# Breeding, stopover, and wintering habitat in the eastern US and the role of private, working forests

Working Forests, Forest Sustainability, and At-risk Species Program
Final Progress Report - November 2024

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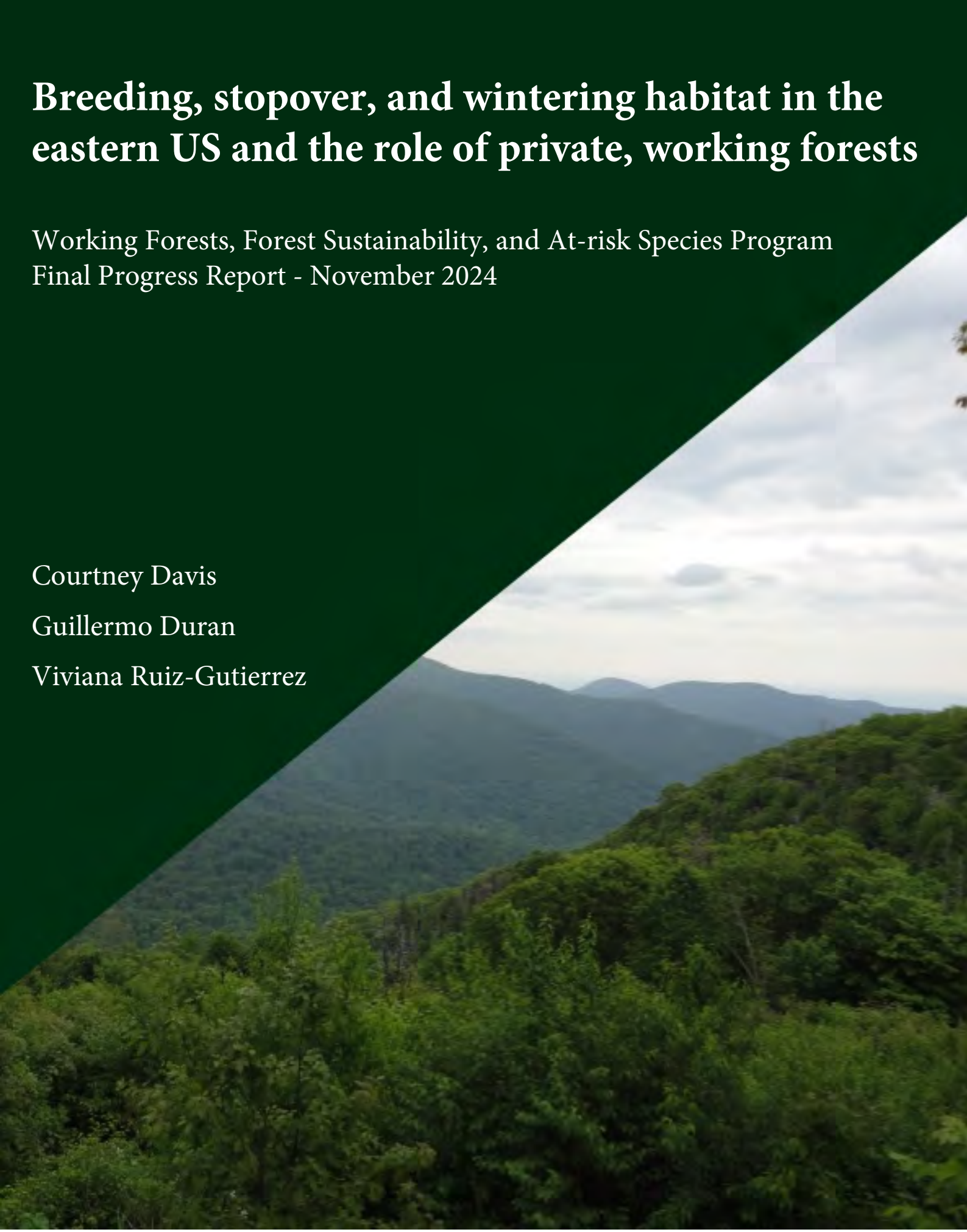

The Cornell Lab of Ornithology

Wildlife Conservation Initiative

NCASI IMPACT. SCIENCE. SOLUTIONS.

NAFO National Alliance of Forest Owners

U.S. Fish & Wildlife Service

# Project Summary

We achieved our overall objective of quantifying the role of private, working forests in conserving and managing critical stopover regions and breeding and overwintering areas for birds across the eastern U.S. Through this project, we have developed a powerful new approach: Bird Concentration Areas [BCAs]. **BCAs provide extremely detailed, landscape-scale information on the most important areas across the full annual cycle, for both individual species and species groups of critical conservation concern (e.g., forest-breeding birds).** Cornell continues to develop and adapt the BCA approach in collaboration with the U.S. Fish and Wildlife Service to support additional information needs for conservation planning and decision-making across the continental United States.

In this report, we present results from our final analysis showing that **private, working forests disproportionately contribute to migratory forest bird populations** relative to all other forested and non-forest areas in the region -- especially during the non-breeding and pre-breeding migratory periods. A manuscript describing the BCA approach and results will be submitted for peer-review in Spring 2025.

Hooded Warbler
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# Next Steps

We are excited to share that this project laid the groundwork for a successful grant application to NASA's Biodiversity and Ecological Conservation Program (ROSES 24-BIODIV24-0083). The project, entitled *"Highlighting and Expanding the Value of Private, Working Forests for Migratory Bird Conservation"*, is scheduled to begin in August 2025.

The end result of this project will be a **scalable, web-based tool** that forest owners and managers can use to more accurately evaluate potential opportunities for bird conservation on their properties and surrounding landscapes. Our work will further provide a **standardized set of data-driven biodiversity metrics** that can be regularly reported on for certification purposes and used to track effects of forest management on biodiversity over time. Additional information can be found on page 5 of this report.

Project team members include PI Courtney Davis (Cornell), Co-I Angela Larsen-Gray (NCASI Inc.), Co-I Daniel Green (Weyerhaeuser Company), Co-I Viviana Ruiz-Gutierrez (Cornell), and Collaborators Jenniffer Baake (Manulife Investment Management), Jeremy Poirier (International Paper), and David Jones-Farrand (U.S. Fish and Wildlife Service).

# Bird Concentration Areas (BCAs)


Acadian Flycatcher
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*Overview*

We created Bird Concentration Areas (BCAs) using eBird data products on species' relative abundance for 175 forest-breeding migratory landbirds that occur in the eastern United States. **These BCAs reflect priority areas that either maximize the total number of birds or the total number of species predicted to occur throughout the full annual cycle.** BCAs are characterized by a continuous **Bird Concentration Index (BCI)** that captures fine-scale differences in the relative importance of locations and can be independently generated for different species groups of interest (e.g., migratory forest birds) and seasons across the full annual cycle (e.g., breeding vs. migratory periods).

Here, we generated season-specific BCAs (**Appendix A**) using species-specific time frames for the breeding, non-breeding, and migratory periods. We also generated year-round BCAs by taking the maximum relative abundance values for each species and pixel across all 52 weeks of the year (**Figure 1**).

*Identifying BCAs based on species diversity*

For each 2.8km x 2.8km cell and species, we thresholded weekly eBird relative abundance estimates to a binary occurrence value. We then summed pixel values across the 175 species included in our analysis to create a continuous BCI of species diversity.

*Identifying BCAs based on species abundances*

For each 2.8km x 2.8km cell and species, we used the eBird relative abundance estimates to calculate the maximum percent of the species' population across the entire range of values for a given season and across all 52 weeks of the year. We thresholded species-specific values to retain pixels above the 80th percentile, and summed pixel values across the 175 species to create a continuous BCI of species abundance.

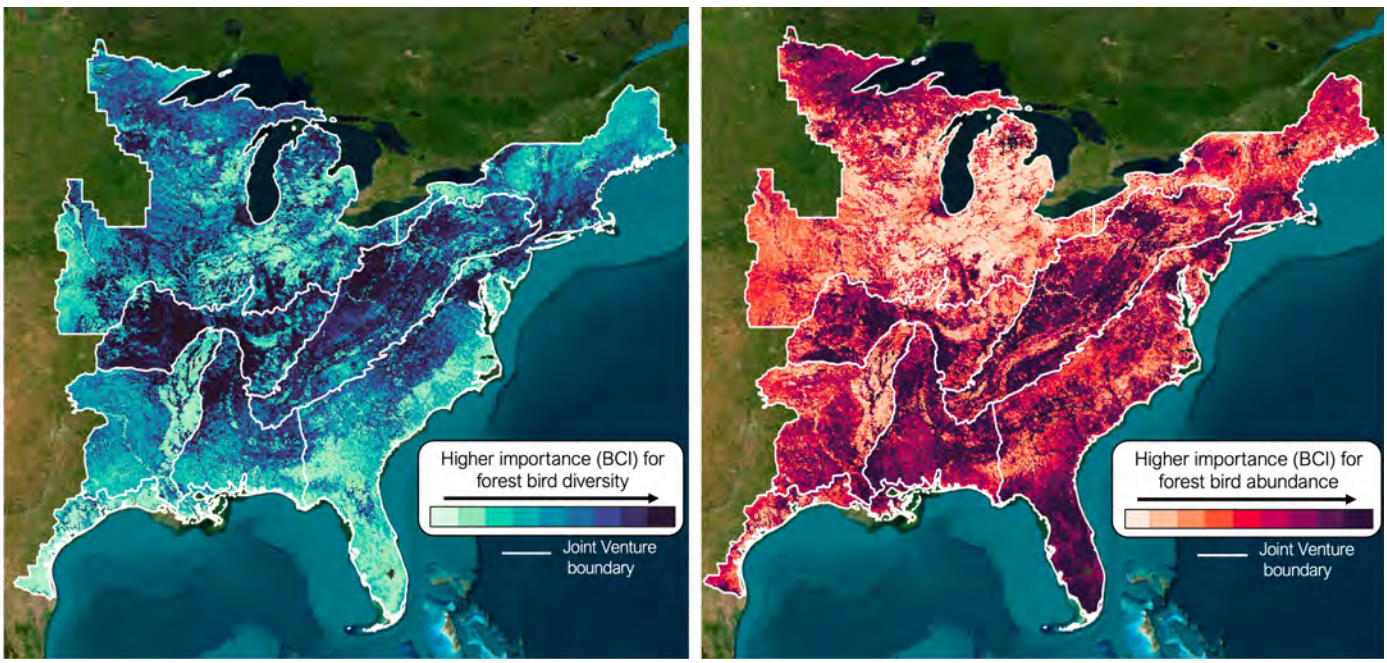


**Figure 1:** Bird Concentration Areas (BCAs) that support a high number of migratory forest bird species (left panel) and abundance (right panel) across the full annual cycle. BCAs are characterized by a continuous Bird Concentration Index (BCI) that differentiate areas of highest importance in each season of the annual cycle and across all 52 weeks of the year (as shown here) at a high spatial resolution of 2.8km x 2.8km.

# Contributions of Private, Working Forests to BCAs

*Overview*

We evaluated the relative contribution of private, working forests to migratory forest BCAs using spatial information from 30 NAFO member companies and the National Land Cover Database (NLCD). From the NLCD, we combined deciduous forest, evergreen forest, and mixed forest into a single forest type and then re-sampled the data to match the 2.8km x 2.8km spatial resolution eBird data. We calculated the percent of each 2.8km x 2.8km pixel covered by forest and classified any pixel with a percent cover ≥33% that did not overlap with NAFO member companies as "Other Forest". All other pixels were classified as "Non-forest" for this analysis.

*Measuring contribution to migratory forest BCAs*

We found that a high percentage of high-BCI pixels (i.e., exceeding the top 20th percentile of all pixel values) for forest bird abundance and diversity occur in forested areas and that **private, working forests are significantly contributing to forest bird populations throughout the full annual cycle** (Figure 2).

In fact, **private, working forests are disproportionately contributing to migratory bird populations relative to the amount of area they cover.** We found a higher percent of private, working forests overlapped with the most important areas for migratory forest birds compared to other forests and non-forest locations (Table 1), particularly in the non-breeding and pre-breeding migratory periods. Our results suggest that private, working forests are indeed providing critically important habitat for abundant and diverse bird communities across seasons.

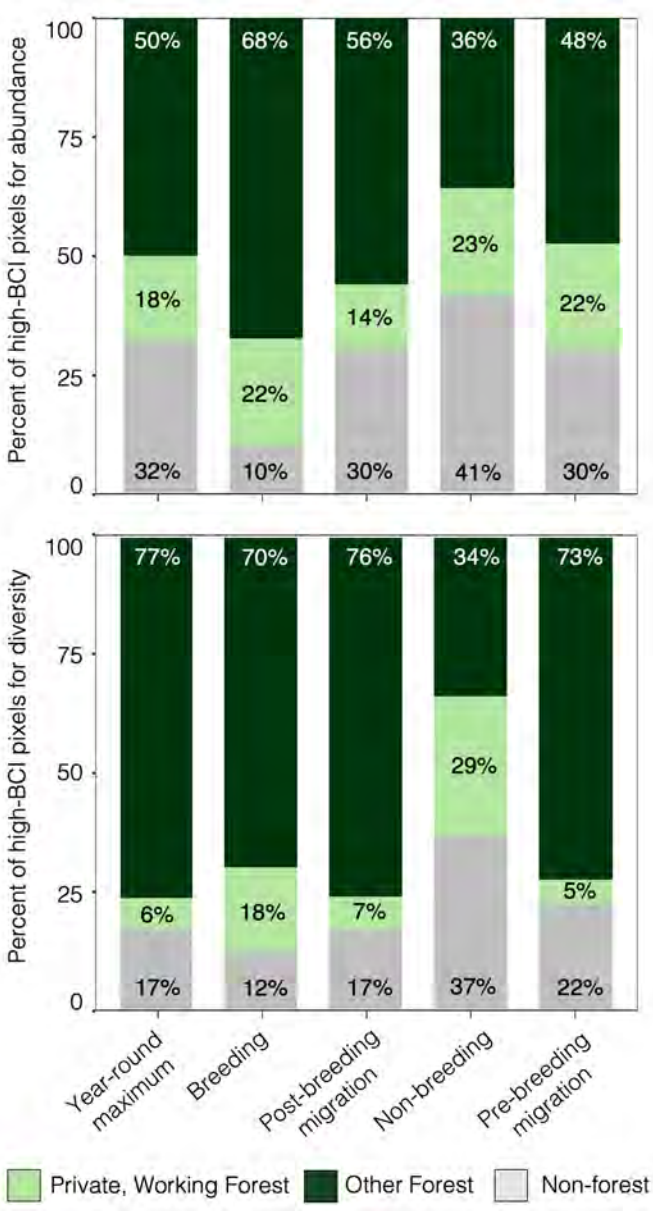


**Figure 2:** Percent of high-BCI pixels for migratory bird abundance (top panel) and diversity (bottom panel) that occur in private, working forests, other forested areas and other land covers (i.e., non-forest) in each season of the annual cycle. High-BCI pixels are those that exceed the top 20th percentile of all pixel values for a given season.

**Table 1:** Percent of 2.8km x 2.8km pixels classified as private working forest, other forest, and non-forest, that overlap with the most important areas for migratory forest birds, defined as the top 20th percentile of BCI values for species abundance and diversity.

| | Year-round max. | Breeding | Post-breeding migration | Nonbreeding | Pre-breeding migration |
|---|---|---|---|---|---|
| *BCAs for abundance* | | | | | |
| Private, Working Forests | 21% | 27% | 16% | 28% | 28% |
| Other Forests | 20% | 27% | 22% | 15% | 19% |
| Non-Forest | 11% | 3% | 10% | 15% | 11% |
| | | | | | |
| *BCAs for diversity* | | | | | |
| Private, Working Forests | 7% | 23% | 8% | 29% | 5% |
| Other Forests | 26% | 29% | 28% | 11% | 26% |
| Non-Forest | 5% | 4% | 5% | 10% | 7% |

# Contributions to Species-specific Priority Areas

*Overview*

We also evaluated the contribution of private, working forests, other forests, and other land covers (i.e., non-forest) to species-specific priority areas that support a high percent of each species' population throughout the full annual cycle. **These priority areas show the most critical locations for each of the 175 bird species included in our analysis.** For example, the Lower Mississippi Valley, East Coast Gulf Plain, and Atlantic Coast are extremely important areas for the pine warbler across its annual life cycle (top panel of **Figure 3**). Additional species-specific maps and summaries for a subset of species are included in **Appendix B**.

*Measuring contribution tospecies priority areas*

For each species, we calculated: 1) the percent of high-BCI pixels (i.e., exceeding the top 20th percentile of a species' seasonal or year-round maximum percent of population) that occur in each of the different land cover types; and 2) the percent of area for each land cover type that overlapped with these important locations.

Of the 9 species highlighted in this report, we found that **private working forests are contributing most significantly to populations of the pine warbler (Figure 3), Acadian flycatcher, hooded warbler, Kentucky warbler, and Swainson's thrush (Appendix B: Figures B1 & B2)** – even exceeding the percent that occur in other forests for some seasons and species. These patterns become more evident after controlling for differences in overall area. For example, we see that **almost half (47%) of the 2.8km x 2.8km pixels classified as private, working forests overlap with the most important locations for pine warbler year-round** (**Table 2**), compared to only 12% of other forest and 4% of non-forest pixels (**Appendix B: Table B1**).

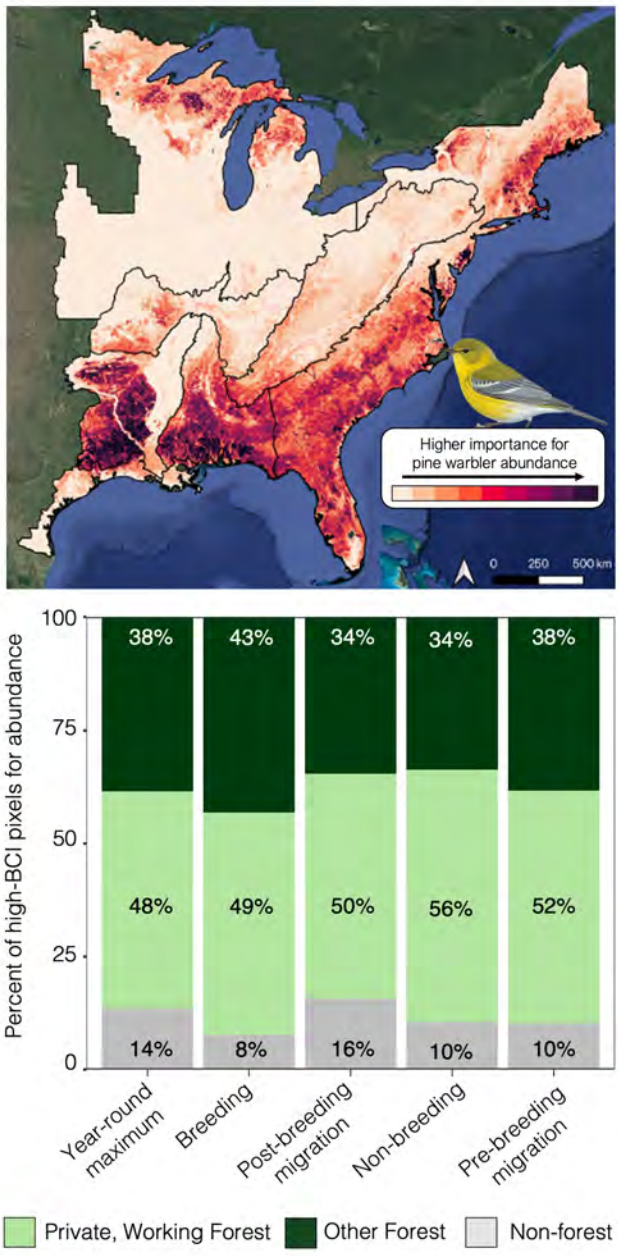


**Figure 3:** Map of year-round maximum percent of population for pine warbler (top panel), used to identify species-specific priority areas, and the percent of high-BCI pixels that occur in private, working forests, other forested areas, and other land covers (i.e., non-forests) in each season of the annual cycle (bottom panel).

**Table 2:** Percent of 2.8km x 2.8km pixels classified as private, working forest that overlap with species-specific priority areas, defined as the top 20th percentile of their seasonal or year-round maximum percent of population. Summaries for other forests and non-forested locations can be found in Appendix B: Table B1.

| | Year-round max. | Breeding | Post-breeding migration | Nonbreeding | Pre-breeding migration |
|---|---|---|---|---|---|
| Acadian flycatcher | 23% | 12% | 20% | -- | 23% |
| Cerulean warbler | 3% | 2% | 2% | -- | 3% |
| Hooded warbler | 28% | 19% | 21% | -- | 27% |
| Indigo bunting | 24% | 14% | 13% | 0% | 31% |
| Kentucky warbler | 15% | 8% | 8% | -- | 17% |
| Pine warbler | 47% | 39% | 47% | 27% | 44% |
| Prairie warbler | 22% | 22% | 13% | 0% | 22% |
| Swainson's thrush | 10% | 4% | 11% | -- | 5% |
| Wood thrush | 25% | 11% | 12% | -- | 31% |

# Continuing the Partnership

We have successfully secured funding from NASA's Biodiversity and Ecological Conservation program to continue the the partnership between the Cornell Lab of Ornithology and WCI. The overall objective of the planned work is to first understand the environmental drivers of migratory forest bird BCAs in the eastern U.S. and then use this information to better support the sustainable management of private, working forests (**Figure 4**). More specifically, we will be:

- Evaluating environmental features linked with high diversity and abundance of migratory forest birds in priority areas (i.e., BCAs) to better understand the potential processes influencing their location and distribution across the eastern United States;

- Evaluating forest structure and management of private, working forests within and near priority areas for migratory forest birds to identify potential management strategies and opportunities with a high return on investment across multiple species; and

- Identifying where projected climate change and land use change are most likely to affect forests within current priority areas for migratory forest birds and where additional climate adaptation and mitigation strategies are most needed to maintain critical areas.

The end result of this project will be a scalable, web-based tool that forest owners and managers can use to more accurately evaluate potential opportunities for bird conservation on their properties and surrounding landscapes. Our decision-making tool will also provide a set of metrics and criteria that land managers can use to communicate their contributions during third-party audits, and when communicating sustainable forestry to the public.

We will be working in collaboration with representatives from Weyerhaeuser Company, Nuveen Natural Capital, Manulife Investment Management, and International Paper to ensure that our information is effective and usable across many different types of private, working forests, managed by diverse landowners, in the eastern United States.

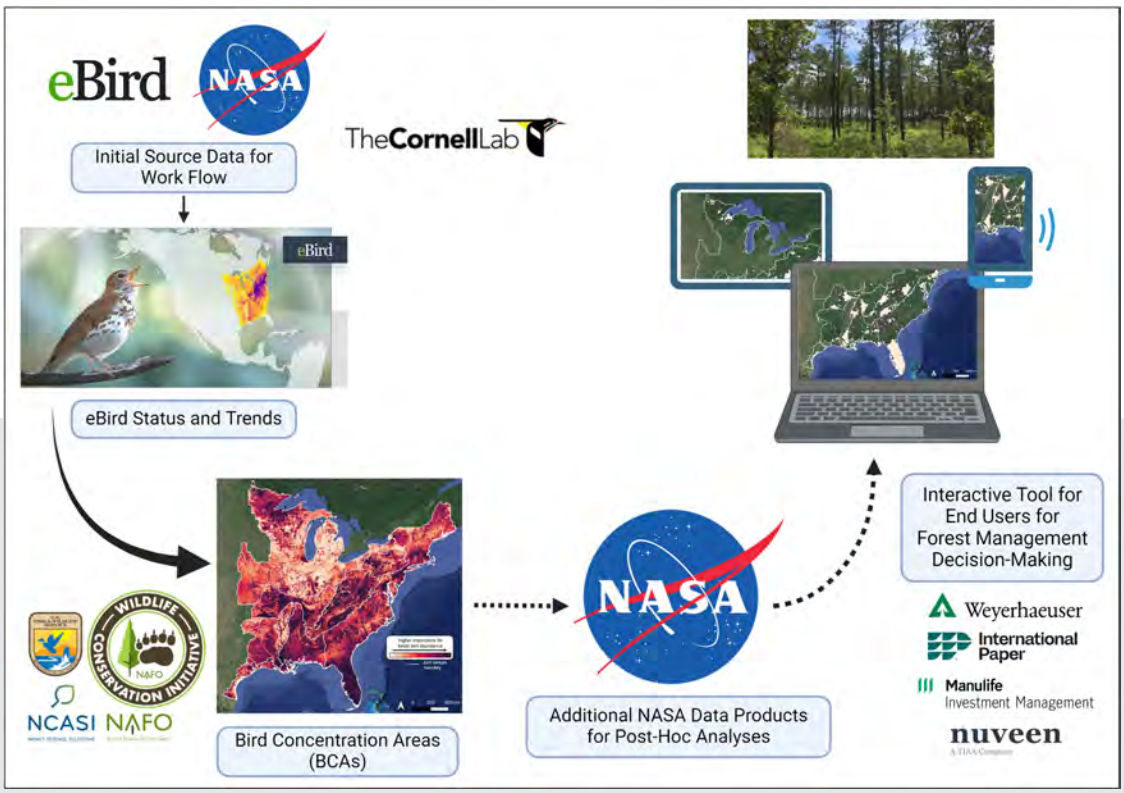


**Figure 4:** Conceptual diagram of our planned project. The solid lines depict what has already been completed through the WCI Working Forests, Forest Sustainability, and At-risk Species program. Dashed lines depict our planned work that aims to further improve integration of our data outputs into forest management decision-making.

# Appendix A: Seasonal BCAs for Species Diversity

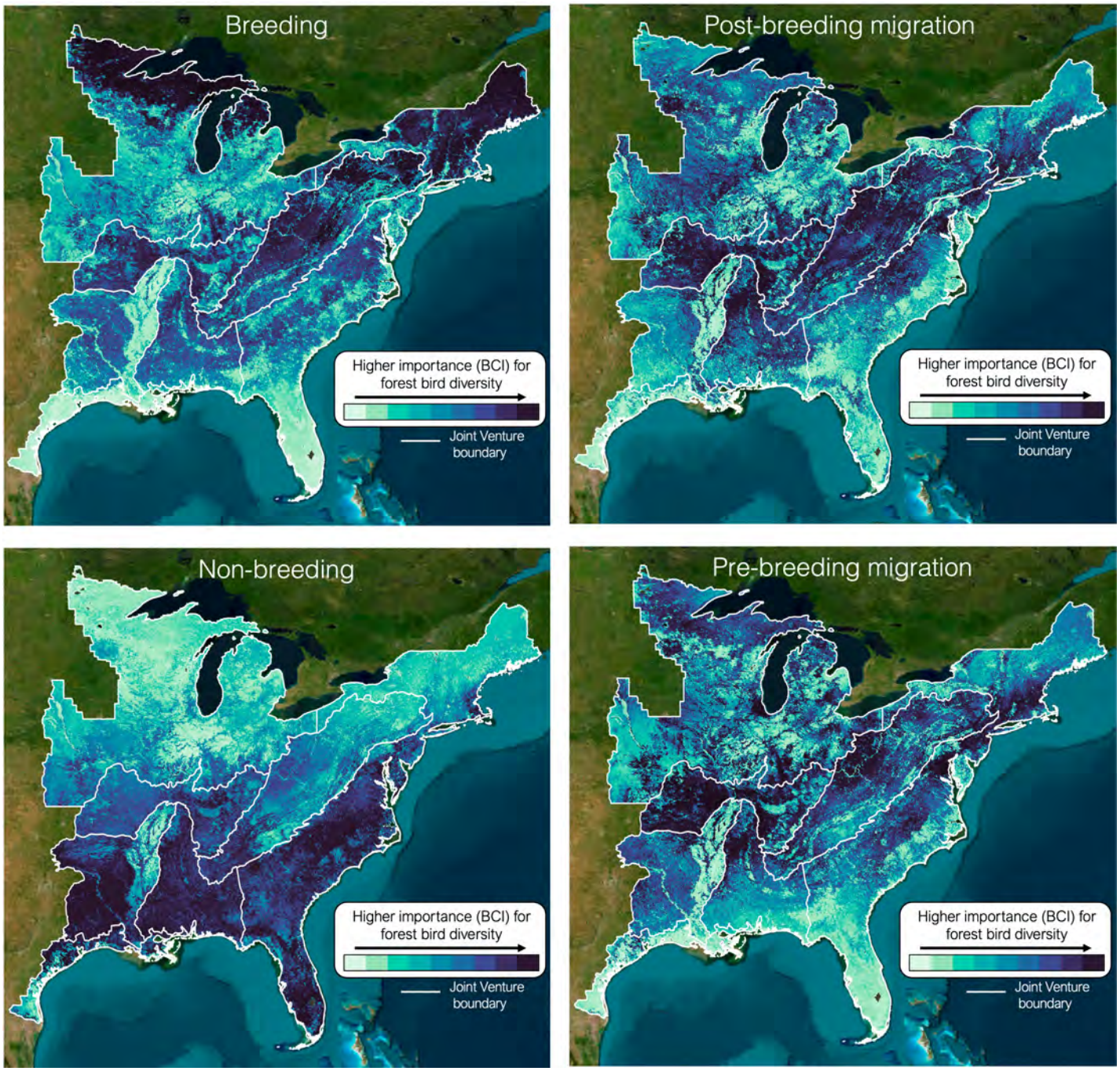


**Figure A1:** Seasonal bird Concentration Areas (BCAs) that support a high number of migratory forest bird species across the full annual cycle. BCAs are characterized by a continuous Bird Concentration Index (BCI) that differentiate areas of highest importance in each season of the annual cycle (as shown here) and across all 52 weeks of the year (shown in Figure 1) at a high spatial resolution of 2.8km x 2.8km.

# Appendix A: Seasonal BCAs for Species Diversity

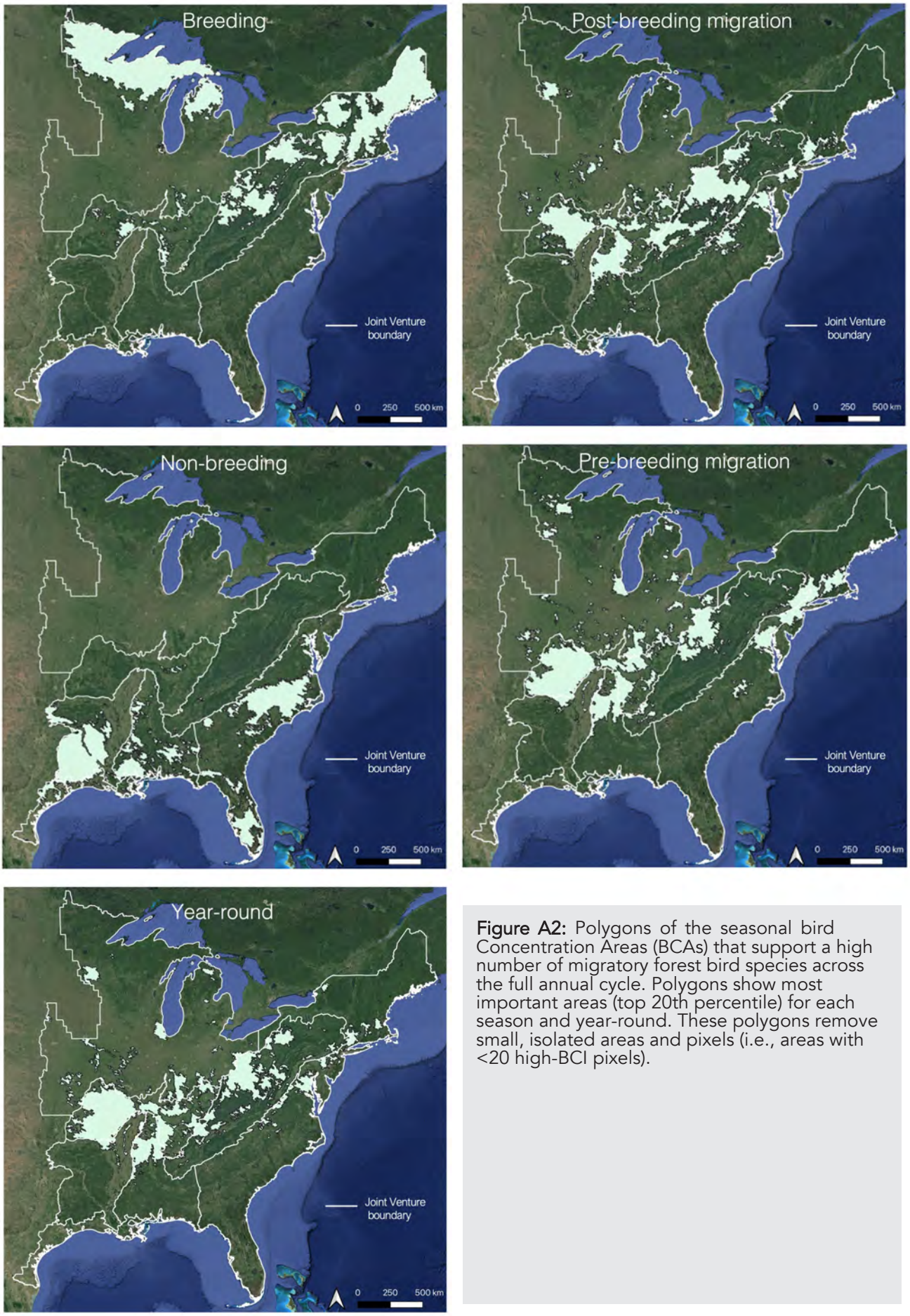


**Figure A2:** Polygons of the seasonal bird Concentration Areas (BCAs) that support a high number of migratory forest bird species across the full annual cycle. Polygons show most important areas (top 20th percentile) for each season and year-round. These polygons remove small, isolated areas and pixels (i.e., areas with <20 high-BCI pixels).

# Appendix A: Seasonal BCAs for Species Abundance

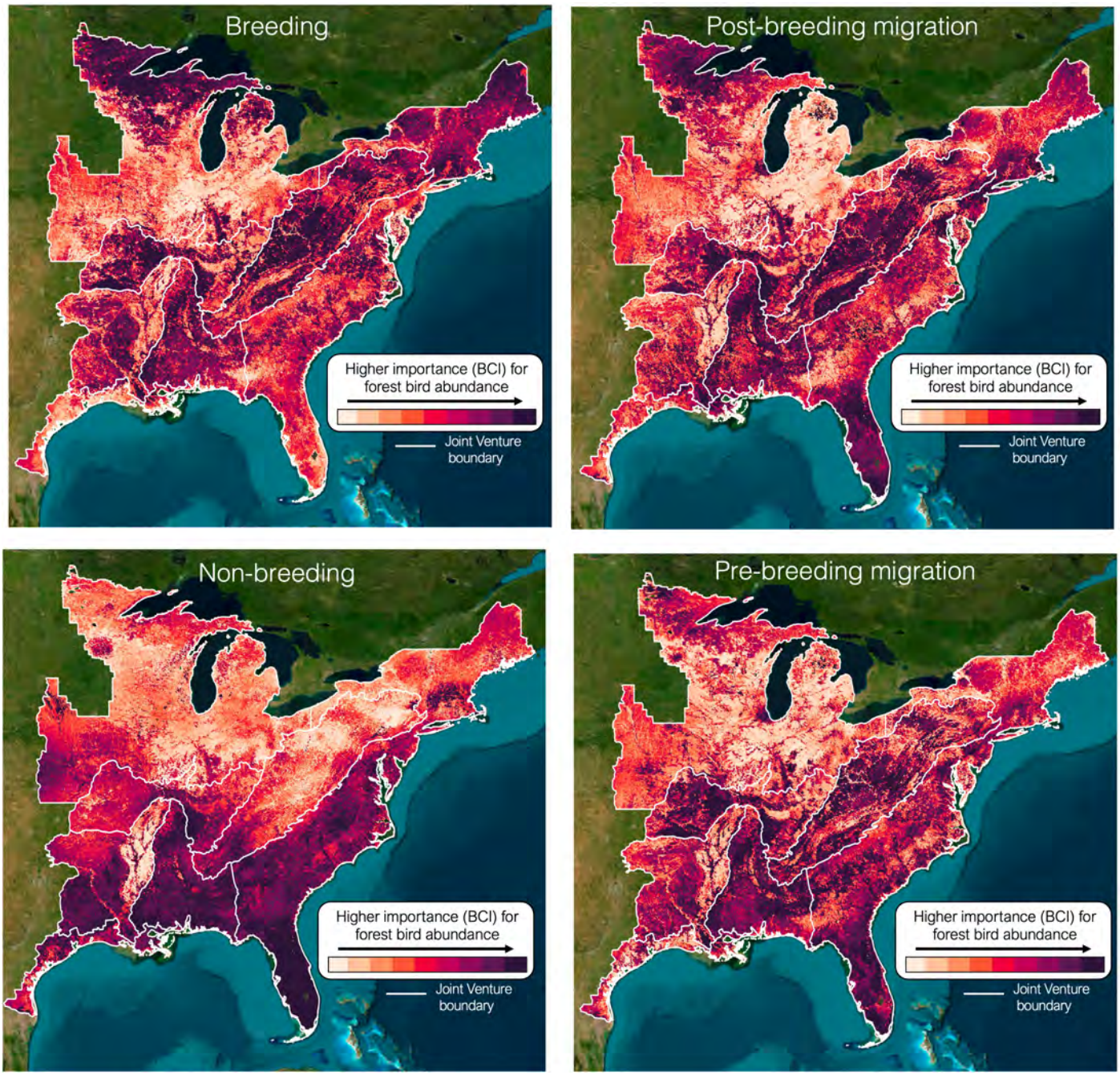


**Figure A3:** Seasonal Bird Concentration Areas (BCAs) that support a high number of migratory forest bird abundance across the full annual cycle. BCAs are characterized by a continuous Bird Concentration Index (BCI) that differentiate areas of highest importance in each season of the annual cycle (as shown here) and across all 52 weeks of the year (shown in Figure 1) at a high spatial resolution of 2.8km x 2.8km.

# Appendix A: Seasonal BCAs for Species Abundance






**Figure A4:** Polygons of the seasonal bird Concentration Areas (BCAs) that support a high abundance of migratory forest bird species across the full annual cycle. Polygons show most important areas (top 20th percentile) for each season and year-round. These polygons remove small, isolated areas and pixels (i.e., areas with <20 high-BCI pixels).

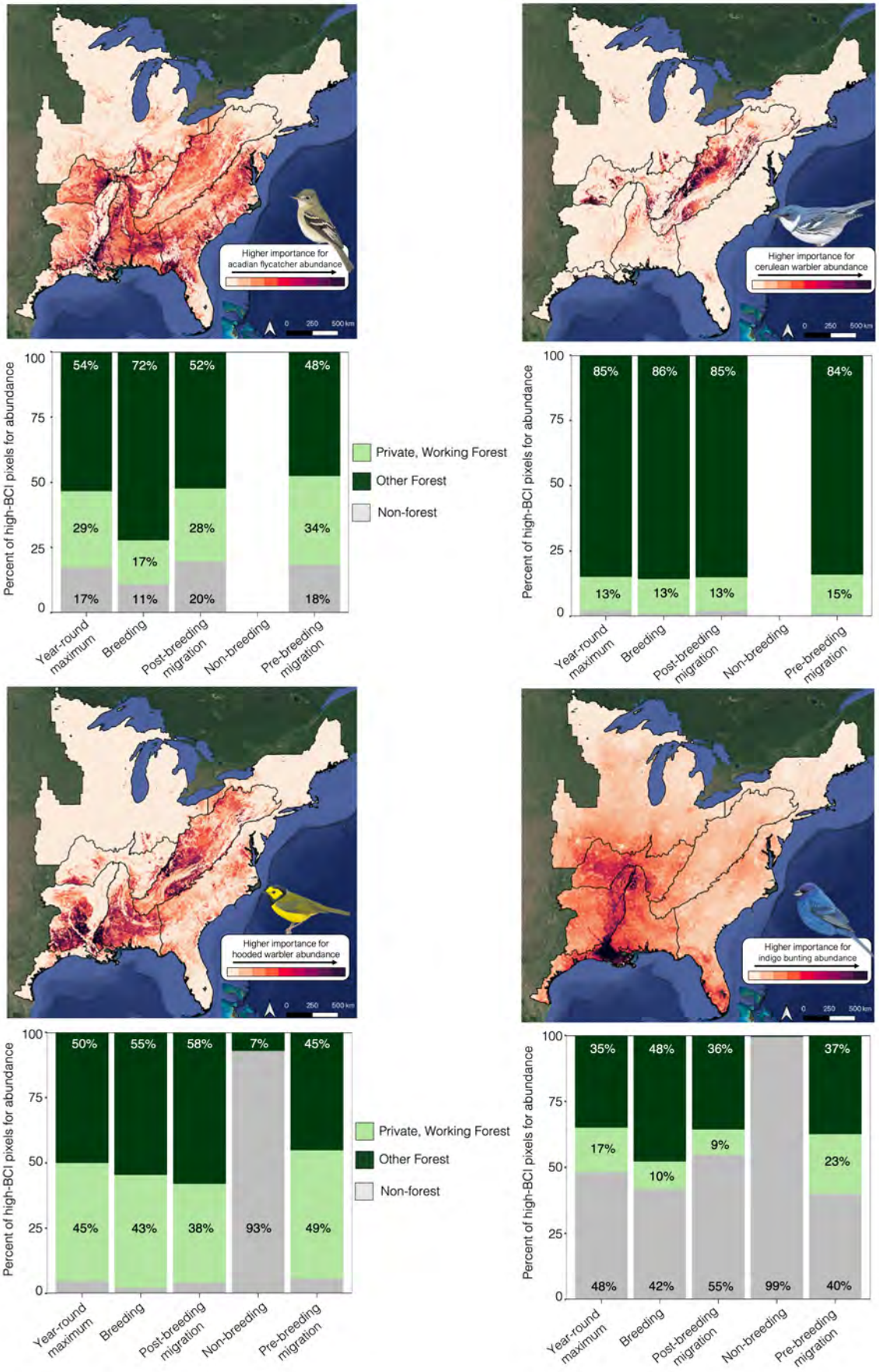


**Figure B1:** Map of year-round maximum percent of population for example species (top panels) and the percent of high-BCI pixels that occur in private, working forests, other forested areas, and other land covers (i.e., non-forests) in each season of the annual cycle (bottom panels).

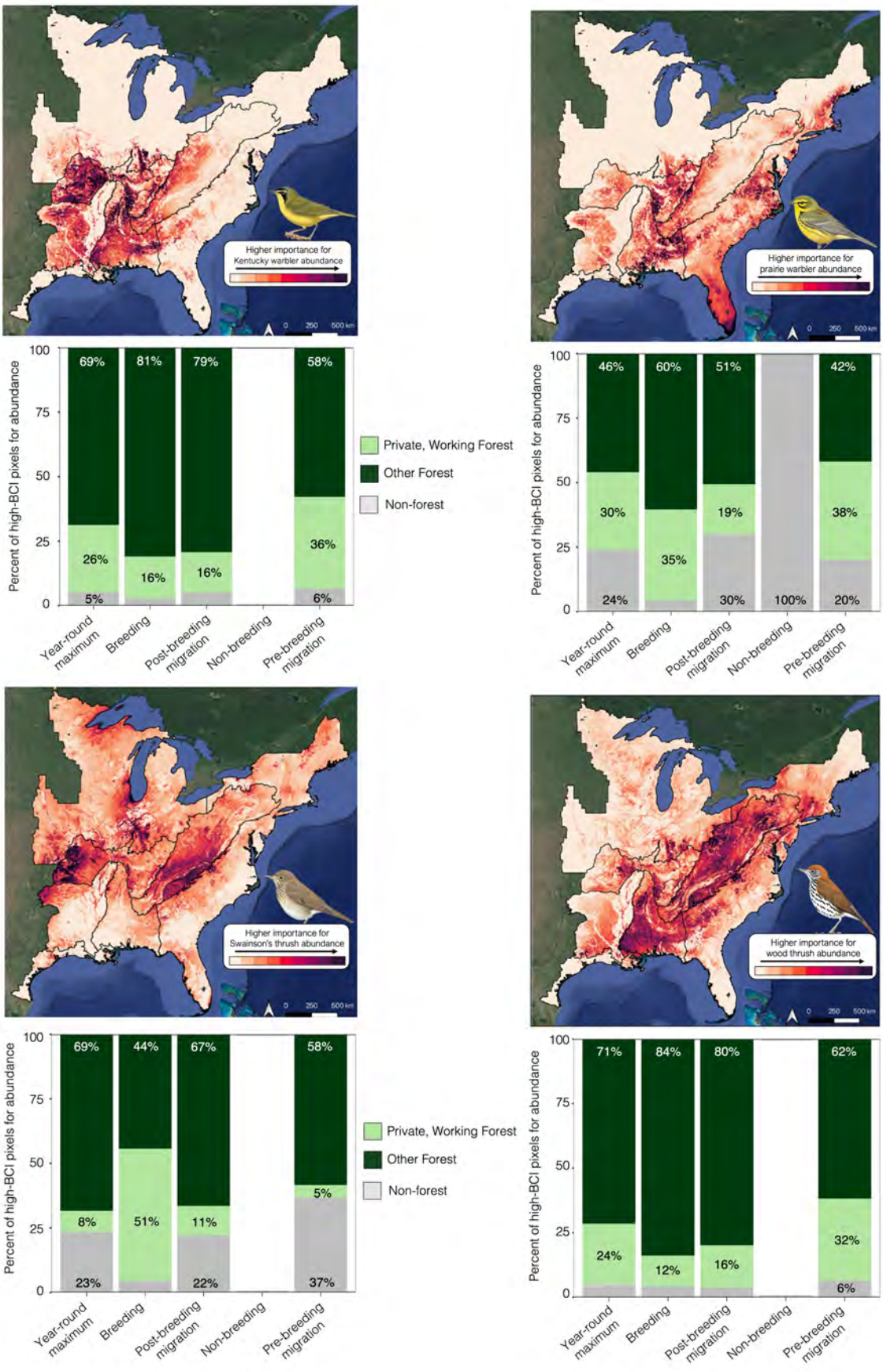


**Figure B2:** Map of year-round maximum percent of population for example species (top panels) and the percent of high-BCI pixels that occur in private, working forests, other forested areas, and other land covers (i.e., non-forests) in each season of the annual cycle (bottom panels).

# Appendix B: Species-Specific Priority Area Summaries

**Table B1:** Percent of 2.8km x 2.8km pixels classified as other forest or non-forest that overlap with species-specific priority areas, defined as the top 20th percentile of their seasonal or year-round maximum percent of population.

| | Year-round max. | | Breeding | | Post-breeding migration | | Nonbreeding | | Pre-breeding migration | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Other Forests | Non-Forest | Other Forests | Non-Forest | Other Forests | Non-Forest | Other Forests | Non-Forest | Other Forests | Non-Forest |
| Acadian flycatcher | 14% | 4% | 17% | 2% | 12% | 4% | -- | -- | 11% | 4% |
| Cerulean warbler | 6% | 0% | 3% | 0% | 3% | 0% | -- | -- | 5% | 0% |
| Hooded warbler | 10% | 1% | 8% | 0% | 11% | 0% | -- | -- | 8% | 0% |
| Indigo bunting | 17% | 20% | 21% | 16% | 16% | 21% | 0% | 1% | 17% | 15% |
| Kentucky warbler | 13% | 1% | 12% | 0% | 13% | 1% | -- | -- | 9% | 1% |
| Pine warbler | 12% | 4% | 11% | 2% | 11% | 4% | 5% | 1% | 11% | 2% |
| Prairie warbler | 11% | 5% | 11% | 5% | 11% | 6% | 0% | 1% | 8% | 3% |
| Swainson's thrush | 26% | 8% | 1% | 0% | 21% | 6% | -- | -- | 17% | 9% |
| Wood thrush | 25% | 2% | 27% | 1% | 19% | 1% | -- | -- | 20% | 2% |