MANAGEMENT PLAN FOR THE EASTERN WOOD-PEWEE *(CONTOPUS VIRENS)* IN NOVA SCOTIA

A report prepared by the Nova Scotia Department of Natural Resources and Renewables

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Cover illustration: Adult Eastern wood-pewee on dead wood. Photographer: Logan Lalonde

PREFACE

Eastern Wood-pewee was assessed as Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2012 and listed under Schedule 1 of the *Species at Risk Act* (S.C. 2002, c. 29) in 2017. The species was listed as Vulnerable under Nova Scotia's *Endangered Species Act* in 2013. The International Union for the Conservation of Nature (IUCN) Red List ranks the Eastern Wood-Pewee as Least Concern. The Eastern Wood-pewee is also protected under the *Migratory Birds Convention Act* in Canada.

Under the *Nova Scotia Endangered Species Act (2007)*, a Management Plan must be prepared for Vulnerable species and is defined as "…*a statement of needs and actions to be undertaken to keep a vulnerable species from becoming at increased risk.*"

This Management Plan borrows heavily from existing literature, primarily the draft *Management Plan for the Eastern Wood-Pewee (Contopus virens) in Canada* (Environment and Climate Change Canada 2020) and the *COSEWIC assessment and status report on the Eastern Wood-pewee Contopus virens in Canada* (COSEWIC 2012). The objectives and actions identified in this Management Plan are based upon the best available information on the species and is subject to modifications and/or revisions as new information becomes available. Management of Vulnerable species at risk is a shared responsibility and the collaborative approach emphasized in this document is reflective of this.

Implementation of the actions and approaches identified in this plan are subject to budget constraints, appropriations, and changing priorities.

ACKNOWLEDGEMENTS

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- Dr. John Brazner
- James Churchill
- Dr. Lisa Doucette
- Dr. Tara Imlay
- Kathy St. Laurent
- Dr. Laura Tranquilla

The Nova Scotia Department of Natural Resources and Renewables would like to thank these individuals for their contributions to the recovery of species at risk in Nova Scotia.

EXECUTIVE SUMMARY

The Eastern Wood-pewee is a medium-sized flycatcher with olive-grey plumage and a distinctive peaked crown which gives the head a triangular shape. The Eastern Wood-pewee can be distinguished from other similar looking species by its distinctive “pee-a-wee” song. The species breeds throughout eastern and central North America, and winters in the tropical forests of Central and South America. The Eastern Wood-pewee is an aerial insectivore and inhabits intermediate and mature mixed or deciduous forests, with canopy opening that allows for foraging. The species was assessed by the Committee on the Status of Endangered Wildlife in Canada as Special Concern, and is listed as Vulnerable and Special Concern under Nova Scotia’s *Endangered Species Act* and the federal *Species at Risk Act*, respectively.

Threats to the Eastern Wood-pewee are not well understood. As with other aerial insectivores, declines in Eastern Wood-pewee are likely the result of changes to insect prey emergence timing, abundance, and quality. In Nova Scotia, loss of habitat resulting from incompatible forestry practices may be a concern but recent changes resulting from the Forest Practices Review may lessen the severity of this threat. Climate change has the potential to alter forest habitat structure, prevalence of forest pests, and abundance and diversity of insect prey, but the overall impact to Eastern Wood-pewee is presently unknown.

The management objective for the Eastern Wood-pewee in Nova Scotia is to maintain a stable or increasing population of Eastern Wood-pewee across its range in Nova Scotia by 2036, assessed through population trend data. Management actions include the establishment of a monitoring program to assess species abundance and distribution, the development of programs on Crown and private lands to support the conservation and management of habitat and supporting research initiatives at the local and national level to address threats impacting aerial insectivores in general.

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Assessment Summary: November 2013

Common Name: Eastern Wood-pewee

Scientific Name: *Contopus virens*

Status: Special Concern (COSEWIC), Vulnerable (NSSARWG)

Reason for Designation: This species is one of the most common and widespread songbirds associated with North America's eastern forests. While the species is apparently resilient to many kinds of habitat changes, like most other long-distance migrants that specialize on a diet of flying insects, it has experienced persistent declines over the past 40 years both in Canada and the United States. The 10-year rate of decline (25%) comes close to satisfying the criteria for Threatened. The causes of the decline are not understood, but might be linked to habitat loss or degradation on its wintering grounds in South America or changes in availability of insect prey. If the population declines continue to persist, the species may become Threatened in the foreseeable future.

Occurrence: Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, Nova Scotia

Status History: Designated Special Concern in November 2012 in Canada and as Vulnerable in Nova Scotia in 2013.

* The following definitions are applicable in this section and elsewhere: NSSARWG (Nova Scotia Species at Risk Working Group); COSEWIC (Committee on the Status of Endangered Wildlife in Canada); NSESA (Nova Scotia Endangered Species Act); SARA (Species at Risk Act).

2. SPECIES STATUS INFORMATION

The Eastern Wood-pewee is considered globally secure (G5), with the breeding and migratory population secure in Canada (N5B, N5M). In 2004, the IUCN Red List classified the species as Least Concern (BirdLife International 2016). At the provincial level, the species has a rarity rank between Vulnerable or Apparently Secure (Table 1).

In Canada, the species was assessed as Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2012 and listed as Special Concern under Schedule 1 of the Species at Risk Act (S.C. 2002, c. 29) in 2017. The Eastern Wood-pewee is protected under the *Migratory Birds Convention Act*, 1994, which protects individuals of the species as well as its nest and eggs on federal and non-federal lands. Eastern Wood-pewee has been listed as Vulnerable under Nova Scotia's *Endangered Species Act* (NSESA) since 2013.

Table 1. NatureServe conservation status ranks for the Eastern Wood-pewee in Canada (NatureServe 2019).*

Global (G) Rank[a]	National (N) Rank[b]	Subnational (S) Rank[c]
G5	N5B, N5M	S3 – Manitoba S4B, S4M - New Brunswick S3S4B - Nova Scotia S4B - Ontario S3B - Prince Edward Island S3B - Quebec S4B - Saskatchewan

[a] G-Rank – Global Conservation Status Rank, G1 = Critically Imperiled; G2 = Imperiled; G3 = Vulnerable; G4 = Apparently Secure; G5 = Secure
[b] N-Rank – Provide ranking for each province the species is found in. National Conservation Status Rank, N1 = Critically Imperiled; N2 = Imperiled; N3 = Vulnerable; N4 = Apparently Secure; N5 = Secure
[c] S-Rank – Sub-national (provincial or territorial) ranks, S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently Secure; and S5 = Secure. B = breeding; and U = Unrankable.
*A full list of definitions can be found in Definitions of NatureServe Conservation Status Rankings at http://help.natureserve.org/biotics/Content/Record_Management/Element_Files/Element_Tracking/ETRACK_Definitions_of_Heritage_Conservation_Status_Ranks.htm

3. SPECIES INFORMATION

3.1. Species Description

The Eastern Wood-pewee is a medium-sized flycatcher weighing between 10-19 grams. Adults have olive-grey plumage and a pale breast, belly, and white wing-bars, with a distinctive peaked crown which gives the head a triangular shape. Juvenile plumage is darker and browner with buffy underparts. The species lacks a prominent eye ring, which helps distinguish them from the similar looking Acadian flycatcher (*Empidonax virescens*) (Watt et al. 2020). In Nova Scotia, the species can possibly be confused with Alder flycatcher (*Empidonax alnorum*), Willow flycatcher (*Empidonax traillii*), Least flycatcher (*Empidonax minimus*), or possibly Olive-sided flycatcher (*Contopus cooperi*), but identification on breeding grounds is primarily by the Eastern Wood-pewee's distinctive "pee-a-wee" song (J. Churchill, pers. comm). Like other flycatchers, the Eastern Wood-pewee forages on flying insects by hawking or sallying[1] (Watt et al. 2020).

[1] Hawking refers to the searching and capturing of prey in flight; sallying refers to searching for prey from a perched position prior to flying out and capturing. Source: Fitzpatrick 1980.

3.2. Population and Distribution

Global Distribution

The Eastern Wood-pewee breeds throughout central and eastern North America, with a range extending from southeastern Saskatchewan to southern Texas, and east to Florida and the Atlantic Coast northwards to the Canadian Maritime Provinces (Figure 1) (Watt et al. 2017 *in* Environment and Climate Change Canada 2020).

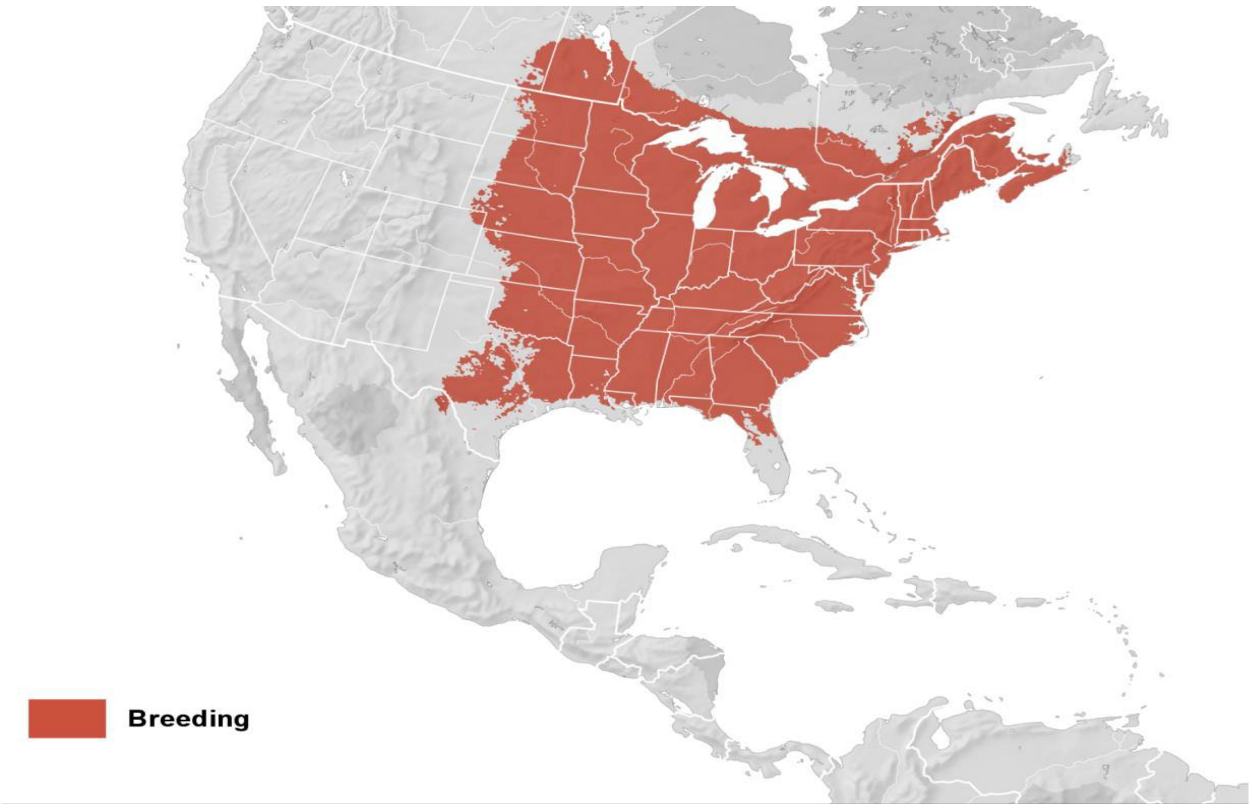


Figure 1. Breeding range boundaries based on eBird data from 2014-2018. Modified from Fink et al. (2020). Reproduced from the federal draft strategy for Eastern Wood-pewee in Canada (Environment and Climate Change Canada 2020).

The Eastern Wood-pewee migrates through eastern and central U.S. Central America, as well as across the Caribbean. Eastern Wood-pewee winter primarily in the tropical forests of Central America and northwestern South America, from the Amazonian forest in Brazil to the Andes in Colombia, Ecuador, Peru, and Bolivia (Figure 2) (Watt et al. 2017 *in* Environment and Climate Change Canada 2020).

Figure 2. Non-breeding range boundaries based on eBird data from 2014-2018. Modified from Fink et al. (2020). Reproduced from the federal draft strategy for Eastern Wood-pewee in Canada (Environment and Climate Change Canada 2020).

Canadian Range

In Canada, the species breeds in south-central and southeastern Canada, along the southern areas of Saskatchewan, Manitoba, Ontario, and Quebec, and throughout New Brunswick, Prince Edward Island, and Nova Scotia (COSEWIC 2012). The Boreal Avian Monitoring (BAM) Project used data from the Breeding Bird Survey (BBS), Atlases, and other sources to model density and population estimates for species at the national and regional scale. Although there are limits to their model predictions (due to regional differences and scale), their model predicted that the highest densities of Eastern Wood-pewee are found in southwestern Ontario and southern Quebec (Figure 3).

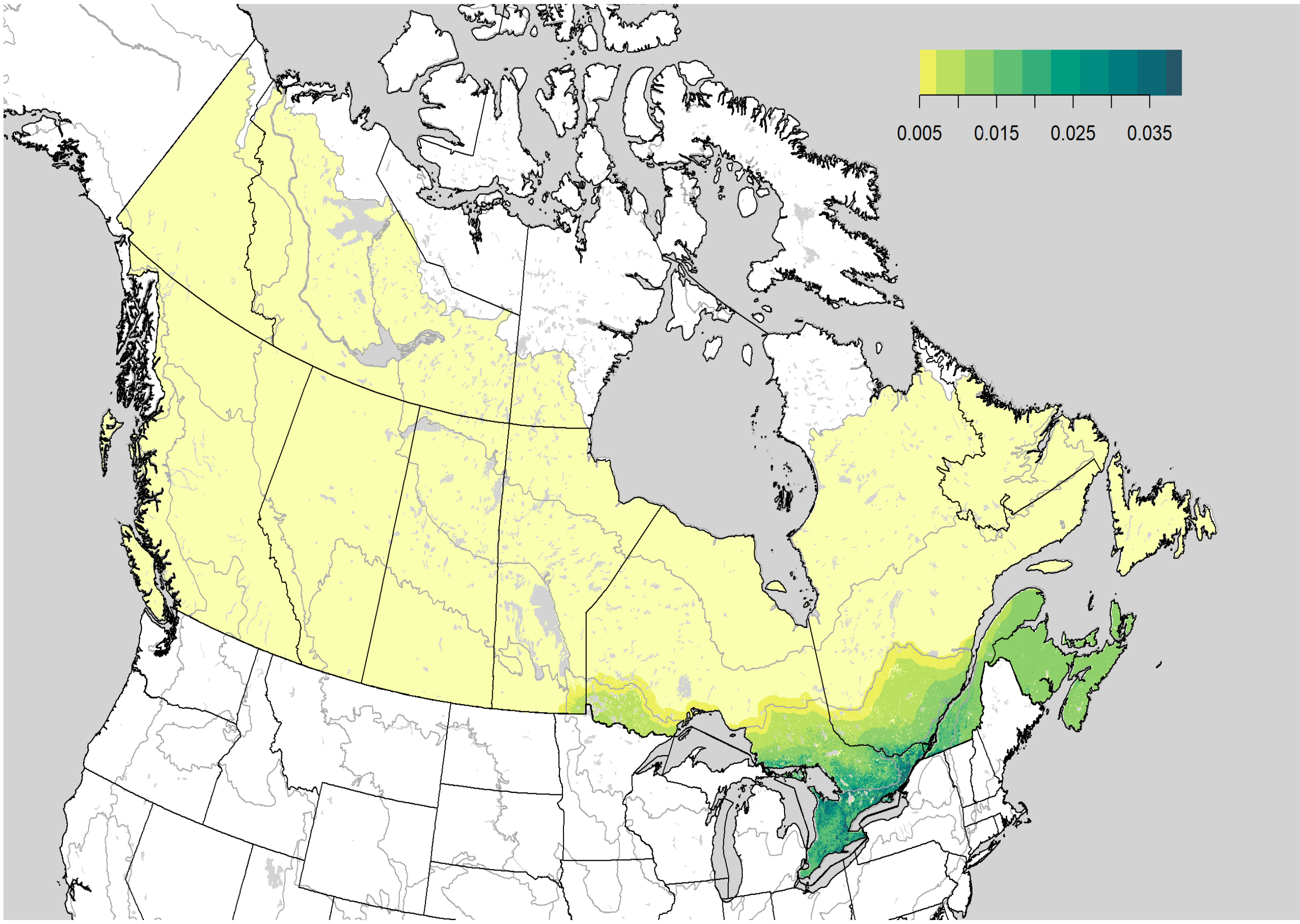


Figure 3. Predicted average density of Eastern Wood-pewee males/ha from combined modelled data for Bird Conservation Regions within Canada. Source: Boreal Avian Modelling Group 2020.

Nova Scotia Range

Eastern Wood-pewee is widely distributed throughout Nova Scotia. The most recent Maritime Breeding Bird Atlas (2006-2010) refers to the species as not being abundant, with larger concentrations in the Valley and Central lowlands ecoregion, as well as the southwestern areas of the province. It is rare for the highlands of Cape Breton, likely due to the presence of more black spruce and fir dominant forests that are incompatible with habitat requirements of the species (Figure 4).

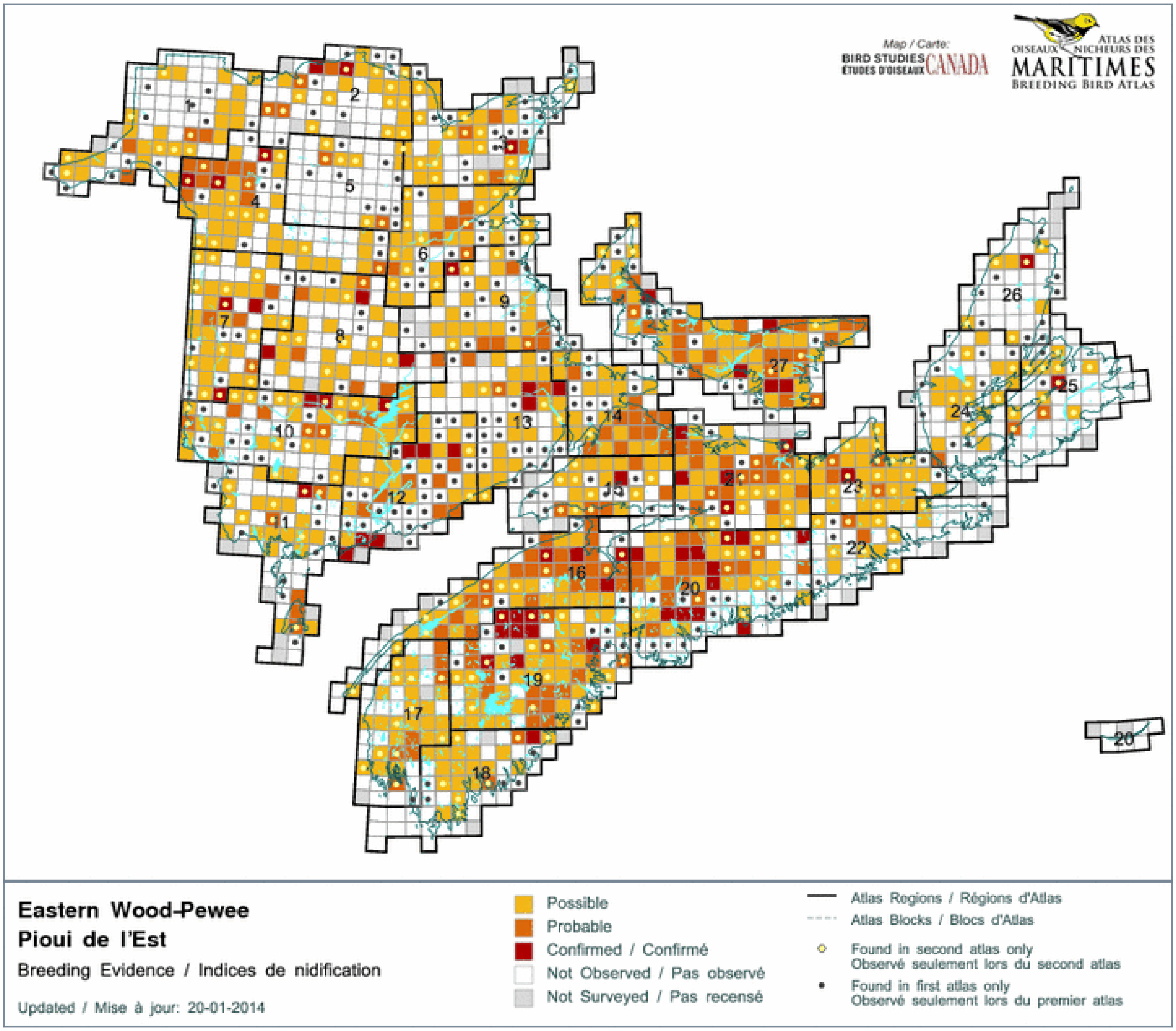


Figure 4. Maritime Breeding Bird Atlas data (2006-2010) showing distribution of possible, probable, and confirmed breeding of Eastern Wood-pewee in New Brunswick, Prince Edward Island, and Nova Scotia.

Population Size and Trends

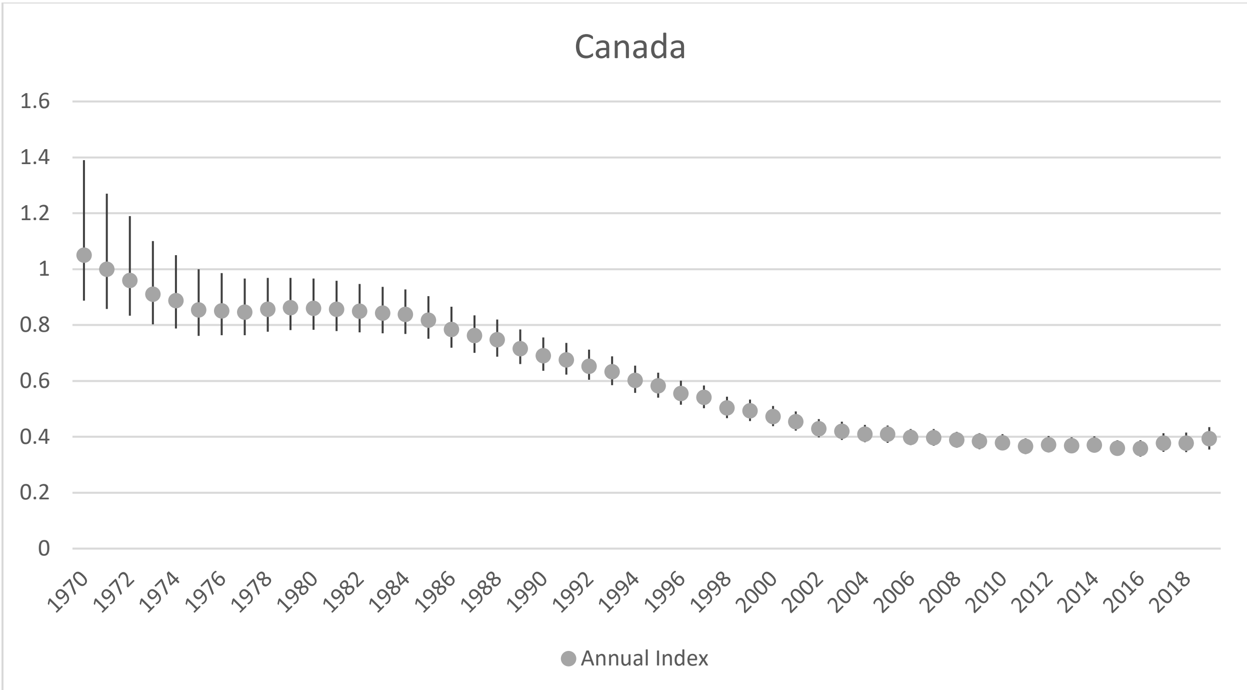
The global Eastern Wood-pewee population is estimated at 6.5 million birds (95% confidence intervals [CI]: 5.9-7.0 million); 360,000 individuals, or 5.5% of the total global population, breeds in Canada (Partners in Flight 2019). Canadian Breeding Bird Survey (BBS) data shows a 63% decline in the population since 1970 (95% CI: -72.3; -54.8), with a 2.01% annual population decline (95% CI: -2.59; -1.16) for the 1970-2019 period. The most recent estimates (2007-2019) show the Canadian population declined 0.856% annually (95% CI -9.26; 12.2; Smith et al. 2020). Declines have slowed since the 2012

COSEWIC assessment when the annual long-term trend (1970 to 2011) was -2.9% per year and the short-term trend (2001 to 2011) was -2.8% per year (COSEWIC 2012). The degree of decline varies across the Canadian range; New Brunswick and Manitoba show the sharpest short- and long-term declines, with Nova Scotia/Prince Edward Island showing the slowest rates (Table 2; Figure 5). Combined Nova Scotia/Prince Edward Island BBS results show a -0.652% annual population decline (95% CI: -1.3; -0.03) for the 1970-2019 period and a 1.38% increase (95% CI: -1.09; 3.9; Smith et al. 2020) for the most recent 10-year period (2007-2019).

Table 2. National and provincial annual percent population change (including 95% Confidence Intervals for the Eastern Wood-Pewee in Canada over the long and short terms, based on North American Breeding Bird Survey results.

Geographic area	Long-term Trend (1970-2019)				Short-term Trend (2007–2019)			
	%/year	Lower CI	Upper CI	Overall reliability**	%/year	Lower CI	Upper CI	Overall reliability**
Canada	-2.01	-2.59	-1.61	High	0.085	-0.967	1.15	High
Manitoba	-3.17	-4.98	-1.72	High	-2.72	-5.39	0.01	Medium
New Brunswick	-3.18	-4.02	-2.37	High	-0.995	-4.55	2.66	Medium
Nova Scotia and Prince Edward Island*	-0.652	-1.3	-0.03	High	1.38	-1.09	3.9	Medium
Ontario	-1.57	-2.03	-1.11	High	0.126	-1.34	1.62	High
Quebec	-2.29	-3.04	-1.51	High	1.76	-0.654	4.37	Medium

* Nova Scotia and Prince Edward Island each have sample sizes too small to reliably calculate trends for each province, so they are pooled together for BBS survey results. Source: Smith et al. 2020.
**This category combines three independent measures of the estimate trend to arrive at an overall ranking of reliability of the estimate. These are: the proportion of species range covered by the BBS (geographic range); proportion of data from region and time series contributing to the estimate (local data weight); and the width of the 95% CI (precision). A full definition and explanation for how these measures contribute to the determination of overall reliability can be found here: https://wildlife-species.canada.ca/breeding-bird-survey-results/P004/A002/?lang=e&m=s&r=EAWP&p=-



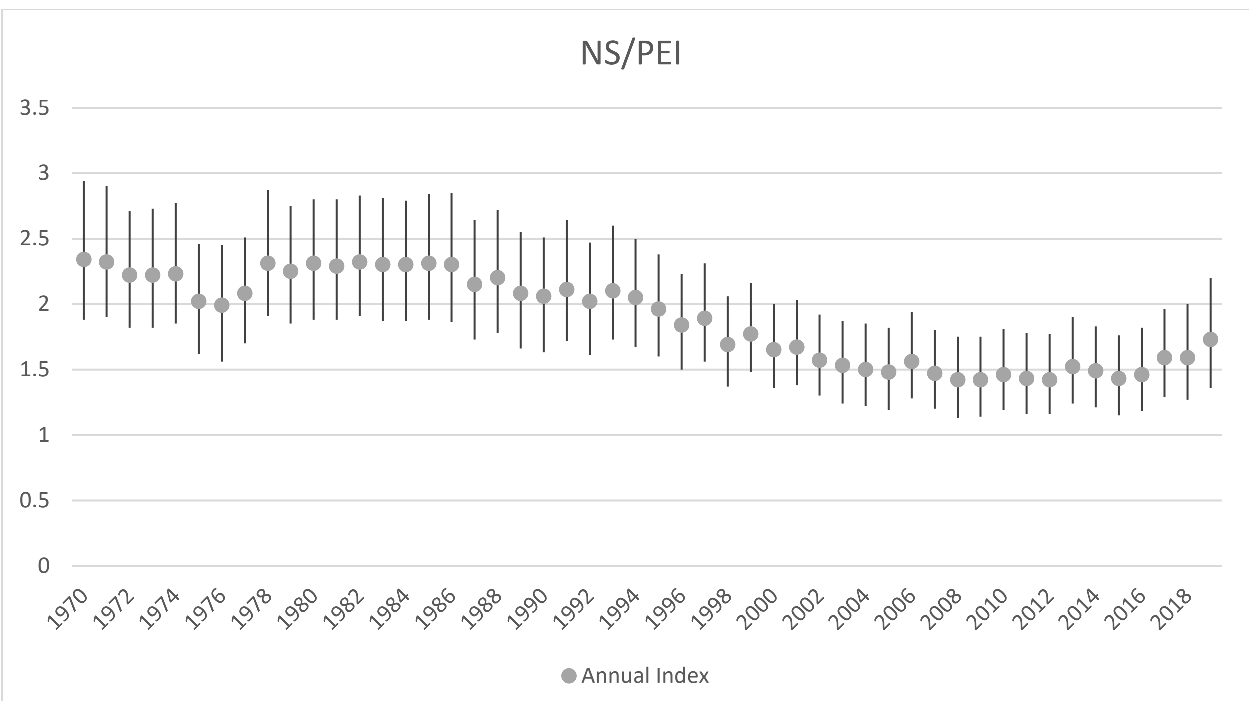


Figure 4. Eastern Wood-pewee population trends nationally and for NS/PEI based on the North American Breeding Bird Survey annual indices. Annual indices show mean bird counts for an average route and as such are proxies for density. Source: Smith et al. 2020.

The Maritimes Breeding Bird Atlas shows that between the first atlas in 1986-1990 and the second in 2006-2010, the Eastern Wood-pewee's distribution across the Maritimes has remained stable but their abundance has declined (Stewart et al. 2015).

3.3. Species Needs

Diet

The Eastern Wood-pewee forages by hawking or sallying (Fitzpatrick 1980, Hartung and Brawn 2005, Watt et al. 2020). Their diet consists of small flying insects such as flies, beetles, butterflies, grasshoppers, and wasps (Watt et al. 2020) and can also include the non-flying larval stage of these species (Sample et al. 1993). The diet of just-hatched nestlings is primarily composed of non-flying insects such as spiders, grasshoppers, and caterpillars (Watt et al. 2020). The Eastern Wood-pewee forages in the lower 15 m of the forest canopy and may avoid the understory shrub layer if it is too dense (Hartung and Brawn 2005, McCracken 2008).

Breeding Habitat

In Canada, breeding habitat for the Eastern Wood-pewee is predominantly deciduous and mixed forests (less commonly conifer-dominant) at intermediate and mature age classes with an open understory (Burke et al. 2011, Watt et al. 2020). This is consistent with information from the Maritimes which found associations with older, deciduous-dominant forest types, with some presence of hemlock and pine, as well as a weak association with riparian areas (Stewart et al. 2015). Within fragmented landscapes the species is more likely to occur in larger forest fragments (Keller and Yahner 2007). Eastern Wood-pewee preferentially inhabits open forest with a high canopy or forested areas associated with clearings and edges (Hespenheide 1971, Conner et al. 2004, and Reidy et al. 2014 *in* Environment and Climate Change 2020), likely a function of these habitats providing increased foraging opportunities. The species generally avoids young coniferous and managed forests as well as human-occupied areas (Stewart et al. 2015).

Studies show conflicting habitat use patterns for the Eastern Wood-pewee with respect to managed versus unmanaged forests. In a study from southern Ontario, Falconer and Nol (2020) found that although the Eastern Wood-pewee used both natural deciduous forests and pine plantations equally, lower nest success rates were present in pine plantations compared to natural deciduous forests; the authors of the study attributed this to an increase in the number of naturally occurring predators in one stand type versus the other. In comparison, a study in Ohio found that the species preferred harvested oak forests to natural oak forests (Newell and Rodewald 2012). Recent work by Brazner and MacKinnon (2020) found that in Nova Scotia the species is not strongly associated with regenerating forests. In Nova Scotia, both deciduous and mixed treed swamps and mature upland forests are considered important habitat for Eastern Wood-pewee (Brazner and MacKinnon 2020); use of mature upland habitat is consistent with other regional studies on habitat use (Stewart et al. 2015). Differences in preferences for harvested and unharvested forests are likely related to the availability of open foraging habitat. Eastern Wood-pewee also seem to prefer dry upland areas over lowlands, but again, this preference is likely driven by the amount of open foraging area available in each habitat type (COSEWIC 2012).

Eastern Wood-pewees build their nests on horizontal branches in areas of low visibility and away from tree trunks, likely to minimize predation (Kendrick et al. 2013). Both adults feed the nestlings (Kendrick et al. 2014). A study from Missouri found predation to be the most common cause of nest failure (96%) (Kendrick et al. 2013), and only 28-43% of nests successfully fledge offspring (Knutson et al. 2004, Falconer 2010). Renesting can occur regardless of the cause of nest failure if there is sufficient time available in the breeding season (Newell et al. 2013, Kendrick et al. 2014).

Migration and Wintering Habitats

Migration and wintering habitat requirements are similar to that used during the breeding season. The Eastern Wood-pewee uses a variety of habitat types during migration, including clearings and early-successional forests, forest edge, lowland tropical forest, scrub forest, and cloud forest, which includes both dry and wet forest types (see COSEWIC 2012 for a full description of habitat types and references). On their winter range, Eastern Wood-pewee are found in a variety of younger, denser forest types and forages at edges or clearings (Stotz et al. 1992, Wolfe et al. 2014). Amaya-Espinel and Hostetler (2019) found that forest patch size on migratory and wintering grounds was 10 ha or greater on average, but the species could be found in areas as small as 2 ha.

4. THREATS

4.1. Threat Assessment

The Eastern Wood-Pewee threat assessment is based on the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threat classification system (IUCN 2012). Threats are defined as the proximate activities or processes that have caused, are causing, or may cause in the future destruction, degradation, and/or impairment of the entity being assessed (population, species, community, or ecosystem) in the area of interest (in this case, the province of Nova Scotia). Limiting factors are not considered during this assessment process. For purposes of the threat assessment, only present and future threats are considered. Historical threats, indirect or cumulative effects of the threats, or any other relevant information that would help understand the nature of the threats are presented in Section 4.2.

Table 2**.** Threat calculator assessment.

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
1	Residential & commercial development	Low	Small	Slight	High	
1.1	Housing & urban areas	Low	Low	Low	Low	Habitat fragmentation due to increased urbanization may reduce habitat availability for the species and increase window collisions. Indirect effects include lighting, noise, and pollution.
1.2	Commercial & industrial areas	Low	Small	Slight	High	Habitat fragmentation due to increased commercial and industrial use may reduce habitat availability for the species as well as reduce abundance in the immediate vicinity and surrounding forests. Increased risk of window collisions due to type of activity and location. Indirect effects include lighting, noise, and pollution.
1.3	Tourism & recreation areas					Not applicable

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
2	Agriculture & aquaculture	Low	Pervasive	Slight	High	
2.1	Annual & perennial non-timber crops	Low	Pervasive	Slight	High	Conversion of forested habitat to unsuitable land use types reduces habitat availability as well as foraging habitat.
2.2	Wood & pulp plantations	Low	Small	Slight	High	Potential decrease in habitat quality, increased predation risk. Potentially creates an ecological trap.
2.3	Livestock farming & ranching	Low	Pervasive	Slight	High	Conversion of forested habitat to unsuitable land use types reduces habitat availability as well as foraging habitat.
2.4	Marine & freshwater aquaculture					Not applicable
3	Energy production & mining	Low	Restricted	Moderate	High	
3.1	Oil & gas drilling					Not applicable
3.2	Mining & quarrying	Low	Restricted	Moderate	High	Habitat loss, fragmentation, conversion, degradation from the mine, lighting, noise, dust, human presence and access, roads, increased road traffic/hauling (accidental mortality).
3.3	Renewable energy	Low	Restricted	Moderate	High	Habitat conversion and fragmentation as well as direct mortality of migratory species associated with wind farms. Increase in the number of wind farms is expected over the next 5-10 years in Nova Scotia.
4	Transportation & service corridors	Negligible	Small	Slight	High	
4.1	Roads & railroads	Negligible	Small	Negligible	High	Habitat loss, fragmentation, and disturbance, as well as direct mortality from vehicle strike. May not be as big of a concern due to either

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
						road avoidance or adaptation (although at a cost of reduced fitness).
4.2	Utility & service lines	Negligible	Negligible	Negligible	High	Increase in number of transmission lines across the landscape tied to expansion of other threats such as residential and commercial development.
4.3	Shipping lanes					Not applicable
4.4	Flight paths					Not applicable
5	Biological resource use	Medium	Large	Moderate	High	
5.1	Hunting & collecting terrestrial animals					Not applicable
5.2	Gathering terrestrial plants					Not applicable
5.3	Logging & wood harvesting	Medium	Large	Moderate	High	Habitat conversion, habitat loss, and fragmentation. Changes to undergrowth density and the availability of mature trees degrade habitat. Impacts may not be as severe depending on silviculture techniques employed.
5.4	Fishing & harvesting aquatic resources					Not applicable
6	Human intrusions & disturbance					
6.1	Recreational activities					Not applicable
6.2	War, civil unrest, & military exercises					Not applicable
6.3	Work & other activities					Not applicable

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
7	Natural system modifications	Medium	Pervasive	Moderate	High	
7.1	Fire & fire suppression	Negligible	Negligible	Negligible	High	Suppression of natural disturbance regime resulting in a reduction in number of natural openings.
7.2	Dams & water management/use					Not applicable
7.3	Other ecosystem modifications	Medium	Pervasive	Moderate	High	Declines in insect prey availability due to agricultural intensification, increased insecticide use, insect habitat loss, and decreased resource diversity.
8	Invasive & other problematic species, genes & diseases	Unknown	Large	Unknown	High	
8.1	Invasive non-native/alien species/diseases	Unknown	Large	Unknown	High	Forest pests such as Hemlock Woolly Adelgid and Emerald Ash Borer which could change the forest structure and result in habitat declines.
8.2	Problematic native species					Not applicable
8.3	Introduced genetic material					Not applicable
8.4	Problematic species/diseases of unknown origin					Not applicable
8.5	Viral/prion-induced diseases					Not applicable
8.6	Diseases of unknown cause					Not applicable
9	Pollution	Unknown	Large	Unknown	High	
9.1	Domestic & urban wastewater					Not applicable
9.2	Industrial & military effluents					Not applicable.

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
9.3	Agricultural & forestry effluents					Not applicable
9.4	Garbage & solid waste					Not applicable
9.5	Air-borne pollutants	Unknown	Large	Unknown	High	Acid raid effects that are both direct (contamination of individual birds, eggshell deformities due to calcium deficiencies) and indirect (changes to abundance/diversity of insect prey).
9.6	Excess energy					Not applicable
10	Geological events					
10.1	Volcanoes					Not applicable
10.2	Earthquakes/tsunamis					Not applicable
10.3	Avalanches/landslides					Not applicable
11	Climate change & severe weather	Unknown	Pervasive	Unknown	High	
11.1	Habitat shifting & alteration	Unknown	Pervasive	Unknown	High	Changes in both tree species composition (habitat structure) as well as range shift over time.
11.2	Droughts					Not applicable
11.3	Temperature extremes	Unknown	Pervasive	Unknown	High	Temperature fluctuations result in insect emergence timing mismatch with arrival of species on breeding grounds.
11.4	Storms & flooding					Not applicable
11.5	Severe / Extreme Weather Events	Unknown	Pervasive	Unknown	High	Severe storms are linked to long-distance migrant songbird declines. Severe weather

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
						events such as high winds can disrupt aerial foraging or temporarily reduce prey availability.
12	Other Threats					

[a] **Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each threat is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: Very High (75% declines), High (40%), Medium (15%), and Low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown); Not Calculated: impact not calculated as threat is outside the assessment timeframe (e.g., timing is insignificant/negligible or low as threat is only considered to be in the past); Negligible: when scope or severity is negligible; Not a Threat: when severity is scored as neutral or potential benefit.

[b] **Scope** – Proportion of the species that can reasonably be expected to be affected by the threat within 10 years. Usually measured as a proportion of the species' population in the area of interest. (Pervasive = 71–100%; Large = 31–70%; Restricted = 11-30%; Small = 1-10%; Negligible < 1%).

[c] **Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within a 10-year or three-generation timeframe. Usually measured as the degree of reduction of the species' population. (Extreme = 71–100%; Serious = 31–70%; Moderate = 11-30%; Slight = 1-10%; Negligible < 1%; Neutral or Potential Benefit ≥ 0%).

[d] **Timing** – High = continuing; Moderate = only in the future (could happen in the short term [< 10 years or 3 generations]) or now suspended (could come back in the short term); Low = only in the future (could happen in the long term) or now suspended (could come back in the long term); Insignificant/Negligible = only in the past and unlikely to return, or no direct effect but limiting.

4.2 Description of Threats

Avian aerial insectivores are experiencing widespread declines more rapidly than any other guild in North America (Nebel et al. 2010). The causes of decline are not well understood and are thought to be related to the quality and quantity of insects as well as prey availability during important biological periods. Additional threats to the Eastern Wood-pewee include habitat loss due to forestry practices and urban development, and climate change. Threats are complex, interconnected, and are not well understood or easily addressed (e.g., IUCN Threat 11. Climate change and severe weather).

Threats to Eastern Wood-pewee are not solely restricted to the breeding grounds. The Monitoring of Avian Productivity and Survival (MAPS) program used capture and banding data from 1992-2006 and showed apparently high adult survival for Eastern Wood-pewee, but lower productivity in comparison to other flycatcher species. In addition, strong negative correlations of adult survival of Eastern Wood-pewee during the non-breeding period (primarily the wintering grounds) was also discovered. DeSante et al. (2015) suggested that "*taken together, these results suggest that some degree of density-dependent population regulation existed, likely effected through competition between young and adult birds on the non-breeding grounds and, possibly, through productivity on the breeding grounds*." Habitat loss on the migratory and wintering grounds may be driving these observations; six of seven Central American countries have less than 50% of forest cover remaining (Redo et al. 2012) and pressure exists to convert tropical Latin American forests to pastureland (Wassenaar et al. 2007). Migratory bottlenecks resulting from decreased habitat amounts can increase competition at these key stopover sites, resulting in lower survival of younger individuals, and can result in lower feeding rates that carry over into lower productivity during the following breeding season (Baker et al. 2004).

Threats associated with migration and wintering grounds are beyond the scope of actions that could be addressed within a provincial management plan for the species but are briefly mentioned in different sections due to their importance.

A description of the major threats to the Eastern Wood-pewee is provided below.

Natural system modifications – Other ecosystem modifications (Medium)

Decline in insect prey availability

Aerial insectivores have shown continuous declines in population size since the 1970s (Nebel et al. 2010, Smith et al. 2015, Michel et al. 2016, Tallamy and Shriver 2021). The temporal and spatial synchrony of the decline among the insectivore guild suggests a common cause. These declines have been more acutely felt since the 1980s, especially for long distance migrants from South America (of which Eastern Wood-pewee is one such species) (Nebel et al. 2010). Long-term insect data is limited but it is speculated that roughly 40% of insect species have declined worldwide over the last 40 years;

many of these declines began as early as the 1950s and continue through to the present day (Sánchez-Bayo and Wyckhuys 2019). Spiller and Dettmers (2019) suggested that it is not the abundance but rather the availability of high-quality prey that may be the driver of aerial insectivore declines.

No tracking of insect populations has occurred in Nova Scotia and it is an important knowledge gap which must be addressed for multiple at-risk aerial insectivores (such as the Bank swallow (*Riparia riparia*) and Chimney swift (*Chaetura pelagica*)). Flycatchers employ different foraging strategies than other aerial insectivores such as swifts, swallows, and nightjars (refer to dietary needs in *section 3.3 Species Needs*), and as such, may be impacted differently by declines.

Insectivorous birds are faced with three options when dealing with reduced diversity and abundance of insect prey species: altering foraging strategies, increasing foraging effort, or changing prey species. The result of any of these strategies are increased effort for less reward, or fewer and lower quality prey items. Energetic and behavioural consequences include increased risk of predation, impacts on territorial defense and incubation, and decreased nesting success (Burgess et al. 1995). Insect declines, and by extension, declines in aerial insectivores, have been linked to a number of possible interconnected causes. Agricultural intensification, environmental contaminants, invasive species, habitat loss, extreme weather events, and climate change have all been attributed to declines in insect abundance and, by extension, insectivorous bird species (Benton et al. 2002, Hallmann et al. 2014, Bellavance et al. 2018, Spiller and Dettmers 2019, Wagner 2020, Møller et al. 2021, Raven and Wagner 2021, Tallamy and Shriver 2021). The application of insecticides to manage forest pests has been suspected as a cause of bird declines since the 1960s through the loss of insect diversity and abundance (Hickey 1961, Peakall et al. 1983, Sample et al. 1993, Burgess et al. 1995). Mosquito spray programs in urban environments is a concern (Poulin et al. 2010). Reduction in water quality due to pollution negatively impacts insect emergence, although impacts are variable due to species-specific habitat needs and foraging behaviours (Manning and Sullivan 2021).

Quality of migratory and wintering ground habitat is an important factor in both the timing and number of individuals returning to breeding grounds, with long-term impacts on breeding success (Bayly et al. 2018). On the wintering and migration grounds, widespread deforestation due to agriculture and development has resulted in habitat loss, increased surface temperatures, and reduced precipitation (Salazar et al. 2015), the combination of which has likely resulted in a reduction in insect abundance.

In addition to the decline in insect abundance, it is also suspected that climate change has resulted in a temporal mismatch between insect emergence on the breeding grounds and the return of aerial insectivores. This mismatch of peak insect abundance with energetic requirements of adults and nestlings has been observed in other aerial insectivores (Visser et al. 2006, Imlay et al. 2018) and may be connected to reduced reproductive success for some species of swallows (Imlay et al. 2018).

Biological resource use - Logging and wood harvesting (Medium)

The overall impact of the forestry sector on the Eastern Wood-pewee largely depends on whether the forestry practices support suitable habitat for the species and the regenerating forest that results from the harvesting method employed. Studies indicate that regardless of the silviculture technique employed, when there is not a complete overstorey removal there appears to be an immediate benefit to the species which disappears over time as the stand ages. Both shelterwood harvest and selection harvest (individual tree or group selection) involve removing portions of the forest canopy to promote understory growth and an uneven forest age condition, with the primary goal of improving wood supply. These changes in the forest structure have been associated with higher nesting success post- harvest (Newell and Rodewald 2012) or increases in abundance (King and DeGraaf 2000, Campbell et al. 2007, Goodale et al. 2009, Perry et al. 2018) in comparison to untreated stands, and stem from improved foraging opportunities due to openings in the forest canopy. Guenette and Villard (2005) found that Eastern Wood-pewee on a managed forest in New Brunswick did not respond significantly to habitat alteration resulting from silviculture treatment. Within 12-16 years post-harvest, any apparent positive impact of forest harvest treatment has disappeared and levels of abundance reach pre-treatment levels (Campbell et al. 2007, Goodale et al. 2009).

There is evidence that Eastern Wood-pewee can use some types of thinned forest, but it is reasonable to expect that there is likely a threshold of fragmentation or thinning at which the stand is no longer suitable habitat. Further research is required to better understand how different non-clearcut forest management techniques may benefit or harm Eastern Wood-pewee nesting ability and success.

Less than 34% of the land in Nova Scotia is under provincial ownership (including Crown land and Protected Natural Areas) (Nova Scotia Department of Lands and Forestry 2017). The Nova Scotia State of Forest 2018 Update (2020) indicated that clearcutting accounted for roughly 70% and 75% of the harvests on Crown and private lands, respectively; although relatively high, the amount of clearcutting has steadily decreased since 1990, when the amount of clearcutting at that time exceeded 95%. Changes to harvesting methods in Nova Scotia resulting from recommendations adopted from the 2018 Independent Review of Forest Practices in Nova Scotia will possibly see the elimination of most clearcutting on Crown land in favour of harvesting that focuses on retention ranging from 1/5-2/3 of a stand, with the goal not just of enhancing biodiversity but of "*creating or maintaining structures representative of natural disturbances specific to the ecosite*" (McGrath et al. 2021). However, application of these guidelines is only enforceable on Crown lands and is completely voluntary on privately managed forests, which, considering the percentage of provincial forest that is privately owned, likely contains most of the suitable habitat for the species. Forest harvesting may have been more of a threat to the species and its habitat historically; proposed changes in forest management focused more on retention harvest techniques should result in somewhat enhancing habitat for Eastern Wood-pewee.

On the non-breeding grounds, Eastern Wood-pewee are more generalist in their habitat requirements (see *section 3.3 Species Needs*), which could imply a higher level of tolerance for forestry activities than other species. Given that Eastern Wood-pewee non-breeding habitat has shown significant annual losses (Aide et al. 2012), and that the species chooses migratory stopover sites based upon vegetative structure (Wolfe et al. 2014), research is necessary to quantify the rate of habitat change and how types of forestry practices impact the population on the wintering grounds.

Energy production and mining (Low)

Extraction of mineral resources at both small (e.g., aggregate quarries) and large-scale (e.g., open pit mines) as well as associated infrastructure can result in varying intensity of habitat degradation, fragmentation, and loss; pollution of air and water; noise, light, and dust; and increased vehicular collision risk. Impacts to Eastern Wood-pewee could include direct mortality, reduced nesting success or nestling survival, and behavioural changes.

Of 105 Environmental Assessment projects that were reviewed for the past 10 years (2011-2021), field surveys for 35% of the projects (37/105) identified Eastern Wood-pewee in the study area. It should be noted that in an additional 37% of projects (39/105), ACCDC records supported the inclusion of Eastern Wood-pewee as part of survey requirements, but none were detected during bird surveys. Proponents are required to provide mitigation measures with respect to species at risk found within the study area; however, given that Eastern Wood-pewee is listed as Vulnerable under the ESA there are no legal requirements to protect the species and its habitat. Nonetheless, general mitigation measures to protect other species at risk birds or migratory bird species (such as vegetation clearing outside of the breeding bird window) would provide some measure of protection for the species.

An increase in renewable energy production (predominantly wind energy) is anticipated over the next decade within Nova Scotia. As part of the *Environmental Goals and Climate Change Reduction Act* (2021, c.1), coal fired energy is to be phased out with a goal of 80% of energy demands generated by clean energy by 2030. Although impacts of wind turbines on migratory and resident birds has been well studied, information specific to Eastern wood-pewee or aerial insectivores is limited and bears further study.

Residential and commercial development - Housing and urban areas (Low)

Increasing urbanization is a concern for bird species with impacts associated with vegetation changes, invasive species, habitat fragmentation, increased predation of adults and nests, and disturbance, among others (Chace and Walsh 2006). Eastern Wood-pewee densities have been found to be lower or the species completely absent in areas of urban development in comparison to natural environments, which may be due to both a reduction in available habitat and an overall shift in foraging opportunities (from canopy to ground foraging) (Amrich and Coffin 1979, Beissinger and Osborne

1982). Eastern Wood-pewee tolerance of urban development is dependent upon intensity of development (Friesen 1998).

Bird window collisions are a hazard for bird species in general, and especially with large buildings (greater percentage glass per unit area) surrounded by green space (Hager et al. 2013, Hager et al. 2017); this risk can be exacerbated by such things as light pollution during key migration periods (Van Doren et al. 2021). Hager and Craig (2014) found that although flycatchers were considered less vulnerable as a guild, the Eastern Wood-pewee was at greater risk of window collisions at the start of the breeding season due to being a long-distance migrant, as well as having elevated risk associated with lower overall abundance; the reasoning for this was unknown.

Agriculture and aquaculture - Annual and perennial non-timber crops (Low) and Livestock farming and ranching (Low)

Conversion of forested habitat to other uses including crop and livestock production reduces available nesting and foraging habitat for the species and increases in the use of chemical applications associated with these activities may have direct and indirect impact to Eastern Wood-pewee. Currently, the amount of forest is considered stable in Canada, with less than 0.5% converted to non-forest use since 1990; conversion to agriculture use has steadily declined during this time (The State of Canada's Forests 2020). The most recent agriculture census data showed Nova Scotia as the only province in Canada with an increase in the total area of farmed land (2.2% increase from 2006-2011), with the largest percentage of the cropland (77%) attributed to hay (Statistics Canada 2016).

Recent studies in Nova Scotia have found that Eastern Wood-pewee are more abundant in the Valley ecoregion than in the Western and Fundy ecoregions and are found in close proximity to agriculture lands where mature forest stands remain (J. Brazner, pers. comm.), possibly indicating that in this portion of the species range the impacts of agriculture may not be as severe.

Deforestation and conversion to non-forested habitat is of much greater concern on the migratory and wintering grounds than the breeding grounds. Agricultural expansion was the most common driver of loss of tropical lowland forests on the wintering grounds, and the migratory stopover sites in Central America face similar pressures (De Sy et al. 2010, Gibbs et al. 2010, Aide et al. 2012, Rivas et al. 2021). Deforestation to create pastures is considered a first step of agricultural intensification, as cattle pasture is often converted into croplands (Wassenaar et al. 2007, Picoli et al. 2020). Additional research on land use on the migratory and wintering grounds is needed to better understand and address this threat to the species and its habitat.

Wood and pulp plantations (Low)

Forest plantations are used by Eastern Wood-pewee and are expected to have an impact if they provide different habitat values (e.g., reduced food availability) or threats (e.g., increased predation). Indeed, increased predation associated with plantations has been shown to result in decreased nesting success for Eastern Wood-pewee (Falconer and Nol 2020). There is a possibility these habitats could become ecological traps for Eastern Wood-pewee, i.e. individuals are lured to lower-quality habitat as a result of environmental cues such as forest structure.

The total amount of plantations in Nova Scotia has averaged 5,000 ha/year since 2012; this is roughly half the total hectares planted annually in the early 2000's (Nova Scotia Department of Lands and Forestry 2020).

Transportation and service corridors (Negligible)

Eastern Wood-pewee do not appear to be particularly susceptible to collision with transmission lines in comparison to other species groups such as waterfowl and raptors; however, it is possible that collisions are contributing to overall aerial insectivore declines (Rioux et al. 2013). The species appears to be at limited risk of collisions with vehicles (Ashley and Robinson 1996, Bishop and Brogan 2013).

For songbirds in general, traffic noise may hinder mate acquisition and territorial defence, resulting in declines in reproductive success and reduced fitness, with overall impacts to densities and species richness (Gentry et al. 2018). An increase in road density is expected to occur, but the amount of increase is unknown, nor is the impact expected to be evenly distributed throughout the species' range. Maritime Breeding Bird Atlas data suggested that Eastern Wood-pewee had negative associations with roads (M. Campbell unpubl. data *in* COSEWIC 2012). The Eastern Wood-pewee has the ability to adjust their song in an effort to counteract road noise impacts; however, this may come at increased fitness costs to males (Gentry et al. 2018). Unpublished research in Nova Scotia suggests a strong negative impact of roads and road density on Eastern Wood-pewee abundance (J. Brazner, pers. comm.).

Invasive and other problematic species, genes, and diseases (Unknown)

A number of invasive forest pests and diseases occur within the Eastern Wood-pewee's breeding range. Both Hemlock Woolly Adelgid (*Adelges tsugae*) and Emerald Ash Borer (*Agrilus planipennis*) were detected only recently in Nova Scotia (2017 and 2019, respectively) and the long-term impacts to Nova Scotia forests are not well understood (Government of Canada, Canadian Food Inspection Agency 2020, Government of Canada, Natural Resources Canada 2020). Recent studies indicate climate change may influence outbreaks through drought and storm stress to trees and accelerate the range expansion of forest pests such as Hemlock Woolly Adelgid (Pureswaran et al. 2018). The effects of these forest pests on Eastern Wood-pewee populations are unknown but suitability of breeding habitat could be reduced through changes in forest structure. Effects may not be all negative; studies have shown increases in Eastern Wood-pewee abundance where Hemlock Woolly Adelgid dieback was present, as canopy openings favour aerial insectivores (Tingley et al. 2002, Becker et al. 2008, Toenies et al. 2018).

Pollution (Unknown)

Acid rain and acidification of watercourses and wetlands has been a concern in Atlantic Canada since the 1970's. Acid rain deposition in Atlantic Canada is the lowest for anywhere in Eastern North America; however, poor acid-neutralizing capacity of aquatic ecosystems in the region has resulted in high surface water acidic content (Clair et al. 2007), and the poor buffering capacity of these systems has meant that reductions in emissions over the last few decades has not translated to noticeable improvements in water quality (Lacoul et al. 2011). The effects of acid rain are considered particularly severe in Nova Scotia in comparison to other provinces.

The effects of acid rain on the Eastern Wood-pewee have not been studied. However, forests experiencing acid rain have more dieback and lower insect abundance; as a result, other insectivorous birds have been found to be less common (Graveland 1998). Studies have shown elevated methylmercury concentrations in species of insectivorous birds such as Rusty blackbird (*Euphagus carolinus*) (Edmonds et al. 2012) and Bicknell's thrush (*Catharus bicknelli*) (Rimmer et al. 2005). Additionally, a side effect of acid rain is lower calcium availability, which results in a reduced breeding success in some insectivorous species due to calcium deficiency in eggshells (Graveland 1998).

Climate change and severe weather - Severe/extreme weather events (Unknown)

Recent research of climate impacts on aerial insectivore declines found that large-scale climate indices were a more significant driver of aerial insectivore declines than any other climate indices and migratory conditions. Wind and storm events appear to be "insufficient to affect population trajectories" but may become more important as drivers of decline with climate change producing storms of greater frequency and intensity in the future (Michel et al. 2021). Extreme weather events are predicted to have significant impacts to species diversity and abundance and can present as either short-term (e.g., changes in activity periods) or long-term (e.g., change in distribution) (Bateman et al. 2020, Cohen et al. 2020).

In studies of aerial insectivores, long-term declines in nestling survival, as well as adult body mass, were associated with punctuated periods of wet weather (Cox et al. 2019) or cold snaps (Winkler et al. 2013, Garrett et al. 2021) during the egg laying and nestling periods. Clement et al. (2019) in their study of BBS data from 1997-2012 found a correlation between extreme temperatures and Eastern Wood-pewee declines but were unable to account for the largest percentage of variation in their model. Further investigation into the causes of declines due to temperature extremes is needed.

Severe weather events can disrupt foraging either through availability or abundance of insect prey species. Fluctuating wind speeds impact prey availability and influences breeding success (Møller et al. 2013). Insect declines have been correlated with rising temperatures and changes in weather patterns associated with climate change, which impact the prey availability for aerial insectivores (Vafidis et al. 2019, Hatsch et al. 2021). Effects are highly variable; insects have short life cycles, high reproductive capacity, and are highly mobile; as a result, changes in precipitation or temperature can influence rapid and large change in a population (Hatsch et al. 2021).

Storm events are also a concern on the non-breeding grounds, especially for long-distant migrants such as the Eastern Wood-pewee (Butler 2000).

5. MANAGEMENT OBJECTIVE(S)

The management objective for the Eastern Wood-pewee in Nova Scotia is to maintain a stable or increasing population of Eastern Wood-pewee across its range in Nova Scotia by 2036, assessed through population trend data.

The COSEWIC (2013) technical assessment stated that “the 10-year rate of decline (25%) comes close to satisfying the criteria for Threatened” and “If the population declines continue to persist, the species may become Threatened in the foreseeable future.” Halting the decline of a species for which the primary cause of decline is unclear is challenging.

An objective based on the population trend was selected over a population size goal, since current estimations of population sizes are less reliable than population trends. Currently, the best available information to assess population trends for NS are the Breeding Bird Survey (BBS) routes. However, there are limitations associated with this data; BBS data for NS is combined with PEI due to the low sample size. BBS data indicates that the population has been increasing for the most recent short-term term (2007-2019) in NS/PEI (Table 2).

The management objective will be assessed using 10-year roving windows, with the first being 2022-2031, and the last roving window 5 years after the first one (2026-2036) (5 years of roving windows total). This population trend objective should be achieved while maintaining the current (2020) extent of occurrence (the area that encompasses the geographic distribution of Nova Scotia populations).

If new data or tools to estimate population size or trends become available, these may be used to support the assessment of the management objective or assist in the development of new objectives.

6. GENERAL APPROACHES TO MANAGEMENT

6.1. Actions Completed or Underway

In Nova Scotia, there has been little conservation work specifically targeting the Eastern Wood-pewee. The following list is not exhaustive, but is meant to illustrate the main areas where work has been completed or is already underway, as well as to give context to the broad strategies outlined in *Section 6.2. Recommended Actions for Management*:

- The Ontario Ministry of Natural Resources (2011) published “A land manager’s guide to conserving habitat for forest birds in southern Ontario” which recommends practices beneficial for the Eastern Wood-pewee. Best Management Practices (BMPs) from Ontario are currently being used in support of a Priority Places Program forest research project in Nova Scotia.
- Parks Canada multi-species action plans identify recovery measures specific to national parks and national heritage places where species at risk occur. One such action plan is in place for Kejimkujik National Park and National Historic Site of Canada, and includes Eastern Wood-pewee in their recovery planning.
- Recent research on Eastern Wood-pewee in Nova Scotia:
    - Breeding bird communities and conservation values of forested wetlands (Brazner and Achenbach 2020, Brazner and MacKinnon 2020)
    - Current research into Eastern Wood-pewee inside and outside of protected areas, adjacent to clearcuts in protected areas, and in different types of old forest (J. Brazner, pers. comm.)
    - Habitat modelling for land bird species at risk in southwestern Nova Scotia (Staicer et al. 2015)
- Several conservation-oriented and citizen-science monitoring and research projects provide information on the Eastern Wood-pewee population in Nova Scotia. These include the following:
    - The Breeding Bird Survey
    - The Boreal Avian Monitoring Project
    - Maritime Breeding Bird Atlas (1986-1990 and 2006-2010)
    - eBird
    - Atlantic Canada Conservation Data Centre

6.2. Recommended Actions for Management

Table 3 provides the recommended conservation measures for achieving management objectives for the species and the timeframe for completing these actions. Conservation measures are organized according to the following categories: Habitat protection, monitoring and stewardship; surveys and monitoring; communication, outreach, and education; law, policy, and enforcement; and research to address knowledge gaps.

Table 3. Conservation measures in support of management objectives and implementation schedule.

Conservation Measure	Threat(s) Addressed*	Priority**	Timeline
Habitat Protection, Monitoring, and Stewardship			
Protect large tracts of contiguous suitable forest habitat where possible.	1.1, 1.2, 2.1, 2.3, 4.1, 4.2, 5.3, 7.3	Medium	2022-2032
Promote silvicultural practices on Crown land that are compatible with EAWP habitat needs.	2.3, 4.1, 4.2, 5.3, 7.3	High	2022-2032
Develop and promote stewardship programs for woodlot management and forest conservation by private landowners that is compatible with species recovery.	2.3, 4.1, 4.2, 5.3, 7.3	Medium	2022-2032
Surveys and Monitoring			
Establish a monitoring program to detect change in EAWP population size and distribution.	All	Medium	2022-2032
Communication, Outreach, and Education			
Support NGOs and researchers in the development and dissemination of outreach materials (such as BMPs).	1.1, 2.1, 2.3, 5.3	Medium	2022-2032
Law, Policy, and Enforcement			
Develop policies and broad conservation measures addressing common drivers of aerial insectivore declines.	7.3	High	2022-2027
Strengthen enforcement of existing Acts and regulations to protect and conserve both the species and its habitat.	1.1, 1.2, 2.1, 2.3, 5.3	High	2022-2027
Research to Address Knowledge Gaps			
Support (nationally, or through research partners) efforts to determine the role of insecticides, pesticides, climate change, and other threats on the species abundance, distribution, and habitat.	7.3	High	2022-2032
Support (nationally, or through research partners) efforts to determine migration routes and winter locations, key demographic parameter estimates, and possible carry-over effects of habitat conditions throughout the annual cycle.	All	High	2022-2032
Develop and test habitat suitability models to better understand species distribution and habitat requirements.	All	High	2027-2032
Support research to understand trends in insect prey population dynamics as it pertains to aerial insectivores as well potential causes of changes in prey quality and abundance.	7.3	High	2022-2032
Determine breeding habitat conditions that promote high productivity and occupancy.	All	High	2027-2032

*Threat or Limitation should refer to the IUCN Threat Classification Table Rankings. Either the first level or second level threat ranking can be used depending on how the Broad Strategy affects the threat. Multiple threats can be addressed under a single Recovery Measure.
**Priority should be classified as High(H), Medium(M), or Low(L). “Priority” is a qualitative measure of the relative degree to which an approach will have a positive impact on the recovery objective. High priority conservation approaches are considered those most likely to have an immediate and/or direct influence on reaching the management objective for the species. Medium priority conservation approaches may have a less immediate or less direct influence on reaching the management objective but are still considered important measures to implement. Low priority conservation approaches will likely have an indirect or gradual influence on reaching the management objective and are more tied to increasing knowledge or public perception/education.

6.3. Narrative to Support the Recovery Options Planning Table

Limited information on the species abundance and distribution, and a lack of knowledge on the impact of threats and threat interaction makes the development of actions in support of Eastern Wood-pewee recovery challenging. Successful management of the Eastern Wood-pewee in Nova Scotia will require engagement with national partners and researchers to support important monitoring and research initiatives; this is indicated through the adoption of management actions developed in support of the national management plan for the species.

Habitat Protection, Management and Stewardship

Although adequate breeding habitat to support the species likely exists, mechanisms for declines in aerial insectivores are generally considered complex and multiple factors acting across the breeding and non-breeding areas could be driving the population declines (Spiller and Dettmers 2019). Adequate breeding habitat for Eastern Wood-pewee must be managed and protected, particularly in areas where habitat is vulnerable to loss or degradation due to human activities like forestry and urban development.

The Eastern Wood-pewee requires intermediate to mature forest canopy structure with open areas for foraging. Although the species has shown some tolerance to fragmentation, not all silviculture approaches would be beneficial. The promotion of compatible forestry practices on Crown land to conserve or augment existing habitat is an important step towards enhancing population growth. Incentivizing private landowners to manage their woodlots in a manner that is beneficial to the Eastern Wood-pewee and conserving large tracts of primary forest will continue to provide forest habitat for the species. Efforts should also target woodlots present within farmlands as the species is prevalent throughout these landscapes in the Annapolis Valley region of Nova Scotia.

Surveys and Monitoring

Lack of detailed knowledge on the species distribution and abundance in Nova Scotia highlights the need to develop a monitoring program; this could be a component of a larger, taxa-based comprehensive approach to monitoring for provincial species at risk birds.

Communication, Outreach and Education

The provincial government has been a partner is support of projects developing species at risk Best Management Practices (including Eastern Wood-pewee) through funding agencies such as the Priority Places program. Promotion of these tools is an important part of stakeholder engagement as well as habitat protection and enhancement.

Law, Policy and Enforcement

Aerial insectivores are in decline across Canada (Nebel et al. 2010). Given the general decline of this guild and the spatial synchrony of some of the declines, broader conservation measures and policies that address common drivers of decline for multiple species is likely a more cost-effective and impactful approach.

Research to Address Knowledge Gaps

A comprehensive approach to research and monitoring is necessary to understand the status of the species, threats, and limiting factors. It is unclear to what extent threats are affecting the overall population decline of Eastern Wood-pewee, but it is understood that is not restricted solely to its breeding ground, and it does not appear that the main threats are species-specific (e.g., insect declines). The province will likely not be the lead agency in research; opportunities to support research programs with institutions and NGOs that are multi-species or multi-jurisdictional, and that align with conservation measures for the species recovery, is strongly encouraged.

Trends in insect prey population dynamics must be better understood to know whether maintaining and/or restoring insect-producing habitats will significantly benefit Eastern Wood-pewee populations. Although challenging, there are new approaches to data analysis and technology for monitoring and assessing insect populations which may prove useful (Didham et al. 2020). Forest pests and diseases and the anticipated impacts to forest structure should be studied to better inform conservation and enhancement of Eastern Wood-pewee habitat. The use of insecticides and other pesticides in the control of forest pest species should be reviewed in the context of impacts to the Eastern Wood-pewee habitat and prey availability, as well as that of other insectivorous forest birds.

The development and testing of habitat suitability models is important to better understand species distribution and habitat requirements and can be updated as habitat conditions change (e.g., silviculture or disturbance). Models can be used to guide fieldwork, the prioritization of management, planning, and conservation actions, as well as predict species distribution under climate change scenarios.

7. MEASURING PROGRESS

7.1. Performance Indicators

The performance indicators presented below provide a way to measure progress towards achieving the management objectives and monitoring the implementation of the management plan:

- By 2036, the population trend of the Eastern Wood-pewee is stable or positive as measured by the Breeding Bird Survey trend information.
- By 2036, the extent of occurrence of the Eastern Wood-pewee is maintained in reference to the 2020 extent.

Currently, the only (and most reliable) information available to assess population trends of Eastern Wood-pewee in Nova Scotia are BBS survey route data and will be done through the use of 10-year roving windows for 2022-2036, for a five-year period (2022-2031, 2023-2033, 2024-2034, 2025-2035, 2026-2036).

Performance will be assessed through the completion of actions identified under Table 3 of *Section 6.2 Recommended Actions for Management*.

Table 4. Performance measures used to determine whether Eastern Wood-pewee management objectives are being met.

Performance Measure	Check-In
Planning:	
Number of Recovery Team meetings to discuss activities and assess performance to date (minimum one per year).	Annually.
Number of initiatives and groups involved in delivering conservation messaging.	Annually.
Number of individuals or teams assigned to, or supported to implement, recovery-related projects such as land protection efforts, habitat mapping, the production of educational material, etc.	Annually.
Conservation:	
Total amount of large contiguous suitable forest habitat protected.	Every five years.
Total amount of private land or number of landowners involved in stewardship.	Every five years.

7.2. Monitoring

Monitoring will be required to assess effectiveness of actions towards the success of the management objective.

Monitoring of threats will be challenging given the lack of information that is currently available (e.g., climate change) or difficulty in assessment (e.g., insect abundance). Monitoring will likely occur opportunistically as need arises. At a minimum, information on threats should be collected at the time of any observation.

Habitat needs of the species are well known (see Section 3.3 *Species needs*) so the focus of monitoring should be on the collection of detailed information required to develop and refine habitat suitability models (Table 3); these parameters would be identified once the model is defined. Unless it is through the support of dedicated research projects, habitat assessments will likely occur opportunistically in support of other initiatives such as population and distribution monitoring or the evaluation of the effectiveness of BMPs.

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