Are birds aiding dispersal of an "invasive native" ?

Using crowd-sourced data to explore the role of avian seed dispersers in recent eastern red cedar (*Juniperus virginiana*) range expansion

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Eastern red cedar (ERC) produces cones which appear as blue "berries" and are ripe during the winter (Nov-March; Lawton 1990). Seeds must germinate in the year they are produced, and passage through a bird's gut may increase germination 1.5-3.5 times (Holthuijzen and Sharik 1985). ERC trees are expanding their range westward and invading new locations throughout their range.

To understand the potential for avian seed dispersers to aid in assisted migration, it would be useful to know:

1. species occurrence during the winter cone production season.
2. spatial locations in which multiple seed dispersing species overlap.
3. migration timing relative to the winter cone production season.
4. estimated maximum migration speed to fit potential dispersal kernel.

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Citations

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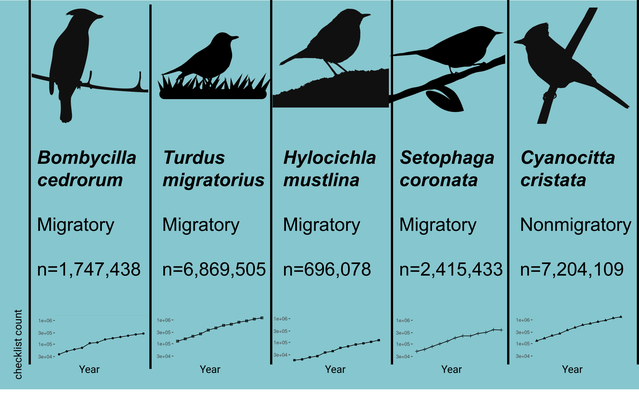
Prasad A, Iverson LR, Matthews S, Peters M. A climate change atlas for 134 forest tree species of the Eastern United States [database]. 2007-ongoing. https://www.nrs.fs.fed.us/atlas/tree, Northern Research Station, USDA Forest Service, Delaware Ohio.

Data | eBird

- Vetted eBird data for 4 migratory and 1 non-migratory species (Sullivan et al. 2014)
- 2008-2019
- Presence-only
- Filtered to eastern flyway (>-103 longitude)
- Total eBird effort records queried for all cells

- **Follow-up analyses will include additional ERC dispersers:** *Siala sialis, Cardinalis cardinalis, Mimus polyglottus, Sturnus vulgaris, and Corvus brachyrhynchos.*

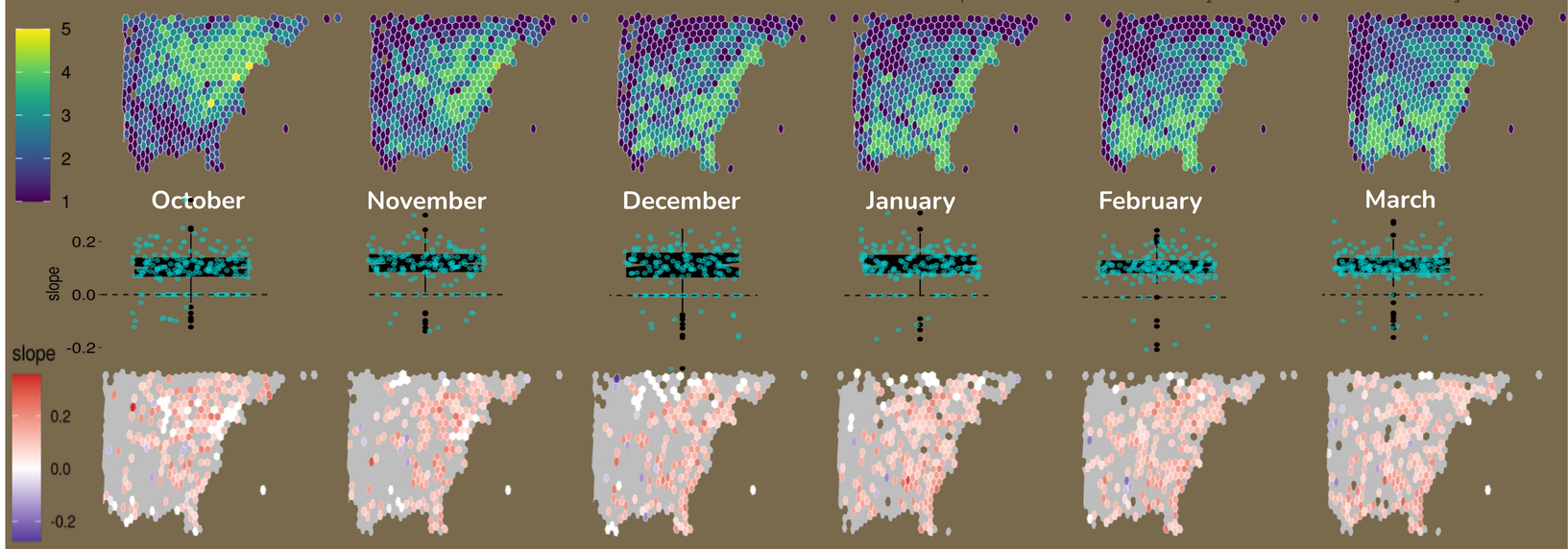


Eastern red cedar range in the eastern United States and Canada, from Little's range map, USDA Forest Service (Prasad et al. 2007).

Methods

- Daily observations aggregated within equal-area hexagonal cells for each year separately (sensu La Sorte et al. 2013; Supp et al. 2015)
- Central latitude and longitude of cells used to calculate a daily mean location, weighted by total eBirder effort.
- Generalized additive model (GAM) fit the daily mean locations to predict centroids for each species in each year.
- Calculated maximum migration speeds using great circle distance
- Estimated migratory timing using segmented regression.
- All analyses performed in R 4.X and openly available at https://github.com/sarahsupp/ERC-bird-dispersal

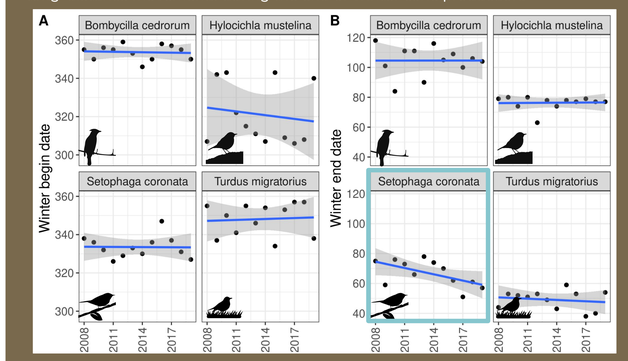
1 & 2. Species occurrence is increasing during the winter cone production season across the range, including increased spatial overlap of potential seed dispersing species (2019 richness is shown).



Potential avian disperser "load" across eastern North America has been increasing from 2008-2019. Most cell slopes (7489/17872; 42%) were significant ($p<0.05$) with a positive trend (red) to overlapping seed dispersing species (mean slope across all months = 0.11, or an effect of 1 additional seed dispersing species during the winter months per decade). 938 negative slopes (13%) and 6551 positive (87%).

3. Migratory species are undertaking long distance movements during cone production.

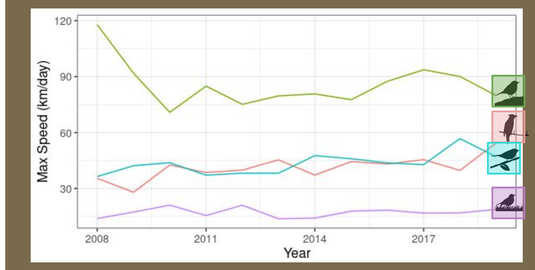
Migration that continues beyond Day 305 (Nov 1) or begins prior to Day 60 (Mar 1) in a given year makes it more likely that a bird consuming an ERC seed has the potential to disperse it while undertaking long-distance movement. All species are undertaking long-distance movements during the beginning of winter cone production. Only *S. coronata and T. migratorius* are undertaking long-distance movements during the end of winter cone production.



Winter begin: autumn migration complete.
Winter end: spring migration starts.

Species appear relatively consistent in their migratory timing over the past 12 years, except *S. coronata*, who is initiating spring migration approximately 2 weeks earlier by 2019 compared to 2008.

4. Max migration speed varies 17-83 km/day, but has potential for intermediate-scale seed dispersal.



Maximum migration speed may help estimate an upper limit to the avian seed dispersal kernel for ERC. These estimates are in km/day, but cone passage through bird gut is likely measured in minutes or hours.

Species appear relatively consistent in their maximum migration speed, where *H. mustelina* migrates the most rapidly (max=82.8 km/day), *S.coronata* and *B. cedrorum* have similar migration speeds (max = 43.2 and 41.2 km/day, respectively), and *T. migratorius* is the lowest speed on average (max = 17.1 km/day; include residents and short-distance migrants).