

Management Plan for the Eastern Wood-pewee (*Contopus virens*) in Canada

Eastern Wood-pewee



2023



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20 For copies of the management plan, or for additional information on species at risk,
21 including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC)
22 Status Reports, residence descriptions, action plans, and other related recovery
23 documents, please visit the [Species at Risk \(SAR\) Public Registry](https://www.sarregistry.gc.ca/)¹.

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¹ www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html

Preface

The federal, provincial, and territorial government signatories under the [Accord for the Protection of Species at Risk \(1996\)](#)² and the [Cooperation Agreement for the Protection and Recovery of Species at Risk in Quebec](#)³ agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of management plans for listed species of special concern and are required to report on progress within five years after the publication of the final document on the SAR Public Registry.

The Minister of Environment and Climate Change and Minister responsible for the Parks Canada Agency is the competent minister under SARA for the Eastern Wood-pewee and has prepared this management plan, as per section 65 of SARA. To the extent possible, it has been prepared in cooperation with the Parks Canada Agency, the Department of National Defense, and the provinces of Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, and Nova Scotia as per section 66(1) of SARA.

Success in the conservation of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this plan and will not be achieved by Environment and Climate Change Canada and the Parks Canada Agency, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this plan for the benefit of the Eastern Wood-pewee and Canadian society as a whole.

Implementation of this management plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

² www.canada.ca/en/environment-climate-change/services/species-risk-act-accord-funding.html#2

³ www.registrelep-sararegistry.gc.ca/virtual_sara/files/agreements/aa_canada_quebec_0513_e.pdf

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Executive Summary

The Eastern Wood-pewee (*Contopus virens*) is a small songbird in the flycatcher family, which forages by flying out from a perch to catch flying insects. The species breeds in woodland and forest across central and eastern North America. In Canada, its range extends from southeastern Saskatchewan, along the southern stretches of Manitoba, Ontario, and Quebec, to the Maritimes. The species migrates through Central America and winters in tropical lowland forests in northwestern South America.

The species 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* in 2017. The International Union for the Conservation of Nature (IUCN) Red List ranks the Eastern Wood-pewee as Least Concern. The Eastern Wood-pewee is protected under the *Migratory Bird Convention Act, 1994* in Canada and the *Migratory Bird Treaty Act* in the U.S.

Of the 6.5 million Eastern Wood-pewees that make up the global population, 5.5% (360,000) breed in Canada. The species has declined by 63% since 1970 and was stable during the 2009–2019 period. The extent of the decline varies regionally; populations declined the most in the Maritimes, the northeastern portion of the species' range. Other birds that forage on flying insects are also declining across North America, often with similar patterns of strong declines in the northeast.

The causes for Eastern Wood-pewee and other avian aerial insectivore declines are unclear, but the common diet of this bird group points towards reduced availability or quality of insect prey. A combination of factors may explain this reduction of insect prey, including widespread insecticide use, climate change, and/or lingering effects of acid rain. The Eastern Wood-pewee may be threatened by loss of wooded habitat and degradation caused by conversion to crops or pastures, particularly on its non-breeding grounds. Additional threats include non-native tree insects and diseases, urban development, and White-tailed Deer (*Odocoileus virginianus*) over-browsing.

The management objectives for the Eastern Wood-pewee in Canada are to achieve a stable or increasing population trend in the short-term (by 2032), maintain, at a minimum, a stable population trend in the long-term (beyond 2032), and maintain a stable or increased geographic distribution, as shown in Figure 1. The North American Breeding Bird Survey provides reliable population trends, both nationally and regionally, that will be used to measure progress towards the management objective.

The broad strategies outlined in this management plan aim to better understand the species' habitat use during the non-breeding season and to determine the threats associated with the species decline. Since much of the species' habitat and population is outside of Canada, developing partnerships with organizations on the bulk of its breeding and non-breeding ranges should play a key role in Canada's conservation strategies for the species.

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1. COSEWIC* Species Assessment Information

Date of Assessment: November 2012

Common Name (population): Eastern Wood-pewee

Scientific Name: *Contopus virens*

COSEWIC Status: Special Concern

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.

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

COSEWIC Status History: Designated Special Concern in November 2012.

* COSEWIC (Committee on the Status of Endangered Wildlife in Canada)

2. Species Status Information

An estimated 5.5% of the global Eastern Wood-pewee (*Contopus virens*) population breeds in Canada (Partners in Flight 2019). In Canada, the species was assessed as Special Concern by COSEWIC in 2012 and listed as Special Concern under Schedule 1 of the *Species at Risk Act* in 2017. Provincially, the Eastern Wood-pewee was classified as Vulnerable under the Nova Scotia *Endangered Species Act* in 2013, as Special Concern under the New Brunswick *Species at Risk Act* in 2013, and as Special Concern under the *Endangered Species Act* in Ontario in 2014. The species is either unlisted or classified as secure in all other provinces. The Eastern Wood-pewee is not listed under the United States' *Endangered Species Act*. The species has been identified as a priority species in three of the twelve Bird Conservation Regions⁴.

The global NatureServe rank is G5 - Secure (reviewed in 2016; NatureServe 2021; see Table 1 for additional sub rankings). In 2004, the IUCN Red List classified the species

⁴ Those Bird Conservation Regions are the Boreal Hardwood Transition, the Lower Great Lakes / St. Lawrence Plain and the Atlantic Northern Forest.

as Least Concern (BirdLife International 2016). 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.

Table 1. Summary of national and provincial or state NatureServe ranks for the Eastern Wood-pewee where it occurs in North America. Source: NatureServe 2021.

Global (G) Rank	National (N) Ranks	Sub-national (S) Ranks
G5	<u>Canada</u> N5B, N5M	Manitoba (S3B), New Brunswick (S3B), Nova Scotia (S3S4B), Ontario (S4B), Prince Edward Island (S3B), Quebec (S3B), Saskatchewan (S4B, S4M)
	<u>United States</u> N5B	Alabama (S5B), Arkansas (S4B), Connecticut (S5B), Delaware (S5B), Florida (SNRB), Georgia (S5), Illinois (S5), Indiana (S4B), Iowa (S4B, S4N), Kansas (S5B), Kentucky (S5B), Louisiana (S5B), Maine (S4B), Maryland (S5B), Massachusetts (S5B), Michigan (S5), Minnesota (SNRB), Mississippi (S5B), Missouri (SNRB), Nebraska (S4), New Hampshire (S5B), New Jersey (S4B), New York (S5B), North Carolina (S5B), North Dakota (SNRB), Ohio (S5), Oklahoma (SNRB), Pennsylvania (S4B, S5B), Rhode Island (S5B, S5N), South Carolina (S5B), South Dakota (S3B), Tennessee (S5), Texas (S4B), Vermont (S5B), Virginia (S5), West Virginia (S5B), Wisconsin (S5B)

National (N) and Subnational (S) NatureServe alphanumerical ranking: 1 - Critically Imperiled, 2 - Imperiled, 3 - Vulnerable, 4 - Apparently Secure, 5 - Secure, NR - Unranked, NA - Not Applicable. Occurrence definitions: B - Breeding, M - Migrant.

3. Species Information

3.1. Species Description

The Eastern Wood-pewee is a small songbird in the flycatcher family (Tyrannidae) that weighs about 14 grams (Watt et al. 2017). Adults have olive-grey plumage and a pale breast, belly, and wing-bars; they lack an eye ring, which helps distinguish them from the visually similar Acadian Flycatcher (*Empidonax virescens*). Juvenile plumage is darker and browner with yellower underparts. Though almost identical in appearance to the Western Wood-pewee (*Contopus sordidulus*), the two species hardly overlap on their breeding range and the Eastern Wood-pewee can be distinguished by its

distinctive *pee-a-wee* song. Like other flycatchers, the Eastern Wood-pewee forages on flying insects by hawking⁵ out from a perch in the canopy.

3.2. Species Population and Distribution

Distribution

The Eastern Wood-pewee is a common bird that breeds throughout central and eastern North America. Its breeding range extends from southeastern Saskatchewan to southeastern Texas in the west and from northern Florida to Nova Scotia and Prince Edward Island in the east (Figure 1; Watt et al. 2017). In Canada, the species is found in southeastern Saskatchewan, along the southern portions of Manitoba, Ontario, and Quebec, and throughout New Brunswick, Prince Edward Island, and Nova Scotia (COSEWIC 2012). The highest Canadian densities are in Ontario (Figure 2).

⁵ When foraging by hawking, an individual perches on a branch until they see a flying insect, flies out to catch it and then returns to either the same perch or a new one.



Figure 1. Breeding, migrating and wintering distribution of Eastern Wood-pewee (adapted from BirdLife International 2016).

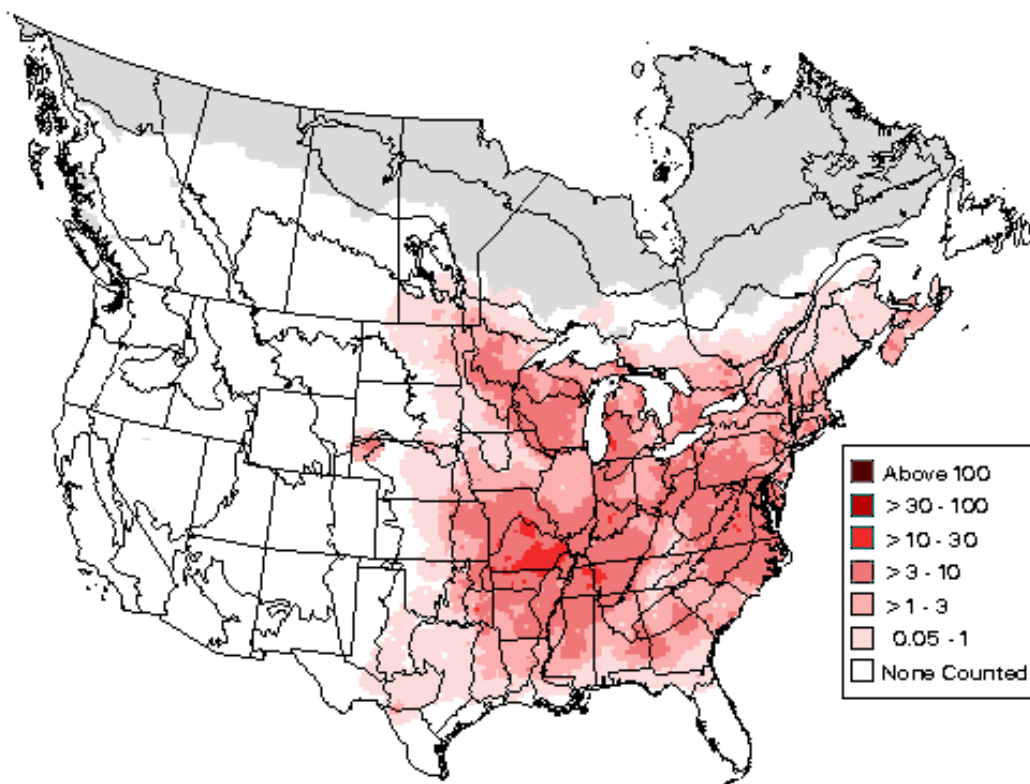


Figure 2. Predicted average number of Eastern Wood-pewees that could be observed in 2.5 hours on Breeding Bird Survey routes, from 2011 to 2015. Source: U.S. Geological Survey.

The Eastern Wood-pewee migrates through eastern and central U.S. and south through Central America. Sometimes, they also fly across the Caribbean. The species follows the same southbound and northbound migration routes. Surveys of Neotropical migrants in Central America and northern Colombia during spring and fall migrations found that the Eastern Wood-pewee was most abundant along the Caribbean slope and lowlands of Panama and Costa Rica (Neotropical Flyways Project; N. Bayly, pers. comm. 2020). The species winters in the tropical broadleaf forests of northwestern South America, from the western portion of the Amazonian forest in Brazil to the eastern slope of the Andes in Colombia, Ecuador, Peru, and Bolivia (Figure 1; Watt et al. 2017).

Population Size and Trends

The Eastern Wood-pewee population is estimated at 6.5 million birds in North America (Partners in Flight Science Committee 2020). The breeding population of the Eastern Wood-pewee in Canada, based on Breeding Bird Survey (BBS) results, is estimated at

360,000 individuals (95% confidence intervals⁶ [CI]: 223,000–566,000), of which approximately 56% breed in Ontario, 14% in Quebec, 13% in Manitoba, 11% in Nova Scotia, 6% in New Brunswick, and 1% in Prince Edward Island (Partners in Flight Science Committee 2020). The Boreal Avian Modelling (BAM) Project estimates the breeding population at 1.25 million males (CI: 1.18-1.33 million) or 2.5 million individuals⁷ in Canada (Boreal Avian Modelling Project, 2020). The BAM models predict the highest densities of the species in the southern portions of Ontario, which closely corresponds to the predicted detection rate on BBS routes and the Partners in Flight (PIF) population estimates (Figure 2).

PIF and BAM use different methods to estimate population size. The BAM Project provides population estimates based on models of species density in relation to environmental variables. PIF relies exclusively on BBS data while BAM includes both BBS and provincial Breeding Bird Atlas data, likely improving the reliability of the BAM population estimate. The higher population estimate derived from the BAM Project compared to the PIF estimate should not be seen as a population increase.

In Canada, the Eastern Wood-pewee population has shown a 2.0% annual decline in abundance between 1970 and 2019 based on BBS data (Table 2). Nationally, the population has been stable from 2009 to 2019, following a slowing rate of decline since the early 2000's (Figure 3; Smith et al. 2020). Since 1970 there have been significant long-term declines in most provinces, but short-term trends are not statistically significant in any province (Table 2). The degree of long-term decline varies moderately across the Canadian range, with the strongest declines in Manitoba and New Brunswick (Table 2). The BBS is thought to be one of the best methods of quantifying the population trend because the Eastern Wood-pewee's distinctive *pee-a-wee* call makes them easily identified by volunteers and the BBS covers most of their range (COSEWIC 2012).

Table 2. National and provincial annual percent population change (including 95% Credible Limits [CL]) 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 (2009-2019)			
	%/year	Lower CL	Upper CL	Overall reliability	%/year	Lower CL	Upper CL	Overall reliability
Canada	-2.01	-2.59	-1.61	High	-0.09	-0.97	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	-1.00	-4.55	2.66	Low

⁶ Confidence interval (CI) is a range of values around a number that is believed to contain the true value of the number. The credible limit (CL) has a similar interpretation.

⁷ The number of males was multiplied by a pair adjustment factor of 2 to obtain the number of breeding individuals of both sexes (see Stanton et al. 2019).

Nova Scotia and Prince Edward Island	-0.65	-1.30	0.03	High	1.38	-1.09	3.90	Medium
Ontario	-1.57	-2.03	-1.11	High	0.13	-1.34	1.62	High
Quebec	-2.29	-3.04	-1.51	High	1.76	-0.65	4.37	Medium

Source: Smith et al. 2020.

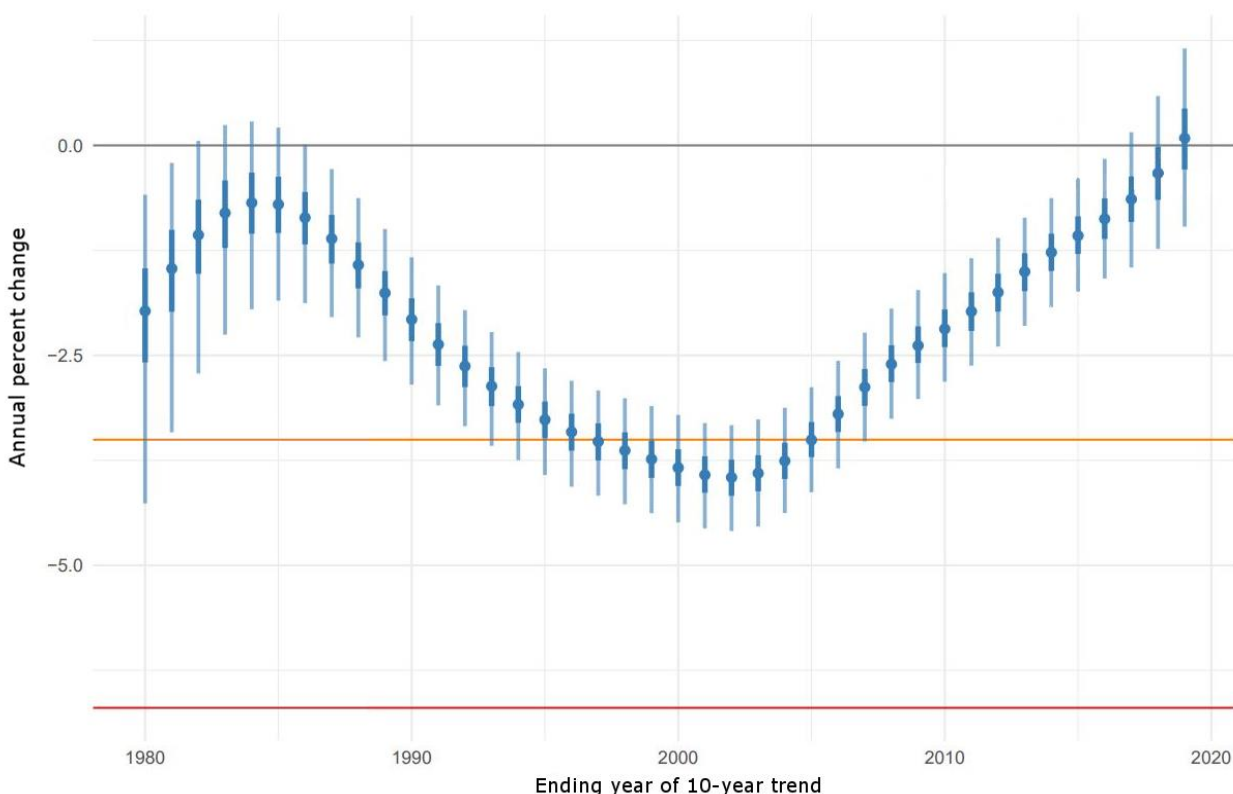


Figure 3. Annual percent change by 10 year periods of the Eastern Wood-pewee population in Canada. The most recent 10 year trend period ending in 2019 represents a 0.86% population increase over ten years. The orange and red horizontal lines represent 10 year population declines of 30 and 50 percent, respectively. Ten-year population declines of 30 and 50 percent correspond respectively to thresholds for threatened and endangered designations by COSEWIC. Light and dark vertical bars represent 50% and 95% confidence intervals, respectively. Trends are based on Breeding Bird Survey data.

Source: Smith et al. 2020.

Data collected for the provincial Breeding Bird Atlases (see Appendix B), the Ontario Forest Bird Monitoring Program (FBMP), and the *Étude des populations des oiseaux du Québec* (ÉPOQ) generally show declining populations.

The Maritimes Breeding Bird Atlas shows that between the first atlas in 1986-1990 and the second in 2006-2010 (Figure B5), the Eastern Wood-pewee's distribution across the Maritimes has remained stable but their abundance has declined (Peckford 2015; Figure B1).

The Quebec Breeding Bird Atlas also suggests that the occurrence of Eastern Wood-pewees in the province has declined between the first (1984-1989) and second (2010-2014) (Figure B4) atlas, particularly in the northern portion of the range (Hachey 2019). ÉPOQ show declining populations in Quebec (COSEWIC 2012).

The Ontario Breeding Bird Atlas shows that between the first atlas in 1981-1985 and the second atlas in 2001-2005 (Figure B3), the species' range has expanded northward and the probability of observation has declined in the south (McLaren 2007). As a result of this range shift and in contrast to the BBS, the Ontario Breeding Bird Atlas shows no net loss of Eastern Wood-pewees in Ontario. FBMP shows declining populations provincially (COSEWIC 2012). Comparisons between these data sources should be interpreted cautiously as differences may be largely driven by different biases in sampling and data analysis methods (COSEWIC 2012). Generally, when results differ, the BBS is thought to be the most reliable data source for this species (COSEWIC 2012).

The Monitoring of Avian Productivity and Survival (MAPS) program is a capture-mark-recapture survey conducted every year during the nesting season in Canada and the United States. The Eastern Wood-pewee was well represented in the data collected from 1992 to 2006⁸ in the United States during the MAPS program (DeSante et al. 2015). Though included in the analyses, data from Canada was much sparser. The 1992-2006 MAPS data showed high adult apparent survival, but very low productivity for the Eastern Wood-pewee that is likely not sufficient to maintain the population (DeSante et al. 2015). Because productivity is uniformly low, annual variation in adult survival drove changes in population size. Population density was negatively correlated with adult survival and productivity, suggesting that young and adult birds may be competing on the non-breeding grounds, which may carry over into the breeding season and result in low productivity (DeSante et al. 2015). A more recent analysis of the 1992-2017 MAPS data again found high adult apparent survival and relatively low productivity for the species (Saracco et al. 2020). However, an overall positive trend was observed at MAPS stations. Results suggest that high adult survival has played an important role in explaining the overall increasing trend, and that recruitment was relatively important in explaining years of greatest increase (Saracco et al. 2020). This more recent analyses did not include data from Canada but coincides with increasing trends observed from the Canadian BBS data from approximately 2002 onwards.

The Eastern Wood-pewee is one of many avian aerial insectivores⁹ that have shown population declines across North America. These declines appear to have begun in the 1980s for most species, and declines are strongest in the northeast (Nebel et al. 2010; Shutler et al. 2012; Smith et al. 2015, but see Michel et al. 2016). However, within the broader avian aerial insectivore guild, there seems to be a distinction between flycatchers, like the Eastern Wood-pewee, and other species (Smith et al. 2015).

⁸ See Section 6.1 for research and management efforts recommended for the Eastern Wood-pewee based on the 1992-2006 MAPS data analysis.

⁹ Avian aerial insectivores are birds that forage on flying insects. This group includes swifts, nightjars, swallows, and flycatchers.

Declines in flycatcher species began in the 1970s in the American Midwest, the 1980s in eastern Canada, and the 1990s in the Prairies. Unlike most other avian aerial insectivores, flycatcher populations were increasing in the east during the 1970s. In the west, flycatchers experienced a brief population increase in the 1990s-2000s but have been declining since approximately 2009 (Smith et al. 2015).

3.3. Needs of the Eastern Wood-pewee

Diet

As a flycatcher, the Eastern Wood-pewee primarily forages by hawking (Johnston 1971; Fitzpatrick 1980; Hartung and Brawn 2005). The species may also sally, where they fly out from their perch to catch a perched insect without returning to a perch, particularly when the canopy is dense (Hartung and Brawn 2005). The Eastern Wood-pewee forages in the lower 0-15 m of the canopy, but it may avoid the shrub layer if it is too dense (Johnston 1971; Hartung and Brawn 2005). Though not well characterized, their diet mainly consists of small flying insects that are less than 15 mm in length, often including Diptera (flies), Coleoptera (beetles), Hemiptera (true bugs), and Hymenoptera (ants, bees and wasps) (Johnston 1971; Watt et al. 2017).

Breeding Habitat

In Canada, the Eastern Wood-pewee lives in most forest types across its range, most commonly deciduous and mixed forests (Hespenheide 1971), and nests in a wide variety of deciduous tree species. The species is usually more abundant in larger forest patches but can be found in patches as small as one hectare (Friesen et al. 1995; Keller and Yahner 2006, 2007; Keller et al. 2009; but see Ambuel and Temple 1983; Blake and Karr 1987). The species preferentially inhabits open forest with a tall canopy or forest habitat near clearings or the forest edge (Hespenheide 1971; Conner et al. 2004; Falconer 2010; Reidy et al. 2014). Foraging in the mid-canopy, the Eastern Wood-pewee likely chooses these open areas because they provide a clear line of sight for aerial foraging and maneuvering. In southern Ontario, the Eastern Wood-pewee show no preference for natural deciduous forests over pine plantations and settle in both habitats equally (Falconer 2010). However, in Ohio, the species preferred harvested oak forests to natural oak forests (Newell and Rodewald 2012). Differences in preferences for harvested and unharvested forests likely stem from the availability of open foraging habitat in each forest. In Nova Scotia, mature upland forests, and treed swamps to a lesser extent, are important breeding habitat for the species; they were not found in regenerating forests (Brazner and MacKinnon 2020). The Eastern Wood-pewee also seems to prefer dry upland areas over lowlands, but again this preference is likely driven by the amount of open space available in each habitat type (COSEWIC 2012).

Regardless of forest type, Eastern Wood-pewee females build their nests on horizontal branches in areas of low visibility and away from tree trunks, likely to minimize predation (Falconer 2010; Kendrick et al. 2013). Mean nest height is 12.24 m (range 2.5-26.6 m)

across a range of canopy closure (Kendrick et al. 2013). Both parents provision the nestlings with insects (Kendrick et al. 2014). In southern Ontario, nests fledged¹⁰ offspring more often in natural deciduous forests than in pine plantations but nesting success¹¹ between natural and harvested oak forests in Ohio was equivalent; researchers attributed the differences between studies to predator abundance (Falconer 2010; Newell and Rodewald 2012). Predation is the most common cause of nest failure (96%) for this species in the Missouri Ozarks (Kendrick et al. 2013); 28-43% of nests fledged offspring (Knutson et al. 2004; Falconer 2010). There is no information on predation rates of nests from Canada. In cases of nest failure, the pair usually renests if there is still time left in the season and it is common that they do so more than once (Kendrick et al. 2014). While not as common as renesting after a nest failure, 21% of Eastern Wood-pewee females will attempt a second nest after a successful first nest (Newell et al. 2013; Kendrick et al. 2014). Males are usually monogamous but 6-20% are polygynous (Newell et al. 2013).

Migration and Wintering Habitats

The Eastern Wood-pewee migrates primarily at night, although there have been daytime migration sightings (Watt et al. 2017). As during the breeding season, the species uses wooded habitats during migration and over the winter. Migrants in Pennsylvania relied on mature forest interior, edge, or suburban woodlots, and avoided young forests (Rodewald and Brittingham 2004). Although the species often forages in forest edges, fall migrants in South Carolina preferentially choose oak forest fragments at least 1.29 hectares in size (Somershoe and Chandler 2004). In Central America, the Eastern Wood-pewee uses a variety of forest habitats on migration, including clearings, scrub forest, cloud forest, early-successional forest, and both primary and secondary forest edge, which includes both dry and wet forests (Leck 1972; Watt et al. 2017). This species chooses stopover sites during migration based on the vegetation and forest structure, not insect abundance (Wolfe et al. 2014).

Over the winter, the Eastern Wood-pewee is widespread in various forest types found below 1,300 metres above sea level (Watt et al. 2017). The species inhabits wooded and shrubby habitats, often foraging in either edges or clearings (Fitzpatrick 1980; Stotz et al. 1992; Watt et al. 2017). The Eastern Wood-pewee winters in tropical lowland forest, with overlap with tropical montane forests (Armenteras et al. 2017).

¹⁰ Fledging is defined as the stage when nestlings' wings develop and they leave the nest.

¹¹ Nest success is defined as the fraction of nests that fledge at least one young.

4. Threats

4.1. Threat Assessment

The Eastern Wood-pewee threat assessment is based on the IUCN-CMP (World Conservation Union–Conservation Measures Partnership, version 2.0) unified threats classification system. For purposes of threat assessment, only present and future threats are considered. Threats are defined as the proximate activities or processes that have caused, are causing, or may cause in the future the destruction, degradation, and/or impairment of the entity being assessed (population, species, community, or ecosystem) in the area of interest (global, national, or subnational). Limiting factors are not considered during this assessment process. 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 the Description of Threats section.

The threats included in the COSEWIC status report pre-date COSEWIC's use of the IUCN-CMP unified threats classification system, so an expert panel reviewed and updated the threats using the new threats classification system. Changes from the COSEWIC assessment include downgrading the severity of Threats 4.1, 4.2, and 5.3 from Slight to Negligible, resulting in the Impact assessment shifting from Low to Negligible. The severity of Threat 7.3 was also assessed as Moderate (previously Unknown), which increased the Impact from Unknown to Medium. The overall Canada-wide threat impact for the species is Medium.

Table 3. Threat calculator assessment.

Threat #	Threat description	Impact ^a	Scope ^b	Severity ^c	Timing ^d
1	Residential and commercial development	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)
1.1	Housing and urban areas	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)
1.2	Commercial and industrial areas	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)
2	Agriculture and aquaculture	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)
2.1	Annual and perennial non-timber crops	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)
2.3	Livestock farming and ranching	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)

Threat #	Threat description	Impact ^a	Scope ^b	Severity ^c	Timing ^d
4	Transportation and service corridors	Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)
4.1	Roads and railroads	Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)
4.2	Utility and service lines	Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)
5	Biological resource use	Negligible	Restricted (11-30%)	Negligible (<1%)	High (Continuing)
5.3	Logging and wood harvesting	Negligible	Restricted (11-30%)	Negligible (<1%)	High (Continuing)
7	Natural system modifications	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)
7.3	Other ecosystem modifications	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)
11	Climate change and severe weather	Unknown	Pervasive (71-100%)	Unknown	High (Continuing)
11.5	Severe / Extreme Weather Events	Unknown	Pervasive (71-100%)	Unknown	High (Continuing)

^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

The exact causes of Eastern Wood-pewee decline are unknown, largely because there is little research focused directly on this species. However, multiple non-mutually exclusive threats emerge from a review of demographic drivers (see MAPS in section 3.2) and a review of threats to the Eastern Wood-pewee (below).

Avian aerial insectivores are declining more rapidly than any other group of birds in North America (Nebel et al. 2010; North American Bird Conservation Initiative Canada 2019). Threats to aerial insectivores include overall reductions in availability, quantity, or quality of flying insects as a result of multiple factors, including pesticide use and climate change, that operate on breeding grounds, wintering grounds and migration (Spiller and Dettmers 2019). Throughout the species' range, agricultural intensification has resulted in extensive pesticide use, which might have pervasive effects on ecosystems (Spiller and Dettmers 2019). While long-term monitoring programs suggest very high adult survival for Eastern Wood-pewees, limited food resources can increase competition on migratory stopover sites (effect known as migratory bottleneck) and in turn reduce the breeding success of adults that return to the breeding grounds.

The Eastern Wood-pewee has very low productivity and recruitment¹², contributing to its population decline. The causes of low productivity and recruitment are unknown, but it has been hypothesized that habitat loss along the migration route may reduce breeding success (Bayly et al. 2017). Alternatively, factors on the breeding grounds may have reduced productivity (DeSante et al. 2015).

Additional potential threats to the Eastern Wood-pewee include habitat loss and degradation due to forestry practices, urban development, agricultural land conversion, and White-tailed Deer (*Odocoileus virginianus*) over-browsing. There is still much uncertainty in identifying the threats that have the largest impact on the species. The specific threats associated with these causes of declines are described in more detail below.

IUCN Threat 1.1 Housing and urban areas (Low Impact)

Increasing urbanization and fragmentation of forests across the Eastern Wood-pewee's annual range may reduce habitat availability for the species, and increase window collisions. This is particularly the case in southern Canada, where most development is concentrated. However, given that there is still ample unoccupied habitat available, the impact of this threat on the population was scored as low.

On the breeding grounds, Eastern Wood-pewees are less abundant in suburban and urban-embedded wooded areas than in natural forests (Beissinger and Osborne 1982) and may be completely absent from developed areas (Amrich and Coffin 1979). Suburban and urban wooded areas typically have less complex structure, with less vegetative cover; after development, the remaining wooded area often comprises of a

¹² Recruitment refers to the probability that a nestling will return to breed in the population in future years.

single canopy layer with no other vegetation at the middle and lower layers (Beissinger and Osborne 1982). This simple forest structure might not provide sufficient insect prey to be attractive habitat for the Eastern Wood-pewee.

Another impact of urbanization is habitat fragmentation. Since the Eastern Wood-pewee is an aerial insectivore that often forages in edge habitat, fragmentation of the forest may be less detrimental to the species than it is to interior forest specialists. The Eastern Wood-pewee may also be less susceptible to negative effects of forest fragmentation like brood parasitism and predator guilds of fragmented landscapes but parasitism rates vary across their breeding range (Kendrick et al. 2013). The Eastern Wood-pewee also appears to tolerate urban development and cottages surrounding their wooded habitat (Friesen et al. 1995; Mancke and Gavin 2000). However, the species is often less abundant in areas surrounded by more intense development (Friesen et al. 1995). During the spring migration, the species preferentially selects larger forest fragments as stopover sites (Keller and Yahner 2007).

Finally, glass windows constitute a collision hazard for Eastern Wood-pewees, especially in wooded residential areas (Hager et al. 2013). Although flycatchers are less vulnerable to window collisions than other bird guilds (Loss et al. 2014), Eastern Wood-pewees do infrequently strike glass windows (Hager and Craig 2014).

IUCN Threat 1.2 Commercial and industrial areas (Negligible Impact)

Commercial and industrial areas development have been deemed a negligible threat to the Eastern Wood-pewee. While the species tolerates disturbance to a certain extent, the development of commercial and industrial areas generally results in permanent loss of habitat. As discussed under “1.1 Housing and urban areas”, urbanization, including commercial and industrial areas, may reduce Eastern Wood-pewee abundance in the immediate vicinity and surrounding forests.

Glass windows in industrial areas present similar hazards as do windows in residential areas (see IUCN Threat 1.1).

IUCN Threat 2.1 Annual and perennial non-timber crops (Low Impact)

Converting forests to agricultural cropland reduces breeding and foraging habitat for the Eastern Wood-pewee. In Canada, conversion of forest to agriculture has declined by 70% between 1990 and 2016. During that period, Canada’s forest area has been stable (Natural Resources Canada 2018). In Ontario, where most of Canada’s Eastern Wood-pewees breed, 44% of farmland was abandoned between 1931 and 2011 as farmers shifted toward high intensity, high-yield farming (Smith 2015). In northeastern North America, much of this land has since reverted to forest habitat, contributing to the net stabilization of forest acreage across the Eastern Wood-pewee’s breeding range (Latendresse et al. 2008; Ramankutty et al. 2010; Masek et al. 2011). Therefore, the current level of forest loss to agricultural land use in Canada likely does not result in

substantial breeding habitat loss at the national scale, especially given the Eastern Wood-pewee's preference for open forest.

On the species' wintering grounds, tropical lowland forests are lost by about 0.8% annually (Armenteras et al. 2017). From 1990 to 2005, commercial and smallholder crops contributed to 16% of deforested area in South America (De Sy et al. 2015). Agricultural expansion was the most frequent driver of tropical lowland forest loss reported from 1980 to 2010 on the species' non-breeding grounds (Armenteras et al. 2017). Despite those declines, the tropical lowland forests of Ecuador, Peru, Brazil and Bolivia remained, as of 2010, the largest forest tracts in South America (Hansen et al. 2013).

Tropical lowland forests in Central America, where most Eastern Wood-pewees concentrate during fall and spring migrations, are under threat of deforestation from conversion to croplands (Redo et al. 2012; Armenteras et al. 2017). For example, in lowland Costa Rica, forest has been extensively cleared for pineapple monoculture plantations (N. Bayly, pers. comm. 2020). Deforestation rates are relatively high in most portions of the South American wintering range, and comparatively lower through most of the migratory route through Central America (Armenteras et al. 2017).

Conversion of tropical lowland forests may negatively impact the Eastern Wood-pewee. Geography constrains migration for neotropical landbirds, including Eastern Wood-pewees, in Panama and Costa Rica, leading to significant concentrations of populations (Bayly et al. 2017). High densities of migrating birds increases competition at stopover sites (i.e. migratory bottleneck), resulting in lower survival of less experienced individuals, and can result in lower feeding rates that carry over into lower productivity in the following season (Baker et al. 2004). While Panama and Costa Rica as a whole do not have high rates of deforestation (Armenteras et al. 2017), some local areas have been identified as hot spots for deforestation resulting from conversion to croplands or pastures, which may affect migrants (Wassenaar et al. 2007).

While the Eastern Wood-pewee use the habitat interface between agricultural land and forest, ongoing encroachment of agricultural land due to conversion to croplands or pastures is expected to reduce the amount of suitable habitat for the species. The impact of annual and perennial non-timber crops on Eastern Wood-pewee populations is currently low. However, this threat could become more important as land-use changes on the non-breeding grounds, with possible disproportionate effects if important stopover areas are lost.

IUCN Threat 2.3 Livestock farming and ranching (Low Impact)

Ranching primarily threatens the Eastern Wood-pewee when ranchers convert forest habitat into pastures. As in the case of annual and perennial non-timber crops, conversion to pastures has largely ceased in the species' breeding range (Masek et al. 2011) but the threat is ongoing on the migration and wintering ranges (Armenteras et al. 2017). From 1990 to 2005, conversion to pastureland contributed to 71% of deforested

area in South America (De Sy et al. 2015). The deforestation rate in northern South America is higher than in Central America, largely driven by Ecuador (2.19% per year) and Colombia (1.7% per year; Armenteras et al. 2017).

Pastures do not provide habitat for Eastern Wood-pewees and when pasture fragments wooded habitat, Eastern Wood-pewees preferentially use larger forest patches (Keller and Yahner 2007). Though the Eastern Wood-pewee primarily uses the edge habitat between pastures and forest, ongoing encroachment from pastures on the wintering range is expected to reduce the amount of suitable habitat for the species. Wooded pastures may be less detrimental than open rangeland, functioning more like a small woodlot that provides some habitat. In addition, deforestation to create pastures can be the first step of agricultural intensification, as pasture lands are often converted into croplands (Wassenaar et al. 2007; Gasparri and de Waroux 2015; Cohn et al. 2016). Currently, livestock farming and ranching are deemed to have a low impact on the species, given the species' ability to move to unaffected areas. This threat could become more important as land-use changes increase on the non-breeding grounds, with possible disproportionate effects if important stopover areas are lost. More research is needed to evaluate the effect of ranching practices and land-use changes on the species' non-breeding grounds.

IUCN Threat 4.1 Roads and railroads (Negligible Impact)

Roads and railroads likely have a negligible impact on the Eastern Wood-pewee. Across the species' breeding range in Canada, the road network is already well established. The species appears to be at limited risk of collisions with vehicles (Ashley and Robinson 1996; Bishop and Brogan 2013). Traffic volume might increase in some areas, but this canopy species is unlikely to collide with vehicles.

Some new road development is expected to encroach on Eastern Wood-pewee undisturbed habitat (including new forestry access roads). Regardless, Eastern Wood-pewees are likely displaced from habitats near roads (COSEWIC 2012). The species likely avoids roads because road noise may hinder songbirds' territory defense, mate acquisition, and breeding success. The Eastern Wood-pewee's song is innate, but they can adjust their song slightly by singing higher and shorter songs when there is lots of road noise (Gentry et al. 2018). Adjusting their song may help Eastern Wood-pewees mitigate some of the potential impacts of roads.

IUCN Threat 5.3 Logging and wood harvesting (Negligible Impact)

The impact of logging and wood harvesting on the Eastern Wood-pewee is currently negligible; however, an important proportion (11–30%) of the population might be exposed to this threat. Canada's forest area has been stable since 1990, with less than half of 1% being converted to non-forest (Natural Resources Canada 2020). However, despite little change in overall forest cover, loss of old forest and increases in less diverse monoculture tree plantations has resulted in breeding habitat loss for many

forest bird species in eastern Canada, including Eastern Wood-pewee (Betts et al. 2021).

Depending on the stand composition and the extent of canopy removal, selective or partial harvest in hardwood or mixed wood stands may provide short-term benefits by opening the canopy and increasing foraging opportunities. These benefits disappear over time as the understory responds to the increased light and reaches a density or height that interferes with foraging activity. Forestry practices in the breeding and non-breeding ground affect Eastern Wood-pewee habitat, though most of the research into their impacts has been conducted on the breeding ground.

The Eastern Wood-pewee is absent from large clearcut areas (King and DeGraaf 2000). It has been shown that abundance was slightly elevated in smaller clearcuts compared to mature forest for the first 8 years following clearcutting and 12 years after harvest had comparable densities to mature forest (Perry et al. 2018). This is likely because in areas where a section of the forest is clearcut while other sections remain intact, Eastern Wood-pewees will perch in the wooded edges and sally out into the clearcut to catch insects (Strelke and Dickson 1980).

Shelterwood harvesting involves harvesting a portion of the mature trees, which provides light to seedlings that will provide the next harvest. The open canopy created by shelterwood harvesting temporarily allows for aerial foraging, until understory growth becomes too dense for the Eastern Wood-pewee to forage. After shelterwood harvesting, the Eastern Wood-pewee has similar nesting success at these sites compared to neighbouring unharvested forests (Newell and Rodewald 2012). The species may also be more abundant in shelterwood systems in the initial years post-harvest (Duguid et al. 2016; King and DeGraaf 2000; Perry et al. 2018). However, as shelterwood forest blocks age, the seedlings grow quickly in response to the extra light and the understory becomes dense. By 12 years into the rotation, Eastern Wood-pewee abundance is lower in shelterwood forests than in unharvested forests (Augenfeld et al. 2008).

Selective harvesting, where foresters harvest trees singly or in small groups and leave the rest of the stand untouched, attempts to mimic natural tree-fall gaps as the forest ages. As usual, the Eastern Wood-pewee's response to selective harvesting is driven by its need for open forest for aerial foraging. For the first 5-8 years after selective harvesting, Eastern Wood-pewee abundance may be equivalent or even higher in selectively harvested compared to unharvested forests, depending on whether or not the unharvested forests was initially open and conducive to hawking or sallying (Jobes et al. 2004; Heltzel and Leberg 2006; Holmes and Pitt 2007; Perry et al. 2018). However, by 15 years after selective harvesting, densities are lower in harvested forests (Flaspohler et al. 2002; Jobes et al. 2004; Heltzel and Leberg 2006 but see Perry et al. 2018). This is likely because the extra light selective harvesting provides to the forest floor causes the understory to grow more densely.

On the breeding grounds, selective cutting, which provides suitable habitat, is the dominant harvesting method (Masek et al. 2011). However, in the Maritimes, clearcutting is common on both public and private land. Within the species' breeding range in Canada, managed forests under private tenure make up a greater proportion of available habitat than Crown-owned forests, particularly in the Maritime Provinces (National Forest Inventory 2016; CCFM-CCMF 2019). The impact of private landownership on the species depends on whether or not landowners choose to actively manage their forest and the type of harvest approach they employ, while forestry operations on Crown-owned forests must adhere to forest management plans. Provincial forest management plans, while not specific to Eastern Wood-pewee, specify wildlife habitat criteria.

On the non-breeding grounds, about 0.8% of Eastern Wood-pewee forest habitat is lost annually, which represents about half of the deforestation rate compared to other forest types (Armenteras et al. 2017). Forestry was associated with 8% of cases of deforestation in the tropical lowland forest; however, Armenteras et al. (2017) did not consider reforestation that generally follows forestry activities. While forestry occurs on the non-breeding grounds, it is not always associated with a permanent loss of habitat. Since the species is often found in shrubby habitats, edges, or clearings during the winter, it may be more tolerant of some forestry activities than other species (Fitzpatrick 1980; Stotz et al. 1992; Watt et al. 2017). Research is needed to quantify the rate of habitat change and the types of forestry practices on the Eastern Wood-pewee wintering grounds. The overall impact of the forestry sector on the Eastern Wood-pewee largely depends on whether forestry practices support suitable or unsuitable habitat for the species.

IUCN Threat 7.3 Other ecosystem modifications (Medium Impact)

This threat category is intended to capture indirect effects of ecosystem modifications, such as invasive species affecting Eastern Wood-pewee habitat or human-caused reductions in their food resources. Direct effects of these threats to the species, such as habitat loss, would be captured under their corresponding threat categories.

Reduction of insect prey availability

The Eastern Wood-pewee is amongst other avian aerial insectivores that have collectively declined since the 1970s (Nebel et al. 2010; Smith et al. 2015; Michel et al. 2016). While it is unknown why avian aerial insectivores are declining, the temporal and spatial synchrony (ie, the similar trajectories) of the decline suggests that their reliance on flying insects puts them at risk (Nebel et al. 2010). Long-term insect data is scarce but about 40% of insect species have declined worldwide over the last 40 years; many of these declines began as early as the 1950s and continue to present day (Sánchez-Bayo and Wyckhuys 2019). Declining insect populations have almost certainly resulted in reduced food availability for birds reliant on flying insects (e.g., English et al. 2018), such as the Eastern Wood-pewee.

There are many possible—and non-mutually exclusive—causes of insect declines. Insect declines, and potential association with aerial insectivore declines, have been linked to agricultural intensification and increasing insecticide use, habitat loss, decreased resource diversity, extreme weather events, and warming climate (Benton et al. 2002; Rioux Paquette et al. 2013; Hallmann et al. 2014; Bellavance et al. 2018; Spiller and Detters 2019). For forest insectivores, insecticides used to control forest pests such as the Gypsy Moth (*Lymantria dispar dispar*) could have a short-term impact on prey availability (Awkerman et al. 2011), but limited or no persistent impacts (Yahner et al. 1985; Scriber 2004; Manderino et al. 2014). Another indirect driver of reduced insect prey population is urbanization, which is associated with wetland drainage, application of pesticides for mosquito control, and application of herbicides for cosmetic purposes.

On the Eastern Wood-pewee's wintering ground and on migration, conversion of primary rainforest and former pastures (i.e., regenerating or shrubby areas) to large monocultures results in habitat loss, increased insecticide use and less rainfall (Lawrence and Vandecar 2015; Salazar et al. 2015). These consequences of agricultural intensification likely interact to reduce prey abundance. In northern Colombia, an area where Eastern Wood-pewees commonly forage before beginning their spring migration, banana plantations are sprayed extensively with pesticides (N. Bayly, pers. comm. 2020). Similarly, lowland forests of Costa Rica have been converted to pineapple monocultures, where pesticides are used to control pest species (N. Bayly, pers. comm. 2020). In stopover areas where large numbers of Eastern Wood-pewee concentrate to gather sufficient energy reserves to pursue their migration, such as the Caribbean slopes of Costa Rica, Panama and Colombia, limited food resources can have negative and disproportionate effects on the population (Bayly et al. 2017). Possible effects include increased competition for resources, lower survival rates, and lower productivity if second year birds return to breeding grounds either too late or with insufficient energetic reserves.

Climate change may also create a mismatch between peak insect abundance and food demands by Eastern Wood-pewee nestlings, as has been seen in other insectivorous birds (e.g., Visser et al. 2006; Imlay et al. 2018). Visser et al. (2006) found an increasing mismatch over 20 years between the peak date in caterpillar biomass and egg laying date of the Great Tit (*Parus major*) in a mixed woodland of the Netherlands. In New Brunswick, Imlay et al. (2018) found decreased reproductive success in Bank Swallows, but not in Barn, Tree and Cliff swallows, the latter having adapted egg laying dates in relation to peak insect abundance over time. In addition, rainier spring weather caused by climate change may cause food shortages during critical nesting periods, as these flying insects are not active in wet, rainy weather (Imlay et al. 2018; Cox et al. 2019). It is unknown whether the reproductive success in relation to the timing of food availability has changed over time for the Eastern Wood-pewee.

The Eastern Wood-pewee population decline might be driven by a combination of factors, including the effects of insect declines, which operate on breeding grounds,

wintering grounds and migration stopovers, and through carry-over effects between those periods.

Acid rain

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 consequence, other insectivorous birds have been found to be less common (Graveland 1998). Additionally, one side effect of acid rain is lower calcium availability in the area. Because birds use calcium to build their eggshells, acid rain and the resulting calcium deficiency in their diet lowers breeding success of some insectivorous birds (Graveland 1998).

Changes in forest structure

In the core of the Eastern Wood-pewee's breeding range, White-tailed Deer populations have increased dramatically since the 1950s. In north-central and northeastern United States, current populations are thought to have grown to 2-4 times that of pre-European settlement populations, with average densities greater than 3 deer per km² (Russell et al. 2001). On the northeastern limit of Eastern Wood-pewee's range in Quebec, deer densities were above 5 deer per km² in most survey areas (Huot and Lebel 2012). In Nova Scotia, less than 1% of survey locations had deer densities in excess of 8 deer per km² (M. McGarrigle, pers. comm. 2021). In other areas of the Canadian range, deer density may be lower or deer may even be absent (e.g., Prince Edward Island). In those areas, foraging habitat might become overgrown and unsuitable for the species in the absence of other natural disturbances or understory thinning. Over-browsing, particularly on seedlings and saplings, has eliminated the forest understory in some areas and slows forest succession (Russell et al. 2001). While an open understory might fulfill the Eastern Wood-pewee's structural habitat needs in the short term, long-term decreases in understory composition and density could have negative effects (DeGraaf et al. 1991; deCalesta 1994; COSEWIC 2012). In one study where enclosures maintained a gradient of deer densities for 10 years in the Pennsylvania hardwood forest, Eastern Wood-pewee was absent from enclosures with more than 7.9 deer per km² (deCalesta 1994). Generally, birds that nest in the intermediate canopy, like the Eastern Wood-pewee, declined linearly with increasing White-tailed Deer abundance due to the removal of subcanopy foraging habitat (deCalesta 1994). Whether over-browsing affects other types of forests similarly is unclear since Eastern Wood-pewees often benefit from more open forest and little understory vegetation.

Multiple non-native pests and diseases harm Canadian forests in the Eastern Wood-pewee's range, including Emerald Ash Borer (*Agilus planipennis*), Pine Shoot Beetle (*Tomicus piniperda*), Hemlock Woolly Adelgid (*Adelges tsugae*), Beech Bark disease, Butternut Canker, and sudden oak death. Not yet present in Canada, oak wilt is a fungus disease found in U.S. states near the Canadian border. The disease causes foliage to wilt and infected trees to die (French and Stienstra 1980). Long-term declines

in Eastern Wood-pewee relative abundance have been observed in areas affected by oak wilt and Dutch elm disease (Ambuel and Temple 1982). The effects on Eastern Wood-pewee populations are still unknown but as these pests and diseases affect forest cover and composition, they will likely impact bird populations. Those diseases could have reduced the suitability of the Eastern Wood-pewee's breeding habitat if they reduce the health of canopy trees, causing the canopy to open and the understory to grow dense. However, these effects may not be all negative. For example, following Hemlock Woolly Adelgid infection, Eastern Wood-pewee densities increased in areas with high tree mortality where the dieback caused by disease opened areas for foraging (Tingley et al. 2002). These benefits are likely short-term.

Multiple contributing factors can result in ecosystem modifications that negatively affect the Eastern Wood-pewee. Cumulatively, these threats likely have a medium impact on the species, with the pervasive reduction of insect prey availability being the most important.

IUCN Threat 11.5 Severe/extreme weather events (Unknown Impact)

Climate change increases storm severity and frequency. Severe storms are linked to migrant songbird decline, particularly for species whose migration takes them across the ocean because they cannot take shelter (Butler 2000). Although some Eastern Wood-pewees migrate across the Gulf of Mexico, most migrate overland through Central America (Watt et al. 2017).

Severe weather events, such as high winds, heavy precipitation or extreme temperatures, can disrupt the ability of aerial insectivores to forage or temporarily reduce the availability of airborne invertebrate preys (Grüebler et al. 2008; Møller 2013; Cox et al. 2019). During cold or rainy weather, aerial insectivores may need to travel longer distances during foraging bouts before returning to the nest (Turner 1980), therefore reducing on a daily basis the amount of food provided to nestlings. The impact of severe weather events on the species is unknown.

5. Management Objective

The management objectives for the Eastern Wood-pewee in Canada are:

- achieve a stable¹³ or increasing population trend in the short-term (by 2032)
- maintain, at a minimum, a stable population trend in the long-term (beyond 2032), and
- maintain a stable or increased geographic distribution, as shown in Figure 1.

The 10-year trend was deemed appropriate to assess population changes in the Eastern Wood-pewee because it corresponds to approximately three generations

¹³ A trend will be considered stable when the 95% confidence/credible intervals around the estimate include zero.

(COSEWIC 2012). The management objective aligns with the COSEWIC criteria for species' assessment that includes reviewing population change within 10 year windows, which will be due in 2032. In addition, the BBS provides reliable estimates of the Eastern Wood-pewee population trend for Canada and provinces using a 10-year timeframe.

An objective based on the population trend was selected over a population size goal given the high variability in available population estimates, compared to the higher reliability of BBS population trends. Additionally, the species' reason for designation as Special Concern was based on declining population trend, not population size.

This management objective should be achieved while maintaining a stable or increased geographic distribution in Canada. Climate change is not expected to prevent this objective from being achievable as favourable climatic conditions for the species are likely to substantially expand the species' breeding range in Ontario and Quebec, and possibly into Newfoundland and Labrador (Bateman et al. 2020).

This management objective recognizes that there are currently adequate numbers of individuals in Canada (360,000) to maintain a breeding population. Considering that only 5.5% of this species' population breeds in Canada, achieving this goal will only be possible through strong collaboration with Canada's international partners on breeding grounds, wintering grounds and migration stopover sites.

6. Broad Strategies and Conservation Measures

6.1. Actions Already Completed or Currently Underway

In Canada, 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, to give context to the broad strategies outlined in section 6.3. Actions completed or underway include the following:

- The Institute for Bird Populations has produced estimates of demographic parameters, including recruitment, adult survival probability, productivity, and post-breeding effects, from data collected from 1992 to 2006 through the Monitoring of Avian Productivity and Survival (MAPS) program (DeSante et al. 2015). Based on those estimates, the following research and monitoring priorities are provided *verbatim* from DeSante et al. (2015):
 - “Determining and addressing habitat conditions on the non-breeding grounds, particularly on the South American wintering grounds, that promote higher survival of adult birds”;
 - “Determining habitat types and characteristics on the breeding grounds that promote overall high productivity”; and

- 894 ○ “Determining habitat types and characteristics on the non-breeding grounds
895 that promote high first-year survival of young birds, especially in regions
896 where low survival of young may contribute to population declines.”
- 897 • International forest certification systems applied in Canada that require addressing
898 threats to species at risk:
- 899 ○ Canadian Standards Association (CSA),
900 ○ Forest Stewardship Council (FSC), and
901 ○ Sustainable Forestry Initiative (SFI).
- 902 • The Ontario Ministry of Natural Resources (2011) published “A land manager’s
903 guide to conserving habitat for forest birds in southern Ontario” which recommends
904 practices beneficial for the Eastern Wood-pewee:
- 905 ○ group or single tree selection systems as preferred forest harvesting
906 methods,
907 ○ Maintenance of large tracts of intermediate aged forests, with some small
908 clearings (See Section 3.3 Needs of the Eastern Wood-pewee),
909 ○ Managing deer densities to be less than 8 deer/km².
- 910 • Ontario’s Managed Forest Tax Incentive Program financially encourages landowners
911 to create 10-year Managed Forest Plans for their woodlots.
- 912 • Birds Canada has been engaging private and public landowners to conserve
913 woodlots in Southwestern Ontario’s Carolinian Forest Region to protect four
914 endangered forest birds. These conservation efforts might indirectly benefit the
915 Eastern Wood-pewee.
- 916 • A bird-friendly building design standard (CSA A460:19) has been developed to
917 reduce the risk of collision of birds with windows. The Standard provides bird-friendly
918 design requirements for glazing, building-integrated structures, and overall building
919 and site design.
- 920 • Parks Canada multi-species action plans identify recovery measures specific to
921 national parks and national heritage places where species at risk occur (for a list of
922 current multi-species action plans including the Eastern Wood-pewee, refer to the
923 documents section of the SAR Public Registry).
- 924 Several conservation-oriented monitoring and research projects have been
925 implemented in Canada and the United States provide information on the Eastern
926 Wood-pewee population. These include the following groups and/or projects:
- 927 • [The Breeding Bird Survey](#)
928 • [The Boreal Avian Monitoring Project](#)

- 929 • [The Ontario Forest Bird Monitoring Program](#)
- 930 • [Breeding Bird Atlases \(and associated rare species reports\)](#)
- 931 • [eBird](#)
- 932 • [Project NestWatch](#), which provides information on the nesting phenology of the
933 species (Rousseu and Drolet 2017)
- 934 • The [Canadian Migration Monitoring Network](#)
- 935 • The [SOS-POP program](#) [in French only] in Quebec.

936

937 **6.2. Broad Strategies**

938 The mechanisms contributing to population declines remain unclear, driving the need
939 for investigation on the species' migratory ecology and habitat use, especially on
940 migration stopovers and on wintering grounds. Strategies fall under the following broad
941 categories¹⁴.

- 942 • Institutional Development
- 943 • Conservation Designation & Planning
- 944 • Livelihood, Economic & Moral Incentives
- 945 • Research & Monitoring

946

¹⁴ The broad strategy categories follow the International Union for Conservation of Nature – Conservation Measures Partnership (IUCN-CMP) [Conservation Actions Classification v2.0](#).

6.3. Conservation Measures

Table 4. Conservation Measures and Implementation Schedule

Conservation Measure	Priority ^a	Threats or Concerns Addressed	Timeline
Broad Strategy: Institutional Development			
Alliance & Partnership Development Develop new international partnerships and maintain existing partnerships to support conservation efforts of Eastern Wood-pewee and their habitat, especially in areas with high deforestation rates.	High	All	2023-2028 (for new); Ongoing (for existing)
Alliance & Partnership Development In areas of the Canadian breeding grounds with high deer densities, engage with provincial wildlife management agencies to implement deer management to prevent deer densities that are detrimental to the Eastern Wood-pewee's habitat.	Low	IUCN Threat 7.3	Ongoing
Broad Strategy: Conservation Designation & Planning			
Conservation Planning Develop policies and broad conservation measures addressing common drivers of aerial insectivore declines.	High	IUCN Threat 7.3	2023-2028
Protected Area Designation &/or Acquisition On breeding grounds, continue to protect large tracts of contiguous forest habitat where possible.	Medium	IUCN Threats 1.1, 1.2, 2.1, 2.3, 4.1, 4.2, 5.3, and 7.3	Ongoing
Broad Strategy: Livelihood, Economic & Moral Incentives			
Forestry Management - On the breeding grounds, use stewardship programs to incentivize compatible woodlot management and forest conservation on private lands. - On the breeding grounds, incorporate co Eastern Wood-pewee habitat needs in forest management planning on public lands, where ecologically appropriate.	Medium	IUCN Threats 1.1, 1.2, 1.3, 2.3, 4.1, 4.2, 5.3, and 7.3	2028-2033
Better Products & Management Practices Support the development and use of affordable and effective window designs and/or applications to reduce mortality from bird strikes.	Low	IUCN Threats 1.1 and 1.2	Ongoing
Broad Strategy: Research & Monitoring			
Basic Research & Status Monitoring Determine key demographic parameter estimates and possible carry-over effects of habitat conditions throughout the annual cycle.	High	Knowledge gap	2023-2028
Basic Research & Status Monitoring Determine key wintering areas, migratory stopover sites, and migratory connectivity between breeding grounds and non-breeding grounds.	High	Knowledge gap	2023-2028

Conservation Measure	Priority ^a	Threats or Concerns Addressed	Timeline
Basic Research & Status Monitoring Determine the role of pesticides, climate change and other threats on habitat condition, particularly insect availability (abundance and quality).	High	IUCN Threat 7.3	2028-2033
Basic Research & Status Monitoring Determine the habitat types and characteristics on the non-breeding grounds that promote high first-year survival of young birds.	High	Knowledge gap	2028-2033
Basic Research & Status Monitoring Determine the habitat types and characteristics on the non-breeding grounds that promote high survival of adult birds.	Moderate	Knowledge gap	2028-2033
Basic Research & Status Monitoring On breeding grounds, determine the habitat conditions that promote high productivity.	Moderate	Knowledge gap	2028-2033
Basic Research & Status Monitoring Monitor progression of oak wilt disease in southern Canada and, as needed, evaluate the effects of this tree disease on the Eastern Wood-pewee breeding population.	Low	IUCN Threat 7.3	Ongoing
Basic Research & Status Monitoring Determine extent of the species' current exposure and the effects of insecticides and other pesticides on the species and their food availability.	Low	IUCN Threat 7.3	2028-2033

^a "Priority" reflects the degree to which the measure contributes directly to the conservation of the species or is an essential precursor to a measure that contributes to the conservation of the species. High priority measures are considered those most likely to have an immediate and/or direct influence on attaining the management objective for the species. Medium priority measures may have a less immediate or less direct influence on reaching the management objective, but are still important for the management of the population. Low priority conservation measures will likely have an indirect or gradual influence on reaching the management objective. Measures are considered important contributions to the address knowledge gaps and foster habitat stewardship and citizen science.

6.4. Narrative to Support Conservation Measures and Implementation Schedule

Management of the Eastern Wood-pewee will require commitment, collaboration, and cooperation among international, federal, provincial and municipal jurisdictions, Indigenous people, landowners, industry, and other interested parties. In addition, identifying key threats to the population of Eastern Wood-pewee and determining the relative importance of nonbreeding versus breeding periods of the species' annual life-cycle are essential components of this management plan. Owing to the Eastern Wood-pewee's widespread range, it will be important to monitor habitat conditions, population trends, and the distribution of the species so that the effectiveness of the management efforts can be evaluated and adjusted as necessary.

971 *Institutional Development and Conservation Designation & Planning*

972 Aerial insectivores are in decline across Canada (McCracken 2008, Nebel et al. 2010,
 973 North American Bird Conservation Initiative 2019). The current state of science
 974 indicates that multiple factors acting across the breeding and non-breeding areas could
 975 be driving the population declines of aerial insectivores (Spiller and Dettmers 2019).
 976 Given the generalized decline of aerial insectivores and the spatial synchrony of some
 977 of the declines, broad conservation measures and policies addressing common drivers
 978 of decline could be an effective approach for the conservation of Eastern Wood-pewee
 979 and other species. This will require building and maintaining strong partnerships with
 980 international partners across the species breeding and non-breeding range.

981 Breeding habitat is unlikely to be limiting in Canada. Nevertheless, adequate breeding
 982 habitat must be managed and protected to ensure the conservation of this species,
 983 particularly in areas where habitat is vulnerable to being lost or degraded due to human
 984 activities such as unsustainable forest management practices and urban development.
 985 These approaches are especially important in areas showing the greatest declines. In
 986 provinces where high deer densities negatively affect suitable breeding habitat,
 987 engaging with provincial wildlife management agencies to encourage deer harvest and
 988 management to promote lower deer densities could be beneficial. In addition,
 989 developing new international partnerships and maintain existing partnerships will
 990 support conservation efforts of Eastern Wood-pewee and their habitat, especially in
 991 areas with high deforestation rates.

992 Wintering habitat is unlikely to be limiting due to the species ecological flexibility, where
 993 large tracts of favourable habitat remain available for the Eastern Wood-pewee. In
 994 contrast, there are notable areas used by the species during migration that have
 995 undergone severe habitat loss (e.g., the Caribbean lowlands of Colombia, the
 996 Caribbean lowlands of Costa Rica and possibly the most dramatic, the Caribbean
 997 lowlands of Nicaragua). The expansion of annual and perennial non-timber crops, and
 998 logging and wood harvesting are the main drivers of deforestation in those regions. It
 999 will be critical to work with local organizations to maintain remaining forest habitat.

1000 *Livelihood, Economic & Moral Incentives*

1001 The Eastern Wood-pewee needs open, high-canopy savannah¹⁵, woodland, or forest
 1002 habitat to thrive. As the species uses various forest types and tolerates moderate levels
 1003 of disturbance, fragmentation, and wood harvest, most wooded habitat is suitable.
 1004 Incentivizing private landowners to manage their woodlots in a manner that is beneficial
 1005 to the species and conserving large tracts of primary forest will continue to provide
 1006 forest habitat for the species.

1007 Voluntary private sector standards and codes may help reduce some of the threats
 1008 faced by the species and its prey. These include third-party sustainable forest

¹⁵ A high-canopy savannah is a mixed woodland-grassland ecosystem characterised by the trees being sufficiently widely spaced so that the canopy does not close. The open canopy allows sufficient light to reach the ground to support an unbroken herbaceous layer consisting primarily of grasses.

management certification and international rating systems that recognize excellence for green building. Public lands should also adopt bird-friendly forestry practices that maintain mature trees on the breeding grounds (e.g., shelterwood or selective harvest). The ongoing provincial regulatory process offers an avenue for ensuring Eastern Wood-pewee habitat is incorporated in the management of public forests, given that the provinces are largely responsible for forestry regulation. Whenever possible, forest management should engage with Indigenous natural resource managers and communities to implement measures to preserve the species and its habitat.

Research & Monitoring

It is unclear to what extent threats in Canada are affecting the overall population decline of Eastern Wood-pewee, or whether threats are occurring elsewhere during another part of the species' annual cycle. A comprehensive approach to research and monitoring (which includes all stages of the annual life cycle and the entire range of occupancy) will be required to understand the status of the species, as well as its threats and limiting factors in Canada and beyond. Based on analyses conducted from data collected through the MAPS program, the two important vital rates that were found to drive Eastern Wood-pewee population change are adult survival and productivity (see section 3.2). Further studies to understand the habitat and landscape characteristics that promote high adult survival in non-breeding areas, and high productivity in breeding areas, will help to focus conservation efforts and will help to understand the underlying threats that affect these rates.

To better understand whether maintaining, and/or restoring insect-producing habitats will significantly benefit Eastern Wood-pewee populations, it would be beneficial to understand how insect prey population dynamics are affecting aerial insectivore populations (e.g., due to their decline, a time shift in occurrence, or, weather related unavailability). The effects of forest pests and diseases, and associated control measures in North America on Eastern Wood-pewee habitat and insect prey must be better understood. Beneficial practices for managing forest pests and diseases should be informed by research into the extent of the species' current exposure and the effects of insecticides and other pesticides on the species and their food availability.

There are no known monitoring programs established on the wintering grounds that targets the Eastern Wood-pewee or the nearly indistinguishable Western Wood-pewee. In contrast, migration routes, key stopover sites and staging regions in Central America and northern Colombia were identified from standardized monitoring conducted through the Neotropical Flyways Project. Increasing monitoring on the non-breeding grounds would provide better information on key migration and wintering areas for the Eastern Wood-pewee.

7. Measuring Progress

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 2032, the population trend of the Eastern Wood-pewee in Canada is stable or positive, as measured by the Breeding Bird Survey over the previous 30 year period (2002-2032)
- By 2032, the geographic distribution of the Eastern Wood-pewee is maintained or increased within Canada, as shown in Figure 1.

The management objective will be assessed based on the 10-year population trend from the BBS for the period ending in 2032.

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Appendix A: Effects on the Environment and Other Species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the [*Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*](#)¹⁶. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or any of the [*Federal Sustainable Development Strategy*](#)'s¹⁷ (FSDS) goals and targets.

Conservation planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that implementation of management plans may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the management plan itself but are also summarized below in this statement.

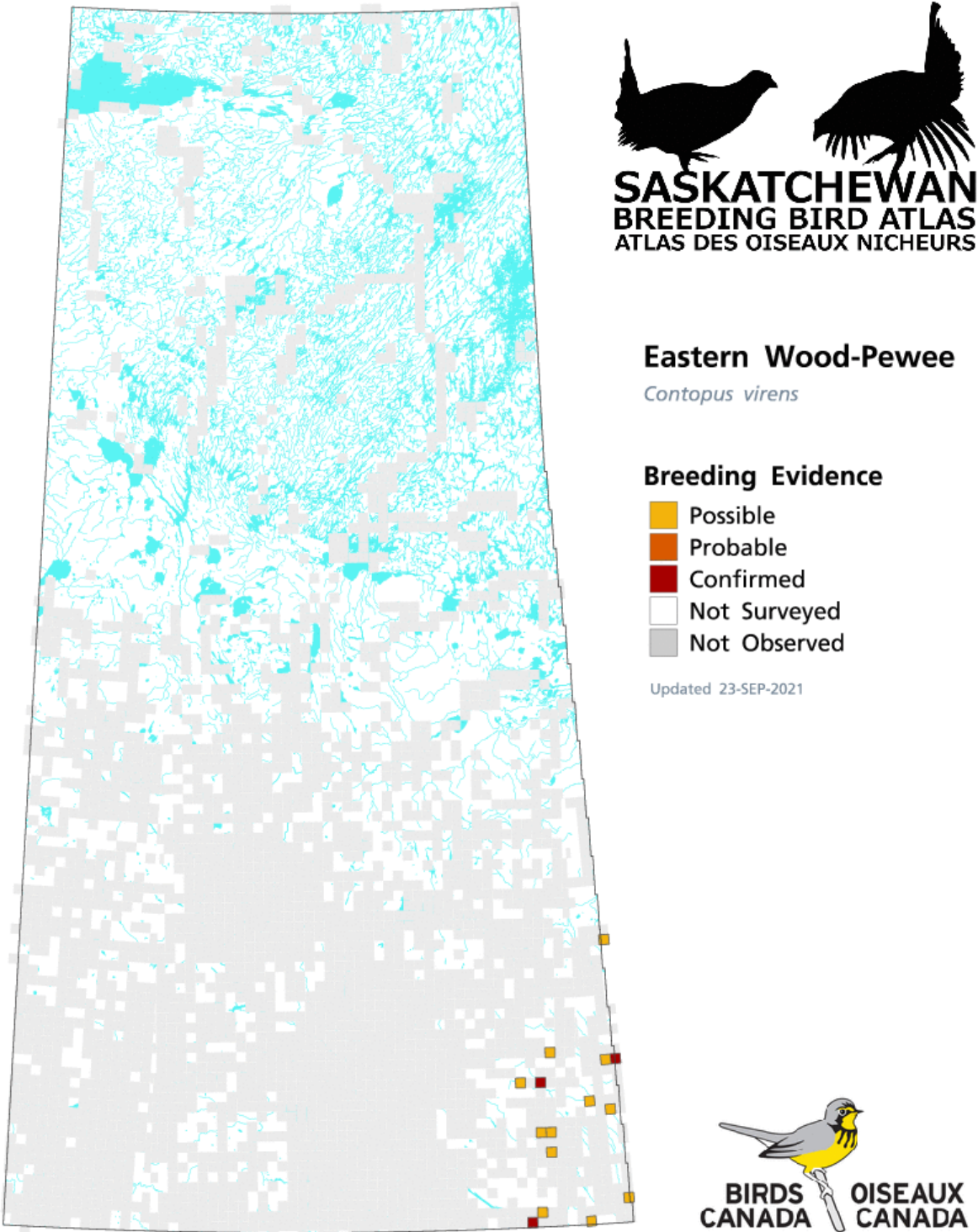
Activities that benefit the Eastern Wood-pewee likely benefit a large suite of forest fauna. In Canada, conservation measures aimed at conserving forests on the breeding grounds are expected to alleviate threats to other forest birds, particularly birds that forage in open areas. Examples include Acadian Flycatcher (*Empidonax virescens*), Cerulean Warbler (*Setophaga cerulea*), Eastern Whip-poor-will (*Antrostomus vociferus*), and Wood Thrush (*Hylocichla mustelina*). Although arguably not beneficial to the White-tailed Deer populations, their management will benefit Eastern Wood-pewee and other forest fauna. On the wintering grounds, Eastern and Western Wood-pewees ranges overlap, so the identification of habitat characteristics and threats to the Eastern Wood-pewee over winter will benefit the Western Wood-pewee as well.

¹⁶ www.canada.ca/en/impact-assessment-agency/programs/strategic-environmental-assessment/cabinet-directive-environmental-assessment-policy-plan-program-proposals.html

¹⁷ www.fsds-sfdd.ca/index.html#/en/goals/

Appendix B: Breeding Bird Atlas Maps

The Breeding Bird Atlases from Saskatchewan, Manitoba, Ontario, Quebec, and the Maritimes provide detailed maps of the breeding distribution of the Eastern Wood-pewee in Canada.



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Figure B1: Eastern Wood-pewee breeding evidence during 2017-2020 from the Saskatchewan Breeding Bird Atlas (Birds Canada 2021).

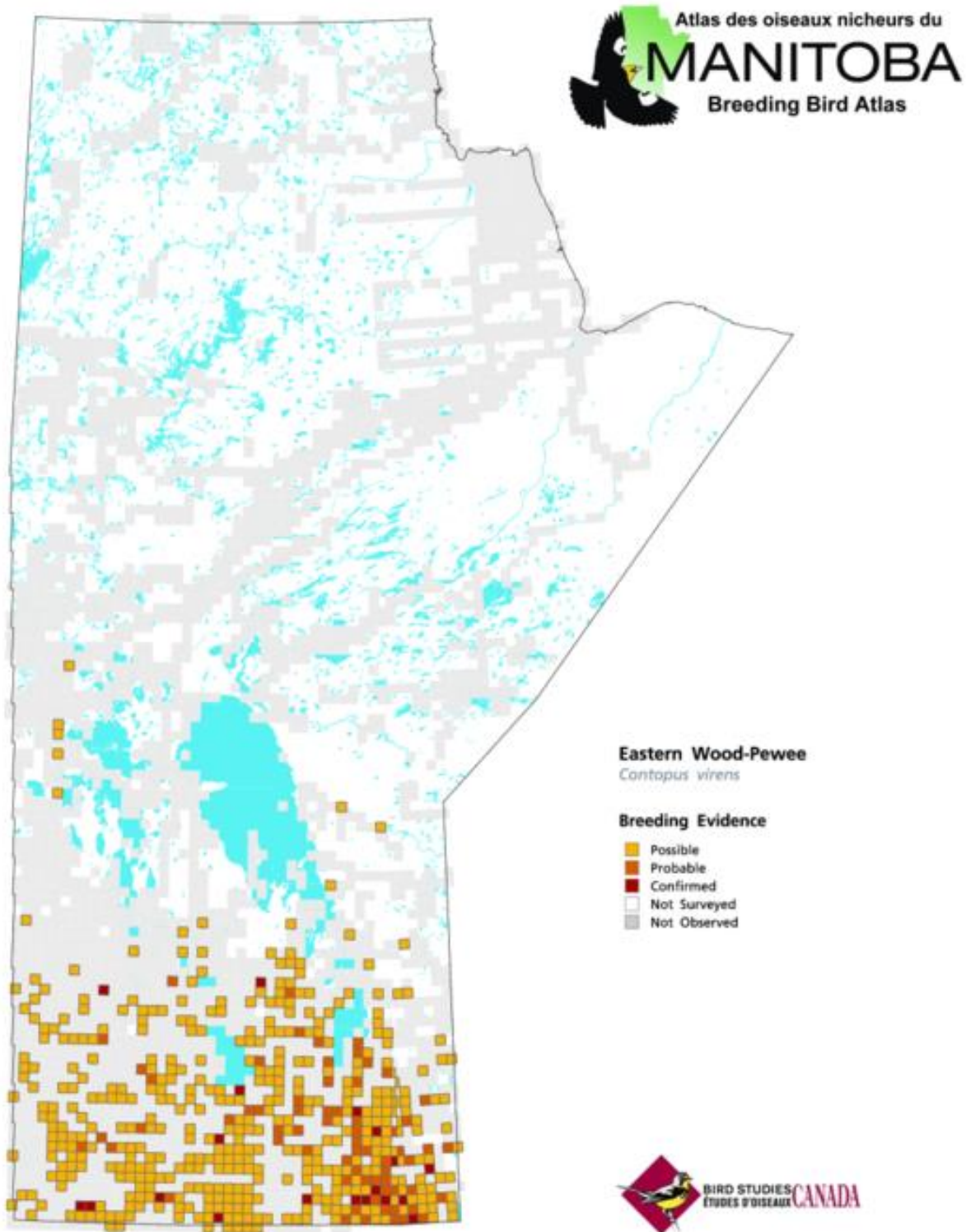


Figure B2: Eastern Wood-pewee breeding evidence during 2010-2014 from the Second Atlas of the Breeding Birds of Manitoba (Artuso 2018).

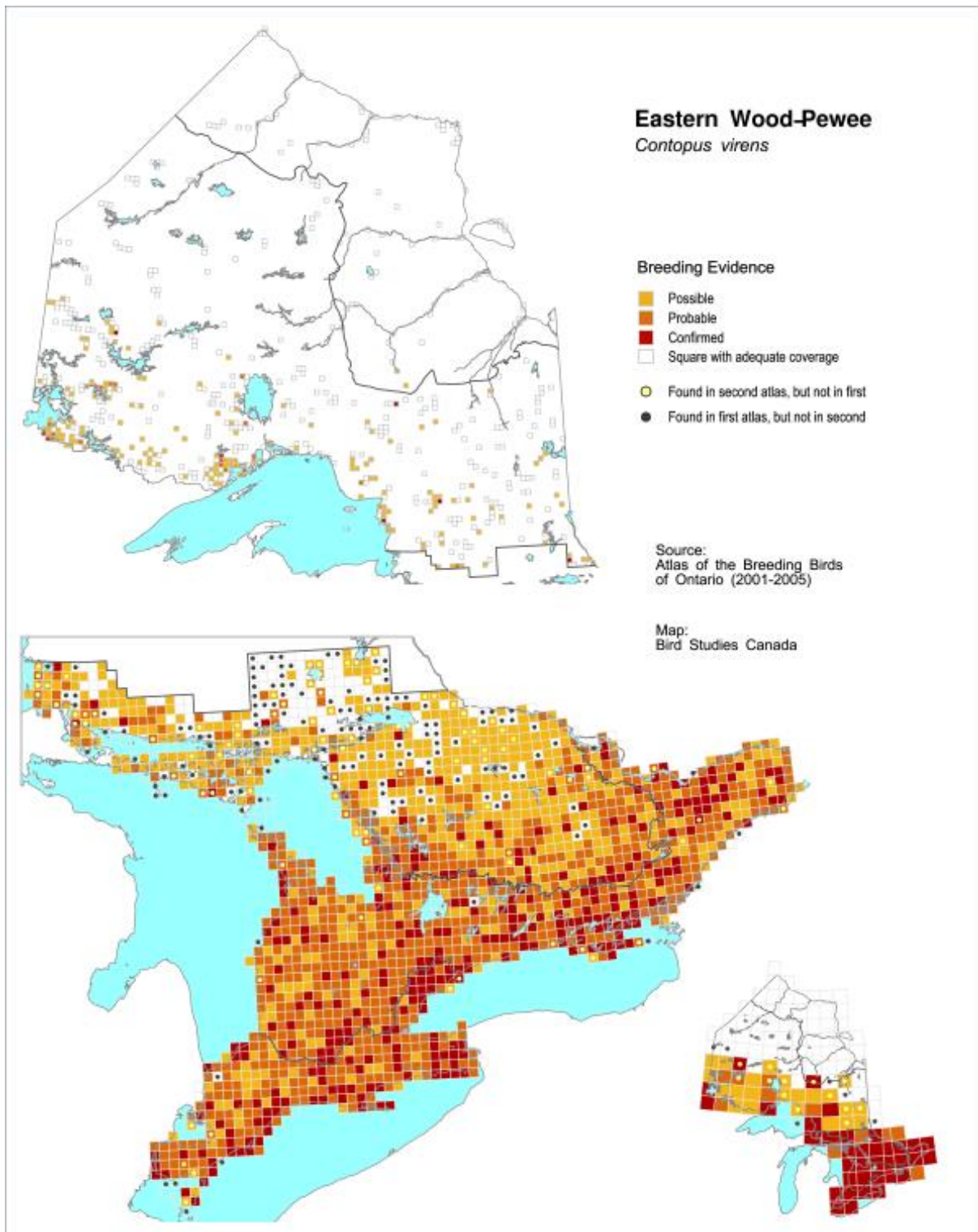


Figure B3: Eastern Wood-pewee breeding evidence during 2001-2005 from the Second Atlas of the Breeding Birds of Ontario (McLaren 2007).

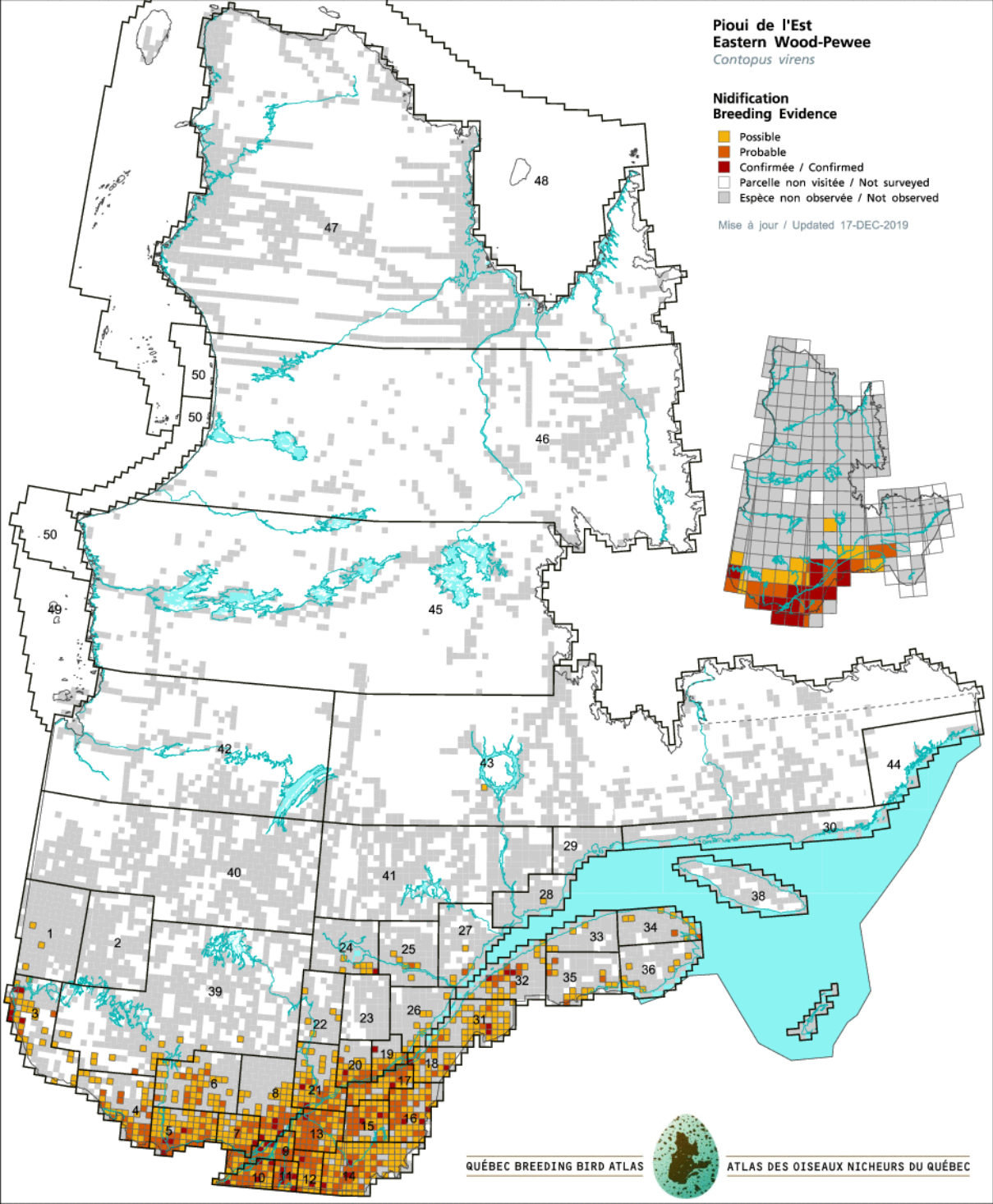


Figure B4: Eastern Wood-pewee breeding evidence during 2010-2014 from the Second Quebec Breeding Bird Atlas (Hachey 2019).

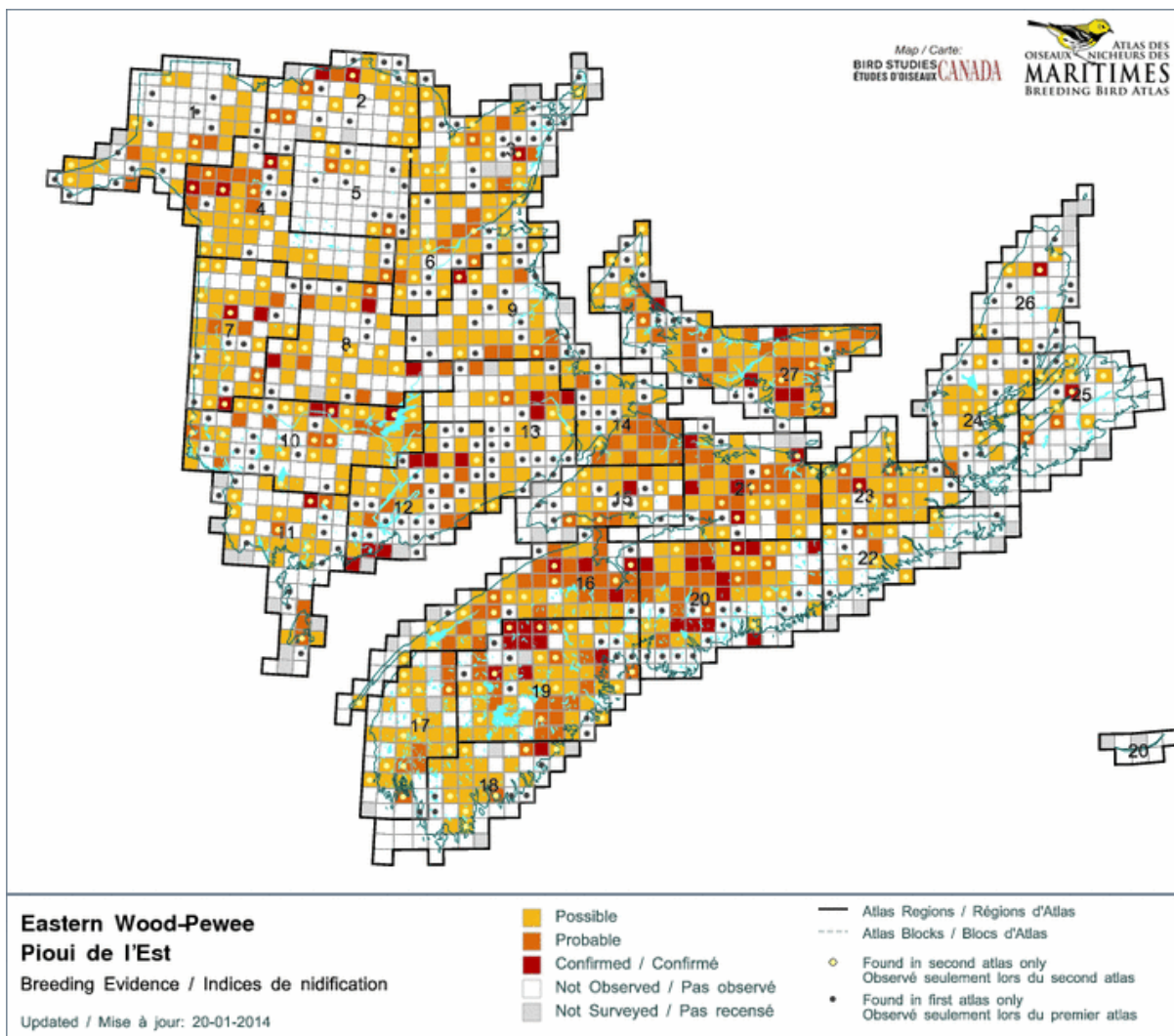


Figure B5: Eastern Wood-pewee breeding evidence during 2006-2010 from the Second Atlas of Breeding Birds of the Maritimes Provinces (Peckford 2015).