THE UNIVERSITY OF BRITISH COLUMBIA

THE ECOLOGY OF RICHARDSON'S MERLINS ON THE CANADIAN PRAIRIES

BY

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B.Sc., University of British Columbia, 1970

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

In the Department

of

Plant Science

We accept this thesis as conforming to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

1976.

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Date April 28/76

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NEWLY FLEDGED RICHARDSON'S MERLIN

ABSTRACT

It is the grassland ecosystem which supports nesting Merlins on the Canadian prairies. This study considered the effects of some factors interfering with processes in operation in the natural functioning of the grassland ecosystem that influences Merlin populations. An important part of this study was the comparison of selected habitat features near Hanna, Alberta, where a segment of the prairie Merlin population continues to nest, and those near Kindersley, Saskatchewan, where Merlins once nested but no longer are present. Additionally, data on nesting ecology of Richardson's Merlins were gathered along the South Saskatchewan River, and near Hanna, in southern Alberta, during the summers of 1968-1974.

The absence of nesting merlins near Kindersley appears to be related to changing human land use patterns in that area. Since 1951, 62% of the land near Kindersley has been cultivated, while the comparable figure near Hanna, where Merlins continue to nest, is 26%. Air photo study of territories around Merlin nest sites showed that 52.3% of the area presumed to have been used by Merlins for hunting in the Kindersley area came under cultivation since the 1940's, as compared to 25.5% for the Hanna territories over the same period. Interpretation of 40 Merlin territories in use since 1971 in the Hanna area, has revealed that Merlins were hunting in areas which averaged 78% grassland. Increase in cultivation in both areas since the early 1960's has been about 7%, leaving Kindersley Merlin territories with less than 42% grassland by 1971. Assuming that at least 50% grassland is required within a Merlin hunting territory in order to provide sufficient small bird prey, it was concluded that the Kindersley area has not been a

prime Merlin nesting area since the 1940's, and that increases in cultivation since the early 1960's has probably reduced grassland below the threshold necessary to support nesting Merlins. It is felt that the heavy use of dieldrin in the early 1960's probably had the effect of administering the "coupe de grace" to the Kindersley Merlins, possibly through the reduction of grassland birds.

Analysis of prey remains at nests indicated that the diet of these prairie Merlins was composed of 50% Horned Larks, 37% Chestnut-collared Longspurs, 6% sparrows, 4% blackbirds and 3% others (passerine birds, shore-birds, rodents, etc.). Destruction of the habitats of these prey species must be viewed as destruction of the habitat for nesting Merlins. The now common practice of seeding open cattle range to crested wheatgrass and other alien monocultures is likely to lead to further regression in the prairie ecosystem and to reduce or extinguish populations of passerines and, consequently, Merlins.

In Alberta, from 1971-1974, an average of 70.9% of occupied nest sites (sites with a pair of Merlins present prior to egg laying) were active, at least to the egg laying stage; 54.9% of nests with eggs hatched young, and 85.3% of these successful nests produced fledglings. Average clutch size was 4.6 eggs, of which an average of 3.5 hatched per nest with eggs hatching, producing 3.2 fledged young per nest with young reaching fledging age. A net productivity of 0.69 fledglings per occupied nest site was determined. Hatching success for all eggs was 57.8%, and 84.4% of the young hatched survived to fledging. These figures include results from 1973 when a single storm accounted for a failure of 41.4% of the nests in the Hanna area. Egg hatchability appears to be related ($p < .02$) to DDE and Dieldrin residues, probably resulting from local application of these pesticides for grasshopper control; eggshell density was inversley related to DDE levels. In Alberta, pesticide levels do not appear to have been sufficient to cause a population decline.

Results from banding of nestlings and trapping and banding of adults showed that males usually return to the general area where they have nested in previous years whereas females may move as far as 100 miles from an earlier nesting site. Apparent records of two birds, one of each sex, breeding at an age of one year, are interesting in that most raptors do not breed until their second or third year. Longevity of these birds in the wild is unknown but one individual was known to have been 5 years old.

ACKNOWLEDGEMENTS

Financing of field work for this project during the 1973 and 1974 field seasons was provided by the Canadian Wildlife Service (C.W.S.). Thanks are especially due to Mr. Richard Fyfe of the Edmonton, Alberta, office of that Service, responsible for the support, who provided encouragement for this project since its inception in 1970. My project on Merlins is a part of a much wider program established by the Toxic Chemical Section (C.W.S.) to monitor raptor population changes and pesticide residue levels in raptors on the Canadian prairies. Acknowledgement is accorded C.W.S. for the use, from their files, of population data, pesticide residue data, and eggshell data, collected before I commenced work on this project. Special thanks goes to Mrs. Lynne Kemper for her work during the 1972 field season, for only through her complete and detailed observations while working for C.W.S. is a continuous account of the prairie Merlin population available since 1971. To Miss Ursula Banasch, who provided the link between field operations and the Edmonton office, I am most grateful. To the people named below and many others I gratefully acknowledge assistance and advice: Mr. Harry Armbruster, Wildlife Technician, Mr. Bob Wroe, Range Specialist, Mr. Randy Semeniuk, Mr. Tom Donald, Mr. Tom Russell, Mr. Pat Harris, Mr. Jim Windsor, Mr. Mike Bradley, Mr. John le Jeune, and Mr. Glen Fox. Particular thanks for the sometimes menial task of collecting plant specimens, and feathers and other prey remains, and for the aid in trapping and banding Merlins go to Kip, Ken and Kelly Fyfe who spent periods of each field season with me, to my brother Kim who spent much of the 1971 field season with me, and to my brother-in-law Darren Ethier who spent most of his 1973 and 1974 school vacations with me. I hope they got as much out of those field seasons as I did from their help.

During the 1973-74 and Fall 1974 sessions spent at the University of British Columbia a number of people were especially helpful. These include Mr. Steve Borden who undertook the computer analysis of much field data, Mrs. M. North who provided source material for vegetation and historical aspects of the study area, and the following members of my committee: Dr. V.C. Runeckles, Chairman; Dr. V.C. Brink, Supervisor; Dr. R.J. Copeman, Assistant Professor, Department of Plant Science; Dr. Ian McTaggart Cowan, Dean, Faculty of Graduate Studies, and Professor, Department of Zoology; Dr. R.C. Fitzsimmons, Assistant Professor, Department of Poultry Science; and Mr. Richard Fyfe, Research Biologist, Canadian Wildlife Service.

Very sincere thanks go to Mr. and Mrs. R. Fyfe of Fort Saskatchewan, Mr. and Mrs. J. Armstrong of Hanna, and Mrs. M. Seminiuk of Edmonton all of whom provided meals and accommodation for sometimes very dirty and weary workers, and to Mr. and Mrs. R. Gore of Scotfield who very kindly provided a place for a field trailer out of which much of the study was carried out during 1973 and 1974 field seasons.

Thanks too must be accorded Mr. Brian Davies, Warden George C. Reifel, Waterfowl Sanctuary, and Mr. Frank Beebe of the B.C. Provincial Museum, retired. Through their consideration and friendship an interest and fascination for raptors was kindled in the early 1960's, and sustained.

Receipt of air phots from the Canadian Wildlife Service Library, Edmonton, Alberta, from the Alberta Department of Lands and Forests Photo

Library, from the Alberta Department of Geography Air Photo Library, and from the National Air Photos Library is acknowledged.

To my sister-in-law, Mrs. Holly Linden, who undertook the final typing of this thesis, I am very grateful.

Above all, thanks go to my wife Heather who, for more than two years, put up with my long absences in the field.

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1. INTRODUCTION

Richardson's Merlin, a distinctive resident of the grasslands, meadows and aspen parklands of the Great Plains of North America, continues to exist despite the destruction of most of the original prairie sod for agriculture. This study of what has happened and is happening to this beautiful raptor, an organism at the apex of a prairie trophic pyramid, reflects the extent and nature of man's modification of grassland systems.

In Western Canada, where the Merlin is resident from April until September, the agricultural system has almost overwhelmed the natural system, but it is not too late to identify the prime factors influencing Merlin distribution and abundance. The identification of these factors, a purpose of the studies reported here, may be an aid in determining the ways in which the prairie environment may accomodate man as well as components of the natural prairie system, such as the Merlin.

2. GENERAL BIOLOGY OF THE RICHARDSON'S MERLIN

The Merlin is a member of the Genus *Falco* and is one of six species native to North America, viz. the Merlin, *Falco columbarius*; American Kestrel, *Falco sparvius*; Aplomado Falcon, *Falco femoralis*; Prairie Falcon, *Falco mexicanus*; Peregrine Falcon, *Falco peregrinus*; and Gyrfalcon, *Falco rusticolus*. But for the kestrel, the Merlin is the smallest. Female Merlins weigh in the range of 185 g to 255 g. The males, as in most other raptor species, are about one third smaller than the females and weigh about 150g to 220 g (Amadon and Brown, 1968). The female Merlin is thus about the size of a small pigeon. Temple (1970) recognizes three subspecies of Merlins in North America, *Falco columbarius columbarius* (formerly *F.c. columbarius* and *F.c. bendirei*) summering in the taiga zone, *F.c. suckleyi* of the Pacific northwest, and *F.c. richardsonii* nesting in the prairie-parkland, the bird of this study.

Richardson's Merlins are characteristically birds of open country; other Merlins are found breeding in heavily forested areas but in such areas they hunt over natural openings and river valleys. Merlins are extremely energetic, and capture most prey on the wing in the fast, long-winged pursuits characteristic of falcons. Their chief prey are small birds, but insects, at times, form a significant part of their diet.

As in the case with other falcons, Merlins do not build their own nest, but use nests built by other raptors, crows, or magpies, or simply nest on the ground in an elevated position on a cliff or hilltop. Four or five, or occasionally six, eggs are laid, and incubation, which begins some time after the first egg is laid, lasts about a month. The young Merlins spend about a month in the nest before they begin to fly.

Plate 1.

Merlin Nest Site Along the South Saskatchewan River

Plate 2.

Merlin Nest Site in an Upland Aspen Grove

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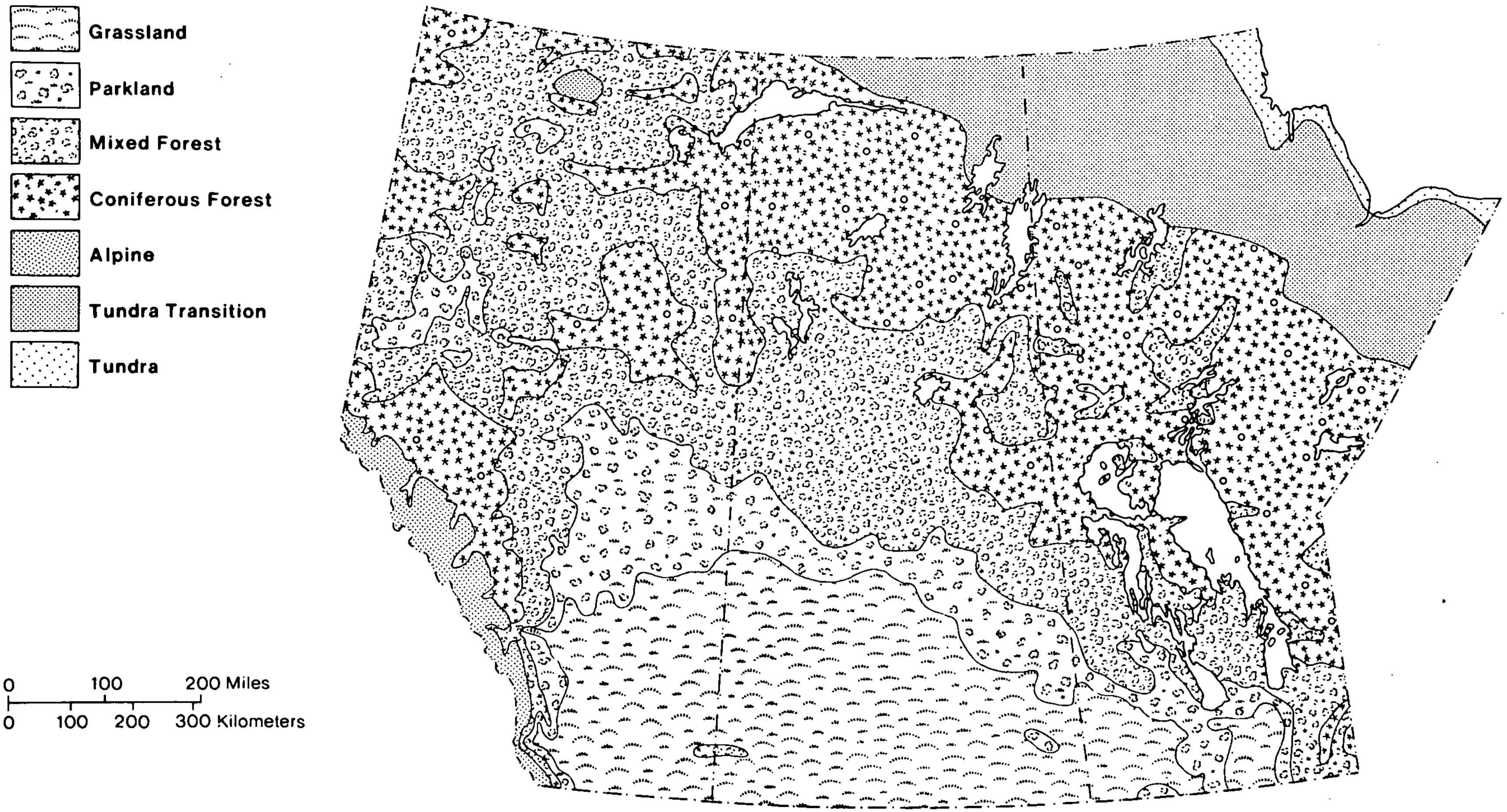
3. MAJOR PHYSICAL AND BIOLOGICAL FEATURES OF THE STUDY AREA

3.1 Physiography

The Great Plains of North America, centrally located on the continent, extend from the Gulf of Mexico to the Arctic Ocean. From south central Canada southward, the plains are prairie. By definition, prairies are stretches of medium to tall grasses in temperate climates with an annual precipitation of between 20 and 40 inches per year; however the popular connotation of prairies is grassland and includes the short-grassed plains or steppes, the tall grassed plains and the sparsely treed grassland-forest transition (savannah). In the Canadian plains provinces (prairie provinces) this "prairie" extends roughly in a triangle bounded on the south by the International Boundary, on the west by the Rocky Mountains, and on the north and east by a line drawn from north of Edmonton, Alberta to the Red River Valley of southern Manitoba (Figure 1). It includes the short grass and mixed grass prairies of Alberta and Saskatchewan, the tall grass prairie of the Red River Valley of Manitoba, and the aspen parkland.

The landscape of the Canadian prairies is not simply the flat and open plain pictured by those unfamiliar with the region, but is a broken and diverse composition of plains and hills and incised river valleys. A basement of Precambrian rock whose origins date back at least two billion years underlie much of the prairie from depths of half mile to over two miles. Periods of inundation by sea waters, sedimentation, retreat of seas, and erosion by warm water and ice are presented in the history of the prairie bedrock and landscape. The impact of Pleistocene ice over the past million years is recorded in nearly all parts of this study area -- in interupted drainage, till sheets, lacustrine soils, sandhills and other terrain features. The

Figure 1. The Vegetation of the Canadian Prairies (after Smith, 1972)



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last retreat of ice began over 12,000 years ago; the varied surficial materials of the wake became the parent materials of the present prairie soils.

Differential melting of the ice resulted in the formation of today's small pothole lakes and sloughs; meltwater cut channels, many of which today, being largely devoid of water, are referred to as coulees. A few upland areas, such as the Cypress Hills and the Porcupine Hills, escaped the work of advancing and retreating ice. The comparatively level macrotopography over which the present prairie vegetation and soil is established slopes from an elevation of about 1200 metres in the southwestern Alberta immediately east of the Rocky Mountains to below 220 metres in northern Manitoba, where it merges with the Precambrian rocks of the Canadian Shield. Numberous upland areas occur on the plains rising 300 to 800 metres above the general surface of the plain. Examples are the Cypress Hills of Alberta and Saskatchewan and Riding Mountain in Manitoba. Many proglacial lakes, now largely drained, left sediments which are level and which are the parent materials of some of the best agricultural soils of the plains. Windsorting of soils, occurring as deglaciation proceeded (and is still occurring in a minor way), has been responsible for extensive loessial loams, blow-out lands, and sandhills.

3.2 Climate

The northerly latitude and the mid-continent location of the prairie provinces accounts for wide fluctuations in temperature and the great variations in precipitation from year to year. The Rocky Mountains to the west impede the flow of mild, moist, Pacific air and place this study area in a rain shadow with limited total precipitation. The Rockies however do not impede but in a sense contribute to the flow of cold air from the north, particularly in winter, and to the flow of warm air from the south in summer. The climate of the study area is one of extremes both in time and location with precipitation that can range from 15.24 cm (6 in) in a dry year to 70.12 cm (28 in) in a wet year in the same location and temperatures which can range from a January low of -45.5° C (-50°F) to a 42.2°C (108°F) July high.

Mean annual precipitation (30 yr normals) over the general area in which the study area is located is 30 cm (11.79 in) and is 50 cm (19.65 in) for the wetter sections -- the Alberta Foothills, the aspen parkland, the Red River Valley, and eminences above the plain such as the Cypress Hills. The region of lowest precipitation is found in the south-central interior of the region on the boundary of south-eastern Alberta and south-western Saskatchewan. Mean temperatures for the prairie region range between -10°C (14°F) and -2°C (-1°F) in January to between 18°C (64.4°F) and 20°C (65.3°F) in July.

A concise account of factors responsible for climatic conditions on the Canadian prairies is given by Laycock (in Smith, 1972).

3.3 Vegetation

The original grasslands of the prairie provinces included the tall grass prairies of the Red River Valley, the mixed grass prairies covering the major portion of the region and extending into the aspen parkland to the north, and the short grass prairie of southern Alberta and Saskatchewan. Today little of the tall grass prairie vegetation remains and much of the mixed grass prairie has disappeared as well for this vegetation has gone under the plow providing some of the most productive cereal lands of the world. The areas of mixed grass prairie and short grass prairie, not suitable for arable agriculture, support a large cattle industry. General descriptions of prairie vegetation are given by Laycock (in Smith, 1972) and by Webb, Johnston, and Soper (in Hardy, 1967); a detailed description for Alberta is given by Moss (1955).

Probably the most complete description of the pristine natural vegetation of the Canadian prairies is that by Watts (1960).

Today the lands of the Pallister triangle in which the study is undertaken are, for the most part, rangelands in the Alberta portion and lands cultivated for cereal production in the Saskatchewan portion. The non-cultivated grasslands of both of these areas are a cover of species maintained by low rainfall, in keeping with the average of 14.64 in (37.19 cm) precipitation per year (based on a 1921-1927 average, Hanna). These grasslands fall largely into the mixed prairie classification of Johnson et al (1970) and are dominated by species of the spear grass-wheatgrass (Stipa-Agropyron) association. On the Alberta side of the study area some lands are established to the shortgrass (Bouteloua-Stipa) association but composition is dependent on the nature of grazing pressure; species such as groundsage (Artemesia frigida) and low sedge (Carex eleocharis) are more common on the more heavily grazed lands. Extensive patches of willow (Salix sp.), wolf willow (Eleagnus commutata), and snowberry (Symphoricarpos occidentalis), as well as other shrubs occur on these grasslands throughout the area. Trees of the grasslands occur in natural groves of poplar (Populus tremuloides) and willow (Salix sp.) around slough margins, and as stands of poplar, willow, and Manitoba maple (Acer negundo) which are the remnants of windbreaks planted about settlers' homesites at some earlier time.

Many of the grassland areas of this region were at one time (see 3.5) under cultivation, abandoned during the depression of the 1920's and 1930's, and through a slow process of natural succession reached their present state of "natural" grassland. Today much of the grassland is again being ploughed under, and reseeded to domesticated alien species such as crested wheatgrass

(Agropyron cristatum) in an effort to increase the productivity of the grassland for livestock husbandry.

3.4 Fauna

Historically, the North American bison (Bison bison) was the most important large mammal in the prairie ecosystem and it ranged over our study area. This magnificant animal suffered a loss of habitat through ranching and farm homesteading and was slaughtered uncontrollably until by 1888 exceedingly few were left, a decimation unprecedented in natural history annals. Today, few bison live outside Elk Island National Park in central Alberta and Wood Buffalo National Park in northern Alberta. These parks were set up, in part, as conservation areas for these animals. To some degree the niche in the prairie ecosystem once occupied by the bison, is, in our study area, occupied by domestic range cattle. When the buffalo disappeared from the prairie as a source of livelihood for native people and settlers alike, the hunting pressure turned on the pronghorn antelope (Antilocapra americana) and the mule deer (Odocoileus virginianus); these likewise were considerably reduced in numbers by the turn of this century. Today, thanks to conservation measures and enforced hunting regulations, pronghorn antelope and mule deer, as well as the whitetailed deer, occur in the general study area and are now common on many parts of the prairies. Kit foxes (Vulpes velox) have disappeared from the prairies, but red foxes (Vulpes fulva) and coyotes (Canis latrans) are common; wolves (Canis lupus), although no longer resident, are seen occasionally when they move south from the northern forests in winter. The prairie grizzly (Ursus arctos horribilis) is today found only in the Swan Hills north of the aspen parkland; mountain lions (Felis concolor) are occasionally seen on the prairies adjacent to the Foothills of the Rocky Mountains. Similarly, moose (Alces alces) normally resident in the mountains have been reported on the grasslands of western Alberta; one such animal was seen by the author in the study area in the summer of 1971.

Small fur-bearing animals such as beaver (Castor canadensis), muskrat (Ondatra zibethica), and mink (Mustela vison) are numerous in many marsh areas of the prairies and provide an important source of revenue for many trappers. Other small mammals include jackrabbits (Lepus sp.) badgers (Taxidea taxus), porcupines (Erethizon dorsatum), groundsquirrels (Citellus sp.), pocket gophers (Thomomys talpoides), bats (Chiroptera), and mice and moles (Microtinae).

For complete lists and natural histories of prairie animals the reader is referred to such works as those of Soper (1964) for mammals, and Salt and Wilk, (1958) for birds.

Bird life is varied on the study area, and on the prairies generally, from spring through fall. The numbers of birds are not many in winter but increase greatly each spring with migrants. Of the many migrants of the prairies the best known are the multitudes of waterfowl that cloud the skies each spring and fall. Prairie raptors include many species that breed there, as well as many others which winter there, or pass "through" in migration. Among the more notable summer residents are Golden Eagles (Aquila chrysaetos), Feruginous Hawks (Buteo regalis), Prairie Falcons, and Richardson's Merlins. Gallinaceous birds include Sharptailed Grouse (Pedioectes phasianellus) of the plains, Ruffed Grouse (Bonasa umbellus) of riverine thickets, and the introduced Pheasant (Phasianus colchicus) common in and near cultivated land.

3.5 Agriculture

It is possible to review the impact of white men on the study area, and on the prairies generally, in many contexts. Inasmuch as agricultural impact on Merlin habitat is so apparent and far reaching, and since the recorded history of the study area is largely agricultural, the account which follows emphasizes agricultural development as summarized by Gray (1967).

The study area near Hanna, in southeastern Alberta, and Kindersley, in southwestern Saskatchewan, lie in what has been called the Palliser Triangle (Figure 2). It was named after the first explorations of this area by Capt. John Palliser in the period 1867-1870. In his surveys, Palliser concluded that these lands were a northern extension of the Great American Desert and would never support a viable agriculture; his forecast, made without a surmise of 20th century technology, was in part wrong. Palliser's journeys were mainly on the periphery of the study area; his surveys made in a series of dry years, and accordingly his judgement of the quality of the land to produce crops was based on a superficial acquaintance. While Palliser's Traingle did include millions of acres of land which should not have been broken by the plow, it included millions of acres suitable for dryland cereal production. Palliser's judgement of the agricultural potential was on the whole correct considering the state of agricultural technology of the day, for cereal varieties and dryland farming techniques, for a northern prairie agriculture, had not evolved in North America. It was the introduction of summer fallowing by the Federal Indian Head Agricultural Station, Saskatchewan, in 1885, however, that turned the Palliser Triangle into a productive breadbasket.

In the system of summer fallowing, crops are grown every second or third year; between the crop years the land is ploughed and cultivated to prevent weed growth and to produce a summer dust mulch, measures which conserve soil moisture. The moisture that accumulates during the fallow years can be used during the ensuing crop year. Summer fallowing made the growing of

Figure 2. The Palliser Triangle -- denoted by coarse vertical lines.

(after Dawson and Younge, 1940)

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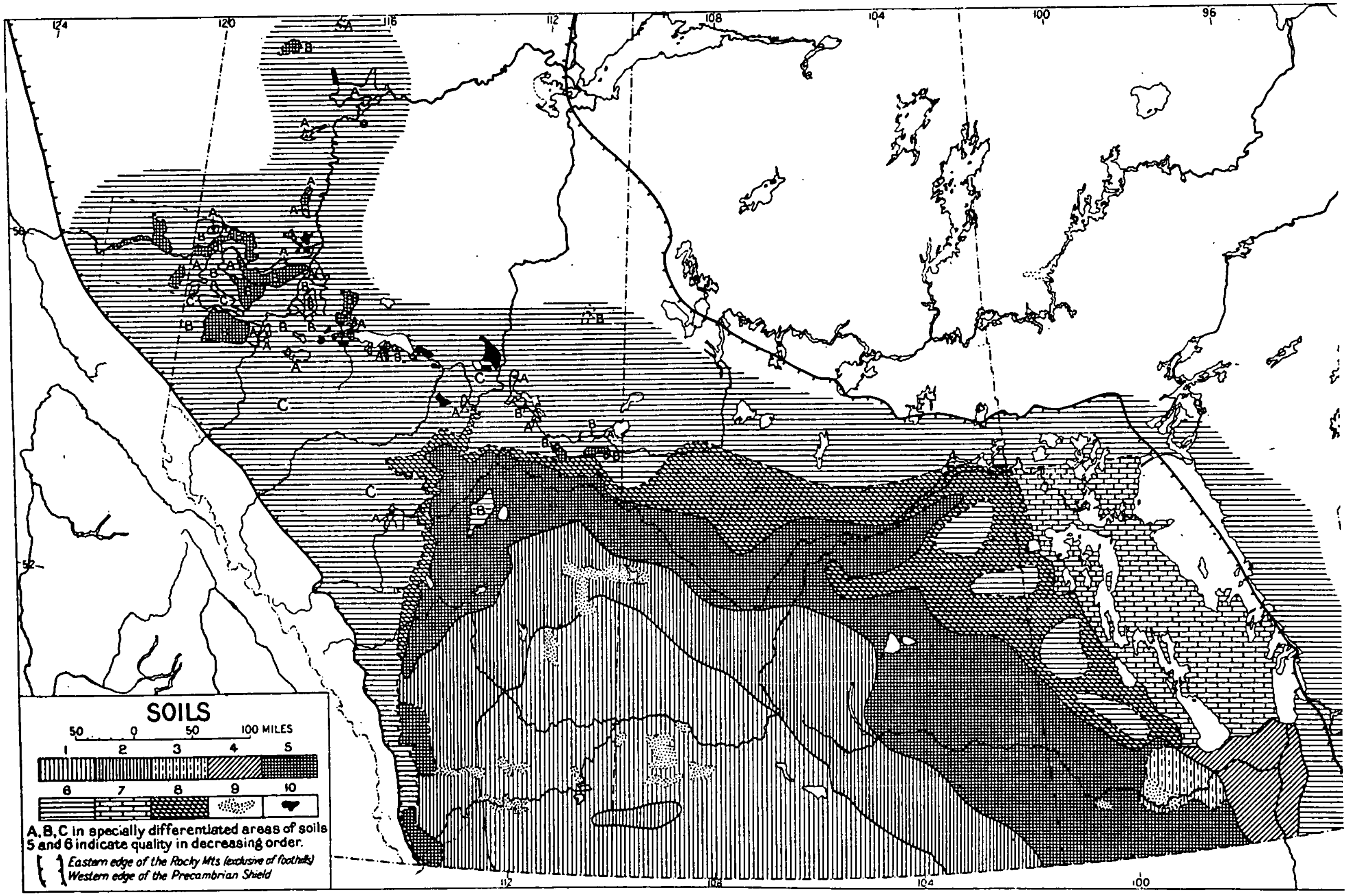


satisfactory crops possible where without it none would be possible. However, in a succession of extremely dry years, in the study area, even summer fallowing can not conserve enough moisture to produce a crop, and the finely tilled mulch becomes increasingly subject to wind erosion. In the droughts of the 1920's and 1930's, it was the bone-dry land in the summer fallow which blew away.

Prior to the turn of the century there was a growing fear that the Palliser Triangle area would be taken into the United States of America. As the rush of American homesteaders into the American west closed old buffalo pastures to the cattlemen, American ranchers were forced westward and northward. The wide open and unsettled spaces of the Palliser Triangle, on both sides of the border, looked inviting to the displaced beef producers. As the American ranching industry drifted north of the border, an aggressive Canadian settlement policy developed by Sir Clifford Sifton, then the Minister of the Interior of the Canadian government, urged that lands of the Palliser Triangle be farmed by Canadians and non-Americans. Between 1896 and 1914 the Dominion Government gave away millions of acres of homestead lands and the railways and land companies sold millions more.

Immediately upon the declaration of war on August 14, 1914, a great drive was launched by the Dominion Government to bring more land under cultivation; over 4,800,000 additional prairie acres were brought into cultivation in 1915. The pressure for more grain production kept up for the next four years and 12,000,000 cultivated acres were added to the cultivated total on the prairies; of this more than 5,500,000 acres were broken in the Palliser Triangle.

The season of 1915 was notable for the high per acre grain yields and the fabulous crops did much to stimulate settlement; yields of 30 to 40 bushels of wheat to the acre were common in the Palliser Triangle and the average yield of 25 bushels was destined to be a record for 40 years. The big crop of 1915 spelled tragedy for the shortgrass prairies of the Palliser Triangle though, because it resulted in the breaking of thousands of acres of submarginal land. Crop failure followed crop failure on marginal lands in 1917, 1918, 1919 and 1920.

In southeastern Alberta movement of settlers out of the country bordering Saskatchewan became almost a stampede between 1921 and 1926. The 1926 census recorded more than 10,000 abandoned farms, half of them were north of Medicine Hat and in the area of this study. The Agricultural Extension Department in Alberta reversed its previous policy of emphasis on grain and little emphasis on livestock to one of livestock first and grain second and began an active program of de-population in 1926. Families desiring to emigrate from the stricken land were given free passage, and train load after train load of destitute farmers were transported to the north and to the west. Gradually a large part of eastern Alberta was taken out of grain growing and returned to grasslands by largely "autogenic" processes. In 1927 a Special Areas Board was set up in Alberta to manage those lands in the south-east where much land had been deserted and reverted to the crown. The patterns of settlement and land abandonment are reflected in the changes in human populations, in the Federal census, 1906-1971, for my study area (Table 1).

In the Kindersley, Saskatchewan, area the brown soils are,of all the soils of the Palliser Triangle, most suited to the growing of grain; in addition, de-population was not encouraged in this area by the Saskatchewan government. Consequently, many people remained on the land on the Saskatchewan side of the border and the struggle to produce crops continued into the dreadful

TABLE 1. CHANGES IN THE HUMAN POPULATION OF THE CENSUS DIVISIONS OF THE STUDY AREA

	1906	1911	1921	1931	1941	1951	1961	1971
Hanna, Alta. Division	479	16,984	30,678	25,261	15,920	13,182	15,020	12,991
Kindersley, Sask. Division	1,111	12,480	35,483	42,632	36,346	30,721	32,994	30,947

(From: Canada Census)

years of the 1930's.

The depression of the 1930's brought an economic disaster of equal magnitude to the continuing physical disaster of drought. The calamatous collapse of farm prices between 1930 and 1933 reduced farm purchasing power to near zero, and the prices for crops that were produced barely paid for their transportation to market. On top of weather and economic adversities, there were plagues of insects (grasshopper, sawfly etc.) and blights of plant disease (wheat rust, cereal smuts etc.) to face. Until the grasshoppers descended in clouds in 1933 a good crop was in the making in parts of the Palliser Triangle. A good crop was in prospect too in 1935 until the rust attacked...

By the late 1930's a glimmer of hope appeared with the return of the rains and the bettering of the world economy; gradually the battle against drifting topsoil was won with new farming techniques and extensive reseeding; the fight against insects gained the upper hand thanks to new and innovative control programs, and the problem of wheat rust was largely overcome by the development of rust resistant strains of wheat. By the 1940's the "battle had been won" and the part of Saskatchewan in our study area was returning to an agricultural economy based again largely on the growing of wheat and other cereals.

4. METHODS

4.1 Merlin Surveys, 1971-74

Following the 1968 observation of a pair of Merlins nesting in the ranching country of southern Alberta near Hanna, a reconnaissance survey for nesting Merlins was undertaken in 1969 by the Canadian Wildlife Service; in this survey 14 pairs were found nesting. In 1970 a more intensive survey located 23 pairs nesting. The area along the South Saskatchewan River system in Alberta also was surveyed in this same season and 30 pairs were found. Following the location of these two sizeable populations a study by Canadian Wildlife Service of the "dynamics" of Richardson's Merlin was proposed; in 1971 this study was begun. During the author's absence in Africa in 1972 the study was undertaken by Mrs. Lynne Kemper under contract to the Canadian Wildlife Service.

The data presented in this report is based on Merlin surveys by vehicle and by river boat undertaken in 1971, 1972, 1973 and 1974. The data are derived mainly from two areas in southern Alberta viz. a portion of the ranching country about Hanna, Alberta and the area along the South Saskatchewan River as it flows through Alberta. River survey included a short stretch of the Bow River upstream from its confluence with the Oldman River; the confluence of the Bow and Oldman marks the beginning of the South Saskatchewan River. In each year these areas were surveyed thoroughly, all occupied sites were mapped, and all active nests were "climbed" to determine reproductive success and to gather other information.

Banding of young Merlins and trapping and banding of adult Merlins at nest sites provided some limited information on fidelity of pairs and re-use of nesting sites by Merlins from year to year.

Although Merlins now do not inhabit the Kindersley area of Saskatchewan, all sites in the Kindersley area of Saskatchewan, where Merlins had been nesting in the 1960's and 1970's, were checked in 1972 and 1974. No nesting Merlins were found. A pair was found in 1972 near the Alberta border which began two clutches but which hatched no eggs, and another pair was found nesting in Saskatchewan near the South Saskatchewan River. Fox (1971) reported that for the Kindersley area the last reported nesting was in 1962 and Merlins have not been found since then by R. Fyfe (personal communication) in periodic checks.

Throughout the Merlin surveys records were kept of features of each nesting site which were deemed to affect nesting Merlin. The type of recording is given in Appendix 9.2. From an analysis of these data, at least some of the habitat requirements of Merlins may be perceived and comparisons of sites in use with sites no longer in use can be made. During these surveys prey remains were collected from Merlin nests and associated plucking perches for later identification. A collection of bird skins of prey species made on the study area aided in the identification of prey remains.

4.2 Land Use Classification

Land use patterns since 1945-1950 were determined through interpretation of aerial photographs. Three series of photographs were used both for Alberta and for Saskatchewan. For Alberta, photographs used were a first set made between 1949 and 1952, a second set made between 1962 and 1965, and a third set made in 1971. The corresponding series of photographs from Saskatchewan were a first set made in 1946, a second set made between 1956 and 1961, and a third set made in 1971. Forty Merlin sites occupied near Hanna, Alberta during this study period and 15 sites of Merlins known from the area of

Kindersley, Saskatchewan were studied in their respective periods of photo availability. Thirty-nine sites along the South Saskatchewan River were also studied in a set of photographs from 1971.

The area within a one mile radius around each Merlin site was mapped into areas of rangeland and cultivated land. A further classification of rangeland was not possible with the scale of photography available. From photo interpretation a picture of land use change, over a period of about 25 years, was obtained and a comparison between land use changes at Merlin sites in use in Alberta and land use changes at Merlin sites no longer in use in Saskatchewan was possible.

An overview of land use changes in both Alberta and Saskatchewan can be derived from statistics in Canada Year Books, based on the ten year census. Statistics on land use for Census Divisions in which study areas in each province fell were organized for comparative scrutiny.

Present land use patterns were determined by the simple mapping about Merlin sites in use in the Hanna area. From _a priori_ Merlin behaviour observations it was believed that Merlin were hunting up to one mile away from their nesting sites, and for this reason an area of one mile radius about nest sites was mapped. A representative collection of common and dominant plant species was made at Merlin sites under consideration. When a detailed classification of rangeland in the Hanna area of Alberta was contemplated it was quickly evident that the rangeland in the Hanna area of Alberta fell into the mixed prairie category (Johnson _et al._ 1970), with differences observed in the rangeland due to differential grazing by livestock.

The South Saskatchewan River area study was different from that of

Hanna in that very little land was under cultivation. This area too falls into the mixed prairie and shortgrass prairie classification of rangeland and is very largely subjected to livestock grazing; however, the species composition of this area differed somewhat from that of Hanna as a representative collection of common and dominant plant species made along the South Saskatchewan River will show. The Suffield Military Reserve along the South Saskatchewan River, except for some concessions, has not experienced livestock grazing for many years.

4.3 The Impact of Pesticides

Work carried out since 1969 for the Canadian Wildlife Service has taken a special interest in the effects of pesticides on Merlins. As aforementioned, Merlins, like other raptors are at the "top" of the trophic pyramid and tend therefore to consume the accumulation of certain chlorinated hydrocarbons, which degrade very little in the trophic chain. A sample of eggs was collected each year and analysis of residue of DDE, dieldrin, heptachlor epoxide, and mercury in them was made. DDE is a breakdown metabolite of DDT which occurs very shortly after its entry into biological tissue. An eggshell index, termed the Ratcliffe Index (Ratcliffe, 1967) was determined for each egg. The outer dimensions of eggs collected were measured, and then the contents were sent to L.M. Reynolds of the Ontario Research Foundation to be analyzed for pesticide residues by gas chromatography. This analysis was done for the Canadian Wildlife Service as a part of the C.W.S. pesticide residue monitoring program. For a complete description of analysis procedure refer to Fyfe, et al., 1969.

Eggshells from samples collected had membranes removed, were washed, and were then allowed to dry at room temperature. Once dry, the shells were weighed to 0.01 g. From eggshell measurements and weights, the Ratcliffe Index was determined for a comparative measure of eggshell density. This index, defined by the formula

$$RI = \frac{\text{weight (mg)}}{\text{length X width (mm)}}$$

has been used widely in recent comparative studies of eggshell characteristics in raptors, (Cooke (1973), review).

Pesticide and residue data were obtained for the years 1968-1973 (unpublished C.W.S. residue data). Using residue levels and eggshell indices, statistical analyses were run to test the correlation between increasing pesticide residue levels and decreasing eggshell density or thickness. In order to test the association between pesticide residue levels and egg hatchability, residue levels in eggs collected from nests in which young had subsequently hatched were compared with levels in eggs from nests which failed to hatch young. Also, eggs collected at random were compared with "dead eggs" (eggs which failed to hatch). As a part of the C.W.S. residue monitoring program, average residue levels for each year in which eggs were collected gave an indication of the changes in level of pesticide contamination in the prairie environment (Appendix 1).

The effects of the use of herbicides was not considered in this study Herbicides have not been widely used in the prairie environment, although as more areas of grassland are put into cereal production the use of herbicides will increase. Use of 2-4-D and related chemicals may have an effect of reducing seed-bearing "weed" species that support some grassland birds.

5. OBSERVATIONS AND RESULTS

5.1 Population Dynamics of Richardson's Merlin

5.1.1 Merlin populations in Southern Alberta, 1971-1974: Some aspects.

In the surveys undertaken in the 1971, 1972, 1973 and 1974 seasons (see 4.1) information was obtained on the use of nesting sites. Occupancy of a Merlin site was determined by the presence of adults and their vocal and aggressive behaviour. In many cases the occupancy of a site was evident prior to egg laying but the basic test for site use was the laying of eggs. In Table 2, a result of four years observations, it is recorded that 70.9% of sites occupied were used for egg laying and 54.9% sites used saw young reared to fledging age.

All immature Merlins studied since work began in 1968 were banded if and where possible; by 1974 over 500 had been banded. In addition, from 1970-1974 159 adult Merlins, all that could be trapped, were banded; of these, 25 adults carrying bands have been retrapped at active Merlin sites and from these recaptures some comments can be made.

From the nesting and banding observations it seems highly probable that pairs part each year and only by chance mate again in ensuing years. It is also highly probable that males return to the same site in successive years while females do not. Of 12 adult male trap-recaptures, 9 were on the same site, 2 were less than 2½ miles away from their earlier occupancies and one was 8 miles away. The one capture of a male, banded as a nestling, was also at a location 8 miles away from where it was banded. By comparison, of 10 adult female trap-recaptures, only 2 were captured on the same site, another 3 were captured over 10 miles away, 3 were captured between 10 and 20 miles away, and 2 were captured more than 75 miles away from the banding site.

TABLE 2. OCCUPANCY AND USE OF NEST SITES BY RICHARDSON'S MERLIN 1971-1974

Year	Area	# Sites Occupied[a]	% Active Sites[b]	Nesting Success-Active Sites		Fledging Success	
				% Hatching	% Fledging	% of Successful Sites[c]	% of Occupied Sites
1971	Hanna	33	69.7(23)	78.3(18)	73.9(17)	94.4(17)	54.5(18)
1972	Hanna	38	78.9(30)	53.3(16)	50.0(15)	93.8(15)	42.1(16)
1973	Hanna	31	60.6(25)	48.0(12)	44.0(11)	91.6(11)	41.9(13)
1974	Hanna	34	79.4(27)	81.4(22)	77.7(22)	94.4(21)	61.7(21)
Mean	Hanna		77.2	65.3	61.4	93.3	50.1
1971	SSR*	34	67.6(23)	69.5(16)	47.8(11)	68.8(11)	32.3(11)
1972	SSR*	37	56.6(21)	47.6(10)	42.9(9)	80.8(8)	24.3(9)
1973	SSR*	35	62.9(22)	59.1(13)	45.6(10)	76.9(10)	28.6(10)
1974	SSR*	49	71.4(35)	68.5(24)	57.1(20)	83.3(20)	40.8(20)
Mean	SSR*		64.6	61.2	48.3	77.4	31.5
Mean Hanna & SSR*			70.9	63.3	54.9	85.3	40.8

* South Saskatchewan River

a Sites with pairs present prior to egg laying

b Sites with pairs producing eggs

c Sites with pairs hatching out young.

Two female Merlins banded as nestlings were retrapped as nesting adults, one 14 miles away and the other 96 miles away from the banding sites.

There were a total of 22 merlins trapped as adults that were retrapped at a later date, of these, 16 were recaptured the year after banding, 4 were recaptured the second year after banding, and 5 were recaptured the third year after banding.

Of the three birds banded as nestlings and captured as breeding adults, one was captured the year following banding, one was captured as a breeding female at two years of age; and the third, a male, was captured as a breeding bird at three years of age.

The nesting data for the Hanna area and the South Saskatchewan River area are given separately in Table 2 since the nesting sites grouped fairly well into two. However, movement of birds from area to area does exist as indicated by the recapture of two breeding females. One bird was trapped as a breeding bird along the South Saskatchewan River and was retrapped one year later near Hanna. The second bird was banded as a nestling on the South Saskatchewan River and retrapped the following year as a breeding bird near Hanna. This last bird is notable in that it was evidently breeding at one year of age while most raptors, it is believed, come of breeding age in their second or third years. It may be of interest to mention that one male trapped as a breeding bird was also evidently breeding at one year of age, as judged by its plumage. The words "evidently breeding" are used since there has been some suggesting that these birds may only be replacements for the bird originally nesting at that site after some misfortune has befallen a member of a pair. This view however has not be substantiated through any observation.

5.1.2 Merlin Productivity

Table 3 contains "reproductive" data by year and by region. In compiling this table, two assumptions were made: 1) nests in which 5 eggs hatched or 5 young fledged had clutches of 5 eggs, except in cases where 6 eggs were actually seen, and 2) birds reaching banding age were considered to have reached fledging age, unless it was noted otherwise. Productivity was 4.58 eggs per nest with eggs and 3.23 young fledged per nest with young fledging (averages over the four years), Fox (1971) during the period of the Kindersley merlin decline gives a comparable figure of 2.7 young per nest (Table 4) for prairie nesting merlins. Net productivity is the number of young produced per total nest sites occupied, whether in fact each nest site produces young or not. This would be a sensitive indicator of the state of health of the population, but has not been used because most studies of raptors have not followed through on the nesting cycle from its beginning, and only gives figures for the number of sites successful in producing eggs or young. In this study, a net production of 0.69 fledging young per nest site occupied was determined.

5.2 Factors Affecting Merlin Populations

5.2.1 Weather

The lowest productivity in the four years of this study occurred (Table 3) in 1973 in the Hanna area. This can be attributed to a storm occurring between June 13 and June 15. During the two weeks prior to this storm all nests in the Hanna area had been checked for hatching, as many

TABLE 3 PRODUCTIVITY OF RICHARDSON'S MERLIN, 1971-1974

Year	Region	1 Eggs per Nest	2 Hatch per Nest	3 Fledglings per Nest	4 Eggs for Analysis	5 Hatching Success %	6 Fledging Success%	7 Net Productivity
1971	Hanna	4.85(19)	3.77(17)	3.58(17)	15	67.7	95.1	0.89
	SSR*	5.11(9)	3.89(9)	3.57(7)	7	72.5	81.0	0.77
1972	Hanna	4.24(29)	2.88(17)	2.94(16)	26	**	**	**
	SSR*	4.81(16)	2.68(6)	3.22(9)	13			
1973	Hanna	4.00(18)	3.08(12)	2.73(11)	9	26.8	73.0	0.61
	SSR*	4.30(10)	4.68(6)	3.56(9)	4	73.7	86.4	0.90
1974	Hanna	4.76(25)	3.52(21)	3.30(20)	10	62.2	89.2	0.80
	SSR*	4.57(30)	3.64(19)	2.90(19)	14	44.1	81.4	0.63
Mean 1971-1974		4.58(156)	3.51(107)	3.23(108)	98	57.8	84.4	0.69

1. of nests with eggs
2. of nests with hatching
3. of nests with fledging
4. removed prior to hatching, i.e. apparently viable
5. of eggs laid
6. of young hatched
7. # fledglings/nest site occupied

* South Saskatchewan River

** No comparable data.

TABLE 4. REPRODUCTIVE SUCCESS OF PIGEON HAWKS

		Eggs Per Nest	Young[a] Per Nest	Hatching Success %	Hatching[b] Failure %
Great Plains	pre-1950	4.7(10)[c]	4.3(3)	92	0(3)
Forested	1950-1969	4.1(9)	4.0(16)	98	13(16)
Prairie	1950-1969	4.5(10)	2.7(17)	49	41(17)

a. young of any age; thus the minimum # eggs hatched

b. percent of nests with advanced young which contained one or more unhatched eggs

c. sample size

(adopted from Fox, 1971)

nests were just at the hatching stage. The storm lasted for two days, during the period the winds gusted to more than 50 mph, over 4 inches of rain fell in the study region, with some nearby areas reporting up to 8 inches, and the daily maximum temperature fell to 52^{o} (Figure 3), the lowest of the month. Following this storm, over a 5 day period, all nests were again checked, with the following findings:

Active nests prior to storm	26
Active nests after storm	15

Two nests, still active, were found with both live young and dead young; one of these nests had one dead and one had two dead young.

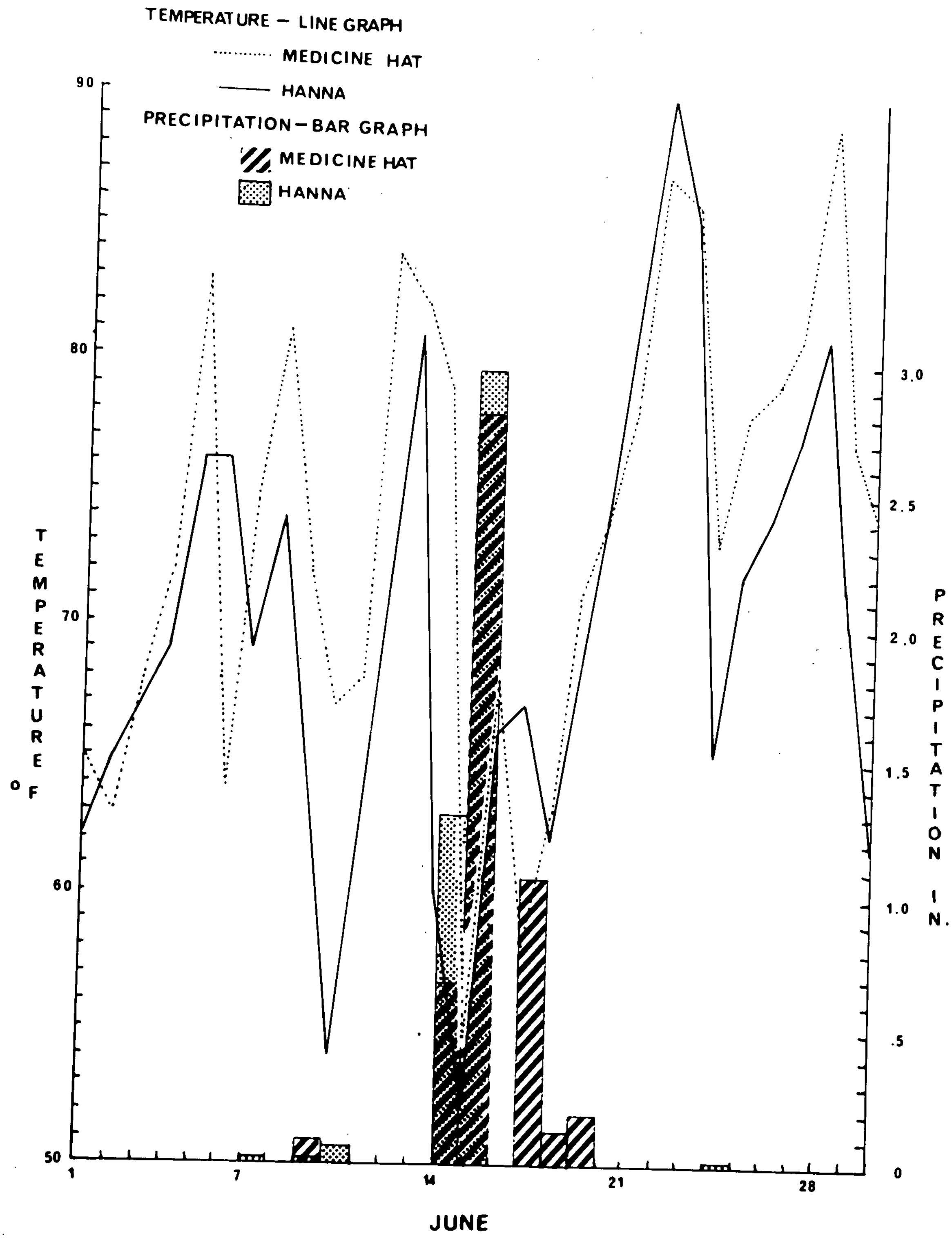
Of the eleven nests no longer active, one was found with two dead young, six were found with cold and dead eggs, two were found with eggshell remnants (indicating that something, probably crows, had already found the deserted nest), and two nests were empty.

Other species living at the same nesting sites as the Merlins also suffered losses from the storm. Five magpie nests, two with three dead young and three with one dead young were found: two crow nests, one with five cold dead eggs and one with 4 dead young were found and two feruginous hawk nests, both with one dead young were found. Beneath one feruginous hawk nest a dead adult feruginous hawk was found, apparently have succumbed during the storm.

One Merlin nest had been blown fifteen feet out of the nest tree and the Merlin eggshells were found twenty feet beyond.

A report referrring to the affects of adverse weather on raptors is that by Rauchenbauch (1969) in which he discusses raptor populations in West

Figure 3. Temperature and Precipitation for Hanna and Medicine Hat, Alberta, June, 1973. (Data from Environment Canada Atmospheric Environment Service)


TEMPERATURE – LINE GRAPH
MEDICINE HAT
HANNA
PRECIPITATION – BAR GRAPH
MEDICINE HAT
HANNA
90
80
70
60
50
TEMPERATURE °F
3.0
2.5
2.0
1.5
1.0
.5
0
PRECIPITATION IN.
1
7
14
21
28
JUNE

Germany. He writes (translation): "Of a total of 43 checked buzzard clutches, 26 were deserted, and in the rest of the "successful" ones - - 9 young died in the nest. Only 18 young were fledged. That gives the average of 0.4 fledged young/clutch started. Most of the clutches failed during (due to) a five day rainfall, even though the four to five week old young were already almost all feathered".

It must be noted that, despite having experienced much the same conditions during the storm under consideration, the Merlins along the South Saskatchewan River seem not to have suffered from the bad weather conditions. Indeed, the hatching success and fledging success of Merlins in 1973 along the South Saskatchewan River were the highest of the three years for which data were available. Three reasons are advanced to explain why this might have been so: first, Merlins nesting along the South Saskatchewan River consistently nested up to a week earlier than those around Hanna, judging from the development of young Merlins: eggs therefore in nests along the river would have hatched prior to the storm; secondly, most of the trees in which Merlins nested along the river were along the shore in the river bottom and therefore out of the main blast of high winds; and thirdly, Merlins nesting along the South Saskatchewan River were nesting in big trees with much leaf cover, and in dense stands which would serve as protection against the elements; nest trees around Hanna by comparison were much smaller, often sparsely leafed, and offered little protection against the elements.

5.2.2 Predation

Predation of nests by crows is felt to be an important factor affecting nesting success in Merlin populations. Throughout the spring of

1971 53 ½ hours were spent in a blind observing a pair of Merlins; instances of the Merlins fighting with crows which came too near their nest were recorded 56 times. These Merlins were attempting to nest in an open feruginous hawk's nest, an attempt which failed some time during the period of egg laying. It is suggested that the crows finally succeeded in breaking through the Merlin's defences during the egg laying period and had destroyed the clutch.

At another nest a clutch laid by May 1 had disappeared by May 19 and a second clutch was begun in a nearby nest by May 27. Numerous fights with crows were observed with this Merlin pair. By July 4, four of the eggs had hatched and a fifth was pipping. On that day the nest was being observed from a distance, and a pair of crows and their offspring were seen approaching the Merlin site with obvious intent. One particularly determined crow was about to raid the nest when it was beset by the Merlins who drew feathers from the crow in the process of driving it away. Nearby most sites in which Merlins were nesting crows were also nesting.

Never was there any indication of nest predation by magpies or of quarreling between these birds and Merlins.

Great horned owls are probable predators of Merlins. One nest which Merlins were using in the spring of 1971 had only a great horned owl regurgitated pellet in it the first week of July. At another site the incubation of eggs ceased about half way and only the female was to be found. On close inspection of the site, feathers and a wing of the male Merlin was found. The marked antagonism of Merlins for great horned owls was very evident in any encounter between the two species; it is this antagonism which provided the means for drawing adult Merlins into a trap for banding.

5.2.3 Human Disturbance

The first form of human disturbance considered in this study was that caused by personal visits to nesting sites for the purpose of scientific study. It must be stressed that in all visits to nests in this study, care was taken to keep duration of visits to a minimum, and these were not made if weather conditions were adverse. For all nestings recorded over the period of this study no relationship between the number of visits to a near site and the nesting success of that pair could be established. It is felt that if consideration is given to the critical periods of egg laying and egg hatching and visits are of minimum duration during early development, visits to nests by researchers have no significant effect on nesting success.

A more direct effect on Merlins that cannot be ignored is that of shooting. At one nest site four young people were caught in the act of shooting a hen Merlin that had been successful in raising 5 young. The transferal of these young to other occupied Merlin nests nearby was effected. Subsequent inquiry indicated that travelling from isolated grove to isolated grove to shoot crows, magpies, and other "vermin" including hawks, was a widely practised diversion for many people on Sunday afternoons in the Hanna area. Further checks of Merlin sites on the same day the shooting referred to above occurred revealed three sites with dead crows that had been shot recently. At one of these sites where a Merlin nest had had young a few days earlier, adult or young Merlins were not to be found. With Merlins so vocal and obvious at nesting sites the effects of a few such shooters on Merlin numbers is very serious. It was only a few years ago that annual "vermin" shoots were held in the Hanna area; the particular targets were ground squirrels and hawks but doubtless other species were shot. Discussions with members of the Rod and Gun Club, and sporting goods store operators were held and now most show very favourable attitudes towards raptors; many local ranchers, particularly, voice their criticism of weekend shooting by people from local towns on their rangelands. It is by the towns' people mainly that shooting probably will continue to take a toll of nesting Merlins.

5.2.4 Pesticides

The correlation analysis of residue levels and Ratcliffe Indices favours a significant relationship between DDE residues and Ratcliffe Indices ($r = .369$); no relationships between Ratcliffe Indices and dieldrin, heptachlor epoxide, or mercury residues were indicated (Table 5). A cause and effect relationship is strongly indicated by the highly significant regression of log. DDE against Ratcliffe Indices ($p < .01$) (Figure 4). (For justification of the use of log DDE, see Blus *et al.*, 1972).

Eggs collected from 1971 until 1974 for pesticide analysis, were put into two categories, (a) those collected at "random" some time during incubation, and (b) those collected after hatching which had failed to hatch (Table 6). A significant (negative) relationship between DDE levels and nest success was indicated, but none with other pesticide residues.

Eggs collected from nests where eggs were left for incubation were also put into two categories, (a) those from nests which succeeded in hatching the remaining egg(s), and (b) those from nests which did not succeed in hatching any egg (Table 7). A highly significant relationship between hatching failure and levels of DDE and dieldrin is indicated.

TABLE 5. A COMPARISON OF PESTICIDE RESIDUE LEVELS AND RATCLIFFE INDICES FOR RICHARDSON'S MERLIN EGGS.

Pesticide Residue[1]	Average	Standard Deviation	Correlation Coefficient
DDE	14.73	18.14	-0.3693
Dieldrin	0.67	0.74	-0.06519
Heptachlor Epoxide	0.61	0.75	-0.01641
Mercury	0.19	0.20	-0.01513

1 in parts per million (ppm) wet weight.

Figure 4. Simple Regression Graph -- DDE as the Dependent Variable and Ratcliffe Indices as the Independent Variable.

DDE - parts per million wet weight (logarithmic scale)

$t = -5.089$

$p < .01$

Data from unpublished files of Canadian Wildlife Service, Edmonton.

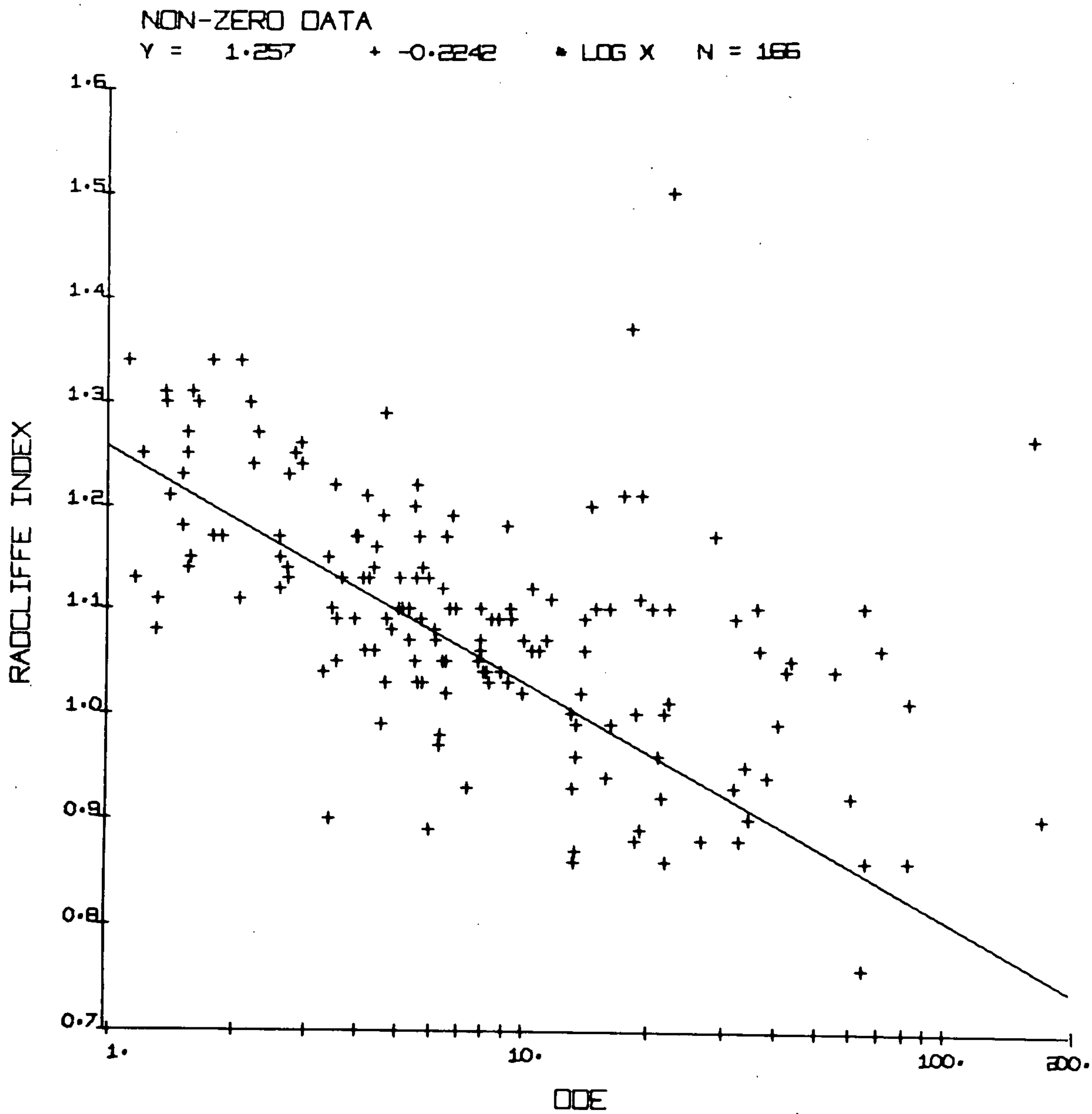

NON-ZERO DATA
Y = 1·257 + -0·2242 * LOG X N = 166
1·6
1·5
1·4
1·3
1·2
1·1
1·0
0·9
0·8
0·7
RADCLIFFE INDEX
1·
10·
100·
200·
ODE

TABLE 6. A COMPARISON OF PESTICIDE RESIDUE LEVELS IN MERLIN EGGS COLLECTED DURING INCUBATION AND EGGS COLLECTED DEAD AFTER INCUBATION

Pesticide[1] Residue	Mean Resudue Level in Eggs Collected		Probability[2]
	During Incubation (ppm) N=112	Dead after Incubation (ppm) N=40	
DDE	12.83	24.66	0.03
Dieldrin	0.59	0.70	0.41
Hept. Epox.	0.56	0.46	0.27
Hg.	0.19	0.20	0.93

1 residue data from unpublished files of Canadian Wildlife Service, Edmonton.

2 probability: probability that differences between equal means would be as great as the observed through chance alone.

TABLE 7. A COMPARISON OF PESTICIDE RESIDUE LEVELS IN EGGS FROM "SUCCESSFUL" NESTS AND EGGS FROM "UNSUCCESSFUL" NESTS.

Pesticide *	Mean Residue level in Eggs from		Probability[3]
	Successful Nests[1] (ppm) N=78	Unsuccessful Nests[2] (ppm) N=53	
DDE	9.97	26.81	0.001
Dieldrin	0.54	0.83	0.02
Hept. Epox	0.54	0.60	0.66
Hg.	0.19	0.19	0.93

1. Successful Nest: a nest that hatched any eggs
2. Unsuccessful Nest: a nest which failed to hatch any eggs
3. Probability: probability that differences between equal means would be as great as the observed through chance alone

* Residue data from unpublished files of Canadian Wildlife Service, Edmonton

5.2.5 Disease

In a nest in a tree near the South Saskatchewan River two healthy young Merlins about three weeks old were found along with a third in a very weak condition. The sick bird was taken for care and a canker similar to that caused by the protozoan parasite Trichomonas gallinae in other raptors was found adhering to the tongue and mouth lining; this condition is known as "frounce" and is quite well known to falconers. It is fairly common in pigeons and domestic fowl. Recently, its treatment with the drug "Emtryl" (Dimetridazol) has proved very successful in raptors, and so the Merlin was treated with this drug. Within four days of the beginning of treatment the canker had disappeared and the Merlin had regained enough strength to take food without being force fed.

5.2.6 Land use change

One prime factor affecting the prairie Merlin population is man-induced land use change. Sources of information used to portray land use change in the study area come largely from the Canada Census reports, 1941 to 1971 (Table 8), aerial photographs (Table 9), and records of the Special Areas of Alberta Board's minutes (Table 10).

A substantial expansion of agriculture between 1941 and 1971 in the Kindersley area from which Merlins have vanished, as compared to that of the Hanna area where they still exist, can be seen in Canada Census statistics. By the end of this period the Kindersley area had at least 67% of land under cultivation as compared to 26% for the Hanna area. A 12% increase at least in cultivation during this period is indicated for the Kindersley area as compared to only 4% for the Hanna area. Air photo study of specific areas now or in the past known to be Merlin sites show a similar difference in land

TABLE 8. The Areas Under Cultivation[1] in the Census Divisions of the Study Area

	1941	1951	1961	1966	1971
Hanna, Alta. (acres)	1,133,506	1,338,255	1,331,823[2]	1,397,513	1,408,079
%	23.1	27.2	25.02	25.8	26.4
Kindersley, Sask.(acres)	2,431,338	2,480,875	2,830,066	2,883,959	2,886,171
%	55.5	56.7	64.7	65.8	67.5

from Canada Census Statistics

1 crop and fallow
2 reduction due to enlargement of Census Division

TABLE 9. Percentage of Areas under Cultivation[1] Within Merlin Hunting Territories Based on Studies of Air Photos taken between the 1940's and the 1970's.

Hanna, Alberta	Kindersley, Saskatchewan
1949	1946
15	51
1962-65	1956-61
21	48
1971	1971
22	58

1 cropland and hayland (cultivated)

TABLE 10. The Acreage Under Cultivation (Permit and Lease) in the Special Areas of Alberta

	1963	1964	1966	1967	1968	1969	1970	1971	1972
Acres	275,122	273,579	270,470	273,587	273,741	274,885	275,356	391,688	391,155
% of Total*	3.5	3.5	3.5	3.5	3.5	3.5	3.5	5.0	5.0

* Special Areas Total Acreage 7,838,826 acres
(Stewart and Porter, 1942)

from Special Areas of Alberta
Board's Minutes

use between the two areas (Table 9); viz. 58% of the territory was under cultivation in the Kindersley area, as compared to 22% for the Hanna area.

In the Kindersley area a 3% decrease in cultivated land from the 1940's to the 1950's is apparent in air photos (Table 9). This is because 3 of the 14 Merlin sites studied in 1946 air photos appeared as totally cultivated ateas. During the 1940's these sites were reseeded to crested wheatgrass (Agropyron cristatum) in the Teo Lake Community pasture to control erosion of soil by wind. This reseeded pasture appeared as cultivated crops in the early photographs. By the 1950's this pasture had taken on the nature of grassland and was considered to be such in the data from the air photos.

Air photo study of 39 Merlin sites along the South Saskatchewan River show that 96% of the area within a one mile radius of nesting sites is grassland. The hunting territories specifically studied range between 84% minimum and 100% maximum of land in grassland.

Since 1971 an increase in the amount of cultivation in the Hanna area is to be noted; this is clearly recorded in the Special Areas of Alberta Board's minutes (Table 10). These show an increase of 116,437 acres of land under the jurisdiction of the Special Areas Board (i.e. not deeded land) for which leases and permits for cultivation were issued between 1970 and 1971. This is about a 1.5% increase in cultivation for all of the Special Areas excluding deeded land. Deeded land accounts for about 19.5% of the lands in the Special Areas (Stewart and Porter, 1942).

A statistical comparison between Hanna and Kindersley of a number of factors which might characterize Merlin nest sites is given in Table 11. In general, it can be said that site "stands" in the Hanna area were larger,

TABLE 11. A Comparison of Certain Environmental Factors of Nest Sites near Hanna, Alberta, and Kindersley, Saskatchewan

Feature	Category	Hanna (N=29) #	Hanna (N=29) %	Kindersley (N=14) #	Kindersley (N=14) %	X^2	p[a]
Stand Tree Type	Acer-Populus	25	86.2	9	64.3		.30
	Acer-Salix	2	6.9	1	7.1	2.58	.30
	Populus-Caragana	2	6.9	4	28.6		
Site Tree Height	10'-19'	2	6.9	4	28.6		
	20'-29'	18	62.1	7	50.0	3.54	.20
	30'-39'	9	31.0	3	21.4		
Site Origin	Upland Grove	6	20.7	4	28.6		
	Windbreak	23	79.3	10	71.4	.68	.50
Site Density	Impenetrable	8	27.6	6	42.9		
	Open	21	72.4	8	57.1	.98	.50
Site Size (1 or dia)	100m-	5	17.2	7	50.0		
	100m+	24	82.8	7	50.0	5.06	.05
Presence of Bare Branches	Yes	23	79.3	8	57.1		
	No	6	20.7	6	42.9	3.05	.10
Presence of Bare Trunk	Yes	26	89.7	6	42.9		
	No	3	10.3	8	57.1	10.75	.01
Presence of Under Cover	Yes	20	69.0	13	92.9		
	No	99	31	1	7.1	3.02	.10
Presence of Nest(s)[b]	Yes	29	100.0	7	50.0		
	No	0	0	7	50.0	17.1	.001

a Probability that utilized Sites (Hanna) were the same as non-utilized sites (Kindersley)

b Nests of crows, hawks, or magpies which could be taken over as nests by Merlin.

had more bare branches extending above the leafy portions of the windbreak or grove, had more trees whose trunks were bare above the level of two feet, and had more often bare ground beneath the "stand". There were a greater number of upland groves (i.e. natural clumps of <u>Populus</u> around low areas and sloughs) in the Kindersley area. Merlins made greater use of windbreaks and groves which were also used by cattle for shelter in the Hanna area. Nest "stands" in the Kindersley area tended to differ from those of the Hanna area in that only 50% of the Kindersley "stands" had nests of crows, hawks or magpies which would be potential nests for Merlins. It may be surmised that changes probably attributable to agriculture made the Kindersley area no longer a suitable area for these other species to nest.

Plate 3.

Merlin Nest Site in Abandoned Windbreak

Plate 4.

Merlin Nest Site in Springtime Showing
Magpie Nests Used by Merlins

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6. Discussion

Merlins nesting along prairie rivers are recorded in the writings of Houseman (1894) and Dippie (1895), both of whom collected Merlins along the Bow River and observed Merlins hunting over the grasslands. Brooks (1896) cites a personal communication reporting that:

> "Falco richardsonii is a common enough bird throughout most of the Rocky Mountain region. It breeds in the Saskatchewan country in such numbers that one of our collectors took four sets of eggs in a single season."

In the first two decades of this century the rapid breaking of the prairie sod, draining of sloughs, the clearing of groves of trees, and other activities attendent on homesteading, would have resulted in a major loss of habitat and, probably, a major population decline.

During the 1920's and the 1930's the Hanna country was almost vacated by farmers and as the plains began the slow process of change to grasslands again, the abandoned windbreaks became available for merlin nesting sites. Bent , (1931) writes of Richardson's pigeon hawk (Merlin):

> "This beautiful little falcon, the palest of the North American merlins, is a bird of the Great Plains, breeding mainly in southern Alberta and Saskatchewan, in Montana, and in northwestern North Dakota. Its summer home is on the wide rolling plains and prairies, where they are dotted with small groves of poplars, aspens, cottonwoods, and other deciduous trees."

Dependence of Merlins on numbers of passerine prey species to nest successfully is documented in this study. Conversion of much of the native grassland which supports passerine populations to agriculture has destroyed much of the Merlins' traditional habitat and much more so in the Kindersley area than in the Hanna area. In the early homesteading days from 1895 to 1920, extensive destruction of native grassland probably produced a marked decline in Merlins in both areas where larger percentages of land with better soil and moisture occur. In the years following the 1914-18 War, relatively much more of the land in the Hanna area was abandoned and has returned to quasi-native grassland.

Thirty-six percent more land in the Kindersley area has been brought under cultivation since the 1940's than that in the Hanna area. Moreover, census statistics indicate a 12% increase in cultivated land in the Kindersley area during this period, as compared to a 4% increase in the Hanna area. Air photo study of Merlin hunting ranges in both the Kindersley area and the Hanna area show the amount of land under cultivation since the 1940's increased 7%. Differences between land use changes apparent from census statistics and those apparent from air photo study can be explained by the more restricted areas (i.e. hunting territories) considered in air photos. Most Merlin terrritories were at one time occupied farmsites, and these were probably located on the best farming locations. In the Kindersley area a greater number of these farms would have remained under cultivation since the original sod breaking. In the Hanna area virtually all broken land went back to grassland, and the better farming sites around old homesteads would be the first areas to be subjected to cultivation again. From the air photo study of 40 Merlin sites in use successfully since 1971, 95% had more than 50% of their area grassland; of the remaining sites one was 40% grassland and one 45%.

In the Kindersley area, air photo study revealed that between 1956 and 1961, the period in which Merlin sites were recorded in the area, 66% of the 15 sites were more than 50% grassland; by 1971 only 27% of these sites were more than 50% grassland.

If, as the above results suggest, a hunting territory must have a minimum of about 50% grassland to support a pair of Merlins, then the Kindersley area cannot be considered as having been a prime Merlin nesting area, at least since the 1940's. It is suggested that the reduction of grasslands in the Kindersley area since 1961 could have had the effect of lowering the amount of grassland below the threshold necessary to support Merlins for many Kindersley sites. Therefore, reduction of grassland emerges as a probable factor in the decline of Merlins in the Kindersley area.

Another very obvious change in Merlin sites in the Kindersley area since the time of their utilization by Merlins is the disappearance of nests of hawks, magpies, and crows which Merlins use. Seven of the 14 sites once occupied by Merlins had no nests of any kind which might have been taken over by Merlins in 1974. It is assumed that "clean" farming practices and extensive cultivations have probably contributed to the disappearance of hawks, crows and magpies as nesting birds in many areas. In any event, where there are no vacant nests to utilize, Merlins do not nest in the prairie habitat.

Destruction of nesting trees by cattle has been suggested as a possible reason for the disappearance of Merlins from the Kindersley area. (Fox, 1964). When cattle are kept near old windbreaks or other trees they will use them for shelter and shade and in doing so are often very destructive to the trees. However, Merlins were found nesting even in a single tree on a number of occasions on the prairies, and in none of the Kindersley sites utilized by Merlins in the 1950's and 1960's was there any substantial reduction of nesting trees by the 1970's. Merlin nest trees characteristically have little underbrush and the trunks are well-rubbed up to a level of about 4' to 5'.

Plate 5.

Merlin Nest Site in Abandoned Windbreak
Showing Effect of Cattle on Windbreaks

Plate 6.

"Highlining" and Breakage by Cattle Using
an Abandoned Windbreak as shelter.

A notable feature of most of the sites formerly occupied in the Kindersley area is the lack of their use by cattle. It must be noted, however, that at many locations on the prairies are remnants of one-time windbreaks and groves that have been utterly destroyed by cattle and it is possible that in some cases cattle may be instrumental in the elimination of Merlin nesting sites.

Much of the increase in cultivation in the Hanna area is a result of a program in the Special Areas by which seral grassland and some climax grassland is being ploughed and cultivated for crops for a number of years, after which they are reseeded in exotic grasses such as crested wheatgrass. This program is an attempt to reach a higher level of primary productivity of grasslands to support more cattle; the process is being encouraged throughout the prairies (Johnson, 1969). These cultivated grasslands lack diversity in cover species and seem to support low populations of passerine birds (personal observation); in time, however, they may take on some of the species diversity of native grasslands (native grasslands here includes old field as well as climax grassland). The Teo Lake pasture in the Kindersley area was seeded to crested wheatgrass in the 1940's for wind erosion control. In early aerial photographs it appeared as cultivated land but now has taken on the appearance of a native grassland. This pasture land had enough passerine birds on it in the 1950's and 1960's to support nesting Merlins. Under present management programs it is proposed that these cultivated grassland be ploughed and reseeded every few years in order to keep primary productivity high.

Since the widespread introduction of chlorinated hydrocarbon pesticides, especially DDT, into many world ecosystems after 1947, population declines in a number of birds of prey have been noted. In particular, peregrine falcons (Falco peregrinus) in the northern hemispere, and ospreys (Pandion haliaetus) and bald eagles (Haliaeetus leucocephalus) in eastern North America have been affected. Chlorinated hydrocarbon residues were generally considered the principal cause of these declines but it was not until Ratcliffe (1967) noted a significant decrease in the density of raptor egg shell after 1947, and showed a correlation between decrease in egg shell weight and an increase in egg shell breakage that a physiological basis for these declines was delineated.

Hickey and Anderson (1968) have shown that for at least three species of birds of prey, in populations where decreases in egg shell weights have amounted to 19% or more, populations were found to be either in a state of decline or had been extirpated. These eggshell reductions are based on a comparison of eggs collected before 1947 (the preorganochlorine insecticide use date) with eggs collected after 1947.

In our study, egg shell density was measured in terms of Ratcliffe Indices; the regression of Ratcliffe Index against DDE is highly significant ($p < .01$) (Figure 4). The hypothesis of thin eggshells explains well a pathway by which high levels of DDE can cause a reduction in raptor populations. This hypothesis states that higher residue levels result in thinner eggshells which, in turn, result in lower hatchability of eggs (probably through breakage of eggs). If hatchability is too low, insufficient young are produced to replace adult mortality and a population decline results. High residue levels could also result in abberrant behaviour affecting hunting or care of the offspring so that posthatching mortality occurs and a lowered productivity results. Much study of raptors today is directed towards investigation of this phenomena (R. Fyfe, personal communication). Merlins would seem to be less susceptible to the effects of DDE in view of an apparently "normal" productivity coinciding with generally high pesticide residue levels. Reduction in the use of DDT (from which DDE is derived) and other chlorinated hydrocarbon pesticides since 1971 will, hopefully, result in some recovery of Merlin populations in any areas affected.

No pesticide residue or egg shell data for Merlins are available from Saskatchewan during the period of decline, i.e. in the 1960's. However, two eggs from a Merlin nest in Saskatchewan just west of the Kindersley area in 1972 had 2.78 and 3.24 ppm dieldrin. Those levels of dieldrin from the Saskatchewan Merlins were the highest, except for one, of 166 samples collected elsewhere, between 1968 and 1973, and far above the mean dieldrin level of 0.70 ppm. Because of the very slow degradation of dieldrin, its heavy use in the 1960's could still account for its presence in the Kindersley environment in the 1970's. Data from our study clearly indicate that both DDE and dieldrin residue are significantly related to lowered hatchability of eggs, however, it would appear that their effects on Alberta Merlins were not sufficient to cause a decline.

One aspect of the heavy use of dieldrin in the Kindersley area which was not studied is the effect it had on the Merlin prey, i.e. on the small bird populations of that area. Any destruction of small birds could only have had the effect of increasing the amount of grasslands Merlins needed to hunt over to get enough prey to sustain themselves and so reduce further the carrying capacity of the Kindersley area for nesting Merlins.

Although the data are by no means satisfactory for comparative purposes the fact that substantial quantities of dieldrin were sold in the

Kindersley area in the years 1958-1964 appears in the records of the rural municipalities (see Table 12). After 1964, dieldrin use for insect control in the area was discontinued and other compounds such as chlordane, aldrin, and endrin were used. The heavy and widespread use of dieldrin is postulated as the factor which rendered the "coupe de grace" to the Merlins of the Kindersley area. Records of dieldrin use in the Hanna area were not available.

Twelve mortalities of nestling Merlins along the South Saskatchewan River which cannot be accounted for occurred on a particular stretch of the river which has been an area of low productivity and nest success for both Merlins and Prairie Falcons since they were first looked at in 1968. This area is located within the Suffield Military Reserve about half way between Medicine Hat and the Saskatchewan border. At one nest in this area in 1969, where 3 well-developed young were found dead, an egg had been collected earlier for pesticide analysis. In it both DDE and dieldrin levels were far above the sample population mean of 20.47 and 0.70, being 65.8 and 2.10 ppm, respectively. Of the eggs collected from the same vicinity (SSR 23-SSR26) (n=18) in this and other years, 41% had DDE residue and 50% had dieldrin residues above the mean of the population sample. (Appendix VI). This would perhaps suggest that these falcons are feeding on a population of small birds from a local contaminated area.

Lockie et al, 1969, in a well documented study presents data indicating that dieldrin used as a sheep dip was responsible for the very low productivity of Golden Eagles (*Aquila chrysaetos*) in Scotland in the early 1960's. Following the 1966 ban of dieldrin from use in sheep dips productivity returned to a level considered normal. The data suggested "an inverse relationship between dieldrin level and success in breeding". A level of

TABLE 12. SALE OF DIELDRIN IN SOME RURAL MUNICIPALITIES OF SASKATCHEWAN 1955-1965

Year	Kindersley	RM 289	Smiley	Marengo	Glidden
1955	-	-	-	-	-
1956	-	-	-	-	-
1957	-	-	-	-	-
1958	$2,380.00	-	-	-	9 gal
1959	1,479.00	-	34 gal	-	202 gal
1960	3,960.00	-	1627.00	360.00	177 gal
1961	14,742.70	2790.00	7915.00	360.00	1408 gal
1962	12,788.00	3546.00	3624.00	360.00	519 gal
1963	8,838.00	1636.00	4281.00	-	453 gal
1964	-	-	120.00	-	-
1965	-	-	-	-	-

1ppm seemed to be the level beyond which upsets to normal breeding occurred in Golden Eagles.

The discovery of a Merlin in a nest which was apparently suffering from "Frounce" opens speculation into a possible cause of Merlin mortality, that of disease. Kocan and Herman (1971) state:

> "Naturally occurring infections of T. gallinae have been reported in raptors, and it is believed that these birds acquire their infections by eating infected pigeons (Stabler, 1941b; Stone and James, 1969). The large number of feral pigeons in many areas of the country make an excellent source of T. gallinae for birds of prey. There has been some speculation that the decline of certain raptorial species may be directly related to their shift in diet from other wild birds to feral pigeons. Although there is no definite proof of this, the presence of naturally occurring trichomoniasis is worthy of consideration when studying the population dynamics of birds of prey".

Merlins (despite the old name of pigeon hawk) are not large enough to prey on pigeons, and it is only speculation that perhaps it is Starlings (Sturnus vulgaris) which are providing an intermediate host for T. gallinae. Starlings are very common along cliffs of the South Saskatchewan River.

Reproductive data for Merlins investigated during this study have been summarized (Table 2); the wide ranges of means between data from different years and different areas indicates considerable variation in reproductive success from year to year. Factors which can be considered "natural" (i.e. not influenced by man) that affect reproductive success and could be responsible for this variation have been outlined. In 1973 a cause of the low net production of young Merlins can be attributed to the severe storm during the critical hatching and post-hatching period. Failure of over 40% of the nests active prior to the storm can probably be attributed directly to it. Of over 500 young Merlins produced during the study period, twenty-four young Merlins were found dead in the nest. Of these deaths, 7 were in the Hanna area and all but one were attributed to the storm. The cause of the remaining mortality is unknown. Along the South Saskatchewan River 17 mortalities were discovered, and only 2 could possibly have been attributed to the storm discussed. The remaining 15, for which causes were unknown, were in all years between 1969 and 1974, and at all stages of development.

The interchange of individual Merlins between the Hanna area and the South Saskatchewan River area serves to establish the continuity of the Merlin population in Alberta. There is no reason to suppose that a similar movement between Merlins of the Hanna area and Merlins of the Kindersley area did not exist. The fact that all male retraps were at, or nearby, the point of original capture lends support to the idea that it is the adult male, or a male offspring raised in the area, which keeps a site under occupancy year after year. If all Merlins are removed over a wide area for a number of years so that there are no male Merlins with a past history of nest site use for that area, reoccupancy of that area would become unlikely. In an area like Kindersley where Merlins have been absent for over a decade and where the few pasture areas which might be good Merlin nesting habitat are so isolated from one another and from areas where Merlins do presently nest, it seems very unlikely that they would be reoccupied again by natural means. However, it is possible that re-introduction of Merlins, especially males, to the isolated pockets of Merlin habitat would be successful in re-establishing Merlins to a formerly vacated area. This might be possible even in the wheat country of Saskatchewan if problems encountered by Merlins in attempting to navigate to a nesting territory over oceans of wheat do not prove insurr-mountable. At present, considerable time and research is being devoted to the breeding of raptors, including Merlins, under artificial conditions, and the reintroduction of these birds to the wild (R. Fyfe, personal communication).

SUMMARY AND CONCLUSIONS

Changes on the Canadian prairies with the advent of white men have been many; modification of the prairie ecosystem has been as great as, or greater than, in any of the major ecosystems of the continent and many prairie species of plants and animals have been brought to extinction or very near to it. The thundering of the feet of millions of bison has been replaced by the bawling of cattle and the humming of tight wire on fence posts. The most dramatic changes and, from a naturalists point of view, the most devastating changes have been effected by the plough. Soil, unturned since the age of ice, have been again exposed to the prairie sunshine, wind, and water, and an agricultural system largely based on annual crops has been established over large tracts of land.

In spite of the great changes in the prairie ecosystem much native life remains or is adapting to the new face of the prairies. One such component of this life is the Merlin and so long as there are trees with suitable nest sites, and smaller birds to hunt, some Merlins "make a living".

Following the disappearance of Merlins from the Kindersley area of Saskatchewan in very recent years (the late 1960's) as recorded by field surveys, my study was instituted with the Canadian Wildlife Service support to intensify documentation of the major features of the prairie Merlin population and habitat, and to probe the cause of the disappearance of Merlins from the Kindersley area of Saskatchewan.

This study, focusing largely on the two above mentioned areas, consisted of:

a) Yearly surveying of nests, recording of reproductive success, banding of nestling Merlins and banding and trapping adult Merlins; this was done to obtain data regarding nest site reoccupancy, productivity of Merlins, and Merlin population dynamics.

b) Investigation of past and current agricultural systems and their effects on the Merlin population.

c) Observation of prey composition and incidence, weather, disease, and human interference and their effects on nesting Merlins, and

d) Statistical analysis of pesticide residue levels in egg tissues, and their relationship to egg hatchability.

In conclusion, the following statements can be made:

1) Prairie grassland areas have been in a continuous state of change since the arrival of settlement, and prairie wildlife populations have been affected.

2) The most long-lasting effect on Merlins (and other prairie wildlife) has been as a result of the plough and the resulting reduction in the diversity of prairie habitat.

3) Abandonment of prairie farmlands has re-established grasslands in dryer parts of the prairies and abandoned windbreaks have resulted in potential nesting habitat for Merlins and other prairie birds.

4) The process of ploughing prairie grasslands soils is a continuing process, though, and of late is expanding; present agricultural policy in Alberta ia advocating the ploughing and reseeding of grasslands to exotic species such as crested wheatgrass; with the improved farming technology today these lands will never be reclaimed by grasslands again.

It may therefore be concluded from my comparative study that, if the Merlin is to be maintained on the Canadian prairies, we must maintain agricultural systems which will leave large segments of the prairie landscape in a near natural state, such as the not-so-highly modified range-livestock systems. The reduction of factors which reduce the diversity of prairie life, such as the use of pesticides and herbicides, must be considered a part of maintaining the natural prairie system.

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APPENDIX 1

AGRICULTURAL CHEMICALS: MEAN RESIDUE LEVELS IN EGGS OF RICHARDSON'S MERLIN 1969-1973*

Residue (ppm wet)		DDE	Dieldrin	Heptachlor	Mercury
1969 1	(N = 12)	23.2	0.99	1.05	0.36
2	(N = 2)	7.82	0.22	0.94	0.22
1970 1	(N = 38)	9.53	.33	0.70	0.22
2	(N = 5)	29.11	0.46	0.37	0.37
1971 1	(N = 13)	25.57	0.57	0.48	0.29
2	(N = 4)	47.17	0.95	0.35	0.15
1972 1	(N = 44)	9.60	0.59	0.31	0.14
2	(N = 15)	20.60	0.78	0.33	0.22
1973 1	(N = 13)	10.76	1.40	0.88	0.07
2	(N = 18)	21.36	0.74	0.58	0.13
MEAN:		20.47	.70	.60	.22

1 Egg collected during incubation prior to hatching

2 Eggs collected dead after incubation.

* Unpublished data from C.W.S. Files, Edmonton

APPENDIX 11

ANALYSIS OF FACTORS OF NEST SITES USED IN ALBERTA BY RICHARDSON'S MERLIN

Factor	Category	Nestings #	%
Site Tree Type	Acer-Populus	84	55.2
	Acer-Salix	10	7.2
	Acer-Caragana	57	37.6
Site Tree Height	10' - 19'	15	10.0
	20' - 29'	56	37.1
	30' - 39'	35	23.2
	Over 39'	45	29.7
Site Origin	Upland Grove	24	15.9
	River Grove	43	31.1
	Windbreak	80	53.0
Undercover	Bare Ground	30	20.6
	Less Than 6"	12	2.2
	6" - 2'	53	36.3
	Over 2'	51	34.9
Site Density	Impenetrable	37	24.5
	See Through	117	74.2
	Bare	2	1.3
Site Size	Less Than 100 yd	21	14.0
	100 yd	71	47.2
	Over 300 yd		
Presence of Bare Branches	Yes	136	90.0
	No	15	10.0
Bare Trunk	Less Than 2'	10	6.6
	2' - 6'	105	69.6
	Over 6'	36	23.8
Nest Type	Open	50	41.3
	Enclosed	71	58.7
Nest Height	6' - 10'	44	37.6
	11'- 15'	47	35.9
	16'- 20'	9	7.7
	21'- 26'	10	8.5
	Over 26'	12	10.3

APPENDIX 11 (Continued)

Factor	Category	Nestings #	Nestings %
Nest Tree Type	*Acer*	50	43.1
	Populus	62	53.5
	Salix	4	3.4
	Caragana	0	0
Nest Tree Height	0' - 9'	1	0.8
	10' - 19'	23	20.2
	20' - 29'	44	38.6
	30' - 39'	23	20.2
	Over 39'	23	20.2
Canopy over Nest	0' - 5'	35	33.0
	6' - 10'	36	34.0
	Over 10'	35	33.0
Live Branches Below Nest	0' - 5'	47	47.5
	6' - 10'	27	27.3
	Over 10'	25	25.2
Position of Nest	Against Trunk	48	45.2
	In Crotch	42	39.6
	On Limb	16	15.2
Distance To Roads	Less than ¼ mi	31	31.0
	¼ - ½ mi	3	3.0
	½ - 1 mi	33	33.0
	Over 1 mi	33	33.0
Distance To Occupied Buildings	Less Than ¼ mi	0	0
	¼ - ½ mi	2	2.0
	½ - 1 mi	13	13.0
	Over 1 mi	85	85.0
Distance To Water	Less Than ¼ mi	29	29.0
	¼ - ½ mi	4	4.0
	½ - 1 mi	58	58.0
	Over 1 mi	9	9.0

APPENDIX III

PREY SPECIES USED BY RICHARDSON'S MERLINS

The occurrences of feather and skeletal remains found and identified from 2070 feather and other prey remains found in nests and at plucking perches is given in Table 13. Chestnut-collared longspurs (Calcarius ornatus) and Horned Larks (Eremophila alpestris) together formed 97% of prey remains.

Of the stomach (crop) contents of Richardson's Merlins examined by Fisher (1863), 2 contained bird remains, 1 insects, and 1 was empty. Amadon and Brown (1968) give the relative proportions of food items of Merlins as being about 80% bird, 5% mammal and 15% insect remains.

Although nesting Merlins are sustained almost entirely by small birds, rodent remains were found twice, and Merlins are known to feed on insects in the study area. A family of new fledged Merlins was seen pursuing and eating grasshoppers during a heavy hatch of these insects (D. O'Dell, personal communication). Insect remains did not show up in prey remains collected.

If Merlins are hunting an area of one mile radius as behaviour observations would lead me to believe, then, based on interpretation of 1971 air photos for 40 Merlin sites, typically Merlins are using an area composed of about 75% grassland and 25% cultivated land. In a study immediately adjacent to my study area, Owens (1971) has shown that breeding populations of prairie birds have densities of 27. and 54. pairs/100 acres on grazed and undisturbed grasslands respectively, 41.5 pairs/100 acres on mowed hayland (native), and only 6.3 and 7.5 pairs/100 acres on seeded and fallow cultivated land respectively. It is obvious that Merlins are hunting predominantly over grasslands where small bird populations are greatest.

TABLE 13. SPECIES UTILIZED AS PREY BY MERLINS

Horned Lark (*Eremophila alpestris*)	50%
Chestnut-collared Longspur (*Calcarius ornatus*)	37%
Sparrows:	
Vesper Sparrow (*Poecetes gramineus*)	6%
Savannah Sparrow (*Passerculus sandwichensis*)	
Chipping Sparrow (*Spizella passerina*)	
Unidentified Sparrows	
Blackbirds:	4%
Red-winged Blackbird (*Agelaius phoeniceus*)	
Brown-headed Cowbird (*Molothrus ater*)	
Western Meadowlark (*Sturnella neglecta*)	
Others:	3%
McCowans Longspur (*Rhynchophanes mccownii*)	
Lark Bunting (*Calamospiza melanocorys*)	
Pine Siskin (*Spinus pinus*)	
Cedar Waswing (*Bombycilla cedrorum*)	
Eastern Kingbird (*Tyrannus tyrannus*)	
Red Phalarope (*Phalaropus fulicarius*)	
Spotted Sandpiper (*Actitis macularis*)	
Unidentified Shorebirds	
Richardson's Ground squirrel (juv) (*Citellus richardsonii*)	
Other Rodents (Family Crecidae-mice and/or voles)	

TABLE 14. PAIR DENSITY AND SPECIES ABUNDANCE OF GRASSLAND BIRDS IN GRASSLAND AND AGRICULTURAL REGIMES (Based on Owens, 1971)

Habitat	# Pairs/100A	Species Most Abundant
Grassland (Undisturbed)	54.5	Sparagues Pipit Baird's Sparrow Savannah Sparrow Western Meadowlark Clay-coloured Sparrow
Grassland (Grazed and Mowed)	27.4-41.5	Chestnut-collared Longspur Western Meadowlark
Cultivated (Seeded and Fallow)	6.3-7.5	Vesper Sparrow Horned Lark

Owens (1971) also indicates that Horned Larks, and Chestnut-collared Longspurs are found abundantly on grazed native grasslands, habitats with the least amount of cover (Table 15). The preponderance of Horned Larks, Chestnut-collared Longspurs and Vesper Sparrows in Merlin prey indicated the preference of Merlins for open habitat over which to hunt. This is to be expected since it is here where prey would find the least amount of escape cover. Despite the higher breeding density of small birds in undisturbed grassland this habitat would probably be used less by hunting Merlins because of the escape cover available. In my study area most of the grassland were grazed.

The habitat most preferred by Horned Larks, next to cultivated land, is grazed grassland (Owen 1971). Weins (1973) states, "Again, however, the response of individual species to grazing effects was more clear cut. Horned Lark density was greater in grazed plots and, at Pawnee, in plots subjected to heavy summer grazing. Western Meadowlarks and Grasshopper Sparrows, on the other hand, were more numerous on ungrazed plots..." This preference of Horned Larks for open habitat would in part account for the high percentage of Horned Larks found in the Merlins' diet.

A second factor accounting for heavy utilization of Horned Larks and Chestnut-collared Longspurs is that of the behaviour of these birds. Cody (1968) in his work on the Pawnee IBP Grassland Study Area has devised a scale of sawtooth curves representing feeding behaviour in fourteen North American species studied (Fig.5). His graph shows the distance moved over a given time span, and the number and duration of stops made in feeding behaviour. It is interesting to note that the two most "active" birds shown are Horned Larks and Chestnut-collared Longspurs. Perhaps these birds'

TABLE 15

AVERAGE NUMBER OF BIRDS, OF SOME SELECTED SPECIES, RECORDED AT ROADSIDE STOPS OF DIFFERENT LAND-USE SUB-TYPES.

SPECIES / LAND-USE	UNDISTURBED	UNDIST.-GRAZED	GRAZED	GRAZED-CULT.	CULTIVATED	BUILDINGS
Number of stops	5	3	11	10	10	6
Native species						
Sprague's Pipit	13.6	10.6	4.5	.4	0	0
Baird's Sparrow	12.6	9.6	4.2	.8	0	0
Savannah Sparrow	9.0	5.0	6.0	6.8	8.5	5.6
Western Meadowlark	8.4	10.6	8.4	7.6	7.0	5.6
Chestnut-collared Longspur	3.4	6.6	12.3	.4	.2	.5
Vesper Sparrow	.6	3.6	3.9	6.7	5.1	6.6
Clay-colored Sparrow	2.0	2.0	1.1	4.6	1.5	3.0
Horned Lark	1.6	1.6	4.4	2.4	5.5	3.5
Barn Swallow	.6	0	.4	2.8	1.0	4.8
Introduced species						
Ring-necked Pheasant	0	0	0	.8	.5	.6
Starling	0	0	0	14.2	11.8	20.6
House Sparrow	0	0	0	4.9	0	7.0
Rock Dove	0	0	0	2.1	.3	3.1

Notes: Underlined figures indicate highest mean value for each species.

Neither Roadside Count route passed any recently mowed native grassland, so there is no column for the "mowed" sub-type of land-use.

(from Owens, 1971)

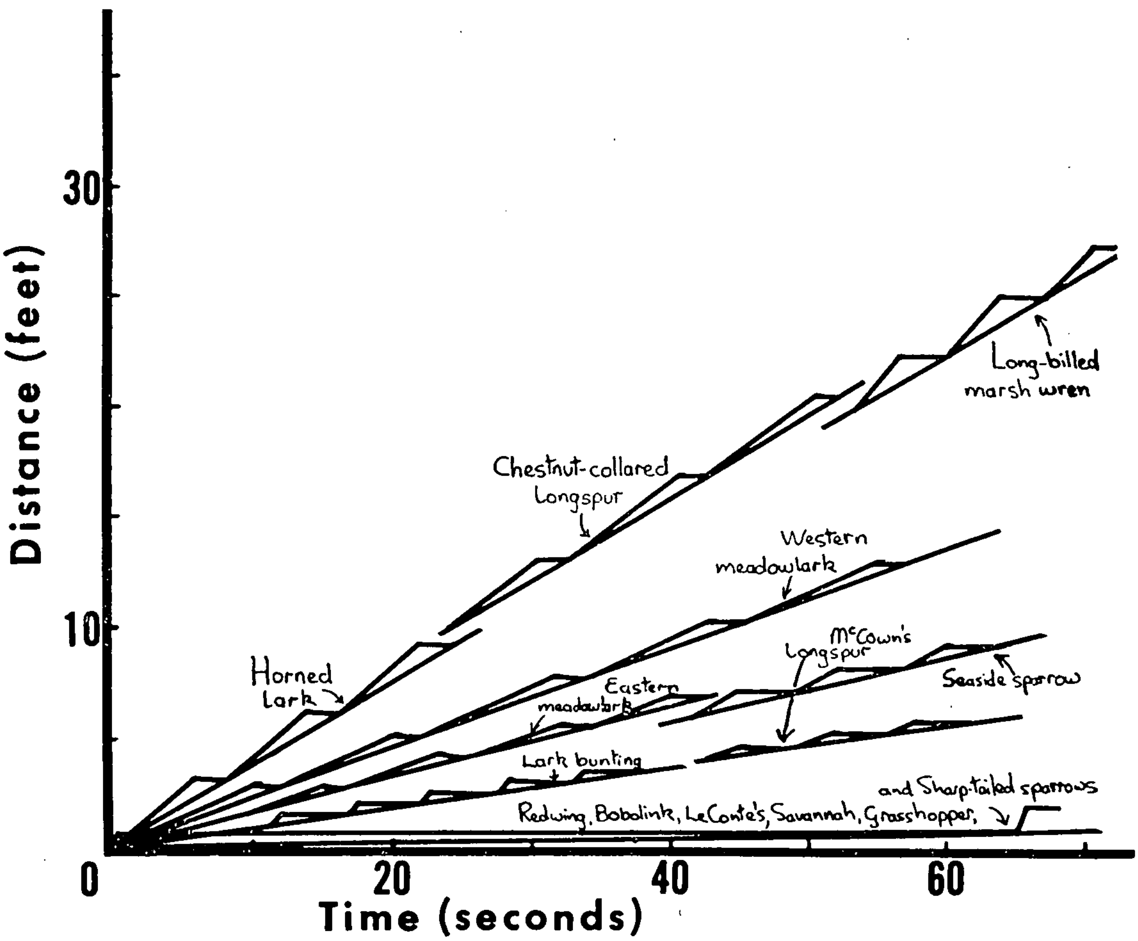
Distance (feet)
30
10
0
20
40
60
Time (seconds)
Long-billed marsh wren
Chestnut-collared Longspur
Western meadowlark
Horned Lark
McCown's Longspur
Eastern meadowlark
Seaside sparrow
Lark bunting
and Sharp-tailed sparrows
Redwing, Bobolink, LeConte's, Savannah, Grasshopper,

Figure 5. Feeding Behaviour of Grassland Birds (from Cody, 1968).

Sawtooth curves representing feeding behaviour in fourteen North American species studied. The horizontal part of a "tooth" is the duration of the average stop in seconds; the ratio between this interval and that between successive "starts" is the proportion of the time spent stationary during a feeding sequence; the slope of the line common to all teeth in a curve is proportional to the average speed of progression for the species during feeding.

more active feeding behaviour makes them more noticeable to Merlins and therefore explains in part the higher rate of predation on them.

APPENDIX IV

COMMON PLANTS OF THE STUDY AREA (SPECIMENS LODGED IN THE BOTANY DEPARTMENT HERBARIUM) UNIVERSSITY OF BRITISH COLUMBIA

A. SOUTH SASKATCHEWAN RIVER

GRASSES

Boutelous gracilis (HBK.) lag.	Blue grama
Stipa comata Trin. and Rupr.	Spear grass
Koeleria cristata (L.) Pers.	June Grass
Oryzopsis hymenoides (Roem. & Schult.)	Indian rice grass
Bromis inermis Leyss.	Awnless brome
Agropyron cristatum (L.) Gaertn.	Crested Wheatgrass
Sitanion hystrix (Nutt.) J.G. Smith	Squirreltail
Festuca spp.	Fescue
Poa sp.	Blue grass

FORBS

Plantage purshii R & S	Pursh's Plantain
Ranunculus glaberrimus Hook.	Buttercup
Smilacina stellata (L.) Desf.	Star-flowered solomon's seal
Thermopsis rhombiflora (Nutt.) Richards	Golden bean
Lygodesmia juncea (Pursh) D. Don	Skeletonweed
Allium textile Nels. & Macbr.	Prairie onion
Viola nuttali (Pursh)	Nuttal's violet

APPENDIX IV (Continued)

A. SOUTH SASKATCHEWAN RIVER

FORBS

Lithospermum canescens (Michx.) Jehm.	Hoary puccoon
Tragopogon dubius Scop.	Yellow goat's beard
Malvastrum coccineum (Pursh) A. Gray	Scarlet Mallow
Erysimum asperum (Nutt.) DC.	Western Wallflower
Pentstemon nitidus Dougl.	Smooth blue beardtongue
Potentilla anserina L.	Silverweed
Lomatium villosum Raf.	Hairy-fruited parsley
Comandra pallida A.D.C.	Pale comandra
Astragalus pectinatus Dougl.	Narrow-leaved milk-vetch
Thlaspi arvense L.	Stinkweed
Achillea millefolium L.	Yarrow
Cleome serrulata Pursh	Spiderflower, Pink cleome
Listris punctata Hook	Dotted blazingstar
Astragalus spp.	Milk-vetch
Hedysarum spp.	Sweet-broom

SHRUBS & TREES

Populus augustifolia James	Narrow-leaved cotton wood
Symphoricarpos occidentalis (Hook)	Wolfberry, Buckbrush
Salix spp.	Willow
Rosa spp.	Rose
Populus spp.	Poplar

APPENDIX IV (Continued)

B. HANNA-YOUNGSTOWN, ALBERTA AREA

GRASSES

Festuca scabrella Torr.	Rough Fescue
Agrostis scabra Willa	Northern bentgrass
Agropyron griffithsii Scribn. & Smith	*A. dasystachyum* (Hook.)
Agropyron smithii Rydb.	Western wheatgrass
Agropyron subsecundum (Link) Kitchc.	Bearded wheatgrass
Boutelous gracilis (HBK.) Lag.	Blue grama
Koeleria cristata (L.) Pers.	June grass
Bromus inermis Leyss.	Awnless brome
Hordeum jubatum L.	Wild barley
Poa interior Rydb.	Inland blue grass
Poa pratensis L.	Kentucky blue grass
Poa palustris L.	Fowl blue grass
Beckmannia syzigachne (Steud.) Fern.	Slough grass
Stipa comata Trin. & Rupr.	Spear grass
Agropyron cristatum (L.) Gaertn.	Crested wheatgrass
Stipa viridula Trin.	Green needlegrass
Calamagrostis montanensis Scribn.	Plains reedgrass
Calamagrostis canadensis (Michx.) Beauv.	Marsh reedgrass
Distichilis stricta (Torr.) Rydb.	Alkali grass
Calamagrostis neglecta (Ehrh.) Gaertn.	Narrow reed grass
Trisetum spicatum (L.) Richt.	Spike trisetum
Muhlenbergia sp.	Muhly

APPENDIX IV (Continued)

B. HANNA-YOUNGSTOWN, ALBERTA AREA

GRASSES

Stipa spartea Trin.	Porcupine grass
Calamovilfa longifolia (Hook.) Scribn.	Sand grass
Poa ampla Merr.	Big bluegrass
Helictotrichon hookeri (Scrion.) - *Avena Hookeri* Scribn.	Hooker's oat grass

FORBS

Ranunculus glaberrimus Hook	Buttercup
Viola nuttalli Pursh	Nuttall's violet
Ranunculus abortivus L.	Buttercup
Cerastium arvense L.	Field chickweed
Arnica fulgens Pursh	Arnica
Zygadenus venenosus Wats. - *Z. gramineus* Rydb.	Death camas
Petalostemon purpureum (Vent.) Rydb.	Purple prairie clover
Grindelia squarrosa (Pursh) Dunal	Gumweed
Solidago decumbens Greene	Mountain goldenrod
Gutierrezia sarothrae (Pursh) Britt. & Rusby	Broomwood, Matchbrush
Orthocaropus lutens Nutt.	Owl clover
Artemisia frigida Willd.	Silver sage
Oenthera nuttallii Sweet	White evening primrose
Anaphalis margaritacea (L.) C.B. Clark	Pearly everlasting
Campanula rotundifolia L.	Bluebell, Harebell
Solidago graminifolia (L.) Salisb.	Flat-topped goldenrod
Penstemon procerus Dougl.	Slender beardtongue

APPENDIX IV (Continued)

B. HANNA-YOUNGSTOWN, ALBERTA AREA

FORBS

Penstemon gracilis Nutt.	Lilac-flowered beardtongue
Galium boreale L.	Northern bedstraw
Antennaria parviflora Nutt.	Pussytoes
Polygonum convulvulus L.	Goosefoot
Anemone multifida Poir.	Cut-leaved anemone
Artemisia sp.	Wormwood
Chamaerhodos erecta (L.) Bunge	Chamaerhodos
Aster pansus (Blake) Cronq.	White prairie aster
Oxytropis sericea Nutt =). macounii	Locoweed
Zizia aptera (A. Gray) Fern.	Meadow parsnip
Erysimum inconspicuum (S. Wats.) MacM.	Small-flowered rocket
Medicago sativa L.	Alfalfa
Cleome serrulata Pursh	Spiderflower, Pink cleome
Castelleja coccinea (L.) Spreng.	Scarlet paintbrush
Achillea millefolium L.	Yarrow
Gaillardia aristata Pursh	Great-flowered gaillardia
Penstemon erianthus Pursh	Crested beardtongue
Tragopogon dubius Scop.	Yellow goat's-beard
Viola nephrophylla Greene	Northern bog violet
Antennaria campestris Rydo.	Prairie everlasting
Anemone patens (Bess.) Koch	Crocus anemone
Phlox hoodii Richards	Moss phlox
Androsace septentrionalis L.	Pygmyflower
Viola adunca J.E. Smith	Early blue violet

APPENDIX IV (Continued)

B. HANNA-YOUNGSTOWN, ALBERTA AREA

FORBS

Potentilla sp.	Cinquefoil
Plantago purshii R. & S.	Pursh's plantain
Carex eleocharis Bailey	Low sedge

TREES AND SHRUBS

Acer negundo L.	Manitoba maple
Caragana arborescens Lam.	Common caragana
Salix exigua Nutt.	Willow
Thermopsis rhombifolia (Nutt.) Richards	Golden bean
Elaeagnus commutata Bernh.	Silverberry, Wolf Willow
Symphoricarpos occidentalis Hook.	Wolfberry, Buckbrush
Rosa woodsii Lindl.	Prairie rose

APPENDIX V

MERLIN POPULATION AND NEST DATA

KEY

Data on file in Library Copy, Main Library, University of B.C.

A bland equals missing or unknown value.

Column		
1.	Region	1. Hanna 2. South Saskatchewan R. 3. Kindersley
2,3	Site Identification #	1. -85
4.	Year	1. 1968 2. 1969 3. 1970 4. 1971 5. 1972 6. 1973 7. 1974
5,6,7.	Area Designation	eg. SNW, YTE.
8,9,10,11.	Location	eg. F10, $L10_2$
12.	# Eggs Analysed	(7 = zero)
13.	Occupied	1. Yes 2. No
14.	# Eggs Layed	(7 = 0)
15.	# Eggs hatched	(8 = Yes)
16.	# Young fledged	(9 = NO)
17.	# Pre-hatched Eggs Removed	
18.	# Visits to Site	
19.	Beta Backscatter	1. Yes 2. NO
20.	Great Horned Owl Flushed	1. Yes 2. No
21.	Nest Type	1. Open (Crow or Hawk) 2. Enclosed (Magpie)

APPENDIX V

KEY (Continued)

22.	Nest Height	1. 0 - 5' 2. 6' - 10' 3. 11' - 15' 4. 16' - 20' 5. 21' - 25' 6. More than 25'
23.	Nest Tree Type	1. <u>Acer</u> 2. <u>Populus</u> 3. <u>Salix</u> 4. <u>Caragana</u>
24.	Nest Tree Height	1. 0 - 9' 2. 10' - 19' 3. 20' - 29' 4. 30' - 39' 5. More than 39'
25.	Live Branches Above Nest	1. 0 - 5' 2. 6' - 10' 3. More than 10'
26.	Live Branches Below Nest	1. 0 - 5' 2. 6' - 10' 3. More than 10'
27.	Position of Nest	1. Against Trunk 2. In Crotch 3. Out on Limb
28.	Site Tree Type	1. <u>Acer</u>-<u>Populus</u> 2. <u>Acer-Salix</u> 3. <u>Populus</u>-<u>Salix</u>
29.	Site Tree Height	1. 0 - 9' 2. 10' - 19' 3. 20' - 29' 4. 30' - 39' 5. More than 39'
30.	Site Origin	1. Upland Grove 2. River Grove 3. Windbreak

APPENDIX V

KEY (Continued)

31.	Undercover	1. Bare Ground 2. Less than 6" 3. 6" - 2' 4. More than 2'
32.	Density of Site	1. Impenetrable 2. See Through 3. Bare
33.	Size of Site (dia. or L.)	1. Less than 100 yd. 2. 100 - 300 yd. 3. More than 300 yd.
34.	Bare Branches Above Foilage	1. Yes 2. No
35.	Bare Trunk Benearth Foilage	1. Less than 2' 2. 2' - 6' 3. More than 6'
36,37,38	% Grassland 1 mile Radius	
39,40,41	% Hay (Cult.) 1 mile Radius	
42,43,44.	% Cultivated 1 mile Radius	
45.	Distance to Roads	1. Less than ¼ mile 2. ¼ mile - ½ mile 3. ½ mile - 1 mile 4. More than 1 mile
46.	Distance to Occupied Bldgs.	1. Less than ¼ mile 2. ¼ mile - ½ mile 3. ½ mile - 1 mile 4. More than 1 mile
47.	Distance to Water	1. Less than ¼ mile 2. ¼ mile - ½ mile 3. ½ mile - 1 mile 4. More than 1 mile
48.	Male Behaviour 1st visit	1. Aggressive 2. Noisy 3. Quiet
49.	Male Behaviour Egg visit	
50.	Male Behaviour Banding visit	

APPENDIX V

KEY (Continued)

51.	Female Bhvr. 1st visit	1. Aggressive 2. Noisy 3. Quiet
52.	Female Bhvr. Egg visit	
53.	Female Bhvr. Banding visit	
54.	Male Trapped	1. Yes 2. No
55.	Male Already Banded	1. Yes 2. No
56.	Male Years Since Banding	-
57.	Male Age at Banding	-
58.	Male Region of Banding	1. Hanna-Youngstown 2. South Saskatchewan River
59,60	Male Site # Where Banded	1 - 85
61,62,63	Male Miles from Banding	-
64.	Female Trapped	1. Yes 2. No
65.	Female Already Banded	1. Yes 2. No
66.	Female Years Since Banding	-
67.	Female Age at Banding	-
68.	Female Region of Banding	1. Hanna-Youngstown 2. South Saskatchewan River
69,70.	Female Site # Where Banded	1 - 85
71,72,73.	Female Miles from Banding	-
74.	Nest Available (Kindersley)	1. Yes 2. No

APPENDIX VI

Merlin Pesticide Data

Key

Data on file in Library Copy, Main Library, University of B.C.

Column

1.	Region	1. Hanna-Youngstown 2. South Saskatchewan River 3. Kindersley
2,3.	Site Identification #	1-85
4.	Year	1. 1968 2. 1969 3. 1970 4. 1971 5. 1972 6. 1973 7. 1974
5,6,7.	Area Designation	eg. BOW, RDR, SSR, YTE
8,9,10.	Site Location Designation	eg. B3, 015, 24A
11.	Egg.#	
13-18.	DDE Residue	
20-25.	Dieldrin Residue	
27-32.	Heptachlor Epoxide Residue	
34-39.	Mercury (Hg) Residue	
41-44.	Ratcliffe Index (RI)	
45-49.	Random or Dead Egg	
51-55.	Nest Hatched or Nest Failed	
57-60.	Condition of Egg	

APPENDIX VII

DDT	dichloro-diphenyl-trichloroethane
dieldrin	endo-exo isomer of 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8, 8a,octahydro-1,4-5,8-dimethanonaphthalene (HEOD)
aldrin	1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1, 4-exo-5,8-endo-dimethanonaphthalene (HHDN)
endrin	1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8, 8a-octahydro-1,4-exo-5,8-exo-dimethanonaphthalene
chlordane	1,2,4,5,6,7,10,10-octachloro-4,7,8,9-tetrahydro-4, 7-endo-methyleneindane
heptachlor	1,4,5,6,7,10,10-heptachloro-4,7,8,9-tetrahydro-4, 7-endomethyleneindene

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1141HAEB151718847                           134
1481SNWM071715557          14332212088010020143
1142HAFB151718827                           134
1052CPWJ05171
1232HAWM051118  1          34121112         141
1332SUFF011114  11  12421 2423              1
1042DYEL051154472
1102GPEL07171                3 2            132
1062DYEM03171
1072DYEM08171
1622YTEF081154312          14312212         141
1532SNWD091143212   22122 113332212093007000341
1482SNWM071115 21          14332212088010020143
1452SNWL081114331          13332212095000005343
1842YTWK071115441   121321113312212045050005333     12
1073DYEM08171
1343SUFF021127 12            3
1303PVED101116551   142533113112113100000000311 3  3
1323PVEM131113  1   22 3   13331312069002029343
1223HAWM041 2              33131212094000006141
1053CPWJ05171
1093GPEE13171
1083DYEN11171
1173HAEL141154 1           15342212         441     12         12
1233HAWM051118 37          34121112         141     12         12
1113GPEL1317155572                              32 3212
1133GPEN061718  7
1483SNWM07A1143314  23253131433221208801002014 3 2  2 12         12
1543WLEC131115441          14322312         444
1533SNWD0913137 13  1324  113332212093007000341                  12
1443SNWL071 2              14332212         143
1623YTEF081 2              14312212         141
1483SNWM0711137     232531 14332212088010020143
1423SNWI061154412   221212212331311097000003333 3  3 12          12
1573YTEB0317141 12         23142213058012030131 3  3 12          12
1413SNWH1111152 1   2 1    13342213093007000443      12          12
1523SNWD081 2              23311222095005000443
1513SNWD071 2              143 2213097003000441
1463SNWL1011143313         13312212097003000344      12          12
1433SNWJ151115441   232321133111122057007036342      12          12
1453SNWL0811127 12  221321113332212095000005343
1713YTEK0511147 1   241431214332211066007033341 1  1
1773YTED1211157 12         14311212099001000441 2  2
1783YTWA111 2              13332212         443
1853YTWD061 2              14322312089004007343
1693YTE11011153313         13311212056031013343 1  1  2          12
1653YTEG081154412   131311 13332212092008000443 11 1112          12
1843YTWK071115441   121321113312212045050005333 22 2211111840001 2
1753YTEM0611157 12         14312222077006017141 1 11
1813YTWI09171                      055014031143
1234HAWM051 2     4        34121112         141
1144HAEB151 2                               134
1334SUFF011 2              423              1
1374SNEB081154418   131311123223120640130231 41 3  3 12          12
1114GPEL131 2
1244HAW01511154413  2223311331412 21            132 32 3212          12
1054CPWJ051 2
1104GPEL071 2                3 2            132
1344SUFF021 2                3
1324PVEM1311153326  132221113331312069002029343 32 32
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1154HAEJ111 2                 3              443
1264PLEC1217155575   1323111331211210610390001 43  1   1
1314PVED102 2              12312212          322
1254PLEB1211157 19   22311123213212207302700014 12   22              12
1204HAEM141 2              14342212
1304PVED101 2              13112113
1194HAEM1317188 87          24332212
1224HAWM0417181174   2233112331312120940000061 41  21  2111111 2300012
1214HAWI0212147 19   132231122111121085000015          2
1184HAEM101 2              133323120750120134 43
1174HAEL141 17             15342212          441
1414SNWH111153318    23132121334221309300700 0443                    12
1424SNWI061 17             1233131109700000 3333
1434SNWJ151 2     6        331111220570070363 42
1384SNEJ1011154419   22122121331212207000302 7343        12
1444SNWL071 17             14332212          143
1524SNW00817155577   22131112331122209500500004433 33  3  12
1604YTEE041 2              133413120570190243 43
1614YTEE05171 7 73   1    11  12313112       444
1624YTEF081 2              14312212          141
1564WLWJ1411154414   131322315312212         441112112
1454SNWL081 2              133322120950000053 43
1474SNWL102 2              14332212          343
1574YTEB03171  374   223431123142213058012030131  1   1              12
1584YTEB051 2              131323120990010003 41
1464SNWL1011154419   131321313312212097003000344  22  2211111 46000
1594YTEC051 2              321  2  12        234
1554WLWG151 2              14332311          241
1484SNWM07A7155472   1213222143322120880100201 43
1484SNWM0711157 12   2325313143322120880100201 43  2   2  1111148000111 11 46004
1494SNWM0912153118   152411234132122089004007343  31  3112            12
1544WLEC1317187 7    1        14322312       44423  23
1514SNW00717154418   2314312143 2213097003000441  12  12             12
1504SNWM092 2              34131112          142
1634YTEF101 2              133422121000000001 43
1534SNW0091 2     4        133322120930070003 41
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1764YTEN061 17    3        34111122          141
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2617SSR23E1 2		
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2627SSR24A111583132 262413234232113	12	12
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2547SSR22B17183373 262533135232312		

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2747SSR29A11157 122
2827SSR31B1  1 7   32          34242311
2827SSR31BA7153 7 2 132433334242311                     12        12
2717SSR28A1  2      2
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2727SSR28B1  2      2
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2737SSR28C1  2      2
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2837SSR32A171544732 16253333523Z213                               12
2797SSR30AA7147      2                                            12
2817SSR31A1  2      2
3087KDYENW1                    3314112100000010 0                                    2
3127KDYPKSN                    1334121103400006 6                                    1
3107KDYBDSN                    1334131102100007 9                                    1
3027KDYTLSW                    1233231210000000 0                                    1
3147KDYPKOW                    1232231704400005 6                                    1
3037KDYTLN1                    1431232210000000 0                                    1
3097KDYERMW                    3312212204600005 4                                    2
3047KDYKDE1                    1434112105000005 0                                    2
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3057KDYKUE2                    1233211104500005 5                                    2
3137KDYPKSS                    1434131105000005 0                                    1
3067KDYESWW                    3313212100200009 8                                    2
3017KDYTLSE                    2332231210000000 0                                    1
3077KDYESWE                    3313211100000010 0                                    2
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	DDE	Diel.	Hept.	Hg.	RI.			
26713SSR26A1	27.5	2.21	5.40	0.14	0.88		NFAIL	FRSH
2012BOW34B1	6.83	0.636	0.57	0.224	1.10			30RT
1 2 1	20.9	1.75	1.78	0.11	1.10			ADUL
1 2 1	9.58	1.93	1.58	0.15	1.10			ADUL
1 2 1	5.45	0.893	1.59	0.45	1.07			30RT
1042DYFL051	14.1	0.067	0.116	0.219	1.02	DEAD	NHTCH	40RT
1532SNWO091	4.72	0.036	0.117	0.34	1.19	RAND	NHTCH	10RT
1 2SNWL71	33.7	0.241	0.084	0.14	0.88			ADUL
1 2 1	5.83	0.651	0.492	0.156	1.09			10RT
1332RAL101	8.13	0.073	0.100	1.29	1.07	RAND		30RT
1842YTWK071	16.7	0.963	0.455	0.17	0.99	RAND	NHTCH	FRSH
1482SNWM071	22.0	1.81	1.38	0.153	0.92	RAND	NHTCH	FRSH
2442SSR19A1	2.77	0.675	2.41	0.352	1.23	RAND	NHTCH	10RT
2712?SR28A1	1.57	0.379	1.76	0.23	1.25	DEAD	NHTCH	ADUL
26? ?R26B1	65.8	2.10	1.30		0.76	RAND	NHTCH	ADUL
2392SSR17B1	3.48	0.300	0.829	0.179	1.15	RAND		20RT
2742SSR29A1	4.30	0.544	0.404	0.277	1.21	RAND		40RT
2672SSR26A1	61.9	1.36	1.22	0.543	0.92	RAND	NFAIL	10RT
2722SSR28B1	2.27	0.353	1.99		1.24	RAND		FRSH
2692SSR26C1	84.6	2.25	1.81	0.12	0.86	RAND		FRSH
1622YTEF081	8.02	1.41	0.627	0.21	1.05	RAND	NHTCH	
2 3SSR 1	5.86	0.076	0.115	0.52	1.03			10RT
1453SNWL081	19.1	0.135	0.161	0.21	0.88	RAND	NFAIL	FRSH
1323PVEM131	72.9	1.05	0.967	0.26	1.06	DEAD	NFAIL	ADUL
2 3RDR 1	12.0	0.306	0.427	0.19	1.11			10RT
1843YTWK071	2.78	0.608	0.286	0.18	1.13	RAND	NHTCH	FRSH
1433SNWJ151	2.11	0.091	0.244	0.10	1.34	RAND	NHTCH	30RT
1753YTEM061	2.12	0.096	0.076	0.14	1.11	RAND	NFAIL	10RT
1423SNWI061	5.22	0.104	0.162	0.44	1.10	RAND	NHTCH	10RT
1483SNWM071	10.2	0.315	1.11	0.14	1.02	RAND	NFAIL	FRSH
1653YTEG081	6.57	0.544	0.566	0.06	1.05	RAND	NHTCH	10RT
1343RAL02 1	22.5	1.81	0.988	0.18	0.86	RAND	NFAIL	FRSH
1773YTEO121	13.5	0.124	0.211	1.07	0.93	RAND	NFAIL	10RT
1233HAWM051	4.69	0.071	0.079	0.67	0.99	DEAD	NHTCH	ADUL
1453SNWL082	41.6	0.413	0.164	0.07	0.99	DEAD	NFAIL	ADUL
1713YTEJ051	8.37	0.114	0.307	0.29	1.04	RAND	NFAIL	10RT
1303PVED101	3.64	0.127	0.419	0.07	1.05	RAND	NHTCH	10RT
1693YTEI101	3.65	0.067	0.125	0.16	1.09	RAND	NHTCH	10RT
1413SNWH111	9.43	0.171	0.361	0.13	1.03	RAND	NHTCH	10RT
1533SNWO092	6.70	0.029	0.229	0.12	1.17	DEAD	NFAIL	10RT
1543WLEC131	4.48	0.248	0.264	0.17	1.14	RAND	NHTCH	10RT
1173HAEL141	19.7	0.775	0.680	0.74	1.21	DEAD	NHTCH	10RT
2023BOW52A1	5.62	0.055	0.234	0.11	1.05	RAND	NHTCH	FRSH
2463SSR20A1	4.53	0.190	0.825	0.10	1.16	RAND	NHTCH	10RT
2133SSR05A1	2.75	0.173	0.562	0.11	1.14	RAND	NHTCH	FRSH
2693SSR26C1	2.98	0.047	0.173	0.05	1.24	RAND		10RT
2 3EAT01 1	1.53	0.154	0.516	0.19	1.18	RAND		10RT
2073BOW54A1	39.3	1.14	0.260	0.34	0.94	RAND	NHTCH	FRSH
2623SSR24A1	1.58	0.309	2.67	0.14	1.14	RAND	NHTCH	10RT
2343SSR12A1	8.58	0.779	1.23	0.14	1.09	RAND	NHTCH	FRSH
2203SSR07B1	2.64	0.058	0.221	0.18	1.12	RAND		ADUL
2723SSR28B1	67.0	0.163	0.228	0.35	0.86	RAND	NFAIL	FRSH
2283SSR10B1	5.66	0.269	0.703	0.06	1.22	RAND		10RT
2533SSR22A1	2.65	0.206	0.319	0.12	1.15	RAND	NHTCH	10RT
2573SSR23A1	1.17	0.732	2.07	0.12	1.13	RAND	NHTCH	FRSH
2033BOW52B1	6.29	0.115	0.403	0.28	1.07	RAND	NHTCH	FRSH
2643SSR25A1	8.11	0.068	0.371	0.06	1.06	RAND	NHTCH	10RT
2193SSR07A1	7.06	0.975	0.665	0.14	1.10	RAND	NHTCH	10RT
2733SSR28C1	16.6	0.597	2.86	0.55	1.10	RAND		10RT
2363SSR17B1	4.82	0.153	0.246	0.20	1.09	RAND	NHTCH	10RT

2743SSR29A1	1.91	0.221	4.63	0.12	1.17	RAND	NHTCH	10RT
2683SSR26B1	4.93	0.389	0.329	0.12	1.08	RAND	NFAIL	10RT
2163SSR06A1	5.66	0.593	0.497	0.20	1.13	RAND	NHTCH	FRSH
1533SNW0091	29.52	0.13	1.01	0.53	1.17	RAND	NFAIL	
1324PVEM131	3.54	0.11	0.11	0.11	1.10	RAND	NHTCH	ADUL
2044BOW53A1	4.04	0.10	0.32	0.20	1.17	RAND	NHTCH	10RT
1244HAW0151	7.53	0.14	0.15	0.12	0.93	DEAD	NHTCH	30RT
2604SSR23D1	4.73	0.08	0.14	0.06	1.29	RAND	NHTCH	20RT
1374SNEB081	6.27	0.07	0.20	0.12	1.08	RAND	NHTCH	10RT
1254PLEB121	173.9	0.89	0.23	0.38	0.90	RAND	NFAIL	FRSH
1564WLWJ141	9.41	0.28	0.37	0.24	1.18	RAND	NHTCH	20RT
2534SSR22A1	10.8	0.74	0.37	0.25	1.06	RAND		20RT
2 45SR36A1	13.8	0.28	0.29	0.15	0.99	RAND		20RT
2624SSR24A1	3.39	0.84	2.84	0.21	1.04	RAND	NFAIL	30RT
1384SNEJ101	8.13	0.31	0.30	0.17	1.10	RAND	NHTCH	10RT
1464SNWL101	5.15	2.90	0.65	0.55	1.10	RAND	NHTCH	
1484SNWM072	4.21	0.17	0.23	0.14	1.13	RAND	NFAIL	
1214HAW1021	166.2	1.22	0.49	0.14	1.26	DEAD	NFAIL	10RT
1734YTEL041	6.48	1.18	0.37	0.18	0.98	DEAD	NHTCH	30RT
1734YTEL042	8.48	1.25	0.38	0.14	1.03	DEAD	NHTCH	40RT
1514SNW0071	85.2	0.59	0.22	1.20	1.01	RAND	NHTCH	20RT
2025BOW52A1	19.6	0.50	0.31	0.16	0.89	RAND		30RT
2035BOW53A1	10.9	0.36	0.28	0.06	.	RAND	NHTCH	ADUL
2135SSR05A1	5.87	0.39	0.30	0.25	1.14	RAND	NHTCH	10RT
2375SSR16A1	1.13	0.52	0.19	0.14	1.34	DEAD		10RT
2375SSR16A2	1.39	0.55	0.24	0.10	1.30	DEAD		10RT
2375SSR16A3	1.38	0.53	0.19	0.14	1.31	DEAD		10RT
2465SSR20A1	5.72	1.10	0.51	0.14	1.03	RAND	NFAIL	10RT
2575SSR23A1	1.60	0.33	0.24	0.08	1.15	RAND	NHTCH	40RT
2575SSR23A2	4.41	0.50	0.41	0.08	.	DEAD	NHTCH	40RT
2585SSR23B1	1.22	0.13	0.12	0.08	1.25	RAND	NFAIL	30RT
2635SSR24B1	6.10	0.10	0.09	0.08	0.89	RAND	NHTCH	10RT
2635SSR24B2	4.78	0.10	0.13	0.09	1.03	DEAD	NHTCH	ADUL
2635SSR24B3	21.6	0.25	0.26	0.09	0.96	DEAD	NHTCH	10RT
2645SSR25A1	1.42	0.20	0.80	0.04	1.21	RAND		FRSH
2655SSR25B1	3.74	0.19	0.11	0.15	1.13	RAND	NFAIL	10RT
2665SSR25C1	34.8	2.33	0.60	0.09	0.95	RAND	NFAIL	10RT
2665SSR25C2	19.2	2.17	0.62	0.09	1.00	DEAD	NFAIL	10RT
2665SSR25C3	32.7	2.21	0.61	0.09	0.93	DEAD	NFAIL	20RT
2685SSR26B1	1.33	0.70	0.41	0.08	1.11	RAND		30RT
2695SSR26C1	2.63	0.70	0.20	0.14	1.17	RAND	NHTCH	30RT
2725SSR28B1	4.36	0.57	0.43	0.08	1.13	DEAD	NHTCH	10RT
2755SSR29B1	2.87	0.14	0.62	0.07	1.25	RAND	NHTCH	10RT
2775SSR29D1	4.02	0.38	0.11	0.10	1.09	RAND	NFAIL	20RT
2 5RDR 1	1.80	0.11	0.27	0.06	1.34	RAND		ADUL
1165HAEL101	4.21	0.21	0.13	0.31	.	RAND	NFAIL	FRSH
1165HAEL102	14.4	0.54	0.39	0.14	1.06	RAND		FRSH
1185HAEM101	9.06	0.45	0.27	0.09	1.04	RAND	NHTCH	FRSH
1175HAEL141	5.18	0.28	0.23	0.08	1.13	RAND	NHTCH	FRSH
1215HAW1021	6.67	0.05	0.04	0.22	1.05	RAND	NFAIL	FRSH
1225HAWM041	6.90	0.87	0.25	0.10	1.19	RAND	NFAIL	FRSH
1295PVEB061	2.33	0.58	0.23	0.07	1.27	RAND	NHTCH	FRSH
1315PVED101	1.61	0.87	0.44	0.11	1.31	RAND	NHTCH	10RT
1375SNEB081	5.73	0.30	0.33	0.05	1.17	RAND	NHTCH	FRSH
1415SNWH111	33.1	1.80	0.39	0.48	1.09	RAND	NFAIL	FRSH
1415SNWH112	44.7	1.86	0.39	0.50	1.05	DEAD	NFAIL	RTTN
1455SNWL081	13.4	3.10	0.72	0.11	1.00	RAND	NFAIL	RTTN
1475SNWL101	19.6	0.37	0.18	0.21	1.11	RAND	NFAIL	FRSH
1465SNWL101	37.8	0.29	0.13	0.22	1.06	RAND	NHTCH	40RT
1485SNWM071	9.62	1.41	0.66	0.23	1.09	RAND	NFAIL	10RT

1505SNWM091	23.2	0.28	0.21	0.13	1.50	RAND	NFAIL	FRSH
1515SNW0071	3.58	0.14	0.23	0.07	1.22	RAND	NHTCH	RTIN
1525SNW0081	8.73	0.51	0.27	0.05	1.04	RAND	NHTCH	FRSH
1595YTEB031	10.8	0.54	0.46	0.26	1.12	RAND	NHTCH	40RT
1595YTEC031	18.6	0.15	0.12	0.47	1.37	RAND	NHTCH	FRSH
1595YTEC052	66.7	0.25	0.13	0.57	1.10	DEAD	NHTCH	40RT
1595YTEC053	37.1	0.21	0.12	0.47	1.10	DEAD	NHTCH	30RT
1595YTEC054	43.7	0.11	0.07	0.52	1.04	DEAD	NHTCH	40RT
1615YTEE051	23.0	2.09	0.92	0.17	1.01	RAND	NFAIL	FRSH
1645YTEG021	16.3	1.18	0.28	0.21	0.94	RAND	NFAIL	ADDL
1655YTEG081	4.27	0.27	0.30	0.12	1.06	RAND	NFAIL	RTIN
1685YTEH061	1.57	0.43	0.23	0.06	1.27	RAND	NHTCH	FRSH
1705YTEJ021	2.97	0.18	0.05	0.11	1.26	RAND	NHTCH	FRSH
1745YTEM031	13.7	0.36	0.20	0.22	0.87	RAND	NFAIL	10RT
1775YTE0121	10.3	0.29	0.21	0.08	1.07	RAND	NHTCH	FRSH
1785YTWA111	6.42	0.16	0.24	0.04	0.97	RAND	NHTCH	FRSH
1785YTWA112	3.50	0.09	0.08	0.13	0.90	DEAD	NHTCH	ADDL
1785YTWA113	22.4	0.41	0.72	.	1.00	DEAD	NHTCH	RTIN
1805YTW1081	4.50	0.53	0.37	0.14	1.06	RAND	NHTCH	FRSH
1835YTWK061	1.53	0.09	0.08	0.07	1.23	RAND	NHTCH	FRSH
1856YTWU061	13.6	1.09	0.57	0.12	0.86	DEAD	NFAIL	RTIN
1856YTWU062	35.4	1.36	0.75	0.20	0.90	DEAD	NFAIL	RTIN
1856YTWU063	13.8	1.15	0.67	0.14	0.96	RAND	NFAIL	10RT
3 6KDY02 1	1.66	2.78	2.00	0.06	1.30			FRSH
3 6KUY01 1	2.23	3.24	2.33	0.10	1.30			FRSH
1586YTFB051	17.8	0.44	0.50	0.01	1.21	RAND	NHTCH	10RT
1606YTEE041	15.3	0.90	1.11	0.01	1.10	DEAD	NFAIL	10RT
1606YTEE041	11.7	0.83	1.04	0.02	1.07	DEAD	NFAIL	30RT
1656YTEG082	27.5	0.45	0.56	0.05	0.10	DEAD	NFAIL	40RT
1656YTEG081	28.4	0.45	0.53	0.04	0.10	RAND	NFAIL	20RT
1656YTEG083	11.8	0.31	0.34	0.02	.	DEAD	NFAIL	ADDL
1666YTEG091	5.45	0.34	0.20	0.04	1.10	DEAD	NATCH	40RT
1686YTEH061	6.68	2.02	1.34	0.04	1.02	RAND	NHTCH	10RT
1726YTEL041	6.55	0.25	0.27	0.04	1.12	DEAD	NFAIL	40RT
1726YTEL042	5.61	0.21	0.22	0.19	1.20	DEAD	NFAIL	40RT
1776YTE0121	23.0	0.57	0.33	0.09	1.10	DEAD	NFAIL	10RT
1186HAEM101	82.7	0.98	0.42	0.03	0.09	DEAD	NFAIL	ADDL
1416SNWH111	23.8	0.63	0.62	0.01	0.09	DEAD	NFAIL	ADDL
1416SNWH112	17.5	0.48	0.50	0.18	0.09	DEAD	NFAIL	10RT
1416SNWH113	19.1	0.49	0.48	0.07	0.09	DEAD	NFAIL	30RT
1486SNWM071	14.9	4.30	1.54	0.01	1.20	RAND	NHTCH	FRSH
1386SNEJ102	56.9	0.39	0.32	0.56	1.04	DEAD	NFAIL	40RT
1326PVFM131	8.97	0.91	1.61	0.21	1.09	DEAD	NHTCH	RTIN
1566WLWJ141	18.3	1.15	0.65	0.39	.	DEAD	NFAIL	
2026BOW52A1	1.32	1.98	0.46	0.09	1.08	DEAD	NHTCH	40RT
2096SSR01A1	4.07	0.47	0.40	0.07	1.17	RAND	NHTCH	40RT
2426SSR18B1	14.4	0.19	0.16	0.04	1.09	RAND	NFAIL	40RT
2696SSR26C	1.82	0.20	0.12	0.05	1.17	RAND		40RT
2766SSR29C1	6.07	1.46	1.10	0.07	1.13	RAND	NHTCH	40RT
1386SNEJ101	11.2	1.20	0.62	0.01	1.06	RAND	NFAIL	30RT
1466SNWL101	16.8	0.30	0.20	0.33	0.10	RAND	NFAIL	30RT
1637YTEF101	.	.	.	.	1.00	RAND	NHTCH	ADDL
1677YTEH051	.	.	.	.	1.18	RAND	NHTCH	ADDL
1722YTEK021	.	.	.	.	1.17	RAND	NHTCH	10RT
1757YTEM061	.	.	.	.	0.95	RAND	NHTCH	10RT
1847YTWK071	.	.	.	.	1.03	RAND	NHTCH	ADDL
1377SNEB081	.	.	.	.	1.03	DEAD	NFAIL	10RT
1377SNEB082		.	.	.	1.02	DEAD	NFAIL	10RT
1377SNEB083	.	.	.	.	1.04	RAND	NFAIL	FRSH
1377SNEB084	.	.	.	.	1.00	DEAD	NFAIL	40RT

1237HAWM051	.	.	.	.	1.18	RAND	NHTCH	10RT
1297PVEH061	.	.	.	.	1.00	RAND	NHTCH	FRSH
1017BSWH121	.	.	.	.	1.07	RAND	NHTCH	ADUL
1567WLWJ142	.	.	.	.	1.04	RAND	NHTCH	10RT
1687YTEH061	.	.	.	.	1.05	DEAD	NHTCH	10RT
1467SNWL101	.	.	.	.	1.18	DEAD	NHTCH	10RT
1777YTE0121	.	.	.	.	1.03	DEAD	NHTCH	40RT
1777YTE0122	.	.	.	.	1.10	DEAD	NHTCH	40RT
1777YTE0123	.	.	.	.	1.13	DEAD	NHTCH	40RT
2037BOW02B1	.	.	.	.	1.19	RAND	NHTCH	30RT
2117SSR02A1	.	.	.	.	1.25	RAND	NHTCH	20RT
2157SSR05C1	.	.	.	.	1.05	RAND	NFAIL	30RT
2187SSR06C1	.	.	.	.	0.93	RAND	NFAIL	10RT
2237SSR08A1	.	.	.	.	1.34	RAND	NHTCH	20RT
2297SSR10C2	.	.	.	.	1.23	DEAD	NHTCH	30RT
2507SSR20E1	.	.	.	.	1.17	RAND	NHTCH	20RT
2627SSR24A1	.	.	.	.	1.11	RAND	NHTCH	20RT
2687SSR26B1	.	.	.	.	1.15	RAND	NFAIL	30RT
2697SSR26C1	.	.	.	.	1.08	RAND	NFAIL	30RT
2747SSR29A1	.	.	.	.	1.16	RAND	NFAIL	30RT
2787SSR29E1	.	.	.	.	1.02	RAND	NHTCH	30RT
2337SSR11D1	.	.	.	.	1.21	RAND	NFAIL	40RT
2587SSR23B1	.	.	.	.	1.00	RAND	NHTCH	40RT
2217SSR07C1	.	.	.	.	1.14	DEAD	NHTCH	ADUL
2297SSR10C3	.	.	.	.	1.25	DEAD	NHTCH	10RT