COSEWIC
Assessment and Status Report

on the

Woodland Vole
Microtus pinetorum

in Canada

SPECIAL CONCERN
2010

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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Woodland Vole — ©Philip Myers.

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COSEWIC
Assessment Summary

Assessment Summary – November 2010

Common name
Woodland Vole

Scientific name
Microtus pinetorum

Status
Special Concern

Reason for designation
This small, rare mammal has a Canadian range restricted to highly fragmented areas of southern Ontario and southern Quebec. However, a lack of adequate monitoring effort and quantification of threats made the re-assessment of this species difficult. There is no evidence to suggest its status has changed since it was last assessed. Threats appear to be limited and not imminent or increasing.

Occurrence
Ontario, Quebec

Status history
Designated Special Concern in April 1998. Status re-examined and confirmed in November 2001 and November 2010.

COSEWIC
Executive Summary

Woodland Vole
Microtus pinetorum

Wildlife species description and significance

The Woodland Vole (*Microtus pinetorum*) is a small vole with an average body mass of 26 g and a length of about 120 mm. Its short tail makes up less than 20% of the length. Woodland Voles are adapted for fossorial (underground) living; they have thick short fur and their eyes, ears and tails are relatively small. Although colouration varies, they are generally dark chestnut dorsally and light grey underneath. Woodland Voles are considered pests in orchards in the US. They reach the northernmost edge of their range in Canada.

Distribution

The Woodland Vole occurs throughout eastern North America, south to the Gulf of Mexico. They reach the northern edge of their range in southern Québec and southwestern Ontario. Less than 2% of their global range occurs in Canada. There is a large unsurveyed area with some potentially suitable habitat between the ranges in each province.

Habitat

Woodland Voles are commonly associated with deciduous forests but also inhabit scrubby sand dunes, swamps, and orchards. They are influenced by the amount and type of cover, soil moisture and soil type, preferring areas with dense herbaceous vegetation and friable soils with low saturation.

Fragmentation of habitat has occurred in southern Ontario over the past century and overall forest cover is low. In the areas where Woodland Voles occur, forest cover is much higher than average and there has been little change since the last assessment.

Biology

Woodland Voles are semi-fossorial, spending most of their time in underground burrows. They live in small communal groups with overlapping home ranges and common nest sites. Home range sizes are similar for males and females (mean = 45 m^2). Dispersal appears to be driven by saturation densities, where individuals of both sexes disperse to gain reproductive opportunities. Maximum dispersal distances are estimated to be 300 m and may be enhanced through the use of edge and hedgerow habitats.

Woodland Voles mature later and produce smaller litters (mean = 3) than most other *Microtus*. The breeding season extends from May to October, with females producing 1-4 litters per year. Survival is low, with most individuals probably living less than 6 months. In Canada, voles likely have a variety of predators including shrews, raptors, and snakes. Woodland Voles do not hibernate or use torpor in winter; instead they nest communally and cache food. Fossorial living provides protection from temperature extremes and predators.

Population sizes and trends

Sampling efforts have been inadequate to accurately determine the distribution and/or population size of Woodland Voles. Most trapping has been part of general small mammal surveys, which are not specifically designed to capture this species. Two small targeted surveys in Ontario did not capture any. Woodland Vole density in the United States ranges from 0 to 44 individuals/ha in natural habitats but it is unlikely to be as high in Canada. It is also unlikely that populations in Canada will be supplemented by rescue because populations in states bordering Canada are generally of low density and patchy in distribution. In Ontario, especially, significant barriers to rescue from the US include large waterways, busy roads and densely populated urban areas.

Threats and limiting factors

Habitat loss and degradation resulting from urban development, agricultural intensification and forest harvest are the most important current threats to the Woodland Vole in Canada. Urban growth will have a greater effect in areas where humans are already concentrated and is likely to cause more habitat loss in Ontario than Québec. Habitat loss due to agricultural intensification is an issue in southern Ontario.

Protection, status, and ranks

The Woodland Vole is listed under the federal *Species at Risk Act* (SARA), the *Ontario Endangered Species Act, 2007* and Michigan's *Natural Resources and Environmental Protection Act*, as a Species of Special Concern. In Québec, the species is likely to be designated as Threatened or Vulnerable. Woodland Voles are considered secure in New York and New Hampshire but uncommon in Vermont and critically imperiled in Maine.

In southwestern Ontario, 95% of remaining natural habitat is privately owned. Less than 1% of the area of occupancy occurs on public lands, or those held by Conservation Authorities, Land Trusts or Conservancies. Woodland Vole habitat is also protected through the *Greenbelt Act,* the *Niagara Escarpment and Development Act*. In Québec, the species is protected by the provincial *Act respecting conservation and development of wildlife* that prohibits collecting, buying, selling or keeping specimens in captivity. In Québec, 1.1% of the area of occupancy occurs on public lands and private conservation initiatives. The *Forest Act* also provides for the conservation of Exceptional Forest Ecosystems and management of private woodlots.

TECHNICAL SUMMARY

Microtus pinetorum
Woodland Vole Campagnol sylvestre
Range of occurrence in Canada:Ontario and Québec

Demographic Information

Generation time (estimated)	6 months
Is there a continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	Unknown
Are there extreme fluctuations in number of mature individuals?	Possible

Extent and Occupancy Information

Estimated extent of occurrence	ON:25,650 km² QC:11,366 km²
Index of area of occupancy (IAO). Based on records since 1956.	148 km²
Is the total population severely fragmented?	Possibly in Ontario but not in Québec
Number of locations	Presumably > 10
Is there a continuing decline in extent of occurrence?	No
Is there a continuing decline in index of area of occupancy?	Unknown
Is there a continuing decline in number of populations?	Unknown
Is there a continuing decline in number of locations?	Unknown
Is there an inferred continuing decline in area and quality of habitat?	Some decline in quality and loss of habitat in Ontario.
Are there extreme fluctuations in number of populations?	Unknown
Are there extreme fluctuations in number of locations?	Unknown
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	Unknown

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
Impossible to estimate given current information.	Unknown
Total	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Not done.

Threats (actual or imminent, to populations or habitats)

Habitat loss and degradation due to urban development, agricultural intensification and forest harvest.

Rescue Effect (immigration from outside Canada)

Status of outside populations? USA: N5 (secure) Vermont: S3 (vulnerable) New York: S5 (secure) Michigan: S3S4 (vulnerable/apparently secure)	
Is immigration known or possible?	Unlikely, but more likely between US and Québec
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Special Concern (November 2010)

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Special Concern	Not applicable
Reasons for designation: This small, rare mammal has a Canadian range restricted to highly fragmented areas of southern Ontario and southern Quebec. However, a lack of adequate monitoring effort and quantification of threats made the re-assessment of this species difficult. There is no evidence to suggest its status has changed since it was last assessed. Threats appear to be limited and not imminent or increasing.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable, no quantitative data on population size.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. May meet Endangered criteria for B2 (IAO < 500) if only known extant range is used but there is likely more suitable habitat. It does not meet any of sub-criteria a, b or c (severely fragmented/ 5-10 locations, continuing decline or fluctuations).
Criterion C (Small and Declining Number of Mature Individuals): Not applicable, no quantitative data on population size or trend.
Criterion D (Very Small or Restricted Total Population): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

PREFACE

The distribution of Woodland Voles in Canada, including extent of occurrence, has not changed markedly since the previous status report although recent search and sampling effort has been limited. The known distribution is still based on records prior to the previous assessment. Two targeted surveys have been conducted in Ontario since 2000 but no voles were caught in either. A general small mammal survey resulted in one record from the Philipsburg Migratory Bird Sanctuary in Québec. Woodland Vole density and distribution is likely greater than suggested by recent surveys but reliable indications of population trends and distribution are not possible given the lack of data.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS (2010)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

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Woodland Vole

Microtus pinetorum

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2010

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and classification

Scientific name: *Microtus pinetorum* (LeConte, 1830)

English name: Woodland Vole

French name: Campagnol sylvestre

Classification: Class Mammalia, Order Rodentia, Family Cricetidae.

The Woodland Vole (*Microtus pinetorum*) is also known as the Pine Vole, Pine Mouse, Mole Mouse, Potato Mouse and Bluegrass Pine Mouse (Wilson and Ruff 1999. There are 62 species in the genus *Microtus*, 17 occur in North America, of which 12 are found in Canada. The Woodland Vole has also been placed in the genus *Pitymys*; however, genetic data do not support this separation (Moore and Janacek 1990). *Pitymys* is often considered a subgenus of *Microtus* (Wilson and Reeder 2005). Cranial similarities between *M. pinetorum* and *M. ochrogaster* have led some authors to include *M. pinetorum* in the subgenus *Pedomys* (Hall 1979) but this is also not commonly accepted due to differences in external characteristics including pelage, claw size, and mammae number (Smolen 1981).

Seven subspecies of *Microtus pinetorum* have been recognized historically (Hall 1979; Smolen 1981). The Integrated Taxonomic Information System currently recognizes 3 subspecies: *nemoralis, parvulus,* and *pinetorum* (ITIS 2010). Based on the 7-subspecies taxonomy, *M. p. scalopsoides* is the one found in Ontario and Québec (Hall 1979) whereas under the 3-subspecies model, *M. p. pinetorum* occurs in Canada. Additional data are required to clarify subspecies classification (Musser and Carleton 2005).

Morphological description

Woodland Voles are relatively small; mean body mass is 25.6 g (range: 22-37 g, not including pregnant females, Banfield 1974). Mean length is 121 mm (range 113-132 mm; Banfield 1974), with individuals from southwestern Ontario being slightly shorter (18 ROM specimens; 119.6 mm; range 107-131 mm; Ross 1998). Woodland Voles have short tails which comprise less than 20% of total body length (mean: 21 mm; range: 16-24 mm; Banfield 1974 and 19.4 mm; 14-23 mm; Ross 1998). Many species of *Microtus* are cryptic. While there is a possibility of confusing Woodland Voles with the sympatric Meadow Vole (*Microtus pennsylvanicus*), the dentition pattern is distinct.

Woodland Voles have large heads and slender bodies (Banfield 1974). Their pelage is thick and short with some longer guard hairs (Banfield 1974). They are dark chestnut dorsally, with tawny sides and silvery or buffy grey ventrally (Banfield 1974; Hall 1979). Winter pelage is darker than summer (May-October; Banfield 1974). Albinos and bright orange-yellow coloured (xanthochromism) individuals are common (Smolen 1981). Ears, eyes and tail are reduced, the skull is dorsally flattened and the forelimbs are more robust than the hind limbs, presumably all adaptations to fossorial life (Smolen 1981).

Population spatial structure and variability

In the US, chromosomal variation of Woodland Voles in New Hampshire, New York, Virginia, North Carolina and Pennsylvania suggests there is reproductive isolation between populations (Wilson 1984). There are no data on movements or genetics for the species in Canada; thus all inferences about spatial population structure are based on fragmentation and likely barriers to dispersal. Fragmentation of deciduous forest habitat in southern Ontario is high, with most forested areas existing as small, isolated patches in an agricultural landscape (McLachlan and Bazely 2003). Other barriers separating populations include large water bodies, densely populated urban areas, and busy roads (Figures 1 and 2). Segregation among populations is likely given the fragmented habitat of southern Ontario and low density populations in adjacent American states (Cooper 2000; Sullivan and Curtis 2002). However, the Canadian populations are not disjunct because they are potentially connected through the US. Habitat fragmentation in Québec is not as severe as southern Ontario due to the lower human population density. There may be some connection between southern Québec populations and those in Vermont and New York but Woodland Voles are rare in the northern parts of both states (UA-CAST and USGS 2010; Figure 1).

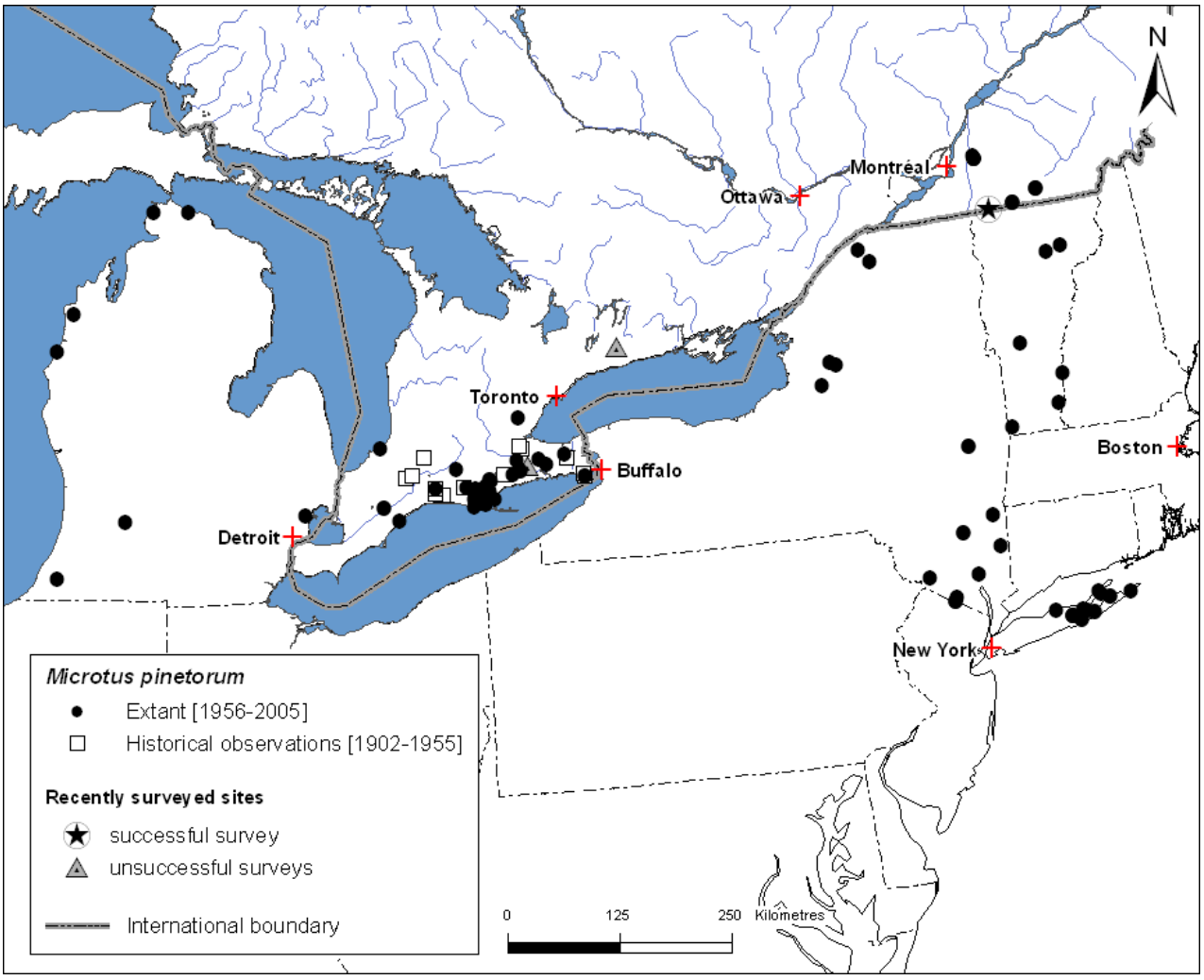

Figure 1. Occurrence of the Woodland Vole in Canada and adjacent US states. Locations are based on trapping records and museum specimens. Recent survey data are from 2003-2009. Historical observations (prior to 1956) were excluded from the calculation of distribution parameters.

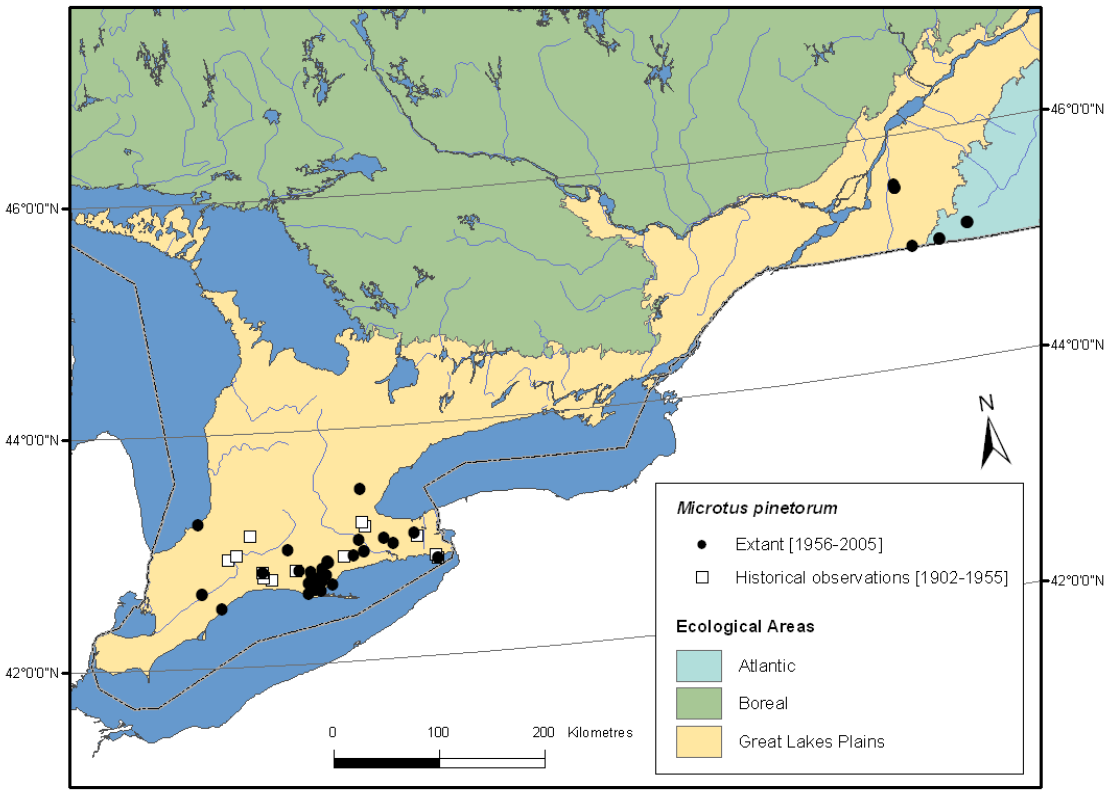

Figure 2. Occurrence of the Woodland Vole in Canada showing ecological areas and latitude. Woodland Voles are found in the Atlantic and Great Lakes Plains ecological areas in Ontario and Québec.

Designatable units

Recognizing more than one designatable unit is currently not justified given that all individuals in Canada belong to a single subspecies (*M. p. scalopsoides*, Hall 1979; or *M. p. pinetorum;* ITIS 2010). There are no genetic data for the species in Canada which would allow a clearer assessment. While the Québec and Ontario populations are separated by large distances, the area in between is largely unsurveyed but does contain potentially suitable habitat (Figure 1). Further, there is a Holocene record for the species in Gatineau Park, QC (Lauriol *et al.* 2003). Finally, the populations occur in similar habitat types within the Atlantic and Great Lakes-Plains ecological areas (Figure 3).

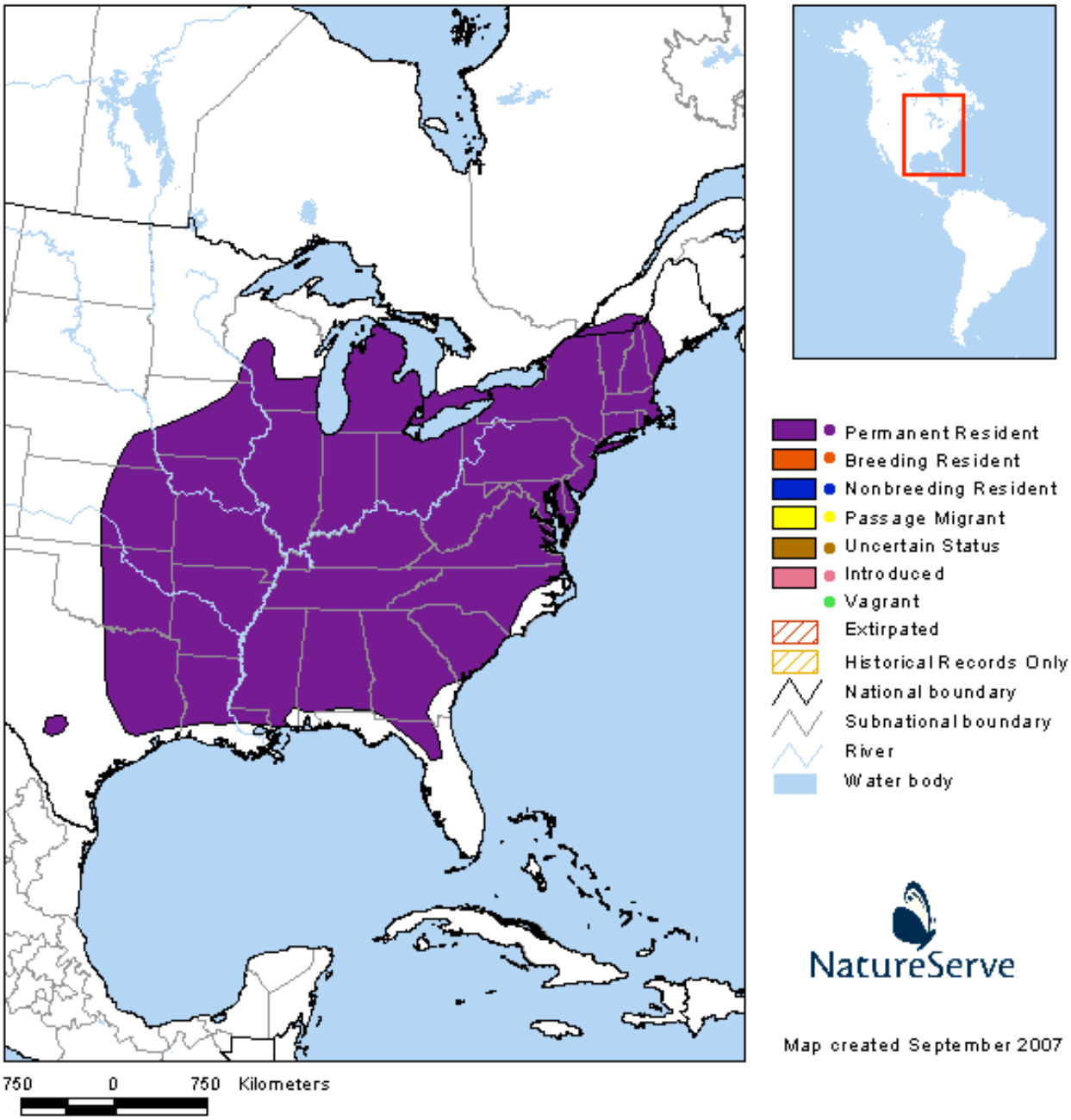

Figure 3. Distribution of the Woodland Vole (*Microtus pinetorum*) in North America (source: Patterson *et al.* 2003). Data provided by NatureServe in collaboration with Bruce Patterson, Wes Sechrest, Marcelo Tognelli, Gerardo Ceballos, The Nature Conservancy-Migratory Bird Program, Conservation International-CABS, World Wildlife Fund-US, and Environment Canada-WILDSPACE.

Special significance

Woodland Voles in Canada are at the northern edge of their range. They are the only fossorial vole in Canada. The value of peripheral populations for conservation may be low due to their tendency to be small, unstable and genetically depauperate (Lesica and Allendorf 1995) but they may be important due to unique genetics and as an indicator of response to climate change (Fraser 2000). Woodland Voles are predicted to expand their range northward in response to climate change (see **Habitat trends** section).

In the US where the species is much more abundant, Woodland Voles cause significant tree mortality and reduce growth, yield and fruit size in orchards (Forshey *et al.* 1984; Byers 1985). Herbivory causes multimillion-dollar losses in orchards, leading to extensive control efforts that involve poisoning (Tobin and Richmond 1993). There is no evidence of voles causing any damage to orchard in Canada or that poison is used to control them (Brooks and Struger 1982, Gartshore 1987, Ross 1998).

There is no information which suggests this species is of major significance to First Nations people.

DISTRIBUTION

Global range

The Woodland Vole occurs throughout eastern North America from the Gulf of Mexico (30° N latitude) to the Great Lakes and southern Québec (Figure 3; Banfield 1974; Smolen 1981). A narrow population band extends into northern Florida below 30° N and a relict population occurs on the Edwards Plateau in south-central Texas (Smolen 1981).

Canadian range

Less than 2% of the global range of the Woodland Vole occurs in Canada (Figure 3). The species' extent of occurrence (EO) is 37,016 km², with 25,650 km² in Ontario and 11,366 km² in Québec. Calculations were done separately for the two provinces because of the large apparently unoccupied area between the ranges in each province (Figure 2).

IAO can be calculated as both 148 km^2 and 18,072 km^2. These differing estimates stem from the area in Ontario being calculated using two different data sets: a) all records since 1956 (148 km^2; see Table 1) and b) all known records and areas of predicted suitable habitat based on a habitat suitability model (18,048 km^2; Bowman *et al.* 2004; see **HABITAT** section). The true IAO is likely intermediate because not all suitable habitats are likely to be occupied. Given the low sampling effort, current records probably underestimate the species' distribution in Canada.

Table 1. Occurrences of Woodland Voles in Ontario and Québec. Shaded records were not included in calculations of index of area of occupancy or extent of occurrence because these records are considered too old. Sources: Ross 1998, M. Léveillé pers. comm. 2010, and S. Giguère pers. comm. 2010.

Location	Coordinates		Year (s)	Number Collected/ Observed	Source/Collector
ONTARIO					
Pinery Provincial Park	43.233	-81.867	1992	1	Royal Ontario Museum (ROM)
Bothwell Woods	42.633	-81.85	1986	1	ROM
Clear Creek	42.6	-80.617	1986	1	Gartshore
Culver Tract	42.867	-80.383	1986	1	Gartshore
Jarvis Northeast Woods	42.9	-80.067	1986	1	Gartshore
Lynnville Chestnut Woods	42.867	-80.383	1986	1	Gartshore
Nixon Black Oak Knoll	42.85	-80.367	1986	2	Gartshore
Port Glasgow Natural Areas Complex	42.5	-81.633	1986	2	ROM
Skunk's Misery	42.633	-81.85	1986	1	ROM
Trout Creek Valley	42.8	-80.45	1986	1	Gartshore
Wycombe Swamp	42.783	-80.583	1986	1	Gartshore
South Walsingham	42.633	-80.567	1985, 1996, 1996	2, 2, 1	ROM, ROM, Michael Patrikeev
Oneida Woodlot	43.033	-80	1984, 1985, 1986	1. 1. 1	ROM
Aftercliffe Station Slough Forest	42.983	-79.6	1985	1	ROM
Backus Woods	42.667	-80.5	1985	2	ROM
Big Creek Floodplain	42.633	-80.533	1985	17	ROM
Caister-Canborough Slough Forest	43.033	-79.7	1985	2	ROM
Deer Creek Conservation Area	42.717	-80.567	1985	1	ROM
Langton Woods	42.75	-80.567	1985	1	ROM
Little Otter Creek	42.8	-80.717	1985	1	ROM
North Cayuga Slough Forest	42.983	-80.833	1985	2	ROM
St. Williams Forest	42.7	-80.45	1985	3	ROM
Venison Creek	42.683	-80.617	1985	1	ROM
Walsh Magnolia Tract	42.75	-80.417	1985	1	ROM
Walsh Woodland	42.75	-80.45	1985	2	ROM
Crawford Lake Conservation Area	43.467	-79.95	1979	1	ROM
Short Hills Wilderness	43.067	-79.35	1979	2	C. Campbell
Charlotteville Township	42.75	-80.4	1978	1	ROM
Spooky Hollow Sanctuary	42.667	-80.333	1978	1	ROM
Port Rowan	42.617	-80.467	1958	1	ROM

Location	Coordinates		Year (s)	Number Collected/ Observed	Source/Collector
Point Abino	42.836	-79.095	1956, 1956, 1942	2, 2, 3	Campbell, Jameson (Canadian Museum of Nature), ROM
Yarmouth Township	42.75	-81.133	1956, 1941, 1941, 1942, 1946, 1948, 1949, 1955,	3, 12, 12, 12, 2, 12, 12, 12, 12	ROM, Brooman
Ridgeville	43.033	-79.317	1954	1	ROM
Southcote	43.183	-79.95	1950, 1951	7, 7	ROM
Mount Hope	43.15	-79.917	1950	2	Royal Botanical Gardens
Jaffa	42.733	-81.033	1941, 1948, 1949	5, 5, 5	ROM
Caradoc Township	42.917	-81.533	1940	2	Museum of Comparative Zoology, (Harvard University)
Nanticoke	42.9	-80.183	1937	2	ROM
Eden	42.8	-80.75	1935, 1935	1, 2	University of Western Ontario, Elson
Komoka	42.95	-81.433	1915, 1923, 1938	4, 4, 4	ROM
Bryanston	43.117	-81.267	1902	3	ROM
QUÉBEC					
Philipsburg Migratory Bird Sanctuary	45.024	-73.366	2006	1	Sylvain Saint-Onge, Alain Desrosiers, Stéphanie Gagnon
Mont St. Hilaire	45.54	-73.179	1966, 1966, 1970, 1976,	1, 1, 1, 1	Redpath Museum, McGill University
South Bolton	45.15	-72.367	1966	1	Robert Wrigley, Canadian Museum of Nature
Mount Pinnacle	45.05	-72.732	1956	1	University of Montreal

Both extent of occurrence and area of occupancy were calculated using all records since 1956. This date was chosen because little targeted sampling or search effort has been undertaken and recent records are comparatively rare.

In Canada, Woodland Voles have been documented in 32 sites in southwestern Ontario since 1956, including Elgin, Kent, Lambton, and Middlesex counties, the municipality of Chatham-Kent, the city of Hamilton and the regional municipalities of Halton and Niagara (Banfield 1974; Ross 1998, Figure 1; Table 1). They have been found at four sites since 1956 in Quebec, including the Eastern Townships and the Montérégie administrative region south of Montréal. These areas include the Memphrémagog, Brome-Missisquoi (including the Philipsburg Migratory Bird Sanctuary), and La Vallée-du-Richelieu regional county municipalities (Banfield 1974; Ross 1998; Figure 1; Table 1).

Search effort

General surveys for small mammals are inappropriate to accurately assess population size or distribution of Woodland Voles because trapping effort is aboveground, where the species is less likely to be captured. Since the previous status report (Ross 1998), only two targeted surveys have been conducted, both covering small geographical areas in Ontario.

One targeted survey occurred in 2003 in the Ganaraska Forest (J. Bowman, pers. comm. 2010) employing pitfalls and Sherman traps (168 trap nights). While north of the known range of Woodland Voles in Ontario, it is within the habitat parameters of the species in Québec and the US (Bowman *et al.* 2004). No Woodland Voles were caught. In 2009, a survey using pitfalls and Sherman traps (70 trap nights) was conducted in Ruthven Park, where Woodland Voles were caught in the 1980s (Gartshore 1987). No individuals were captured in slough forest or retired pine plantation habitat (K. Pickett, pers. comm. 2010). Neither survey found any signs of vole digging either. Prior to the previous assessment, surveys in Haldimand and Norfolk Counties using both pitfall and snap traps caught 41 voles in 12,431 trap nights (Gartshore 1987). Thus even in prime habitat, considerable effort is required to detect the species. Targeted surveys of areas with historical records in the Region of Niagara, City of Hamilton and Haldimand County are planned for the fall of 2010 but no data from these are yet available (K. Pickett, pers. comm. 2010).

During a general small mammal survey conducted during 2006 in the Philipsburg Migratory Bird Sanctuary, Québec, one Woodland Vole was captured (S. Giguère, pers. comm. 2010). In total, 205 small mammals were captured in snap traps and pitfalls over 1604 trap nights.

The Haldimand-Norfolk Inventory is one of the few large surveys for small mammals in the known range of the Woodland Vole in Ontario. This survey included snap traps (64 traplines) and pitfalls (144 traplines) across the region (Gartshore 1987). Woodland Voles were more commonly captured on the Norfolk sand plain than the Haldimand clay plain and were rarely captured in woodlots isolated by agricultural land or in swampy areas. Gartshore (1987) suggested that voles may occur in the wet areas at low density, resulting in low capture rates. The Kent-Elgin Natural Areas Survey also covered a large area but only three Woodland Voles were among 460 small mammals captured (Ross 1998). Small mammal trapping surveys in Halton Region in 1979 (Paton and Sharp 1979) and 1980 (Sharp 1980) resulted in only one Woodland Vole captured among 229 small mammals caught over 2,372 trap nights.

Captures during the Haldimand-Norfolk Inventory represent the bulk of occurrence records for Ontario (Ross 1998; Table 1). No surveys of this magnitude have been done since. There is only one record for Ontario reported since 1998.

HABITAT

Habitat requirements

Ross (1998) described the animal's habitats in the US as heavy woods, old and cultivated fields, pasture, railroad embankments, fencerows, pine plantations, lawns, borders of cypress swamps and ponds, damp sphagnum and cranberry bogs and rocky hills. Woodland Voles are a common pest in US fruit orchards (Tobin and Richmond 1993), but not in Canada (Brooks and Struger 1982). Vegetation type and cover both influence distribution. Woodland Voles are most common in areas with dense herbaceous vegetation, which they use for food and cover (Getz 1985). Dense vegetation also moderates the microclimate that voles are exposed to, reducing temperature and moisture stress (Getz 1965; 1971). Woodland Voles are most commonly associated with well-drained soils (Goertz 1971; Smolen 1981). They occasionally occur in swampy locales, although they may only disperse into these marginal habitats when at high densities (Hamilton 1938; Miller and Getz 1969).

In southwestern Ontario, Woodland Voles are restricted to the Carolinian zone. Although found in most habitat types, they are most common in mesic mixed or dry deciduous forests (Gartshore 1987). Canopy species in forests where they occur include: Black Oak (*Quercus velutina*), White Oak (*Q. alba*), Red Oak (*Q. rubra*), Bitternut Hickory (*Carya cordiformis*), Black Walnut (*Juglans nigra*), Ironwood (*Carpinus caroliniana*), Hornbeam (*Ostrya virginiana*), Beech (*Fagus grandifolia*), Tulip Tree (*Liriodendron tulipifera*), Black Cherry (*Prunus serotina*), Choke Cherry (*P. virginiana*), Pin Cherry (*P. pennsylvanica*), Red Maple (*Acer rubrum*), Sugar Maple (*A. saccharum*), Silver Maple (*A. saccharinum*), Basswood (*Tilia americana*), White Ash (*Fraxinus americana*), White Pine (*Pinus strobus*), Eastern Hemlock (*Tsuga canadensis*), and Yellow Birch (*Betula lutea*) (Banfield 1974; Gartshore 1987; Ross 1998). Less typically, Woodland Voles are found in scrubby sand dunes (Banfield 1974). In Ontario, most forest sites where Woodland Voles have been caught have well-developed duff and humus layers (A. Dextrase, pers. comm. 2010).

Woodland Voles are commonly found on the edges of forests including areas near roads and railway tracks and field margins (Ross 1998). Based on capture records, Ross (1998) predicted they would regularly use marginal habitats adjacent to forests, particularly hedgerows in agricultural areas.

Their fossorial nature explains the influence of moisture conditions and soil type on distribution. Woodland Voles occur in drier habitats than most other *Microtus* species (Getz 1985), although they may inhabit areas with layers of humus and higher relative humidity (Peterson 1966; Lowery 1974). They avoid highly saturated soils that make burrow construction difficult (Miller and Getz 1977; Rhodes and Richmond 1985). Woodland Voles prefer light, friable soils which make digging easy (Fisher and Anthony 1980; Rhodes and Richmond 1985).

Bowman *et al.* (2004) modelled Woodland Vole habitat requirements in Ontario by examining landscape capability in 30 ha hexagons, corresponding to a maximum dispersal range of 308 m. Hexagons had to have > 20% suitable habitat to be considered capable of supporting Woodland Voles. The model predictions for areas that could potentially support vole populations assumed: a) a northern range limit of 43.5° N (a surrogate for temperature limits), b) forest cover (dense deciduous forest, mixed-wood forests with both coniferous and deciduous dominance, and sparse deciduous forest), and c) soil drainage (rapid, well or imperfect). The model identified 280,440 ha of potentially suitable habitat. Field validation of the model has not been done (J. Bowman, pers. comm. 2009).

Habitat trends

The Canadian range of Woodland Voles appears limited by their ability to cope with low winter temperatures (Ross 1998). Increases of 2.6-2.7° C in average annual temperature and 2.8-3.1° C in average winter temperature are predicted by the 2050s for the Great Lakes Plains ecosystem (Expert Panel on Climate Change Adaptation 2009). This may allow voles to expand northward assuming that suitable habitat to the north has not been fragmented or converted to other uses.

Ontario

Southern Ontario was one of the first areas of Canada settled by Europeans and was rapidly converted for agriculture. By 1920, 90% of southern Ontario's forests had been cleared, primarily for agriculture and urban areas (Larson *et al.* 1999). Significant efforts since then have resulted in reforestation of close to 20% of the cleared areas (Larson *et al.* 1999). However, southwestern Ontario remains dominated by agriculture and urban areas, with <5% of the overall land area being forested (McLachlan and Bazely 2003). Forest cover in the Stratford South, St. Thomas and Niagara ecodistricts where 90% of the post-1956 Woodland Vole records occur, ranges from 8 to 17% (Henson and Brodribb 2005). Notably, recent records for Woodland Voles are concentrated in the St. Thomas and Niagara areas, which have 12-17% forest cover. Further, the area with the highest concentration of Woodland Vole records within the St. Thomas ecodistrict has substantially greater forest cover compared to the ecodistrict average of 11.9%. Thus there is evidence for greater than average forest cover in areas where Woodland Voles occur. Quantitative measures of forest cover do not, however, define the presence of marginal habitats or dispersal corridors.

Because they live in small groups, have relatively small home ranges, and are habitat generalists, Woodland Voles can likely survive in habitat fragments. However, isolation between fragments likely means limited gene flow among populations and limited likelihood of repopulation (Pearce 1993, Andrén 1994). Woodlots and edge habitats are still being cleared to grown soybeans and corn in southern Ontario, but these conversions are not occurring in all areas where Woodland Voles occur (D. Kirk. pers. comm. 2010; T. Zammit, pers. comm. 2010).

Québec

By 1999, >70% of the original forest cover at the time of European settlement in southern Québec had been lost to urban and agricultural development (Bélanger *et al.* 1999). Habitat loss is likely to be proportionally less in Québec than Ontario, however, given the relatively lower rate of population increase in areas where Woodland Voles occur (see **Threats and Limiting Factors** section).

Most habitat conversion for agriculture had occurred by the 1970s and current records for Woodland Voles are in large forest patches within agricultural or agri-forest matrices (M. Léveillé, pers. comm. 2010). During the 1990s, increases in intensive farming (Bélanger *et al.* 1998) led to some consolidation of activity on fewer, larger farms. This likely resulted in habitat loss as small remnant forest tracts and hedgerows were converted for agricultural production (Duchesne *et al.* 1998; Gouvernement du Québec 2010a).

In the last 10 years, deciduous forest cover has been mostly stable at levels of approximately 40% in the Montérégie region and 70% in the Estrie region (M. Léveillé, pers. comm. 2010). Fragmentation is greater in Montérégie, where average patch size is 20-40 km^2, versus Estrie, which has an average patch size of 3000 km^2 (M. Léveillé, pers. comm. 2010).

BIOLOGY

Woodland Voles have been well studied in US orchards where they are considered a pest (Tobin and Richmond 1993). There are enough data from natural habitats in the US to provide some comparison. In Canada, there are few data (Ross 1998).

Life cycle and reproduction

Woodland Voles are social and may be monogamous, polyandrous or promiscuous (Wolff 1985; Oliveras and Novak 1986; McGuire and Bemis 2007). Both males and females are aggressive towards non-resident conspecifics. However, males are more aggressive towards other males, whereas females exhibit similar levels of aggression towards both sexes (Back *et al.* 2002). This suggests that males mate-guard while females are defending food or young (Back *et al.* 2002).

The breeding season typically occurs from January to November in the northeast US (Smolen 1981), but the start and end varies between populations and among years (Cengel *et al.* 1978). Populations in North Carolina have been recorded to breed year-round (Fitzgerald and Madison 1983), while a population in Oklahoma ceased breeding from August to May (Glass 1949; Goertz 1971). Breeding in Ontario and Québec likely occurs in the warmer months of May to October (Sutherland and Zammit 2001). Woodland Voles exhibit a limited response to photoperiod, suggesting cues such as food resources define the best breeding periods making for flexible responses to environmental conditions (Hasbrouck *et al.* 1986; Derting and Cranford 1989).

Females exhibit both male-induced estrus (Schadler and Butterstein 1979) and post-partum estrus (Kirkpatrick and Valentine 1970; Schadler and Butterstein 1979). Gestation is 20-25 days (Golley 1962; Kirkpatrick and Valentine 1970). Females produce 1-4 litters of 1-6 young each (mean number = 3.11 $\pm$ 0.09) per year (Goertz 1971; Schadler and Butterstein 1979; Linzey 1998). In litters with >4 pups, excess individuals generally die as young remain attached to the nipple and females have only 4 mammae (Hamilton 1938). Litter size increases with normal rather than reduced light intensity (Geyer and Rogers 1979) and with increased maternal size (Fitzgerald and Madison 1983). Litter size may be affected by maternal diet given data for larger litter sizes in females who consumed mostly grass versus forbs and woody plants (Cengel *et al.* 1978).

Young are born with eyes and ears closed and are completely dependent on parents for the first few days of life (Smolen 1981). Neonate body mass is 1.9-3.2 g and they are 39-48 mm long (Hamilton 1938; Fitzgerald and Madison 1983; Goertz 1971). Weaning occurs at 17-21 days of age (Geyer and Rogers 1979; Hamilton 1938; Fitzgerald and Madison 1983). Females mature at 10-12 weeks and conceive as early as day 77, but on average at 105 days (Schadler and Butterstein 1979). Males mature at 6-8 weeks (Schadler and Butterstein 1979).

Woodland Voles exhibit bi-parental care, though males invest less than females (McGuire and Novak 1984; Oliveras and Novak 1986; Salo *et al.* 1993; McGuire and Bemis 2007). Woodland Voles exhibit some co-operative breeding, with philopatric juveniles grooming and brooding young and maintaining burrows (Powell and Fried 1992; Jennions and Macdonald 1994). Social groups can consist of several adults with an equal sex ratio plus sub-adult individuals from the same or related litters (Raynor 1960; Renzullo and Richmond 1982; Marfori *et al.* 1997). One or 2 nests are used by a social group during the breeding season (Wolff 1985).

Woodland Voles have a lower reproductive potential than most other species of *Microtus*; they mature two to five times later and have smaller litters (Schadler and Butterstein 1979). However, females are likely to have frequent litters, leading to relatively high lifetime reproductive output given small litter size and late maturation (Keller 1985).

Most Woodland Voles survive less than 6 months, an estimate based on maximum time between first and last capture. This underestimates lifespan because many individuals are first captured as adults. In Connecticut, recapture rates indicated a disappearance of over 80% of the population within the first 2 months of trapping (mean 2.6 months, maximum 12; Miller and Getz 1969). Goertz (1971) reported similar results in Oklahoma with mean disappearance at 2.3 months and maximum at 14. Individuals in an enclosure in South Carolina persisted longer, with nearly 80% of the population surviving 2-6 months from first capture (Gentry 1968). Anthony *et al.* (1986) based on data from a kill-trap study in Pennsylvania orchards, found that 57% of individuals were 60-179 days of age, 21% were 180-350 and only 5% were >1 year old. Generation time is likely about 6 months based on average lifespan (3-6 months) and average age at first reproduction (most around 3.5 months). In Canada, because of the short breeding season, most voles likely do not reproduce until the subsequent year, making them at least 6 months old.

Diet varies with seasonal availability and the habitat in which voles live (Cengel *et al.* 1978). They prefer succulent shoots, roots and tubers, and store roots and fruit in underground caches for winter (Hamilton 1938). Woodland voles sometimes also eat seeds, bark and insects (Hamilton 1938; Cengel *et al.* 1978).

Physiology and adaptability

Woodland Voles have low rates of energy use (Derting and Austin 1998). Daily maintenance energy requirements (DMER) for captive males varied from 0.58 kcal g^{-1} day^{-1} during summer to 0.98 during winter while for females it was 0.54 kcal g^{-1} day^{-1} during summer and 0.96 in winter (Lochmiller *et al.* 1983). When given access to exercise wheels, DMER increased by 80% in females and 93% in males. Energy intake was approximately 50% higher for lactating females (Lochmiller *et al.* 1982). Females exhibit no substantial changes in gut capacity during breeding nor do they have large fat reserves (Derting and Austin 1998), which likely contributes to the relatively long gestation and slow postnatal growth rates (Lochmiller *et al.* 1982).

Woodland Voles have high metabolic heat production (Bradley 1976; cited in Rhodes and Richmond 1985) and high rates of evaporative water loss (Rhodes and Richmond 1981) compared to other voles. Water loss is reduced when voles are in humid burrows (Getz 1965).

Woodland Voles do not hibernate. To cope with winter they cache food (Hamilton 1938). Caching activity increases with decreasing photoperiod and in the presence of other voles (Geyer *et al.* 1984). Males cache more food than females, which perhaps ensures food for females unable to cache when they are rearing young (Geyer *et al.* 1984). Woodland Voles also nest communally, which reduces thermoregulatory costs (Wolff 1985). Additionally, Woodland Voles may decrease energy use by being active during daylight when temperatures are higher (Madison 1985).

Woodland Voles are excellent burrowers, using their forelimbs and teeth to dig (Hamilton 1938). Tunnels are shallow, generally just below the leaf litter (Hamilton 1938; Linzey 1998). Voles eat most food below ground and avoid surface activity (Cengel *et al.* 1978).

Dispersal and migration

The maximum dispersal distance recorded for Woodland Voles is 308 m (Goertz 1971). There are few other measures of dispersal distance, but home range size and dispersal distance are typically proportional across mammal species (Bowman *et al.* 2002). Home range estimates do not vary significantly between males (44.7 m^2) and females (41.7 m^2; Fitzgerald and Madison 1983), and suggest small home ranges with relatively small dispersal distances (predicted maximum dispersal distance of 267 m; Bowman *et al.* 2002). Home ranges are often linear, making diameter a reasonable proxy of home range size (Fitzgerald and Madison 1983). Estimates vary from 19-30+ m (Burt 1940; Benton 1955; Miller and Getz 1969). Goertz (1971) reported mean home range diameters of 68 m for females and 87 m for males. During the breeding season, home ranges of sexes in the same social group overlap, although males may travel slightly farther from the nest (Fitzgerald and Madison 1981; 1983).

Even though estimates of home range size and dispersal distance are relatively small, dispersal by small mammals of similar size suggests that voles only disperse 100s of metres (Maier 2002). Prairie Voles (*Microtus ochrogaster*) in Illinois made natal dispersal movements of 2-136 m, with a mean of 33.0 m for males and 28.7 m for females (McGuire *et al.* 1993). Longer dispersal movements of 157.7 $\pm$ 87.2 m (mean $\pm$ SE) for Prairie Voles and 265.7 $\pm$ 164.4 m for Meadow Voles were reported by Verner and Getz (1985). The use of hedgerows or ditches by Woodland Voles during dispersal may allow them to increase the distance they can move, increasing connectivity among populations in fragmented landscapes.

Woodland Vole dispersal may be partially driven by the need for sub-adults to leave to reproduce (Lidicker 1985; Solomon *et al.* 1998). Dispersal was nearly uniform across seasons in Georgia (Briese and Smith 1974). There are few data on dispersal behaviour or the characteristics of dispersing individuals but Briese and Smith (1974) reported that all dispersing Woodland Voles were adults.

Interspecific interactions

White-footed Mice (*Peromyscus leucopus*), Deer Mice (*Peromyscus maniculatus*) and Woodland Voles are occasionally sympatric (i.e. voles in tunnels, mice above ground). However, virtually complete spatial separation implies that resource competition is unlikely (Miller and Getz 1969). Woodland and Meadow voles frequently inhabit the same areas, though the latter prefer grassy orchards (Tobin and Richmond 1993). During surveys in southwestern Ontario, Meadow and Woodland Voles were rarely caught in the same habitats (Gartshore 1987). Meadow Voles tend to dominate Woodland Voles in encounters in the wild (Novak and Getz 1969; Cranford and Derting 1983). However, in most staged encounters there was no aggression, suggesting they avoid interactions even when in the same locations (Novak and Getz 1969; Cranford and Derting 1983). Woodland Voles and Short-tailed Shrews (*Blarina brevicauda*) are frequently caught in the same trap, suggesting they often use one another's tunnels (D.A. Sutherland, pers. comm. 2010). Voles also make use of Hairy-tailed Mole (*Parascalops brewer*) burrows (Eadie 1939).

Woodland Voles are likely taken most often by predators capable of hunting in tunnels such as Short-tailed Shrew, Ermine (*Mustela erminea*), and snakes (Pearson 1985; Ross 1998). Woodland Voles have been found in stomachs of Copperheads (*Agkistrodon contortrix*; Savage 1967) and Corn Snakes (*Elaphe guttata*; Linzey 1995) in Tennessee and North Carolina. In Ontario, Eastern Milk Snakes (*Lampropeltis triangulum*), Eastern Fox Snakes (*Elaphe gloydii*), and Black Rat Snakes (*Elaphe obsoleta*) are potential predators (Oldham and Weller 2000); of these only the Eastern Milk Snake occurs in Québec.

Voles were reported as common in owl pellets (Pearson 1985), although Gartshore (1987) found Woodland Vole remains in only 1 of 360 owl pellets examined. Raptors are less likely to prey on Woodland Voles, which spend most time underground, than other *Microtus* spp. that use surface runways. Several owls occur in Woodland Vole habitat including Barn Owls (*Tyto alba*), Great Horned Owls (*Bubo virginianus*), Barred Owls (*Strix varia*) and Short-eared Owls (*Asio flammeus;* Ontario Field Ornithologists 2009). Raptors reported as predators in New York include: Northern Harriers (*Circus cyaneus*), Red-tailed Hawks (*Buteo jamaicensis)*, and Broad-winged Hawks (*B. platypterus;* Saunders 1988).

Larger mammals such as Coyote (*Canis latrans*), Red Fox (*Vulpes vulpes*) and Bobcat (*Lynx rufus*) may eat Woodland Voles (Ross 1998). These species could ambush voles running in tunnels or runways (Pearson 1985). Striped Skunks (*Mephitis mephitis*) excavate nest sites (Fitzgerald and Madison 1981) and domestic cats and dogs commonly prey on small mammals, including voles (Pearson 1985; Ogan and Jurek 1997; Ross 1998).

In central Connecticut, fleas and mites were the only ectoparasites found on Woodland Voles despite local concentrations of botfly larvae in White-footed Mice (Miller and Getz 1969). In high density vole populations, ectoparasite numbers were higher, with large numbers of mites (*Laelaps microti*) and lice (*Hoplopleura spp.*) per individual (Hamilton 1938).

POPULATION SIZES AND TRENDS

Sampling effort and methods

Woodland Voles are generally live trap-averse. To adequately sample populations, subsurface trapping is required. Directed trapping effort of this type has been inadequate to effectively estimate population size or assess distribution in Québec or Ontario.

Only two small-scale surveys which were conducted in 2003 and 2009 have occurred since the previous status assessment (Ross 1998) and neither captured any Woodland Voles. Pickett plans to survey additional areas with historical records for Woodland Voles (K. Pickett, pers. comm. 2010) but these data are not yet available. There are currently not enough data to estimate population abundance or infer anything about population trends in Canada.

Abundance

Density of Woodland Voles has not been estimated in Canada. In the US, density varies from <1-44 individuals/ha in natural environments (Bole 1939; Miller and Getz 1969) and 17-741/ha in orchards (Anthony *et al.* 1986; Hamilton 1938; Solomon *et al.* 1998). Density may reach up to 15/ha in Canada (Miller and Getz 1969); however, this estimate is based on a US population study at northern latitudes.

Woodland Voles are likely more populous in Canada than suggested by their infrequent captures (Saunders 1932; Elson 1937; Connor 1953; Wrigley 1969; Ross 1998).

Fluctuations and trends

Populations of Woodland Voles have been hypothesized to cycle or fluctuate in areas with high resource availability where high densities occur (e.g., orchards; Hamilton 1938). In contrast, populations in natural areas are likely more stable, although densities can vary both during and between years (Hamilton 1938; Miller and Getz 1969; Goertz 1971; Smolen 1981; Anthony *et al.* 1986). In Canada, high population densities have not been reported and are unlikely to occur (Ross 1998). Yearly peak population sizes generally occur in July, with lows in December-January (Miller and Getz 1969).

Given the limited survey effort in Québec and Ontario since Ross (1998), the status of populations (e.g., increase, decline or stability) in Canada is unknown. Trends are impossible to assess directly given the lack of a reliable historical estimate for either Canadian population.

Rescue effect

Rescue between Québec and Ontario populations is unlikely given the large area between the known ranges in the two provinces (Figure 1). Both Québec and Ontario border US states where Woodland Voles occur, but New York is the only state with a secure population. Woodland Vole populations have not been reported in the areas of New York or Michigan that directly border Canada (Figure 2; Cooper 2000; Sullivan and Curtis 2002). Barriers to dispersal from Michigan into Ontario include large highways, significant waterways and large urban areas (Figure 2). Vermont has Woodland Voles in areas that may allow for rescue of Québec populations. The conclusion that connectivity of Woodland Vole populations is more likely to be maintained between the US and Québec is confirmed by the gap analysis completed for the US distribution of Woodland Voles (UA-CAST and USGS 2010).

THREATS AND LIMITING FACTORS

The greatest current threats to Woodland Voles are habitat loss and degradation due to urban development, agricultural intensification, and forest conversion. Intensification of agriculture in the range of this species is restricted to parts of southern Ontario but urban development and forest harvest are threats in both Ontario and Québec. Habitat degradation is due primarily to forest harvest as part of conversion.

Urban growth is likely to continue in both Ontario and Québec for the foreseeable future as human populations continue to increase. Human populations in the ecozone where Woodland Voles are found increased by over 22,000 in Québec but over 800,000 in Ontario from 2001-2006 (Statistics Canada 2009). Southern deciduous forests, especially within the Ontario part of the range of the Woodland Vole occur in areas of high development pressure (Henson *et al.* 2005). Some areas have higher proportions of forest cover (St. Thomas, Niagara eco-districts; Henson and Brodribb 2005) and are likely to maintain sufficient habitat for Woodland Voles. Urban development is likely to be highest close to areas of population density e.g., the Stratford South eco-district (Henson and Brodribb 2005). In Québec, urban development is less likely to affect Woodland Vole habitat by virtue of there being many fewer people in the species' range (M. Léveillé, pers. comm. 2010). Although development has caused habitat loss near South Bolton, this is in an area with little current habitat fragmentation and thus some development should not cause declines in Woodland Voles (M. Léveillé, pers. comm. 2010).

Agricultural development played a historical role in the loss of Woodland Vole habitat but the rate has slowed (Henson *et al.* 2005). Agricultural intensification and changes in practices in both provinces may still result in loss of remnant woodlands and hedgerows. Much of the Woodland Vole's range in Ontario has experienced either maintenance or decreased pressure from changes in agriculture (D. Kirk. pers. comm. 2010; T. Zammit, pers. comm. 2010).

In the US, Woodland Voles are considered a pest species in fruit orchards. They are persecuted extensively through poisoning. There is no evidence that this is currently occurring in Canada.

Woodland Voles are sensitive to temperature extremes (Ross 1998) and the Canadian range appears limited by their ability to cope with low winter temperatures. During winter, voles conserve energy by communal huddling (Wolff 1985). However, once the temperature drops enough, these measures cannot compensate for the costs of foraging. Bowman *et al.* (2004) used latitude as a proxy for temperature, predicting the range limit was 43.5° N, in line with the most northern record in Ontario. Woodland Voles are reported as far north as 45.6° N in Québec and 45.4° N in Michigan (Figure 3). Other ecological factors likely limit the known distribution in Ontario.

PROTECTION, STATUS, AND RANKS

Legal protection and status

The Woodland Vole is listed as a Species of Special Concern under SARA and under the Ontario *Endangered Species Act*, 2007. The Woodland Vole has not been listed under the Québec government's *Act respecting threatened or vulnerable species*, but it is listed as a species susceptible to designation as threatened or vulnerable (Gouvernement du Québec 2010b)

Non-legal status and ranks

Canada

The Woodland Vole is ranked as Vulnerable (N3) in Canada (NatureServe 2010). In both Québec, and Ontario the Woodland Vole is considered Vulnerable (S3; NatureServe 2010). The Woodland Vole is ranked 3 or sensitive in Ontario, Québec and Canada by the general status evaluations (CESCC 2006).

United States of America

In the United States, the Woodland Vole is widespread but with a sparse distribution in natural habitats. It reaches high densities in orchards and other agricultural lands. Its population in the United States is stable and there are no major threats to its survival, giving it a rank of N5 (NatureServe 2010). The Woodland Vole is considered Secure (S5) in New York State, Apparently Secure (S4) in New Hampshire and Critically Imperiled (S1) in Maine (NatureServe 2010). It is listed as a *Species of Special Concern* under Michigan's *Natural Resources and Environmental Protection Act* and is ranked as Vulnerable/Apparently Secure (S3S4) owing to a lack of recent data (NatureServe 2010). The Michigan designation does not confer any legal protection. The species is ranked as Vulnerable (S3) in Vermont (NatureServe 2010).

International

The Woodland Vole is listed as G5 globally (NatureServe 2010). Its stable and widespread population is the rationale for its global listing as *Least Concern* by the IUCN (Linzey and Hammerson 2008; NatureServe 2010).

Habitat protection and ownership

Ontario

In southern Ontario, most remaining natural habitat is privately owned (93%; Henson *et al.* 2005). Of the remaining area, 4.3% is conserved in protected areas or conservation lands (Henson *et al.* 2005). Some forest ecosystems, including forests that support Woodland Voles, are protected through federal and provincial regulations, Conservation Authorities, and as Areas of Natural and Scientific Interest, or by the Nature Conservancy (Henson *et al.* 2005). Currently, 1665 ha is fully protected, which corresponds to 0.2% of the Ontario area of occupancy. Conservation is also provided by regional Land Trusts, which currently protect 1180 ha in the range of the Woodland Vole from development (OLTA 2010). This corresponds to 0.14% of the area of occupancy in Ontario. Land Trusts protect land through ownership and direct management (1061 ha) and through conservation easements (119 ha; OLTA 2010). Ontario Nature protects 281 ha of deciduous forest in Ontario (Ontario Nature 2010). The Bruce Trail Conservancy protects approximately 2500 ha throughout Ontario, a small proportion of this area is Woodland Vole habitat (BTC 2010). Other programs in southern Ontario that may contribute to long-term protection of Woodland Vole habitat include: the Community Conservancy Program, Ontario Parks Legacy 2000 (Environmental Commissioner of Ontario 2001), and tax relief programs for the protection and responsible management of woodlots. Permanent protection of ecological features and functions of the landscape in the area surrounding the Niagara Escarpment in Ontario is planned through the *Greenbelt Act*, which corresponds to a small area of Woodland Vole range.

The Ontario *Endangered Species Act, 2007* prohibits the damage or destruction of the habitat of endangered or threatened species; thus it potentially provides indirect protection by maintaining the habitat of endangered and threatened species that have similar distributions to the Woodland Vole.

Québec

The conservation, development and use of public lands in Québec are managed through the *Act Respecting the Lands in the Domain of the State*. However, more than 75% of the forested land in the Woodland Vole's Québec range is privately owned (Ressources naturelles et Faune Québec 2009). Woodland Voles are known, or suspected, to occur in some protected areas in Québec (i.e. Nature Conservancy of Canada's Green Mountain Nature Reserve, Gault Nature Reserve of McGill University, Mont Saint Hilaire and Philipsburg Migratory Bird Sanctuaries; Réserve Écologique de la Vallée-du-Ruiter, and land owned and managed by the Ruiter Valley Land Trust). The total amount of potential Woodland Vole habitat protected by these measures is 12,300 ha, or 1.1% of the area of occupancy. In addition, the Appalachian Corridor Project has protected over 8,500 ha of land (ACA 2009).

Most forested habitat in southern Québec occurs in privately owned woodlots, approximately 65% of which are active (Ressources naturelles et Faune Québec 2009). Although the *Forest Act* does not specifically protect the habitat of Woodland Voles, it does provide mechanisms for habitat protection and sustainable harvest that will protect vole habitat in the long term. For example, plans for private forests must be consistent with land use planning and development plans of the regional county municipality. The *Forest Act* also requires the protection of Exceptional Forest Ecosystems (EFEs) to preserve biological diversity. Protection of these ecologically important areas is encouraged by identification of EFEs, their inclusion in regional development plans and the requirement for EFE protection, to receive financial assistance for woodlot development (MRNFP 2003).

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

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Authorities contacted are listed in Table 2.

Table 2. Authorities contacted during preparation of update status report.

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COLLECTIONS EXAMINED

None.