LRH: J.D. Lloyd

RRH: Fox Sparrow range expansion

**The recent expansion of Fox Sparrow (*Passerella iliaca*) breeding range into the northeastern United States**

**John D. Lloyd1**

1 Vermont Center for Ecostudies, PO Box 420, Norwich, VT 05055, USA; email: [jlloyd@vtecostudies.org](mailto:jlloyd@vtecostudies.org)

**Abstract**

The breeding range of the Red Fox Sparrow (*Passerella iliaca iliaca*) is generally recognized as comprising the boreal forest of Canada. However, recent observations suggest that the species is present during the summer months throughout much of the northeastern U.S., unexpected for a species characterized as a passage migrant in the region. To clarify, I conducted a literature review to document the historical status of the species in the northeastern U.S. and then analyzed observations submitted to eBird to describe its recent and current status in the region. Historical accounts consistently identify Fox Sparrow as a passage migrant through the region during early spring and late fall. Beginning in the early 1980s, observers began noting regular extralimital records of Fox Sparrow in northern Maine. A single nest was discovered in the state in 1983, and another in northern New Hampshire in 1997. Despite the paucity of breeding records, observations submitted to eBird suggest that the southern limit of the breeding range of Fox Sparrow has expanded rapidly to the south and west in recent years. The proportion of complete checklists submitted to eBird that contained at least one observation of Fox Sparrow grew at an annual rate of 18% from 2003-2016 and was independent of observer effort. Fox Sparrow now occurs regularly on mountaintops and in young stands of spruce (*Picea* spp.) and balsam fir (*Abies balsamea*) during the breeding season throughout northern and western Maine and northern New Hampshire, with occasional records from the Green Mountains of Vermont and the Adirondack Mountains of New York. The cause of this rapid expansion of its breeding range is unknown, but may be related to an increase in the amount of young conifer forest in the northeastern U.S. created by commercial timber harvest.

*Keywords*: Fox Sparrow, *Passerella iliaca*, distribution, biogeography, Maine, New Hampshire, range expansion

Fox Sparrow (*Passerella iliaca*) is a polytypic species that breeds in montane and boreal forest across western and northern North America. Red Fox Sparrow, the nominate subspecies (*P*. *i*. *iliaca*), nests in early-successional coniferous or mixed forests; shrubby thickets along waterways and wetlands; and stunted conifer forests on mountaintops or cool coastlines from Manitoba eastward to the Maritime Provinces [(Bisson and Limoges 1996, McLaren 2007, Stewart 2015, Artuso 2018)](https://paperpile.com/c/PA7Pdn/wGMH+kCX8+kSi7+MPYa). Most general references identify the subspecies’ breeding range as extending into the eastern United States only in the northernmost part of Maine [(Rising 1996, Sibley 2000, Weckstein et al. 2002)](https://paperpile.com/c/PA7Pdn/mMnv+3ew5+A960). However, anecdotal reports from birders and observations submitted to eBird suggest that Fox Sparrow now occurs regularly during the breeding season throughout northern and western Maine and the mountains of central and northern New Hampshire. This would constitute a fairly rapid southward expansion of the species’ breeding range, yet this phenomenon has remained undescribed in the ornithological literature. Here, in an effort to address this gap and to clarify the status of Fox Sparrow as a breeding species in the northeastern U.S., I review historical and current literature describing the distribution of Fox Sparrow in this region and describe temporal changes in occurrence using data submitted to eBird by citizen scientists.

**Methods**

I began by reviewing general summaries of bird distribution for the two northeastern states that appear to represent the leading edge of the southward expansion of Fox Sparrow breeding range: Maine, the bird life of which still has only a single definitive reference [(Palmer 1949)](https://paperpile.com/c/PA7Pdn/PM9w), and New Hampshire, which has both an historical account of bird distributions [(Allen 1903)](https://paperpile.com/c/PA7Pdn/hLVs) and an authoritative recent update [(Keith and Fox 2013)](https://paperpile.com/c/PA7Pdn/6eoZ). I also consulted two older accounts of the birdlife of New England [(Samuels 1875, Forbush 1929)](https://paperpile.com/c/PA7Pdn/VvFV+F4Bx). These accounts formed the basis for understanding the historic distribution of Fox Sparrow in Maine and New Hampshire.

I supplemented these historical accounts, and located more recent references to the species’ distribution, by searching Google Scholar with the string “("fox sparrow" OR "passerella iliaca") AND ("New Hampshire" OR Maine)”. I also manually searched for records of Fox Sparrow in regional reports for the northeastern U.S. and southeastern Canada that appeared in American Birds, National Audubon Society Field Notes, and North American Birds from 1980-2006. Finally, I searched breeding-bird atlases for Maine, New Hampshire, Vermont, and New York for any information pertaining to the presence of Fox Sparrows.

To describe and quantify recent changes in the incidence of Fox Sparrow reports during the breeding season, I used data submitted to eBird (<http://www.ebird.org>). To describe the current distribution, I used the July 2018 version of the eBird Basic Dataset, which includes both incidental (i.e., potentially incomplete checklists without associated information on observer effort) and complete-checklist records. To quantify temporal changes in the incidence of Fox Sparrow observations, I began by downloading the 2016 version of the eBird Reference Dataset [(Fink et al. 2017)](https://paperpile.com/c/PA7Pdn/jZiZ), which includes only complete checklists and is zero-filled such that Fox Sparrows were treated as absent from any checklist without a positive record of the species. I then filtered this dataset to include only checklists from June and July, which should eliminate nearly all records of migrant birds, as Fox Sparrow migration through the region occurs very early in April [(Weckstein et al. 2002)](https://paperpile.com/c/PA7Pdn/A960). The mean arrival date on the breeding grounds in Newfoundland, for example, was 9 April over a six-year period from 1973-1978 [(Threlfall and Blacquiere 1982)](https://paperpile.com/c/PA7Pdn/nd5l). Regionally, the species is also a late fall migrant, with southward movements typically not beginning until mid- to late September [(Weckstein et al. 2002)](https://paperpile.com/c/PA7Pdn/A960). I further reduced the dataset by including only checklists from counties in the northern halves of Maine (Aroostook, Penobscot, Piscataquis, Somerset, Franklin, and Oxford) and New Hampshire (Coos and Grafton). I limited the analysis to this extent because it includes all breeding-season Fox Sparrow observations in the region - both in the complete eBird data set and in my literature review of distributional records - and because these counties include potentially suitable habitat in the form of krummholz forest on mountaintops and young stands of balsam fir (*Abies balsamea*) and spruce (*Picea* spp.) regenerating after harvest in the region’s extensive commercial forestland.

Analyzing the regional occurrence of Fox Sparrows in eBird checklists posed two problems. First, because of the species’ rarity and its localized distribution in the region, many checklists were submitted from the same locale on approximately the same date and presumably recorded the presence of the same individual or individuals. For example, when an individual was located on an accessible mountaintop, many birders would actively seek out that individual and submit a checklist recording its presence. As these are not independent observations, this phenomenon would potentially lead to an overestimate of the frequency with which the species is observed in the region. At the same time, the localized regional distribution of Fox Sparrows resulted in an exceedingly small proportion of checklists reporting the species. To address both issues, I used as my dependent variable not the raw proportion of checklists with Fox Sparrow but instead the proportion of 10 km2 grid cells within the region that had at least one complete checklist containing Fox Sparrow. To accomplish this, I first overlaid a 10 sq. km grid atop the study area within the QGIS version 2.18 Geographic Information System [(QGIS Development Team 2016)](https://paperpile.com/c/PA7Pdn/nqCr) and then determined whether each grid cell contained at least one complete checklist with a record of Fox Sparrow for each year. Doing so avoided the problem of treating multiple observations of the same bird as independent and also yielded clearer insight into large-scale changes in the occurrence of Fox Sparrow. The choice of the grid size was essentially subjective, but reflected a trade-off between cells that were too large to accurately quantify changes in distribution over time and cells that were too small to accurately record the location where Fox Sparrows were detected during traveling counts submitted to eBird (i.e., situations where an observer started observing birds in one grid cell, which would be identified as the location of the observation in eBird, but walked far enough to cross into an adjacent grid cell).

I analyzed changes in the proportion of grid cells occupied by Fox Sparrow over time using a generalized linear model, with the conditional distribution of the response variable assumed to be binomial (i.e., a grid cell did or did not contain a record of Fox Sparrow in that year). I included year as the predictor variable in the model. Any change in the proportion of cells with Fox Sparrow records could be due in part to increased observer effort over time, so I analyzed a second model that included both year and a measure of observer effort, which I quantified as the summed value of observation hours spent on each complete checklist in the grid cell. I used analysis of deviance to choose the preferred model for inference. I tested for overdispersion via a chi-squared test of the ratio of the squared sum of Pearson residuals to the residual degrees of freedom [(Venables and Ripley 2002)](https://paperpile.com/c/PA7Pdn/m8kJ). None of the models showed evidence of overdispersion (i.e., chi-squared P <0.05), and as such I made no adjustments.

Although the measure of observer hours spent birding can help address the confounding effect of effort on the apparent frequency with which a rare species like Fox Sparrow is detected, it does not address changes in observer behavior that may increase the likelihood of encountering the species. For example, over time, birders may have become more adventurous in their explorations and more likely to visit the locales - remote mountaintops or commercial forestlands with limited access - potentially inhabited by Fox Sparrows. To address this potential source of confounding, I repeated the above analysis for two other species that occupy similar habitat as Fox Sparrows: Bicknell’s Thrush (*Catharus bicknelli*) and Blackpoll Warbler (*Setophaga striata*). Bicknell’s Thrush populations have likely been declining slowly in the region [(Lambert et al. 2008, King et al. 2008)](https://paperpile.com/c/PA7Pdn/kdQw+Bc6A) in recent decades, whereas Blackpoll Warblers have shown no significant trend in numbers [(King et al. 2008)](https://paperpile.com/c/PA7Pdn/Bc6A), so any increase in the proportion of grid cells occupied by these species in the study area might reflect increased observer activity in habitat suitable for Fox Sparrows.

All analyses were conducted in R version 3.4.4 [(R Core Team 2018)](https://paperpile.com/c/PA7Pdn/aUaE).

**Results**

**Historical distribution of Fox Sparrows in the northeastern United States**

Early reviews of the region’s avifauna were unequivocal in describing Fox Sparrow as a passage migrant. Palmer [(1949:568)](https://paperpile.com/c/PA7Pdn/PM9w/?locator=568&noauthor=1) identified the species as “transient” in Maine; Allen [(1903:145)](https://paperpile.com/c/PA7Pdn/hLVs/?locator=145&noauthor=1) as a “rather common migrant” in New Hampshire, a conclusion also reached by Keith and Fox [(2013)](https://paperpile.com/c/PA7Pdn/6eoZ/?noauthor=1) in their comprehensive review of historical and recent records; and both Samuels [(1875)](https://paperpile.com/c/PA7Pdn/F4Bx/?noauthor=1) and Forbush [(1929)](https://paperpile.com/c/PA7Pdn/VvFV/?noauthor=1) classified the species as spring and fall migrants throughout New England. None of these references indicated that Fox Sparrows were present in the region outside of early spring and late fall.

**Recent distribution of Fox Sparrows in the northeastern United States**

The first indication that Fox Sparrows were breeding in the northeastern U.S. came in 1981 in an eBird checklist submitted as an historical record in 2017. Three observers (Jeff Cherry, Jim Eckler, and Lynn Sheldon), working on a study of the effects on birds of spraying pesticides to control an outbreak of eastern spruce budworm (*Choristoneura fumiferana*), located a singing Fox Sparrow in northern Somerset County, Maine on several occasions between 21 June and 3 July. As described in the comments associated with the checklist, this bird was reported to have responded aggressively to a broadcast recording of a Fox Sparrow song. Confirmation of nesting was obtained further north, several kilometers south of the U.S.-Canada border in Aroostook County, Maine, in 1983 by Peter Vickery during Maine’s first breeding bird atlas [(Adamus 1988)](https://paperpile.com/c/PA7Pdn/NAFD).

Outside of these records, evidence of a southward range expansion first began emerging in the mid-1980s in southern Quebec. In 1985 and again in 1986, birders observed singing Fox Sparrows “well south” of their breeding range in southeast Quebec near the border of Maine [(Yank and Aubry 1986)](https://paperpile.com/c/PA7Pdn/qy5R). In 1988, four Fox Sparrows in two different locations in southern Quebec were also noteworthy for being “well s. of their usual summer range” [(Gosselin et al. 1988:1272)](https://paperpile.com/c/PA7Pdn/1iAC/?locator=1272). In 1993, three singing Fox Sparrows were observed in “suitable nesting habitat in n. Maine during late June” (Petersen 1993:1091). The species was still uncommon enough to warrant attention in 1999 and 2000, when notable records of singing birds were obtained in central Maine near Mount Katahdin [(Petersen 1999)](https://paperpile.com/c/PA7Pdn/Ov61). Meanwhile, in northern New Hampshire, a Fox Sparrow was discovered singing in 1996, with nesting confirmed at the same location in 1997 [(Keith and Fox 2013)](https://paperpile.com/c/PA7Pdn/6eoZ). This was the first confirmed nesting attempt by Fox Sparrow in New Hampshire, none having been found during the state’s breeding bird atlas, conducted from 1981-1986 [(Foss 1994)](https://paperpile.com/c/PA7Pdn/Lr32). Fox Sparrows were also absent from statewide breeding-bird atlases conducted in New York from 1980-1985 [(Andrle and Carroll 1988)](https://paperpile.com/c/PA7Pdn/ZXYU) and 2000-2005 [(McGowan and Corwin 2008)](https://paperpile.com/c/PA7Pdn/dM6m), and in Vermont from 1976-1981 [(Laughlin and Kibbe 1985)](https://paperpile.com/c/PA7Pdn/ydgx) and 2003-2007 [(Renfrew 2013)](https://paperpile.com/c/PA7Pdn/0sgc).

Based on all eBird records submitted through July 2018, including incidental observations or otherwise incomplete checklists, the current distribution of Fox Sparrow during June and July in the northeastern U.S. ranges from northern Maine, the mountains of central and western Maine, northern New Hampshire, the White Mountains of central New Hampshire, the central Green Mountains of Vermont, and into the High Peaks of the Adirondack Mountains of New York (Fig. 1). The single record from southern Maine (in July 2016) is of unknown significance, but its location, at a frequently birded nature preserve near the city of Bangor with no other breeding-season records of Fox Sparrow, suggests that bird observed was not on a breeding territory. The records in Vermont stem from surveys conducted by citizen-scientists working on the Vermont Center for Ecostudies’ Mountain Birdwatch Program, an annual, trail-based survey of birds breeding at high elevations in the northeastern U.S. The detections occurred on 1 survey route in 2011, 1 in 2012, and 3 different routes in 2016. The sole observation of Fox Sparrow in New York occurred on Whiteface Mountain in 2012, with multiple observers detecting at least one singing male during June and July.

**Temporal changes in the frequency of Fox Sparrow detections in the northeastern United States**

The proportion of grid cells containing complete eBird checklists that noted the presence of Fox Sparrow increased from 2003-2016 (*b*year = 0.18, 95% CI = 0.097 - 0.275; P < 0.001; Fig. 2), ranging from a low of 0% in 2003 (0/28 cells), 2004 (0/29), 2006 (0/32), and 2007 (0/41) to a high of 8.7% (20/231 grid cells) in 2015. Despite a large increase in observer effort – ranging from a low of 145.8 hours in 2005 (with a total of 20 grid cells containing at least 1 complete checklist) to a high of 3063.5 hours in 2016 (with a total of 277 grid cells containing at least 1 complete checklist) – the model containing a term for observer effort was not preferred relative to the simpler model containing only the effect of year (P = 0.67). Overall, the proportion of grid cells containing a complete checklist with a Fox Sparrow detection increased 18% per year from 2003-2016.

Neither Blackpoll Warbler nor Bicknell’s Thrush showed a similar pattern of increasing frequency of detection (Fig. 2). The proportion of grid cells containing a record of Blackpoll Warbler during June and July may have declined slightly, although results were equivocal (*b*year = -0.030, 95% CI = -0.064 - 0.005; P = 0.09), whereas the proportion of grid cells containing a record of Bicknell’s Thrush was apparently steady (*b*year = 0.03, 95% CI = -0.029 - 0.109; P =0.30; Fig. 2). As with Fox Sparrow, the simpler model without an effect of observer effort was preferred for both species (Bicknell’s Thrush, P = 0.31; Blackpoll Warbler, P = 0.06).

**Discussion**

Red Fox Sparrows appear to be in the midst of a significant southward expansion of their breeding range. I found no evidence that the species was present in the northeastern U.S. during the breeding season until the early 1980s, yet they are now widely reported in New Hampshire and Maine during June and July. Observers have confirmed nesting in both states. Given that Fox Sparrows nest in remote or difficult-to-access locales — clearcuts and mountaintops — it is difficult to rule out the possibility that they may have nested in small numbers in the northeastern U.S. in the past. However, the avifauna of the region’s mountains has been well-described since the early 1900s, yet no breeding-season records for the species exist in the historical literature. Likewise, although the commercial forestlands of western and northern Maine are rarely visited by birders, numerous ornithological investigations conducted during the spruce-budworm epidemic of the 1980s failed to find the species, suggesting that if the species was present it was far less common than at present. And, during the last decade, the increased frequency of breeding-season eBird reports of Fox Sparrow in Maine and New Hampshire appears to reflect a real increase in the species’ abundance and extent of occurrence, not an increase in observer effort in the right habitat; Bicknell’s Thrush and Blackpoll Warbler, which co-occur with Fox Sparrow during the breeding season, have shown no such increase.

During the mid-1980s, birders in southern Quebec began noting what were then considered extralimital records of Fox Sparrow, at about the same time that observers in far northwestern Maine first discovered evidence that Fox Sparrows were nesting in the state. The breeding range for Fox Sparrows continued to expand south and west out of southern Quebec and northern Maine over the next decade, reaching northern New Hampshire by the mid-1990s. Although Fox Sparrows have not spread substantially further west since then – only a handful of breeding-season records exist for Vermont, and only one for New York – they have continued moving south and now occur regularly during summer throughout the White Mountains of New Hampshire.

Fox Sparrows found in the northeastern U.S. during the breeding season tend to occur either in krummholz forest at high elevations or in young stands of spruce and fir regenerating after harvest (J. Lloyd, unpubl. data), which is consistent with descriptions of nesting habitat occupied in the core of the species’ range in Canada [(Weckstein et al. 2002)](https://paperpile.com/c/PA7Pdn/A960). Other locales with potentially suitable nesting habitat include the Green Mountains of Vermont and the Adirondack Mountains of New York, both of which contain areas of krummholz forest. Extensive stands of young spruce-fir forest at lower elevations are uncommon outside of the commercial forestlands of western and northern Maine, although parts of far northeastern Vermont and northern New Hampshire support lowland spruce-fir forests that might provide suitable conditions for nesting Fox Sparrows following harvest.

Why the distribution of Fox Sparrows has expanded so rapidly is not clear. Breeding Bird Survey data reveal no evidence of population increases in eastern Canada [(Environment and Climate Change Canada 2017)](https://paperpile.com/c/PA7Pdn/ggN1), as might be expected if growth in the core of the range was forcing individuals to wander south in search of suitable breeding habitat. The arrival of Fox Sparrows in Maine coincides approximately with the extensive salvage logging that occurred during and after the last outbreak of eastern spruce budworm, which created vast areas of young spruce-fir forest in northern and western parts of the state. Given that Fox Sparrows will nest in these young stands, the species’ southward expansion may have been in part due to the increased availability of nesting habitat created by logging; Banks [(1970)](https://paperpile.com/c/PA7Pdn/jaSi/?noauthor=1) suggested a similar explanation for the spread of Fox Sparrows onto the western slopes of the Cascade Mountains of Oregon (but see Marshall et al. [[2003]](https://paperpile.com/c/PA7Pdn/LU9c/?noauthor=1)).

In sum, Red Fox Sparrows were historically a passage migrant through the northeastern U.S. during late spring and early fall, but within the past few decades have become widespread and regular during the breeding season. Although confirmed nesting records remain scarce, the consistent presence of singing males suggests that the southern limit of the breeding range now extends several hundred kilometers south of where it is placed on most published range maps. In particular, the species’ breeding range now encompasses the northwestern half of Maine and the highlands of northern New Hampshire from the White Mountains to the U.S.-Canada border. Scattered recent records in Vermont and New York, along with the presence of suitable habitat in the higher mountains of both states, suggests that Fox Sparrow may continue expanding its range to the west.

**Acknowledgments**

Thanks to C.C. Rimmer and K.P. McFarland for constructive reviews of an early draft of this manuscript. Funding for this work was provided by the Vermont Center for Ecostudies.

**Literature Cited**

[Adamus, PR. 1988. Atlas of Breeding Birds in Maine. Maine Department of Inland Fisheries and Wildlife, Augusta, M USA.](http://paperpile.com/b/PA7Pdn/NAFD)

[Allen, G. M. (1903). A list of the birds of New Hampshire. Nature Study Press, Manchester, NH, USA.](http://paperpile.com/b/PA7Pdn/hLVs)

[Andrle, R. F., and J. R. Carroll (1988). The atlas of breeding birds in New York State. Cornell University Press, Ithaca, New York, USA.](http://paperpile.com/b/PA7Pdn/ZXYU)

[Artuso, C. (2018). Fox Sparrow. In The Atlas of the Breeding Birds of Manitoba (C. Artuso, A. R. Couturier, K. D. De Smet, R. F. Koes, D. Lepage, J. McCracken, R. D. Mooi and P. Taylor, Editors). Bird Studies Canada, Winnipeg, MB, Canada.](http://paperpile.com/b/PA7Pdn/kSi7)

[Banks, R. C. (1970). The fox sparrow on the west slope of the Oregon Cascades. The Condor 72:369-370.](http://paperpile.com/b/PA7Pdn/jaSi)

[Bisson, R., and B. Limoges (1996). Fox Sparrow. In The breeding birds of Québec: atlas of the breeding birds of southern Québec (J. Gauthier and Y. Aubry, Editors). Association québécoise des groupes d’ornithologues, Province of Quebec Society for the Protection of Birds, Canadian Wildlife Service, Environment Canada, Québec Region, Montréal, Canada.](http://paperpile.com/b/PA7Pdn/wGMH)

[Environment and Climate Change Canada (2017). North American Breeding Bird Survey - Canadian Trends Website, Data-version 2015. [Online.] Available at](http://paperpile.com/b/PA7Pdn/ggN1) <https://wildlife-species.canada.ca/breeding-bird-survey-results>[.](http://paperpile.com/b/PA7Pdn/ggN1)

[Fink, D., T. Auer, F. Obregon, W. Hochacka, M. Iliff, B. Sullivan, C. Wood, I. Davies, and S. Kelling (2017). The eBird Reference Dataset, Version 2016. Cornell Lab of Ornithology, Ithaca, NY, USA.](http://paperpile.com/b/PA7Pdn/jZiZ)

[Forbush, E. H. (1929). Birds of Massachusetts and other New England states. Norwood Press, Norwood, MA, USA.](http://paperpile.com/b/PA7Pdn/VvFV)

[Foss, C. R. (1994). Atlas of Breeding Birds in New Hampshire. Audubon Society of New Hampshire, Concord, NH, USA.](http://paperpile.com/b/PA7Pdn/Lr32)

[Gosselin, M., R. Yank, and Y. Aubry (1988). Quebec region. American Birds 42:1270–1272.](http://paperpile.com/b/PA7Pdn/1iAC)

[Keith, A. R., and R. P. Fox (2013). The birds of New Hampshire. Nuttall Ornithological Club, Cambridge, MA, USA.](http://paperpile.com/b/PA7Pdn/6eoZ)

[King, D. I., J. D. Lambert, J. P. Buonaccorsi, and L. S. Prout (2008). Avian population trends in the vulnerable montane forests of the Northern Appalachians, USA. Biodiversity and Conservation 17:2691–2700.](http://paperpile.com/b/PA7Pdn/Bc6A)

[Lambert, J. D., D. I. King, J. P. Buonaccorsi, and L. S. Prout (2008). Decline of a new Hampshire Bicknell’s thrush population, 1993-2003. Northeastern Naturalist 15:607–618.](http://paperpile.com/b/PA7Pdn/kdQw)

[Laughlin, S. B., and D. P. Kibbe (1985). The atlas of breeding birds of Vermont. University Press of New England, Hanover, NH, USA.](http://paperpile.com/b/PA7Pdn/ydgx)

[Marshall, D. B., M. G. Hunter, and A. Contreras (2003). Birds of Oregon: a general reference. Oregon State University Press, Corvallis, OR, USA.](http://paperpile.com/b/PA7Pdn/LU9c)

[McGowan, K. J., and K. Corwin (2008). The second atlas of breeding birds in New York State. Cornell University Press, Ithaca, NY, USA.](http://paperpile.com/b/PA7Pdn/dM6m)

[McLaren, M. A. (2007). Fox Sparrow. In Atlas of the Breeding Birds of Ontario (Cadman, D. A. Sutherland, G. G. Beck, D. Lepage and A. R. Couturier, Editors). Bird Studies Canada. Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto, pp. 558–559.](http://paperpile.com/b/PA7Pdn/kCX8)

[Palmer, R. S. (1949). Maine birds. Bulletin of the Museum of Comparative Zoology at Harvard College 102:1–656.](http://paperpile.com/b/PA7Pdn/PM9w)

[Petersen, W. R. (1999). New England region. American Birds 53:363–366.](http://paperpile.com/b/PA7Pdn/Ov61)

Petersen, W.R. (1993). [New England region. American Birds 47:1088–1091.](http://paperpile.com/b/PA7Pdn/Ov61)

[QGIS Development Team (2016). QGIS Geographic Information System. Open Source Geospatial Foundation Project.](http://paperpile.com/b/PA7Pdn/nqCr)

[R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.](http://paperpile.com/b/PA7Pdn/aUaE)

[Renfrew, R. R. (2013). The second atlas of breeding birds in Vermont. University Press of New England, Lebanon, NH, USA.](http://paperpile.com/b/PA7Pdn/0sgc)

[Rising, J. D. (1996). A guide to the identification and natural history of the sparrows of United States and Canada. Academic Press, San Diego](http://paperpile.com/b/PA7Pdn/mMnv), CA, USA.

[Samuels, E. A. (1875). The Birds of New England and adjacent states. Lockwood, Brooks, and Company, Boston, MA, USA.](http://paperpile.com/b/PA7Pdn/F4Bx)

[Sibley, D. A. (2000). The Sibley Guide to Birds. Alfred A Knopf, Inc., New York, NY, USA.](http://paperpile.com/b/PA7Pdn/3ew5)

[Stewart, R. (2015). Fox Sparrow. In Second Atlas of Breeding Birds of the Maritime Provinces (R. L. M. Stewart, K. A. Bredin, A. R. Couturier, A. G. Horn, D. Lepage, S. Makepeace, P. D. Taylor, M.-A. Villard and R. M. Whittam, Editors). Bird Studies Canada, Environment Canada, Natural History Society of Prince Edward Island, Nature New Brunswick, New Brunswick Department of Natural Resources, Nova Scotia Bird Society, Nova Scotia Department of Natural Resources, Prince Edward Island Department of Agriculture and Forestry, Sackville, NB, Canada.](http://paperpile.com/b/PA7Pdn/MPYa)

[Threlfall, W., and J. R. Blacquiere (1982). Breeding biology of the Fox Sparrow in Newfoundland. Journal of Field Ornithology 53:235–239.](http://paperpile.com/b/PA7Pdn/nd5l)

[Venables, W. N., and B. D. Ripley (2002). Modern Applied Statistics with S. Springer, New York, NY, USA.](http://paperpile.com/b/PA7Pdn/m8kJ)

[Weckstein, J. D., D. E. Kroodsma, and R. C. Faucett (2002). Fox Sparrow (Passerella iliaca), version 2.0. The Birds of North America (A. F. Poole and F. B. Gill, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA.](http://paperpile.com/b/PA7Pdn/A960) https://birdsna.org/Species-Account/bna/species/foxspa/

[Yank, R., and Y. Aubry (1986). Quebec region. American Birds 40:1180–1182.](http://paperpile.com/b/PA7Pdn/qy5R)

Yank, R., and Y. Aubry (2000). New England Region. American Birds 54: 358–62.

Yank, R., and Y. Aubry (1985). Quebec Region. American Birds 39: 889–90.

Figure captions:

Figure 1. Observations of Fox Sparrow (black circles) during June and July in the northeastern United States reported to eBird as of July 2018.

Figure 2. The proportion of 10 km2 grid cells in northern and western Maine (Aroostook, Penobscot, Piscataquis, Somerset, Franklin, and Oxford counties) and northern New Hampshire (Coos and Grafton counties) containing breeding-season records (observations in June or July) of Fox Sparrows reported to eBird increased 18% per year from 2003-2016 (top panel). Neither Bicknell’s Thrush (middle panel) nor Blackpoll Warbler (bottom panel), both of which occur in similar forest types as Fox Sparrow, showed a significant temporal trend in the proportion of grid cells reported as occupied.