

## A HISTORY OF MAMMALOLOGY IN CANADA TO 1990

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Until at least 1900, mammalogy was not considered a scientific discipline in its own right. Much information on mammals had been collected over the centuries by people who had explored and lived in Canada, but this information was scattered and sometimes incorrect. Aboriginal people of Canada knew infinitely more about Canadian wildlife, including mammals, than did Europeans, but they had no written record of their knowledge. The history of mammalogy in Canada begins with four hundred years of sporadic observations supplanted in this century first by extensive data collection on the distribution of species (often made by specially-commissioned collecting expeditions) and then by extensive research projects on all aspects of mammals. This research blossomed with the founding in 1919 of the quarterly *Journal of Mammalogy* as will be discussed later.

Mammals played a decisive role in the exploration and settlement of Canada by Europeans in the sixteenth, seventeenth, and eighteenth centuries. Native Peoples had always used mammal hides and furs for a variety of necessities from shelters, bedding and clothing to hand towels of rabbit pelts. The early explorers to eastern Canada, disappointed at not finding precious metals or jewels in the New World, also recognized the value of the native fur-bearers such as beaver (*Castor canadensis*) for the manufacture of men's stylish high hats ("beavers"), and the pelts of mink (*Mustela vison*), marten (*Martes americana*), fisher (*Martes pennanti*), ermine (*Mustela erminea*), fox (*Vulpes vulpes*), and lynx (*Lynx canadensis* - now [*L. lynx*?]) for popular fur collars and cloaks. Many of these species were representatives of holarctic species, or had closely-related species in Europe which were seriously over-exploited at that time. The larger game species were also valuable as a source of meat.

From the first landfall of John Cabot in 1497 and for the next 400 years thereafter, virtually all European visitors or settlers who wrote of their experiences in what is now Canada mentioned native mammals, not because they were especially interested in this part of the fauna but because mammals were an obvious aspect of this vast unknown land. Some of the earliest observations about mammals in Canada came from the Jesuits, who worked in this country between 1611 and 1789 in an effort to convert and help the native peoples. They sent home each year long reports of their experiences which are now published as *The Jesuit Relations and Allied Documents*, and they also kept brief records of day to day events, now collected as the *Journal des Jesuites*. Father Paul Le Jeune, for example, described three mammals which were new to him because they did not exist in France (Kenton, 1965: 69). What is undoubtedly the woodchuck (*Marmota monax*) he called the whistler or nightingale because of its shrill alarm call. It was correctly believed to hibernate all winter like the dormouse. The skunk (*Mephitis mephitis*) was described accurately, but was regarded by Le Jeune as a symbol of sin because of the vile smell it could emit. The third novelty was the flying squirrel (*Glaucomys* sp.); "Not that they have wings, but they have a certain piece of skin on both sides, which they fold up very neatly against their stomachs when they walk, and spread out when they fly."

Because Aboriginals were vitally involved in the fur trade, the Jesuits became interested in fur-bearers too. Indeed, their descriptions were often slanted more toward economics than towards zoology. Thus Father Le Clercq wrote about 1680, "The Beaver is of the bigness of a water-spaniel. Its fur is chestnut, black, and rarely white, but always very soft and suitable for the making of hats" (in Innis, 1956: 3). The Jesuits reached as far west as the prairie provinces during their tenure in Canada, where

ather Claude Jean Allouez commented in 1666 on a terrible brown bear (*Ursus horribilis*, now *U. arctos*) described by native peoples living near the Assiniboine River (Banfield, 1974: 308).

The first academically-oriented naturalist in what was to become Canada was Michel Sarrazin (1659-1734) who was born in France but emigrated as a doctor to New France in 1685 (Rousseau, 1969). Sarrazin became so interested in the natural history of the New World that when he returned to France in 1694 for three years to further his medical training, he spent much of his time learning botany at the Jardin Royale des Plantes, a science of particular interest to doctors of that period because most of their medicines were derived from plants. When Sarrazin returned to New France he arranged to send back plant collections and observations on plants and animals to the Academie Royale des Sciences de Paris which had been founded in 1666 and reorganized by Louis XIV in 1699. At that time biology was mostly confined to three fields: the anatomical and systematic study of plants and animals; the rudiments of plant and animal physiology; and ethnobiology, involving observations of the use of plants and animals by "primitive" peoples. Because Sarrazin was a doctor, he was able to dissect a number of Canadian mammals using his surgical instruments. He sent articles to the academy describing intricate dissections of beaver, wolverine, muskrat, seal, woodchuck, and porcupine which were published and favorably received, although some have since been lost. Sarrazin was not a great biologist, but he was a conscientious and meticulous researcher, certainly as competent as many academicians of his time. He is important in Canadian history because at the time he was working he was virtually the only European in Canada with a knowledge of or an interest in natural history.

Other early Europeans to write about Canadian mammals were either explorers and/or fur traders. Twenty-five years after Father Allouez wrote about grizzlies, Henry Kelsey of the Hudson's Bay Company actually watched them feeding on the prairies near herds of bison (*Bison bison*). This was over a century before the grizzly bear was described by Lewis and Clark on their expedition to the Pacific via the Missouri River (Seton, 1929). During the brief period that the French occupied York Factory on Hudson Bay, the fur trader Nicolas Jeremie (1720) described the muskox (*Ovibos moschatus*) and its habitat on the southern shore of Hudson Bay. His account, translated into English, found its way into many early English texts on the New World. Observations of other travellers on such topics as the behavior of the vast herds of bison are invaluable, because never again will such information be available (Roe, 1970: 225, 283ff).

About 1770 the Royal Society in London asked the Hudson's Bay Company to obtain for it natural history specimens from the trapping grounds of Canada, possibly at the prompting of Thomas Pennant, author at that time of *British Zoology*, and Andrew Graham, a long-time employee of the Hudson's Bay Company (Williams, 1978). The factors responded with varying degrees of enthusiasm to this request. Among the keenest were Graham himself and Thomas Hutchins who in 1772 sent to England from York Factory the skin of an inland deer, some reindeer heads, a half-grown beaver preserved in a small cask of brandy, and the skins of muskrat, rabbit, hares, and mice, as well as 72 bird skins, together with explanatory notes on these specimens plus descriptions of many other mammals. During their lifetime these men and other traders continued to supply information on the wildlife in Canada to zoologists in Europe. Specimens were received by the Royal Society and the Zoological Society of London and later deposited in the British Museum of Natural History (Banfield, 1961).

Some data gleaned from fur trading records were not helpful. For example, the German taxonomist Schreber described in 1778 the type locality of the American badger (*Taxidea taxus*) as "Labrador and Hudson Bay," places where this grassland species has not been found. Schreber had never been to North America, nor seen badgers in their natural habitat, so he did not realize his mistake. Presumably the badger pelt which became the type specimen had been collected on the prairies by Plains Indians and traded to Swampy Crees or Chipewyans who transported it down the Nelson or Churchill Rivers to a post on

Hudson Bay. There it was labelled before being shipped to Europe (Smith, 1981).

Comments by fur traders about some species were also misleading. For example James Isham, the Chief Factor at Churchill in 1741, wrote at length about the habits of the beaver, describing the slave beaver which did much of the work, and the interior of the beaver lodge which was divided into three rooms, one for food, one for excrement, and one for sleeping quarters. Samuel Hearne (1795) disagreed with his remarks about the beaver house, claiming that the inside was only constructed by beaver to leave a dry place to lie on.

About 1800 explorers in Canada were investigating the Rocky Mountains and the Yukon and Northwest Territories where they discovered more new mammals. Samuel Hearne (1795) was the first European to see and describe the northern range of the wood bison (*Bison bison athabascae*) on the shores of Great Slave Lake during his incredible overland journey from Fort Prince of Wales on Hudson Bay to the mouth of the Coppermine River. David Thompson of the Northwest Company also provided valuable notes on the species he met on his exploratory trips across the prairies and Rocky Mountains from 1800 to 1807. Notably he sent back to Britain the first collection of hides of the Rocky Mountain goat (*Oreamos americanus*) which Alexander Mackenzie had described in 1789 as "white buffalo" (Tyrrell, 1916). His companion Duncan McGillivray's account of the big-horn sheep (*Ovis canadensis*) led to its scientific description (Thorington, 1947).

In general, the comments on mammals provided in early journals and reports are important chiefly because they enable mammalogists to map the historical ranges of the mammals which were useful either for meat or for furs. Small or secretive species were rarely observed and seldom mentioned. Even though the number of voyageurs and traders increased in Canada as the fur trade expanded to the north-west, the information they collected on mammals did not increase to anything like the same extent. These men tended to travel over the same routes, and because they carried their food with them they did not stop long to hunt or observe wild animals.

The earliest summary of knowledge on Canadian mammals was published by Thomas Pennant in 1784, in his *Arctic Zoology*, Vol. 1. Pennant based his work on the early reports of explorers and missionaries to the New World, but unfortunately he was an uncritical editor and included much unverified folklore as well, such as a fanciful account of "sea apes." He disregarded the new binomial system of nomenclature of Linnaeus, using instead English vernacular names which greatly reduced the value of his work for future zoologists. About the same period J. R. Forster (1772) applied binomial nomenclature to several northern species, notably the masked shrew (*Sorex personatus*, now *S. cinereus*), and as a result although the scope of his work was much smaller he left a greater impression on Canadian mammalogy than did Pennant.

The fur-trade was the backbone of Canadian commerce for over three centuries. Its most important contribution to mammalogy was not the superficial descriptions written down by Europeans working for the fur companies, but the records of these companies themselves, especially the Hudson's Bay Company. These data provided valuable information on the cyclic abundance of northern mammals. Duncan MacLulich (1937) pioneered field studies on cycles in the snowshoe hare (*Lepus americanus*), while a compilation of Hudson's Bay Company records on the lynx enabled Charles Elton and Mary Nicholson in 1942 to trace out the years of abundance in this species for a period of over 200 years. These cycles were to stimulate great interest in northern mammals following World War II; William Rowan (1950, 1954) of the University of Alberta analyzed the various theories of cycling while Leonard Butler (1953) of the University of Toronto extended cycling studies to include many other species. Rowan's studies in population cycles have been continued by his student Lloyd B. Keith (1962) and more recently by Keith's students and colleagues.

Serious study into Canadian mammals began in the 19th century. One of the earliest naturalists was Charles Fothergill (1782-1840) who in 1816 came to Canada specifically to study zoology - not just the obvious economic animals, but obscure species too (Black, 1934). His notes include a description of vast numbers of black squirrels (*Sciurus carolinensis*) which then inhabited the extensive hardwood forests of southern Upper Canada (now Ontario). In the same period (ca 1830) William Gapper studied mammals in the Toronto region. At this time despite the early importance of mammals in Canada as a source of food and clothing, relatively little was known about them compared to other animals. When P. H. Gosse published *The Canadian Naturalist* in 1840, he mentioned briefly only about 15 different mammals, while he discussed 63 species of moths and butterflies. In the first four volumes of the *Transactions* of the newly-founded Ottawa Field-Naturalists' Club (1879-1883) there is much information about geology, plants, insects, birds, and shells but almost nothing about mammals --only a mention by John Macoun that buffalo and deer had "...eaten the district [of the prairies] bare" (Smith, 1981, 9).

When the Ottawa Field-Naturalist Club organized four working parties in 1881 to study the environment, there was little interest in mammals and no effort to do research on them; rather, the groups concentrated on geology, botany, entomology and ornithology, and oology (anon, 1975). Mammals, because of their agility and secretive habits, were obviously much more difficult to study than other aspects of natural history. Even today few amateurs are interested in the mammals of Canada beyond those encountered in the works of G. D. Roberts, Grey Owl and Ernest Thompson Seton, whereas many thousands are enthralled by her birds.

Some nineteenth century scientists chose not to work in the settled areas of Upper and Lower Canada (Ontario and Quebec respectively) but to accompany expeditions of exploration westward, often those of military men or survey crews which were government-sponsored. Thus Dr. John Richardson (1787-1865), who served as a doctor on the first John ., Franklin expedition of 1819-1822, was also charged with collecting zoological and botanical specimens. Richardson had studied medicine at the University of Edinburgh, then served as doctor on various ships and at various scenes of combat until 1815 when he returned to Edinburgh to study botany and minerals. He was thus well qualified for his appointment which involved wintering in successive years at Cumberland House on the Saskatchewan River, at Fort Enterprise, and at Fort Providence. In the narrative of this exhausting trip published in 1823 Franklin wrote "To Dr. Richardson the exclusive merit is due of whatever collections and observations have been made in the department of natural history...." The more interesting mammals which had been collected, however, were described by Joseph Sabine in an appendix to Franklin's narrative. Despite being passed over in Franklin's work, some of Richardson's data were written up as an appendix (pp. 287-341) to *Captain Parry's Journal of a Second Voyage for the Discovery of a North-west Passage from the Atlantic to the Pacific, performed in His Majesty's ships Fury and Hecla, in the years 1821-22-23*. In this work Richardson described 19 northern species including seven marine mammals, all of which frequent the coasts within Hudson's Strait visited on Parry's voyage. His anecdotal approach relied heavily on the observations of other men, including the surgeon of the *Fury*, John Edwards, who had made three voyages of discovery under Captains Ross and Parry. A typical comment (p. 294) read "In December, 1821, an ermine was caught on board the *Hecla*, led thither in pursuit of a new prey, the English domestic mouse which then for the first time visited those quarters, and which is still unknown in the interior of the fur countries." Richardson also included a general discussion about the possibilities of interbreeding among foxes, wolves and dogs.

In 1825 Richardson accompanied Franklin on his second expedition to the mouth of the Mackenzie River, taking with him as assistant the Scottish botanist Thomas Drummond (1830). Drummond was very diligent as he collected 50 mammals, some while on a special trip to the Rocky Mountains in the vicinity

of Jasper, Alberta. There he discovered the bushy-tailed wood rat (*Neotoma cinerea drummondi*) and the Drummond vole (*Microtus pennsylvanicus drummondi*) which bear his name. Fort Carlton, on the Saskatchewan River in Saskatchewan, was an important base camp where many local prairie birds and mammals were first collected and thus have that post as their type locality. These type specimens include three ground squirrels: *Spermophilus richardsoni*, *S. franklini* and *S. tridecemlineatus hoodi*, all named for British explorers. All of Richardson's specimens were sent back to England where they are now stored in the British Museum (Banfieldt 1961).

As a result of these two trips, Richardson wrote his *Fauna Boreali-Americana* (1829), a publication subsidized by the British government for £1000 which was to become a milestone in Canadian natural history. The 300-page Part I which dealt with mammals, or quadrupeds as they were often called, was illustrated by 24 black and white plates drawn by Richardson. It included mainly the species found north of the 49th parallel east of the Rocky Mountains, and west of Lake Huron. For this compendium Richardson consulted the works of 110 authors although it was largely based on

a) the collections and reports of Drummond and David Douglas who had also travelled and collected in the north-west;

b) specimens and observations made by expeditions led by Sir E. Parry and Captain Beechey;

c) information supplied by resident chief factors and traders of the Hudson's Bay Company; and

d) specimens, furs, and range data housed at the museum of the Hudson's Bay Company or sent by this company to the Zoological Society of London or the British Museum. The book discussed 84 land mammals, using about 50 generic names not now valid and about 39 ones which are still in use. (These numbers are approximate because sometimes it is difficult to know to what species Richardson was referring). In general, like all zoologists of his time, Richardson was conservative in his use of scientific names, for example lumping moose, caribou, wapiti, white-tailed deer and mule deer all in the genus *Cervus*. For various species he listed such things as external measurements description, a vague idea of distribution, general biology, anecdotes from trappers and other aboriginal peoples, and names used by various groups to identify them.

A later government-sponsored expedition was that of Captain John Palliser (1860, 1863), organized in part to discover passes through the Canadian Rockies. It provided information on big game distribution from the Waterton Park area north to Howse Pass in Banff National Park, including bison and bighorn sheep.

About 1860, following the discontinuation of the search for Sir John Franklin's expedition and with it the end of active exploration in the arctic, British involvement with Canadian fauna virtually stopped. The British absence was not replaced by a Canadian presence, since Canadian scientists were few in number with little or no government support, but by an American presence. For example Prof. Baird of the Smithsonian Institute sent the gifted naturalist Robert Kennicott for three years (1859-1862) to the Mackenzie region. Kennicott's enthusiasm and energy so impressed various officers of the Hudson's Bay Company with whom he came in contact in the north that they themselves became ardent collectors of native animals. During the next few years they sent thousands of specimens to the Smithsonian Institute, so that knowledge of the natural history of the area increased more than it had in the whole period since Samuel Hearne entered it in 1770-71. Unfortunately Kennicott died in 1866 before any report of his work had been made, but his name is remembered in a race of the arctic ground squirrel *Spermophilus parryi kennicotti* found in the lower Mackenzie River area. John Macoun deplored in 1887 the inactivity of Canadian naturalists and the lack of a great museum in Canada to which collections of specimens could be sent. He noted "It is painful to confess that all our best specimens, whether mineral, animal, or archaeological are going to Washington, and the apathy of our people is such that I see no help for it."

Even though many North American species have type localities in Canada, the early Geological and Natural History Survey collection of mammals in Ottawa and later the National Museum of Natural Sciences do not contain a single holotype of a Canadian mammalian species (Smith, 1981, 7, II).

In 1888 J. B. Tyrrell (1858-1957), who served on the Geological Survey of Canada from 1881 to 1898, published a pamphlet entitled *The Mammalia of Canada* based on his five years of travel in Manitoba and the Northwest Territories, on over 15 reports printed previously on Canadian mammals, and on specimens collected for the Geological and Natural History Museum at Ottawa. He listed 123 species, most of which have been renamed or reclassified since that time. His genera had all first been described elsewhere in the world, which is not surprising considering that mammals in Canada are similar to those in the United States and Eurasia. However, the following year a strange mouse-like specimen was sent by Dr. G. M. Dawson, former Director of the Geological Survey of Canada, to Dr. C. Hart Merriam in Washington, who called it *Phenacomys*, the only genus to be described first from a Canadian mammal (Banfield, 1974: 191). Merriam, following the invention and marketing of the breakback mousetrap in 1888, encouraged more collectors to come to Canada who sent back many thousands of small mammal skins for him to study and describe in his role as first Director of the United States Department of Agriculture's Branch of Economic Ornithology in the Division of Entomology.

The nineteenth century saw an influx into Canada of gentlemen naturalists and big game hunters from Europe who subsequently published diaries of their trips including extensive notes on the wildlife they encountered. Several of these men were titled, including Maximilian, Prince of Wied-Neuwied (1906), who in 1833 described the pocket-mouse, *Perognathus fasciatus*, and the "bean mouse", *Microtus pennsylvanicus*, of the Mandan Indians in the vicinity of the Red River, Manitoba. Count Bonaparte (1838) described several weasels (*Mustela frenata longicauda*, *M. erminea cicognani* and *M. e. richardsoni*) from Hudson's Bay Company specimens. One of the most interesting accounts of the big game of western Canada was written by the Earl of Southesk (1875).

These members of the aristocracy were followed by a large phalanx of hunters, naturalists, and adventurers who travelled into distant parts of Canada and then returned to write books about their experiences. They included J. G. Millais (1907) and H. H. Prichard (1910) in Newfoundland; Mina Hubbard Ellis (1908) in Labrador; J. K. Lord (1866) on Vancouver Island and southern British Columbia; and David Hanbury (1904), Caspar Whitney (1896) and Warburton Pike (1892) in the Northwest Territories. Caspar Whitney, for example, was primarily a hunter who travelled with the artist Arthur Heming a distance of 2801 miles in the north-west by snow-shoe, canoe, horse, boat, and foot to shoot wood bison, caribou, and muskox. His notes on these mammals are those of a hunter, dealing with such things as each species' behavior during the hunt, the texture of its hide and meat, the shape of its hooves, and the length of its horns or antlers. Native peoples proved useful in telling Whitney about the fauna.

Warburton Pike was also mainly a hunter, but one who was particularly anxious to observe and shoot the little-known muskox. The story of his trip to the barren grounds from 1889 to 1891 includes a 12-page appendix by G. M. Dawson entitled "On some of the large unexplored regions of Canada" which listed 16 unknown areas. Dawson reported that exclusive of the arctic islands, between one-third and one-quarter of the Dominion of Canada in 1890 was entirely unknown. Significantly, although he urged that explorers or surveyors to these areas should possess some scientific training, he felt that this should be in geology, climatology and botany. He made no mention of the living fauna of Canada being worth observing and recording.

By the turn of the century, as the classic work of Miller and Rehn in 1901 indicates, the study of North American mammals had passed through three phases. The first phase up until about 1865 was marked by a paucity of material. A large number of species had been described by zoologists, but because

everyone believed that species were fixed, variations within a species were not considered important. Only a few examples of a species instead of as many as possible were commonly collected. With the widespread acceptance of Charles Darwin's theory of evolution through natural selection, the importance of variation within a species was recognized. There were sweeping reductions in the total number of species as soon as it was realized that any individual not exactly like others need not necessarily be a separate species, but rather could be a variant of the same species. The brown bear (*Ursus arctos*) has shown such extreme individual variation that it is only within the past few decades that the many species in western North America have been incorporated into a single species. **(See article on the bear taxonomy by Dagg.)**

After 1865, many more specimens of mammals were collected, described and preserved in Canada, but although variations were considered important, the concept was still only vaguely understood. From 1889 such vagueness disappeared as the difference between geographic and individual variation became clear. There was no further reduction in the number of land mammals recognized in North America, but a significant increase from 363 species in 1885 to 1450 in 1900.

To round out what was known about North American mammals, professional mammalogists of the United States under the aegis of the Biological Survey of Washington continued their work on the distribution and variation of animals, by 1900 turning their attention to the vast regions of northern Canada. (Canadians can be grateful that Americans have often studied mammals on a continental basis; otherwise we would know far less about our native fauna than we do. Canadians, by contrast, have tended to confine themselves to species found in Canada.) The Americans paid particular attention to small mammals which had been ignored by most earlier travellers to Canada interested in fur species and big game. One man sent into the field by the Biological Survey was E. A. Preble, who with a companion, collected many mammals in 1901 while on a trip to the region about the Athabaska and Great Slave Lakes. In 1903-4 Preble led a second trip, this time visiting the Great Bear Lake and the Mackenzie River area further north. His report on these trips (1908) plus one on an expedition to the Hudson Bay area (1902) are still considered the starting points for students interested in those areas, as are W. H. Osgood's important studies in the Yukon Territory and the Queen Charlotte Islands (1900 and 1901) and A. J. Stone's (1899 and 1900) works on northern British Columbia. Preble is remembered in the scientific names of races of the red squirrel, *Tamiasciurus hudsonicus preblei*, from northern and western Canada and of the otter from the Mackenzie valley, *Lontra canadensis preblei*. The deer mouse of the southern prairies, *Peromyscus maniculatus osgoodi*, is named after Osgood and Stone's sheep, *Ovis dalli stonei*, after Stone.

Hunters, naturalists, and explorers continued to report on the mammals of little-known regions of Canada well into the 1900s. Among later works of travellers in Canada, Charles Sheldon's descriptions of wildlife conditions in the Yukon (1911) and Queen Charlotte Islands (1912) are classics, as are William Hornaday's (1906) account of Rocky Mountain travels and Radclyffe Dugmore's (1913) book on Newfoundland caribou. Long after southern Canada was settled the Northwest Territories continued to lure naturalists including Ernest Thompson Seton (1911), J. C. Critchell-Bullock (1925, 1930-31), Helge Ingstad (1933), and the ill-fated John Hornby (1934).

As for the rest of Canada, the fauna of the arctic was also largely first described by non-Canadians, beginning with Rear Admiral John Ross (1819, 1835) who discovered Boothia Peninsula and King William Island in his arctic voyage of 1829-33; Captain George Back (1836) who explored the Great Fish River (now the Back River) and the arctic coast of Canada in the 1830's; and John Rae (1888) who charted hundreds of miles of previously unmapped coastline in the arctic between 1846 and 1854. More recently the American explorers Adolphus Greely (in 1881-84) and Robert Peary (between 1893 and 1909) have increased our knowledge of mammals of the arctic archipelago. Since then a number of American mammalogists sponsored by American universities have continued to fill in gaps in our distributional data

including notably: Francis Harper for Keewatin and Ungava (1956, 1961); Kenneth Doult for Ungava (1954); George M. Sutton and William Hamilton for Southampton Island, NWT (1932); Rollin H. Baker for southern Yukon (1951); and Charles Swarth for British Columbia (1912, 1922, 1924, 1926).

Canada has been fortunate in having a number of amateur mammalogists who have undertaken serious studies of mammal taxonomy, distribution, life history and ecological relations. The best known was Ernest Thompson Seton (1860-1946), whose *Life-Histories of Northern Animals* (1909) was originally an account of the mammals of Manitoba. This led to the enlarged *Lives of Game Animals* (1929) which is still accepted as a classic among reference books in this field. Other naturalists who have made a significant contribution to the literature of Canadian mammals include Stuart and Norman Criddle of Aweme, Manitoba, who have collected and studied large populations of small mammals; Kenneth Racey of Vancouver who studied mammals in south-west British Columbia; W. E. Saunders who worked on mammals in Ontario; F. Roe of Toronto who wrote a definitive work on the buffalo; T. H. Manning of Ottawa who has worked extensively in the arctic; Craig A. Campbell and Ron Brooman of Waterloo, Ontario, who have studied mammals in the Waterloo Region area; and James Munro of Okanagan Landing, British Columbia, an ornithological field officer for the Wildlife Division of the National Parks Service who also published reports of mammals in southern British Columbia. J. Dewey Soper, who also served in the National Parks Service for many years, deserves special mention. He was a diligent student of small mammals, whose considerable collections are housed both at the National Museum of Canada (with which he was also associated) and at the University of Alberta. His field work was conducted mostly in the prairie provinces, particularly Alberta, and the Northwest Territories.

If Dr. John Richardson was the grandfather of modern mammalogy in Canada, Rudolph Martin Anderson (1876-1961) was the father (Soper, 1962). Anderson was born and educated in Iowa, where as a boy he had a passion for the outdoors and wildlife, especially birds. He attended the State University of Iowa where he earned a PhD in 1906 in systematic zoology and comparative anatomy. The next year he published the nearly 300-page *The Birds of Iowa*. From 1908 to 1912 he worked for the American Museum of Natural History, spending years of field work in Alaska and northern Canada. In 1913, with his appointment as zoologist to the Geological Survey of Canada, he became a naturalized British subject. In this year he published his first work on mammals, an addendum to V. Stefansson's *My Life with the Eskimo* entitled "Report of the Natural History Collections of the Expedition". As a government zoologist he accompanied the Canadian Arctic Expedition to the arctic from 1913 to 1916 as second in command to Stefansson, and was later general editor of the 16 volumes which reported on the findings of this important expedition. From 1920 until his retirement in 1948 he was Chief of the Division of Biology of the National Museum of Canada. He collected extensive data from summer field camps spread across Canada, mostly on mammals, and with the many specimens he added to the collection he was able to describe over 30 new subspecies of 17 genera of Canadian mammals. Anderson wrote 134 papers and through his work "a knowledge of Canadian mammals was elevated to a level previously unknown in the history of the nation."

Two years before his retirement, Anderson published the *Catalogue of Canadian Recent Mammals* which is still an important text in taxonomy. In it he praised the advance of exploration and the intensive field work of modern naturalists which enabled museums to gather together large numbers of specimens from which they could describe new species and races "far beyond the imagination of the older systematists." Anderson was doubtful, however, about all the subdivisions which had been described, and many were later to be proved untenable. Species had often been described from immature or non-typical specimens because of a lack of sufficient material for comparison; as well, the extent of the range of some forms of mammals was underestimated. Anderson's 1946 list of recent Canadian mammals included 231 species while Banfield's (1974) list included only 196, so the process of "lumping" various species

together, especially of bears, has continued over the years. Of the 594 species and subspecies of Canadian mammals described by Anderson in his Catalogue, only 484 had representatives in the National Museum of Canada, and only 46 of these were type specimens of subspecies. The other type specimens are presently housed in European collections, and in the Smithsonian Institution, the United States National Museum, the Biological Survey of the U.S. Department of Agriculture, plus collections of various states, universities, and large city museums that realized that systematic comparative work on North American zoology demanded material from the whole continent.

Many eminent zoologists succeeded Anderson at the National Museum of Canada, all dealing primarily or entirely with mammals, rather than with other animals. They were J. D. Soper who has written books on the mammals of Manitoba (1961) and Alberta (1964), A. L. Rand who wrote *Mammals of Yukon* (1945), A. W. Cameron who worked on the mammals of Prince Edward Island (1958a) and of Newfoundland (1958b), P. M. Youngman who has studied the mammals of the Yukon (1975) and the cytogenetics of northern species, and C. G. van Zyll de Jong who has clarified the taxonomy of otters. Recently D. R. Gray of the National Museums of Canada has worked on muskox behavior and arctic hares and C. R. Harington has focused on large quaternary mammals, especially of the Yukon.

Canadian museums where mammalian specimens are preserved for taxonomic and distributional research do not have a long history, but there are 21 collections with at least 100 specimens each in eight provinces (Choate and Genoways, 1975). The largest collection of mammals (73,360 specimens in 1973), many not from Canada, was in the Royal Ontario Museum, Toronto; this was the eighth largest collection in North America. The second largest (43,500, mostly Canadian), was in the National Museum of Natural Sciences, Ottawa. The next largest collections were in the University of British Columbia (9,525), the British Columbia Provincial Museum (9,000, where J. Bristol Foster and David Nagorsen have been active), Carleton University (8,500), the University of Alberta (7,800), and the Manitoba Museum of Man and Nature (6,000).

Until this century, as we have seen, most of the men who studied Canadian mammals were not Canadians, but rather Americans and Britons who spent most of their lives outside Canada. John Macoun (1831-1920) was the first professional biologist who made Canada his home and Canadian natural history his life work (1882), but he was mainly a botanist. The first professional Canadian zoologist was Charles Gordon Hewitt (1885-1920) who came to Ottawa from England in 1909 as Dominion Entomologist. He became, as well, Consulting Zoologist to the Dominion in 1916, in which capacity he wrote *The Conservation of the Wild Life of Canada* (1921), a comprehensive book which deals with economically important mammals and birds. Unfortunately he died prematurely before the book was published. This work remained the only one of its type until 1974, when Anne Innis Dagg published *Canadian Wildlife and Man*. More recently Janet Foster (1978) has described the history of mammalian (and other) conservation in her book *Working for Wildlife--The Beginning of Preservation in Canada*. Hewitt was important because he considered mammals primarily from an ecological point of view, rather than primarily as subjects for distributional or taxonomic research.

Up until the first World War, interest in mammals had focussed mainly on their distribution and taxonomy. With the founding in 1919 of the American Society of Mammalogy and its publication, the *Journal of Mammalogy*, attention was focussed both on mammals and on new research techniques. For the first time, professionals and amateur naturalists could publish their research in a journal devoted exclusively to this group. The *Journal of Mammalogy* not only tacitly encouraged naturalists to undertake scientific projects, but it gave them ideas about other research possibilities as well as the names of people working on similar species or techniques. The importance to Canadians of the Society was soon evident. In 1920 27 members of this society had Canadian addresses, a number that began to rise sharply after

World War II to a total of 229 in 1978 (Smith, 1981, p. 13). Two Canadian mammalogists, Ernest Thompson Seton in 1941 and Rudolph M. Anderson in 1947, were elected honorary members and Randolph L. Peterson of the Royal Ontario Museum, known for his research on moose and bats, served as its President from 1966 to 1968, at the time his important book *The Mammals of Eastern Canada* was published. J. Mary Jackson, of the University of British Columbia, was president from 1982 to 1984.

The variety of mammalian research expanded in this century as new technologies became available. Just as the appearance of the snap trap in 1888 enabled field workers to collect large numbers of specimens of small mammals for taxonomic analysis, the invention and marketing of live-traps right after World War I was important because they could capture individual mammals that could be tagged or marked and released after records had been made on such things as their weight, size, coloration, location, and reproductive status. Many data could thus be collected from one animal over a period of weeks, or months, or even years.

Similar data have been collected from bats, which were first banded in Canada in the late 1930s by Harold Hitchcock of the University of Western Ontario. His work was carried on in Ontario and Quebec after 1961 by Donald Smith and his students of Carleton University. In 1976 and 1977 they found two hibernating little brown bats (*Myotis lucifugus*) that Hitchcock had banded in 1947, making them at least 29 and 30 years old, world record longevities for bats of all species (Smith, 1981, p. 16). Since 1950, a number of new technologies have been perfected for the study of mammals, including the use of tranquilizing drugs in darts immobilize large mammals for study, radiotelemetry and fluorescent dyes to allow tracing of the movements of designated individuals, radioactive V isotopes for physiological research, video cameras and night-vision scopes to study diurnal and nocturnal behaviors, tape recorders to record mammalian noises, biochemical techniques to study affinity between populations by blood serum markers, and microscopic techniques to study karyotypes of chromosomes for taxonomic work. A large part of research has been done not by a few mammalogists, but by a large number. Of the 370 zoologists who wrote papers between 1931 and 1970, 67% authored a single work and 13% wrote only two papers. Many of these works probably represent the results of MSc or PhD theses of zoologists who then stopped working on mammalian research (Dagg, 1972).

Despite an increase of interest in mammals after 1920, there was little opportunity for Canadians to study mammals except on an amateur basis. Canadian institutions were slow to employ professional mammalogists. (Frank Banfield, wrote to R. M. Anderson in 1938 concerning employment possibilities, but he could only recommend continuing studies in university.) Prior to the Second World War there were only a handful of professionals involved in studies in mammalogy: Ian McT. Cowan at the University of British Columbia; William Rowan at the University of Alberta, Edmonton; Leonard Butler working for the Hudson's Bay Company, Winnipeg, Manitoba; E. C. Cross, Acting Curator of Mammals at the Royal Ontario Museum and Secretary of the Zoology Department, University of Toronto; R. M. Anderson at the National Museum in Ottawa; and C. H. D. Clarke with the National Parks Service. At the end of World War II, a number of government positions in mammalogy opened up, largely through the foresight of Prof. J. R. Dymond of the University of Toronto, who had led a government advisory committee during the closing war years. A number of younger men including war veterans found various positions with government agencies. C. J. Guiguet became Curator of Mammals at the Provincial Museum of British Columbia, James Hatter joined the British Columbia Game Commission, and R. L. Peterson became the first full-time Curator of Mammals at the Royal Ontario Museum. Frank Banfield was appointed mammalogist of the National Parks Service in 1946.

Mammals in Canada fall mainly under provincial jurisdiction, and are "managed," if necessary, by laws passed by the ten provinces and two territories. However, the federal government has biologists who

investigate problems of national interest such as diseases, effects of pesticides and pollution, and the status of threatened or endangered species and species which cross international boundaries (polar bear, caribou). The Canadian Wildlife Service used formerly to be responsible for mammal research in the Yukon and Northwest Territories, but at present it has jurisdiction only over transboundary mammal research.

With the establishment of the Canadian Wildlife Service in 1947, research on Canada's northern big game, furbearers, and wildlife in the National Parks became paramount. Studies on barren-ground caribou were initiated in 1948 by A. W. F. Banfield (1954) and continued by J. P. Kelsall, D. C. Thomas, G. P. Parker, Frank L. Miller, T. Charles Dauphine and Anne Gunn. Research on muskox was begun by John S. Tener (1965) and carried on by David Greer. Work on polar bears, conducted originally by Allan Loughrey (1956) and C. R. Harington (1968) was continued by Ian Stirling and others. Grizzly bear work was organized Arthur M. Pearson (1975) and continued by Stephen Herrero and Brian Horejsi. Early studies on furbearers and small species, which included the work of William A. Fuller (1951) and Ward E. Stevens (1953) on northern muskrat, have been continued by Nicholas S. Novakowski, Andrew Macpherson, Joseph E. Bryant, Vern D. Hawley, Eoin H. McEwen and Arthur M. Martell. Studies of mammals in the National Parks initiated by J. E. Soper and A.W.F. Banfield have been carried on by Donald R. Flook, J. G. Stelfox, L. N. Carbyn, and Richard Russell. Much less research is now being done on wild mammals than in the past.

Most provinces since the second World War have studied economically important native mammals. The largest of these was the Wildlife Division of the Province of Ontario established by C.H.D. Clarke in 1944 (included in the Ministry of Natural Resources since 1972). J. Douglas Roseborough directed the research of the Fish and Wildlife Branch, which emphasized the ecology of game species such as moose and deer, studied especially by D. F. Fraser and A. B. Bubenik, and the wolf (*Canis lupus*) studied by Antoon de Vos, Douglas H. Pimlott, G. B. Kolenosky, P. Joslin, and John Theberge (of the University of Waterloo). In the early 1950s the Department of Fisheries took on the responsibility of marine mammal research, hiring several professional mammalogists: the first director of the Arctic Group was H. Dean Fisher who was later joined by A. W. Mansfield and David Sergeant. Gordon Pike was stationed at Nanaimo, B.C. to study Pacific whales and pinnipeds. More recently, Canadian government workers on marine mammals have included Edward D. Mitchell and K. A. Hay. David Gaskin of the University of Guelph focussed on the harbor porpoise.

Mammalogy was not one of the traditional disciplines attractive to French-Canadian science students and the field developed slowly in Quebec. The first mammalogists such as Gaston Moisan typically received their doctorates out of their home province. This situation has changed in the past few decades and there are an increasing number of native French-Canadian mammalogists such as Pierre des Meules. Similarly the discipline has developed slowly in the Maritime Provinces, where fisheries and oceanography provide a greater attraction to students. Bruce S. Wright of the University of New Brunswick was perhaps the main mammalogist of the maritimes, notable for his studies on the eastern cougar (1972). Austin Squires (1968) has been important as curator of a historical collection of regional specimens of mammals housed at the New Brunswick Provincial Museum, St. Johns, and Robert E. Wrigley has been important as Curator of Mammals and Birds at the Manitoba Museum of Man and Nature.

The research published on Canadian mammals since 1930 has been analyzed by Anne Innis Dagg (1972, 1988). Most of it has appeared in four journals (Table 1), in order of importance recently: *Canadian Journal of Zoology*, *Canadian Field-Naturalist*, *Journal of Wildlife Management* and *Journal of Mammalogy*. Up until 1970, about one-third of the published research appeared in American journals, but since then this proportion has decreased to 26 per cent. This is in large part owing to relatively fewer

papers being published in the *Journal of Mammalogy* than in the other major journals. It is evident from Table 1 that there has also been a relative or actual reduction of papers on Canadian mammals being published by government agencies, namely the National Museums of Canada, the Royal Ontario Museum, and the Canadian Wildlife Service. (Other Canadian journals are still heavily underwritten by government subsidies, however, as is most research.)

Forty years ago, governments were heavily involved in research on mammals in Canada. Before 1950, one-third of mammalian studies (32%) was directly sponsored by the federal government, followed by non-Canadian sources (25%), Canadian universities (18%), provincial governments (14%), and unaffiliated (amateur) Canadians (11%). Since then, the proportion of sponsors has changed markedly. From 1971-1986, only 16% of researchers whose papers were published in the 11 listed publications were sponsored by the Canadian government, 14% were sponsored by provincial or territorial governments, while 64% were affiliated with universities (Table 2). Unaffiliated or amateur naturalists from Canada published only 1% of the papers between 1971-1986, down from 4% in the 1931-1970 period. It seems that the work of amateurs is less likely to be published now than was the case formerly, when natural science was perceived as being less elitist.

This increase in professionalism is reflected also in the number of authors who write papers. From 1931-1940, 95% of the published papers were written by single authors and 5% by two authors. Subsequently the number of single authors (which includes most amateurs) has decreased until in the period 1971-1986 it was only 38% for all papers, whereas 44% were then written by two authors and 18% by three or more authors. Multiple authors are common at universities and in governments where several people often work together on one research project, and they are also common in sophisticated research which involves complex technology, as is increasingly being tackled. Sometimes active researchers put the names of mentors on their papers to facilitate their future research.

At present universities in Canada are a major sponsor of research on mammals (Table 2). Thirty-five had personnel who published research on mammals between 1971 and 1986, and three western community colleges did too. Before 1946, Canadian universities had little interest in mammals, but in the next decade and a half the University of British Columbia and the University of Toronto were preeminent in mammalogy. Ian McTaggart Cowan provided the impetus at the former institution, particularly in training graduate students, and at the latter A. F. Coventry (in small mammals) and J. R. Dymond (as head of the Department of Zoology) provided encouragement. In the 1960s, the University of Guelph became important in mammalogy, in large part because of its links with the wildlife management of the Ontario government. Professors were Antoon De Vos, Art T. Cringan, Ed D. Bailey, Anne Innis Dagg and Ron Brooks. More recently, the research output of the University of Toronto has decreased, while that of the University of Alberta has increased.

The three most active universities-- University of Guelph, University of British Columbia, and University of Alberta-- all had zoologists working on a variety of species. The University of Guelph is well known for its research on seals, especially the harp seal (D. M. Lavigne, R. E. A. Stewart, Kit Kovacs, Keith Ronald) and parasites (Roy Anderson); the University of Alberta for its research on ground squirrels (Jan O. Murie, A. L. Steiner, David A. Boag), northern microtines by W.A. Fuller, and large Albertan game animals; and the University of British Columbia for work on small mammals (Dennis Chitty, Charles J. Krebs, Rudy Boonstra), deer (Ian McTaggart Cowan) and marine mammals. Other universities have only one or two mammalogists, but these have often been active enough to have created a fine reputation for their universities, such as Arthur Bergerud of the University of Victoria for his work on caribou; Brock Fenton and Donald A. Smith of Carleton University for their research on bats and other small mammals; John S. Millar of the University of Western Ontario for his small mammal studies; J. R.

Bider of McGill University for his studies on rodents; William O. Pruitt of the University of Manitoba for research on northern species; R. M. F. S. Sadlier of Simon Fraser University for work on a variety of species; Gail Michener and Lucius L. Stebbins of the University of Lethbridge for research on ground squirrels and other small mammals; Jean Ferron from the University de Quebec for his work on squirrels; Robert T. M'Closkey of the University of Windsor for his studies on small rodents; and Valerius Geist and Stephen Herrero of the University of Calgary for their behavioral research on ungulates and bears, respectively.

The provincial and territorial governments continue to be active in mammalian research, with the most densely-populated provinces usually producing the most publications (Table 2). However, the Alberta, Newfoundland, and especially Northwest Territories and Yukon governments carried out more research than might have been expected from their relatively small human populations. Mammal resources in these areas are important in the form of game animals for subsistence hunting and tourism, predators which attack livestock, and furbearers for fur, which explains in part their extensive research records. William Wishart, A. W. Todd and John R. Gunson have been especially active in the Alberta government.

Regional research in general reflected this pattern of the most heavily populated provinces (Ontario, Quebec, and British Columbia) having the most mammalian research done in them (Table 3). This is largely because research is often carried out at or near the funding institution. However, the most research was carried out in the Northwest Territories, the last great frontier for wildlife in Canada. This research was primarily on caribou and polar bear, both species which cross international boundaries and whose populations could be drastically affected by exploitation of natural resources. There was also research on the impact that gas and oil extraction could have on smaller species. Such research was largely sponsored by the federal and territorial governments, by some universities, and by commercial oil and gas companies, for all, a substantial commitment given the remoteness of the area.

Dagg's 1988 study included an assessment of what bodies recently supported research financially (Table 4). The federal government via the National Research Council or the Natural Sciences and Engineering Research Council funded at least to some extent 41% of all the research published, most of it pure rather than applied research, while provincial and territorial governments (27%) and Canadian universities (23%) were supportive to a lesser extent. Research projects were usually more practical if funded by the non-federal governments (i.e. management and harvesting studies), and less so if funded by universities.

With the advent of the environmental assessment process in the early 1970s, Canadian industry sponsored environmental studies as part of the engineering planning phase. Several megaprojects proposed by the petroleum industry in northern Canada involved investigations of the status of the local flora and fauna, including mammals. The paucity of available literature on the distribution, status and probable responses to industrial development necessitated large-scale efforts. Much information was collected that forms a useful data base for future studies. Two independent professional consulting firms that undertook much of the mammal research in the Yukon and Northwest Territories in connection with these environmental impact studies were L.G.L. Environmental Research Associates of King City, Ontario, and Renewable Resources Consulting Services of Edmonton and Sidney, B.C.

Well over fifty private and non-commercial groups have also funded research recently on Canadian mammals, most notably the Canadian National Sportsmen's Fund and the World Wildlife Fund. They also included eight hunting organizations, groups involved with specific mammals (Canadian Wolf Defenders, Wild Canid Research and Survival Centre, People's Trust for Endangered Species, North American Wild Sheep Foundation, Vancouver Aquarium), and groups involved in the arctic (Arctic Institute of North America, Arctic Pilot Project, Arctic and Alpine Research Grants, and Institute of Arctic Ecophysiology).

Almost all of the research published between 1971 and 1986 was practical (98%) rather than theoretical; this reflects the interest of many biologists in field and experimental research, the pressure for academics to seek grants for practical work, and the need for government workers to solve practical problems.

Mammal behavior, studies in anatomy and physiology, research on population and status, and research on ecology and habitat were the four most common research areas (Table 5). The increase in research activity over that noted before 1971 was most striking for the behavior category, in part because of new technology. Many mammalogists continued to observe mammals in the wild, however, as they have done for decades.

The distribution of mammals was the most studied area between 1931 and 1970, which reflects the work of mammalogists spreading into unexplored (mammalogically speaking) terrain in a new country, but recently this work has decreased in importance. Research on the general biology of various mammals has decreased recently also, as has management research involved with such procedures as harvesting game. Pollution studies continue to be rare, perhaps because birds and fish are more readily analyzed for pollution and perhaps because such studies are published in journals which deal more with the environment than with wildlife.

Mammalian species in Canada are not studied equally (Table 6). The species selected for the most research after 1970 were similar to those studied earlier. In Canada game animals and rodents have been the most studied groups, often because of their economic importance. Carnivores were studied in 240 papers, in part because many are trapped for fur. Wolves and polar bears, which have a high popular appeal, were studied most often, even though such research involves great expense while working in distant and difficult terrain.

Other groups were less often researched. Of the pinnipeds, the harp seal has had the most attention, mainly because of the large populations which gather each spring in the Gulf of St Lawrence and because there has been controversy about whether or not the young should be harvested for their pelts. The ringed seal is important because it is common in the high arctic and often harvested by the Inuit. Whales are less commonly studied; the most researched species, the harbor porpoise, the narwhal and the beluga, all occur close to shore in the high arctic or off temperate Canada. Larger whales sighted in the Atlantic or Pacific or washed up on shore were described in only a few papers.

The least studied groups were the lagomorphs, bats and insectivores. Even so, the snowshoe hare was fairly intensively studied, usually in connection with its cyclical increase and decrease in population. A few uncommon species did not have any research carried out on them during the 16-year period. We hope that the science of mammalogy will increasingly flourish in the future as it has in the past. "We need to continue our inventories of mammals in remote areas of Canada and to work out some of the details of their life histories, physiological and behavioral adaptations, population dynamics, and management." (Smith, 1981, 17). We need also to concentrate on subdisciplines that have been little studied in the past. One such area is paleomammalogy, to which only recently individual mammalogists have turned their undivided attention.

The Dawsons were among the first to discover and describe fossil mammals in Canada; neither was especially interested in mammals *per se*, but in their time each discovery of mammal remains was momentous, given how little was known about prehistoric Canadian fauna. John William Dawson (1820-1899) was born in Nova Scotia and studied geology in Scotland before returning to Canada, eventually to become principal of McGill University and a geologist preeminent in the discipline. He collected considerable fossil material, including mammal remains, from Quebec and Ontario. His son, George Mercer Dawson (1849-1901), also became a geologist, joining the Geological Survey of Canada in

1875. He worked extensively in the northwest, and made a number of finds of fossil mammals.

Another father/ son(s) team was that of Charles H. Sternberg and sons Charles M. and, to a lesser extent, Levi. The father was an American "bone hunter" in the last century who made a living by selling specimens he discovered to museums, universities, and other institutions; he usually concentrated on dinosaur remains, because they brought a high price on the market. Charles M. Sternberg (1885-1981), following in the footsteps of his father, came to Canada from the American west to exploit the rich fossil fields of the Red Deer River valley in Alberta for the Geological Survey of Canada. From 1919 on he progressively took over the description of fossil vertebrates, mostly dinosaurs but some mammals, too. He collected fossils mainly in Alberta, but also in Saskatchewan, northeastern British Columbia and Nova Scotia. After he retired in 1950, he helped set up the dinosaur Provincial Park in Alberta. As recently as 1963, he wrote his second paper on records of mastodons and mammoths in Canada.

Another important collector of fossils, some of them mammalian, was William Arthur Parks (1868-1936), professor of geology at the University of Toronto and head of the Geological Museum, now part of the Royal Ontario Museum. He worked both in northern Ontario and in Alberta.

More recently, some men have made paleomammalogy one of their chosen fields of research and have published a number of papers in it. Loris Shano Russell, who worked at both the Royal Ontario Museum and the National Museum of Canada, has done important work on Cretaceous and Tertiary mammals and on the evolution of mammals in general. C. Richard Harington, who is OKOK?currently curator of Quaternary Geology at the National Museum of Natural History, National Museums of Canada, has studied the Pleistocene mammals of the Yukon and more generally of Canada and the Champlain Sea. Charles Stephen (Rufus) Churcher of the University of Toronto and the Royal Ontario Museum and Michael Clayton Wilson of the University of Lethbridge have done extensive research on the Pleistocene deposits of mammals in Alberta and Saskatchewan.

Another subdiscipline that needs more research is that of endangered species. The status of populations of large mammals is fairly well monitored in Canada, but that of smaller mammals is not. So little is known about some populations of species such as *Phenacomys* and the wolverine that their survival might be in doubt in some areas without anyone being aware of it. At present, the Committee on the Status of Endangered Wildlife in Canada lists the following species (World Wildlife Fund, 1988):  
EXTINCT: Any indigenous species of fauna or flora formerly indigenous to Canada no longer existing elsewhere: Dawson caribou, sea mink.

EXTIRPATED: Any indigenous species of fauna or flora no longer existing in the wild in Canada but existing elsewhere: Atlantic gray whale, Atlantic walrus (St Lawrence population), Black-footed ferret, swift fox.

ENDANGERED: Any indigenous species of fauna or flora whose existence in Canada is threatened with immediate extirpation or extinction throughout all or a significant portion of its range, owing to the actions of man: bowhead whale, eastern cougar, right whale, St Lawrence River beluga whale, sea otter, Ungava Bay beluga whale, Vancouver Island marmot.

THREATENED: Any indigenous species of fauna or flora that is likely to become endangered in Canada if the factors affecting its vulnerability do not become reversed: Eastmain beluga whale, maritime woodland caribou, Newfoundland pine marten, North Pacific humpback whale, Peary caribou, prairie long-tailed weasel, wood bison.

RARE: Any indigenous species of fauna or flora that, because of its biological characteristics, or because it occurs at the fringe of its range, or for some other reasons exists in low numbers or in very restricted areas in Canada, and so is vulnerable, but is not a threatened species: Black-tailed prairie dog, blue whale, eastern mole, fin whale, fringed myotis, Gaspé shrew, grey fox, Keen's long-eared bat, Northwest Atlantic

humpback whales, pallid bat, plains pocket gopher, Queen Charlotte Islands ermine, spotted bat, southern flying squirrel, western woodland caribou, wolverine.

In 1988, the wood bison became the first mammal in Canada to be dropped from the endangered category. Its population has grown from a low of 200 animals in 1957 to about 2,500 animals.

Research should also be encouraged on urban mammals. Relatively little has been published in this subdiscipline since the First Canadian study by Anne Innis Dagg (1969). Yet urban mammals are the ones with which most Canadians come in contact and which might induce them to work toward the preservation of less domestic wildlife in the far reaches of Canada. We may hope that future development will not decrease the number of species of mammals in Canada, but will increase the interest of Canadians in preserving them and in finding out more about them.

### Acknowledgements

We would like to thank all the institutions which have helped us collect the material for this chapter, including universities, governments and museums across Canada, the Public Archives in Ottawa, the British Museum, and the World Wildlife Fund of Canada. We are especially grateful to C. G. van Zyll de Jong who provided the Provisional Checklist of Canadian Mammals, to C. S. Churcher and Paul Karrow who gave us valuable information on paleomammalogy, and to Kai Curry-Lindahl and Ian McTaggart Cowan who read an earlier version of this paper.

Table 1. Number of Articles on Canadian Mammals, 1931-70\* and 1971-86+ inclusive

in 11 Major Journals.

	1931-70		1971-86		Percentage Change
	Number	Percentage	Number	Percentage	
Canadian Field-Naturalist	144	23%	224	20%	-3%
Journal of Mammalogy	128	21	123	11	-10
Canadian Journal of Zoology	120	19	472	42	+23
Journal of Wildlife Management	79	13	154	14	+1
National Museums of Canada Publications	32	5	9	1	-4
Transactions of the North American Wildlife and Natural Resources Conference	28	5	2	-	-5
Canadian Wildlife Service	27	4	24	2	-2
Arctic	18	3	56	5	+2
Royal Ontario Museum Publications	16	3	1	-	-3
American Midland Naturalist	15	2	14	1	-1
Naturaliste Canadien	13	2	45	4	+2
	<u>620</u>		<u>1124</u>		

\*from Dagg, 1972 and +Dagg, 1988  
1

Table 2. Number of Authors Affiliated with Various Universities, Governments, and Other Groups. From Dagg, 1988

Jurisdiction	Government	Universities	Other	Total
Canada	333	-	21	354
British Columbia	19	231		250
Alberta	52	222		274
Saskatchewan	3	27		30
Manitoba	14	45		59
Ontario	83	437		520
Quebec	42	149		191
New Brunswick	3	8		11
Nova Scotia	4	20		24
Prince Edward Island	3	-		3
Newfoundland	21	18		39
Northwest Territories	28	-		28
Yukon	8	-		8
Foreign	22	168	16	206
Commercial Companies	-	-	55	55
Totals	635	1325	92	2052

Table 3. Regions where Research on Mammals was Carried Out. From Dagg, 1988.

	62	Number of Studies per Region	Number Rank of Studies
Maritimes			8
			34
			23 <sup>7</sup>
			10
			27 <sup>9</sup>
		2	12
	Labrador		
	Newfoundland		96 <sup>4</sup>
	Nova Scotia		
	New Brunswick		138 <sup>2</sup>
	Prince Edward Island		
Prairies			67 <sup>6</sup>
	Quebec		21 <sup>11</sup>
			80 <sup>5</sup>
	Ontario		
			105 <sup>3</sup>
	Manitoba		
	Saskatchewan		39 <sup>8</sup>
Alberta		147 <sup>1</sup>	
All across Canada	British Columbia		25
	Yukon		
	Northwest Territories		820*

\*Some research was carried out in several regions, so this number is greater than the number of actual field studies.

Table 4. Institutions and Groups which Financed Research Projects. From Dagg, 1988.

	Number of Projects Financed	
Canadian Government		811
National Research Council and Natural Sciences and Engineering Research Council	456	
Canadian Wildlife Service	170	
Other departments	185	
Provincial and Territorial Governments		303
Canadian Universities		261
American Universities		65
American Governments		65
Arctic Gas and Oil Companies		47
Canadian National Sportsmen's Fund		46
World Wildlife Fund		17
Canadian Consultants and Non-Gas/Oil Companies		16
Arctic Institute of North America		12
Non-North American Governments and Universities		10
Forty-nine groups with fewer than 9 projects		117
	each funded	
		<hr/> 2581

Table 5. Percentage of Papers Published during Five Periods by One, Two and Three or More Authors.

Periods	Percentage of Papers by		
	One Author	Two Authors	Three or More Authors
1931-40 <sup>*</sup>	95	5	0
1941-50 <sup>*</sup>	82	17	1
1951-60 <sup>*</sup>	69	23	8
1961-70 <sup>*</sup>	62	27	11
1971-86 <sup>t</sup>	38	44	18

<sup>\*</sup>from Dagg, 1972 and +Dagg 1988

Table 6. Frequencies of Subject Areas Studied in Research,  
1971-86 and 1931-70.

	Number of Papers Published Subject Areas between 1971-86 and their Percentage		Number of Papers Published between 1931-70 and their Percentage		
Behavior (activity, movements, food, etc.)	374	30%	115	15%	
physiology (growth, weights, etc.)	204	16%	96	12%	
Populations and status	122	10%	65	8%	
Ecology and habitat trapping, etc.)	108	9%	34	4%	
Distribution		9	1	0%	
and genetics	85	7%	41	5%	
cycles, mortality, etc.)	81	6%	110	14%	
Taxonomy		35	3%	54	7%
Production and Management	31	2%	43	5%	
Pollution		9	<1%	3	<1%
Disease and Accidents	7	<1%	26	3%	
Total	1249	100%	793	100%	

Table 7. Number of Papers Published and Species Studied by Order and Family. From Dagg, 1988 NUMBERS HOPELESS SHIFTED HERE

	Number of Species Studied	Number of Studies
Mammals		
Order Insectivora		
Fam. Soricidae	827	Order Chiroptera
Fam. Vespertilionidae	647	Order Lagomorpha
Fam. Ochotonidae	1	6
Fam. Leporidae	3	44
Order Rodentia - several families		10
Fam. Sciuridae	11	106
Fam. Castoridae	1	17
Fam. Geomyidae	1	1
Fam. Zapodidae	2	5
Fam. Muridae	14	199
Fam. Erethizontidae	1	5
Order Carnivora - several families		4
Fam. Canidae	4	90
Fam. Ursidae	3	60
Fam. Procyonidae	1	1
Fam. Mustelidae	10	71
Fam. Otariidae	1	3
Fam. Odobenidae	1	4

Fam. Phocidae	670	50
Fam. Felidae	314	
Order Artiodactyla - several families	14	
Fam. Cervidae	5242	
Fam. Antilocapridae	114	
Fam. Bovidae	578	
Order Cetacea - several families	4	
Fam. Zipiidae	11	
Fam. Physteridae	12	
Fam. Kogiidae	11	
Fam. Monodontidae	216	
Fam. Delphinidae	414	
Fam. Eschrichtidae	12	
Fam. Balaenopteridae	48	
Fam. Balaenidae	2	
Marine Mammals in general		
Small mammals in general	30	
Many species in one paper	24	
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Total	1247	

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