COMMITTEE ON THE
STATUS OF ENDANGERED
WILDLIFE IN CANADA

OTTAWA, ONT. K1A 0H3
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COMITÉ SUR LE STATUT
DES ESPÈCES MENACÉES
DE DISPARITION AU
CANADA

OTTAWA (ONT.) K1A 0H3
(819) 997-4991

STATUS REPORT ON THE TOWNSEND'S MOLE *SCAPANUS TOWNSENDII* IN CANADA

BY

S. TIM SHEEHAN

AND

CARLOS GALINDO-LEAL

**STATUS ASSIGNED IN 1996
THREATENED**

REASON: A SMALL POPULATION RESTRICTED TO A VERY LOCALIZED AREA OF ABOUT 15 - 20 SQUARE KILOMETERS IN THE FRASER VALLEY, ASSOCIATED WITH A VERY SPECIALIZED TYPE OF SOIL; THREATENED BY HABITAT LOSS FROM URBANIZATION AND INCIDENTAL TRAPPING.

OCCURRENCE: BRITISH COLUMBIA

COSEWIC - A committee of representatives from federal, provincial and private agencies which assigns national status to species at risk in Canada.

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le 10 juillet 1996

MEMBRES DU CSEMDC
LISTE DE DIFFUSION DU CSEMDC
CONTACTS DU SCF CONCERNANT LES ESPÈCES EN PÉRIL

OBJET: RAPPORT FINAL DE SITUATION - TAUPE DE TOWNSEND

Au cours de la réunion générale annuelle d'avril 1996, le CSEMDC a désigné la taupe de Townsend comme étant une espèce « menacée ». Le rapport de situation de cette espèce a été finalisé et vous en trouverez un exemplaire ci-joint.

Les trois autres mammifères terrestres qui ont été considérés à la réunion d'avril dernier sont : la martre (population de Terre-Neuve), qui est passée de la catégorie « menacée » à « en danger de disparition »; la loutre de mer, qui est passée de la catégorie « en danger de disparition » à « menacée »; et le campagnol des armoises est maintenant considérée comme une espèce dont le statut est « indéterminé ». Au fur et à mesure que ces rapports seront finalisés, nous vous en enverrons des exemplaires.

La coordonnatrice des secrétariats
du CSEMDC et du RESCAPÉ

Sylvia

Sylvia Normand
a\s Service canadien de la faune
Environnement Canada
Ottawa (Ontario)
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p.j.

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COMITÉ SUR LE STATUT DES ESPÈCES MENACÉES DE DISPARITION AU CANADA

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JUNE 1994

NOTES

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SPECIES:	"Species" means an indigenous species, subspecies, variety or geographically defined population of wild fauna and flora.
VULNERABLE: (V)	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
THREATENED: (T)	A species likely to become endangered if limiting factors are not reversed.
ENDANGERED: (E)	A species facing imminent extirpation or extinction.
EXTIRPATED: (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
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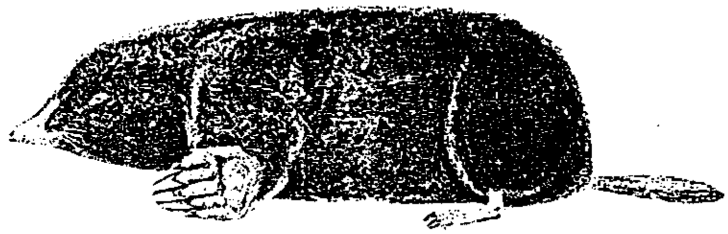
STATUS REPORT ON TOWNSEND'S MOLE

(*Scapanus townsendii*)

IN CANADA



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STATUS ASSIGNED IN 1996
THREATENED

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A. EXECUTIVE SUMMARY

Introduction

Townsend's mole (*Scapanus townsendii*) is the largest North American mole. Two subspecies are recognized; *Scapanus townsendii olympicus* and *Scapanus townsendii townsendii*, but only the latter persists in Canada and it is the most widespread. Adults vary in length from 179 to 237 mm and males average 142 g in weight while females average 119 g. This fossorial species is covered with a thick, velvet-like pelage ranging from dark grey to black in colour. They possess broad forefeet that are each equipped with five strong claws designed for shearing soil. Although Townsend's mole is nearly identical to the smaller coast mole (*Scapanus orarius*), criteria exists which allows for the differentiation of specimens.

Distribution

Townsend's mole range from northwest California along the west coast of Oregon and Washington into southwestern British Columbia. This species distribution in the Fraser Valley is apparently restricted to 13 km^2 around Huntingdon near the international border. Despite new records which indicate this mole persists further north than previously thought, it has one of the smallest distributions of any mammal found in Canada.

Protection

Townsend's mole is not classified as 'wildlife' and it receives no protection. Although this mole has been recently upgraded to the provincial Red List as *Threatened*, it is also a Schedule B *pest* species which can be removed at anytime to protect property.

Habitat

Townsend's mole are found in moist meadows, lowlands, prairie and shrub habitats, but they prefer manured pastures and hayfields partly because they can support greater populations of earthworms and soil invertebrates. Ideal habitat has been reduced by intensive agricultural practices and urbanization which has created a highly fragmented landscape. The population of the Fraser Valley has increased dramatically in recent years and this trend is not expected to subside. Even land within the Agricultural Land Reserve, originally set aside specifically for farming, has been rezoned for non-farm uses.

General Biology

Townsend's moles are sexually mature by the first breeding season following their birth which begins sometime in January. Nestlings are born throughout March and April and the average litter size is three. Townsend's mole is not prolific; individual moles are probably limited to three breeding periods and the progeny of a pair would average 9. Moles are generally solitary except during the brief breeding season. There is little overlapping of movements between neighbouring moles which suggests they are also territorial. Densities range from .42 to 12 individuals per hectare and are highly correlated to habitat quality. Although this mole is capable of colonizing large tracts of land, this has not occurred in the Fraser Valley.

Limiting Factors

Townsend's mole has few natural enemies. Domestic dogs and cats are considered to be this species most important predators, but their impact is considered negligible. Although this mole can swim, they often drown during periods of intense flooding. Mole trappers and landowners intolerant of mole activity are undoubtedly this species greatest direct threat.

Special Significance of Species

In Canada, Townsend's mole is found only in the Fraser Valley of British Columbia. This region marks the northern limit of their distribution and some authors believe that marginal populations have a high evolutionary significance to their species.

Recommendations/ Management Options

Townsend's mole should be removed from the Schedule B 'pest' list and granted 'wildlife' status which will provide some protection. The majority of the land where this mole persists is privately owned and expensive. Therefore, education and awareness are the only feasible alternatives to facilitate the preservation of habitat for this mole.

Evaluation and Proposed Status

Townsend's mole is not considered at risk in California, Oregon or Washington and its global rank is G5. In British Columbia this mole is very rare, localized and has been assigned the subnational rank of S1? Habitat loss and urbanization threaten the long-term persistence of this mole in Canada. We recommend that *Scapanus townsendii townsendii* be designated by COSEWIC as **THREATENED**.

B. INTRODUCTION

Townsend's mole (*Scapanus townsendii*) belongs to the family Talpidae (moles, shrew-moles and desmans) and is the largest of the New World moles (subfamily: Talpinae). Two subspecies are recognized; *Scapanus townsendii townsendii* and *Scapanus townsendii olympicus*, but only the former persists in Canada and it is the most widespread (Carraway, Alexander and Verts 1993, Nagorsen 1996) (Fig. 1).

This cylindrical-bodied obligate fossorial mammal is covered with a short, velvet-like pelage which varies in colour from dark grey to black (Jameson and Peeters 1988). Forefeet are broad, flat and equipped with five strong, straight claws designed for shearing soil and tunnelling. The palmar surface of the manus is effectively broadened for digging by a sesamoid bone called the os falciforme (Hartman and Yates 1985). The finely boned, narrow hindfeet also possess five claws, but they are too small for digging and instead provide the mole with locomotion and mobility within their tunnel systems. Moles are capable of moving easily either forwards or backwards belowground -- an ability undoubtedly enhanced by the fact that each hair follicle is capable of uni-directional movement.

Adult Townsend's mole range in total length from 179 to 237 cm (van Zyll de Jong 1983). The body weight of females averages 119 g while the males are significantly heavier and average 142 g (Pedersen 1963). They possess 44 teeth and their dental formula is i 3/3, c 1/1, p 4/4, m 3/3 (Nagorsen 1996).

Townsend's mole have no visible pinnae and their minute blue eyes are usually hidden by hair. Although Talpids lack visual acuity, they are blessed with acute hearing and a well-developed sense of touch. The organs of Eimer, located within the papillae on the rostrum, are a group of touch-sensitive structures that exhibit the highest degree of nerve ending development in the mole (Carraway et al. 1993). The stimuli provided by Eimer's organs synergizes with other sensory input and allows the mole to detect prey and danger.

Townsend's moles construct molehills with sheared dirt that is expelled to the surface during the construction and maintenance of their extensive underground tunnel systems. Fresh molehills are large, conical and cloddy.

This species can be distinguished from the nearly identical coast mole (*Scapanus orarius*) by its larger size: total length of adults exceeds 175 mm; hind-foot length is greater than 24 mm and skull length (not including incisors) is more than 37 mm (van Zyll de Jong 1983, Nagorsen 1996). Furthermore, the coast mole is unlikely to exceed 91 g in weight (Glendenning 1959) and its sublachrymal ridge is indistinct; however, it is prominent on Townsend's mole (Carraway et al. 1993). Also, the plantar tubercles on the hindfeet of Townsend's mole are much more prominent than those found on the coast mole.

C. DISTRIBUTION

Townsend's mole inhabits the western portion of North America. *S. t. townsendii* is relatively widespread and ranges from the coastal region of extreme northwest California northwards along the Coast Range and interior valleys of Oregon up through the Olympic Mountains of Washington and into southwestern British Columbia (Hall 1981, Carraway et al. 1993, Nagorsen 1996) (Fig. 1). Conversely, *S. t. olympicus* is confined to Olympic National Park in Washington (Johnson and Yates 1980).

In Canada, *S. townsendii* is restricted to the Fraser Valley of southwestern British Columbia. This region is situated within the dry subzone of the Coastal Western Hemlock biogeoclimatic zone that is characterized by a mild climate which is similar to the areas of Washington and Oregon where Townsend's mole persists. Researchers have delineated the distribution of this mole to a 13 km^2 region of low-lying black humus land around Huntingdon near the international border (Glendenning 1959, Nagorsen 1996). This estimation was likely based upon the small number of voucher specimens available and the localized nature of these museum records (Table 1). In fact, the records suggest that all 23

Townsend's mole specimens catalogued into Canadian museums, prior to 1995, were collected from only three sites that are all within a 1 km radius of each other (i.e. Village of Huntingdon; Sumas, Washington; Racey Farm) (Fig. 2).

Table 1. List of locations, year and number of *S. t. townsendii* collected in Canada

Num.	Location	Municipality	Year	No. of Specimens
1.	Post Office/Village	Huntingdon	1927	5
			1980[a]	1
2.	Village (Sumas)	Washington (USA)	1927	1
3.	Racey Farm	Huntingdon	1930	3
			1934	1
			1935	1
			1942	1
			1944	1
			1945	1
			1946	2
			1947	1
			1949	1
			1976	3
			1981[b]	1
			1995[c]	1
4.	Marshall Rd.	Abbotsford	1995	1
5.	Ledgeview Golf Course	Abbotsford	1995	1*
			1995	2**
			Total	**28**

[a] The only reference assigned to this voucher specimen is 'Huntingdon'.
[b] The origin of this voucher specimen is RR2 Farmer Road - same as Racey Farm.
[c] This voucher specimen came from property less than 20m west of the Racey Farm.
* This specimen is in a private collection and was captured in 1986 - identification confirmed in 1995 by Sheehan and Galindo-Leal.
** Two additional specimens from this location were submitted to the UBC Vertebrate Museum in Nov.1995 by S.T. Sheehan. They have not yet been officially catalogued.

In 1995, a live-trapping effort targeting moles was conducted in the Fraser Valley which resulted in 12 new Townsend's mole records (Sheehan and Galindo-Leal submitted). Twenty-two sites were sampled (1,308 trap-nights) and three Townsend's moles and 22 coast moles were captured in a live-trap similar to the one described by Moore (1940). These captures verify the presence of Townsend's mole in the Racey Farm vicinity. Previous attempts to live-trap *Scapanus* species in Canada have been unsuccessful (Schaefer 1978, Kremsater and Andrusiak 1991). Of the remaining 9 Townsend's moles: 4 were directly captured alive (i.e. shovel) and 5 carcasses were provided by landowners and professional mole trappers. The voucher specimens collected from locations number 4 and 5 are important (Table 1). The Marshall Road (n = 1) and Ledgeview Golf Course (n = 3) specimens are 5 and 8 km respectively, from the international border at Huntingdon. Although this suggests that Townsend's mole may inhabit a range exceeding 13 km^2 in Canada its distribution may be patchy and nevertheless, remains small. Mapping the locations where Townsend's mole has been collected based upon museum records before 1995 (n = 3) and recent fieldwork (n = 11) will illustrate this species restricted distribution (Fig. 3).

Campbell (1983) discovered the remains of one *S. townsendii* in Agassiz during the winter of 1978 while analysing the composition of barn owl pellets. This location is also outside the published Townsend's mole range. Interestingly, the majority of Glendenning's (1959) study on the biology and control of the coast mole (*S. orarius*) also took place in Agassiz, at the Experimental Farm. He trapped 940 coast moles over ten winters in this region and does not mention any Townsend's moles being captured. In fact, Glendenning (1959) believed that Townsend's mole range was restricted to 5 square miles around Huntingdon. If Townsend's mole persists in the Agassiz region then it is difficult to imagine how it could have remained undetected for such a long period of time. After nearly a century of agriculture in this area it is likely that a farmer or a mole trapper would have presented a carcass of this large mole to a biologist for inspection. The fact that this town is on the north side of the Fraser River and approximately 60 km from Huntingdon suggests that the remains identified by Campbell (1983) may have been transported northeast by a raptor. Unfortunately, there is no voucher specimen available to verify the identification made by Campbell (1983).

Anecdotal information from professional mole trappers in the Fraser Valley suggests that this species is restricted to the Abbotsford/Huntingdon region. This view is supported by the fact that over 120 coast mole voucher specimens have been taken in the past 100 years from throughout the Fraser Valley, but only 28 Townsend's mole specimens are known (Nagorsen 1996).

Townsend's mole has probably always had a restricted range in B.C. Of the five collecting stations Laing (1927) sampled in southwestern B.C. only the Huntingdon camp produced any Townsend's mole specimens. Even if this species presence was confirmed in the inadequately sampled Sumas and Matsqui Prairie regions around Abbotsford, it would still have one of the smallest distributions of any provincial mammal. This is in stark contrast to its relatively extensive distribution across the border in western Washington state (Fig. 1).

Sheehan and Galindo-Leal (submitted) have developed and are field testing criteria (e.g. mound width, height and tunnel diameter) to differentiate between the two *Scapanus* species found in the Fraser Valley. This methodology should provide a reliable alternative to live-trapping when conducting research on the presence and distribution of either species.

D. PROTECTION

Townsend's mole has been upgraded from the Blue List (Sensitive/Vulnerable) to the Red List (Endangered/Threatened) by the B.C. Ministry of Environment because of its rarity and restricted range (Munro 1993). However, because this species is not deemed *wildlife* under the Wildlife Act (1982) it cannot be protected from being captured, possessed or deliberately killed. In fact, this mole is a Schedule B species which categorizes them as a *nuisance* or *pest* that can be trapped and killed anytime to protect property (MOE 1995).

E. POPULATION SIZE AND TRENDS

There is no information pertaining to population sizes or trends of Townsend's mole in Canada. A crude estimation may be obtained by approximating this species distribution in the central Fraser Valley and multiplying it by an average density figure from research conducted in Oregon, the only data available.

Townsend's mole appears to persist in isolated populations throughout the central Fraser Valley from Huntingdon to northeast Abbotsford (Fig. 5). The fact that Townsend's mole has been recently found in northeast Abbotsford implies that their frequently cited 13 km^2 distribution is too restrictive. However, assuming that this mole is unevenly distributed throughout its range suggests that the actual population would certainly be less than a hypothetical one based upon a larger approximated range. Therefore, it may be more realistic to utilize the smaller 13 km^2 figure for estimating the population.

Reported Townsend's mole densities range from .42 to 12 per hectare (Pedersen 1963, Kuhn et al. 1966, Giger 1973). Because this mole is at the northernmost extent of its geographical range here in B.C. the densities are not expected to be as high as in Washington or Oregon. Also, to compensate for lost (e.g. roads and buildings) and unsuitable (e.g. water and rock) habitat throughout the 13 km^2 range we will adopt a low density value (i.e. 0.5/ha). Therefore, the complete Townsend's mole population in Canada may be smaller than 700 individuals. However, this number reflects a potential population and should only be considered a crude estimate.

To obtain a more reliable estimate, it is necessary to first obtain the average density in the areas inhabited by Townsend's mole and then to identify the amount of suitable habitat. While it is difficult to estimate mole densities, it would be relatively easy to obtain the rate of habitat loss and habitat availability in specific areas.

F. HABITAT

Research from the American Northwest indicates that this mole prefers manured pastures and hayfields (Pedersen 1963, Giger 1973). Grasslands are known to contain more earthworms than forested and arable land (Edwards and Lofty 1972). Townsend's mole is also found in moist meadows, lowlands, river flood plains, prairie and shrub habitats and fir (*Abies*) forests (Dalquest 1948, Johnson and Yates 1980, Maser et al. 1981, Yates and Pedersen 1982). Their abundance can vary dramatically within an area based upon the availability of earthworms, type of vegetation, amount of humus, drainage and soil type (Pedersen 1963). Townsend's mole numbers are supposedly low in gravelly soils (van Zyll de Jong 1983).

The dyking, draining and clearing of land for urban and agricultural purposes has destroyed much of the original natural habitats in the Lower Fraser Valley such as wet meadows, bogs and wooded habitat (Moore 1990). Wildlife had to adapt to this landscape manipulation which favoured those species that could utilize farmland as habitat. Earlier authors (Glendenning 1959, Schaefer 1978) suggested that the introduction of earthworms and the cultivation of this region were responsible for increased populations of moles. However, it is unlikely that such a trend continues today as intensive agricultural practices, mole control efforts, habitat loss and fragmentation have surely synergized to depress existing mole populations.

The presence and abundance of earthworms is integral to their selection of habitat since earthworms comprise from 54.9% (Whitaker et al. 1979) to 85.6% (Wight 1928) of the food items by volume. Vegetable matter accounts for 15.9% (Moore 1933) to 37.9% (Whitaker et al. 1979).

Interestingly, Glendenning (1959) discovered that earthworms comprise 93% of the diet of the more widely distributed (Vancouver to Hope) coast mole (*S. orarius*). Therefore, it is not clear why Townsend's mole is so restricted in range considering pastures and hayfields with bountiful populations of earthworms are present throughout the Fraser Valley. Also, the fact that both the *Scapanus* spp. have overlapping ranges in the Fraser Valley makes the identification of specific Townsend's mole habitat characteristics difficult.

1. Soil

Townsend's mole appears to prefer a specific soil type. Sheehan and Galindo-Leal (submitted) sampled various soil types in the Fraser Valley, but the 12 Townsend's mole specimens they collected came from either Lynden or Alderwood Silt Loam (Fig. 3). No Townsend's moles were found in Lynden Gravelly Silt Loam or Monroe Clay; however, these and the Peat soils have not been adequately sampled (see Appendix 1 for a profile of the five soil types illustrated in Fig. 3).

Although the older soil maps lack the detail and complexity of those available today (e.g. Luttmerding 1981) their simplicity clearly illustrates Townsend's mole association to the silt loam soils. Interestingly, the Alderwood Silt Loam section is rugged and has limited potential for agriculture as opposed to the gently rolling topography of the Lynden Silt Loam area where dairy farming, which produces ideal habitat, is widespread. However, it should not be surprising to find Townsend's mole capable of surviving in rugged terrain because the subspecies *S. t. olympicus* inhabits the Olympic Mountains in Washington up to an elevation of approximately 1615 m (Johnson and Yates 1980). Possibly, Townsend's mole may have inhabited the northern portion of the Lynden Silt Loam region around Abbotsford, but has since been marginalized eastwards into the Alderwood Silt Loam belt as a result of urbanization.

Silt Loam soils are medium textured; water infiltration and transmission through the soil is moderately high, yet they hold water quite well (Bertrand et al. 1991). They are suitable for both urban and agricultural purposes (Luttmerding 1981). Since these soils are friable to firm when moist and soft to slightly hard when dry (Bertrand et al. 1991), they are undoubtedly well-suited to the moles occupation of year-round tunnelling and mound building. Also, light and medium loam soils are able to support greater populations of earthworms than heavier clays or more sandy and alluvial soils (Edwards and Lofty 1972). Although silt loam soils are acidic (Luttmerding 1981), *Lumbricus terrestris* is not overly pH sensitive like some earthworm species whose distribution and abundance are adversely affected by low pH levels (Edwards and Lofty 1972). These soil characteristics and capabilities help to explain why Townsend's mole appear to prefer this soil type.

In addition to the relationship between Townsend's mole and silt loam soils, most sites where this mole was found had grass cover. This may be partly explained by the fact that pastures and grasslands support a greater biomass of *L. terrestris* than arable and forested habitats (Gorman and Stone 1990). Because grassland soils are highly structured they doubtlessly provide a more secure, stable environment for the construction of mole tunnels. Also, grass cover insulates the soil from extreme temperatures -- freezing is considered to be the most important factor influencing the seasonal decrease in earthworm numbers (Edwards and Lofty 1972). However, since mole activity (i.e. molehills) is more visible on cut hayfields, lawns and pastures than in bush and/or alder/salmonberry habitats it reasons that grasslands would be sampled more frequently.

Of the first Townsend's moles captured in B.C. "a nice one [was] taken in the yard of the Huntingdon Post Office...from the rather heavy clayey soil" (Laing 1927). The old post office sat on Monroe Clay which extends roughly 10 km east of Huntingdon along the international border north to the Trans Canada Highway and is referred to as the Sumas Prairie (Fig. 3). In 1995, Sheehan and Galindo-Leal (submitted) sampled three sites in this soil type, but captured only coast moles. However, because this region has not been adequately sampled it is premature to conclude that Townsend's mole is absent from this soil type.

It remains unclear why Townsend's mole has not colonized large tracts of land throughout the Fraser Valley like the coast mole. However, the soil map indicates that Townsend's mole presence coincides with Silt Loam soil. Although a small, unsampled section of Lynden Silt Loam occurs north of the Fraser River around Mission (Fig. 3), just over 30 km^2 of this soil type exists in the Fraser Valley. This fact may contribute to the restricted distribution of this species.

2. Habitat Distribution

In the Fraser Valley, Silt Loam soils cover an area slightly exceeding 30 km^2 with the largest portions in the Abbotsford and Mission vicinities. Although suitable habitat may exist in the Mission vicinity there are no Townsend's mole records from this area. Conversely, the 20+ km^2 existing in the Abbotsford/Huntingdon district supports the only verified populations of this species and therefore, provides the only known habitat. In this modified and fragmented landscape Townsend's mole must contend with urbanization, industrial/business interests and intensive farming for existence.

Trends in quality and quantity of habitat

1. Farming

It is apparent that suitable habitat for the Townsend's mole is created by certain types of farming (e.g. dairy farms with manured pastures and hayfields). Soils that are constantly tilled and treated with pesticides and herbicides (i.e. cash cropping) have poor structure, provide less attractive and inferior habitat. The proliferation of intensive cash cropping (e.g. berries, vegetables and flowers) in the lower Fraser Valley will increase the amount of arable land (Moore 1990). This trend will reduce the amount of grassland available for mole habitat.

Farms in the Abbotsford/Huntingdon region average only 25 ha (Ministry of Economic Development 1986). Favourable mole habitat is more likely to become fragmented as less land is owned by more individuals who use their property for different purposes. This reality presents the danger of isolating Townsend's mole into remnant populations which will adversely affect this species long-term persistence in the Fraser Valley. Also, despite the economic importance of specialty crops in this region much of the prime agricultural land continues to be lost to urbanization (Moore 1990).

2. Agricultural Land Reserve

The Agricultural Land Reserve (ALR) was established in 1974 to preserve 135 000 ha of farmland in the Lower Fraser Valley for the future (Ministry of Agriculture, Fisheries and Food 1995). Non-farm use throughout the ALR is supposedly restricted; however, from 1974 to 1987 almost 6% of the land has been withdrawn for urban and industrial interests and applications for the withdrawal of more land from the ALR are continually filed (Moore 1990). Furthermore, golf courses are now valid non-farm uses for land in the ALR. Although golf courses can provide suitable mole habitat (dependent upon the application of biocides), applications to withdraw the surrounding properties from the ALR for housing developments and commercial interests inevitably follow. Golf courses also have the tendency to raise the price of land which makes the purchase of land for farming in their vicinity very expensive and often uneconomical.

The southern section of the ALR in the Huntingdon and Sumas Prairie region is isolated from the northern section around Clayburn and the Matsqui Prairie area by a wide non-ALR strip (i.e. urban Abbotsford) (Fig. 3). This void in the connectivity of potentially suitable habitat (e.g. pastureland) represents a formidable barrier to the northern migration of Townsend's mole from the southern ALR region and vice versa. If this mole exists in the northern ALR then it is very likely that they are isolated from the southern population because of the highly fragmented non-ALR landscape.

Mole habitat within the ALR is less likely to disappear than that outside, but soil management practices on farms (e.g. crop rotation, ploughing and pesticides) also have the potential to reduce and alter mole habitat.

3. Human Population Growth

The human population of the Central Fraser Valley in 2006 is expected to be over 320,000 -- an increase of 100,000 from the current figure (B.C. Research 1983). In fact, the projected population of Matsqui is expected to nearly double to 132,363 by the year 2011 (Matsqui Development Services 1994). As the residential and industrial activities continue to increase (already surpassing the relative importance of agriculture, Ministry of Economic Development 1986) and convert this region into a suburb of Vancouver the amount of mole habitat will undoubtedly decline. The population growth in the Lower Mainland of B.C. has been staggering since the turn of the century (Fig. 4).

Another disturbing trend becomes visible when analyzing how inefficient Vancouver's commuter hinterlands are at converting rural land into urban space. For example, based upon the number of hectares urbanized per 1,000 increase in population Vancouver had a rate of 28 ha/1,000 while Chilliwack converted 89 ha/1,000 (Moore 1990). It is known that larger urban centres convert land more efficiently than do small ones, but unless some far sighted planning is initiated in the Fraser Valley the impending population boom will drastically reduce and fragment mole habitat. To what degree the ALR will be eroded by this substantial forecasted population growth remains to be seen.

Rate of Habitat Change

The heavy sodded grasses of lawns, golf courses, pastures and hayfields over Silt Loam soils were the habitats from which all 12 Townsend's moles were recently collected (Sheehan and Galindo-Leal submitted). Although approximately 20+ km^2 of this soil type exists in the Abbotsford/Huntingdon region, there are factors which threaten to reduce the present amount of mole habitat available within this area. The forecasted population growth for this area and the necessary infrastructure will undoubtedly impact potential habitat outside the ALR. Of the Lower Fraser Valley's 300,000 ha, an additional 29,000 ha could be urbanized by 2001 if present trends continue (Moore 1990). Increased cash cropping and other intensive agricultural practices will continually destroy and modify Townsend's mole habitat both inside and outside the ALR. It is predicted that land-use competition between urban, industrial, recreational, agricultural and wildlife interests will remain acute in this region (Moore 1990).

Although it is unlikely that a significant reduction in the quantity and quality of potential mole habitat will occur over the next ten years, it is certain to be reduced. A reduction in habitat will force Townsend's moles to concentrate into fewer fields that will become further isolated. This will subject the isolated mole populations to the deleterious effects of species relaxation and to the numerous extinction vortices (Saunders et al. 1991). Both the effects of agricultural practices; tilling, ploughing, crop rotation, the application of biocides and urbanization pose serious threats to the quality and integrity of existing Townsend's mole habitat.

G. GENERAL BIOLOGY

There has been no research conducted in Canada on Townsend's mole reproduction or ecology so the findings from American studies are reviewed to provide general information.

Reproductive capability

1. Breeding season

The majority of males apppear to be in breeding condition from November to February as evidenced by the cycle of testes enlargement (Moore 1939, Pedersen 1963). However, males with enlarged testes have been documented in June (Maser et al. 1981).

The presence of an enlarged, perforated vaginal opening indicating females in breeding condition, is evident from early December to late February when embryos begin to appear in some individuals (Pedersen 1963). It is advantageous for the species to have males in breeding condition longer than the females to ensure that most females are bred. In Oregon, the breeding period peaks throughout January and into early February (Pedersen 1963).

The Eastern American mole (*Scalopus aquaticus*) exhibits a two month delay in its breeding season between the 32nd and 45th N parallels which also results in different timing of juvenile dispersal (Eadie and Hamilton 1956). The breeding period of Townsend's mole in Canada may be delayed because of the latitudinal gradient between Oregon and British Columbia. The scanty breeding data for British Columbia summarized by Nagorsen (1996) suggests that the breeding season is later than Oregon.

Male European moles (*Talpa europaea*) and coast moles dig long, straight tunnels which radiate from their encampments in search of receptive females during the breeding season (Schaefer 1978, Gorman and Stone 1990). Research on the Townsend's mole does not mention this behaviour. However, Sheehan and Galindo-Leal (in prep) live trapped one large Townsend's mole that had constructed an 87 m long, winding tunnel from its encampment in February that was likely constructed for mating purposes.

2. Nesting

During the breeding season, female Townsend's moles construct natal nests by excavating spherical underground cavities. Nests average 1,639 cm^3 in size and are usually located in elevated areas - most likely to prevent the nest from flooding during late winter/early spring rains (Kuhn et al. 1966, Pedersen 1966, Carraway et al. 1993). The use of damp, usually green, vegetation in the construction of the nests outer core suggests that the heat produced from fermentation is intentionally and ingeniously harnessed to add warmth to the nest (Kuhn et al. 1966, Pedersen 1966). Nests are generally located only 15 to 20 cm from the surface (Pedersen 1963). They are constructed in a short period of time just prior to parturition (Pedersen 1963). Females occassionally reveal their nest building activities by expelling the excavated dirt up onto the ground in one of three identifiable forms: a single large mound (greater than 76 cm in diameter and 30 to 45 cm high), a cluster of several smaller mounds (2 to 3 m in diameter), or a single large molehill at the base of a fencepost (Pedersen 1963, Kuhn et al. 1966). Cautious probing with a steel rod in these locations will usually reveal the nest site. Locating a 'soft spot' by pressing the foot down gently in the vicinity of these mounds is another method deemed productive (Kuhn et al. 1966). These nesting cavities are sometimes reused by the same female in following years (Carraway et al. 1993).

If a nest is disturbed (e.g. dug up by researchers) prior to parturition the female will usually abandon the site (Pedersen 1966). However, females are less inclined to leave disturbed nests containing young (Kuhn et al. 1966) although this sometimes does occur (Pedersen 1963). There is no evidence to suggest that females will relocate the nestlings to the safety of another nest if threatened or disturbed excessively.

Kuhn et al. (1966) discovered that a number of nests located in pastures were destroyed by farm equipment and dug up by cattle which often trampled the nestlings in the process.

3. Breeding age/frequency

Townsend's mole are believed to be sexually mature at ten months of age and thus, most juveniles are capable of breeding during their first winter (Pedersen 1963, van Zyll de Jong 1983). Because of the short breeding season it is unlikely that more than one litter is produced per year. However, because a large number of spermatozoa can be stored in the epididymes of European moles for nearly three months after the cessation of sperm production many males remain capable of siring a second litter (Gorman and Stone 1990). Although there is no evidence to indicate Townsend's mole have more than one litter/year this information reveals the simplicity and possible inaccuracy of demarcating the end of the breeding season as coinciding with testes collapse and regress. The gestation period is estimated to vary from four to six weeks (Yates and Pedersen 1982).

4. Offspring

Townsend's mole litters are delivered from late March to mid-April, but probably later in Canada. Three young is the mode (Pedersen 1963, Kuhn et al. 1966), although as few as one and and as many as six have been reported (Moore 1939). Because the litter size of most mole species decreases as latitude increases (Gorman and Stone 1990) the average Townsend's mole litter in Canada is likely less than in Oregon.

Neonates are pink, naked, lack teeth and distinguishable eyes, possess soft claws and pronounced paddle-like front feet (Pedersen 1963). They average 5 g in weight and 60 mm in length (Pedersen 1963, Kuhn et al. 1966). Nestling moles can be separated into three age-groups according to differences in skin color, body length, weight and fur development (Kuhn et al. 1966). Class III nestlings (those ready to leave the nest) are between twenty-two and thirty-six days old, possess a sleek, soft and short coat of fur, exceed 115 mm in length and weigh between 60 and 80 g (Kuhn et al. 1966).

Population structure

There is scant information on the spatial organization of the sexes within Townsend's mole populations. Pedersen (1963) trapped out a 6 and 8 ha field and then sexed each of the 124 Townsend's moles killed, but he did not report any disproportionate male/female ratio or distribution within these fields. However, analysis of his total trapping results (n=300) indicates that males were captured by an almost 2:1 ratio over females. This is consistent with the capture data of other mole species which indicates that males are more easily captured than females (Gorman and Stone 1990). However, Giger (1973) toe-clipped 180 Townsend's mole nestlings and a relatively proportional ratio of males to females (20 and 24 respectively) were recaptured almost four months later. Also, research on the coast mole indicates that males and females of this species are randomly distributed within a population by sex and age (Schaefer 1978).

There are no specific criteria available to age Townsend's mole to help establish a population structure. Histological sections through the jaws and teeth are used to age the European mole (Gorman and Stone 1990). Glendenning (1959) used skin texture and weight to estimate the age structure of the coast mole and found that; 55% were less than 1 year old, 39% were between 1 and 3 years old, and 6% were over 3 years. Schaefer (1978) devised a key based upon tooth wear to also calculate coast mole age and discovered; 70% were 1 year old, 26% were 2 years old, and 4% were 3 years old. However, the methodologies used by both Glendenning (1959) and Schaefer (1978) are somewhat problematic which renders their figures as crude estimates. Although currently unknown, the age structure of Townsend's mole likely resembles that of the coast mole.

Reproductive potential and recruitment

If Townsend's moles have similar survival as coast moles then they are limited to three breeding seasons. Based on an average annual litter size of three and the fact that juveniles are capable of breeding during their first winter, one female can be expected to produce an average of nine offspring in her lifetime. Pedersen (1963) reported the following litter sizes based upon the collection of 43 nests; 12% contained 4 young, 56% contained 3, 30% contained 2 and 2% contained one. This reproductive potential is low, but it seems to be inherent to the genus *Scapanus* (Glendenning 1959).

The recruitment rate for coast moles is high as evidenced by their ability to re-invade cleared areas. For example, Glendenning (1959) trapped-out a 160 acre field for nine consecutive years until the number of coast moles dropped appreciably. However, some research suggests that Townsend's mole may have a lower recruitment potential than the coast mole. For example, Pedersen (1963) reported that a field cleared of Townsend's moles did not re-establish itself; instead, the field was subsequently re-invaded by coast moles.

Food habits

Analyses of stomach contents indicates that Townsend's mole is dependent upon a variety of soil invertebrates like earthworms and their cocoons, insect larvae and pupae, centipedes, beetles and *Diptera* (Carraway et al. 1993). However, earthworms are this species primary food source, comprising over 70% of their diet in some instances (Wight 1928, Moore 1933, Pedersen 1963). Vegetable matter such as bulbs and grain (Wight 1928), garden peas, potatoes and carrots (Moore 1933), grass roots (Pedersen 1963, Whitaker et al. 1979) are also consumed Townsend's mole. However, these food items account for a small percentage of their diet.

Due to the high moisture content of its diet (water constitutes 75-90% of earthworm body weight; Grant 1955, from Edwards and Lofty 1972) Townsend's mole may not require a supply of free water to supplement its diet. Captive moles fed ground beef did require additional water, but this need was attributed to the high protein content of the beef (Pedersen 1963). If water was necessary, it is logical to assume that these moles could burrow down and satisfy their thirst with the moisture contained in the subsoil.

It has been reported that to survive, Townsend's mole must consume between 33 and 66% of their weight in food daily (Cahalane 1947, from Carraway et al. 1993). Based upon these figures the average female and male (average weights of 119 and 142 g, respectively; Pedersen 1963) Townsend's mole would require from 14 to 29 kg and 17 to 34 kg of food each year, respectively. Moles inhabiting pastures would be able to satisfy their annual diet mass requirements relatively easier than individuals persisting in other habitats.

The application of biocides is a common soil management procedure where intensive agriculture (e.g. cash cropping) is practiced. Where exposed, invertebrates are known to contain high levels of these toxins which become invariably consumed by the foraging mole. Due to their high metabolic and consumption rates, moles are prone to the accumulation of significant levels of toxic chemicals in their bodies (Nagorsen 1996). The adverse effects of biocides on insectivores in the Fraser Valley are unknown.

Interestingly, European moles are known to store large quantities of earthworms in caches for later use (Gorman and Stone 1990). Worms are immobilized when the mole bites three to five segements from their anterior ends (Evans 1948, from Edwards and Lofty 1972). This behaviour has not been verified in *Scapanus*, but Glendenning (1959) discovered small chambers 4 inches long by 3 inches wide throughout coast mole tunnel systems which may serve this purpose. These chambers have not been found in Townsend's mole tunnel systems.

Tunnels

Pederson (1963) suggested that Townsend's mole construct four types of tunnels: shallow tunnels (average 15 cm in depth), deep tunnels (from 30 to 76 cm deep), surface tunnels (directly below objects laying flat on the ground, e.g. boards) and surface runs (<10 cm). The later one is common in frequently tilled fields and characterized by shallow ridges and the absence of mounds.

Shallow tunnels are most frequently encountered and may cover the entire home range (Pedersen 1963). Considering most earthworms are present in the top 7.5 cm of soil for a significant portion of the year (Edwards and Lofty 1972) shallow tunnels are important to Townsend's mole for capturing prey.

Tunnel depth is doubtlessly determined by the vertical distribution and seasonal migration of prey (e.g. earthworms). Earthworms have been found at depths of 150 to 240 cm (Edwards and Lofty 1972) during periods of intolerably high soil temperatures. This condition creates low moisture levels and forces earthworms deeper into the soil which may partially explain why some Townsend's mole tunnels exceed 3 m in depth (Yates and

Pedersen 1982). This species will burrow under obstacles (e.g. foundations and roads) they encounter which will also necessitate the construction of deep tunnels. In addition, deeper tunnels are less prone to damage and likely serve as 'bunkers' - providing a safe retreat when the more shallow tunnels become damaged by such things as machinery or cattle.

Moles expend considerable amounts of energy constructing and maintaining their tunnel systems. This would suggest that most tunnels are permanent eventhough many are continually modified (Giger 1973). In uncultivated pastures, it has been estimated that one Townsend's mole could inhabit a tunnel system hundreds of feet in length (Pedersen 1963). Community tunnels exist under fencelines and other permanent structures that are protected from the damaging effects of cattle and heavy equipment. These tunnels seem to facilitate dispersal and re-colonization (Pedersen 1963, Kuhn et al. 1966).

Townsend's mole produce large surface mounds with the dirt excavated from their tunnelling activities. In some localities, mound density can reach 805 per ha (Yates and Pedersen 1982) and one male can produce about four mounds in one day (Nowak and Paradiso 1983). This species mounds are the largest of the native moles (van Zyll de Jong 1983), but no data on their dimensions has yet been published. However, Townsend's mole mound heights, widths, tunnel diameters and volumes have been recently measured by Sheehan and Galindo-Leal (submitted). These researchers discovered that all four variables for the Townsend's mole are significantly different than those of the smaller coast mole. This data will help biologists differentiate between the two *Scapanus* spp. in the field.

Mounds are the bane of most farmers, greenskeepers and landowners and are probably the sole reason why *Scapanus* has been classified as a pest in British Columbia.

Species Movements

1. Diurnal

Although some researchers suggest that Townsend's mole is nocturnal (van Zyll de Jong 1983) Sheehan and Galindo-Leal (in prep) were able to directly captured this mole as they constructed mounds during the daytime. This discovery supports the claim of those researchers who believe that this species is probably active throughout a 24-hour period (Pedersen 1963, Giger 1973, Nowak and Paradiso 1983).

There is no information on the length of time Townsend's mole devotes daily to the activities of digging, moving, sitting or sleeping. Live tracking research conducted on one coast mole showed that this species spends most of its waking time in the vicinity of its nest and that trips to the perimeter of its range are infrequent (Schaefer 1978).

2. Local movements

Giger (1973) calculated that the average distance, for both sexes, between the sites where twenty-four Townsend's moles were recaptured two times was 23 m. Among the 14 separate individuals recaptured three or more times this average distance increased to 41 m. Land prone to drought with poor drainage and a scarcity of earthworms is poor mole habitat. These conditions were believed to be responsible for the greater distances (up to 116 m) travelled by some Townsend's moles. The local movements of individuals in the most suitable habitat did not exceed 38 m. However, this mole does not appear to abandon their burrow systems in search of more productive areas, even if situated in low quality habitat once they are established (Giger 1973).

Coast moles living in cultivated fields during the summer begin to migrate to the protection of heavily sodded grasslands sometime in October (Glendenning 1959). It is possible that some coast moles found inhabiting cultivated fields are not there intentionally. Instead, they may become isolated from grassland habitat when their home range is ploughed under during crop roatation.

3. Spatial distribution

Although Giger (1973) did not report any overlapping of movements between established adult mole burrow systems, he did not rule out the possibility that limited overlapping may exist. The speed with which trapped out areas are re-invaded by Townsend's mole (Pedersen 1963) and vacant tunnel systems are appropriated by neighbouring individuals (Giger 1973) is believed to illustrate this species opportunistic nature more than the existence of overlapping adult movements. There is evidence of interconnecting tunnel systems, but Giger (1973) believes their role is to aid dispersal, homing and the adoption of abandoned tunnels. Sheehan and Galindo-Leal (in prep) observed that the mound clusters of one Townsend's mole encampment were identifiable and spatially isolated from their neighbours. This pattern suggests that the overlapping of Townsend's mole movements are kept to a minimum except during the breeding season.

4. Juvenile disperal

Class III nestlings (see: **Offspring**) are sufficiently developed to leave the natal nest. In Oregon, most juveniles disperse from the nest and maternal home range during May and June (Giger, 1965) although it is probably delayed in Canadian Townsend's mole populations. The distance juvenile moles disperse averages 181 m for females (range: 13 to 856 m) and 166 m for males (range: 13 to 722 m) (Giger 1973). Dispersal appears to be more dependent upon habitat quality than mole density as Giger (1973) found that there is an inverse relationship between the distance travelled and habitat suitability.

Old, well-established tunnel systems under fencelines known as 'community highways' function as subterranean dispersal avenues for juvenile moles. However, dispersal is not restricted to underground tunnels. Many juvenile Townsend's moles are killed on roads and some are found in barn owl pellets which suggests aboveground dispersal (Pedersen 1963). Aboveground dispersal is believed to constitute the majority of this species annual surface activity. This is the period when juveniles are most vulnerable to predation. Despite the absence of data it is logical to assume that most of the aboveground dispersal occurs during the nightime.

Based upon our own observations of captive Townsend's moles aboveground locomotion over pavement is relatively brisk, straight and sustained. Apparently, this species realizes its vulnerability while travelling over hard surfaces (e.g. paved road) because they immediately stop and begin to dig when they encounter softer ground (e.g. the shoulder of the road). Regardless, this mole appears to be capable of travelling significant distances across most types of terrain found in the Fraser Valley. However, this capability makes their limited distribution perplexing, especially knowing that females disperse further from the natal nest than males.

5. Homing

There is some evidence to suggest that Townsend's moles are capable of homing. Giger (1973) artificially displaced 32 moles from their homesites across one of four situations (small canal, elevated and paved highway, river, and no barrier) and discovered that 14, or 44% demonstrated the ability to home. The greatest percentage of homing individuals occurred where there was no barrier; however, all 'situations' were crossed by at least one individual. Homing became more difficult for displaced moles as the distance from their homesites and severity of the terrain increased. Although both sexes were not equally represented in this research it showed that females may be more proficient at homing than males (11, or 85%). The greatest homing movement (455 m) as well as the only river crossing were accomplished by females.

The ability of moles to home would greatly assist in the re-establishment of populations that are frequently displaced by natural disasters (e.g. flooding). Giger (1973) observed how severe flooding can quickly displace Townsend's mole from their homesites. However, he acknowledges that once these flooded areas begin to dry up they are just as quickly re-inhabited. This suggests that their homesites are not distributed randomly throughout an area, but instead they are more likely constructed within the most suitable habitat available and thus, worth returning to. In addition, the construction and maintenance of a tunnel system requires a considerable investment of time and energy which may help to explain why this mole can home.

Giger (1973) suggested that moles displaced short distances probably rely upon familiar runway systems, scents and chance explorations to facilitate most homing. However, he was unable to provide an explanation to account for the formidable homing accomplished by some individuals (e.g. across water and overland distances too great to be interconnected by tunnels).

Urbanization, diverse and intensive agricultural practices that continue to fragment and alter the Lower Fraser Valley landscape undoubtedly constrain the ability of Townsend's mole to effectively home if displaced. Ploughing, ditching and construction all have the potential to destroy runway systems, eliminate familiar scents and create barriers to homing.

Behaviour

The local movements of this mole (see: **Spatial distribution**) suggests that they lead a solitary existence for most of the year. The only known exception is the breeding season which is a characteristic of most mole species (Giger 1973). In addition, Giger (1973) found that captive Townsend's moles "frequently intimidated each other or fought violently, displaying agonistic behaviour" which indicates this species is probably territorial.

Sheehan and Galindo-Leal (in prep) found that captive coast moles would sometimes fight violently. Conflicts between coast moles are noisy (loud, high pitched Eek! Eek! Eek! sounds are emitted), rolling affairs that involve furious biting and batting with their large, powerful forefeet.

During flooding, Giger (1973) found large numbers of Townsend's moles concentrated on temporary islands and road banks to avoid the rising water and drowning.

However, it is unclear whether this species is more tolerant towards conspecifics under such crowded conditions.

Some researchers report that moles are passive and gentle when handled by humans (Maser et al. 1981). Others found that captured individuals would often bite and struggle enough to make it difficult to handle them (Pedersen 1963, Sheehan and Galindo-Leal in prep).

Pedersen (1963) captured two Townsend's mole nestlings and kept one alive for 32 days and the other for 179 days in a cardboard box. Both were fed warm cow's milk from an eye-dropper for the first 10 days (about 9 cc's per nestling every four hours) and then switched to a diet of ground beef (2 tablespoons per nestling twice a day) and water for the remainder (Pedersen 1963). Sheehan and Galindo-Leal (in prep) kept adult Townsend's moles captive and healthy for a week in soil filled terrariums (12" by 20") on a diet of fresh earthworms. One mole requires about 2 dozen earthworms per day to remain healthy.

Prior to consuming an earthworm the mole will skilfully and speedily orient this prey by using their teeth, nose and forefeet so that the anterior end can be eaten first. The earthworm is then threaded between the front forefeet by numerous upward, jerky movements of the head that tears the worm into pieces which are instantly swallowed. The specific direction with which most earthworms are eaten is likely preferred because it facilitates the 'stripping out' of the gritty organic matter contained within the worms digestive system. Whether this gritty material is avoided to reduce tooth wear or because it is unpalatable is unclear; however, it is usually all that remains after a worm is consumed.

Townsend's moles have small blue eyes that are barely visible beneath their hair. Their eyesight is poor, like most moles, and probably only allows this animal to distinguish between light and dark (Gorman and Stone 1990). However, their fossorial existence precludes the need for keen vision.

Adaptability

The clearing of land in the Fraser Valley for agricultural purposes coupled with the introduction of exotic earthworm species undoubtedly provided moles with enhanced and expanded habitat. Although Townsend's mole was never intended to benefit from the effects of agriculture -- it is evident that this species is somewhat tolerant to human disturbance and can thrive in man-made environments (e.g. pastureland). Lawns and golf courses are other examples of human disturbances which can provide good mole habitat. However, these environments are also where the greatest conflict between moles and man occurs. Therefore, it is worthwhile to consider some types of human disturbances as 'positive' (e.g. manured pastureland) while others such as building construction, roadways and some types of agriculture (e.g. cash cropping) can be viewed as 'negative' which adversely affect mole populations.

The ability of Townsend's mole to disperse and home indicates that this species has the potential to expand its range through colonization and to repopulate temporarily vacated regions. These mechanisms of population establishment are known to be advantageous to a species persistence (Howard 1949; from Giger 1973). In fact, Giger (1973) believes that Townsend's mole is capable of colonizing and repopulating "large tracts of land." However, the effects of escalating habitat loss due to negative human disturbances have likely contributed to the inability of this species to populate large tracts of land. The extent to which these disturbances have limited the establishment of Townsend's mole populations in the Fraser Valley is unknown. Regardless, some factors have restricted Townsend's mole distribution in the Fraser Valley because this species is as rare now as it was seventy years ago when the first specimen was captured by Laing (1927).

The two new Townsend's mole locations discovered by Sheehan and Galindo-Leal (submitted) that extend this species known range (i.e. Marshall Rd. and Ledgeview Golf Course) may be remnants from the meta-population to the south. It is possible that the urban expansion of Abbotsford eastward has significantly contributed to the creation of isolated, marginalized and still undiscovered Townsend's mole remnants. Unlike their closest kin the coast mole, which is abundant and widespread throughout both urban and rural environments, Townsend's mole appears to be less tolerant of negative human disturbances. The largest identified population of this mole exists on agricultural land, in the ALR, west of Huntingdon where the level of negative human disturbance is still relatively minimal.

H. LIMITING FACTORS

1. Protection of habitats

There is no Townsend's mole habitat protected within this species known range in the central Fraser Valley. Private ownership for agricultural, industrial and residential interests is the norm for most of the land in the Abbotsford-Huntingdon region. Although there is some patchy Government ownership of land in the area (e.g. Experimental Farm, Abbotsford Airport, Matsqui Correctional Centre, Fish Hatchery and the Huntingdon Post Office) it is almost negligible. The present level of habitat protection for this species is not adequate.

2. Predators

Natural enemies of Townsend's mole include: small weasels (*Mustela* spp.), rubber boas (*Charina bottae*) on nestlings, great horned owls (*Bubo virginianus*), barn owls (*Tyto alba*), red-tailed hawks (*Buteo jamaicensis*) and coyotes (*Canis latrans*) (Carraway et al. 1993). The extent to which these natural predators keep this species population numbers in check is unknown, but it is believed to be minimal (van Zyll de Jong 1983).

Domestic dogs and cats are considered to be the most important predators of Townsend's mole (Pedersen 1963). Possibly due to their unpleasant taste and smell moles are rarely consumed by these animals (Glendenning 1959, Maser et al. 1981). Cattle are believed to be attracted by the odour of fermenting grasses in Townsend's mole nests in pastures and many nestlings are trampled to death as a result (Pedersen 1963).

3. Specialization

Townsend's mole is reportedly a capable and excellent swimmer (Moore 1939, Giger 1973). In fact, Moore (1939) claims that one Townsend's mole was able to swim continuously for 45 minutes while being chased by a rowboat. Also, there is evidence to suggest that Townsend's mole can pass through water-filled tunnels (Moore 1939). This capability is vital for survival since many low-lying areas inhabited by this species are prone to severe flooding from heavy rainfall and snow-melt. Although proficient swimmers, Giger (1973) observed that many animals burrowed long distances ahead of the rising flood waters - they tended to follow the upward contour of the land. Floods can still be devastating, Giger (1973) found 62 drowned Townsend's moles in piles of debris at one study area. He believes that many moles perish during floods because their poor eyesight does not allow them to orient in the direction of higher ground.

The soft torso pelage of Townsend's mole is characterized by 3,000 hairs/cm^2 (Carraway et al. 1993) which helps to insulate this subterranean animal. Sometime in October, moles molt and undergo the change to winter pelage (Hartman and Yates 1985). Even during the most severe winters this impressive coat of hair is probably more than adequate as the temperature belowground is relatively constant in the Fraser Valley.

4. Moles as pests

Moles and humans are generally not compatible. In fact, most mole studies are initiated because of the damage and economic losses caused by their tunnelling activities (Glendenning 1959, Pedersen 1963, 1966, Giger 1973, Schaefer 1978).

Basically, there are three reasons why moles are considered pests (Gorman and Stone 1990). First, property owners experience small economic losses from the construction of tunnels under lawns, gardens, golf courses and other playing fields which produces molehills that many feel detract from the beauty of these manicured landscapes. Secondly, their tunnelling and mound building activities creates the opportunity for more damaging animal (e.g. *Microtus*) and weed species to invade and colonize. Thirdly, moles are considered serious pests for the damage they cause in the agriculture industry. In the late 1960's in Tillamook County, Oregon, the damage caused by Townsend's moles to dairy farmers apparently exceeded $100 000/year (Wick 1961). Although moles have been credited with improving the aeration and drainage of the soil, consuming damaging soil invertebrates and circulating soil minerals (Kuhn and Edge 1990), many believe that these advantages have been replaced by modern agricultural practices (Glendenning 1959, Stone 1989, Gerber 1995). For a detailed list of the damages assigned to moles by the agricultural industry see Kuhn (1970).

Homeowners intolerant of mole activity are this small mammals greatest adversaries. While mole control efforts in large fields would be extremely time-consuming and expensive (professional mole trappers won't touch them) a small lawn could be inundated with traps rather quickly. One pest management specialist believes, "Vanity about our lawns is the real reason why most people kill moles" (Conniff 1994). Increased urbanization in the Lower Fraser Valley means more lawns and an escalation of mole/human conflict.

I. SPECIAL SIGNIFICANCE OF SPECIES

Townsend's mole is found only in western North America. In Canada it is restricted to the Abbotsford-Huntingdon region of the Fraser Valley, British Columbia which is the northern limit of their geographical distribution. In fact, there are several Pacific coastal mammals that reach their northernmost limits in this region and are found nowhere else in Canada, for example; the coast mole (*Scapanus orarius*), the Shrew-mole (*Neurotrichus gibbsii*), the Pacific water shrew (*Sorex bendirii*), Trowbridge's shrew

(*Sorex trowbridgii*), and Townsend's chipmunk (*Eutamias townsendii*). There are some authors who believe that marginal populations have a high evolutionary significance to their species and are instrumental in the maintenance of genetic diversity (Scudder 1993).

J. RECOMMENDATIONS/MANAGEMENT OPTIONS

Townsend's mole has been upgraded to the Red List as a *Threatened* species (Munro 1993) in British Columbia. It should therefore be removed from Schedule B as a *pest* and assigned 'wildlife' status with all of the protection and regulations governing such a designation. Professional mole trappers should be required to purchase a licence and be regulated by seasons and quotas like other trappers, especially when some kill over 800 moles/year (mole trapper: pers. comm.). It is highly probable that some mole trappers do not even know that there are two *Scapanus* spp. inhabiting the Fraser Valley and that one is considered 'Threatened'. Regardless, a communication link with professional mole trappers should be initiated so that any large mole specimen will be brought to the attention of a qualified biologist for identification.

All of the land known to be inhabited by Townsend's mole is privately owned so the issue of habitat protection becomes tenuous. If traditional habitat management guidelines were constructed landowners would not be obligated to follow them and they could not be legally enforced. Also, at more than $30,000/acre it is unlikely that the government would purchase agricultural land for a mole refuge. Therefore, education is the only feasible alternative to ensure that Townsend's mole habitat is preserved in this area. Farmers and landowners in this area should be initially educated on Townsend's mole ecology (e.g. they are insectivores *not* rodents) through the distribution of an informative pamphlet. This objective could be incorporated into a landowner contact program that should be designed to accommodate other small mammals at risk in the Lower Fraser Valley. As well, it may be possible to bring captive moles into schools to educate the students on mole ecology. Posting Townsend's mole 'Wanted' leaflets at farm supply stores and home and garden centres may yield additional presence data.

The Ministry of Environment is mandated to maintain the diversity of species over their historical ranges. Therefore, further research on the presence, abundance and distribution of this species in the Fraser Valley is necessary (widespread sampling is currently being conducted). Also, information on habitat size requirements and the effects of fragmentation (patch size and shape, isolation and edge effects) would be useful (Muhlenberg et al. 1991). This knowledge could then be converted into habitat recommendations and discussed with landowners to help ensure the persistence of Townsend's mole.

In the future, studies on Townsend's mole should incorporate live trapping techniques to ensure that no individuals of this rare species are removed. It is important for researchers to discuss this issue with landowners prior to the commencement of trapping on private property. Therefore, the identification of a protected location with suitable habitat to relocate unwanted Townsend's moles should be carried out prior to trapping (e.g. grassed medians along Hwy. 1 or possibly municipal parks).

K. EVALUATION AND PROPOSED STATUS

According to the global ranking system utilized by the Nature Conservancy, Townsend's mole is currently a G5 suggesting that it is secure globally and widespread (B.C. Conservation Data Centre). This mole is not considered at risk in California, Oregon or Washington. However, the subnational rank assigned to this species in British Columbia is S1? because it is very rare and localized, but more fieldwork on its distribution is required (B.C. Conservation Data Centre).

It is difficult to determine the status of Townsend's mole in British Columbia due to the lack of specific studies necessary to answer this question. However, the most obvious concern involves this species restricted distribution (the Ledgeview Golf Course specimens are only 8 km from international border at Huntingdon). Also, the presence of this mole is strongly correlated to Silt Loam soils which encompass only 30 km^2 in the Fraser Valley. There are no significant parcels of crown land in this region; instead, most of the land is privately owned.

The fact that Townsend's mole is Red-Listed, but considered a *pest* and not *wildlife* is a paradox. Until this changes, attempting to convince landowners of the need to protect habitat for a *pest* species would be futile. Meanwhile, the burgeoning urban, industrial and agricultural interests in the Fraser Valley will continue to synergize, reducing the amount of suitable habitat and fragmenting the remainder into isolated patches. The transformation of habitat into urban and suburban landscapes is permanent and constrains the ability of small populations to colonize and persist. Even the ALR, established to ensure farmland exists for future generations, is reduced on a yearly basis.

Rabinowitz, Cairns and Dillon (1986) have proposed different types of rarity based upon the size of the geographic range, degree of habitat specificity and population size. Townsend's mole is rare due to a combination of these factors. This mole has a small geographical range, they require a somewhat specialized habitat and their estimated population sizes are low. Townsend's mole rarity is cause for concern because small populations are vulnerable to extinctions due to habitat loss and to natural, stochastic environmental perturbations (Gilpin and Soule 1986). If habitat loss continues in the Fraser Valley then there will likely be a resultant reduction in population size and distribution of Townsend's mole. Consequently, a small population is more vulnerable to the effects of demographic fluctuations, predation and increased genetic problems (Gilpin and Soule 1986).

It is unlikely that the Townsend's mole population in British Columbia exceeds 700 individuals. In addition, recent fieldwork and anecdotal information from professional mole trappers suggests that this species is rare. This claim is supported by the fact that less than 30 Townsend's moles have been catalogued into Canadian museums since the first one in 1927 (Table 1).

We recommend that *Scapanus townsendii townsendii* be designated by COSEWIC as **THREATENED.**

L. REFERENCES

Bertrand, R.A., G.A. Hughes-Games and D.C. Nikkel. 1991. Soil Management Handbook For The Lower Fraser Valley. British Columbia Ministry of Agriculture, Fisheries and Food. 109pp.

British Columbia Research. 1983. Summary of Historical and Projected Total Population. p.74, in British Columbia Population Projections: 1984-2006.

British Columbia Ministry of Economic Development. 1986. Matsqui-Abbotsford Area. pp.230-234, in British Columbia Regional Index.

British Columbia Ministry of Agriculture, Fisheries and Food. 1995. Strengthening Farming in British Columbia: Consultation Background Report, 11pp.

Cahalane, V.H. 1947. Mammals of North America. The Macmillan Company, New York, 682pp.

Campbell, R.W. 1983. Feeding ecology of the common Barn Owl in North America. M.Sc. Thesis. Univ. of Washington, College of Forest Resources. 87pp.

Carraway, L.N., L.F. Alexander and B.J. Verts. 1993. Scapanus townsendii. Mammalian Species. N. 434:1-7.

Conniff, R. 1994. "The mole has a way of undermining our assumptions." Smithsonian, Vol. 24. N. 12:52-63.

Cowan, I. McT. and C.J. Guiget. 1965. The mammals of British Columbia. B.C. Prov. Mus. Handbook, 11:1-414.

Dalquest, W.W. 1948. Mammals of Washington. Univ. Kans. Mus. Nat. Hist. Publ., 2:1-144.

Eadie, W.R., and W.J. Hamilton Jr. 1956. Notes on reproduction in the star-nosed mole. J. Mamm., 37:223-231.

Edwards, C.A., and Lofty, J.R. 1972. Biology of Earthworms. Chapman and Hall Ltd., London, 283pp.

Gerber, H.S. Jan., 1995. Factsheet: Mole Control in British Columbia. British Columbia Ministry of Agriculture, Fisheries and Food.

Giger, R.D. 1965. Surface activity of moles as indicated by remains in barn owl pellets. The Murrelet, 46:32-36.

Giger, R.D. 1973. Movements and homing in Townsend's mole near Tillamook, Oregon. J. Mamm., 54:648-659.

Gilpin, M.E., and M.E. Soule. 1986. Minimum viable populations: processes of species extinction. p. 19-34, in: Soule, M.E. (ed.). Conservation Biology, the science of scarcity and diversity. Sinauer Associates Inc., Massachusetts.

Glendenning, R. 1959. Biology and control of the coast mole, *Scapanus Orarius Orarius* True, in British Columbia. Can. J. Anim. Sci., 39:34-44.

Gorman, M.L., and D.R. Stone. 1990. The Natural History of Moles. Comstock Publishing Associates, Ithaca, New York, 138pp.

Hall, E.R. 1981. The mammals of North America. Vol. 1. J.Wiley & Sons, New York, 600pp.

Hartman, G.D., and T.L. Yates. 1985. Scapanus orarius. Mammalian Species. N.253:1-5.

Jameson, E.W., and H.J. Peeters. 1988. California mammals. Univ. of California Press, Berkeley, 403pp.

Jensen, I. M. 1982. A New Live Trap For Moles. J. Wildl. Manage. 46(1):249-252.

Johnson, M.L., and T.L. Yates. 1980. A new Townsend's mole (Insectivora: Talpidae) from the state of Washington. Occasional Papers, The Museum, Texas Tech University, 63:1-6.

Kremsater, L. and L. Andrusiak. 1991. Status report for the Townsend's mole (*Scapanus townsendii*). Ministry of Environment, Lands and Parks. Victoria, B.C. Unpublished. 44pp.

Kuhn, L.W., W.Q. Wick and R.J. Pedersen. 1966. Breeding nests of Townsend's mole in Oregon. J. Mamm., 47:239-249.

Kuhn, L.W. 1970. Mole control. pp.71-76, in Proceedings 4th Vertebrate Pest Conference (ed. R.H. Dana), West Sacramento, California.

Kuhn, L.W., and W.D. Edge. 1990. Controlling moles. Oregon State University, Extension Service, EC 987:1-4.

Laing, H.M. 1927. Collecting Stations in British Columbia - 1927, fieldnote diaries. Canadian Museum of Nature, Ottawa.

Luttmerding, H.A. 1981. Soils of the Langely-Vancouver Map Area. Vol. 3. Description of the Soils. RAB Bulletin 18. Report No. 15, British Columbia Soil Survey. Assessment and Planning Division, B.C. Ministry of Environment, Kelowna, B.C. 227pp.

Maser, C., J.F. Mate, J.F. Franklin, and C.T. Dyrness. 1981. Natural history of Oregon coast mammals. USDA General Technical Report PNW-133:1-496, Oregon.

Matsqui Development Services. 1994. Matsqui Population Statistics.

MOE. 1995. British Columbia 1995-96 Hunting and Trapping Regulations Synopsis. Wildlife Branch, Victoria, B.C., 103pp.

Moore, A.W. 1933. Food habits of Townsend and coast moles. J. Mamm., 14:36-40.

Moore, A.W. 1939. Notes on the Townsend mole. J. Mamm., 20:499-501.

Moore, A.W. 1940. A live mole trap. J. Mamm., 21:223-225.

Moore, K.E. 1990. Urbanization in the Lower Fraser Valley, 1980-1987. Technical Report Series No. 120, Canadian Wildlife Service, Environment Canada, 12pp.

Muhlenberg, M.T., T. Hovestadt and J. Roser. 1991. Are there minimal areas for animal populations? In: A. Seitz and V. Loeschcke (Eds.) Species Conservation: a population-biological approach. Birkhauser. Verlag, Basel.

Munro, W.T. 1993. Designation of Endangered Species, Subspecies and Populations by COSEWIC. In: M.A. Fenger, E.H. Miller, J.F. Johnson and E.J.R. Williams (Eds.) Our Living Legacy; Proceedings of Symposium on Biological Diversity. Royal British Columbia Museum. Victoria, Canada. 392 pp.

Nagorsen, D.W. 1996. The opossum, shrews and moles of British Columbia. Royal British Columbia Museum Handbook, University of British Columbia Press. Vancouver, Canada.

Nowak, R.M., and J.L. Paradiso. 1983. Walker's mammals of the World, 4th ed. The John Hopkins Univ. Press, Baltimore, MD., 1:1-568.

Pedersen, R.J. 1963. The life history and ecology of Townsend's mole *Scapanus townsendii* (Bachman) in Tillamook County, Oregon. M.S. Thesis, Oregon State University, Corvallis, 60pp.

Pedersen, R.J. 1966. Nesting behaviour of Townsend's mole. The Murrelet, 47:47-48.

Rabinowitz, D., S. Cairns, and T. Dillon. 1986. Seven forms of rarity and their frequency in the flora of the British Isles. pp.182-204, in: Soule, M.E. (ed.). Conservation Biology, the science of scarcity and diversity. Sinauer Associates Inc., Massachusetts.

Saunders, D.A., R.J. Hobbs, and C.R. Margules. 1991. Biological consequences of ecosystem fragmentation: A Review. Conservation Biology, 5:18-32.

Schaefer, V.H. 1978. Aspects of habitat selection in the coast mole (*Scapanus orarius*) in British Columbia. Unpublished PhD Thesis, Simon Fraser University, Burnaby, B.C. 205pp.

Scudder, G. 1993. Biodiversity over time. In: M.A. Fenger, E.H. Miller, J.F. Johnson and E.J.R. Williams (Eds.) Our Living Legacy; Proceedings of Symposium on Biological Diversity. Royal British Columbia Museum. Victoria, Canada. 392 pp.

Sheehan, S.T., and C.Galindo-Leal. 1995 (in prep). Sampling techniques for fossorial mammals: moles and gophers. Ministry of Environment, Wildlife Branch. Victoria, B.C.

Sheehan, S.T., and C. Galindo-Leal. 1996 (submitted). Tunnel and mound differences between two species of moles (Scapanus spp.) in southwestern British Columbia. 12 pp.

Sheehan, S.T., and C. Galindo-Leal. 1996 (submitted). Townsend's mole (Scapanus townsendii) distribution and live-trapping methods in the Fraser Valley. 16 pp.

Surveyor General and Chief, Hydrographic Service, Ottawa. 1938. *Soil Map of the Lower Fraser Valley (Eastern Sheet)*. Experimental Farms Branch, Ottawa.

Van Zyll de Jong, C.G. 1983. Handbook of Canadian Mammals: Marsupials and Insectivores. National Museum of Natural Sciences. Ottawa, 210pp.

Whitaker, J.O., C. Maser, and R.J. Pedersen. 1979. Food and ectoparasitic mites of Oregon moles. Northwest Science, 53:268-273.

Wick, W.Q. 1961. Mole control takes some doing! Oregon Farmer, 84(12):5-6.

Wight, H.M. 1928. Food habits of the Townsend's mole, *Scapanus townsendii* (Bachman). J. Mamm., 9:19-32.

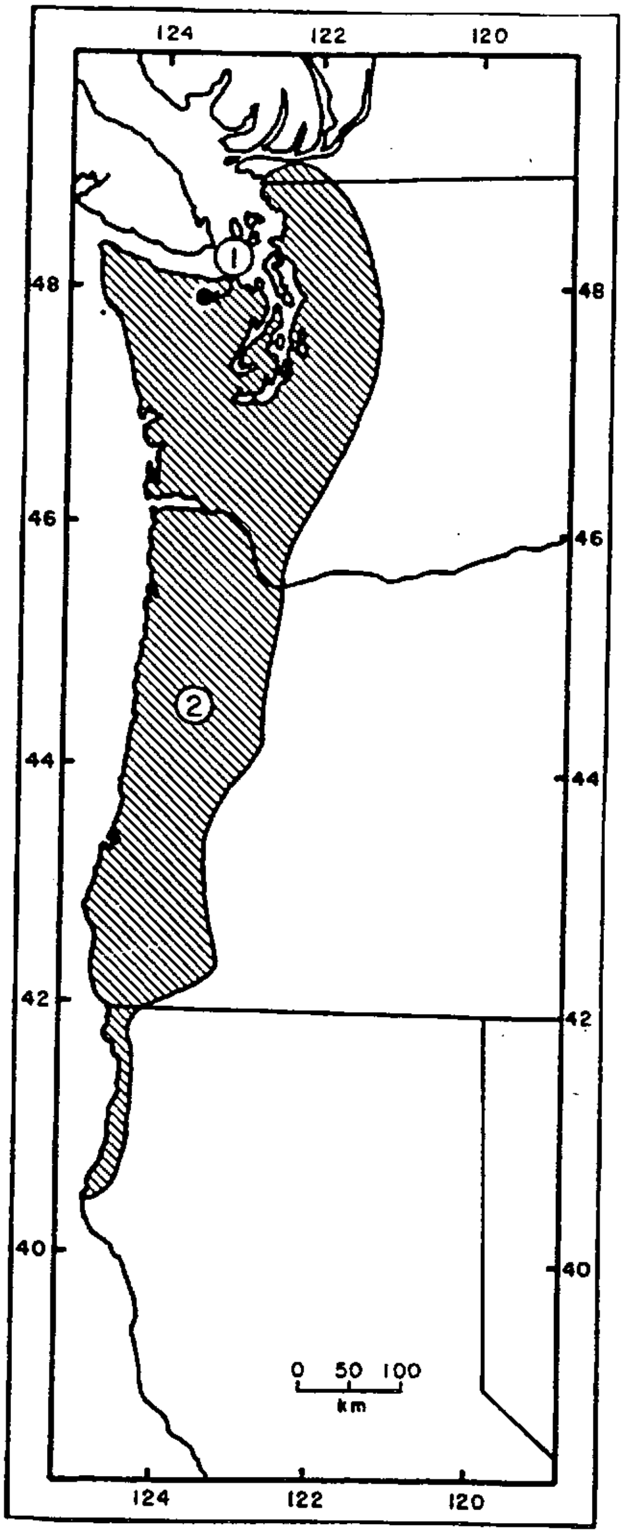
Wynn, G. 1992. The Rise of Vancouver. pp. 69-145, Vancouver and Its Region. Wynn, G. and T. Oke, eds. University of British Columbia Press. Vancouver, Canada.

Yates, T.L., and R.J. Pedersen. 1982. Moles. pp.37-51, in: J.A. Chapman and G.A. Feldhamer (eds.). Wild mammals of North America: biology, management and economics. The John Hopkins University Press, Baltimore, 1147pp.

M. ACKNOWLEDGEMENTS

We would like to thank Laura Friis at the Ministry of Environment (Wildlife Branch) for her commitment to mole research. David Nagorsen of the Royal British Columbia Museum kindly provided the database containing all Canadian *S. townsendii* records and Laing's (1927) fieldnotes.

Figure 1. Geographical distribution of *Scapanus townsendii* (Hall 1981).



1 *Scapanus townsendii olympicus*

2 *Scapanus townsendii townsendii*

Figure 2. Distribution of *Scapanus townsendii townsendii* in British Columbia. Derived from all known museum records prior to 1995.

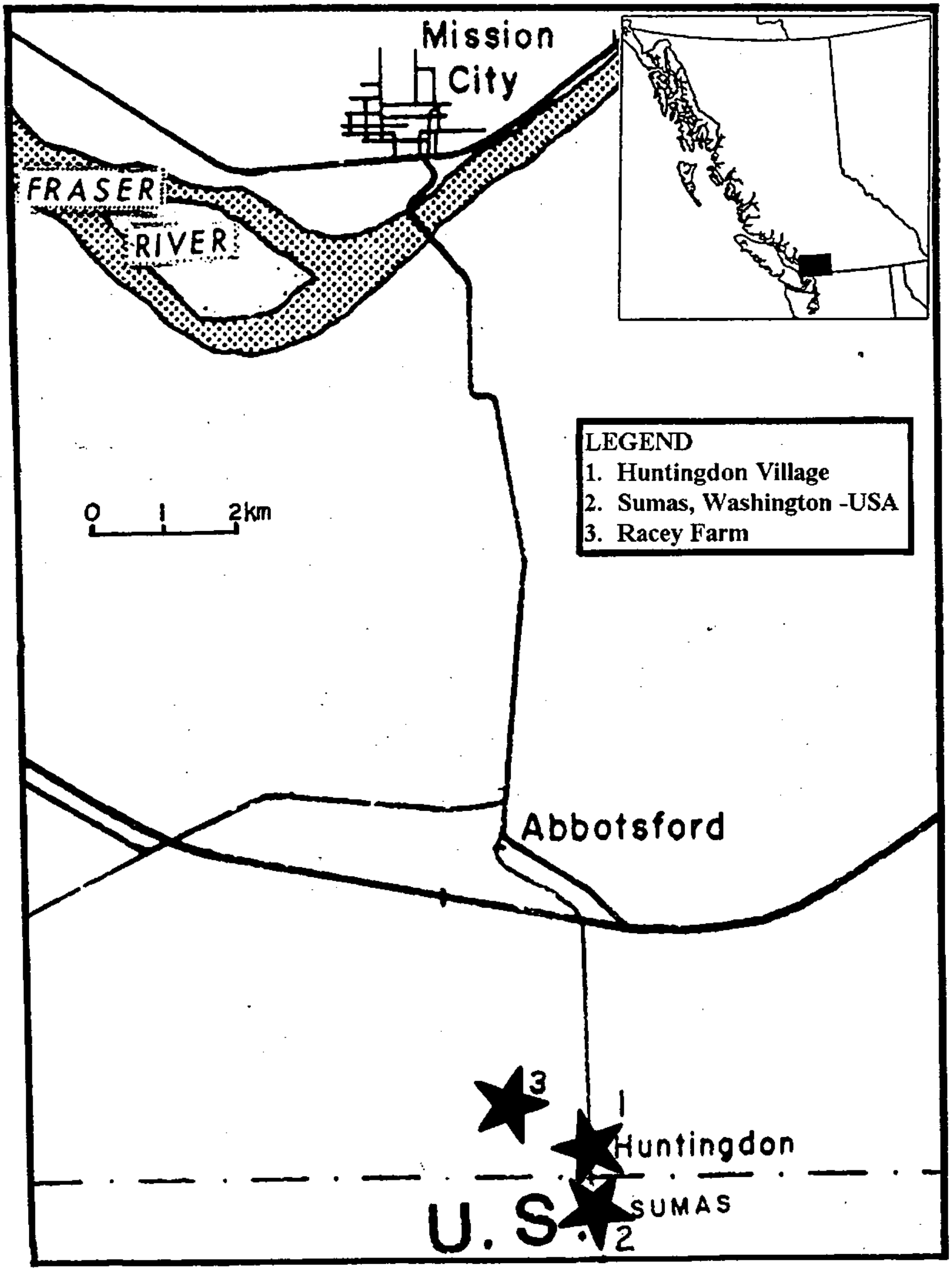


Figure 3. Distribution of *S. t. townsendii* in British Columbia. Derived from all museum records and recent field survey (1995). ALR border and soil types.

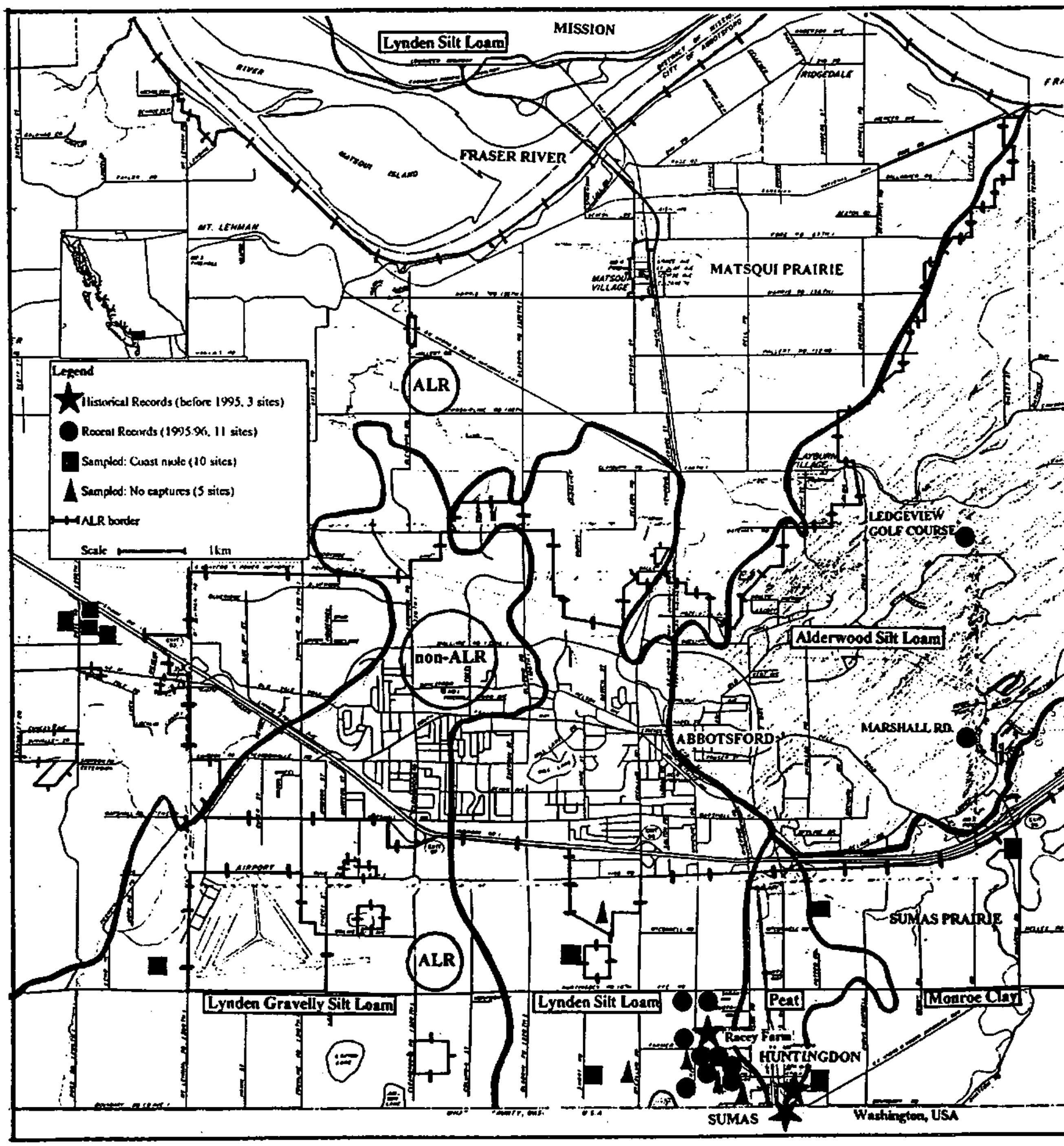
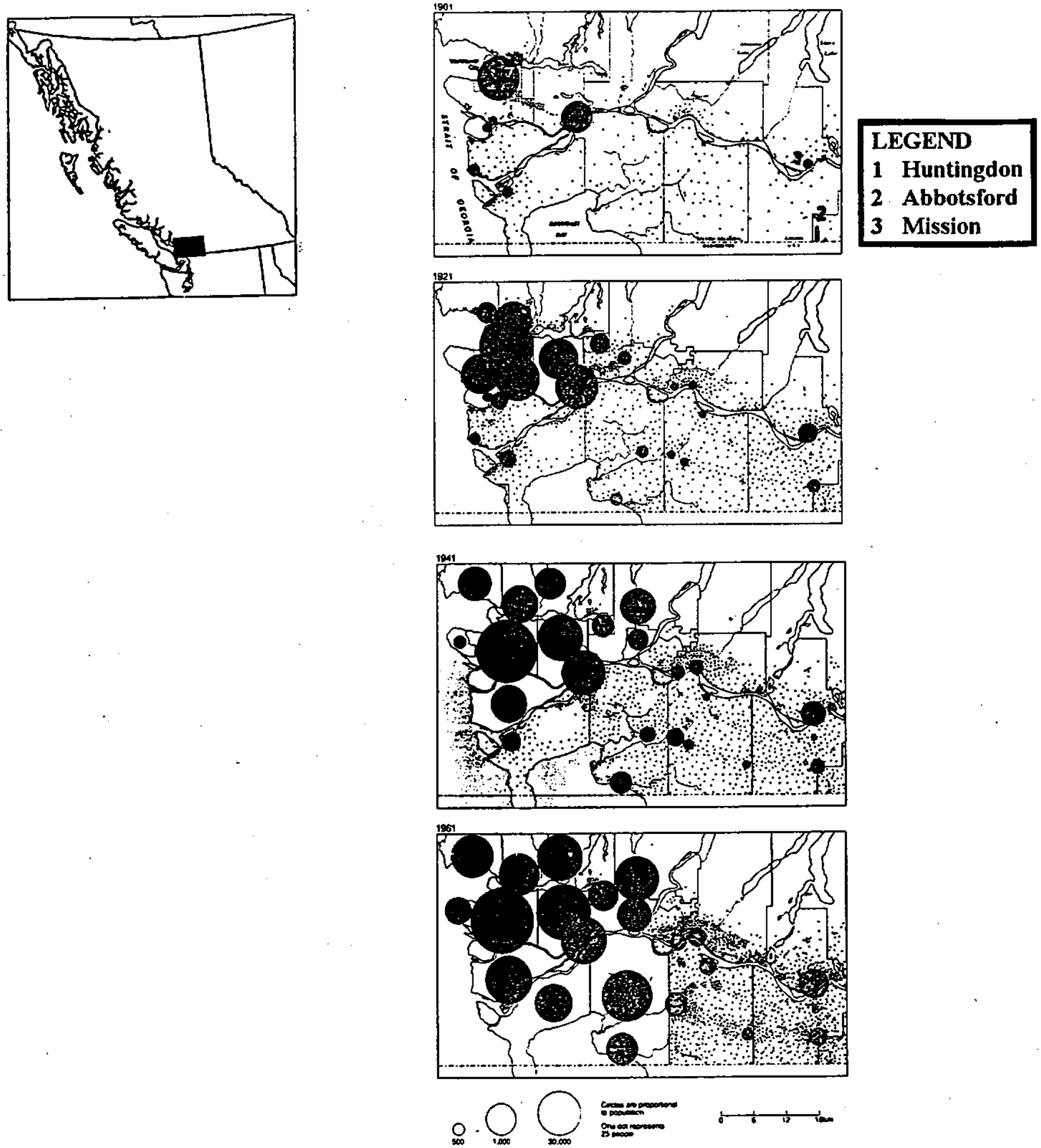


Figure 4. Urbanization of the Lower Mainland in British Columbia from 1901-1961 (Wynn 1992).



Appendix

Profile of five soils illustrated in Figure 3.