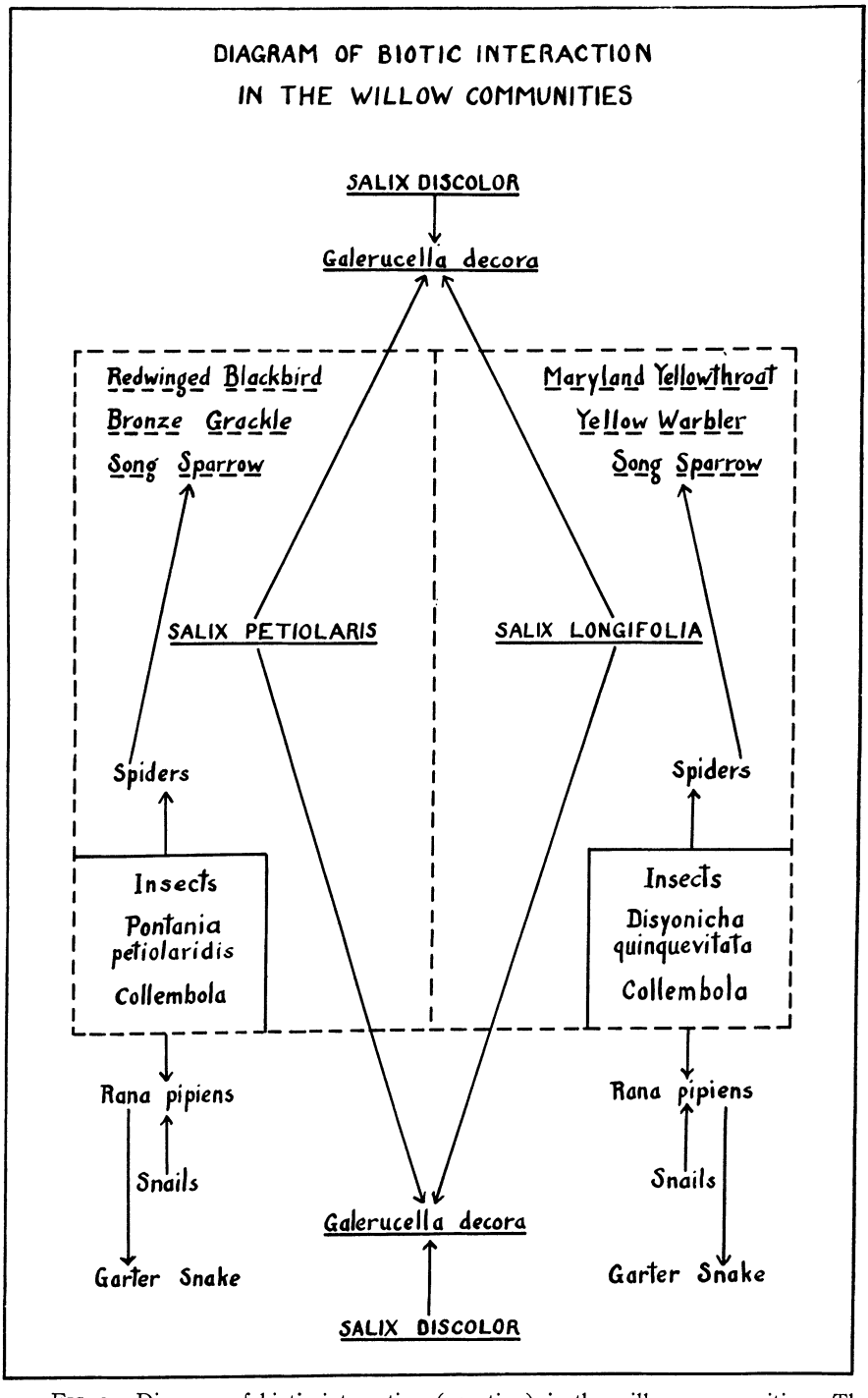


FIG. 9. Diagram of biotic interaction (coaction) in the willow communities. The *Salix discolor* community is indicated as surrounding the *Salix petiolaris* and *S. longifolia* communities, a position it actually occupies in succession. Arrows point from the animals or plants eaten to the animals that eat them. Dominants are in capitals underlined, predominants have every second letter underlined and influents are in small letters.

dle, N. '11*a*). Rabbits, *Lepus americanus,* come in from the aspen edge consocies to feed on the willows and snakes, *Thamnophis,* to feed on the frogs (see Fig. 9).

C. Aspen Communities

1. *Aspen-Edge Community*

Populus-Symphoricarpos-Lepus Associes

The edge of the aspen groves may be classed as a separate community from the mature aspen forest. The aspen, *Populus tremuloides,* it is true, is dominant in both; but the shrubs, herbs and animal presociety are quite different. The aspen forest is also of great importance as a shelter for the hibernating migrants from the neighboring prairie.

The edge of the aspen grove adjoining the prairie station on the east was selected as a station for intensive study, but, owing to lack of time, it was not possible to run a full series of collections. Enough was made, however, to give, with the help of observations and scouting, a clear understanding of the community.

a. Plants. The dominant plants are young aspens, *Populus tremuloides* Michx., 5 to 12 feet in height and 2 to 3 inches in diameter, and snowberry, *Symphoricarpos racemosus* Michx. Subdominants belong to the shrub stratum, and consist of hazelnut, *Corylus americana* Walt., choke cherry, *Prunus virginiana* L., and rose, *Rosa blanda* Ait. On the study area there are no herbs, but in other locations *Viola canadensis* L. was found in considerable abundance and might be classed as a subdominant.

A quadrat of 25 square meters, equivalent to 29.4 square yards, or .006 of an acre, was laid out in the study area to determine the abundance of the plants. The results are presented below. The quadrat was crossed by several rabbit runways.

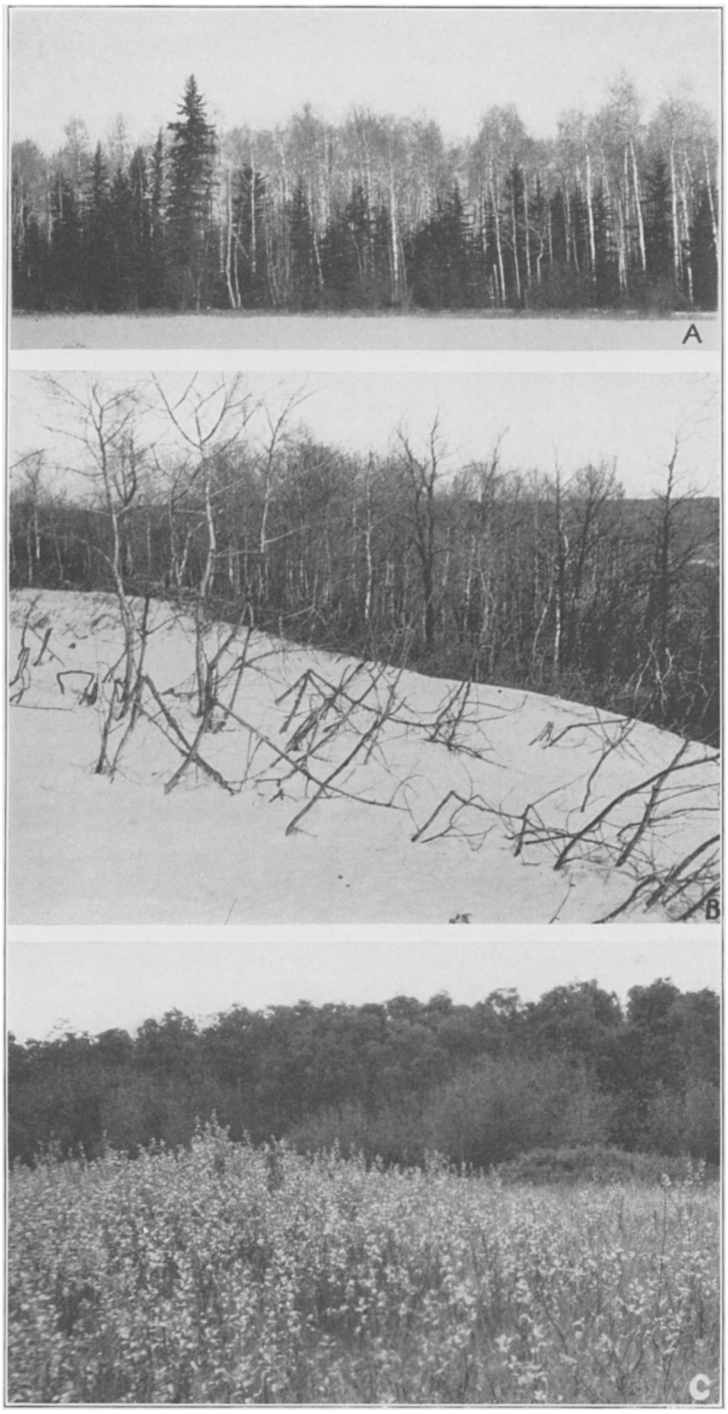
Healthy aspen	31
Aspen ringed by rabbits in 1928 and killed	14
" " " " before " " "	6
Healthy hazelnut	0
Hazelnut killed by rabbits	18
Healthy rose	0
Rose killed by rabbits	17
Healthy choke cherry	0
Choke cherry killed by rabbits in 1928	6
" " " " " before "	2

b. Animal Presocies.

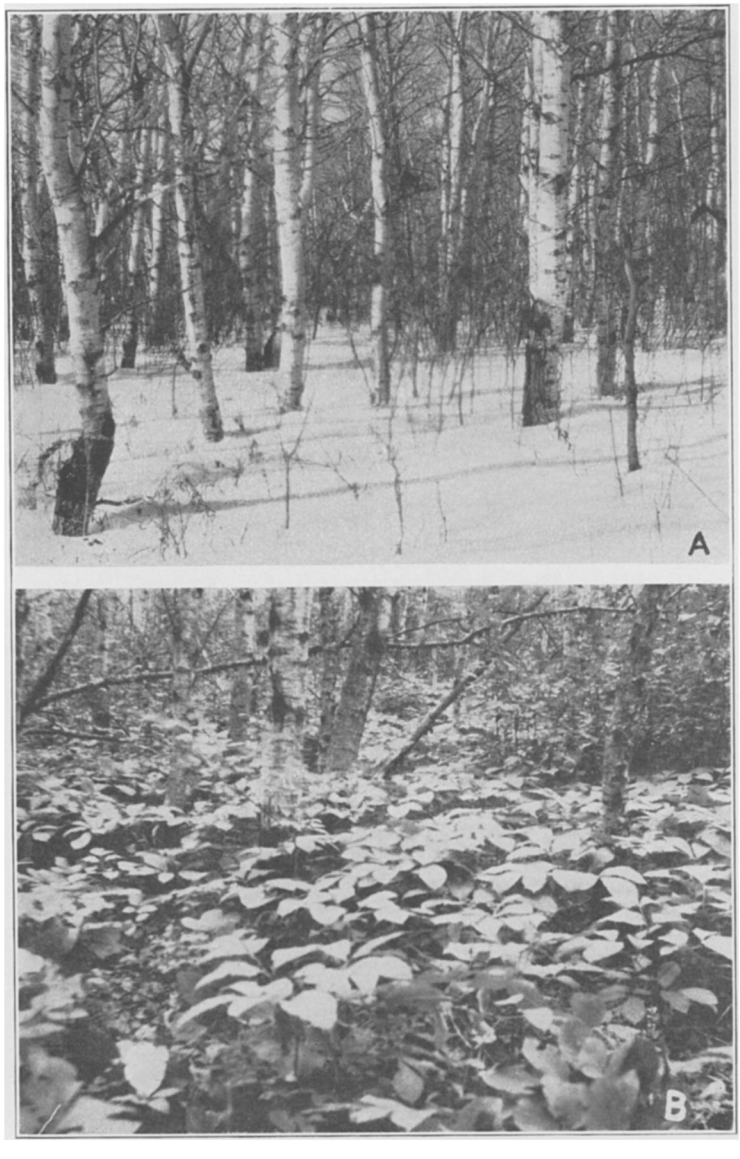
Influent—*Lepus americanus phaeonotus*

Sub-influents—American goldfinch, yellow warbler, red-eyed vireo. The aspen-edge is distinctly a vertebrate community, the insects being mainly of importance as migrants.

The snowshoe rabbit, *Lepus americanus phaeonotus* Allen, is an outstanding influent of the aspen-edge community. This animal is subject to great



A. White spruce, *Picea canadensis,* replacing aspen near Mafeking, Lake Winnipegosis. **B.** The effect of drifting snow on young aspen at the edges of the groves. Photograph taken at Birtle, Manitoba, on April 16, 1928, when the drift was half melted. **C.** A typical scene in the aspen parkland illustrating succession. The shrubs with the whitish leaves in the left foreground are *Elaeagnus argentea* which is replacing grass to the right. The patch of low shrubs to the right just in front of the background of an aspen grove is *Symphoricarpos occidentalis.*



A. A typical aspen forest floor in winter. **B**. A typical aspen forest floor in summer. The herb is *Aralia nudicaulis*.

fluctuations in abundance (Seton '09*b*, Elton '24). The peaks of abundance are approximately seven years apart and are followed by a sudden decline due to some plague-like disease, the causitive organism of which is unknown. From the survivors the population is slowly built up again until another peak is reached. At times of minimum numbers the population may be as low as 10 to the square mile, and at the maximum reach into the hundreds. At Birtle, in 1928 it was estimated that there were 400–500 to the square mile of immature aspen (not parkland) and it is doubtful if they had reached their peak of abundance.

Their home is the young aspen about the edges of groves and the second growth of burnt over and cut over forest, preferably with considerable shrubby undergrowth. In the summer, with an abundance of green food and protection from their enemies by the growth of leaves, they multiply rapidly. From 4 to 5 broods of 2 to 5 young each are produced, and those of the first brood breed during the same season. In the winter, food is scarce and they subsist on the twigs and bark of practically all the woody plants found in the community, a great many of which are stunted and killed (see Pl. XVII). By referring to the quadrat mentioned under the plant society it will be seen that in this case all the hazelnut, rose and choke cherry were killed back to the roots (many sent up shoots during the summer), and that 64.5 per cent of the aspen were ringed and killed. This is a normal occurrence when rabbits are plentiful. Some shrubs are preferred to others, and in this way are selectively killed. *Elaeagnus* is eagerly sought after (Pl. XVII, *C.*) and oak seedlings are cut back year after year (Pl. XVII, *D.*) producing stunted plants which eventually die. It is safe to say that oak would be much more abundant, and that the aspen would advance much more quickly on to the prairie, if it were not for the rabbits.

In winter a great many rabbits are killed by predators. The great horned owl and coyote are its chief enemies. Numbers are also taken by the goshawk and the weasel, while man, both white and Indian, kills many for food and fur.

Birds are abundant in the aspen-edge and the associated shrubs, subinfluent characteristic species being: the American goldfinch, *Astragalinus tristis* L., which nests in the young aspens and feeds on the sunflower and thistle seeds from the neighboring fields and prairie; the yellow warbler, *Dendroica aestiva* L., which is 97 per cent insectivorous (Henderson '27) and the red-eyed vireo, *Vireosylva olivacea* L., whose food is 85.28 per cent animal (Henderson '27).

The leopard frog, although not as abundant as on the prairie, is found here and is a local sub-influent.

The coyote, weasels and skunk mentioned in the prairie community breed here. The red-backed mouse, *Evotomys gapperi loringi* Bailey, the chipmunk, *Eutamias q. quadrivittatus* (Say) and Franklin's ground-squirrel, *Citellus franklini* (Sab.) are characteristic minor sub-influents. The latter

in 1882 was the rarest of the ground squirrels. Since then it has increased until 3 pairs might be found in 100 yards of forest edge (Seton '09a). This increase can be explained by the enlargement of the animal's favorite habitat, scrub, due to fencing, grazing and cutting of mature trees. With more intensive cultivation it has become less numerous.

Birds which are found here but are more abundant where there are patches of choke cherry and saskatoon, *Amalanchier spicata* (Lam.), are the towhee, *Pipilo maculatus arcticus* L., the catbird, *Dumetella carolinensis* L., the robin, *Planesticus migratorius* L., and the brown thrasher, *Toxosroma rufum* L., which may all be classed as sub-influents of minor importance.

The bison was an important local influent in the aspen edge as indicated by Henry ('97), p. 119: "Buffalo have ravaged this small island (grove); 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."

The invertebrate life of the aspen-edge associes was found to be small compared with that of both the prairie and mature aspen forest. No species was found to be peculiar to it, except those confined to special food plants, such as the Cerambycids, *Ropolopus sanguinicollis* (Horn), which is confined to cherry, and *Saperda bipunctata* Hopkins which bores in *Amelanchier* stems. None were of decided ecological importance, excepting perhaps a species of Cerambycid beetle which was found boring in considerable numbers in the stems of young aspen not on the study area.

In the fall surface socies of this community is considerably increased by an influx of invertebrate migrants from the adjoining prairie and down from the trees and shrubs of the aspen-edge itself. They, however, were not studied quantitatively.

In the spring and fall, seasonal socies of juncos (*Junco heymalis* L.) and tree sparrows (*Spizella monticola* L.) occur about the forest edge, and in the winter a hiemal socies of pine (*Pinicola enucleator* L.) and evening grosbeaks (*Hesperiphona vespertina* L.)

2. *Mature Aspen Forest Community*

Populus-Saperda Consociation

The ultimate stage of all courses of succession in the country occupied by the aspen parkland is a mature forest of aspen. This kind of forest is found in the center of the larger groves and along the east and north slopes of the river valleys.

The aspen is a soft wooded, quick-growing tree which in this region rarely reaches a greater age than 60 years, or height of 55–60 feet, and diameter of 16 inches. The great majority of trees never attain this size. The trees do not reproduce in their own presence, and senescence is hastened by the white heart rot, *Fomes ignarius,* and the beetle, *Saperda calcerata*

Say. The trees die, and there is a temporary reversion to a subclimax condition with many shrubs, *Prunus, Amelanchier, Rubus,* etc. These, however, are soon crowded out by young aspen which in time produce a mature forest again.

The area selected for intensive study was half a mile east of the town of Birtle, on the north slope of the Birdtail river valley. It was with some hesitation that a north slope was chosen, and it was only because the mature forest on the level ground has been largely cut over that this selection was made. Subsequent observations, however, showed no appreciable difference from that on the level ground, and that the station was typical of the mature forest wherever found.

a. Plants. The sole dominant, *Populus tremuloides* Michx., on the study area reaches a height of 50 feet, a diameter of 6–8 inches, and an age of 45–50 years. It is characterized in the mature stand by a slowly tapering trunk bearing a few dead branches up to a height of 30–35 feet. The remaining 10–15 feet bears numerous leafy branches. The bases of the trees are covered to a height of about a foot with moss. There are from 800 to 900 trees per acre.

The shrub stratum is composed of two outstanding subdominants, the hazelnut, *Corylus americana* Walt., and the red-osier dogwood, *Cornus stolonifera* Michx., which form a scattered growth and reach a height of 4–5 feet. Other shrubs of less importance are the highbush cranberry, *Viburnum opulus americanum* (Mill.) Ait., the rose, *Rosa blanda* Ait., the buckthorn, *Rhamnus alnifolia* L'Her., choke cherry, *Prunus virginiana* L., and snowberry, *Symphoricarpos racemosus* Michx.

The subdominants of the herb stratum are: sarsaparilla, *Aralia nudicaulis* L., wintergreen, *Pyrola asarifolia* Michx., and dwarf dogwood, *Cornus canadensis* L. Herbs of minor importance are: mayflower, *Maianthemum canadensis* Desf., false Solomon's seal, *Smilacina stellata* (L.), strawberry, *Fragaria virginiana* Duch., dwarf raspberry, *Rubus triflorus* Rich., *Aster Lindleyanus* T. & G., *Thalictrum* sp., *Arenaria lateriflora* L., *Galium triflorum* Michx. and some grass (unidentified).

A quadrat of 25 square meters on the study area included the following trees and shrubs; 8 living aspen and 5 dead, 9 bushes of dogwood, 8 roses, 3 cranberry bushes, 5 choke cherry, 2 hazel and 1 snowberry. Hazel in this case were unusually few, but this indicates its patchy nature of growth, for nearby there were a great many.

A count was made of the herbage growing on the sample areas at the time the collections were made whenever it was possible to identify the leaves or flowers. The following were found on seven sample areas each of 1/40,000 of an acre; sarsaparilla 9, wintergreen 40, dwarf dogwood 19, snowberry 3, rose 1, grass 5, *Thalictrum* 1, *Arenaria* 6, strawberry 3, dwarf raspberry 1, mayflower 3, aster 2.

Several species of fungi are very common and of great importance to

the community: *Fomes ignarius* (L.) Gillett, or white heart-rot of aspen is extremely abundant and causes the premature death of many trees. It enters through injuries caused by beetles (*Saperda calcerata*), fire, hail and other agents. From its importance in destroying the dominant tree it may be ranked as an important subdominant. It has been carefully studied in Minnesota by Schmitz ('27).

Hypoxylon pruinatum, or poplar canker, is another fungus of scarcely less importance than *Fomes.* It kills the trees by attacking them and blackening the bark, usually at some distance from the ground. In some places only occasional trees are infected, and, in the early stages of the disease, they may be told by the brownish color of their leaves; in other localities as many as 60 per cent are infected.

Professor G. R. Bisby of the Manitoba Agricultural College, Winnipeg, who kindly identified the fungi for me writes, "There are two other aspen diseases of some importance, one being the canker caused by *Cytospora* in which amber tendrils or spores ooze out upon the surface, and the other *Dothischiza* canker in which there are finely small cup-shaped fruit bodies on the surface. The aspen are especially likely to the attack of fungi when their natural environment is disturbed."

Interesting differences were noted in the mature aspen forest at Birtle which is here described as typical for the parkland, and that at Treesbank, which is unlike the former on account of the sandy nature of the land. The Treesbank forest differs as follows: *Aralia* is comparatively scarce, and its place is taken to a large extent by *Rhus Toxicodendron.* The herbage is considerably more dense at Treesbank, and *Astragalus canadensis* L. is abundant. *Symphoricarpos,* rose, and false Solomon's seal are about the same. *Cornus canadensis* and *Maianthemum canadensis* are absent or nearly so. The shrubs are about the same. There is much *Juniperus horizontalis* and *Arctostaphylos Uva-ursi* L.

b. Animal Presocies. Several animals of importance used to be found here but are now extinct in the area of study. The wapiti, *Cervus canadensis manitobensis* Millais, was an animal to which groves of trees were essential for care of young, though it was an influent of the prairie (see p. 28). The accounts of the early travellers are full of comments on the abundance of this "great stag." Its numbers began to decline in the early part of the 19th century, and by 1850 had reached a very low ebb. In 1882 the last wild wapiti was seen at Carberry, Manitoba, and the survivors had been forced to seek refuge in the Riding, Porcupine and Duck Mountains. About 1895 legislative measures were introduced for its protection and it began to increase until in 1907 it numbered 5,000 in the Province (Seton '09*a*). Since then it has decreased somewhat but is now about holding its own. In 1897 Seton estimated the abundance of elk in Yellowstone Park as about 10 per square mile, and probably this was close to its abundance in the parkland in the early days.

Of less general distribution, but more numerous than elk in hilly country, where it occurred, was the black-tailed deer, *Odocoileus hemionus hemionus* (Rafinesque). In such country Seton gives its probable abundance at 50 per square mile, but states that, owing to its great preference for broken country, there would not be more than 5 per square mile on the average. It, too, decreased rapidly before settlement, and was scarce in Manitoba in 1882. By 1900 it had practically disappeared and its place was largely taken by the white-tailed deer, *Odocoileus virginianus borealis* (Miller), which, on the contrary, advanced with settlement. It is an animal which prefers groves of trees alternated with fields or meadows, and here, protected from wolves by the proximity to man, it is able to increase and protect itself from its human enemies by its wariness, superior to any other deer. It has advanced to the northward as the forests have been broken by fields, and will hold its own as long as it has woods for shelter and is not unduly persecuted.

In 1800 Alexander Henry records the plain grizzly bear, *Ursus horribilis horribilis* Ord., as common in certain parts of the Red River valley, about Devils Lake, North Dakota, and the Pembina Mountains in Manitoba. It preyed on the buffalo and disappeared with them.

The black bear, *Ursus americanus* Pallas, was at one time very numerous throughout all the parkland country, and may still be found in the sand hills near Onah, Manitoba. It is at the present time common in the Riding and Duck Mountains and in the coniferous forest to the north.

The birds, as well as the mammals, have shown a fluctuation in numbers since the coming of the white man, but to a lesser extent. Perhaps the most striking is the historical disappearance of the passenger pigeon, *Eclopistes migratorius* L., "at one time a common summer resident, which last came to Manitoba in force in 1878. The next year it was comparatively scarce, and each year became more so." Stragglers were taken until 1898, which year marked its final extinction in the Province (Seton '09*a*).

The present day influent of the aspen consociation is *Saperda calcerata,* and the sub-influents are the downy woodpecker, least flycatcher, willow thrush, rose-breasted grosbeak, Baltimore oriole, and black-capped chickadee.

The animal presociety of the aspen association is based on the insect population, but, apart from the one insect influent, *Saperda calcerata* Say., the predominating species are all birds of insectiverous habits. The outstanding insect group is the Diptera which is 5 times as abundant as the next 2 most abundant groups, the Coleoptera and Homoptera. Other invertebrates of outstanding importance are the spiders which are more than half as abundant as the Diptera, and the Mollusca which are more abundant than either the Coleoptera or Homoptera.

The invertebrate population was studied by regular quantitative collections and the results plotted in graphical form (Fig. 10). The total population, which averaged about 2 million per square acre, closely followed that

of the surface society which was the greatest. It started with a minimum of slightly less than 2 million in March before the break of hibernation, and rose to a maximum of almost 4.5 million by June 11. It then declined steadily to a fall minimum of less than 0.25 million. The soil and surface populations started at about the same numbers, but the latter rapidly fell

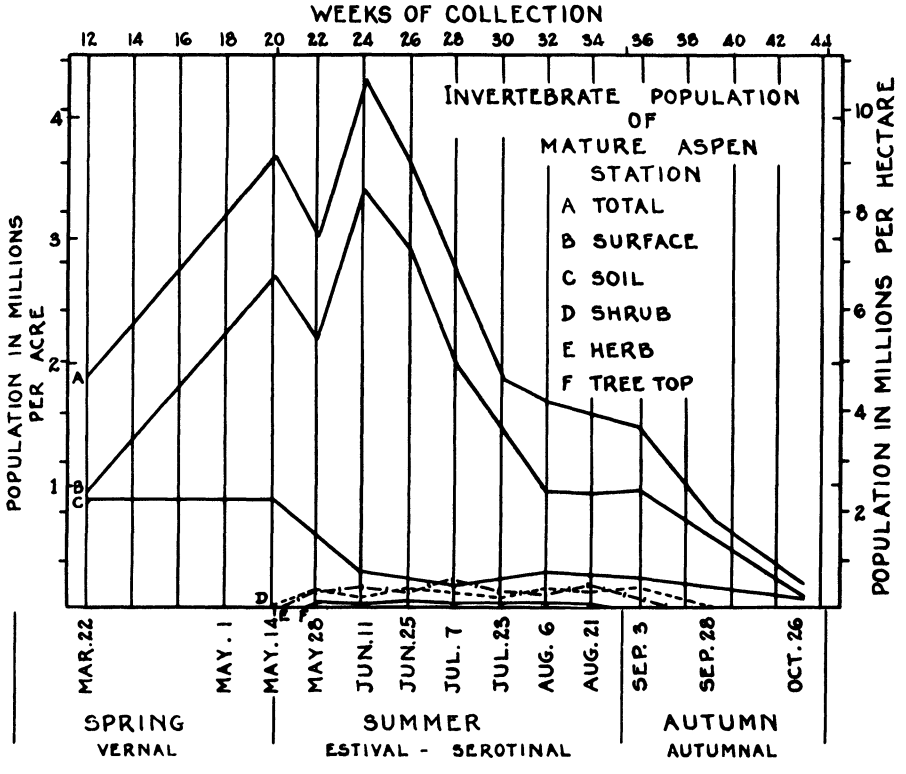


FIG. 10. Graph showing the invertebrate population of the "mature aspen station" as indicated by the quantitative collections in 1928. The surface curve (*B*) differs from those of the "prairie" and "*Salix petiolaris*" stations but resembles that of "*S. longifolia*" in having a maximum in the middle of June. This is due to numbers of diptera which multiplied rapidly in the moist leaf mould but practically disappeared with the onset of drought. The soil curve (*C*) shows a spring maximum and an early July minimum from which there is an indication of a rise to a fall maximum but which falls off with the drought. This is similar to the "prairie" and "*S. petiolaris*" stations. The other strata are estival-serotinal as in the other stations where they are found.

off to a minimum of 0.25 million in early July at which point it remained fairly constant for the rest of the year. The populations of the other strata were all small, but remained fairly constant throughout the growing period of the year. That of the herbage was the greatest and reached a maximum of 0.25 million. The shrub stratal society reached a maximum of about 0.16 million, and that of the tree top about 0.08 million.

During the winter the whole invertebrate population is hibernating, and many of the birds have migrated. Winter observations and estimates were made in March with the following results:

Rabbits, *Lepus americanus,* are not resident here but frequently cross the area and feed on the branches of fallen trees and any shoots or shrubs that are palatable.

Characteristic bird life consists of: Chickadees, 40 per square mile; downy woodpecker, 12 per square mile; hairy woodpecker, 6 per square mile; blue jay, 6 per square mile; great horned owl, 2 per square mile; goshawk, 1 per square mile.

In some places as much as 50 per cent infestation with *Saperda calcerata,* and in others little or none, was noted. The larvae usually attack the tree at 30–40 feet from the ground boring for some time round the trunk at about ¼ inch beneath the bark, but later entering and always hibernating in the very heart of the tree in a chamber plugged with frass. About 1 larva to a foot of the infested part on the trunk is a liberal estimate. Thirty to fifty per cent of the larvae are eaten by woodpeckers. The empty hibernating and pupal chambers are sometimes used by ants for hibernating. The exit holes are often entered by a fungus, *Fomes ignarius,* which rots and kills the tree, which is then attacked by buprestid beetles.

Forty individuals of a dipterous larva (Cecidomyidae) were noted to one foot of trunk, beneath the bark of a tree killed by *Hypoxylon pruinatum.*

Nothing was found on or in the bark of healthy trees. In the tree tops an egg cluster of *Malacosma* and a small number of lepidopterous case-bearing larvae, 1 per cent or less, were found.

(1) Stratal Societies. The aspen association may be subdivided into six fairly definite stratal societies which show considerable overlapping as some animals occur in two or more strata, but on the whole they are well marked and will be discussed separately as follows:

(a) *Tree-top Society* (*Icterus, Vireosylva, Malacosma*). This society is small, has no influent of the association, but it has one sub-influent, the Baltimore oriole, *Icterus galbula* L., which reaches an abundance of about one per acre. This bird is very noisy, conspicuous by its bright colors, and attracts much attention. It is a summer resident which arrived in 1928 on May 17.

The warbling vireo, *Vireosylva gilva gilva,* is a common and characteristic bird of this stratum which may be classed as an important minor sub-influent, but, owing to its inconspicuous color which blends with the foliage, it is usually heard but not seen. It arrives about the end of May—on the 28th in 1928.

The invertebrate population is composed almost entirely of insects, which as a group predominate and form the food supply of the above birds, but individually are of little importance. The Diptera is the most abundant order. A few spiders are found. One moth of this stratum, the fall web-

worm, *Malacosma disstria,* at times occurs in outbreak form and completely strips the trees of their leaves. In 1928 only one egg mass was found.

The following were the most abundant insects in the collections: *Empoasca* sp., *Idiocerus alternatus* Fitch., *Cyphon variabilis* (Thurnt.), Geometrid and Microlepidoptera larvae unidentified, Cecidomyidae spp., *Homoneura deceptor* Mall., *Homoneura pernolata* Mall., *Minettia americanus* Mall.

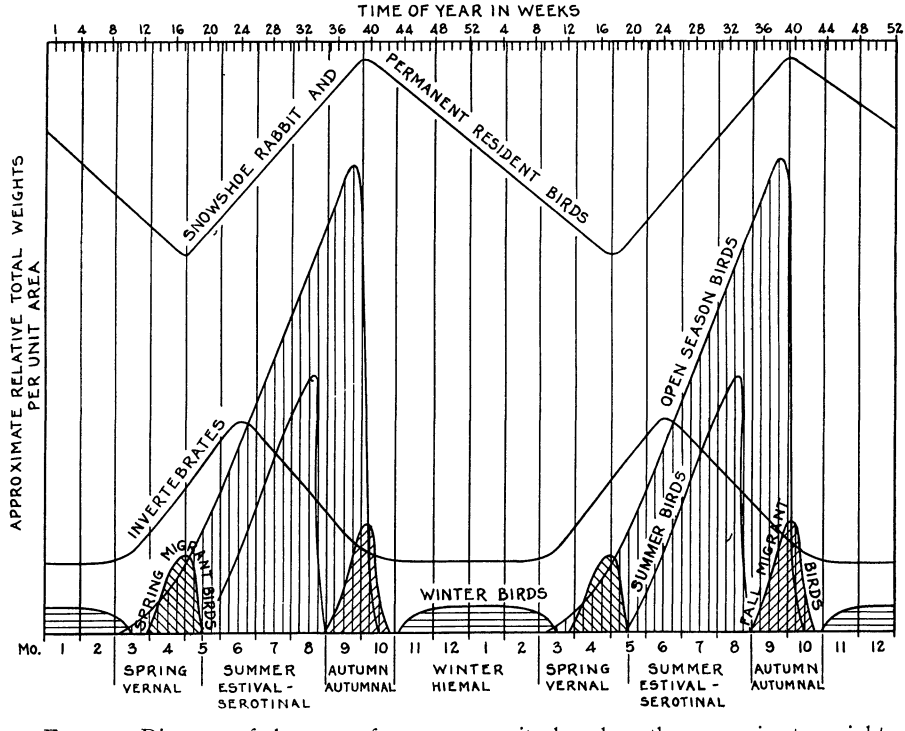


FIG. 11. Diagram of the aspen forest community based on the approximate weights and numbers of the animals as in figure 3. The "summer birds" are included within the "open season birds" in a similar manner. In addition are included spring and fall migrant birds which occur about the forest edge.

(b) *Tree-trunk Society* (*Saperda, Dryobates, Empidonax*). This society contains the only influent of the aspen association, a cerambycid beetle, *Saperda calcerata* Say. The infestation of this beetle is local, and one may go for considerable distances through the woods without seeing signs of its presence. It attacks trees that have begun their senescence, or are weakened by some other agent, and causes their early death. Practically every tree is attacked by it sooner or later. In some localities the infestation may be as high as 50 per cent.

The sub-influents and important minor sub-influents of this community are birds which are discussed as follows in order of their abundance: The

downy and hairy woodpeckers, *Dryobates pubescens* L. and *D. villosus* L., may be classed as sub-influents. They are permanent residents, and, in the winter when the estimates were made, there were about 12 of the former and 6 of the latter to the square mile. Their chief importance in the community is as the destroyers of cerambycid and buprestid larvae, particularly *Saperda calcerata*. In this respect the hairy, on account of its larger size and preference for these larvae compared to other articles of diet, is as influential, if not more so, as the downy, even though less numerous. Their food is discussed in detail by Beal ('11).

The least flycatcher, *Empidonax minimus* L., is another sub-influent of this stratum, but feeds mainly in the shrubs. There are from 1 to 2 birds per acre. Their food is 97 per cent insects (Henderson '27). In 1928 they arrived on May 14.

The yellow-bellied sapsucker, *Sphyrapicus varius* L., is a very common bird of the forest, and is rather destructive to many trees and bushes by drilling holes in the bark from which to drink the sap which oozes out. It thus literally saps the vitality of the plants, and sometimes kills them. The holes also allow inroads by the wood-destroying fungi. The bird is a summer resident, which in 1928 arrived on May 5.

The flicker, *Colaptes auratus* L., is difficult to classify as to the community to which it belongs. It is an abundant species which is chiefly influential on account of the large numbers of ants which it destroys. It feeds much on the ground on the prairie and about the forest edge. It is restricted to the neighborhood of mature trees which form its nesting sites, but prefers those standing in the open, and in recent years has largely forsaken them for telephone posts and has wandered farther afield.

The great horned owl, *Bubo virginianus occidentalis,* is the most important predator of the forest, but also hunts over the forest-edge, prairie, and sloughs. In 1928 it was estimated that there was one nesting pair per square mile of well-wooded parkland. Five nests were found near Birtle, Manitoba, and one on the study area. From an examination of the pellets near the nest it was found that the food consisted chiefly of rabbits and mice, mainly Drummond's vole; only a few birds were eaten (Bird '29). It is a permanent resident.

The goshawk, *Astur atricapillus* L., is a common winter visitor from the north which feeds principally on rabbits, grouse and poultry. In the winter of 1927–8 it was estimated that there was one bird per square mile of parkland. The numbers fluctuate in accordance with the severity of the winter and with the numbers of rabbits and grouse.

The cooper and sharp-shinned hawks, *Accipiter cooperi* L. and *A. velox*, are common summer residents which feed chiefly on birds.

The flying squirrel, *Glaucomys sabrinus sabrinus* (Shaw), is a mammal which, on account of its nocturnal habits, is seldom seen although fairly common.

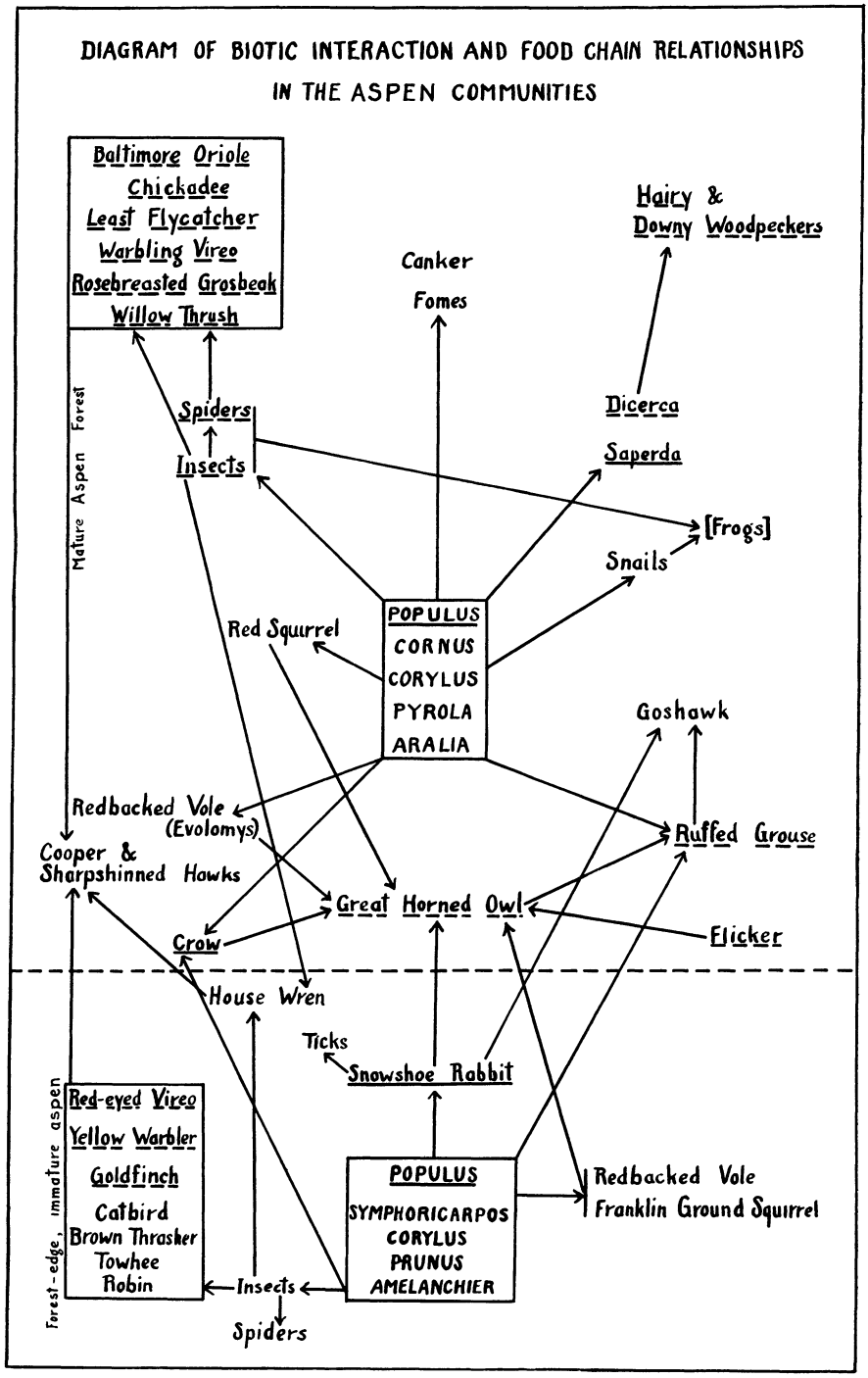


FIG. 12. Diagram illustrating the biotic interaction (coaction) within the aspen communities. The forest edge community is separated from the mature forest by a broken line. Arrows point from the animals or plants eaten to those that eat them. Dominants are in capitals underlined, subdominants in capitals, predominants with every second letter underlined and influents in small letters.

A few insects and spiders are found in this stratum, but they are of minor importance, except a beetle, *Dicerca prolongata* Lec., which aids in the destruction of aspens which have been killed by *Saperda calcerata* and other causes.

(*c*) *Shrub Society* (*Hylocichla, Hedymeles, Penthestes*). This stratum is also one in which birds predominate as individuals. There is no influent of the association, but several sub-influents and minor sub-influents in order of their abundance as follows:

The willow thrush, *Hylocichla fuscescens salicicola* L., is a sub-influent of this and the surface stratum, and returned from the south in 1928 on May 12. It nests on the ground and in low bushes. According to Henderson ('27) its food is 57 per cent insects and 42 per cent wild fruit. It was estimated that there was about one bird per acre on the study area.

The rose-breasted grosbeak, *Hedymeles ludovicianus* L., is another sub-influent. It returned in 1928 on May 8 and is about as numerous as the willow thrush, but is more conspicuous on account of its bright colors and the song of the male. It is also more partial to the edge of the mature forest than the thrush, which is typically a bird of the dense woods.

The black-capped chickadee, *Penthestes atricapillus* L., is a permanent resident and sub-influent which was estimated at 40 per square mile. It destroys great numbers of the over-wintering eggs and pupae of insects, and feeds in all strata from the herbage to tree-top.

The house wren, *Troglodytes aedon* L., whose food is 98 per cent insects, is a common summer resident and minor sub-influent in the mature forest. It is more abundant in the neighborhood of buildings. In the forest it nests in old woodpecker and chickadee holes. In 1928 it returned on May 10.

The blue jay, *Cyanocitta cristata* L., is a common permanent resident which numbers about 15 per square mile.

The mourning dove, *Zenaidura macroura* L., is a common summer resident, reaching us in 1928 on April 25. It nests in the woods but feeds largely on seeds and grain from fields and prairie adjoining the forest.

The red squirrel, *Sciurus hudsonicus hudsonicus* (Erx.), feeds on hazelnuts, and, in its season, is very destructive to the birds' eggs and young. It is fairly common and one was often see about the study area.

The invertebrates predominate as groups, although no single species was of outstanding abundance or importance, but the most abundant were the Diptera, Spiders, and Homoptera. The species most commonly taken were: *Clestoptera obtusa* Say, *Empoa* sp., *Erythoneura comes* (Say), *Erythoneura vulnerata* (Fitch), *Cyphon variabilis* (Thumb.), *Aedes riparius* D. & K.

(*d*) *Herb Society* (*Diptera, Araneida*). This is a small, short-lived society which is present only from the time the herbage grows up in the spring (May) to the time it dies down in the fall (August). No vertebrates are confined to this stratum, although the chickadee and willow thrush feed here to some extent. The invertebrates predominate in groups, but not as

individuals. By far the most abundant are the Diptera and Spiders. A few snails are also found crawling up on the herbage.

(*e*) *Surface Society* (*Mollusca, Annelida, Corrodentia*). Here again we find the invertebrates predominating as a group, the Mollusca, Annelida (Enchytraeidae) and Corrodentia (Psocidae) being the most abundant. No species, however, is of any great importance. There is no influent of the community, and the sub-influents are found among the vertebrates.

A sub-influent of this stratum is the ruffed-grouse, *Bonasa umbellatus* L. At one time it was very abundant, but in 1928 it was estimated that there were only about 6 nesting pairs per square mile. It is rather tame and easily shot, which, combined with the goshawks and great horned owls, probably accounts for its reduction in numbers. The willow thrush may be classed as a sub-influent here as well as in the shrub stratum. The oven-bird, *Seiurus aurocepillus* L., is a common minor sub-influent of this stratum, but is seldom seen.

The leopard frog, *Rana pipiens* (Shreber), and the wood frog, *Rana cantabrigiensis cantabrigiensis* (Baird), are both minor sub-influents on the forest floor, and, besides feeding on insects and spiders, consume many snails.

The red-backed vole, *Evotomys gapperi loringi* Bailey, is one of the most diurnal of the mice and may be seen running during the day. It is a minor sub-influent.

(*f*) *Soil Society* (*Annelida, Elateridae, Diptera*). This is a small and comparatively stable society composed of small white earthworms (Enchytraeidae), wireworms (Elateridae), the larvae of Diptera, and few other insects which were not identified closer than the family, and none of which are of any great importance within the society or community as a whole.

(2) Seasonal Socies. The seasonal socies of the mature aspen community consists of a few spring migrant birds of which the myrtle warbler, *Dendroica coronata,* is the most important. This community does not have as well developed spring and fall socies as the forest-edge community, and has no hiemal socies. Those of the fall are indicated in figure 13.

There is an estival-serotinal group of invertebrates on the foliage of shrubs and woody plants (curves D, E, F, Fig. 10) and a number of strictly summer birds, such as: warbling vireo (*Vireosylva gilva* L.), Baltimore oriole (*Icterus galbula* L.), least flycatcher (*Empidonax minimus* L.) and rose-breasted grosbeak (*Hedymeles ludovicianus* L.) The autumnal socies consist of the returning myrtle warblers.

c. Influence of Man. The influence of man on the aspen association has been considerable. As there are no local coal mines, the wood is eagerly sought for fuel. Hundreds of cords are cut during the winter and hauled into every little village. The great majority of the mature trees are thus cut off. As the older trees are found at the centers of the groves they are cut off, and, in the many cases, not systematically, but by a slashing method, so that many of the standing trees are injured and form ideal breeding

grounds for the Cerambycid beetle, *Saperda calcerata,* and the white heart rot, *Fomes ignarius.* The dead boughs, too, become as dry as kindling and enable prairie fires to sweep into the groves and burn them out, killing many healthy trees. Even after severe burning, aspen quickly regenerates from the roots by sending up numerous shoots which form a very close stand

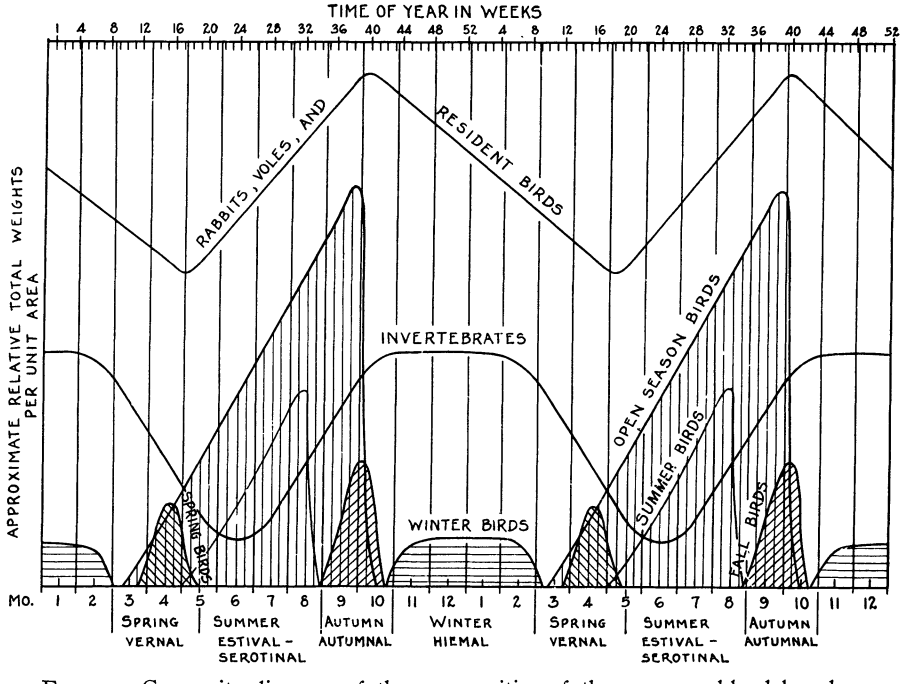


FIG. 13. Composite diagram of the communities of the aspen parkland based upon the approximate weights and numbers of the animals to show the relative abundance and importance of the components at different seasons of the year. The "summer birds" are shown within the "open season birds" in a similar manner, and the fall and spring migrants of the forest edge are indicated.

of young trees. This second growth forms an ideal breeding and feeding ground for the snowshoe rabbit, *Lepus americanus,* which increases and multiplies exceedingly. In years of abundance 90 to 100 per cent of the saplings are ringed and killed by the rabbits. When less abundant, the rabbits are more or less beneficial, for they thin out the stand of young trees. It is not until a tree is 4–5 inches in diameter that it is safe from the attack of rabbits.

It is by these two methods, cutting and fire, that man is chiefly detrimental to the aspen groves. Excessive trampling by grazing stock is also injurious.

d. Biotic Interaction (Coaction) and Food Chain Relationships of the Aspen Community (Fig. 12). In the aspen communities, as in all others,

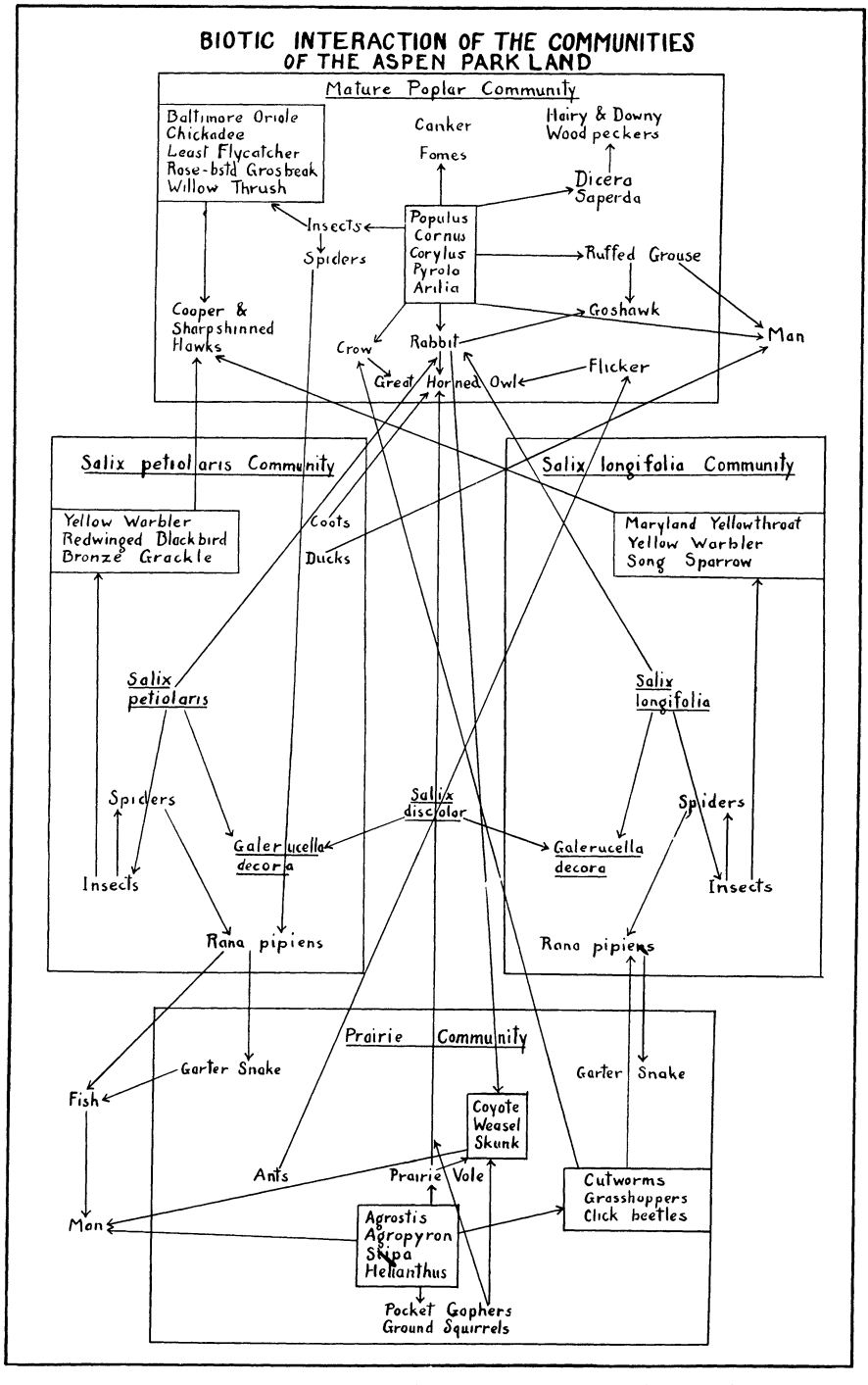


FIG. 14. Diagram illustrating the biotic interaction (coaction) within and between the communities of the aspen parkland. The arrows point from the animals eaten or killed to those that prey upon them.

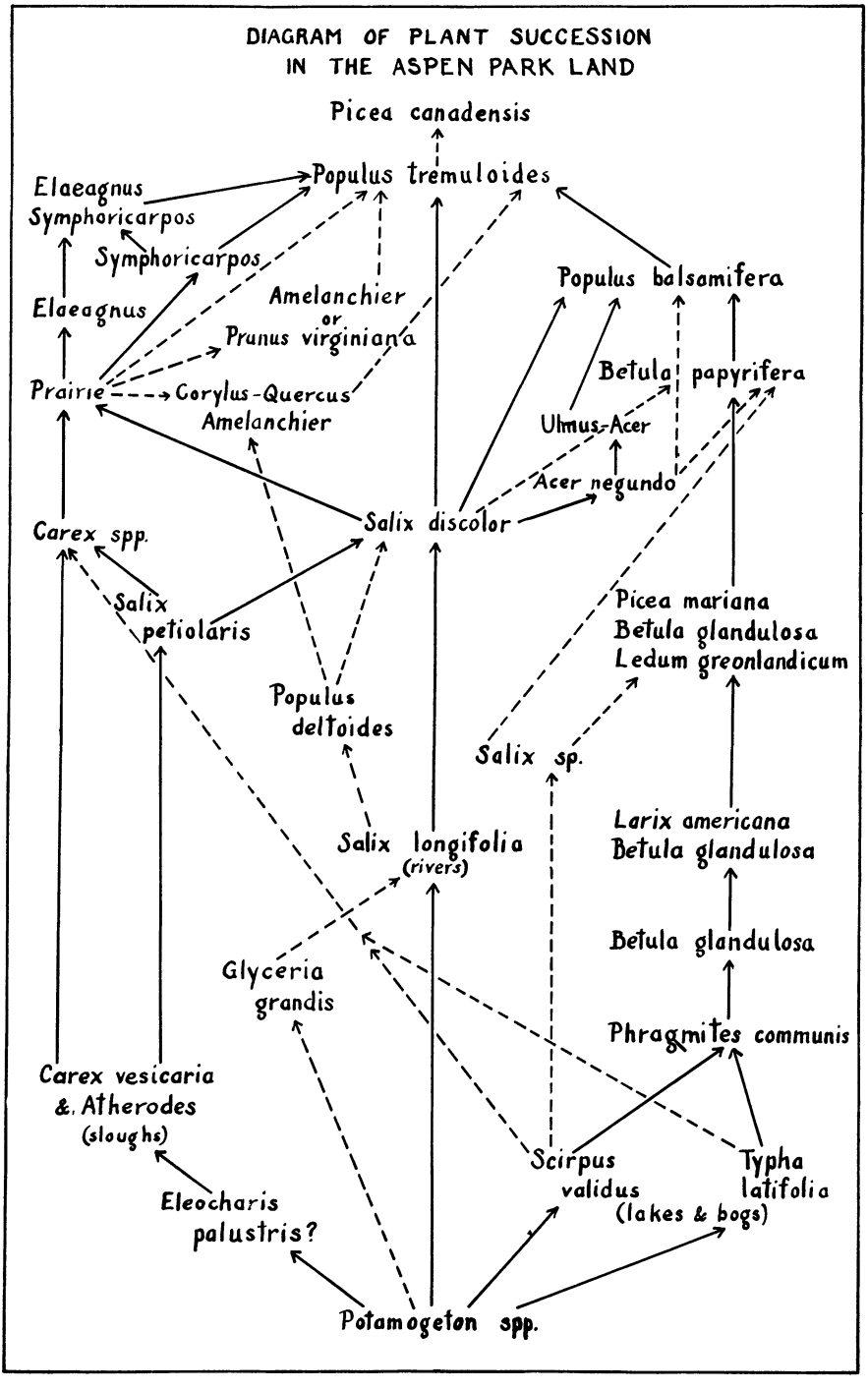


FIG. 15. Diagram illustrating the general trend of succession as observed in the aspen parkland. The arrows indicate the direction of succession, heavy ones the routes more commonly followed, and the broken ones those less frequently found.

the plants support a large number of herbiverous animals which in turn support a population of insectiverous and carniverous species. The most influential species is the beetle, *Saperda calcerata,* which, by its borings in the mature trees and the subsequent enlargement of the holes by woodpeckers, forms inroads for attack by the white heart rot of aspen which causes premature death of the trees. The snowshoe rabbit in the forest-edge is very important in girdling and killing many shrubs and young aspens, thus checking their spread on the prairie. The great horned owl is a sub-influent carnivore which feeds not only on the birds and mammals of the forest, but also hunts over the prairie and sloughs.

3. Biotic Interaction (Coaction) of the Communities. The communities, prairie, willow and aspen, discussed above are really intimately interwoven units of an ecotone community group represented by the aspen parkland. A brief glimpse of this interrelationship may be obtained by reference to Fig. 14.

VI. Coaction, Seasonal Phenomena and Biotic Succession in the Aspen Parkland

Plants are dominant on land because they are conspicuous, and as the dominant species are easily recognized, greater emphasis has been laid on them in the study of succession included in the present report than on the animal part of the community. Animals, however, have been noted whenever they are conspicuously influential in aiding or checking the process of succession, and certain typical areas in important successional stages were set aside for their study alone (see section IV, Methods).

Succession in the aspen parkland, with few exceptions, is hydrarc, and always terminates in a forest climax. From an aquatic community it proceeds in 3 directions according to whether the body of water is a lake, a river, or a slough. These types may grade into one another if the lake be shallow and marshy and the river sluggish, but as a rule they are well marked.

1. Succession from Lakes

Succession from lakes is initiated by various species of *Potamogeton* which are the first rooted plants. This vegetation dies down, and, after some years, forms an accumulation of organic debris which is invaded by the next plant stage composed of either bulrushes, of which *Scirpus validus* Vahl. is the common species, by *Typha latifolia* L., or by species of *Carex*.

Certain birds are characteristic of this community. They are: the pied-billed grebe, *Podilymbus podiceps* L.; the red-winged blackbird, *Agelaius phoeniceus* L., which is usually associated with the cat-tails, and the yellow-headed blackbird, *Xanthocephalus xanthocephalus* L., which nests, often in large colonies, among the bulrushes. This blackbird is characteristic of the bulrushes, and is seldom found nesting elsewhere, although it is not as abun-

dant as the red-wing, and does not occur in all areas of *Scirpus*. A less abundant, but nevertheless characteristic, bird is the long-billed marsh wren, *Telmatodytes palustris iliacus* (L.).

As late as 1900 geese, *Chen hypoborea* L. and *Branta canadensis* L., and cranes, *Gyrus mexicanus* L., were very abundant during migration, and many remained to breed on the larger sloughs and marshes. Now they are comparatively rarely seen.

From this point, succession may follow several courses, and depends on the nature of the surrounding country, whether it be well-drained, low-lying or bordered by cold bogs fed by springs. The latter is the case with the majority of the lakes in the northern part of the aspen parkland where it borders on the northern coniferous forest, and applies to many within this formation. It is exemplified by the northern part of Lake Winipegosis in the vicinity of Dawson Bay, the country about Molson and to a lesser extent Douglas Lake near Carberry, Manitoba. There, bulrushes, cat-tails and sedges form a mass of rooted vegetation over a quaking bog which is further strengthened by *Phragmites communis* L. and willows of which *Salix candida* Flug. is a common species. Here the herbs, buckbean, *Menyanthes trifoliata* L., and pitcher plant, *Sarracenia purpurea* L., grow in profusion. This vegetation is followed by a shrub stage in which the dwarf birch, *Betula glandulosa* Michx., is dominant. The next associes is a forest in which the larch or tamarack, *Larix americana* (DuRoi), is dominant, but the dwarf birch still persists as a sub-dominant of the shrub stratum. As the soil becomes somewhat drier, but may still be considered a bog, the larch is replaced by the black spruce, *Picea mariana* (Mill.) BSP. The dwarf birch continues, but is supplemented by a smaller shrub dominant, Labrador tea, *Ledum groenlandicum* Oeder. The ground is carpeted by sphagnum and other mosses (*Hypnum* spp. ?). If the land rises comparatively rapidly from the lake, succession may jump from the rush through a willow associes to the black spruce forest or even to the next stage in which the paper birch, *Betula papyrifera* (Marsh), is dominant. This tree, however, not only forms a pure stand but is also scattered through the black spruce and following associes. As the soil loses the nature of a bog, but is still wet, a consocies of balsam poplar, *Populus balsamifera* L., is formed, and, as the area becomes better drained is replaced by aspen, *Populus tremuloides* Michx., which in turn, in some localities, gives place to a climax of white spruce, *Picea canadensis* (Mill.) BSP., and balsam fir, *Abies balsamea* (L.) Mill. This community was noted on the east shore of Dawson Bay, Lake Winnipegosis, and on Butter Island, but sufficient observations have not been made to say whether it is the true climax over large tracts of country.

Succession from the lakes with low-lying, marshy shores grades into that from sloughs, and the early associes may be a *Caricetum*. In lakes surrounded by alkaline soil, such as the Quill lakes, Saskatchewan, the early *Caricetum* passes into a second *Caricetum* and thence to prairie, or to a

willow community dominated by *S. discolor,* and from thence into groves of balsam poplar which will in time give way to aspen. If no alkali is present it passes from a willow associes to balsam poplar and thence to aspen. Succession from lakes with well-drained shores is comparatively rapid, and may be direct to prairie through a *Caricetum,* if conditions are xeric, through *Salix longifolia* and *S. discolor* associes if mesic, and to aspen through *S. longifolia, S. discolor* and *Populus balsamifera* if hydric.

2. Succession from Rivers

Succession from rivers depends, in its initial stage, on whether the river be sluggish or swift. In the aspen parkland the smaller streams are usually of the former and the larger of the latter type. In the former case succession begins, as in the lakes, with *Potamogeton* spp., though with *Sagittaria latifolia* Willd. usually present as a sub-dominant, and may then pass through a *Scirpus,* a *Typha* or grass associes with *Glycera grandis* Wats. as a dominant. Such a condition is found along the Birdtail river.

The beaver, *Castor canadensis* Kuhl., which finds an ideal habitat in the sluggish streams of the aspen parkland which are well wooded with aspen, its favorite food, is still abundant wherever protected. Unfortunately, however, its fur is of such value that the laws are frequently broken, and it is fast disappearing. In 1915 there were hundreds of beaver along the Birdtail river, and a dam at almost every half mile, but in 1928 only one colony was left.

Otter, *Lutra canadensis* (Sch.), was abundant in the early 1800's, but was very rare in 1900, and became extinct in the parkland shortly after.

The next stage is always a willow one with *Salix longifolia* as the dominant, and, in swifter rivers or those with a large deposition of sediment, such as the Assiniboine, it is the initial one and is found on mud banks and sand bars. Beginning here and running through to the aspen, but more abundant in hydric conditions, is the red osier dogwood, *Cornus stolonifera* Michx. The hop, *Humulus lupulus* L., and the bindweed, *Convolvulus sepium* L., are present in abundance and bind the closely growing living and dead willows and driftwood together so that an almost impassible barrier to man or other large animals is presented. Dominant herbs are: *Mentha arvensis canadensis* (L.), *Potentilla Anserina* L. and *Ranunculus Cymbalaria* Pursh.

Following the long-leafed willow another willow, *S. discolor,* appears as a dominant, and with it an animal predominant of widespread influence,—*Galerucella decora.* It appears on this willow, no matter in what series of successional stages, and, in years of abundance (Criddle, N. '11*a*), completely strips it of its foliage and spreads to other willows and aspen.

From this stage, succession may follow one of several courses. If conditions are xeric it may go directly to prairie, and, if less so, directly to

aspen. If there is considerable moisture, or if the stream is large enough to develop flood plains, balsam poplar, or the box elder, *Acer negundo* L., and balsam poplar, sometimes with considerable paper birch, precedes the aspen. This is the case with the smaller streams of the Assiniboine drainage and the whole Saskatchewan river system where elm and box elder are not present. It is well illustrated at Saskatoon on the South Saskatchewan river.

It is only on the larger rivers of the Assiniboine drainage that the full series of successional stages is found. Here the valleys are terraced. The willow community occupies the mud flats and sand bars, and the lower terrace, which is often flooded. The next higher terrace, which is covered only during the spring floods, supports a community first of box elder, as it is fast growing, and then of elder and elm, *Ulmus americana* L. Ash, *Fraxinus americana lanceolata* (Borkh.), is present as a subdominant.

This community rapidly gives place as the ground rises, sometimes with a little paper birch, to one of balsam poplar and then to aspen.

In some localities along the rivers, as near the mouth of the Souris, wide flood plain beaches composed largely of gravel and boulders are present. Here a scattered growth of cottonwood, *Populus deltoides* Marsh., is found usually after some *S. longifolia*. It may give place to *S. discolor* and follow one of the normal courses of succession, or to a scrub associes composed of hazel, *Corylus americana* Walt. (or *rostrata* Ait.), saskatoon, *Amelanchier spicata* (Lam.), and scrub bur oak, *Quercus macrocarpa* Michx. This latter stage, composed of oak, hazel and saskatoon, is also present, without passing through the cottonwood associes, as a narrow but definite ecotone between prairie and the aspen of the river valley along the Assiniboine in the vicinity of Treesbank.

Succession from rivers is largely dependent on the direction in which the streams flow. It is only on the moist north and east facing slopes that the full series of successional stages is found. The south and west slopes, being xeric, are covered with prairie, except along the tributary water courses.

3. Succession from Sloughs

Succession from sloughs, as in lakes and sluggish rivers, is initiated with *Potamogeton* spp. The next stage is of *Eleocharis palustris,* which may be followed by one of *Scirpus validus* or *Typha,* but is usually a *Caricetum* in which the dominant sedges are *Carex vesicaria* L. and *C. atherodes,* and the subdominant is *Alisma brevipes.*

The predominating animal forms of this community are birds. The predominant species is the coot, *Fulica americana* L. and the sub-influents, the horned grebe, *Colymbus auritus* L., the pied-billed grebe, *Podilymbus podiceps* L., the red-winged blackbird, *Agelaius phoeniceus fortis* (L.), the blue-winged teal, *Neottion carolinense* L. and mallard, *Anas platyrhynchos* L. Many other ducks are abundant, and it is a difficult matter to classify them as to their importance in the community, because the sloughs of the three

prairie Provinces of Canada are the most important breeding grounds of the ducks of North America. Among the mammals, the muskrat, *Ondatra zibethica cinnamomina* (Hollister), may be classed as a sub-influent.

From the *Eleocharis palustris* stage, succession may follow one of two well-marked courses either through a *Caricetum* (*Carex* spp. and *Juncus bulbosus*), direct to prairie or through 2 willows to either prairie or aspen. The first willow is *Salix petiolaris* Sm. which forms a very definite zone from a little below to a little above the average water level. It may occasionally give place through *Populus balsamifera* to aspen, but usually *Salix discolor* Muhl. intervenes, on ground above the water level, between it and the prairie if conditions be xeric or between it and aspen if mesic.

From prairie, in which *Agropyron Richardsonii* Schrod., *Koeleria cristata* (L.) Pers., and *Stipa comata* Trin. & Rupr. are dominants, succession toward aspen passes through a shrub associes of wolfberry, *Symphoricarpos occidentalis* Hook, or silverberry, *Elaeagnus argentea* (Tourn.) L., and wolfberry. The former gains a foothold in hollows and moist places in the prairie, and is materially aided by any disturbance of the soil such as is created by the burrowing of gophers and badgers and the distribution of seeds by the pine grosbeak, *Pinicola enucleator* L., which feeds on the berries in large numbers during the winter. It grows in close stands, choking out the grass and enabling aspen seedlings to take root. Silverberry, on the other hand, grows in drier situations and in open stands, so that it does not kill the grass but may weaken it sufficiently and hold the moisture so that the wolfberry can gain a foothold, to be followed in its turn by aspen. When once the aspen is established it spreads directly onto the prairie by means of underground runners and shoots.

It will thus be seen that all succession is toward an aspen community, but, as to whether this community is a climax or not, is still an open question. Many indications seem to show that it is climax over the greater part of the area occupied by the aspen parkland but, on the other hand, it is being replaced by white spruce near Dawson Bay on Lake Winnipegosis, and Lewis *et al* ('28 p. 23), in their study of the vegetation of Alberta in the vicinity of Edmonton, sum up their doubts on the subject as follows: "It may be doubted whether this belt which separates the coniferous forest from the prairie region can truly be considered as a climatic formation. Although the soil and topography of the country simulates prairie, two characteristic trees of the Northern Coniferous area are present, *Picea albertiana* and *Picea mariana;* the former is usually found along ravines and the latter on muskegs. Much of the general vegetation is characteristic of that of the northern forest and it appears reasonable to regard the Parkland as a transition belt, where slight differences of soil, climate and topography, have allowed grassland to become invaded by the northern vegetation, these special conditions giving preference to *Populus tremuloides* and other members of the Salicaceae and where conditions offer a suitable habitat, by two of the characteristic trees of the northern forest."

Conditions in the aspen parkland of Manitoba and Saskatchewan are quite different from those at Edmonton. The two spruces mentioned by Lewis are not present, except in a few isolated localities such as the sand hills about Onah, Manitoba, and the general vegetation is not so characteristically northern; hence it is in this region that one would expect to find a true aspen climax, if such exists.

It is the opinion of the writer that aspen is climax over a large area in Manitoba and Saskatchewan, and that the spruce is restricted to soils of a rocky and sandy nature such as are present over the great area covered by the northern formation, and is found south of this region only where soils approach this condition. It is generally believed that the coniferous forest was forced south by the great ice sheet in Pleistocene times, and that it retreated to the north as the ice melted. Why then is spruce found only in isolated localities south of the pre-Cambrian shield if climatic conditions are favorable? It certainly looks as if the coniferous forest were isolated in relict areas by edaphic conditions which enable it to survive in otherwise unfavorable surroundings. The writer's observations tend to show this, but an intensive study of the ecotone between the two forests is needed to prove it.

4. Retarding Factors

Four important factors tend to retard succession. They are, in order of their importance, fire, rabbits, snow and hail.

a. Fire

Fire is a factor which has been present for a great many years. The Indians periodically burnt off large tracts of prairie to cre te fresh grazing grounds for the buffalo; and the fires would sweep on into the surrounding forests of aspen. Even before the time of the Indians, occasional fires were started by lightning. Following settlement the large fires were stopped, with the result that the aspen quickly encroached on the prairie.

Occasional fires do not particularly harm aspen. They kill the trees, but regeneration quickly takes place from the roots since they are unhurt. Continued burning, however, does seriously retard succession, for, after a time, even the roots are killed. The shrubs' are killed back, particularly *Symphoricarpos,* which normally choke out the grass and tend to hold the moisture. By their removal drier conditions are created which enable grass to advance on the forest.

Fire is also well exemplified in the Spruce Woods Forest Reservation near Carberry, Manitoba, where former extensive tracts of prairie are now covered with young aspens. In later years the fire hazard has increased, for, with frequent fields and roads, the danger of large fires has been so reduced that people have lost all fear of them. In fact in the spring, after the snow has gone and the grass is as dry as tinder, people seem to develop

a perfect mania for setting fires, and a great deal of the vacant land is burnt over. The result is disastrous to forests and fauna alike. The fires sweep into the groves of aspen, killing many of the trees and so weakening others that they are soon killed by the heart rot, *Fomes ignarius,* other fungi and wood-boring insect larvae. On the other hand, certain plants are benefited by periodic burning, particularly the raspberry, *Rubus idaeus aculeatissimus* R. & T., the fire weed, *Epilobium angustifolium* L., and many asters, sunflowers, and goldenrods. Some insects are killed by the fires, but the greatest danger is to the birds whose nests and nesting sites are destroyed. Sometimes the eggs are only scorched, but enough to kill the germ, and the birds continue to sit. One pintail duck whose eggs were scorched on May 2 continued to sit on them until the first week in August. It would have been far better if the eggs had been completely destroyed by some predator or in some other manner, for then she would in all probability have laid a second batch and raised them successfully.

b. Snowshoe Rabbits

The snowshoe rabbit, *Lepus americanus phaconotus* Allen, is always present and is at times very abundant. It is increasing rather than decreasing with sett ement, due largely to the removal of predatory enemies and the large amount of second growth aspen after cutting and fire which forms its ideal habitat, although large numbers are killed yearly by whites and Indians alike. The bark of the young aspens is its favorite food during the winter, and a large number of these trees and shrubs of many species are girdled and killed. In years of abundance a band of the girdled trees about the edges of the groves, showing white against the dark background, may be seen for considerable distances. This is a severe check on succession second only to fire.

c. Snow

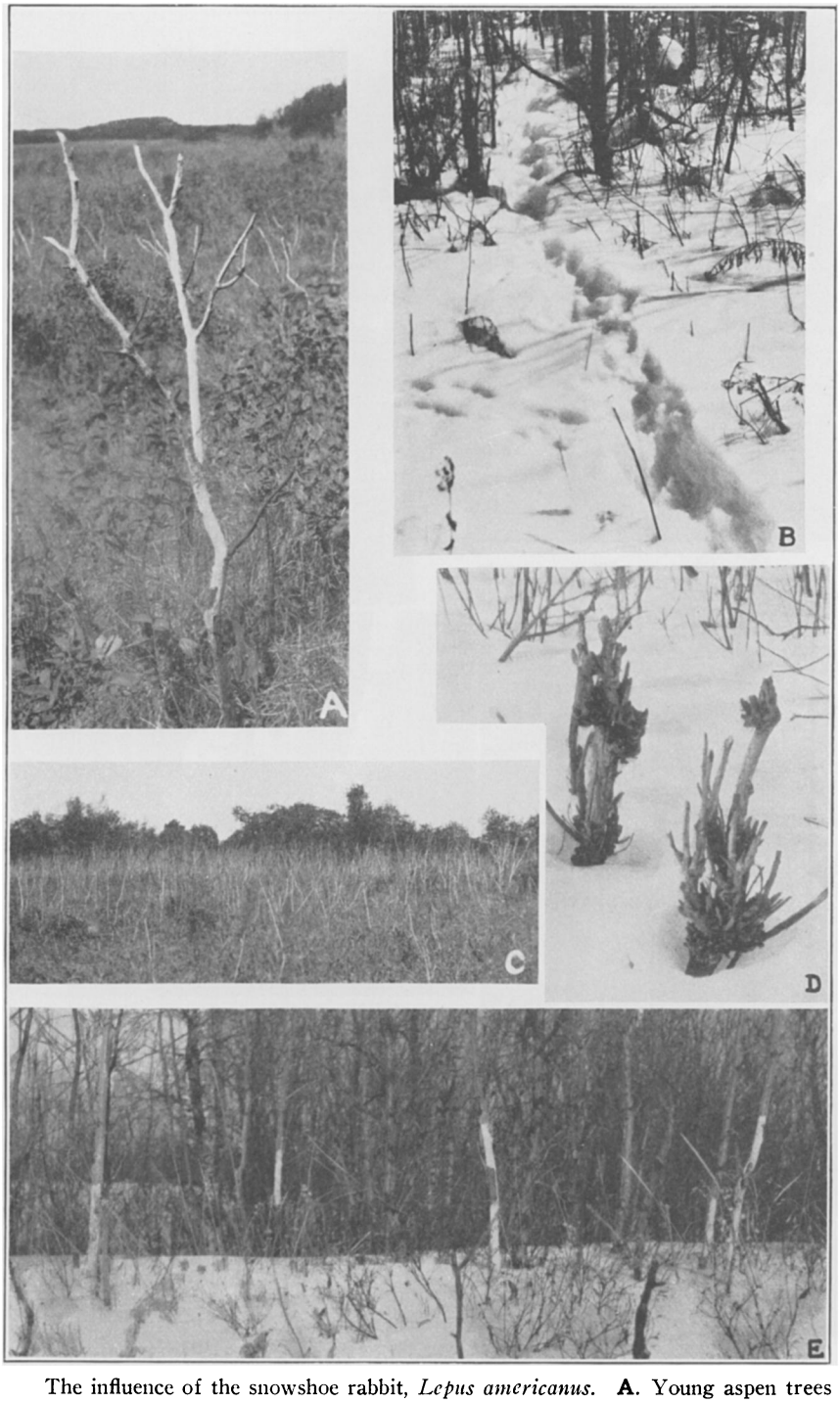
Aspens growing on the edge of large tracts of prairie, are buried in snow drifts during the winter (Pl. XV, *B*). They are broken and bent. The following years they send out upright shoots, only to be again bent over the following winter. In this way many stunted trees of fantastic shapes are produced which are weakened and subject to the attacks of wood-destroying fungi and insects.

d. Hail

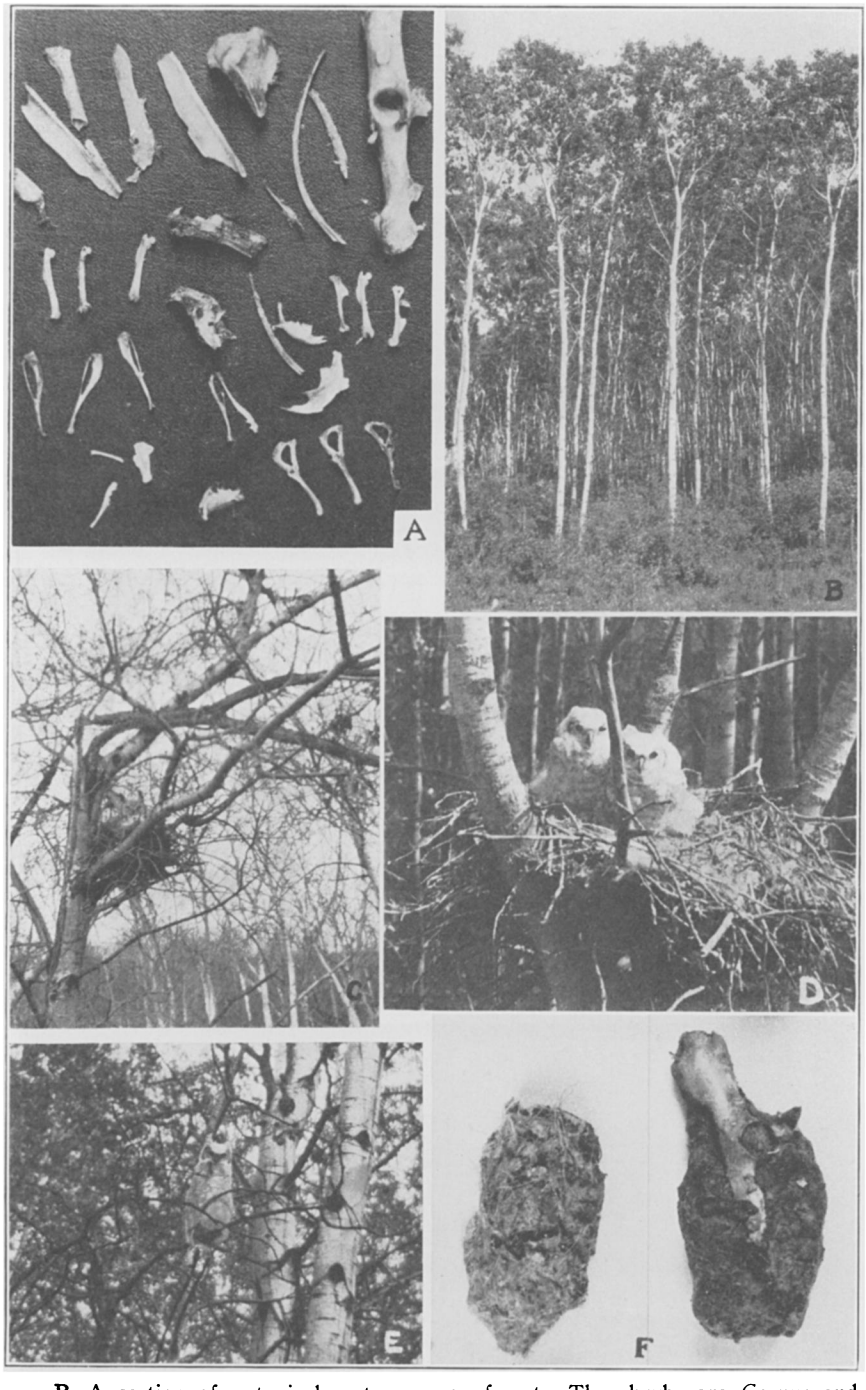
Periodic hail storms sweep across the country, stripping the leaves and small branches from the trees and so bruising the bark that young trees are stunted and entrance is afforded for fungi and insects.

VII. **Discussion**

1. In natural areas, the predominants for the greater part are vertebrate species. It is largely due to the interference of man and the consequent



The influence of the snowshoe rabbit, *Lepus americanus*. **A**. Young aspen trees completely stripped of bark. **B**. Runway made in one night after a snow fall. **C**. A patch of *Eleaegnus* stripped of its bark. **D**. Oaks which have been eaten back year after year and are of an age of about 20 years. **E**. Girdled and killed young aspens about the edge of a grove.



B. A section of a typical mature aspen forest. The shrubs are *Cornus* and *Corylus*.

The following illustrate scenes in the life of the great horned owl, a bird of major influence in the aspen forest: **A.** Contents of a pellet, showing rabbit and vole bones. **C.** Old bird on nest. **D.** Young birds about three weeks old. **E.** Young about five weeks old. **F.** Typical pellets.

upsetting of nature's balance by the destruction of the vertebrates that insects are able to occur as predominants.

2. Accompanying the destruction of certain of the larger mammals and birds during the early days of settlement, there was a corresponding increase in other species of vertebrates which were benefited by the enlargement of their habitat and reduction in the numbers of their enemies. Such species were: the white-tailed deer, which increased and advanced northward with the destruction of wolves and the partial replacement of the dense forest by cultivated fields; the coyote, which increased with the introduction of sheep and poultry and the destruction of its chief competitors, the wolves and foxes; Franklin's ground squirrel and the snowshoe rabbit, which increased with the cutting of the mature trees and the consequent enlargement of the forest edge and second growth timber; and the prairie chicken and the jack rabbit, which increased with the enlargement of cultivated fields.

3. The communities of the aspen parkland are biotic because:

a. Plant and animal communities tend to be coextensive. The animal life associated with a plant community is characteristic of it and distinct from that of other communities. It is true that there are some animals which are found in more than one community, but, if these are studied, it is found that they are chiefly carniverous species which breed in one community (their home) and merely wander into other communities in search of food during diurnal or nocturnal migrations. Also, some animals migrate into other communities for hibernation, such as the prairie insects which migrate into the forest edge.

b. The physiological requirements of some animals confine them to certain communities where the plants provide favorable conditions such as light, shade or humidity.

c. The plants of a community constitute food and shelter directly for the herbiverous animals, which are the most numerous, and indirectly for the less numerous carnivores.

d. The animals of a community influence the plants.

(1) Favorably through:

(*a*) The dispersal of seeds by fruit-eating birds which scatter them with their excreta and drop them while gathering them. Such species as the crow, robin and pine grosbeaks are the most influential in Manitoba.

(*b*) The dispersal of seeds in burs by mammals.

(*c*) The pollination of flowers by insects.

(*d*) The manuring of the soil by excreta and dead bodies, and the loosening and turning over of the soil by burrowing species.

(*e*) The aiding of succession by throwing up mounds of earth, *e.g.* badger and pocket gopher, which form the

starting place for patches of snowberry, the forerunner of the forest.

(*f*) Light trampling and grazing of large animals. This is not so noticable in Manitoba at present but Formosov ('28) finds it of great importance in Asia.

(2) Unfavorably through:

(*a*) The destruction of woody and leafy tissue by feeding, and secondarily forming entrance for the attack of parasitic fungi, *e.g. Saperda* in aspen.

(*b*) Denuding areas by overgrazing and trampling.

(*c*) Retarding succession by girdling and killing trees advancing on the prairie, *e.g.* snowshoe rabbits.

4. The invertebrate population of the aspen parkland is characterized by seasonal fluctuations and variations as follows:

It is largest in the surface debris and in the soil. Where the amount of surface debris is large, as in the forest and *Salix petiolaris* communities, it contains the greatest population found; but where the amount of debris is small, as in the prairie and *Salix longifolia* communities, the soil contains the greatest population. The population of these two strata thus controls the total population curve which, in the *S. petiolaris* and prairie stations, showed a spring maximum and a late June minimum. It then rose until August when it started to fall off on account of a drought. Doubtless it would have containued to rise to a fall maximum which would have been approximately equal to that of the spring if it had not been checked by the drought. In his studies of the invertebrate population of the prairie at Saskatoon, Saskatchewan, for a number of years King ('27) found this regularly to be the case in dry falls. In wet falls, on the other hand, there was a maximum higher than that of the spring.

The invertebrate population of the *Salix longifolia* community showed a variation from the above in having a maximum in June caused by a large number of very small Dipterous larvae which, however, were of little ecological importance. The curve representing this population would be as in the other communities if the population were plotted on the basis of weights instead of numbers.

The invertebrate population of the mature aspen forest showed a marked variation from the above in that there was a decided maximum in June with a minimum in spring and fall. Here again the lower fall population as compared to that of spring was doubtless due to the drought.

5. The structure of the communities of the aspen parkland is that of a fluctuating perennial nucleus of predominant animals, mostly vertebrates, present all the year, to which are added others in the form of birds which are present throughout the active period of the community (April to September). Seasonal socies are not formed by invertebrates, but by birds which pass

through in their spring and fall migrations, and birds which are resident only during the winter months.

Smith ('28), in studying the animal communities of a deciduous forest succession in Illinois, demonstrated " (1) that the community structure consisted of a perennial nucleus and various seasonal groups, (2) that the fluctuations in the total population were due to the annual changes in the numbers of the predominants and to striking increases in the constituents of the community through the addition of seasonal groups of species to the nucleus of predominants, and (3) that the period of duration of these seasonal groups as units divided the year into biotic seasons."

Shackleford ('29), who worked a year later than Smith, found that a similar community structure existed in the prairie of Illinois.

Both these workers based their conclusions on the present population which was found to be largely invertebrate, as the vertebrates had been greatly reduced in numbers by conditions accompanying intensive cultivation.

In Manitoba, where the total population, both plant and animal, of a more primitive area was studied, it was found that the true predominants were almost entirely vertebrates, and, judging from the accounts of such early traders as Alexander Henry in 1799–1814, the predominance of the vertebrates were even more pronounced in primitive conditions. In Illinois a similar condition doubtless existed before the coming of the settlers.

The community structure as found in Manitoba differed from that of Illinois as described by Smith and Shackleford in the predominance of vertebrates, and in the lack of well developed seasonal socies of invertebrates except for the estival-serotinal groupings. The fluctuations in the total population were due for the greater part to a fluctuation in the numbers of the individuals of the predominant vertebrates resident and active all year, which increased with the seasons of growth and successful reproduction and decreased with seasons of adverse conditions, and to other predominants (birds) which were present from spring to fall and which increased during this, the active, period of the community. To this nucleus were added poorly developed seasonal socies of birds. Those species which nest farther to the north passed through the communities in their biannual migrations, and lingering to feed, produced small spring and fall seasonal socies, particularly such species as the slate-colored junco and the tree sparrow. These transient species are largely seed eaters, and have but little effect upon the other animals of the community. Very few insectivorous birds pass through in such migrations. In the winter a still better developed socies is seen in the winter resident birds, evening and pine grosbeaks, red-polls and snow buntings, all of which are seed eaters and which help to scatter the seeds of the plants upon which they feed.

The seasonal socies of birds are doubtless present in Illinois and one would expect to find them better developed since a greater number of species are involved. Smith and Shackleford did not study them.

To this nucleus in Manitoba were added small numbers of seasonal invertebrates which, however, were not numerous enough and were not arranged in such definite groups as to form seasonal socies or societies other than a general estival-serotinal group. This was due to the northern latitude of Manitoba and to the shortness of the growing season. The total invertebrate population, however, was large and formed an important part of the community.

The total population is hence made up of three major components:

1. The vertebrate population which is active throughout the year, and which shows a fall maximum and spring minimum.
2. The population of summer resident birds which is nil in winter and increases rapidly from spring to fall.
3. The invertebrate population which, with the exception of that of the mature forest, shows spring and fall maxima and an early spring minimum.

Hence, if we should plot the three components as curves on one graph (Fig. 13), we would find that they all showed fall maxima and spring or early summer minima. The period of growth and increase of the animals is thus seen to coincide with that of the plants upon which they are either directly or indirectly dependent, and shows a true biotic relationship. The poorly developed seasonal socies plotted on the same graph change the total population curve but little.

6. Most carniverous, and, especially, omnivorous animals, are not confined to any particular food, but eat whatever is abundant at the time or whatever they happen to find.

The food of the crow (p. 378), the frog (p. 378), and the great horned owl (Bird '29), was studied, and it was found that these, the most influential of the carniverous and omniverous feeders of the aspen parkland, fed on whatever they happened to find, and on what was abundant at different seasons of the year. Thus the crow fed on vegetable food in the spring, and later on a local outbreak of Bertha armyworms, the frog on miscellaneous insects as none were particularly abundant when the studies were made, and the great horned owl on voles. Other food was merely incidental.

The numbers of the various groups of invertebrates taken on the different communities studied is summarized in Table V.

7. Succession in the aspen parkland is for the greater part hydrarc, from wet to dry conditions, and follows slightly different courses for sloughs, rivers and lakes. It usually passes through a willow stage and always terminates in an aspen association which may, or may not give way to one dominated by white spruce, *Picea canadensis*.

The climatic factors are favorable to a forest climax, but such factors as fire and snowshoe rabbits are tending to check the spread of the forest onto the prairie.

TABLE. V. *Comparison of the numbers of individuals of invertebrate animals taken in the different groups within the communities studied, on an area of 1.1 square meter.*

Animals	Prairie	*Salix petiolaris*	*Salix longifolia*	Aspen
Annelids	6	65	25	54
Molluscs	9	86	113	162
Chilopods	0	2	0	5
Diplopods	5	0	0	4
Mites	26	37	17	22
Spiders	21	128	56	233
Collembola	0	114	113	28
Orthoptera	10	0	0	0
Neuroptera	0	1	0	1
Ephemerida	0	0	1	2
Odonata	1	5	0	2
Plecoptera	0	0	2	1
Corrodentia	1	0	0	86
Thysanoptera	22	0	4	0
Hemiptera	108	18	16	16
Homoptera	93	111	156	103
Coleoptera	112	220	117	104
Trichoptera	0	3	0	3
Lepidoptera	28	28	16	40
Diptera	279	864	454	527
Hymenoptera	216	59	60	53
Totals	897	1,741	1,150	1,452

VIII. Summary

1. In natural areas, predominants are for the greater part vertebrates: mammals in the prairie and birds in the forest.

2. The invertebrate population is characterized as follows:

a. The population above the surface debris is small compared to that of the surface debris and soil. It shows a midsummer maximum and is very small in the spring and autumn.

b. The population of the surface debris is usually greater than that of the soil.

c. Both surface debris and soil strata have a maximum population in the spring and autumn, and show an early summer minimum, except in the mature forest where there is a maximum in early summer.

3. The population of the communities of the aspen parkland is made up of three major components:

a. The vertebrates (birds and mammals) which are present and active throughout the year.

b. The birds which winter to the south.

c. The invertebrates.

To this population is added small seasonal socies of birds which are present only in the winter or during the spring and fall migrations.

IX. Acknowledgments

The study outlined in the preceding pages has been carried out under the direction of Dr. V. E. Shelford to whom I am much indebted for advice and help in carrying it through to completion. His assistance included a visit to the area of study in the late summer of 1929. At that time he reviewed both my stations and the manuscript with me, and later directed the drafting of figures, 2, 3, 5, 6, 7, 8, 10, 11 and 13. Professor F. E. Clements was kind enough to read and criticise the manuscript.

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XI. Appendix

1. Lists of Invertebrates taken in Quantitative Collections

The following is a list with as complete identifications as possible of all the invertebrates taken in a series of quantitative collections with the cylinder of 1/40,000 acre or 1/100,000 hectare. The lists are arranged according to the latest classification of Comstock ('25), and the numbers of individuals (in Arabic numerals) taken in each week of collection of the year (in italics) are listed with the stratum in which they were collected (in Roman numerals) as follows: I. Tree-top Stratum. II. Tree-trunk Stratum. III. Shrub Stratum. IV. Herb Stratum. V. Surface Stratum. VI. Soil Stratum to depth of two inches. VII. Soil Stratum to depth of 3–4 inches. VIII. Soil Stratum to depth of 5–7 inches.

The abbreviation of "n" for nymph and "a" for adult is also used.

The collection of the twelfth week was before the snow melted and all animals were in hibernation.

a. Prairie Station

Annelida: Enchytraeidae, *18,* 3, VI, 3, VIII. **Mollusca**: *Succinia* sp. juvenile, *20,* 1, V; *22,* 1, V; *28,* 1, V, 2, IV. *Euchonulus* sp. juvenile, *22,* 2, V. *Cochliopa lubrica* Linn., *26,* 1, V; *28,* 1, V. **Diplopoda**: *Parajulus* sp. juvenile, *18,* 1, VII, 3, V; *34,* 1, VI. **Acarina** (Mites): Unidentified species: *12,* 5, V; *18,* 2, V; *20,* 3, V; *22,* 1, VI; *26,* 3, V; *30,* 1, VI, 8, V; *32,* 2, IV. **Araneida** (Spiders): *Aranea marmorea* Clerch, *24,* 1, IV; *Dictyna volupis* Keys, *28,* 1, IV; *Grammonota pictilis* Camb., *24,* 2, V; *26,* 1, IV; *Pardosa diffusa* Em., *28,* 1, IV; *Tetragnatha caudata* Em., *26,* 1, IV; *Xysticus trigattus* Keys, *26,* 1, IV. Unidentified species: *18,* 2, V; *22,* 1, V, 1, IV; *26,* 1, IV; *28,* 1, IV; *30,* 2, IV; *32,* 2, IV, 1, V; *34,* 1, V. **Orthoptera**: *Acrididae* n, *12,* 1, V. *Melanoplus dawsoni* (Scudder), *28,* 4n, IV; *32,* 3a, IV. *Melanoplus flavidus* Scudder, *30,* 1n, IV. *Orphuella pectorata, 32,* 1n, IV. **Odonata**: *Lestes congener* Hagen, *26,* 1, IV. **Corrodentia**: Psocidae, *32,* 1n, IV. **Thysanoptera**: Unidentified species, *12,* 8, V; *20,* 1, V; *26,* 13, IV. **Hemiptera**: *Chlamydatus suavis* Reut., *28,* 5, IV. *Homaenus aerreifrons* Say, *30,* 8, IV; *32,* 1, IV; *34,* 2, IV. *Laccocera vittipennis* Van Duz., *26,* 5, IV; *30,* 3n, IV. *Lobops hesperius* Uhl., *24,* 1, IV. Lygaeidae n sp., *30,* 1, IV. Nabidae spp. n, *24,* 1, IV; *28,* 5, IV; *30,* 11, IV. *Nabis* spp. a, *26,* 2, IV; *28,* 1, IV; *32,* 30, IV. Pentatomidae sp. n, *30,* 1, IV. *Phytocoris pallicornis* Reut., *34,* 1, IV. *Strongylocoris stygica* Say, *26,* 1a, 2n, IV; *28,* 2, IV; *30,* 2, IV; *34,* 3, V. Scuteleridae spp. n, *26,* 1, IV; *28,* 4, IV, 1, V; *32,* 2, IV. **Homoptera**: Aphidae spp., *28,* 4, IV; *30,* 1, IV; *32,* 1, IV. *Aphrophora 4-angularis* Say, *32,* 3, IV. Chermidae sp., *26,* 1, IV. Cerco-

pidae sp., *36,* 1, IV. *Philaronis bilineata* Say, *32,* 2, IV. *Scalops sulcipes* Say, *32,* 1, IV. (Cicadellidae), *Agallia sanguinolenta* (Prov.), *12,* 1a, V; *20,* 2a, V; *22,* 2n, 1a, IV; *26,* 3a, IV; *32,* 7n, 8a, IV. *Balilutha osborni* V. Duz., *26,* 3a, IV. Cicadellidae spp., *22,* 4n, IV, 2a, 2n, V; *24,* 1n, IV; *30,* 2n, IV; *32,* 2a, IV; *36,* 1n, V. *Chlorotettix unicolor* (Fitch), *32,* 1a, IV. *Deltocephalus auratus* G. & B., *28,* 3a, IV; *30,* 1a, IV. *Deltocephalus collinus* Dahlb., *28,* 1a, IV. *Deltocephalus configuratus* Uhler, *24,* 1n, V; *26,* 1n, V, 3a, IV; *28,* 9a, IV. *Deltocephalus debilis* Uhler, *28,* 2a, IV; *30,* 1a, IV. *Deltocephalus missilus* Ball, *28,* 2a, IV; *32,* 4a, IV. *Deltocephalus unicoloratus* G. & B., *32,* 1a, IV. *Dikraneura mali* (Prov.), *12,* 1a, V; *20,* 1a, V; *28,* 2a, IV; *32,* 2a, IV; *36,* 1a, IV. *Empoasca fobae* Harris, *28,* 1a, IV, 1a, V. *Erythraneura vulnerata* (Fitch), *36,* 1a, IV. *Euscelis extrusus* (V. Duz.), *24,* 1a, V; *26,* 2a, IV. *Neocoelidia tumidifrons* G. & B., *24,* 1a, V. *Oncometopia lateralis* (Fab.), *32,* 4n, 3a, IV. *Philonia bilineata* Say, *32,* 1a, IV. **Coleoptera** Adults: *Aegialia* sp. near *pusilla* Hom., *18,* 3, V. *Agonum seminitidus* Kby., *26,* 1, V. *Amata* sp., *30,* 1, VI. *Anisotoma punctatostriata* Kby., *18,* 1, VI. *Atheta* sp., *18,* 1, V; *26,* 1, V. *Celia subaenia* Lec., *30,* 1, VI. *Ceutorhyncus* spp., *12,* 1, V; *32,* 1, IV. Chrysomelidae sp., *30,* 1, V. *Corticaria* sp., *12,* 4, V; *20,* 2, V. *Disonycha xanthomelaena* (Dalm.), *12,* 1, V; *34,* 1, V. *Disonycha davisii, 22,* 1, V. *Dyschirius globulosus* Say, *18,* 1, V. *Eustilbus* sp., *30,* 1, IV, 1, V. *Eustilbus apicalis* Melsh, *20,* 1, V; *32,* 12, IV. *Exochomus septentrionis* Weis., *22,* 1, V. *Galerucella decora* (Say), *22,* 1, V. *Glyptina* sp.?, *36,* 1, IV. *Harpalus pleuriticus* Kby., *20,* 1, V. *Hippodamia parenthesis* (Say), *34,* 1, V. *Melanophthalma distinguenda* Com., *24,* 1, V. *Micromaseus femoralis* Kby., *24,* 1, V. *Micromaseus patruelus* (Dej.), *20,* 1, V. *Philonthus* spp., *18,* 1, V; *34,* 2, V. Staphylinidae sp., *12,* 1, V. *Stenolophus conjugatus* Say, *26,* 1, V. *Tachyporus jocosus* Say, *24,* 1, V; *26,* 1, V; *34,* 1, V. *Tychius lectus* Lec., *26,* 1, V. **Coleoptera** Larvae: *Aphodius* sp., *18,* 1, VI; *22,* 24, VI, 1, VII; *26,* 1, VI; *34,* 1, VI. Carabidae spp., *26,* 1, VI; *30,* 1, V. Chrysomelidae spp., *28,* 4, IV, 1, V; *30,* 1, V. *Ludius aeripennis* Kby., *18,* 2, VI, 1, VII. Elateridae spp., *22,* 2, VI; *26,* 1, VI. Spp., *22,* 10, VI, 3, VII, 2, VIII. Staphylinidae sp., *34,* 1, VI. **Lepidoptera:** *Crambus leachellus?, 30,* 1, IV. Geometridae spp. larvae, *28,* 1, IV; *32,* 3, IV; *34,* 1, IV. *Gnorimoschena* sp., *28,* 2, IV. Larvae spp., *18,* 1, VII; *28,* 1, IV; *30,* 2, IV, 1, V; *32,* 1, IV; *34,* 1, IV; *36,* 1, IV, 1, V. Microlepidoptera Adult, *28,* 1, IV; *32,* 6, IV. Noctuidae spp., larvae, *12,* 2, V; *34,* 1, IV. Pupae sp., *34,* 1, VI. Tortricidae spp. Larvae, *26,* 1, IV. **Diptera** Adults: *Aedes dorsalis* Meigen, *28,* 3, IV. *Camptocladius bissinus* Schrank, *36,* 2, IV. Cecidomyidae spp., *22,* 1, IV; *26,* 1, IV. Chironomidae spp., *24,* 1, IV; *32,* 1, IV; *36,* 1, IV. *Coenosia lata* Walk., *26,* 1, IV. *Coenosia* sp., *28,* 4, IV; *30,* 10, IV; *32,* 3, IV. Culicidae sp., *26,* 1, IV. *Dinera cinerea* Tns., *34,* 1, IV. *Diophorus* sp., *32,* 3, IV. *Dolichopus canadensis* V. Duz., *28,* 3, IV. *Dolichopus bifractus* Lw., *30,* 1, IV. *Hylemyia elicrura* Rond., *22,* 1, IV; *28,* 2, IV; *30,* 5, IV. *Doli-*

chopodidae sp., *32,* 1, IV. *Melanoechelia surda* Zett., *26,* 1, IV; *28,* 4, IV; *30,* 2, IV. *Oscinella coxendix* Fitch., *34,* 1, IV. *Pogonomyia* sp., *26,* 3, IV. *Sphaeraphoria robusta* Metc. (M.S.), *22,* 1, IV. Spp., *20,* 3, V; *26,* 6, IV; 1, V; *28,* 31, IV; *30,* 18, IV; *32,* 9, IV. **Diptera** Immature. Bibionidae Larvae, *18,* 2, VI. Cecidomyidae Larvae, *28,* 1, VI. Chironomidae Larvae, *12,* 3, V; *18,* 7, V. Dolichopodidae Larvae, *18,* 1, VI; *20,* 2, V. Leptidae Larvae, *18,* 1, VI, 2, VII. Mycetophalidae Larvae, *12,* 12, V; *18,* 8, V, 35, VI, 12, VII, 6, VIII; *20,* 1, V; *22,* 1, V; *26,* 1, VI. Muscidae Larvae. *18,* 1, VI; *20,* 1, V; *34,* 2, VI. Spp. Larvae, *18,* 5, VI, 7, VII, 6, VIII; *20,* 4, V; *22,* 1, V, 2, VI; *26,* 2, VI; *28,* 1, V; *30,* 1, VI. Tipulidae Larvae, *22,* 1, V, 2, VI; *28,* 1, V. Syrphidae Larvae, *12,* 2, V. Pupae (cycloraphous), *20,* 5, V; *22,* 3, VI; *26,* 1, VI; *28,* 1, VI. Pupae (orthoraphous), *22,* 2, V, 1, VI; *26,* 1, VI. **Hymenoptera**: *Lasius brevicornis* Emery, *24,* 1, V; *34,* 171, VI. *Lasius latipes* Walsh, *30,* 3, VI. *Leptothorax* sp., *30,* 2, VI. *Formica fusca* Linn. Var., *30,* 1, VI. *Myrmica scabrinoides* Nylander, *12,* 5, V, 10, VI, 6, VII; *20,* 1, VII, 2, VIII; *22,* 4, V; *24,* 1, V; *30,* 2, V; *32,* 1, VII. Chalcidae sp., *20,* 1, IV. Ichneumonidae sp., *32,* 1, V. Tenthredinidae pupae, *20,* 1, VI. Nematinae larva, *22,* 1, V. Cynipidae sp., *26,* 1, IV. Proctrotrypidae sp., *34,* 1, IV.

b. *Salix Petiolaris* Station

Annelida: Enchytraeidae, *12,* 12, V; *21,* 15, V; *23,* 3, VI, 5, V; *25,* 30 V. **Chilopoda**: *Lenotsenia chionophila* Wood, *12,* 2, V. **Acarina** (Mites): Unidentified species, *12,* 15, V; *19,* 7, V, 2, VI; *21,* 6, V; *23,* 3, V, 1, VI; *25,* 5, V; *27,* 1, V; *31,* 1, IV; *33,* 1, IV; *35,* 1, V. **Araneida** (Spiders): *Aranea trivittata* Keys, *25,* 1, IV; *Clubiona furcata* Em., *12,* 1, V; *Diplocephalus elongatus, 35,* 1, V; *Epeira displicata, 27,* 1, III; *Erigone atra* Blacknall, *25,* 1, IV; *Gongylidium arenarium* Em., *21,* 1, III; *Lophocarenum minutum* Em., *12,* 1, V; *Pirata insularis* Em., *25,* 3, V; *29,* 3, V; *Tetragnatha cordata* Em., *27,* 4, IV; *Tmeticus conicus* Em., *25,* 1, IV; *Tmeticus debilis* Banks, *12,* 2, V. Unidentified species, *12,* 29, V; *19,* 1, III, 2, V; *21,* 4, V; *23,* 1, III, 2, V; *25,* 3, V; *27,* 1, IV, 1, V; *29,* 2, V; *31,* 4, IV, 3, V; *33,* 3, III, 14, IV, 3, V; *35,* 5, III, 26, IV, 7, V. **Mollusca**: *Cochliopa lubrica* L., *12,* 2, V; *19,* 1, V; *21,* 7, V; *23,* 2, V; *25,* 4, V. *Vertigo* sp. juvenile, *12,* 4, V; *19,* 1, V; *23,* 2, V; *25,* 4, IV; *27,* 1, V; *31,* 1, V; *35,* 1, V. *Vertigo ovata* Say, *25,* 2, IV. *Gonyodiscus* sp., *12,* 2, V. *Pyramidula cronkhitei anthonyii* Pill, *19,* 1, V; *25,* 4, V. *Polita* sp. juvenile, *21,* 5, V; *23,* 1, V; *33,* 1, V. *Polita hammonis* St., *25,* 2, V; *35,* 1, V. *Planorbis crista* L., *29,* 1, V. *Spherium* sp., *29,* 1, V. *Lymnea* sp. juvenile, *31,* 1, IV, 3, V; *35,* 4, V. Spp. very young, *23,* 23, V; *25,* 1, V. Eggs, *25,* 2, V; *27,* 2, V. **Collembola**: *Entomobrya* sp., *25,* 1, IV. *Isotoma olivacea* Tullberg, *21,* 1, V. *Isotoma palustris prasina* Reuter, *21,* 1, V. *Isotoma violacea caerulenta* Guthrie, *12,* 8, V. *Isotoma viridis riparia* Nicolet, *19,* 1, V. *Lepidocyrtus*

cyaneus Tullberg, *12,* 1, V. *Lepidocyrtus* sp., *12,* 4, V; *21,* 2, V; *25,* 1, IV. *Sminthurus spinatus* Macg., *25,* 16, IV; *27,* 31, IV; *29,* 12, IV; *31,* 6, IV; *33,* 10, IV; *35,* 9, IV. *Tomocerus flavescens americanus* Schott, *12,* 5, V; *21,* 5, V. **Neuroptera**: *Chrysopa* sp., *23,* 1, III. **Odonata**: *Coenagrion angulatum* Walk., *27,* 1, III. *Lestes congener* Hagen, *33,* 1, IV. *Nehallenia irene* Hagen, *27,* 1, IV; *29,* 1, IV. *Coenagrion resolutum* Hagen, *23,* 1, III. **Hemiptera**: *Anthocoris antevolens* Wht., *31,* 1, III; *33,* 1, IV. *Antholytus translucens* Tuck., *33,* 1, III. *Gerris buenoi* Kirk., *12,* 1, V. *Lygus elisus* V. Duz., *19,* 1, III. *Lygus pratensis* Linn., *12,* 1, V. *Orthotylus dorsalis* Prov., *31,* 1, III. *Orthotylus marginatus* Uhl., *29,* 1, III. Spp. n, *27,* 2, V; *29,* 3, III, 2, IV; *31,* 2, IV; *35,* 1, IV. **Homoptera**: Aphidae spp., *23,* 1, III; *29,* 2, III; *31,* 12, III; *33,* 6, IV; *35,* 2, IV. *Aphropora 4-angularis* Say, *33,* 1, IV. Chermidae spp., *21,* 2, III; *25,* 1, III; *29,* 2, IV; *35,* 1, III, 1, IV. *Balclutha punctatus* (Thumb.), *33,* 4a, IV. Cicadellidae spp., *12,* 4n, V; *19,* 3n, V; *21,* 5n, V; *25,* 1a, IV; *27,* 1n, III; *29,* 4n, III, 6n, IV; *31,* 1n, IV; *33,* 1n, III, 1n, V; *35,* 1n, V. *Deltocephalus configuratus* Uhl., *27,* 1n, IV. *Draeculacephala noveborasensis* (Fitch), *31,* 1a, IV. *Draeculacephala mollipes* (Say), *29,* 1n, III; *31,* 1a, IV; *35,* 1a, IV. *Empoasca fobae* Harris, *35,* 2a, IV. *Empoasca ameragdula* Fall, *35,* 1a, III, 1a, IV. *Erythroneura zigzac* Walsh, *21,* 1a, III, 1a, IV. *Helochara communis* Fn., *33,* 14a, IV. *Idiocerus alternatus* Fn., *23,* 2a, III; *33,* 1a, III. *Idiocerus pallidus* Fab., *27,* 3n, III; *29,* 1a, III; *31,* 5a, III; *33,* 1a, III; *35,* 1a, IV. *Macropsis ferruginoides* (V. Duz.), *27,* 1a, III. *Oncometopia lateralis* Fab., *12,* 1a, V. **Coleoptera** Adults: *Acylophorus pronus* Er., *29,* 1, V. *Anisostricta bitriangularis* Say, *12,* 1, V; *35,* 1, IV. *Apion pennsylvanicus* Boh., *12,* 2, V; *27,* 4, IV. *Apion* sp., *33,* 1, IV. *Atheta* sp., *12,* 3, V. *Argrilus politus* Say, *27,* 1, III. *Bembidion cautum* Lec., *35,* 1, V. *Berosus striatus* (Say), *31,* 1, VI. *Ceutorhyncus* sp., *12,* 1, V. Chrysomelidae spp., *29,* 2, IV; *31,* 1, III, 1, V. *Chalcoides helxines* Linn., *12,* 1, V; *23,* 2, III; *25,* 1, IV, 1, V; *27,* 4, III; *29,* 1, III. *Cyphon variabilis* (Thumb.), *12,* 2, V; *19,* 1, III, 1, V; *21,* 1, III, 1, V; *23,* 1, III; *27,* 4, III; *29,* 2, IV; *31,* 2, III; *33,* 1, III, 2, IV. *Cercyon lugubris* Payk., *31,* 1, VI; *35,* 1, V. *Cymbiodyta* sp., *25,* 1, V. *Deinopsis* sp.?, *29,* 1, V. *Dorytomus brevicollis* Lec., *12,* 1, V. *Europhilus lenis* Dej., *21,* 1, V. *Eustilbus apicolis* Melsh.?, *25,* 1, IV. *Eustilbus* sp., *33,* 1, III. *Galerucella decora* (Say), *19,* 1, VI; *21,* 4, III; *23,* 5, III, 1, VI; *25,* 2, III; *27,* 7, III; *31,* 1, IV; *33,* 2, III, 1, IV, 2, V; *35,* 3, III, 2, V. *Galerucella decora* Immature, *29,* 4, III, 2, IV; *31,* 2, III, 3, IV, 1, VI; *33,* 1, III. *Lathrobium* spp., *12,* 2, V. *Lepyrus geminatus* Say, *23,* 1, III; *27,* 1, III. *Mecopeltis fuliginosus* Dietz, *12,* 4, V. *Melanophthalma distinguenda* Com., *23,* 1, VI. *Myceloporus flavicollis* Lec., *12,* 2, V. *Olophrum marginatum* Kby., *21,* 2, V. *Olibrus* spp., *12,* 5, V. *Philonthus* spp., *12,* 2, V; *19,* 1, V; *27,* 1, V; *32,* 2, V; *35* 2, V. *Platynus obscurus* Hbst., *12,* 1, V. *Paracymus divestus* Lec., *12,* 1, V. *Paederus littorarius* Grav., *19,* 2, V. *Rhyncophora* sp., *23,* 1, V.

Seymorus sp., *12*, 2. V. Staphylinidae spp., *12*, 1, V; *21*, 4, V; *23*, 3, V, 1, VI; *25*, 2, V; *29*, 1, V. *Stenus* spp., *12*, 10, V. Spp., *19*, 1, V; *21*, 3, V; *23*, 2, V; *25*, 1, IV, 3, V; *27*, 2, IV; *31*, 2, V; *35*, 1, V. *Tachyporus jocosus* Say, *12*, 2, V. *Trichopteryx* spp., *12*, 4, V. **Coleoptera** Larvae: Carabidae spp., *33*, 3, V. *Dytiscidae* spp., *19*, 1, V; *21*, 2, V; *25*, 1, V; *27*, 1, V. Coccinellidae sp., *35*, 1, IV. Staphylinidae spp., *35*, 3, V. Spp., *19*, 1, V; *21*, 3, V; *25*, 2, V; *29*, 2, V, 2, VI. **Trichoptera**: *31*, 1, III, 2, IV. **Lepidoptera**: Geometridae Larvae spp., *12*, 1, V; *21*, 3, III; *23*, 2, III; *33*, 5, III, 1, IV. Larvae spp., *19*, 1, V; *21*, 1, V; *23*, 3, III, 2, V; *25*, 1, III; *33*, 1, III; *35*, 1, III. Pupae spp., *21*, 2, V. *Rhynchargrotis placida* Larva, *12*, 1, V. **Diptera** Adults: *Aedes dorsalis* Meigen, *27*, 1, IV. *Aedes vexans* Meigen, *27*, 1, IV. *Bicellanis angustifurca* Mel., *27*, 2, III; *29*, 9, III, 7, IV; *31*, 2, III. *Borborus equinus* Fall., *31*, 1, III, 16, IV. *Camptocladius bissinus* Schrank, *21*, 17, III. Cecidomyidae (minute) spp., *23*, 18, III; *25*, 3, IV. Chironomidae spp., *21*, 2, III; *23*, 19, III; *25*, 3, IV; *27*, 1, III; *31*, 2, III, 9, IV; *33*, 3, IV; *35*, 2, III, 7, IV. *Chironomous dux* Joh., *25*, 1, III. *Chironomous* sp. near *stageri*, *21*, 3, III. *Chironomous tentans* F., *23*, 1, III. *Chironomous* sp., *23*, 2, III. *Caenia* sp.?, *27*, 1, IV; *35*, 1, IV. *Calythea* sp., *31*, 2, IV. *Chaetosa punctipes* Mgn., *25*, 1, IV. *Chlorops* sp., *35*, 1, IV. *Chrysotus hirtipes* V. Duz., *27*, 8, IV. *Chroborus crystallina* Dej., *21*, 4, III. *Coenosia lata* Walker, *25*, 1, IV; *33*, 4, III; *35*, 2, IV. *Coenosia* sp., *33*, 3, III; *35*, 2, IV. Culicidae spp., *23*, 1, III; *33*, 1, IV. *Diophorus opacus* Lw., *31*, 2, IV. *Diophorus* sp., *29*, 9, IV. *Dichaeta brevicauda* Lw., *33*, 2, IV. *Dolichopus canadensis* V. Duz., *27*, 1, III, 2, IV; *29*, 2, IV. *Dolichopus gladius* V. Duz., *29*, 1, III; *33*, 1, III. *Dolichopus fulvipes* Lw., *31*, 4, IV. *Dolichopus lobatus* Lw., *31*, 4, IV. *Dolichopus obcordatus* Ald., *27*, 1, III, 2, IV. *Dolichopus renidescens* M. & Br., *29*, 1, IV. *Dolichopus uxoscula* V. Duz., *23*, 1, III; *25*, 1, IV. *Dyctia obtusa* Fallen, *33*, 3, IV; *35*, 2, IV. *Dyctia* sp. near *obtusa*, *25*, 1, IV; *35*, 2, IV. *Dyctia nana* Fallen, *33*, 11, IV; *35*, 2, IV. *Elachiptera* n. sp. near *planicollis*, *35*, 6, IV. *Empis* sp., *27*, 2, III. *Ephydra* sp., *25*, 1, IV. *Eulimnophora* sp., *31*, 1, III. *Eusimulium mutatum* Mall., *27*, 1, III. *Eutreta* sp., *33*, 1, III. *Fannis generalis* Stn., *33*, 1, III. *Helina* sp., *31*, 1, IV. *Homoneura bispina* Lw., *35*, 1, IV. *Haplogaster mollicula* Fallen, *31*, 2, III, 2, IV; *33*, 1, III. *Hydrellia* sp., *33* 20, IV. *Hydrotaea meteorica* L., *27*, 7, III. *Orthellia caesarion* Mg., *33*, 1, III. *Orthocladius minutus* Zett., *21*, 3, III. *Oscinella coxendix* Fitch., *12*, 1, V; *21*, 7, III; *29*, 8, IV; *31*, 9, III, 36, IV; *33*, 70, IV; *35*, 1, III, 16, IV. *Parasyntormon* sp., *35*, 3, IV. *Pelina truncatula* Lw., 25, 3, IV. *Platypalus cellarius* Mel., *25*, 1, IV; *27*, 10, III, 4, IV. *Platypalus* n. sp. near *postpositus*, *25*, 1, III; *29*, 8, III, 1, IV. *Platypalus xanthopodus* Mel., *25*, 1, IV; *27*, 10, III, 4, IV; *35*, 5, IV. *Procladius* sp., *21*, 3, III. *Sapromyza hyalinata* Mg., *27*, 4, III. *Scatophaga suilla* F., *21*, 1, III. *Scatophaga* sp., *31*, 1, IV. *Schoenomyza chrysosoma* Lw., *27*, 1, III, 1, IV. *Schoenomyza dorsalis* Lw., *27*, 1, IV. *Sepsis violacea* Mg., *25*, 1, IV; *33*,

3, III. *Hylemyia depressa* Sta., *27,* 5, III; *29,* 2, III, 1, IV; *33,* 2, III, 1, IV. *Hylemyia elicrura* Rond., *29,* 1, III, 5, IV. *Hylemyia pluvialis* Mall., *33,* 1, III. *Hedroneura rufa* Panzer, *33,* 2, IV. *Leptocera atra* Adams, *27,* 1, IV. *Leptocera lutosa* Stenk, *33,* 2, IV; *35,* 16, IV. *Leptocera fontinalis* Fallen, *12,* 1, V; *33,* 3, IV. *Lispa uliginosa* Fallen, *31,* 1, IV. *Lispocephala albifrons* Zett., *29,* 7, III, 6, IV. *Melanostoma melinum* L., *33,* 1, IV. *Melanoechalia melinum* L., *27,* 1, IV. *Melanoechalia surda* Zett., *27,* 1, III; *29,* 1, III. *Melanoechalia* sp., *25,* 1, III; *31,* 1, III. *Notiphila* sp., *25,* 1, IV. *Odontomyia vertebrata* Say, *29,* 1, III. *Sciara* sp. ※1, *21,* 6, III. *Sciara* sp. ※6, *21,* 5, III. *Symphoromyia montana* Ald., *27,* 1, III, 1, IV. Spp. (small), *27,* 3, III; *29,* 3, IV; *31,* 10, III, 14, IV; *33,* 14, III, 16, IV, 1, V; *35,* 1, III. Spp. (minute), *27,* 20, III, 21, IV; *31,* 6, III, 6, IV. *Themira minor* Halid., *35,* 1, IV. *Thrypticus* sp., *29,* 3, III. *Tipula ultima* Alex., *35,* 2, III. Tipulidae spp., *33,* 4, IV; *35,* 1, IV. **Diptera** Immature: Cecidomyidae spp. Larvae, *12,* 18, V; *19,* 2, V, 8, VI. Chironomidae spp. Larvae, *23,* 11, V. Dolichopodidae spp. Larvae, *19,* 1, VI, 2, VII; *21,* 1, V; *31,* 1, VI. Mycetophalidae spp. Larvae, *19,* 17, V, 7, VI, 6, VII; *21,* 4, V; *35,* 1, V. Spp. Larvae, *12,* 2, V; *19,* 2, V, 6, VI, 1, VII; *21,* 9, V; *23,* 2, V, 2, VI; *27,* 4, V, 1, VI; *29,* 1, V; *33,* 1, V; *35,* 3, V, 1, VI. Spp. Larvae (minute), *25,* 18, V. Syrphidae Larvae, *12,* 2, V; *31,* 1, V; *33,* 1, V; *35,* 1, V. Tipulidae Larvae, *12,* 1, V; *19,* 2, V, 2, VII; *23,* 1, V, 1, VI; *31,* 13, V. Pupae (cycloraphous), *12,* 2, V; *23,* 1, VI; *25,* 2, V; *31,* 2, V; *35,* 1, V. Pupae (orthoraphous), *21,* 9, V; *35,* 1, V. **Hymenoptera**: Sawflies: Tenthredinidae larva, *12,* 1, V. *Pontania pomum* Walsh, *21,* 1, III. *Amaouronematus* sp. larva, *21,* 1, III; *23,* 4, III. Nematinae larvae, *29,* 1, III; *33,* 3, IV; *35,* 1, IV. Emphytinae larvae, *35,* 1, III, 5, IV. Ichneumonidae, *12,* 1, V; *21,* 1, V; *23,* 4, III; *25,* 1, V; *27,* 1, V; *29,* 1, IV; *31,* 2, III, 3, IV; *33,* 7, IV; *35,* 1, IV. Chalcidae, *23,* 1, III; *25,* 1, IV; *27,* 2, III; *29,* 4, III; *31,* 1, III, 2, IV; *33,* 1, III. Proctotrypidae, *35,* 2, IV. Ants: *Formica fusca subaenescens* Emery, *33,* 2, V. *Lasius unbratus mixtus* var. *aphidicola* Walsh, *19,* 1, V; *21,* 4, V.

c. *Salix Longifolia* Station

Annelida: Enchytraeidae, *25,* 7, V, 4, VI; *27,* 1, V. Lumbricidae, *25,* 4, V, 4, VI; *29,* 2, VI; *33,* 1, VI. **Mollusca**: Eggs spp., *29,* 3, VI; *31,* 1, V. *Lymnea* sp. juvenile, *23,* 3, V; *25,* 2, V; *29,* 15, IV, 3, V. *Polita* sp. juvenile, *25,* 2, V. *Succinea* sp., *12,* 1, V; *19,* 3, V; *23,* 2, V; *25,* 4, IV, 4, V; *29,* 14, IV, 3, V; *31,* 16, IV, 2, V; *33,* 3, IV; *35,* 1, IV, 2, V. *Succinia rostrata, 27,* 14, IV, 8, V. *Vallonia* sp., *12,* 1, V. *Vertigo* sp., *25,* 1, V. Very young, *19,* 2, V. *Zonitoides* sp., *29,* 2, V; *33,* 1, V. **Acarina** (Mites): Unidentified species, *12,* 3, V; *21,* 1, V; *23,* 2, V; *25,* 1, V; *27,* 1, III; *29,* 1, V; *31,* 4, III; *33,* 2, V; *35,* 1, III, 1, IV. **Araneida** (Spiders): *Aranea displicata* Hertz., *23,* 1, III; *Ceratinella emertoni, 25,* 2, V; *Lophoca-*

renum decemoculatum Em., *25,* 2, III; *Pachygnatha brevis, 12,* 1, V; *Pedanostethus riparius* Htz., *12,* 3, V; *Tetragnatha laboriosa* Htz., *25,* 3, IV. Unidentified species, *12,* 3, V, 2, IV; *19,* 1, III, 2, V; *21,* 5, III; *25,* 3, IV, 2. V; *27,* 2, IV; *29,* 1, III, 1, IV; *31,* 1, IV; *33,* 4, IV; 2, V; *35,* 2, III, 15, IV. **Collembola:** *Sminthurus spinatus* MacG., *27,* 62, IV; *29,* 10, IV; *31,* 8, IV; *33,* 31, V. **Ephemerida,** *19,* 1, III. **Plecoptera,** *23,* 1, III; *27,* 1, III. **Thysanoptera:** *Lispothrips birdi* Moul., *19,* 3, III. Unidentified species, *23,* 1, III; *27,* 4, III. **Hemiptera:** *Anthocoris antevolens* Wht., *27,* 1, III; *29,* 1a, 3n, III. *Lygus rubicunda* Fall., *31,* 3, III. *Scolopastethus thomsoni* Reut., *12,* 3, V. Spp., *23,* 1n, III; *25,* 1n, III; *27,* 1n, III; *29,* 1n, III; *31,* 2a, III, 3a, IV. **Homoptera:** Aphidae spp., *23,* 1, III; *27,* 2, IV; *29,* 1, V, 4, IV; *35,* 1, IV. Chermidae spp., *21,* 2, III; *27,* 1, III; *29,* 2, III. *Philaronia bilineata* Say, *33,* 2a, III. *Balclutha impicta* (V. Duz.), *35,* 3a, III. Cicadellidae sp., *23,* 1a, III; *27,* 1a, IV; *29,* 4n, 1a, III; *31,* 6n, III, 2n, IV; *33,* 1n, 2a, III, 1n IV; *35,* 1n, III, 11n, 2a, IV. *Draeculacephala mollipes* (Say), *25,* 1n, III, 12n, IV, 1n, V; *27,* 27n, IV; *Draeculacephala noveboracensis* (Fitch), *31,* 1a, V; *33,* 1a, IV. *Empoasca* sp., *29,* 5a, III; *31,* 3n, 13a, III; *33,* 6a, III; *35,* 1a, III. *Euscelis striolus* (Fallen), *29,* 2a, IV. *Helochara communis* Fitch, *27,* 4n, IV, 1n, III; *29,* 4n, IV. *Idiocerus alternatus* Fitch., *21,* 2a, III; *25,* 1a, III; *31,* 1a, III; *33,* 2a, III; *35,* 1n, 3a, III. *Idiocerus pallidus* Fitch., *29,* 1n, 4a, III. *Idiocerus snowi* G. & B., *33,* 3n, 1a, III. *Macropsis basalis* (V. Duz.), *27,* 1a, III. *Macropsis ferruginoides* (V. Duz.), *27,* 1a, III. *Macropsis viridis* (Fitch), *27,* 1on, 1a, III. **Coleoptera** Adults: *Atomaria ephippiata* Linn., *33,* 1, IV. *Atheta* sp., *12,* 1, V. *Bembidion acutifrons* Lec.?, *12,* 1, V. *Bembidion cautum* Lec., *12,* 1, V; *23,* 1, V; *33,* 3, V; *35,* 1, V. *Bembidion* sp. near *vile* Lec., *12,* 1, V. *Bembidion petruele* Dej., *12,* 1, V; *23,* 1, V; *25,* 1, VI. *Bembidion* sp., *12,* 1, V; *23,* 1, V. *Cantheris excavatus* Lec., *25,* 4, III. *Chalcoides helxenes* Linn., *21,* 12, VI; *23,* 13, III; *25,* 5, III; *27,* 2, III; *29,* 3, III. *Corticaris* spp., *27,* 2, III; *35,* 1, IV. *Cyphon variabilis* (Thumb.), *23,* 2, III; *27,* 2, III. *Ceutorhyncus* sp., *35,* 1, IV. *Dolopius lateralis* Esch., *27,* 1, III. *Galerucella tuberculata* Say, *23,* 2, III; *29,* 1, III larvae; *31,* 3, III larvae; *33,* 2, III. *Galerucella decora* (Say), *27,* 1, III. *Lathrobium* sp., *12,* 6, V. *Omaseus caudicalis* (Say), *25,* 1, V. *Orchastes ephippiatus* Say, *25,* 1, V. *Mycetoporus flavicollis* Lec., *35,* 1, V. *Paracynus digestus* Lec., *35,* 1, V. *Platynus anchomenoides* (Rond.), *25,* 3, V. *Philontheos* spp., *12,* 1, V; *23,* 2, V. Spp., *23,* 2, III; *29,* 1, III, 2, VI. *Stenus* spp., *12,* 5, V; *19,* 1, V; *25,* 1, V. *Stalicus biammatus* Lec., *12,* 3, V. *Tachyporus jocosus* Say, *12,* 3, V. Larvae: Elateridae, *21,* 1, VI. Scrabidae, *25,* 1. VI. Sp., *31,* 1, III. Staphylinidae, *31,* 1, V; *33,* 2, VI. **Lepidoptera:** Larvae Spp., *12,* 1, V; *21,* 5, III; *25,* 1, III; *27,* 3, III; *33,* 1, III; *35,* 1, IV. Geometridae larvae, *19,* 1, V; *21,* 1, III. Microlepidoptera Adult, *25,* 1, III; *29,* 1, III. **Diptera** Adults: *Aphiochaeta* sp., *12,* 2, V. *Becellania* sp. near *pilosa, 27,* 2, III. Cecidomyidae spp., *25,* 1, V; *35,* 1, IV.

Camplocladius bissinus Schrank, *25,* 2, III. *Chaerosa punctipes* Mg., *27,* 1, III. *Chrysopila cameroni* Curran, *29,* 2, IV. *Chrysopila* sp., *27,* 1, III. *Chrysotus hirtipes* V. Duz., *31,* 1, III. *Chironomous dux* Joh., *21,* 1, III. Chironomidae sp., *23,* 6, III; *35,* 1, IV. *Coenosia* sp., *25,* 5, III. *Coenosia lata* Walker, *33,* 2, IV; *35,* 3, III, 1, V. *Crictopus* n. sp.?, *21,* 1, III. *Culicoides multipunctatus* Mall., *21,* 1, III. Culicidae spp., *27,* 9, III; *31,* 1, IV. *Diaphonus opacus* Lw., *31,* 1, III. Dolichopodidae sp., *29,* 1, V. *Dolichopus canadensis* V. Duz., *27,* 1, III. *Dolichopus fulvipes* Lw., *25,* 1, IV; *31,* 1, IV. *Dolichopus lobatus* Lw., *25,* 1, IV. *Dyctia obtusa* Fallen, *25,* 1, IV. *Dyctia* n. sp., *31,* 1, III. *Dyctia trabeculata* Lw., *31,* 2, IV. *Elachiptera decipiens* Lw., *19,* 1, V; *35,* 1, IV. *Hylemyia coenosiaeformis* Stn., *25,* 1, IV. *Hylemyia depressa* Stn., *25,* 1, III; *27,* 6, III; *33,* 1, III. *Hylemyia elicrura* Rond., *25,* 2, IV; *27,* 3, III. *Hoplogaster mollicula* Fallen, *31,* 1, III. *Fannia leucostricta* Hg., *31,* 1, III. *Lucilia sylvarum* Mg., *27,* 2, III. *Leptocera lutosa* Stn., *33,* 1, IV. *Melanoechelia brevicornis* Mall.?, *23,* 1, III; *25,* 1, III. *Minettia lupulina* Fallen, *29,* 2, IV. *Orthocladius minutus* Zett., *21,* 1, III. *Orthocladius* sp., *21,* 1, III. *Lyptocera quadrisetosa* Mall., *12,* 1, V. *Parasryntormon* sp., *33,* 1, III, 2, IV. *Palina truncatula* Lw., *33,* 1, IV. *Platypalus* n. sp. near *postpositus, 27,* 11, III. *Rahampium effilatum* Walker, *23,* 1, III; *33,* 1, III. *Renocera cyathiformis* Mell., *25,* 3, IV. *Rhamphomyia* n. sp. ✻2, *21,* 1, III. *Rhamphomyia* n. sp. ✻3, *25,* 1, IV. *Schoenomyza dorsalis* Lw., *25,* 1, IV. *Scaptomyza terminalis* Lw., *21,* 1, III. Spp. (minute), *21,* 1, III; *27,* 10, III; *31,* 30, III, 12, IV. Spp., *27,* 9, III, 60. IV; *29,* 15, III, 11, IV; *31,* 4, IV; *33,* 12, III, 4, IV; *35,* 1, IV. *Sepsis violacea* Mg., *35,* 1, IV. *Tephritis albiceps* Lw., *27,* 1, III. *Tetanocera rotundicornis* Lw., *25,* 3, IV. Tipulidae, *25,* 1, III; *27,* 1, III; *29,* 1, IV. **Diptera** Immature. Dolichopodidae Larvae, *21,* 4, VI; 1, VII; *23,* 2, V. Mycetophalidae Larvae, *23,* 3, V; *25,* 2, V, 2, VI; *35,* 1, V. Spp. Larvae, *12,* 2, V; *21,* 1, V, 5, VI, 6, VII; *23,* 1, V; *25,* 2, V, 6, VI; *27,* 2, V; *29,* 2, VI; *33,* 1, VI. Spp. Larvae (minute white), *25,* 50, VI. Spp. Larvae and Pupae (minute white), *29,* 40, VI. Tipulidae Larvae, *21,* 2, V, 1, VI, 1, VII; *23,* 1, V. Tipulidae Pupae, *21,* 3, VI; *23,* 1, V; *31,* 1, V; *33,* 1, VI. Pupae (cycloraphous), *25,* 5, VI. Pupae (orthoraphous), *23,* 3, V. Pupae (orthoraphous, minute red), *25,* 20, VI. **Hymenoptera**: Tenthredinid larvae, *25,* 2, IV. *Pteronidea menidca* Walsh, Adults, *21,* 2, III. *Amauronematus* sp. larvae, *21,* 2, III; *23,* 1, III. Nematinae larvae, *25,* 1, IV; *27,* 8, III, 3, IV; *35,* 1, III. Chalcidae spp., *21,* 2, III; *23,* 5, III; *25,* 2, III; *27,* 3, III; *29,* 11, III, 1, IV; *31,* 6, III. Ichneumonidae spp., *23,* 1, III; *25,* 1, III; *27,* 1, III, 1, IV; *31,* 5, IV.

d. **Mature Poplar Station**

Mollusca: *Succinea ovalis* Say, *12,* 3, V; *22,* 1, V; *30,* 2, V. *Succinea* sp. juvenile, *12,* 6, VI; *34,* 1, V, 1, IV. *Vertigo* sp. juvenile, *20,* 1, V; *24,* 6, V; *28,* 1, V, 24, IV; *30,* 7, IV; *32,* 3, IV; *34,* 4, IV; *36,* 2, IV. *Polita*

sp. juvenile, *20,* 2, V; *26,* 1, V; *28,* 1, V; *32,* 3, V; *34,* 1, V; *36,* 5, V; *Polita hammonis* St., *22,* 1, V; *24,* 3, V. *Cochliopa lubrica* L., *22,* 1, V; *24,* 2, V; *26,* 1, V; *28,* 1, V; *30,* 2, V; *34,* 1, V; *36,* 1, V. *Pyramidula cronkhitei anthonyii* Pill, *22,* 1, V; *26,* 2, V; *28,* 2, V; *30,* 1, V. *Euchonulus* sp. juvenile, *24,* 1, V; *26,* 1, V; *28,* 18, IV; *30,* 1, V; *32,* 4, V; *34,* 2, V. *Euchonulus chersinus polygyratus* Pill., *28,* 3, V. *Vallonia costata* Müller, *24,* 1, V. Spp. very young, *22,* 3, V; *30,* 5, V; *34,* 2, V, 1, IV. Eggs, *24,* 14, V. **Nematoda,** *32,* 1, VI. **Annelida:** Enchytraeidae, *12,* 2, V; *20,* 5, V, 15, VI, 2, VII; *22,* 1, V; *24,* 1, VI, 5, V; *26,* 16, V; *28,* 4, V, 3, VI; *30,* 1, V; *32,* 2, VI. **Chilopoda:** *Linotaenia chionophila* Wood., *24,* 1, V; *26,* 2, V; *32,* 1, VI; *36,* I, V. **Diplopoda:** *Cleidogona coesioannulata* (Wood), *20,* 2, V. **Acarina** (Mites): Unidentified species, *12,* 1, V; *20,* 4, V; *24,* 1, V; *28,* 3, III; *30,* 1, V; *32,* 5, III, 3, IV, 1, V; *36,* 1, IV, 1, V. **Araenida** (Spiders): *Amaurobius borealis* Em., *22,* 2, V; *30,* 1, V; *36,* 1, V; *Aranea angulata* Clerch., *32,* 1, I; *Aranea displicata* Hertz., *24,* 1, III; *Aranea marmorea* Clerch., *34,* 2, III; *Ceratinella fissiceps* Camb., *30,* 1, IV; *36,* 1, IV; *Ceratinella lactabilis* Camb., *20,* 1, V; *Dendryphantes aestivalis* Peckham, *24,* 1, IV; *Dictyna frondea* Em., *24,* 1, III; *26,* 1, III; *Epeira displicata, 28,* 1, IV; *Epeira patigiata, 21,* 1, IV; *Hahnia cinerea* Em., *24,* 1, V; *30,* 1, V; *Helophara insignis, 34,* 1, IV; *Linyphia phyrgiana* Koch., *21,* 1, IV; *22,* 1, III; *34,* 1, III; *Lophocarenum decemoculatum* Em., *21,* 1, IV; *22,* 4, III; *Lophocarenum minutum, 22,* 1, V; *Neon nelli* Peckham, *24,* 1, V; *Pardosa diffusa* Em., *20,* 1, V; *Pedanostethus riparius* Htz., *26,* 1, IV; *Philodromus vulgaris, 21,* 1, II; *Tetragnatha laboriosa* Htz., *22,* 1, IV; *Theridion aurantium, 20,* 1, V; *Theridion frondeum, 21,* 1, IV; *28,* 1, IV. Unidentified species, *12,* 4, V; *20,* 2, III, 14, V; *22,* 12, III, 12, IV, 9, V; *24,* 3, III, 4, IV, 7, V; *26,* 2, III, 3, IV, 7, V; *28,* 10, III, 9, IV, 2, V; *30,* 1, I, 5, III, 5, IV, 7, V; *32,* 1, I, 12, III, 7, IV, 10, V; *34,* 2, III, 9, IV, 4, V; *36,* 1, I, 14, III, 11, IV, 3, V. **Pseudoscorpionida:** *34,* 1, V. **Thysanoptera,** *12,* 2, V; 20, 1, V. **Collembola:** *Isotoma* sp., *22,* 1, V. *Isotoma viridis riparis* Nicolet, *12,* 3, V; *22,* 5, V. *Isotoma olivacea* Tullberg, *20,* 7, V. *Tomocerus flavescens americanus* Schott, *20* 5, V; *22,* 2, V. *Plenothrux testudineatus* Folson, *28,* 5, IV. **Neuroptera:** *Chrysopa* sp., *28,* 1, I. **Ephemerida:** *22,* 1, III; *32,* 1, IV. **Corrodentia:** Psocidae, *24,* 1, V; *28,* 1, V; *30,* 1, V; *32,* 1, I, 27, III; *34,* 6, I, 15, III, 14, IV; *36,* 20, III. **Odonata:** *Lestes congener* Hagen, *30,* 1, III; *32,* 1, IV. **Plecoptera,** *26,* 1, III. **Hemiptera:** *Clestoptera obtusa* Say, *32,* 5, III; *36,* 4, III, 1, IV. *Lygus pratensis* Linn., *24,* 1, IV. Spp. nymphs, *28,* 1, IV; *30,* 1, III, 1, IV; *34,* 1, I; *36,* 1, III. **Homoptera:** Aphidae spp., *22,* 2, III; *30,* 3, III, 1, IV; *32,* 1, III; *36,* 2, III, 1, IV. *Agallia novella* (Say), *22,* 5a, V, 1n, IV; *24,* 1a, III; *26,* 1a, V, 2n, V. *Balclutha punctatus* (Thumb.), *28,* 2a, III; *32,* 1a, III. Cicadellidae spp., *22,* 2a, III, 2a, IV; *24,* 2a, IV; *26,* 1n, IV; *28,* 1a, III, 3n, IV; *30,* 1a, III, 2a, IV, 1n IV; *34,* 1a, I, 4a, IV. *Cicadula variata* Fall., *28,* 1a, IV. *Empoasca fobae* Harris, *22,* 3a, IV; *24,* 2a, IV; *34,* 2a, III, 4a, IV, 5n, IV. *Empoasca* spp..

28, 1a, I; *30,* 1a, I. *Empoa* sp., *30,* 1a, III; *32,* 4a, III, 2n, III; *34,* 4a, III; *36,* 4a, III. *Erythroneura comes* (Say), *32,* 1a, III; *36,* 4a, III, 4a, IV. *Erythroneura vulnerata* (Fitch), *22,* 10a, III; *24,* 2a, III, 1n, III; *30,* 1a, III; *34,* 1a, IV; *36,* 3a, III. *Idiocerus alternatus* Fitch, *34,* 1a, I. *Gypona octolineata* (Say), *34,* 1n, IV. *Thamnotettix aburatus* V. Duz., *32,* 1a, III. *Thamnotettix belli* Uhl., *22,* 1a, III. **Coleoptera** Adults: *Anthonomus rubidus* Lec., *22,* 1, IV. *Atheta* sp., *12,* 1, V. *Bemidion versicolor* Lec., *34,* 1, V. *Blethisa multipunctata* (L.), *28,* 1, VI. *Bothriopterus luczoti* Dej., *26,* 1, V; *36,* 2, VI. *Cantharis extensicornis, 26,* 1, III. *Chalcoides helxenes* Linn., *26,* 1, IV. *Ceutorhyncus* sp., *28,* 1, III. *Cyphon variabilis* (Thumb.), *12,* 2, V; *20,* 1, I; *22,* 1, III; *24,* 3, IV; *36,* 4, III. *Corticaria* spp., *22,* 1, V; *24,* 2, V; *26,* 2, III, 5, IV, 1, V; *28,* 1, III; *30,* 5, III. *Europhilus sordens* Kby., *22,* 1, V; *26,* 2, V. *Gonioctena pallida, 36,* 1, V. *Hyperaspis signata* Oliv., *24,* 1, IV. *Lathrobium* sp., *24,* 3, V; *26,* 1, V. *Mycetophagus splendidus, 24,* 4, V; *34,* 1, V. *Philonthus* sp., *20,* 3, V; *26,* 2, V. *Platynus gemellus* Lec., *20,* 1, V. Staphylinidae spp., *22,* 5, V; *24,* 2, V; *26,* 1, V; *30,* 1, V; *36,* 1, V. Spp., *20,* 2, V; *28,* 1, V; *30,* 2, V. *Tachyporus jocosus* Say, *20,* 3, V. *Tachinus pallines* Grav., *32,* 1, VI. **Coleoptera** Larvae: Carabidae, *12,* 1, V; *20,* 1, V; *24,* 1, V, 1, VI; *26,* 1, V; *28,* 1, V. Elateridae spp., *22,* 1, V; *24,* 1, V, 1, VI; *26,* 4, V; *28,* 1, V; *30,* 2, V; *34,* 1, V; *36,* 1, V. *Ludius aeripennis* Kby., *20,* 1, VII. Staphylinidae spp., *12,* 1, V; *28,* 1, V. Spp., *20,* 1, V; *24,* 1, V; *26,* 1, V. **Trichoptera:** *28,* 2, I, 1, III. **Lepidoptera:** Larvae spp., *22,* 1, IV; *24,* 1, III, 3, IV; *28,* 1, III; *32,* 4, IV; *34,* 2, III, 4, IV. Geometridae Larvae Spp., *20,* 1, V, 1, I; *22,* 1, I; *28,* 1, IV; *32,* 2, III, 1, IV; *34,* 1, IV. Geometridae Adult Sp., *28,* 1, I. Eggs, *28,* 6, V; *30,* 3, V; *32,* 4, V. *Hematocampa limbata* Adult, *32,* 1, III. Microlepidoptera spp. Adult, *26,* 1, III; *28,* 1, I; *34,* 1, I. Tortricidae spp. Larvae, *32,* 2, III, 1, IV; *36,* 1, V. **Diptera** Adults: *Aedes excrusians* Walker, *24,* 5, III; *26,* 1, III, 1, IV. *Aedes fitchii* F. & Y., *24,* 11, IV; *26,* 2, IV, 1, V. *Aedes flavescens* Müller, *24,* 8, IV. *Aedes impiger* Walker, *24,* 2, III. *Aedes riparius* D. & K., *25,* 3, III; *28,* 4, III; *30,* 1, II. *Aedes vexans* Meigen, *26,* 1, I; *28,* 5, IV; *30,* 1, IV; *32,* 2, III. *Anthalia* sp., *34,* 1, I; *36,* 1, III. *Beris annulifera* Bigot, *26,* 1, III. Cecidomyidae spp. (small), *22,* 7, IV, 4, V; *24,* 4, IV. *Cecidomyidae* spp. (minute), *22,* 4, III; *26,* 15, I, 45, III, 35, IV, 4, V; *30,* 1, V; *32,* 1, III, 1, V; *34,* 1, III, 1, IV. *Camptocladius bissinus* Schrank, *20,* 6, I, 4, III. *Chironomous* sp. near *similis, 24,* 2, III. *Chironomous dux* Joh., *30,* 2, I. Chironomidae spp., *22,* 19, III, 12, IV; *24,* 6, IV; *26,* 1, IV; *32,* 3, III; *36,* 1, III, 1, IV. *Chloropisca glabra* Mg., *28,* 1, I. *Coenosia* sp., *32,* 2, III; *34,* 1, IV. Culicidae sp., *36,* 1, III. *Dolichopus canadensis* V. Duz., *24,* 1, III. *Dolichopus uxoscula* V. Duz., *24,* 1, III. *Gymnopternus* sp., *28,* 1, IV. *Hoplogaster mollicula* Fallen, *30,* 3, IV. *Homoneura deceptor* Mall.?, *28,* 2, I. *Homoneura pernotata* Mall., *32,* 6, I, 3, III, 1, IV; *34,* 1, I, 1, III, 2, IV. *Hylemyia*

elucrura Rond., *24,* 1, III. *Fannia spathiophora* Mall., *26,* 1, III. *Metrioenemus exagitans* Joh., *20,* 1, I. *Minettia americana* Mall., *24,* 1, III; *26,* 1, I. *Mycetophila* sp., *30,* 1, IV. Mycetophalidae spp., *34,* 3, IV; *36,* 3, III. *Mycomyia* n. sp., *34,* 3, III. *Lonchaea ursina* Mall., *24,* 1, III. *Oscinella anthracina* Mg., *30,* 3, IV. *Pegomyia vanduzeii* Mall., *36,* 1, IV. *Phaonia apicata* Joh., *26,* 1, I. *Platypalus* n. sp. near *tenius, 28,* 1, I. *Pseudopsila perpolata* Joh., *36,* 1, III. *Psila dimidiata* Lw., *30,* 1, III. *Rhamphomyia* n. sp. ✻2, *26,* 1, III. *Sapromyza hyalinata* Mg., *22,* 1, IV; *26,* 3, I, 2, III, 1, IV; *28,* 1, I. *Sciara* sp., *30,* 1, II. *Sciara* sp. ✻1, *22,* 12, III. *Sciara* sp. ✻3, *24,* 1, III. *Sciara* sp. ✻5, *24,* 1, III. *Sapromyza* n. sp., *26,* 2, IV. *Suillia assimilis* Loeni, *36,* 1, III. Spp., *22,* 4, V; *24,* 8, I, 2, III, 8, IV; *26,* 2, I, 8, III, 5, IV; *30,* 1, V; *34,* 1, IV. Spp. (minute), *28,* 8, I, 32, III, *27,* IV, 1, VI; *30,* 9, I, 4, III, 3, IV; *32,* 8, I, 1, IV; *34,* 8, III. Tipulidae spp., *24,* 1, IV; *28,* 1, IV. *Tipula* sp., *24,* 1, IV. **Diptera** Immature: Dolichopodidae spp. Larvae, *20,* 1, VI; *24,* 1, V; *26,* 1, V; *36,* 2, V. Muscidae Larvae, *32,* 1, VI. Mycetophalidae Larvae, *32,* 1, VI; *34,* 1, V; *36,* 1, VII. Larvae spp., *12,* 5, V; *20,* 9, V, 1, VIII; *22,* 3, V; *26,* 2, V; *28,* 7, V; *30,* 2, V; *32,* 1, V; *36,* 4, VI. Tipulidae Larvae, *24,* 1, V; *26,* 1, V. Larvae spp. (minute), *24,* 8, V, 2, VI. Pupae (cycloraphous), *20,* 2, V; *24,* 4, V, 5, VI; *28,* 4, V, 1, VI. Pupae (orthoraphous), *24,* 4, V; *26,* 1, V. **Hymenoptera:** Tenthredinidae larva, *24,* 1, III; *32,* 5, III. Nematinae larva, *26,* 1, IV. Emphytinae larva, *28,* 2, IV, 1, V; *30,* 1, IV, 1, III; *34,* 1, III. Ichneumonidae: Pupae, *12,* 1, V; *22,* 1, V; *24,* 1, V. Adults spp., *24,* 1, III, 1, IV, 1, V; *26,* 2, III, 2, IV, 1, V; *28,* 6, III, 1, IV; *30,* 3, III, 3, IV; *32,* 2, III, 2, IV; *34,* 1, IV; *36,* 1, I, 3, III. Chalcidae: Adults spp., *30,* 1, IV; *36,* 1, III. Proctotrypidae: Adult sp., *34,* 1, IV. Ants: *Myrmica scabrinoides* Nylander, *28,* 2, V; *32,* 2, V. *Camponotus herculeanus whymperi* Forel, *34,* 1, III. *Myrmica brevinodis subcinodiodis* Emery, *36,* 1, IV, 1, V.

2. Calender of Bird Migration at Birtle, Manitoba, 1928

The dates recorded are those at which the birds were first seen. Those marked with an asterisk go farther north to breed, the others commonly nest in the aspen parkland. The list is in no way complete as to the land birds, and contains but few aquatic species. It contains most of those commonly seen and of the greatest ecological significance.

Marsh Hawk	March 22	Meadowlark	March 31
Crow	" 22	Killdeer	April 2
Mallard	" 23	Bronzed Grackle	" 5
Barrow Golden-eye	" 24	Rusty Blackbird	" 6
Tree Sparrow*	" 24	American Roughleg Hawk	" 6
Red-tailed Hawk	" 26	Song Sparrow	" 6
Junco*	" 30	Redwinged Blackbird	" 9
Robin	" 30	Sparrow Hawk	" 12

American Merganser	April	16
Herring Gull	"	17
Brewer Blackbird	"	19
Fox Sparrow	"	20
Pintail Duck	"	24
Green-winged Teal	"	24
Sharp-shinned Hawk	"	27
Belted Kingfisher	"	27
Mourning Dove	"	27
Wilson Snipe	"	28
Tree Swallow	"	28
Vesper Sparrow	"	28
Flicker	"	28
Franklin Gull	"	28
Coot	"	28
Greater Scaup	"	28
Widgeon	"	28
Cowbird	"	28
Double-crested Cormorant	April	29
Swainson Hawk	"	30
Bittern	May	4
Sapsucker	"	5
Horned Grebe	"	5
Blue-winged Teal	"	5
Phoebe	"	6
White-throated Sparrow	"	6
Golden Plover *	"	7
Clay-colored Sparrow	May	7
Rose-breasted Grosbeak	"	8
Myrtle Warbler *	"	8
Hermit Thrush	"	8
Yellow-headed Blackbird	"	9
Logger-headed Shrike	"	9
Barn Swallow	"	9
House Wren	"	10
Thrasher	"	11
Yellow Warbler	"	12
Willow Thrush	"	12
Towhee	"	12
Least Flycatcher	"	14
Red-eyed Vireo	"	14
Harris Sparrow	"	15
Baltimore Oriole	"	17
Goldfinch	"	19
Black Tern	"	24
Catbird	"	24
Ruby-throated Hummingbird	"	24
Kingbird (probably earlier)	"	25
Nighthawk	"	27
Warbling Vireo	"	28
Black-billed Cuckoo	June	2
Cedar Waxwing	"	9