COMMITTEE ON THE STATUS OF ENDANGERED WILDLIFE IN CANADA

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COMITÉ SUR LE STATUT DES ESPÈCES MENACÉES DE DISPARITION AU CANADA

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SECOND UPDATE OF STATUS REPORT ON THE BURROWING OWL *SPEOTYTO CUNICULARIA* IN CANADA

BY

TROY I. WELLICOME

AND

ELIZABETH A. HAUG

STATUS ASSIGNED IN 1995
ENDANGERED*

REASON: IN DECLINE; STILL FACING HABITAT LOSS AND FRAGMENTATION, INCREASED USE OF PESTICIDES; INCREASED PREDATOR POPULATION. NOW FEWER THAN 2,000 PAIRS.

OCCURRENCE: ALBERTA, BRITISH COLUMBIA, MANITOBA AND SASKATCHEWAN

*DESIGNATED THREATENED IN 1979 AND RECONFIRMED AS THREATENED IN 1991; RE-EXAMINED IN 1995 AND "UPLISTED" TO ENDANGERED.

SECOND UPDATE OF STATUS REPORT ON THE BURROWING OWL
SPEOTYTO CUNICULARIA

IN CANADA

BY

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Contents

Statement of Purpose:

This report addresses the following questions relevant to the status of the Burrowing Owl in Canada: 1) Is the Burrowing Owl's population declining in all or part of its range? 2) Upon which habitat types does the Burrowing Owl specialize? 3) Is the habitat upon which they specialize declining? 4) What other factors could be related to their population decline? This document is not a review of all existing information relevant to the status of Burrowing Owls in Canada; it is intended only to supplement information presented in the last status report (Haug and Didiuk 1991). For additional information, the Burrowing Owl Recovery Plan (Haug *et al.* in press) may be consulted.

A. ABSTRACT

The Burrowing Owl (*Speotyto cunicularia*) is a small, fossorial bird of prey that is distributed discontinuously throughout the grasslands of North America. In Canada, it is a summer resident, breeding in the southern regions of Alberta, Saskatchewan, and Manitoba and in the southern interior of British Columbia. The winter distribution of Canada's owls is unknown but is thought to be south of the United States-Mexico border. Breeding Burrowing Owls require an adequate nest burrow in an open area immediately surrounded by short vegetation, and enough permanent vegetative cover and tall grasses within their foraging home range to provide a sufficient amount of prey. The quantity and quality of such grassland habitat has declined substantially on the Canadian prairies. The most striking recent loss occurred between 1976 and 1986 although the conversion of grassland to cropland has slowed considerably since then. Concurrent with this decrease in habitat was an increase in habitat fragmentation, pesticide use, and predator populations - all of which may have negatively affected Burrowing Owl populations. The present breeding population in prairie Canada is estimated to be between 1010 and 1685 pairs, a historical low, and the small number of owls in B.C. (5-10 pairs) exist only because of intensive reintroduction programs. The density of owls has diminished greatly in the center of their Canadian range, and they have disappeared from much of the periphery, particularly the eastern and northern portions. Intensive and extensive surveys over the last 7 years reveal a rapid and ubiquitous population decline. Unfortunately, the exact cause of this decline is presently unknown. Unless the population trend is reversed, however, all indications are that the Burrowing Owl will be extirpated from Manitoba within a few years and from the entire country within a couple of decades. The status of *Endangered* is, therefore, recommended for the Burrowing Owl in Canada.

B. DISTRIBUTION

B.1. *North America*

Within the broad range limits in western North America (Fig. 1), Burrowing Owl occurrence is variable in open, well-drained grasslands, steppes, deserts, prairies, and agricultural lands.

B.1.1 *Canada*

The range of the Burrowing Owl in Canada is shown in figure 2. The range in the prairies has contracted considerably over the last quarter-century, particularly on the northern and eastern periphery.

B.1.2. *winter distribution*

The winter distribution of the prairie population is unknown but is thought to be south of the United States-Mexico border (James 1992). British Columbia's population is thought to migrate south along the west coast, but the extent of this migration is unknown. A few owls were also reported overwintering in the Lower Mainland, the southern end of Vancouver Island, and most recently near Kamloops.

C. PROTECTION

The species is legally classified as endangered in British Columbia, Alberta, and Manitoba, and is protected under The Wildlife Act in Saskatchewan (Haug *et al.* in press).

D. POPULATION SIZE AND TREND

D.1. *Population Trend (Canada)*

In general, population trends can be estimated either by demographic analyses with stage-specific birth and death rates, or by comparing successive counts from population surveys. For animals that occur at low densities, the demographic approach can be more powerful than counts (Taylor and Gerrodette 1993). Unfortunately, the data required for full demographic analyses are available only for the most easily- or long-studied bird populations (Goodman 1980). Hence, because many of the required parameters have not been, or cannot be, obtained for many rare animals, demographic analyses have seldom been performed for endangered species populations (Price and Kelly 1994).

Using best-estimate demographic information, James *et al.* (in press) modeled the decline of a sub-population of Burrowing Owls on the Regina Plain, Saskatchewan. When juvenile-survival values of 20 or 30% were used, the model's predicted decline corresponded generally with that determined by yearly nest counts (see *D.1.1. intensive monitoring*).

Population trends for Burrowing Owls in other areas of Canada were estimated solely on the basis of counts or surveys of breeding pairs. Such estimates can be categorized as intensive, requiring concentrated searches of relatively small areas, or extensive, involving rough estimates of numbers over large areas.

D.1.1. *intensive monitoring*

Few quantitative data exist documenting the historic size of Canada's Burrowing Owl population (Haug and Didiuk 1991). However within the last decade, the numbers of breeding pairs in many small sub-populations were recorded by investigators involved in a variety of research projects. Habitats and survey methods varied between projects, but within each study area researchers attempted a complete owl count and verified the presence of pairs by visiting nest sites. Figure 3 presents data from studies with at least three years of information. In two of the studies, search effort and/or total area surveyed was not constant from year to year (Fig. 3a). Data from Hanna, Alberta, are shown only for years in which search effort was rated "high" (J.K. Schmutz, pers. comm.). K. De Smet (pers. comm.) noted that both search effort and knowledge of how and where to look for owls increased over the years in the Manitoba area, and for this reason any population decline was, in reality, steeper than that shown by the Manitoba survey data. Although pair numbers fluctuated from year to year, both sub-populations appeared to decline overall.

This downward population trend becomes more apparent when results from studies with constant yearly search effort are examined (Fig. 3b). The sub-population in the Hanna2 study area has declined at an average rate of approximately 5 pairs per year, the sub-population in the Regina area at approximately 10 pairs per year, and in an adjacent site, near Avonlea, Saskatchewan, at 21 pairs per year for the last three years. There has never been an increase in the number of pairs from one year to the next on any of the three study areas searched with constant yearly effort. Further, the number of unpaired (single) owls increased over time in the Avonlea, Regina, and Manitoba areas (TIW, P.C. James, K. De Smet; pers. comms.), suggesting a general shortage of potential mates in each area.

D.1.2. *extensive monitoring*

In the past, population trends for many endangered birds were assessed using successive total counts (*e.g.*, Whooping Crane *Grus americana*, Peregrine Falcon *Falco peregrinus anatum*, Piping plover *Charadrius melodus*; Schmutz 1994). For species like the Burrowing Owl, which exist in small agglomerations spread thinly over vast areas of land, such censuses are not feasible[1]. However, repeatable techniques, which employ broadcasted conspecific calls, were recently developed for the purpose of surveying Burrowing Owls (Schmutz and Wood 1992, Haug and Didiuk 1993). When used in combination with random sampling over an extensive area, such techniques can produce relatively accurate, scientifically rigorous population estimates at a fairly large scale (Schmutz 1994). Unfortunately, the number of hectares of searched land necessary for enough precision (low enough variance) to reliably extrapolate survey results to the population level make this method extremely labour intensive. Nonetheless, such surveys are now being conducted in Alberta and will undoubtedly provide valuable population trend data in the future.

At present, the best quantitative data for gauging recent changes in the Canadian owl population are provided by the Operation Burrowing Owl private land steward programs in Alberta and Saskatchewan (see Dundas 1993, Scobie 1993, and Hjertaas in press for descriptions). These programs rely on the thousands of rural landowners within the Burrowing Owl's range to sign up if owls nest on their property and to thereafter report the

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[1] This is not true for British Columbia and Manitoba, which now have less than 10 pairs of owls each. In these regions, comprehensive counts are the most effective method for tracking owl populations.

numbers of pairs each year. As of 1993, Operation Burrowing Owl (OBO) had 249 members monitoring 21 568 ha (53,254 acres, or the equivalent of 333 quarter-sections) of grassland habitat in Alberta and 499 members monitoring approximately 16 200 ha (40,000 acres, or the equivalent of 250 quarter-sections) of land in Saskatchewan. These programs are very successful at educating the public about Burrowing Owls, and also deter the conversion of permanent cover to cropland (Hjertaas in press), but there has been some apprehension about using OBO data to assess population changes. A discussion of the criticisms associated with this survey technique is therefore warranted.

The first concern raised about OBO data is that censuses by private landowners are likely to be less accurate than counts by trained biologists. OBO attempts to remedy this potential problem by visiting many sites to verify counts (especially sites reporting a large number of owls). Concern may not be justified in most cases, however, because landowners monitor their land on a number of occasions between May and August, whereas biologists conducting large-scale surveys usually visit a site only once. Regardless, such problems are only relevant when a population estimate is desired; indices used to examine population trend assume only that data-collection inaccuracies remain consistent from year to year. On the other hand, OBO census data may not be comparable among areas of different land use. In regions with broad stretches of rangeland, members are less likely to thoroughly search their land sites than they are in regions where grassland exists only in small pastures. Therefore, OBO data from south-western Saskatchewan are probably less accurate than data from the rest of that province, and data from Alberta, where the hectares/member ratio is also high, are probably less accurate overall than data from Saskatchewan (see *E.2. Habitat Loss*).

The second and most frequent criticism relates to population monitoring that relies on revisiting previously occupied nest sites rather than sites that were initially chosen at random. In Idaho, Rich (1984) demonstrated that burrow re-use declined sharply over three years simply because owls changed nest sites[2], not because there were fewer owls. This "nest-hole shifting" may be an adaptive behaviour that counteracts predator place-learning, as has been suggested for Tengmalm's Owls (*Aegolius funereus*; Sonerud 1985). Hence, any decline observed in the OBO census data could simply be an artifact of the owls' nest-shifting behaviour. However, Rich went on to show that after a third year of monitoring, nest re-use began to increase again, so that "the average burrow occupancy function... approximate[d] a dampening sine wave with a 6-year period". Rich also stated that, although previously-used burrows became vacant, new burrows were often found within a few hundred meters (see also Schmutz 1989). Fortunately, the OBO program does not simply census previously occupied *burrows*; landowners are asked to report the total number of owls each year at a given *land site*[3]. Therefore, short-distance breeding dispersals will not be missed with this survey technique. Nevertheless, as Schmutz (1994) points out, a program that selects occupied land sites for subsequent monitoring could indicate a false decline if a significant number of adult owls move several hundred meters from year to year and are not replaced by other pairs. However, in the absence of a population decline, vacated sites should only remain empty the next year if habitat is not saturated *and* if owls

[2] Nest-site shifts occurred even in the absence of burrow deterioration.

[3] A land site represents an area of grassland of up to one quarter-section (65 ha). Members monitoring more than one quarter-section report each as a separate land site.

do not preferentially occupy the highest quality sites available to them. The latter is not likely to be true, though, given the large number of landowners who have, until recently, had Burrowing Owls on their property every year for "as long as they can remember". Schmutz himself noted, "We were surprised by the frequency with which we found the same or adjacent burrows used in subsequent years, yet not by the same owls" (Schmutz 1989). Most importantly, the scenario of only searching previously occupied sites does not adequately describe the Operation Burrowing Owl programs because countless non-members that do not have owls monitor their property each year and can sign up at any time if owls appear on their land[4].

Figure 4 shows the total number of owl pairs reported by Operation Burrowing Owl members. Over the first three years of the program in Alberta, the number of reported owls increased in parallel with the number of members (Fig. 4a) but declined substantially between 1991 and 1993, despite a continued increase in the number of members. Thus, the average number of pairs reported per member has declined substantially since the program's inception. Although the numbers of owls reported by OBO members in Saskatchewan fluctuated from year to year, they suggest an overall population decline (Fig. 4b). This decline is evident despite a steady increase in the number of program members. In addition, the percentage of members providing their yearly census information increased after 1990 because OBO staff began actively collecting survey information by phoning members that had not returned yearly questionnaires. Hence, reports before 1991 seriously underestimate the number of owls on OBO sites. If the total number of OBO pairs is estimated using a simple correction factor (the average number of pairs per responding member × the number of members not responding), a severe and steady decline of Burrowing Owl numbers in Saskatchewan becomes apparent, despite the doubling of members.

The decline in the total number of owls in Canada could be symptomatic of either a disappearance of birds from the periphery of their range (often the first sign of a population decline; Wilcove and Terborgh 1984) or of a ubiquitous decline throughout the Canadian range. To further examine characteristics of the owl population change, each land site in the Saskatchewan OBO database was analysed separately (a single site is used to represent a colony). Separate regressions were run to obtain measures of population change (regression coefficients) for each site. To ensure adequate sample sizes, only those land sites for which at least 4 years of reporting had been received within the 8-year period (1987-1994, inclusive) were used in the analysis. Unfortunately, this regression method would cause ephemeral sites (those which hold breeding pairs for only one year) to be counted as declining because a few owls would be reported for the first year and zero owls in all subsequent years. To eliminate this effect, sites were only included in the analysis if they contained owl pairs in at least two of the four or more census years. The trends in pair numbers at 513 OBO sites and the statistical significance[5] of those trends are indicated in Figure 5. It would be inappropriate to use regressions that were each obtained with only 4 to 8 data points to calculate an average overall rate of decline for the population, but it *is* valid to use the results in a qualitative way, examining the number of positive and negative

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[4] A random survey in 1992 showed that 62% of rural landowners were aware of Operation Burrowing Owl. A highly publicized, toll-free telephone line is available for any member of the public to report owls.

[5] To lower the probability of committing a type-II error due to small sample sizes, a type-I error probability of 0.10 was *a priori* deemed as acceptable for significance testing (see Krebs 1989).

changes at sites (Dr. T. Taerum, Stats. Consultant, Univ. Alberta; pers. comm.). Of the 513 regression coefficients calculated, 434 (85%) were negative (suggesting decreases in colony size). Of the 184 sites that had statistically-significant changes in pair numbers, 182 (99%) indicated declines. Therefore, declines in Burrowing Owl numbers do not seem to be limited to a few colonies. It appears, rather, that *most* of the colonies in Saskatchewan are declining, and many of them quite rapidly.

To examine this decline in a more spatially-explicit manner, the number of "occupied" OBO land sites (those containing one or more owl pairs) within regions that correspond to four 1:50,000-scale topographical maps were tallied for 1987 (Fig. 6a), 1990 (Fig. 6b), and 1993 (Fig. 6c). It is clear that substantial reductions in the number of occupied sites occurred over time throughout the Burrowing Owl's range. These reductions are apparent despite a near doubling of OBO members from 1987 to 1993 and from 1990 to 1993 in Saskatchewan and Alberta, respectively. Over the 7-year period, owls disappeared entirely from regions along the northern and eastern periphery of their range. Even in what appears to have been the core of the owl's range - the Regina Plain and Missouri Coteau - the number of occupied sites declined drastically.

D.2. ***Population Size (Canada)***

"In much of wildlife research, the single greatest challenge is simply to obtain reasonably accurate estimates of population size" (Goodman 1980). Burrowing Owl research is no exception. Although Operation Burrowing Owl surveys provide relative numbers of Burrowing Owls over most of the Canadian range, some indication of how many owls are *not* counted by this program is also needed.

From 1992 to 1994 in the Avonlea study area (> 100,000 ha), fairly thorough searches of grassland fragments, combined with personal reports from local residents, uncovered sites with owl nests that would not have been reported to OBO or to Saskatchewan Environment and Resource Management. Nests that OBO members had overlooked on their land were also located. Of the 25 occupied sites found in the study area, 18 land-sites were owned by OBO members (TIW, pers. obs.). When the average number of nests located on sites not reporting the owls on their land is combined with the average number of pairs not detected on existing OBO sites, an estimated 24% of owl pairs go unreported in the area each year. In regions that are far from major cities or have larger stretches of rangeland, the proportion of owls not reported is undoubtedly greater than this. If, for lack of a better method, a correction factor of between 24 and 75% is used for Saskatchewan, and, because Alberta's OBO program is younger and covers more rangeland, between 100% and 300% for Alberta, a crude estimate for the core of the Burrowing Owl range can be obtained (Table I). Because of the small population sizes, total counts of owl pairs were attempted in British Columbia and Manitoba. An error potential of 100% was arbitrarily assigned to these counts because of the difficulty of detecting all owls over a large area; however, most of the uncertainty associated with the total population estimate comes from the Alberta and Saskatchewan regions.

In 1994 randomly chosen habitat blocks were surveyed on 12 Wildlife Management Units (WMUs) in Alberta, totaling 28,219 km^2. The resulting population estimate for the sampled area was 280.7 pairs. In 1995, Alberta Fish and Wildlife Services will survey the remaining 18 WMUs within the owl's range (J.K. Schmutz, pers. comm.). Assuming these remaining areas support densities of owls similar to those already surveyed, a total of 762 pairs is predicted for Alberta. While the estimate is associated with a very large confidence interval (J.K. Schmutz, pers. comm.), it appears to be somewhat accurate in that it falls within the population range calculated using an alternate data source, Alberta's OBO reports (Table 1).

Table I. Crude breeding population estimates for the Burrowing Owl in each province. Additional pair reports were those called in to Operation Burrowing Owl (OBO) or to wildlife agencies but not located on property enrolled in OBO. Estimates of the number of pairs not reported were obtained by multiplying the known population count by 100% for British Columbia and Manitoba, by 100-300% for Alberta, and by 24-75% for Saskatchewan. Actual pair totals may lie outside of the indicated intervals. Estimates do not include the number of single (and thus non-breeding) owls.

Survey region (1993 or 1994)	Census source	No. pairs from census	Additional pair reports	Est. # pairs not reported	EST. TOTAL # PAIRS
Brit. Columbia	D. Lowe	2	3	0-5	5-10
Alberta	O.B.O.	146	70	216-648	432-864
Saskatchewan	O.B.O.	322	138	110-345	570-805
Manitoba	K. De Smet	8	0	0-8	8-16
TOTALS		**478**	**211**	**326-1006**	**1015-1695**

D.3 *Population Size and Trend (North America)*

The Burrowing Owl[6] has been on the Blue List in the United States (U.S.) since 1972 (James in press). In questionnaires mailed to wildlife agencies in the U.S., 11 of 24 jurisdictions (46%) judged that they had between 1,000 and 10,000 pairs of owls and 8 (33%) reported between 100 and 1,000 pairs. Thirteen jurisdictions (54%) felt that their populations were declining, and none reported increases (James in press).

The Burrowing Owl population size and trend in Mexico is unknown (G.L. Holroyd, pers. comm.).

E. HABITAT

E.1. *Habitat Use*

E.1.1. *nest site*

Specific habitat characteristics of sites occupied by Burrowing Owls vary with geographic location. The three basic attributes of nesting habitat for the western Burrowing Owl are available nest burrows, short or sparse vegetation, and open terrain (Zarn 1974). On the Canadian prairies, nests are found on flat to gently undulating, treeless plains (Wedgwood

[6] Subspecies *Speotyto cunicularia hypugaea.*

1978), and in B.C., on dry grasslands, benchlands, and valley bottoms (R.A. Cannings, pers. comm. *in* Howie 1980). Ground squirrel (*Spermophilus* spp.) or prairie dog (*Cynomys ludovicianus*) burrows, badger (*Taxidea taxus*) excavations, and occasionally fox (*Vulpes* spp.) dens are used for nesting, roosting, and caching food. Of 665 burrow sites examined in Saskatchewan, most were located on lacustrine, solonetzic, saline, and alluvium land systems with few rocks. In particular, owl densities on lacustrine systems were five times higher than those in the second most highly selected land system category, solonetzic soils (Harris and Lamont 1985). Vegetation type does not appear to be important as long as it is kept short or sparse by soil or climatic conditions, grazing, haying, mowing, or burning (Wedgwood 1978). With present land-use practices, areas grazed by livestock provide the vast majority of nesting habitat in Canada. On the Avonlea study site in Saskatchewan, 83% (110/132) of nest attempts in rural areas between 1992 and 1994 were in pasture, 6% (8/132) in stubble, 5% (6/132) in cropland, 3% (4/132) on roadsides, and 3% (4/132) in hayland. Additional nests were located in urban areas, where expanses of grass were kept short by mowing.

E.1.2. *foraging habitat*

Little information is available on the foraging habitat of Burrowing Owls. A telemetry study conducted in an intensively-farmed area south of Saskatoon, Saskatchewan found that minimum foraging home-range size for six radio-tagged males averaged 2.41 km^2 (min.=0.14 km^2, max.=4.81 km^2; Haug and Oliphant 1990). Maximum distance from the nest averaged 1.73 km. Peak foraging activity and maximum distances from nests occurred at night between 2030 and 0630 hours. Diurnal foraging is confined to the vicinity of the nest burrow (Gleason 1978, Haug and Oliphant 1990), and hence usually to pasture. In the daytime, Burrowing Owls hunt almost exclusively for insects, while small mammals (which comprise the majority of their caloric intake) are primarily captured at night further from the nest (Haug and Oliphant 1990, Plumpton 1992). When further than fifty metres from the nest burrow, radio-tagged males foraged over uncultivated areas and roadside habitats more often then expected by chance (Haug and Oliphant 1990). Both of these habitat types had dense, permanent vegetation greater than 30 cm in height. Owls tended to avoid crop and pasture and used fallow in proportion to its availability. Small mammal trapping in Avonlea, Saskatchewan, showed that these habitats have high densities of cricetines (Wellicome 1994). Therefore, owls were concentrating their foraging in habitats with high prey abundances.

Loggerhead Shrikes (*Lanius ludovicianus*) have diets similar to Burrowing Owls and also forage most frequently in undisturbed grass areas (Prescott and Collister 1993). Interestingly, Prescott and Collister (1993) found that breeding territories occupied by shrikes contained higher proportions of tall grass than unoccupied sites.

In summary, Burrowing Owls have special habitat needs during the breeding season. They require an open area with an adequate nest burrow immediately surrounded by short vegetation, and enough permanent cover and tall vegetation (30-60cm) within their foraging home range to supply a sufficient amount of small mammals and other prey.

E.2. *Habitat Loss*

Every fifth year, Agriculture Canada tallies land use associated with farming and ranching. The categories of "improved" and "unimproved" pasture provide a coarse index of potential nesting habitat for Burrowing Owls. The agricultural census data show that pasture habitat within the Burrowing Owl's range (as defined in Wedgwood 1978) has declined over the past quarter-century (Fig. 7). From 1966 to 1991, the amount of total farm area allocated as pasture within the owl's range decreased by approximately 8% (664 330 ha) in Alberta, 6% (991 950 ha) in Saskatchewan, and 8% (316 520 ha) in Manitoba. Concurrently, there were increases of similar magnitudes in cultivated land (cropland plus fallow; Fig. 7). This means that, of the pasture existing in 1966, approximately 15% (0.6% per year) was converted to crop in Alberta, 19% (0.8% per year) in Saskatchewan, and 31% (1.2% per year) in Manitoba by 1991. Note that the most drastic habitat loss in each of the three provinces occurred between 1976 and 1986, the decade that followed a peak in wheat prices. If the total area of potential breeding habitat before the turn of the century is assumed to have equalled the present total of pasture plus cultivated land[7] (*cf.* Telfer 1992), the pasture remaining today composes approximately 46% of the original habitat within the Burrowing Owl's range in Alberta, 26.5% in Saskatchewan, and only 19% in Manitoba. However, it must be stressed that, because this "pasture" category also contains land not used by Burrowing Owls for nesting (e.g., rocky soil, hilly terrain, and low land that is occasionally flooded), the areas that Burrowing Owls select have undoubtedly been converted to cropland *more quickly* than the reduction in total pasture suggests. In the Weyburn and Regina areas of Saskatchewan (mapsheets #62E and #72I, respectively), 21% (191/ 894) of grassland plots deemed suitable for Burrowing Owl nesting were cultivated between 1979 and 1986, a loss of 3% of the plots per year (Hjertaas and Lyon 1987). Furthermore, inventories conducted on eight-tenths of the Burrowing Owl's present range in Saskatchewan (Hart and Barber 1979, Stelfox 1979, Flory 1980, Hart and Hunt 1980, Hart and Hunt 1981, Hart and Stewart 1981, Flory 1981, Barber 1982) indicated that only 14% of the remaining native vegetation was on land systems that owls select for nesting (see *E.1.1. nest site*) and only 2.4% was on the most highly preferred land system, lacustrine.

Perhaps a more direct method of quantifying nesting habitat loss is to revisit previously occupied sites and look for land-use changes. Owl sites reported by Wedgwood (1978) as used at least once between 1970 and 1977 in the Saskatoon area were revisited by E.A. Haug in 1981 (Haug 1985). Of 53 nest sites, 23% had been destroyed (primarily by cultivation), representing a loss of between 2.1% (minimum) and 5.8% (maximum) of previously occupied sites per year. Similarly, by 1988, cultivation and urban development in Manitoba resulted in the loss of 20% of sites (26/129) that were used at least once between 1982 and 1987 (a minimum loss of 3.3% per year; Haug 1991).

The rate of disappearance of foraging habitat has not been quantified although uncultivated areas with tall vegetation harbouring abundant prey (Wellicome 1994) have undoubtedly declined with the advent of modern farming practices. Farm consolidation has led to larger fields, which necessitate the use of larger equipment. To increase yields and facilitate the use of modern farm machinery, large-scale farming operations often incorporate areas into crop production that were formerly left as "wasteland" (Girt 1990).

[7] Total pasture plus total cultivated land averages 97.6% of all farm land reported within the Burrowing Owl's range in Alberta, 98.0% of that reported in Saskatchewan, and 93.8% of that reported in Manitoba.

E.3. *Habitat Degradation*

Other modifications of habitat, often not as obvious as habitat destruction, can lower the quality of a site for a given species and thus lower its carrying capacity. Modification of the prairie landscape has been extensive over the past century (Jenkins 1993), and habitat degradation may have left many areas unsuitable for Burrowing Owl breeding.

Because Burrowing Owls prefer short or sparse vegetation in the vicinity of their nests (James *et al.* 1991), the cessation of grazing in small pastures makes them less attractive to the owls. Questionnaires returned by OBO members in Saskatchewan indicate that grazing has stopped on 7% of 320 nesting colonies over the last one to three years (Dundas 1993). It has often been suggested that Burrowing Owls in nests surrounded by tall vegetation are more susceptible to "surprise-attack" predators such as foxes, coyotes (*Canis latrans*), and cats (*e.g.*, Green and Anthony 1989).

Agricultural practices and the extirpation of wolves (*Canis lupus*) from the prairies have encouraged increases in many predator populations (Sargeant *et al.* 1993) and thus lowered habitat quality for breeding Burrowing Owls. Populations of red foxes (*Vulpes vulpes*), coyotes, and striped skunks (*Mephitus mephitus*) are thought to have grown considerably since historic times (Rosatte 1987, Voigt 1987, Voigt and Berg 1987, Sargeant *et al.* 1993). These species thrive in agricultural areas despite persecution by humans. The increased number of trees in the prairies, which resulted from fire suppression and planting (*e.g.*, shelter belts), has also allowed some avian predator populations to increase (Schmutz *et al.* 1980). Great Horned Owls (*Bubo virginiamus)*, Swainson's Hawks (*Buteo swainsoni*), and Red-tailed Hawks (*Buteo jamaicensis*) are found in greater abundance than they were on the previously treeless plains of the prairies. The provision of den sites in farm buildings allowed the range of another potential predator, the raccoon (*Procyon lotor*), to expand northward well into the Canadian prairies, where they were absent in the past (Sanderson 1987). Conversely, one predator, the badger, has been virtually eliminated by shooting in British Columbia. While this elimination probably had a positive influence on the B.C. population due to a lowering of predation, it also had a negative effect on Burrowing Owl habitat because of the resulting shortage of nest burrows (Howie 1980).

Pesticides, such as Carbofuran, can affect habitat quality both directly and indirectly: directly, by causing adult mortality and low reproductive success (James and Fox 1987), and indirectly, by lowering the availability of prey (Brusnyk and Westworth 1987; see *G.5. Pesticides*).

Agricultural land use has undoubtedly transformed small mammal communities on the Canadian prairies. Wheat fields contain a very low diversity of small mammals and are dominated by deer mice (*Peromyscus maniculatus*; TIW, unpubl. data). Although wheat fields have high densities of mice late in the breeding season, they have very low abundances early in the season (TIW, unpubl. data). Most authors consider Burrowing Owls to be opportunistic foragers, capturing prey in accordance with abundance (Zarn 1974; Green 1983; Green *et al.* in press; Haug *et al.* 1993); however, studies in areas with large tracts of grassland found that owls ate more voles than predicted by their abundance in relation to other small mammals (Olenick 1990; Schmutz *et al.* 1991). Meadow voles (*Microtus pennsylvanicus*) and prairie voles (*Microtus ochrogaster*) on the Avonlea study site were associated almost exclusively with areas of permanent vegetative cover (TIW, unpubl. data). Meadow voles seemed to also require vegetation with at least moderate moisture levels.

Given the steady conversion of permanent cover to cropland and the drainage of wetlands (Kooten and Schmitz 1992), vole populations have almost certainly declined substantially during this century (*cf.* Sargeant *et al.* 1993).

Deterioration of the surviving grassland within the Burrowing Owl's range has resulted from over-grazing (Coupland 1987). Although heavy grazing positively influences Burrowing Owls by enhancing nesting sites, it can also lower the quality of their nearby foraging areas by eliminating tall grasses. Grazing pressure on mixed-grass prairie has increased by one-third in Saskatchewan and by one-half in Alberta between 1956 and 1976 (Coupland 1987; Fig. 8). Native pasture is often associated with a high diversity of small mammal prey, but heavily-grazed pasture has a very low relative abundance of prey (TIW, unpubl. data)

E.4. *Habitat Fragmentation*

The subdivision of once extensive and continuous areas of natural habitat into smaller, isolated patches is known as *fragmentation* (Temple 1986). Although grassland habitat is destroyed outright during the process of fragmentation, it is not just the loss of habitat *per se* that causes problems for grassland birds in fragmented habitat; "there are a syndrome of effects that make it impossible for some species to survive in small [isolated] patches" (Temple 1986). Three outcomes of habitat fragmentation, aside from a decrease in the total area of available habitat, will be considered here: 1) small size of habitat patches, 2) increased edge habitat, and 3) increased isolation (distance between sites).

E.4.1. *size of fragments*

Preliminary analysis of data from OBO in Saskatchewan suggests that occupied pasture fragments are larger than randomly chosen, unoccupied fragments (Robert Warnock, unpubl. data). James (1993) found that larger fragments on the Regina Plain tended to remain occupied longer than smaller fragments. This may result either because small fragments have few birds, and are thus more likely to become locally extinct purely by chance (James 1993), or because small pastures are more susceptible to being completely depleted of owls by such events as predation or flooding. Small pastures also have greater densities of owls than do larger pastures (James 1993). High densities of nests may cause predators to actively search for Burrowing Owl nests; whereas, low densities would encourage them to concentrate on their staple prey (*cf.* Dunn 1977, Sugden and Beyersbergen 1986). In addition, the crowding of pairs into small pastures can increase intraspecific competition and thus lead to foraging interference, aggression (Saunders *et al.* 1991), and even conspecific predation (TIW, pers. obs.). Many authors suggest that increased competition is responsible for the high nest abandonment and low productivity observed when Burrowing Owls nest very close together (*e.g.*, Olenick 1990, Green and Anthony 1989).

Schoener (1968) showed that home-range sizes of raptors are significantly correlated with the densities of their prey. Similarly, when foraging habitat (*i.e.*, the supply of prey) is fragmented into small patches, raptors require larger home ranges (*e.g.*, Redpath 1991). The home-range sizes of six male Burrowing Owls in Saskatchewan (Haug 1985) were significantly correlated with the proportion of cultivated land (crop plus fallow) within their home ranges ($r_S = 0.93$; $p < 0.05$; Spearman Rank Correlation). This suggests that fragmentation, resulting from cultivation near Burrowing Owl nests, increases foraging distances and, hence, time spent away from the nest.

E.4.2. *amount of edge habitat*

Virtually all mortality of the large predators of Burrowing Owls - badgers, skunks, foxes, and coyotes - is caused by humans or other predators (Messick 1987, Rosatte 1987, Voigt 1987, Voigt and Berg 1987). These owl predators, except perhaps the badger, use tall crops for cover while on foraging trips, thus decreasing their probability of being either persecuted by humans or detected by quarry. Owls choose their nest sites before seeding time, when visibility is still good near croplands, and thus do not avoid nesting at pasture edges (Schmutz 1989). Therefore, because predators probably search areas more thoroughly along pasture edges close to cover, owls nesting near crops may be more susceptible to predation by mid-summer than those nesting towards the center of pastures. Consequently, owls in pastures with high edge-to-area ratios (*i.e.*, either small or oblong fields) would experience higher rates of predation. Pastures occupied by owls in Saskatchewan have a lower edge-to-area ratio than randomly chosen, unoccupied sites (R. Warnock, unpubl. data). The Hanna study area in Alberta, where 85% of the original grassland remains uncultivated, experiences the lowest predation rates (< 5% of nests; D. Wood, pers. comm.) of any study area in Canada .

E.4.3. *degree of isolation*

In many parts of the Burrowing Owl's range in Canada, fragment isolation (distance from a site to its neighbours) is substantial. Characteristics of the landscape such as isolation are unique in that they can have effects on owl sites that are independent of the traits of the sites themselves. For example, Burrowing Owl numbers in habitats that have *not* been modified in any way can decline because of habitat modification at distant sites. Isolation affects populations mainly by interrupting the normal flow of individuals between habitat patches: the further a site is from other sites, the lower the probability that individuals will successfully disperse from or into it (Wilcove *et al.* 1986; Verner 1992). Smaller populations in an "archipelago" of habitat islands will continue to function as a part of a larger metapopulation[8] only if they remain connected through dispersal (Verner *et al.* 1992). There is often the misunderstanding that, because neotropical migrants travel such great distances each year, they should not have trouble moving shorter distances within the breeding grounds. Burrowing Owls are physically capable of traveling distances equal to those separating any fragments on their breeding grounds, but if a reduction occurs in the rate of successful dispersal between colonies because of increased exposure to predation or because the owls are not behaviourally as well adapted to dispersing far from natal sites, or if fragment distance delays their finding another occupied colony, selecting a nest burrow, accumulating food in a cache, and/or attracting a mate, then isolation will negatively affect reproduction and population recruitment. A decrease in mixing between sites can also lead to genetic inbreeding (Johnson 1993). Preliminary analysis of data in Saskatchewan (R. Warnock, unpubl. data) found that distance to the nearest occupied pasture is four times

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[8] Metapopulation is defined here as a population comprised of a set of isolated sub-populations that are "linked" by the dispersal of individuals, allowing for recolonization of unoccupied habitat patches after local extinction events.

further from randomly chosen, unoccupied fragments than it is from occupied pasture fragments (23.6 vs. 5.2 km, respectively), and the number of occupied sites within a 20-km radius of a given occupied site is higher than the number around an unoccupied site (8.7 *vs.* 5.2, respectively). This suggests that pastures are more likely to be occupied if they are closer to other occupied pastures. In addition, when distances between habitat patches are large, owls may be more likely to attempt to nest in inter-patch habitats of poorer quality such as cropland or fallow, where they can fall victim to cultivation during the season, or on roadsides, where they or their young have an increased chance of being hit by vehicles.

In summary, the many small isolated owl sites with high edge-to-area ratios that exist today are highly vulnerable to the various stochastic events that make fragments so prone to local extinction. On the Canadian prairies, fragmentation increases disproportionately with decreases in habitat. Therefore, given present levels of land use on the prairies, the many symptoms associated with fragmentation should be obvious in Saskatchewan and especially Manitoba, but should not be observed in most of Alberta. This may explain why rates of population decline are greatest in Manitoba and Saskatchewan, and least in Alberta (see *G.1. Habitat modification*).

E.5. *Habitat Changes on Migration and Wintering Grounds*

In general, grassland areas in the United States were cultivated extensively over the last century and are heavily-fragmented although the Conservation Reserve Program has led to recent increases in permanent grass cover. Habitat changes in Mexico are unknown, but extensive prairie dog (*Cynomys* spp.) eradication during this century has no doubt had a negative effect on the quality of Burrowing Owl habitat in northern Mexico (G.L. Holroyd, pers. comm.).

F. GENERAL BIOLOGY

Refer to the original status report (Wedgwood 1978), the first status update (Haug and Didiuk 1991), and the recovery plan (Haug *et al.* in press) for details.

G. LIMITING FACTORS

Limiting factors are any components of a species' environment that either cause mortality of individuals or constrain recruitment into the breeding population. The following potential limiting factors are presented separately, but are likely inter-related, acting in concert on Burrowing Owl populations. The relationships among them and the demographic parameters affected by each are indicated.

G.1. *Habitat Modification*

At present, habitat modification is the most important cause of endangerment for bird species in the world (Temple 1986). During this century on the Canadian prairies, the amount of grassland has declined substantially within the Burrowing Owl's range (see *E.2. Habitat Loss*). The most striking recent loss of grassland habitat occurred between 1976 and 1986, reaching low levels in Manitoba and Saskatchewan. Alberta retains much of its grassland but generally has poorer soils than the other two provinces (Alberta Land Resource Unit, Agriculture Canada, Edmonton; pers. comm.). "Grassland" represents Burrowing Owl habitat only at a very coarse level. Because the land systems that Burrowing Owls select (Harris and Lamont 1985) are also favoured for farming, highly preferred nesting habitat has undoubtedly declined at a faster rate than has grassland in general.

The conversion of pasture to cropland has now slowed in Canada, yet the owl population continues to decline steadily. It is conceivable, however, that the present decline is a lagged response to habitat loss during the previous decade.

At present the evidence for habitat limitation in Burrowing Owls on the prairies is equivocal. On a broad scale, the rate at which owls are disappearing from areas appears to relate roughly to the amount of grassland available: Manitoba's population is faring worst, Saskatchewan's intermediate, and Alberta's best. At a finer scale, there is some evidence that a non-breeding "floater" population of owls exists; on the Avonlea study site, a minimum of four pairs that abandoned their nests were replaced by other owls immediately or within a couple of weeks (*cf.* Newton and Marquiss 1991), yet other pairs were not replaced. If habitat is limiting, however, one would also expect sites that owls select to differ in some way from those that they do not select. In July of 1989 on the Hanna study area, Schmutz (1989) compared three attributes of occupied nest sites to those of sites located 1 km north of occupied sites. Grasshopper abundance, weight of vegetation, and number of mammal burrows did not differ significantly between the occupied sites and the systematically-chosen unoccupied sites, suggesting that, in mid-summer, these components of habitat are not limiting for Burrowing Owls in Hanna. Conversely, on the Regina Plain, owls selected certain pastures over others based on specific physical and biotic parameters: occupied pastures were more level, more likely to be grazed, and had a greater density of ground squirrel holes (James *et al.* 1991) than unoccupied pastures. However, *within* a pasture, the availability of nest holes was not limiting (James 1990). Many researchers point out that the owl decline has caused habitat recently containing owls to become unoccupied. In Saskatchewan, for example, 68% of OBO sites (all of which had, at some time after 1986, been occupied by owls) were unoccupied by 1993.

Other modifications of habitat, often not as obvious as habitat destruction, can lower the quality of a site and thus lower its carrying capacity for a given species (Temple 1986). Habitat degradation may have caused many previously suitable areas to become unsuitable for Burrowing Owl breeding. Although owls react positively to grazing by using burrows that are in heavily-grazed areas, the effects of this land use on foraging habitat quality is not yet understood. Extensive grazing and modern farming practices in the vicinity of owl pastures have left few areas with tall vegetation, where small mammal diversity and abundance are high. In addition, the increases in predator populations and the escalation of pesticide use have decreased habitat quality for Burrowing Owls (see relevant sections below).

There may be a minimum proportion of suitable habitat distributed throughout a region that is necessary for population persistence. Even in the absence of continued habitat loss or degradation, a species may decline if the rate of local extinctions exceed the rate of recolonizations (Lande 1987). For Burrowing Owls, this could occur if habitat loss in the past has led to a level of fragmentation that interrupts normal inter-colony movement, such that colonies temporarily emptied by stochastic events (*e.g.*, predation or inclement weather) do not get repopulated. Indeed, preliminary research in Saskatchewan suggests that pastures are more likely to remain occupied if they are closer to other occupied pastures (see *E.4.3. degree of isolation*). Because it is natural for some emigration of owls to occur, colony persistence relies in part on owl immigration. This means that owl numbers in habitats that have *not* been modified in any way can decline because of poor reproduction or colony failure at distant sites.

Habitat loss and subtle factors that uniformly decrease habitat quality or increase fragmentation can lead to greater distances between habitat patches, a reduction in successful inter-patch movement, fewer pairs on individual "islands", and eventually fewer pairs overall (Verner *et al.* 1992). If such habitat characteristics are limiting owl populations on the Canadian prairies, the symptoms should be obvious in Saskatchewan and especially Manitoba, but should not be observed in much of Alberta (see Fig. 7). The fact that the number of unmated (single) owls, the preponderance of depredation, and the rate of population decline all appear to be higher in Saskatchewan and Manitoba than in Alberta lends support to this theory. One would also predict that average dispersal distances would be smaller in Alberta, but this remains to be determined.

G.2. *Mortality on Breeding Grounds*

On the Avonlea study site, breeding adult mortality averaged 0 to 4% for males, and 0 to 7% for females from 1992 to 1994 (TIW, unpubl. data). Post-fledging survival of juvenile owls could not be adequately monitored, but a minimum of 5% died shortly after fledging. Very little is known about owl survival after fledging or during fall dispersal.

G.2.1. *predation*

In the Avonlea study, all adult male mortality (4) resulted from avian predation; whereas, all but one (5 of 6) adult female mortality between 1992 and 1993 resulted from mammalian predation in the nest.

The number of fledglings that are depredated is unknown, although predation in birds is thought to act primarily on juveniles (Ricklefs 1973).

The proportions of nests emptied by predators in the Avonlea area were 23%, 6%, and 14% in 1992, 1993, and 1994, respectively (TIW, unpubl. data). However, during the latter two years, some degree of predator exclusion was achieved through the use of modified artificial burrows. It is difficult to know if these nest predation rates can be considered high because no stable Burrowing Owl populations exist in Canada for comparison.

Because Burrowing Owls do not nest in trees, they have many potential predators. The predators are of two general types: 1) predators that enter or dig up burrows eating eggs, nestlings, and/or adult females; or 2) predators that prey on older nestlings and adults when they are above-ground. In Canada, mammals that can potentially access nest chambers are badgers, foxes (*Vulpes* spp.), striped skunks, weasels (*Mustela nivalis* and *M. frenata*), and raccoons. Species that mainly catch owls above the ground are the coyote, the domestic dog, the cat, the Swainson's Hawk, the Great Horned Owl, the Ferruginous Hawk (*Buteo regalis*), the Northern Harrier (*Circus cyaneus*), the Short-eared Owl (*Asio flammeus*), and the Prairie Falcon (*Falco mexicanus*). Badgers, skunks, and long-tailed weasels (*Mustela frenata*) seem to present the most serious threats to female Burrowing Owls and their eggs in Canada (TIW, pers. obs.); while avian predators cause the majority of mortalities in adult males and fledglings.

G.2.2. *collision with vehicles*

In 186 separate breeding attempts over a three-year period in Avonlea, only one of 372 (0.3%) breeding adults was killed by a collision with a vehicle. Also, only one of 114 (1%) fledglings (over two years) was known to have been hit by a vehicle, despite the proximity of the majority of nests to highways, city streets, or major grid roads. These data suggest vehicle mortality has only a negligible effect on Burrowing Owl populations in Canada. Although other authors have implicated vehicle collisions as a major mortality factor (*e.g.*, Wedgwood 1978), the number of mortalities per number of individuals monitored have not been presented. More quantitative information is needed on this mortality factor.

G.2.3. *shooting*

The number of Burrowing Owls shot in Canada is unknown but is likely negligible at present.

G.3. *Mortality on Migration or Wintering Grounds*

Over-winter mortality is extremely difficult to measure in any long-distant migrant not highly fidelic to its nest site. It is unlikely that mortality can be estimated by recovering bands from dead owls because the bands are quite small and the birds probably winter in the neotropics. Mortality must therefore be deduced from survival, based on resightings of live banded birds on breeding grounds (see pp. 206-207 in Newton 1979 for discussion). Unless site fidelity is 100%, this method invariably results in an overestimate of mortality (Haas and Sloane 1989). Deciding whether mortality rates are "high" is somewhat subjective because, again, no stable populations of Burrowing Owls exist in Canada with which to compare. However, because mortality rates in raptors are generally correlated with body weight (Newton 1979), any deviation from this relationship may indicate an abnormal mortality level. Given their body weight, Burrowing Owl mortality observed on the Regina Plain (James *et al.* in press), Saskatchewan, ranged from average to slightly above average; whereas, mortality on the Hanna site in Alberta (J.K. Schmutz, unpubl. data in Haug *et al.* 1993) ranged from average to slightly below average (Fig. 9). Values from such studies can only be taken as maximum mortality rates, however, because banded birds that emigrate from the study area are presumed dead (Ricklefs 1973, Haas and Sloane 1989).

Estimates of juvenile survival (from fledging to first-year breeding) in Burrowing Owls are even more difficult to obtain because natal dispersal in birds is almost always further than breeding dispersal (M.-A. Villard, Univ. of Moncton, pers. comm.). The low resighting rates for juvenile Burrowing Owls may indicate either low natal fidelity or high mortality, but the two cannot be easily separated (Haas and Sloane 1989).

G.4. *Productivity*

Because Burrowing Owls nest underground, few studies report clutch size. Investigations using artificial nest burrows consistently observed large clutches, averaging 8.3 in Idaho (Olenick 1990) and 8.9 in Avonlea (Wellicome in press). However, few of the eggs laid result in fledglings; the number of young surviving to the late-nestling stage per successful nest has varied between 2.1 and 6.3 in Canada (Haug *et al.* in press), and the number of fledglings per attempt has ranged from 1.1 to 5.5. The number of nests that successfully raised at least one young averaged 69.6% in Manitoba, 63.6% in Saskatchewan, and 86.0% in Alberta (Haug *et al.* in press). The high nesting success in Alberta is due to low predation rates (D. Wood, pers. comm.). Loss of hatchlings in successful nests results from brood reduction (Wellicome 1994; see *G.4.1. food supply*). In most years reproduction does not replace mortality (based on adult resightings).

G.4.1. *food supply*

Burrowing Owl reproduction on the Avonlea site is limited by food intake. The placement of extra food in nests during egg laying had little effect on clutch size (Wellicome in press), but supplemental feeding during the nestling period resulted in 17% to 160% more young (1992 and 1993, respectively; Wellicome 1994). Food intake was thus more limiting during brood rearing than during egg laying. Brood reduction was quite prevalent in nests that did not receive extra food, and probably explains the discrepancy between the number of eggs that Burrowing Owls lay and the number of young that they usually fledge. Food intake at the nest may be limited for many reasons: 1) habitat quality limits prey abundance or prey availability (see *E.3. Habitat Degradation*), 2) foraging areas are far from nesting areas, so costs of transporting prey are high (see *E.4. Habitat Fragmentation*), or 3) weather limits the number of hunting hours or modifies the behaviour of prey, making them less available (Wellicome in press).

Although food limits reproduction, it will only limit the population if productivity is limiting. At present, there is not enough information available to ascertain this.

Low post-fledging survival of Burrowing Owls should also result if food supply is limiting (Ricklefs 1973).

Prescott and Collister (1993) concluded that "loggerhead shrikes in southern Alberta were habitat limited, and that habitats were occupied only if they contain sufficient quantities of tall grass", suggesting that foraging habitat (and food supply) was limiting breeding populations. Food limitation is a common problem resulting from human-caused habitat changes (Temple 1986).

G.5. *Pesticides*

James *et al.* (1990) did not observe any mortality of owls that nested in pastures where ground squirrels were poisoned with strychnine. Although both the number of successful nests and the number of young produced per successful nest were lower in treated than in untreated pastures, the differences were not statistically significant. However, the power of the statistical tests was not indicated, and was probably low given the small sample sizes.

Exposure to carbofuran within 50 m of nest burrows was associated with a 54% reduction in the number of young per nest and a 50% reduction in the proportion of pairs raising one or more young relative to controls (James *et al.* 1987).

Carbofuran may also affect Burrowing Owls indirectly by affecting their prey supply. There is a considerable reduction in the number of invertebrate prey immediately following spraying (Anonymous, Agriculture Canada, 1993). In addition, survival of tagged deer mice and meadow voles in grassland sprayed for grasshopper control was 40% and 33%, respectively, less than that of unsprayed populations (Brusnyk and Westworth 1987).

H. SPECIAL SIGNIFICANCE OF THE SPECIES

Refer to the original status report (Wedgwood 1978), the first status update (Haug and Didiuk 1991), and the recovery plan (Haug *et al.* in press) for details.

I. EVALUATION AND PROPOSED STATUS

When the Burrowing Owl was listed as *Threatened* in 1978, its population likely exceeded 3000 pairs and was declining, and B.C.'s population was considered extirpated. As of 1990, the steadily declining prairie population was estimated at roughly 2500 pairs, and a large range retraction was evident. B.C. reported a total of six breeding pairs in 1990 largely because of an intensive reintroduction program (Haug and Didiuk 1991). The present population estimate for prairie Canada is between 1010 and 1685 pairs. The density of owls has diminished greatly in the center of their Canadian range, and they have disappeared from much of the periphery, particularly the eastern and northern portions. B.C.'s population is still only 5 to 10 pairs and relies on the continuation of reintroduction programs. While the national estimates have been only crude, it is clear that there has been, and continues to be, a considerable and ubiquitous decline in the country's Burrowing Owl population. Intensive monitoring in discrete study areas over the last decade confirms this decline. Unless the population trend is reversed, all indications are that the Burrowing Owl will be extirpated from Manitoba within a few years and from Canada within a couple of decades.

The objectives of the Burrowing Owl recovery plan are 1) to reverse the population decline across the Canadian prairies and subsequently maintain a stable or increasing population averaging at least 3000 pairs and 2) to re-establish a self-sustaining population in British Columbia of more than 50 pairs (Haug *et al.* in press). As the population continues to decline in Canada, we get further and further from accomplishing these objectives. Therefore, the authors of this status update and the members of the Recovery Team urge that the Burrowing Owl be uplisted to the status of *Endangered* in Canada.

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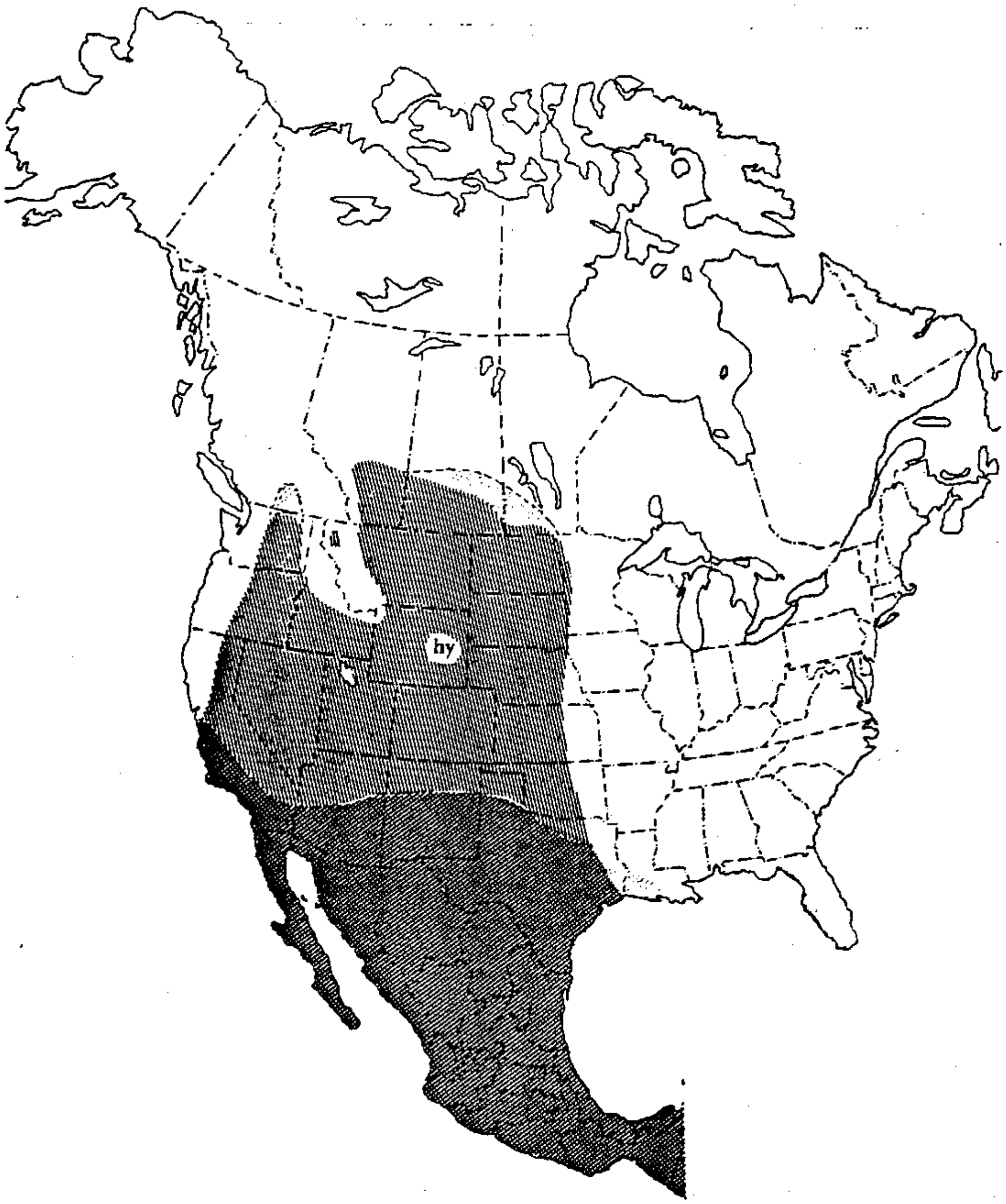


Fig. 1. Distribution of resident and migratory populations of the Burrowing Owl (*Speotyto cunicularia hypugaea*) in North America (from Johnsguard 1988).

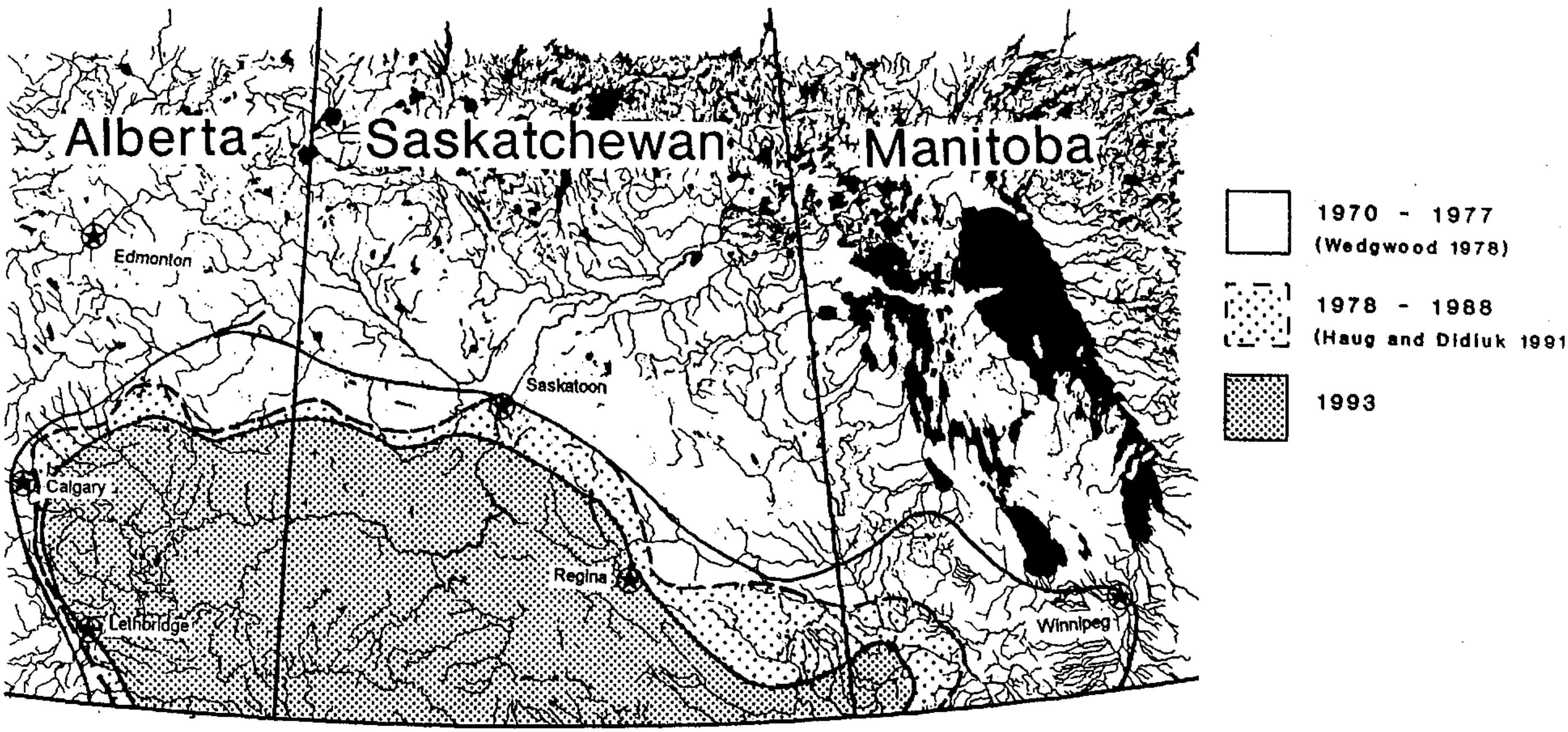


Fig. 2. Historic and present breeding range of Burrowing Owls in prairie Canada. Note the considerable range retraction, particularly on the northern and eastern periphery.

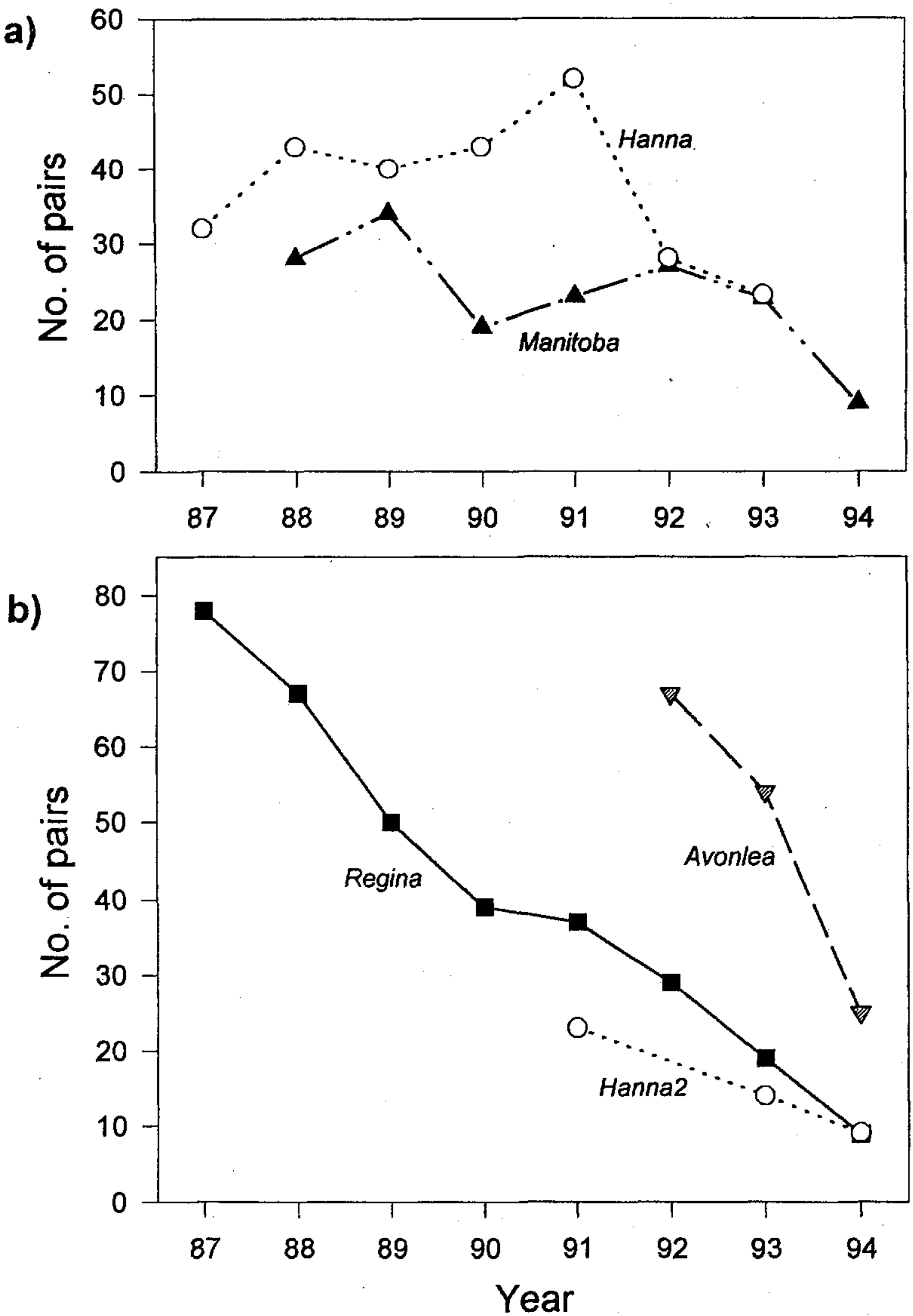


Fig. 3. Number of owl pairs recorded in discrete research areas with at least 3 years of information. Survey methods varied between projects, but within each area investigators attempted complete owl counts and verified the presence of pairs by visiting individual nests. In two of the studies, search effort and/or total area surveyed were not constant from year to year [a]. Data from the Hanna site are only shown for years in which search effort was rated "high". Search effort and knowledge of how and where to look for owls increased with time in the Manitoba site, so population decline is probably underestimated. The number of owl pairs in sites with constant yearly search effort are also indicated [b]. All three areas have had steady declines over recent years, the least drastic of which was in Alberta.

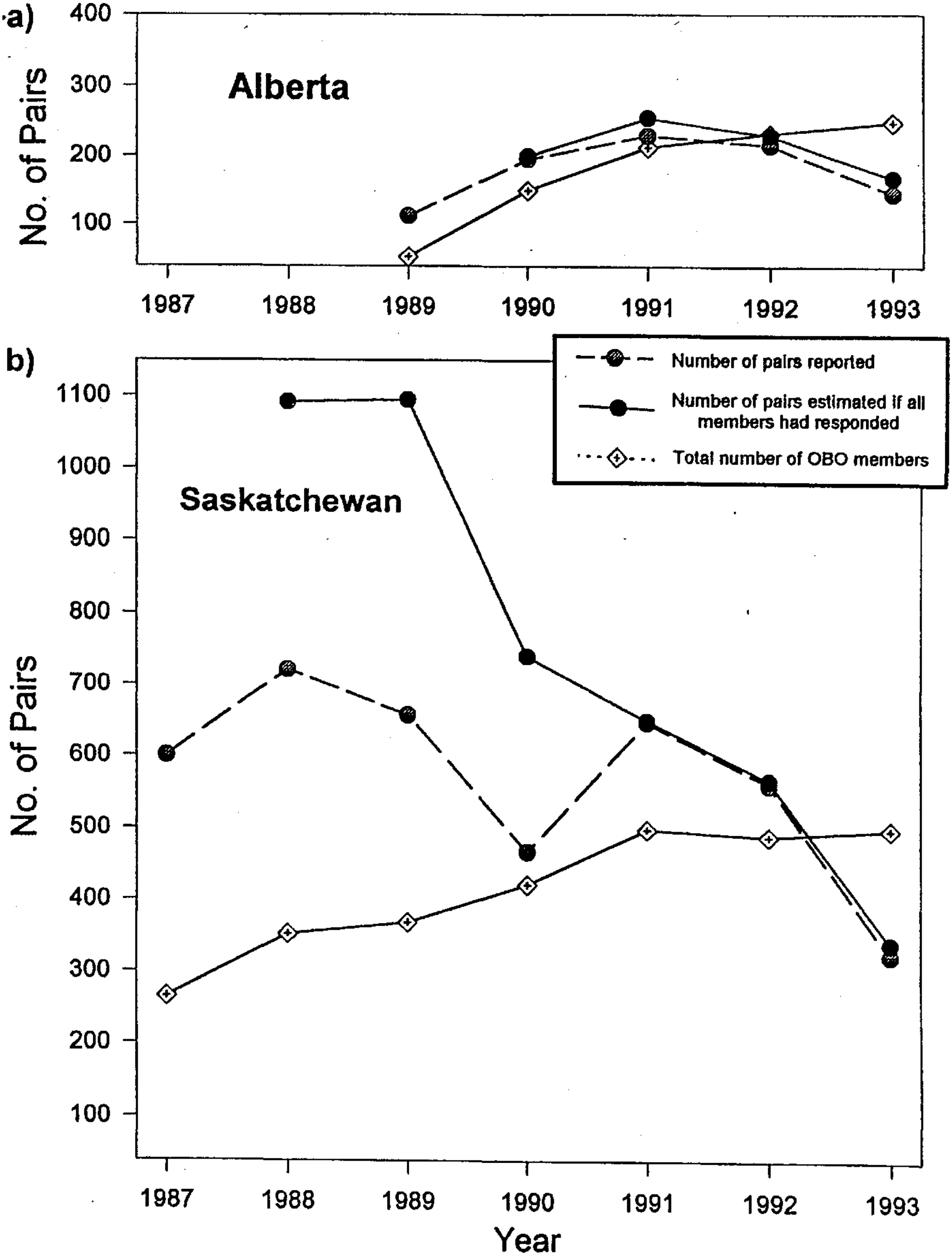


Fig. 4. Number of owl pairs reported by Operation Burrowing Owl (OBO) members in Alberta [a] and in Saskatchewan [b]. Because the percentage of members providing yearly census information was low in Saskatchewan, reports before 1991 seriously underestimated the number of owls on OBO sites in that province. A more accurate estimate of the total number of pairs on sites each year was obtained using a simple correction factor: average number of pairs per responding member × number members not responding. Declines are apparent, despite a quadrupling of the number of cooperating members in Alberta and a doubling of members in Saskatchewan since the inception of the programs.

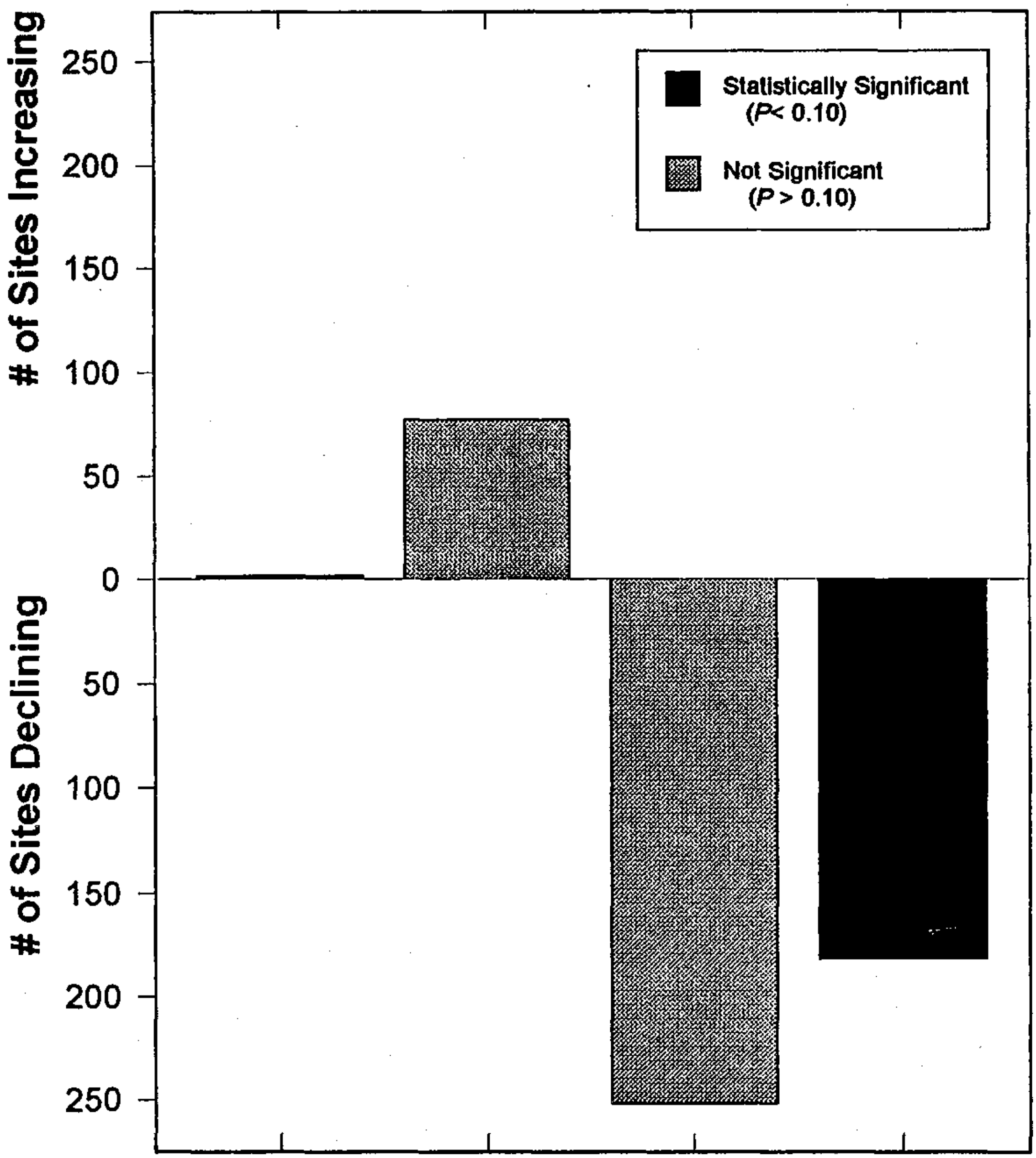


Fig. 5. Number of Operation Burrowing Owl (OBO) land sites in Saskatchewan with increasing and decreasing numbers of owls. Separate regressions were run for each colony to obtain measures of colony-size change during the 1987 to 1994 period. To lower the probability of committing a type-II error due to small sample sizes, a type-I error probability of 0.10 was *a priori* deemed as acceptable for significance testing (Krebs 1989). See text for details on the exclusion of some sites. The high number of significant declines at sites and the extreme scarcity of significant increases suggest that the Burrowing Owl population decline in Saskatchewan is rapid and ubiquitous.

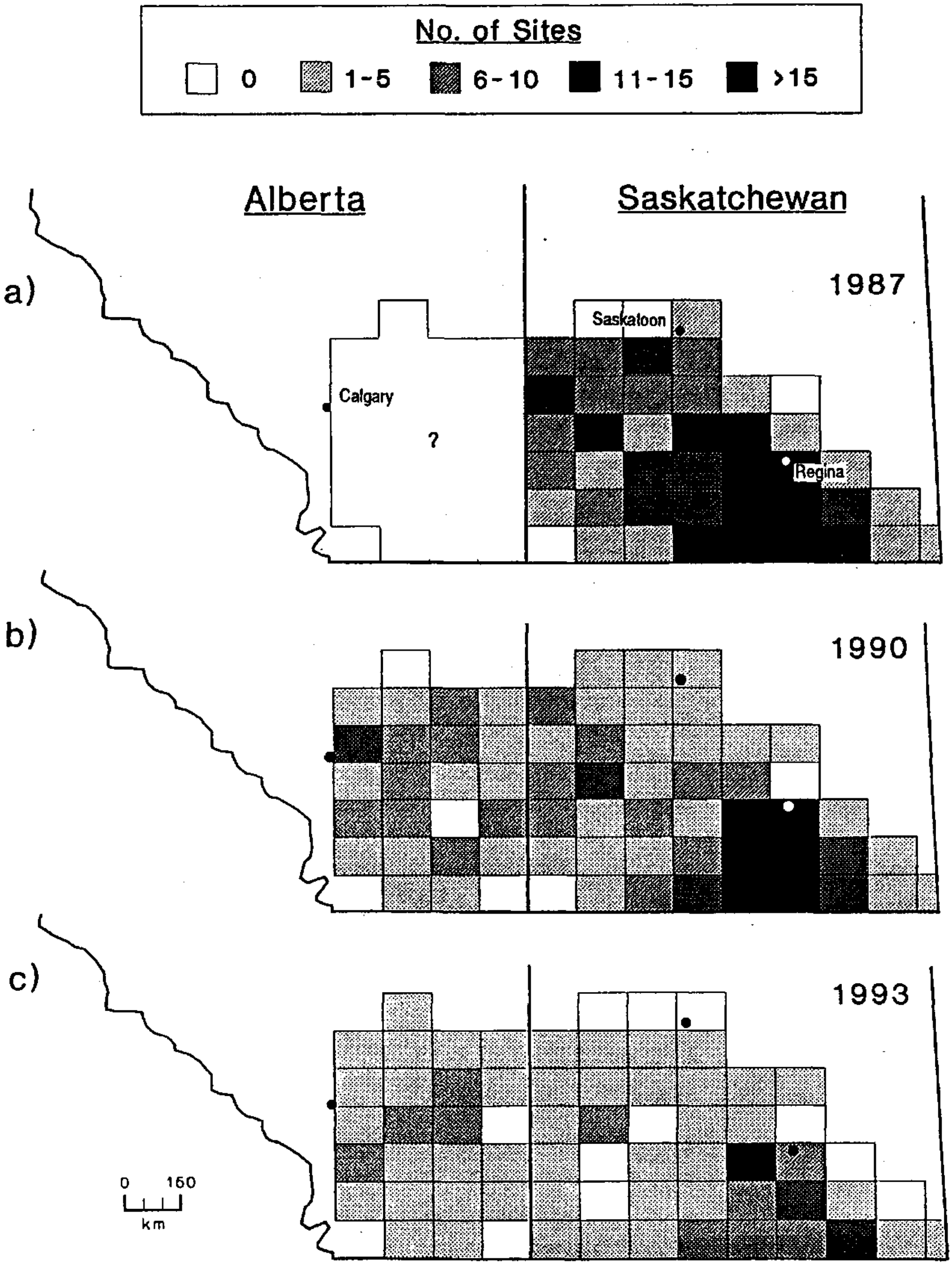


Fig. 6. Numbers and distribution of occupied sites ("colonies") as reported by Operation Burrowing Owl members in Saskatchewan for 1987 [a], and in both Alberta and Saskatchewan for 1990 [b] and 1993 [c]. Each square on the figure indicates the number of occupied sites in a group of four 1:50,000 scale mapsheets. Each owl site is ≤ one quarter-section (64.8 ha) of pasture. Note that the number of occupied sites declined over time throughout the Burrowing Owl's range in both provinces, including what appears to be the core of their range, the Regina Plain and the Missouri Coteau. The actual decline is likely more severe than indicated, given the substantial increase in membership over the same period (see Fig. 4).

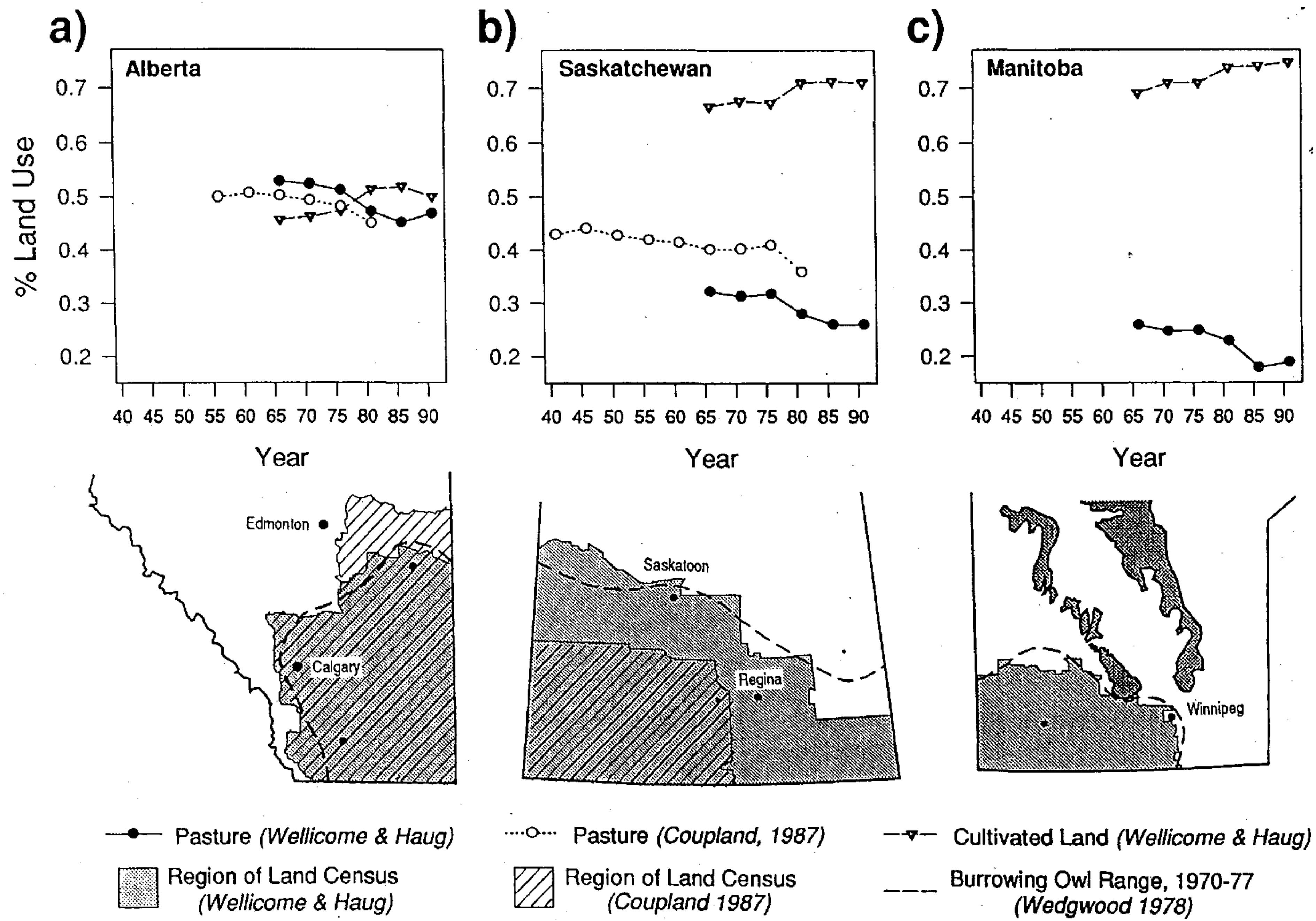
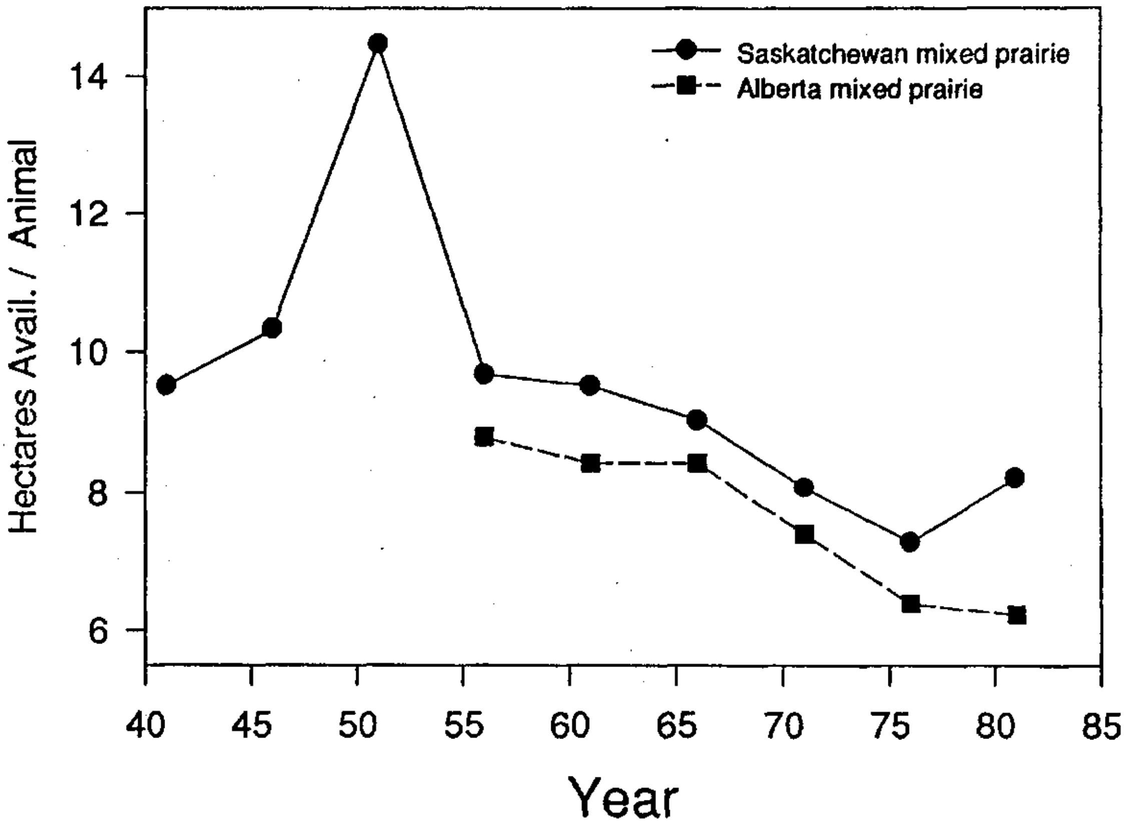


Fig. 7. Land-use changes over time in Agricultural Census Divisions within the Burrowing Owl's range (see Wedgwood 1978). Proportion of pasture represents the sum of tame pasture ("Improved Pasture" category) and native pasture ("Other Unimproved Land" category) divided by "Total Farm Area" reported for each census year. Proportion of cultivated land equals the sum of acres in "Crops" and "Summerfallow" categories divided by "Total Farm Area". Census Divisions 1, 2, 3, 4, 5, 6, and 7 were used in Alberta [a] and 1, 2, 3, 4, 6, 7 ,8 , 11, 12, and 13 in Saskatchewan [b]. Because Census Division boundaries changed over time in Manitoba [c], land use totals were obtained by combining Rural Municipality reports. Historical data on pastureland were obtained from Coupland (1987) for Fescue Prairie plus Mixed Prairie Census Divisions 1, 2, 3, 4, 5, 6, 7, 10; native plus seeded) in Alberta, and Mixed Prairie (Census Divisions [illegible] 7, 8; native plus seeded) in Saskatchewan. Substantial losses of pasture within the Burrowing Owl's range occurred between 1976 to 1986 in all three provinces.



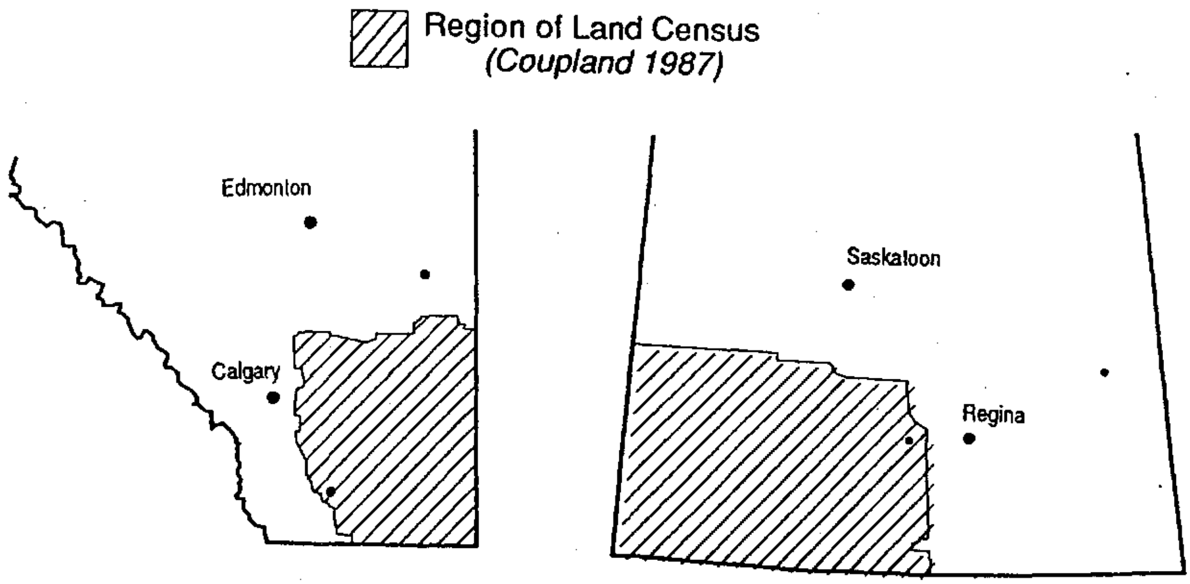


Fig. 8. Change in total grazing load, measured as the area of pasture (tame plus native) available to each animal unit of livestock (modified from Coupland 1987). Seeded pasture is assumed to have three times the carrying capacity of native pasture. Agricultural Census Divisions examined in Mixed Prairie are 1, 2, 4, and 5 in Alberta, and 3, 4, 7, and 8 in Saskatchewan.

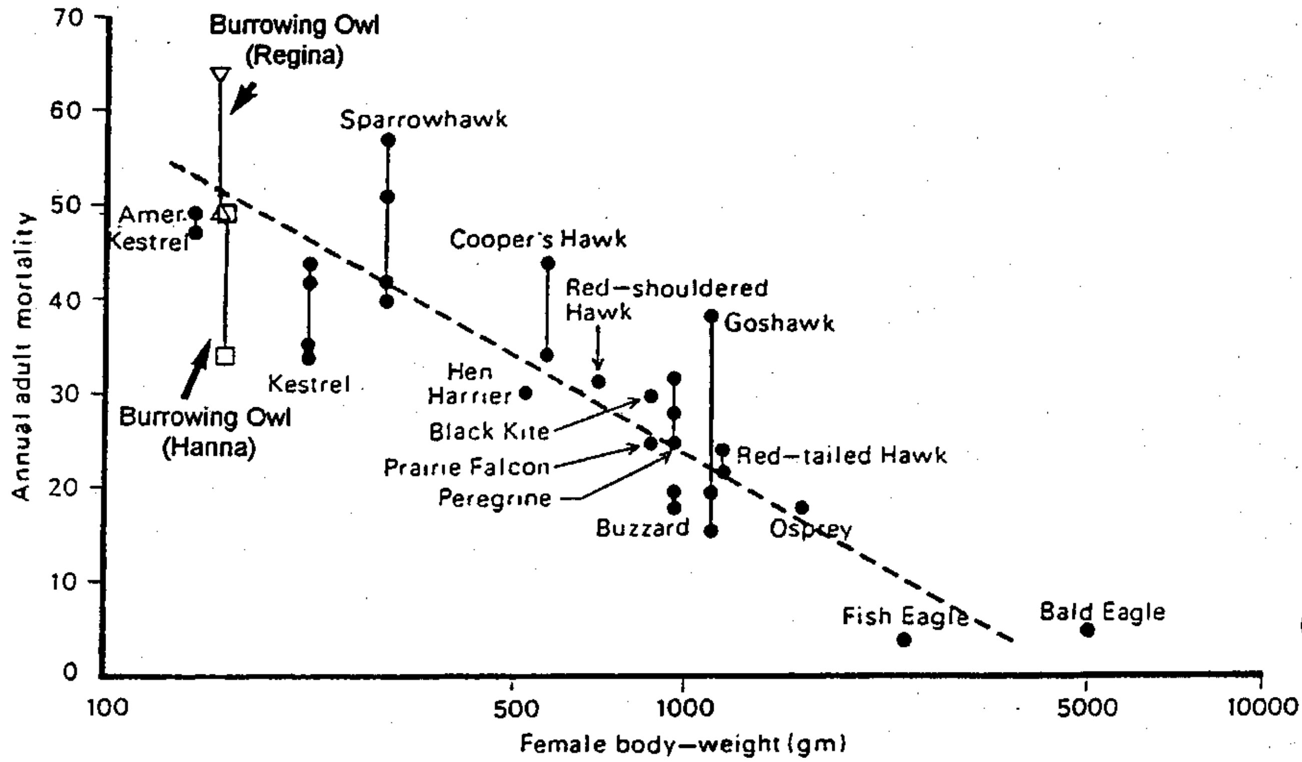


Fig. 9. Annual mortality of adult Burrowing Owls and other raptors against female body weight. Separate estimates for the same species are joined by solid lines. The scale for body weight is logarithmic. Mortality estimates for the falconiforms are based on band recoveries, except those for Bald Eagles, which use adult/immature plumage ratios. Estimates for Burrowing Owls are calculated from resightings of live, banded birds. This method may underestimate mortality because birds that emigrate from the study area are presumed dead. Owl mortality on the Regina Plain, Saskatchewan (▽) varied from average to above average, and in Hanna, Alberta (□) from average to below average.