Technical Summary and Supporting Information for an Emergency Assessment of theTri-colored Bat *Perimyotis subflavus*

Graham Forbes, Co-Chair, Terrestrial Mammal Subcommittee, COSEWIC

February 2012

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

Assessment Summary – February 2012

Common name
Tri-colored Bat

Scientific name
Perimyotis subflavus

Status
Endangered

Reason for designation
Most of the Canadian population of this species has recently been exposed to a fungal pathogen. Catastrophic declines of several species of bats and predicted functional extirpation (<1% of existing population) of Little Brown Myotis in the northeastern United States will very likely apply to the Canadian population of this species within 3 generations. Results for Little Brown Myotis are considered applicable to this species; massive mortality events recorded in New Brunswick in 2011, significant declines in Quebec and Ontario hibernacula, and evidence of flying bats in winter at numerous sites where White-nose Syndrome (WNS) is known. WNS recorded in 4 Canadian provinces and expanding at minimum rate of 200km/yr. For this species, 76% decline in northeastern U.S. hibernacula infected for 2 years and a 94% decline in a Canadian hibernaculum. Much of the Canadian population is likely already impacted and the remainder will be impacted within several years.

Occurrence
New Brunswick, Nova Scotia, Ontario, Quebec

Status history
Designated Endangered in an emergency assessment on February 3, 2012.

Executive Summary

Between 5.7 and 6.7 million bats, of several species, but mainly Little Brown Myotis, are estimated to have died in the last 6 years in the northeastern United States and eastern Canada. Tri-colored Bats are relatively rare in Canada and the response to White-nose Syndrome (WNS) by Little Brown Myotis is used as a surrogate for the response by Tri-colored Bat when information on Tri-colored is lacking. Mortality associated with White-nose Syndrome (WNS), caused by a fungus likely from Europe, has reduced populations of Little Brown Myotis by >75% in infected hibernacula, and this species has been modelled to be functionally extirpated (<1% population) in 16 years in the northeastern U.S. (Frick *et al*. 2010). There is strong evidence that the same result will occur in the Canadian population of Tri-colored Bat; significant declines and mortality events were recorded in Canada in 2011 and susceptibility to WNS is expected to be similar across most of Canada.

Population size and trends for Tri-colored Bat before arrival of WNS are not known, but they were considered rare to uncommon but stable. Declines of Tri-colored Bat in the northeastern U.S. hibernacula have been 76% (Turner *et al*. 2011) and summer populations indicate similar rates of decline.

Imminent decline and threat to survival is based on results from the northeastern U.S. and eastern Canada and the fact that most of the range of Tri-colored Bat is within the range of WNS. The rate of spread is less important as a variable for assessment in Tri-colored Bat compared to Little Brown Myotis and Northern Myotis, whose range extends beyond WNS at present.

Technical Summary

Perimyotis subflavus
Tri-colored Bat (Eastern Pipistrelle) Pipistrelle de l'Est

Range of occurrence in Canada: New Brunswick, Nova Scotia, Ontario, Quebec

Demographic Information

Generation time (*Mean age of longevity – 1 year for subadult period = 7; mean age of adult females = 9*?) *Range of 3-9 years accounts for mean age of longevity – 1 year for subadult period = 7; mean age of adult females = 9?, and data from banding data on Little Brown Myotis in Manitoba, which suggests 3 years.*	3-9 years (est.)
Is there an observed continuing decline in number of mature individuals? *Populations considered stable until present, although they receive minimal survey attention*	Yes, significant declines noted in northeastern U.S. and some sites in Canada in last year
Estimated percent of continuing decline in total number of mature individuals within 2 generations (6-18 yrs). *Populations considered stable until present, although they receive minimal survey attention*	Unknown, but considered high in future
Inferred percent reduction in total number of mature individuals over the last 3 generations (9-27 yrs). *Populations were considered stable until WNS, although they receive minimal survey attention.*	Unknown, but likely stable prior to WNS
Projected percent reduction in total number of mature individuals over the next 3 generations (9-27 yrs). *Catastrophic decline is predicted within 5 years, based on mortality data collected to date.*	At least 75%
Estimated percent reduction in total number of mature individuals over 3 generations, over a time period including both the past and the future.	At least 75%
Are the causes of the decline clearly reversible and understood and ceased? *WNS is cause of mortality but without remedy it is expected to continue; spores persist in cave environments*	Understood, but not ceased, nor reversible
Are there extreme fluctuations in number of mature individuals? *Variation in individual hibernacula recorded but extreme fluctuations not evident for any known populations.*	Unknown, but not likely

Extent and Occupancy Information

Estimated extent of occurrence. Southern half of Ontario eastward to Nova Scotia	Southeastern Canada
Index of area of occupancy (IAO) (Always report 2x2 grid value). *Hibernacula and maternity roosts historically reused specific locations but summer foraging is over entire range*	Southeastern Canada
Is the total population severely fragmented? *Nova Scotia population may be isolated from remainder, but not severely.*	Unlikely
Number of locations* *1 location, based on WNS as an all-encompassing threatening event.*	1
Is there an observed continuing decline in extent of occurrence? *Predictions are based largely on mortality data from northeastern U.S.*	Not yet, but predicted over next 3 generations
Is there an observed continuing decline in index of area of occupancy? *Predictions are based largely on mortality data from northeastern U.S.*	Not yet, but predicted over next 3 generations
Is there an observed continuing decline in number of populations? *Predictions are based largely on mortality data from northeastern U.S.*	Not yet, but predicted over next 3 generations
Is there an observed continuing decline in number of locations*? *Canadian population exists as 1 population.*	No
Is there an observed continuing decline in area of habitat? *Hibernacula are habitat critical for population sustainability; WNS appears to turn sites into mortality sinks. Declines recorded in some hibernacula, may have occurred in others.*	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*? *Canadian population exists as 1 location*	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

* See Definitions and Abbreviations on COSEWIC website, IUCN 2010 for more information on this term.

Number of Mature Individuals (in each population)

Population	**N Mature Individuals (estimated minimum)**
Unknown, considered rare in Quebec and New Brunswick and uncommon in Nova Scotia and Ontario. Low numbers recorded in hibernacula throughout species' range.	
Total	20,000 (?)

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years]. *Model predictions (Frick* et al*. 2010) for similar Little Brown Myotis in northeastern U.S. (based on 30 years data and documented declines since WNS) predict 99% probability of 'regional extinction' within 16 years. Increased productivity in Tri-colored suggests extinction would take longer than for Little Brown Myotis but significant declines expected based on high (76%) declines recorded in United States.*	Assuming results from Little Brown Myotis apply to Tri-colored Bat, probability of extinction is 99% in northeastern U.S. Similar results expected for central-eastern Canada.

Threats (actual or imminent, to populations or habitats)

White-nose Syndrome is caused by a fungal pathogen (*Geomyces destructans*), likely from Europe, that was first recorded in North America in 2006 and 2010 in Canada. Mortality of Tri-colored Bat in infected hibernacula averages 76% in the northeastern United States after several years of exposure. Autumn mixing of bats results in likely spread to all hibernacula.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)?	
Is immigration known or possible? *Tri-colored Bats are mobile and undertake significant movement between seasons and hibernacula*	Likely
Would immigrants be adapted to survive in Canada? *Climate and food sources are similar to American conditions but any immigrants would not be adapted to* Geomyces destructans.	Yes/No
Is there sufficient habitat for immigrants in Canada? *Roosts and food are thought to be not limiting but hibernacula infected with* Geomyces destructans *would become population sinks.*	No
Is rescue from outside populations likely? *Populations only exist south of Canada and they have been near extirpated in the American northeast.*	No

Current Status

COSEWIC: Not assessed. Considered uncommon throughout most of range. Assessment for endangered status underway in the United States.

STATUS SUMMARY:
Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** A3bce+4bce; E
Reasons for designation: Most of the Canadian population of this species has recently been exposed to a fungal pathogen. Catastrophic declines of several species of bats and predicted functional extirpation (<1% of existing population) of Little Brown Myotis in the northeastern United States will very likely apply to the Canadian population of this species within 3 generations. Results for Little Brown Myotis are considered applicable to this species; massive mortality events recorded in New Brunswick in 2011, significant declines in Quebec and Ontario hibernacula, and evidence of flying bats in winter at numerous sites where White-nose Syndrome (WNS) is known. WNS recorded in 4 Canadian provinces and expanding at minimum rate of 200km/yr. For this species, 76% decline in northeastern U.S. hibernacula infected for 2 years and a 94% decline in a Canadian hibernaculum. Much of the Canadian population is likely already impacted and the remainder will be impacted within several years.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets A3b,c,e: COSEWIC criterion of 'projected reduction in total number of mature individuals is >50% over 3 generations' is met, based on evidence of WNS in Canada and documented declines after 2 years exposure averaging 76% in 36 infected hibernacula in 5 nearby U.S. states. Three generations is 15-27 years; range of WNS already overlaps this species range in Canada and all hibernacula will likely be impacted in the next several years, and definitely within 15 years. Meets A3b because the number of mature individuals is projected to decline by over 90**%** over the next 3 generations based on the current rates of mortality recorded in 36 infected hibernacula in the U.S. after 2 years of exposure and 94% decline recorded in 1 hibernaculum in Quebec. Meets A3c because the EO and IAO are projected to decline by more than 50% over the next 3 generations as populations are extirpated following the spread of the disease. This species has been extirpated from 13 of 36 (36%) hibernacula in northeastern U.S. by 2010, 5 years after the discovery of WNS. Meets A3e because *Geomyces destructans*, the cause of WNS, is believed to be an introduced pathogen from Europe and is responsible for population declines of 76% in hibernacula within two years of infection. Meets A4b,c,e because impact of WNS at present, combined with future predictions exceeds 50%, and reduction or cause may not cease and may not be reversible, given lack of remedy (see rationale for b,c,e above).
Criterion B (Small Distribution Range and Decline or Fluctuation): not applicable
Criterion C (Small and Declining Number of Mature Individuals): not applicable
Criterion D (Very Small or Restricted Total Population): not applicable
Criterion E (Quantitative Analysis): Using results from Little Brown Myotis as a surrogate for this species, the COSEWIC criterion of minimum 20% probability of extinction within 20 years or 5 generations is met because results for similar species (Little Brown Myotis) from nearby and similar regions have modelled regional extinction of Little Brown Myotis within 16 years at 99% probability.

Emergency Assessment – Tri-colored Bat

Graham Forbes, Co-Chair, Terrestrial Mammal Subcommittee, COSEWIC

Context for the report

The *Species at Risk Act* and Section 5.5 of the Operations and Procedures Manual for COSEWIC contains the context of an emergency assessment. The following report outlines evidence of the serious decline in the population of Tri-colored Bat that results in an imminent threat to their survival.

Overview of the species and evidence of threat to survival

The Tri-colored Bat (*Perimyotis subflavus*) (formerly called Eastern Pipistrelle) is an insect-eating bat found in southeastern Canada and the eastern United States (Fig. 1). It is rare in Quebec and New Brunswick and uncommon in Nova Scotia and southern Ontario (Broders *et al*. 2001, 2003; van Zyll de Jong 1985). Overall population size is not known. They roost with Little Brown and Northern Myotis, but in much lower numbers.

The impact of White-nose Syndrome (WNS) is equal between the Little Brown Myotis, Northern Myotis and Tri-colored Bat. All species are similar in body size, longevity, foraging habitat, food items, and overwintering habitat (Fujita and Kunz 1984). All 3 species are susceptible to White-nose Syndrome. All 3 species hibernate in the same hibernacula and it is difficult to identify to species if bats are at a distance, or in crevices. Less information is available on Tri-colored Bat and this report uses data on Little Brown Myotis as a surrogate, when data on Tri-colored Bat are absent.

There is some evidence that Tri-colored Bat are at greater risk than other species from WNS because they hibernate at a temperature that is optimum for the growth of *G. destructans*, they hibernate for the longest period of the group of species, and they have essentially no immune system while hibernating (Raesly and Gates 1987, DeeAnn Reeder, pers. comm.)

Small-bodied bat species that winter in caves or mines are dying from White-nose Syndrome, caused by a fungus, *Geomyces destructans* (*Gd*), that is hypothesized to have originated in Europe (Pikula *et al*. 2012, Turner *et al*. 2011), and was first detected in North America in 2006 (Lorch *et al*. 2011). The fungus grows in humid, cold environments, typical of caves where bats hibernate (Blehert *et al*. 2009). Mortality during winter is hypothesized to be caused by starvation through excessive activity; insect-eating bats that would normally hibernate become active, dehydrated and hungry because of infection from the fungus that grows on them while their body temperature (Turner *et al*. 2011) and immunity (Carey *et al*. 2003) is low. The bats leave the caves in search of food and water but die outside, or at the hibernacula entrance. Physiological processes associated with hydration, and damage to wings, may also be related to mortality (Cryan *et al*. 2010).

Population modelling has not been conducted for Tri-colored Bat. The Little Brown Myotis is predicted to be functionally extirpated (i.e. <1% of existing population) in the northeastern United States within 16 years (Frick *et al*. 2010). An estimated 1 million bats died in the northeastern U.S. within 3 years of WNS arrival (Kunz and Tuttle 2009). A recent mortality estimate of 5.7-6.7 million bats within 6 years of WNS arrival was made by the WNS management team in the United States (U.S. Fish and Wildlife Service news release; January 17, 2012). Mortality results to date support the predictions in the Frick *et al*. (2010) model (Turner *et al*. 2011).

The populations of affected species are not expected to recover quickly because bats, typically, have slow population growth rates. Mortality is high in yearlings while adults are long-lived and only produce 1-2 young every year or two. Such a life-history strategy heightens the vulnerability of these bat species to high adult mortality rates. Experience from the U.S. indicates significant declines often occur in the second year after first detection (Turner *et al.* 2011) and thus we emphasize data with > 1yr post-exposure in this report. Population declines in infected areas (much of the northeastern United States) have been 76% for Tri-colored Bat (Table 1; Turner *et al*. 2011). Thirteen of 36 hibernacula declined to 0 bats. As of 2011, WNS has been recorded in 190 hibernacula in 16 states and 4 provinces. The same results are occurring in Canada where WNS has been reported for > 2 years (see details below).

Recent Canadian data

In eastern Ontario, 8 hibernacula are being monitored for changes in abundance; all had significant declines of mainly Little Brown Myotis but also Tri-colored Bat after 1 year of exposure to WNS, with an average decline of 30%. After 2 years' exposure, the average decline was 92% (Table 2). The Tri-colored Bat comprised a small percentage of the bats collected but their decline is expected to be proportional. Additional hibernacula are being identified but monitoring for WNS often is restricted to search for flying bats or carcasses near the entrance, and % declines cannot be calculated from these data.

In Quebec, 5 hibernacula are being monitored relative to WNS using laser counters at the hibernacula entrance. In autumn 2011, 1 hibernaculum (Mine-aux-Pipistrelles, in southern Quebec near the U.S. border and the closest site to the origin of WNS) had a decrease from >5000 to 8 bats (min. 99% decline), concurrent with hundreds of dead bats on the ground (Mainguy and Desrosiers 2011). Tri-colored Bat abundance was 15-17 per year during the two preceding pre-WNS years, then declined to 1 bat in November 2011, a 94% decline. Ten other sites are monitored by observation but access and quality of survey results varies; 1 site (Emerald Mine) recorded signs of WNS and "many" dead bats in February 2010.

In New Brunswick, 11 sites have been monitored for WNS in 2010-12. The first record of WNS was in March 2011 when over 80% of 6000 bats in Berryton Cave died in 1 month (McAlpine *et al*. in press). A total of 350 bats were counted in December 2011, a 94% decline over 2 years. Tri-colored Bat are presumed to be impacted as has been found elsewhere. WNS was recorded in an additional 3 sites in December 2011.

In Nova Scotia, permission to enter caves is restricted and surveys have been limited to winter-time visits to the entrance of caves, collecting dead bats, and reports from the public of bats flying during winter. Carcasses are submitted to veterinary pathologists, who have confirmed *Gd*.

Issue of movement by Tri-colored Bat

New work by Erin Fraser and Brock Fenton (paper in review) suggests that Tri-colored Bat may be more migratory than believed. Stable isotope analyses were performed on museum specimens (sample size unknown) and some specimens indicated they were non-migratory, while some moved far enough to produce different isotope signatures. The extent of southward movement in winter is not known because point-of-origin analyses have not been done (Erin Fraser, pers. comm.). However, it raises the possibility that Tri-colored Bat are migrating south for winter and may thus be at less risk from WNS if they overwinter in Florida-Texas where WNS is unlikely to persist (Fig. 1,3).

It is difficult to assess if Tri-colored Bat are migrating beyond WNS range. A similar species in Europe (*Pipistrellus pipistrellus*) migrates 1200km (Fleming and Eby 2003). In North America, Tri-colored Bats are considered short-distance regional migrants (Barbour and Davis 1969). As of 1984, the longest distance moved, as recorded by banding, was 53km (Griffin 1940; cited in Fujita and Kunz 1984). Relatively few Tri-colored Bat are recorded in hibernacula; on the other hand, dense overwintering populations have not been recorded anywhere in their range (Sandel *et al*. 2001) and a lack of numbers in northern hibernacula may not indicate absence.

Notwithstanding our ignorance of migratory movements for Tri-colored Bat, a decline in summer abundance post-WNS would suggest that the species is vulnerable to WNS, wherever they happen to be hibernating. Jurisdictions presently are organizing data and so few results are available. Where data are available for sites with post-WNS data, summer declines in Tri-colored Bat are evident. For example:

Recent Summer data

In New York State, in a state-wide, acoustic-based monitoring effort, detection of Tri-colored Bat in summer was 0.7 detections/30km road in 2009 and declined to 0.4/30km in 2011. This decline is an underestimate because monitoring was not initiated until severe bat declines from WNS had already taken place (Carl Herzog, pers. comm., unpublished data; NY State Biologist). Captures of Tri-colored Bat from mist netting in NY state were rare before WNS (38 total from 737 net nights [0.052] in 2003-2007) and are essentially absent after WNS (3 total from 1856 net nights [0.002] in 2008-2011) (Carl Herzog, unpublished data; NY State Biologist).

In West Virginia, 386 Tri-colored Bat were captured before WNS (2008) and 101 were captured 1 year post-WNS (2010) (Craig Stihler, pers. comm., unpublished data, West Virginia State Biologist).

In Pennsylvania, capture rates were 0.005 during summer pre-WNS (55-70 Tri-colored Bat with a trap effort of approximately 10-14000 $1m^2$ mesh units set for 1 hour) and declined to 0.0004 post WNS in 2010 (13 bats from approximately 31,000 $1m^2$ mesh unit) (note: not all 2010 included yet but with higher effort, numbers not likely to change) (Calvin Butchkoski, pers. comm., Pennsylvania State Biologist, Butchkoski 2011).
In Virginia, captures at 5-6 autumn swarm sites declined from early-WNS levels of 15 Tri-colored Bat captures per site to approximately 2 bats per site in 2011 (Fig. 4) (Rick Reynolds, pers. comm., unpublished data; Virginia State Biologist).

In conclusion, populations in the northern part of the species' range (i.e. New York, Vermont) have nearly disappeared post-WNS and it is unlikely the animals on the Canadian side of the border have different migration patterns, susceptibility to WNS, and declines than those recorded in New York and Vermont.

Imminent Threat to Survival

An imminent threat to the survival of this species is based on three assumptions: a) the expectation that mortality results from the northeastern United States will apply to the Canadian population; b) that there is a high probability that WNS will rapidly spread to all hibernacula in the Canadian range; and c) there is no likelihood of rescue effect.

a) Application of U.S. Results to Canada

The outbreak of WNS occurred first in the northeastern U.S. and more data are available for this population on the effects of WNS after multiple years. Also, hibernacula were generally better monitored and populations trends more known in the U.S., which facilitated population modelling of WNS impacts. Mortality rates recorded in the U.S. are expected for Canadian populations because hibernacula conditions, such as temperature and humidity, are similar and fall within the range of *Gd* growing conditions. There likely is movement of some bats between the two countries and no genetic differences are expected between bats in the northeastern U.S. and Canada. As such, there is no reason to expect increased resistance within Canadian bats and results from the northeastern U.S., including the population model, mortality rates, and rate of spread should be similar.

b) Rate of spread

White-nose Syndrome was first recorded 6 years ago (February 2006) in a cave near Albany, New York (Frick *et al*. 2010, Fig. 2). It has spread at a rate of approx. 200-400km per year, reaching Ontario and Quebec in 2010, and New Brunswick and Nova Scotia in 2011 (Fig. 1, 2). Straight-line distance of WNS spread from the epicentre at Albany, NY to the farthest site (Missouri) from 2006-2011 was approximately 1000km, a rate of 200km/yr. A recent case from Oklahoma is 2200km from the epicentre (440km/yr) (Turner *et al*. 2011, Fig. 1, 2). In Canada, the rate to New Brunswick was 200km/yr, and from epicentre to the farthest western site to date (Wawa, Ontario) was 250km/yr. The average rate of spread appears to range between 200-400km/yr. The distance from the epicentre to the first site in Ontario (Cochrane) was 1000km, which may indicate WNS can spread in large leaps, either by bat or human movement, or that WNS was already present in Ontario sites closer to Albany.

The vector for transmission is believed to be bats that have been in contact with conidia of infected bats or walls of the hibernacula, and people visiting caves. A proportion of Little Brown Myotis, and presumably Tri-colored Bat, move hundreds of kilometres between their summer and winter ranges. Swarming behaviour in August and September is likely a main mechanism for *Gd* transfer between subpopulations. Swarming behaviour shows young where to go to hibernate and also heralds the start of the mating season. Extensive bat-to-bat contact during swarming is believed to be instrumental in the spread of WNS (B. Fenton, pers. comm.). Bats have been recorded swarming at one site but hibernating in another (Humphrey and Cope 1976), potentially transmitting spores between sites (Turner *et al*. 2011).

WNS is expected to continue spreading throughout Canada and the western United States because most caves and mines used by bats have similar conditions. Based on *Gd* growing conditions (minimum and maximum temperatures in hibernacula, and the relationship of temperature and lipid reserves in Little Brown Myotis) (Hallam and Federico 2011), it is predicted that much of the United States has the conditions for WNS, and assuming spread between colonies will occur as it has in eastern North America, much of the area will be impacted by WNS by 2018 (Fig. 3). The predictive map was not made for Canada but similar hibernacula conditions in Canada would suggest similar potential for WNS as shown in the U.S. map (Fig. 3).

c) Potential for refugia and rescue effect

There is no expectation of a rescue effect. The Tri-colored Bat in Canada is at the northern edge of its geographic range (Fig. 1) and therefore any rescue would need to come from southern populations in the United States. The high mortality rates associated with WNS have occurred in the regions south of Canada and populations are so reduced that immigration north into Canada is very unlikely.

Southern regions in the United States, where it is warmer and bats need fewer lipid reserves, may not be susceptible to WNS (Fig. 3). However, *Gd* spores have been recorded in soil in hibernacula (Lindner *et al*. 2011) and it is likely that any populations expanding northward would be impacted by WNS when they use hibernacula in Canada.

Hope for any recovery of the species is based on the likelihood that some small percentage of the population will be resistant to the effects of *Gd*. These survivors would pass on this resistance to their offspring and populations would increase. It is believed that such a situation occurred in Europe because several species of bats get WNS, but mortality levels are low (Turner *et al*. 2011).

There is evidence that some individuals exposed to WNS can survive, based on laboratory (Meteyer *et al*. 2011) and banding studies (Dobony **et al**. 2011). In the Dobony study, in Fort Drum, New York, a small number (i.e. <20) of Little Brown Myotis were captured in summer showing evidence of WNS-related wing damage and then recaptured the following year. Five females were recaptured after two years, and with lactation noted in some females, there is evidence of possible reproduction in some animals. One cave in New York has had a population of 1,000 bats for 4 continuous years, suggesting stabilization (Turner *et al*. 2011). These results suggest hope for recovery. It is noted, however, that declines at these sites were 88% (Ft. Drum) and 93% (New York) and apparent stability at some hibernacula may be due to movements of uninfected bats from other areas, and that lactation does not mean that pups survived if adults are physiologically stressed (Dobony *et al*. 2011).

Factors related to specific COSEWIC criteria

Generation Time

Generation time in the COSEWIC guidelines is based on the mean age of the breeding population. The mean age is not known but wild Tri-colored Bat start breeding after one year of age, continue breeding annually and have been recorded to live over 15 years (Walley and Jarvis 1971). The mean age of breeding animals likely is near 9 years for Tri-colored Bat.

However, data from 22 years of banding of Little Brown Myotis in Manitoba were analyzed for this report by Craig Willis and he recommends a shorter generation period. Dr. Willis writes: “based on our data 5 years would be a very generous average. Over the 22 year period, folks have been collecting banding data in Manitoba and NW Ontario, the mean ± SD from capture (before 2000) to last recapture is 3.04 ± 2.85 years (n = 1,386 recaptures between 1989 and 2011). In other words, after about 3 years on average, they disappear. We occasionally get a bat or two close to 20 but they are exceedingly rare.” (Craig Willis, pers. comm. January 2012). Similar conclusions on generation time could not be found in the literature and the results from Manitoba constitute a single study; however, the sample size is robust and suggests that the generation time is likely less than 10 years for this species. As a compromise, generation time in this report is given as a range of 3-9 years.

COSEWIC criteria use 3 generations, thus the time period over which declines must be calculated is 9-27 years for Tri-colored Bat.

Limits of census data

Pre-WNS data on Tri-colored Bat in Canada are limited to distribution and relative abundance, and locations of hibernacula. Overwintering sites are critical to bat survival, but we only know a small number of hibernacula that contain wintering populations of bats and the number of bats within these caves. Several COSEWIC criteria rely on population trend information. Estimates on the number or percent of bat mortality in Canada are severely limited because of little survey effort. In addition, bats are inherently difficult to survey.

Systematic acoustic surveys of summer bat activity levels have begun in some jurisdictions, but it is unclear if some areas had already been impacted by WNS before the survey. In the end, however, the lack of summer acoustic data should not preclude an emergency assessment because WNS is already present across most of the species’ range and population declines that occurred in the U.S. will likely occur in Canada, if they have not already.

Threat and number of locations

The Tri-colored Bat population in Canada would comprise a single location because the fungus is an invasive, exotic pathogen impacting a naive population. Hibernacula conditions are similar across the range of Tri-colored Bat and mortality rates are predicted to be the same for the entire population. WNS impacts *Myotis* and *Perimyotis* species (Turner *et al*. 2011) and since the genetic variation between species of *Myotis* and *Perimyotis* is greater than variation within the Perimyotid Tri-colored Bat, it is unlikely that any genetic-based differences in the Canadian population would provide resistance.

Designatable units

Tri-colored Bat in Canada comprise a single designatable unit. There is a possibility that Tri-colored Bat in Nova Scotia are disjunct (Broders *et al*. 2003) and warrant subspecies status because of morphometric differences (Broders and Hunyh, unpub. data). However, this work has not been published and a single DU is presently recognized.

Acknowledgements

This overview was written with input from numerous people involved with bats and White-nose Syndrome in North America, and was, in part facilitated by discussion during the recent North American Bat Research Conference in Toronto (October 2011). The author wishes to thank everyone and, in particular, to Al Hicks, Lesley Hale, Simon Dodsworth, Jeremy Coleman, Krishna Gifford, Brock Fenton, Mark Brigham, Hugh Broders, Jeff Bowman, Mark Elderkin, Justina Ray, Don McAlpine, Karen Vanderwolf, Carl Herzog, Rick Reynolds, Craig Stihler, Calvin Butchkowski, Eric Britzke, Emily Brunkhurst, Erin Fraser, Julien Mainguy, Tom Hallam.

The report was reviewed by bat and WNS specialists Jeremy Coleman, Brock Fenton, Mark Brigham, Ian Barker, Hugh Broders, and Craig Willis, as well as members of the COSEWIC Terrestrial Mammals Subcommittee and the Emergency Assessment on Bats Subcommittee.

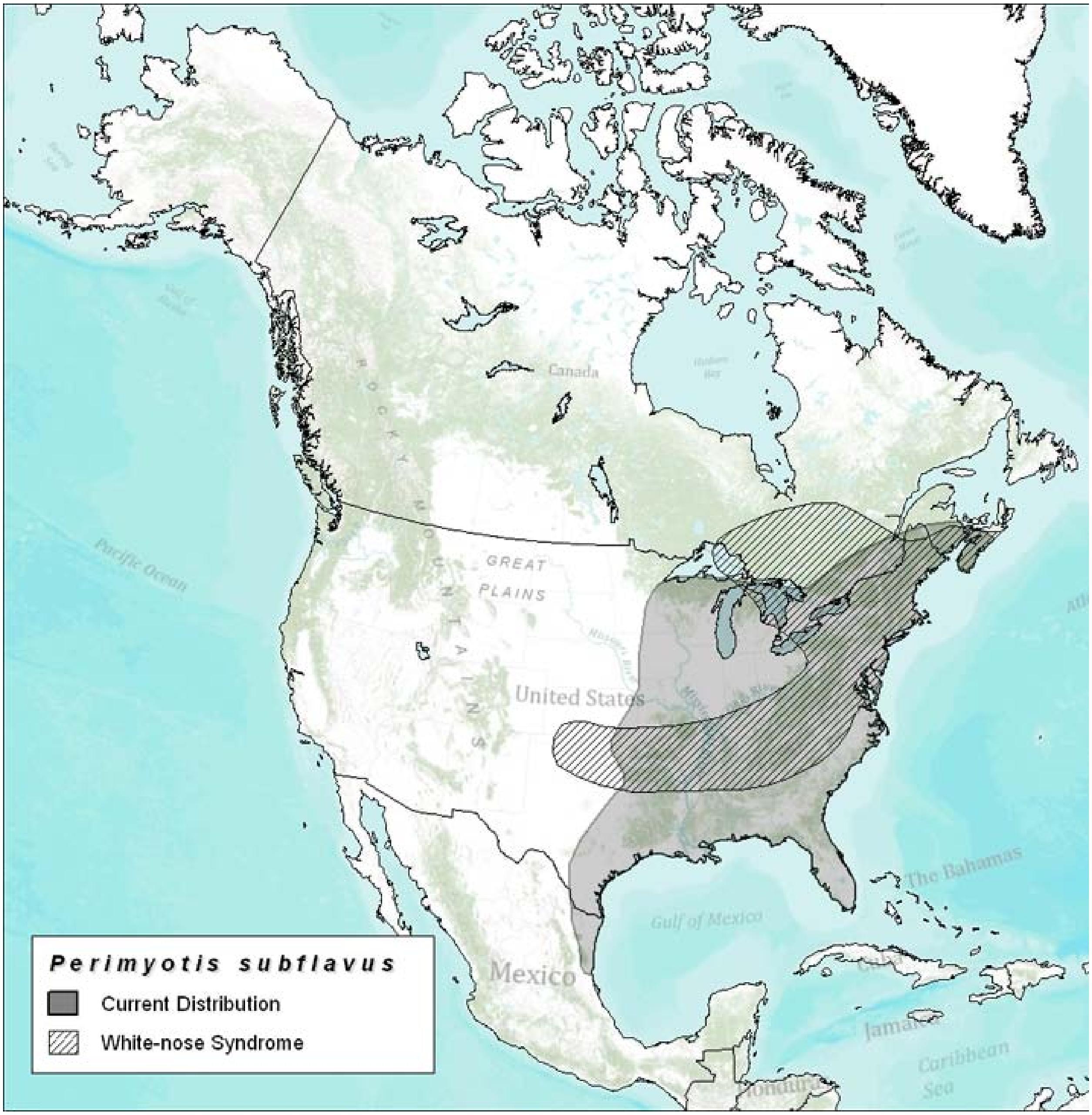

Figure 1. Approximate distribution of the Tri-colored Bat and White-nose Syndrome, as of October 2011. Distribution based on Van Zyll de Jong (1985) and National Wildlife Health Centre; http://www.nwhc.usgs.gov/disease _ information/white-nose_syndrome/) (Map created by J. Wu, COSEWIC Secretariat).

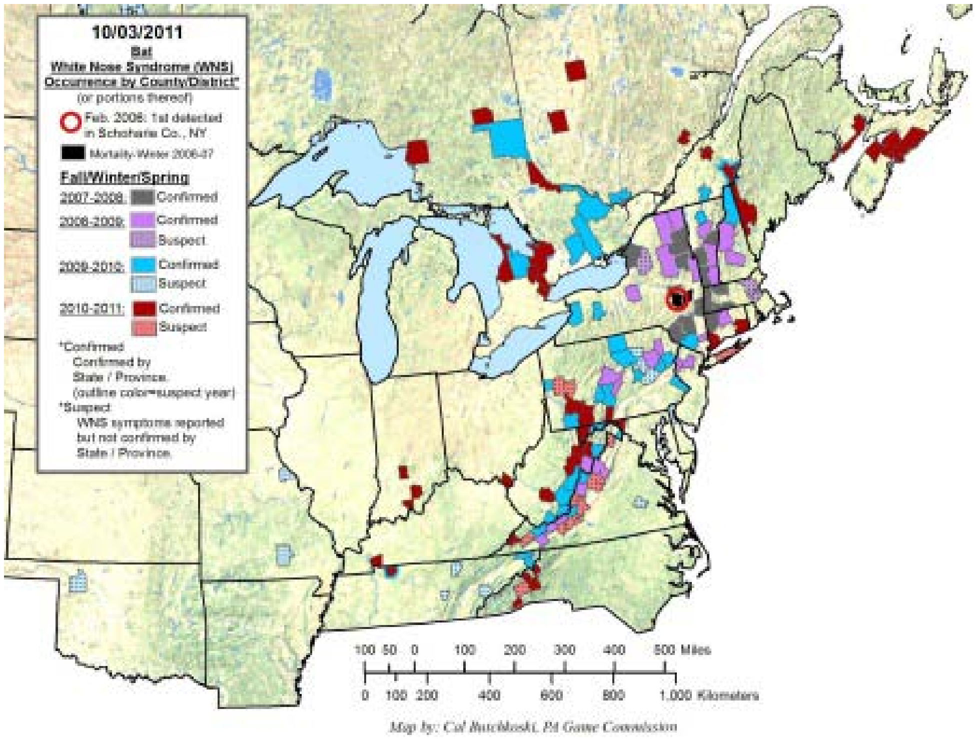

Figure 2. Location of confirmed and suspected cases of White-nose Syndrome in North America as of October 2011. First record was in Albany, New York (shown as a circle) in 2006. The suspected case in Oklahoma is >2000km from epicentre. Source: National Wildlife Health Centre; http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/.

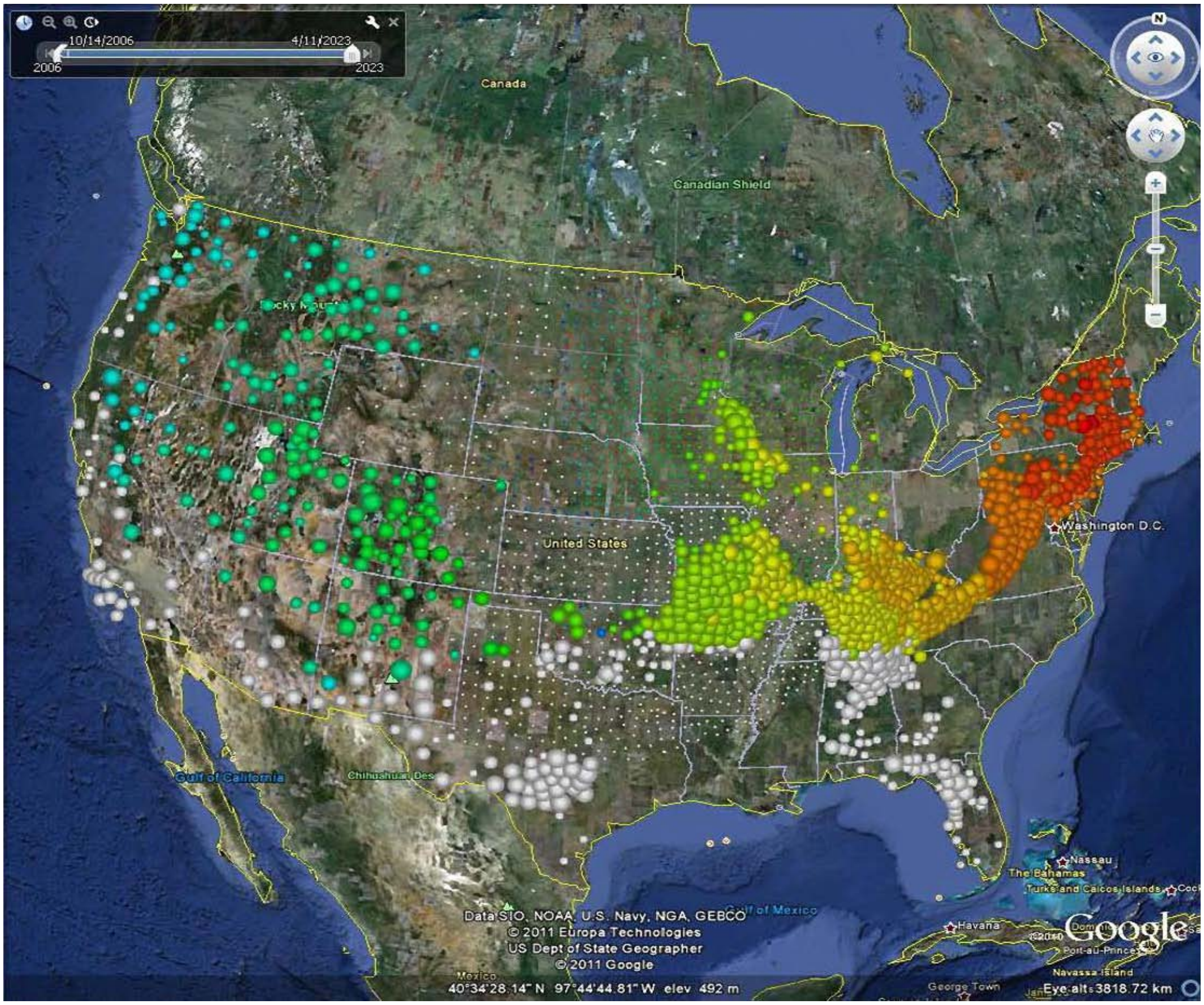

Figure 3. Baseline simulation of the epizootic dispersal based on minimum and maximum temperatures in hibernacula and lipid reserves in Little Brown Myotis. The projected epizootic wave throughout the U.S. study area as determined by 1000 simulations. The dynamic evolution of the epizootic wave of *Gd*-affected hibernacula for the stochastic resolution of the suite of 1000 simulations is indicated. The projected years of the *Gd*-affection occur according to the colour scheme: red shades, 2007-08; dark orange shades, 2008-09; light orange shades, 2009-10; yellow shades, 2010-11; light green shades, 2011-12; medium green shades, 2012-13; darker green shades starting in Oklahoma, 2013-14; additional dark green shades, 2014-15; light blue shades, 2015-2016; dark blue, 2016-17; purple, 2017-2018. White represents caves that are unaffected during the 15-year simulation. The size of the circle is indicative of the size of the colony in the cave. Image was created from Google Earth. Map supplied by Tom Hallam (University of Tennessee, Knoxville) in association with publication: Hallam and Federico (2011).

Table 1. Change in Tri-colored Bat (*Perimyotis subflavus*) population counts at winter hibernacula with a minimum of 2 years exposure to White-nose Syndrome in 5 states of the northeastern United States. Adapted from Turner *et al.* (2011).

State (# sites)	Pre-WNS #	# >2 yrs Post-WNS	% Difference	# Sites to 0 bats
New York (20)	1042	47	-95	9
Pennsylvania (6)	284	28	-90	2
Vermont (5)	15	8	-47	2
Virginia (2)	746	627	-16	0
West Virginia (3)	1020	73	-93	0
Totals (36)	**3107**	**783**	**-76**	**13**

Table 2. Changes in abundance estimates for bats using hibernacula (caves or mines) in Ontario. The majority of bats are Little Brown Myotis, but sites also include Northern Myotis and Tri-colored Bat. Average decline is 90% in sites with >2 years of post-WNS exposure. Information courtesy of Ontario Ministry of Natural Resources.

Site Name	Individuals Counted and Date Count Completed			Percent Change 2009 to 2010	Percent Change 2010 to 2011	Total Percent Change
	2009	2010	2011			
Craigmont	30,461 November 2, 2009	24,837 November 1, 2010	1,457 October 24, 2011	-18%	-94%	-95%
Hunt (Renfrew)	14,378 October 20, 2009	7,005 November 7, 2010	2,638 November 5, 2011	-51%	-62%	-82%
Crystal Lake	725 Fall? 2009	539 November 29, 2010	10 November 4, 2011	-26%	-98%	-99%
Croft*	N/A	3000+ October 2, 2010	1,537 November 4, 2011	N/A	-49%+	-49%+
Silver Crater	N/A	251 November 29, 2010	29 November 4, 2011	N/A	-89%	-89%
MacDonald	N/A	21 November 23, 2010	0 November 4, 2011	N/A	-100%	-100%
Watson	N/A	96 November 23, 2010	0 November 4, 2011	N/A	-100%	-100%
Clyde Forks	N/A	117 November 30, 2010	7 November 2, 2011	N/A	-94%	-94%

*Croft population estimate in 2010 was only completed in a portion of the mine (approximately 50% chamber length counted)

Notes:

1. All sites are known to be infected with *Geomyces destructans* either through lab testing or visual observation. Abundant mortality has not been documented at any of the sites although small numbers have been recorded. None of these sites are monitored frequently enough in the winter to observe abundant mortality episodes; however, a notable decline in population is evident at all sites.

2. WNS was first visually observed in Craigmont Mine during the 2008-2009 season. It was documented during a site visit May 6, 2011. The 2009 population estimate is indicative of the pre-population estimates periodically recorded at Craigmont and Hunt Mines. WNS was confirmed by CCWHC through lab results in Craigmont and Hunt Mine in 2009-2010 season.

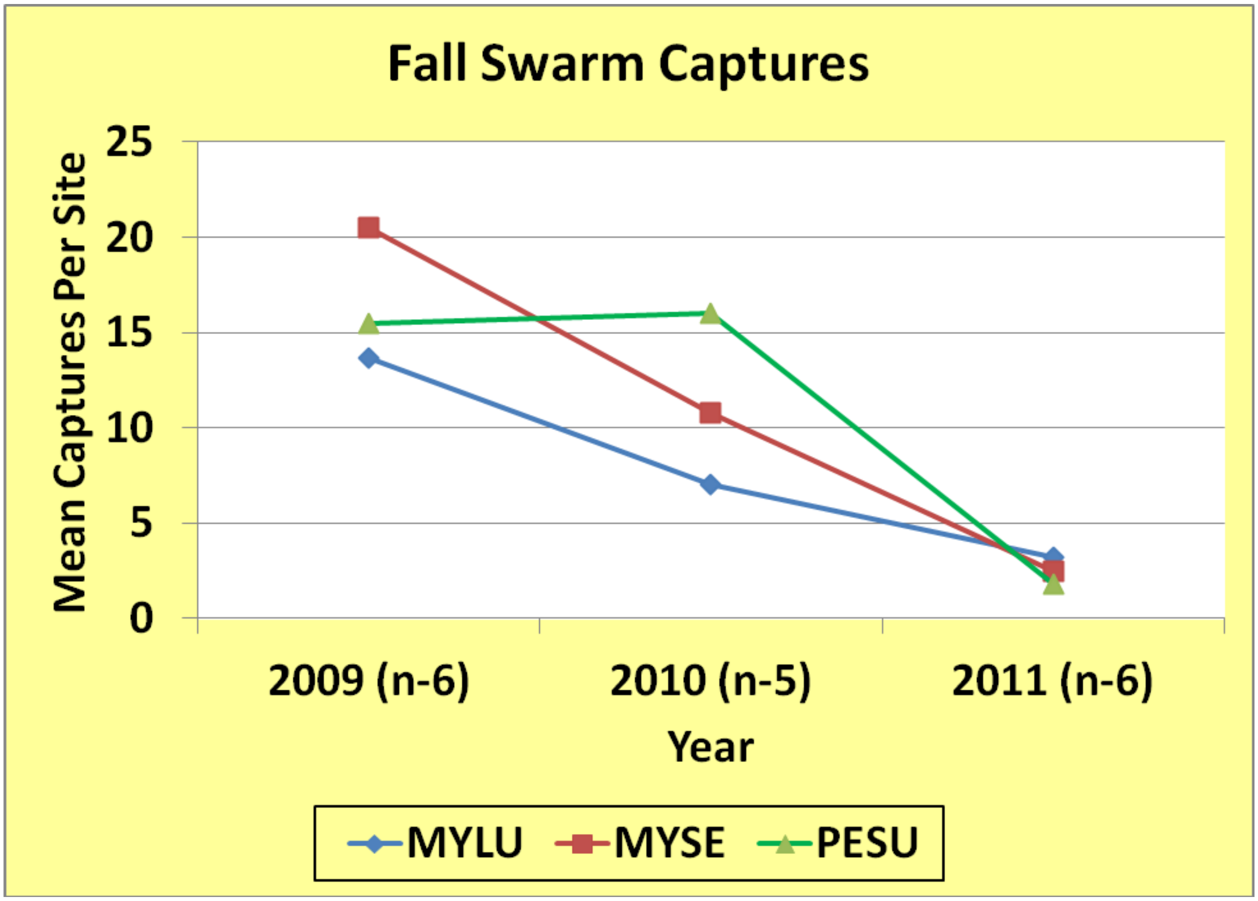

Figure 4. Fall swarm captures in Virginia. Work was predominately conducted in September and early October. MYLU = *Myotis lucifugus*, MYSE = *Myotis septentrionalis*, PESU = *Perimyotis subflavus*. The values within brackets (i.e. 'n-6') refer to number of sites sampled. (Figure courtesy of Rick Reynolds, Virginia State Biologist.)

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