

Monitoring program coverage of species' range

What proportion of species' range is sampled by a long-term monitoring program?

Measuring the proportion of a species' range that is within the region sampled by a given monitoring program helps to understand the potential for bias in estimates of that species' population status and trend. Put simply, a species' status can vary across its range due to spatial variation in factors that affect its status, such as variation in human activity, landcover-change, interactions with other species, and climate. If our monitoring data are derived exclusively from a portion of that range, estimates may not reflect the species' trends and status in the unmonitored portion.

Our goal is to demonstrate one possible approach to measuring this proportion. We will demonstrate the definitions, calculations, and some potential complications, using the North American Breeding Bird Survey as an example monitoring program, and species' ranges derived from eBird status and trend results.

“Spatial Coverage”

Here we will use the term “spatial coverage” or simply “coverage” to refer to the general concept of the spatial sampling of a given species' population by a particular monitoring program. A monitoring program with complete coverage of a given species would have monitoring data from all parts of that species' range; i.e., 100% of the species' range is within the regions sampled by the monitoring program.

Spatial grain

Coverage, defined as the proportion of a species' range within the regions sampled by a monitoring program, requires some definition of the “regions sampled by a monitoring program”. Here we have used an equal area, hexagonal grid with cells approximately 12,000 km² in area (approximately 120km distance between parallel sides) that extends across the land area of the

western hemisphere. This hexagonal grid implicitly assumes that this spatial grain is somewhat meaningful in relation to the particular monitoring program and to the spatial variation in a species' distribution and its status and trends. We will not try to explore how this spatial grain might influence our understanding of monitoring coverage here. However, we caution that alternative spatial grains may generate very different estimates of coverage.

Example: American Robin

American Robin has a relatively broad range and is one of the most common bird species in much of Canada and the United States where the BBS has been conducted. In the map below, the yellow cells are cells with at least one BBS route that has at least two years of observations of American Robin. The red line is the breeding season range limit as defined by the eBird status and trend version 2022 ((Strimas-Mackey et al., n.d.)). Purple cells have at least 25% of their land area inside the range limit.

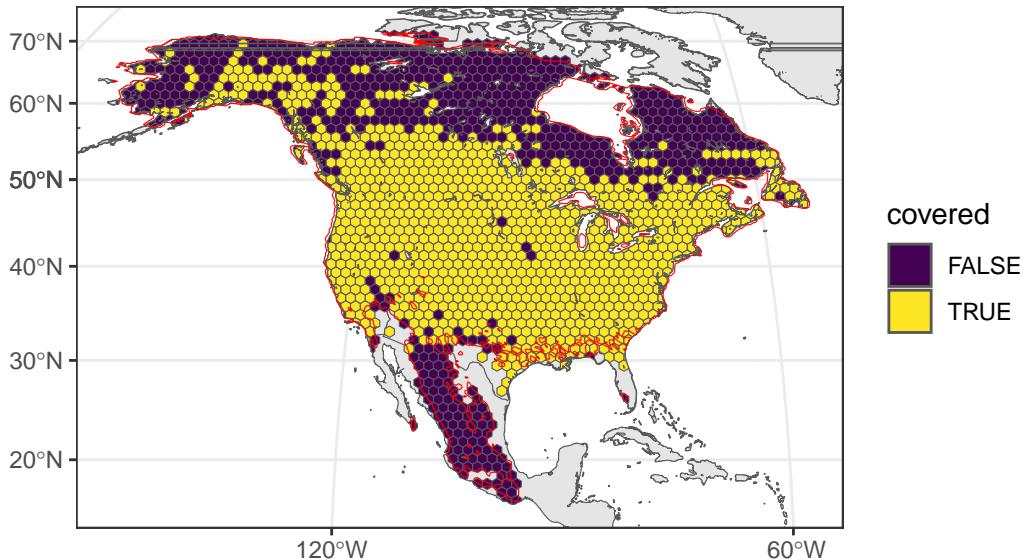


Figure 1: Based on western hemisphere land area of $12,000\text{km}^2$ hexagonal grid cells. Assuming that any grid cell with monitoring data is completely covered. Range is both the land area of all grid cells with $>25\%$ overlap with the species' range layer from eBird, and all grid cells with monitoring data for >2 years.

Across the entire western hemisphere range, the BBS coverage estimate for American Robin is 61.2% of the species' range. That is 61.2% of the land area inside the species' range is within the yellow cells.

If we select only the cells that intersect the United States, 88.8% of the species' range in the United States is within the yellow cells. If we select only the cells that intersect Canada, 44.2% of the species' range in Canada is within the yellow cells.

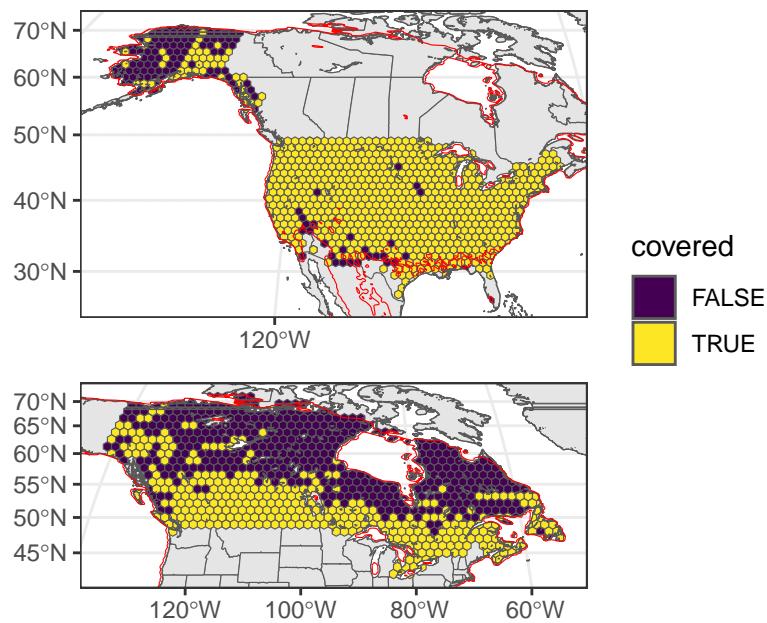


Figure 2: Coverage of American Robin breeding range in the United States and Canada by the BBS.

Example complications

Mismatches between range and monitoring data

For some species we may have monitoring data from outside of the predicted range. For example, Connecticut Warbler populations have decreased so much in the southern portion of their range that there are relatively many grid cells with monitoring data, that fall outside of what is currently considered their breeding range.

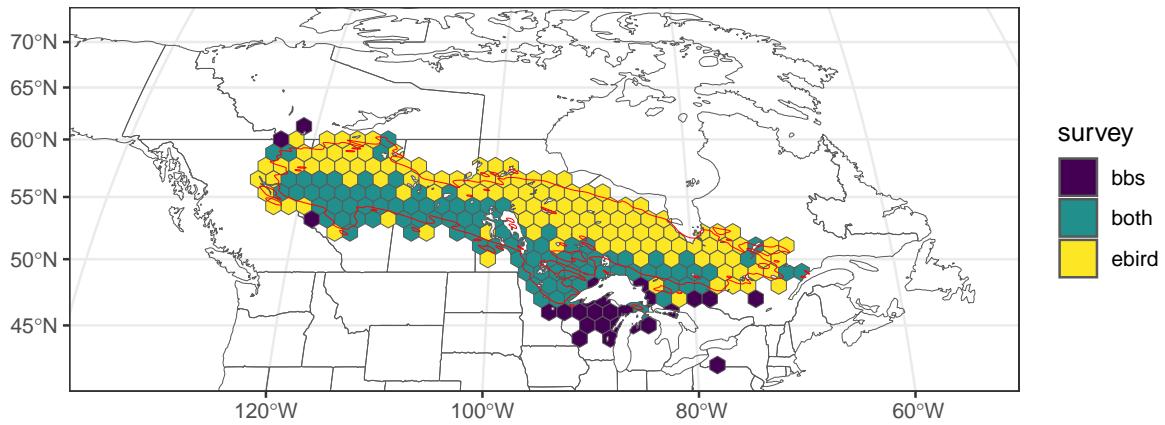


Figure 3: Connecticut Warbler coverage: Grid cells with BBS monitoring data but outside the species' eBird range (purple), cells that overlap the species' range polygon from eBird status and trends but with no BBS monitoring data (yellow), and cells with both monitoring data and overlapping the species' range

Reconciling the mismatches

One approach to reconciling the two sources of information is to assume that any grid-cell with observations from either source is part of the species' range, and that any cell that intersects either the range map or observations from a the monitoring is part of the species' range. However, this will likely generate artifacts of low coverage at the edge of a species' range, where many cells may overlap a very small portion of the range map. To reduce this range-edge effect, we can set a minimum threshold overlap between the range and the grid-cell, such as 25% (the threshold applied above in the American Robin example).

Removing the grid cells with < 25% overlap of the species' range polygon increases the estimate of the overall coverage by -6.2%, from 48.8 within the edge cells included to 55% with edge cells excluded.

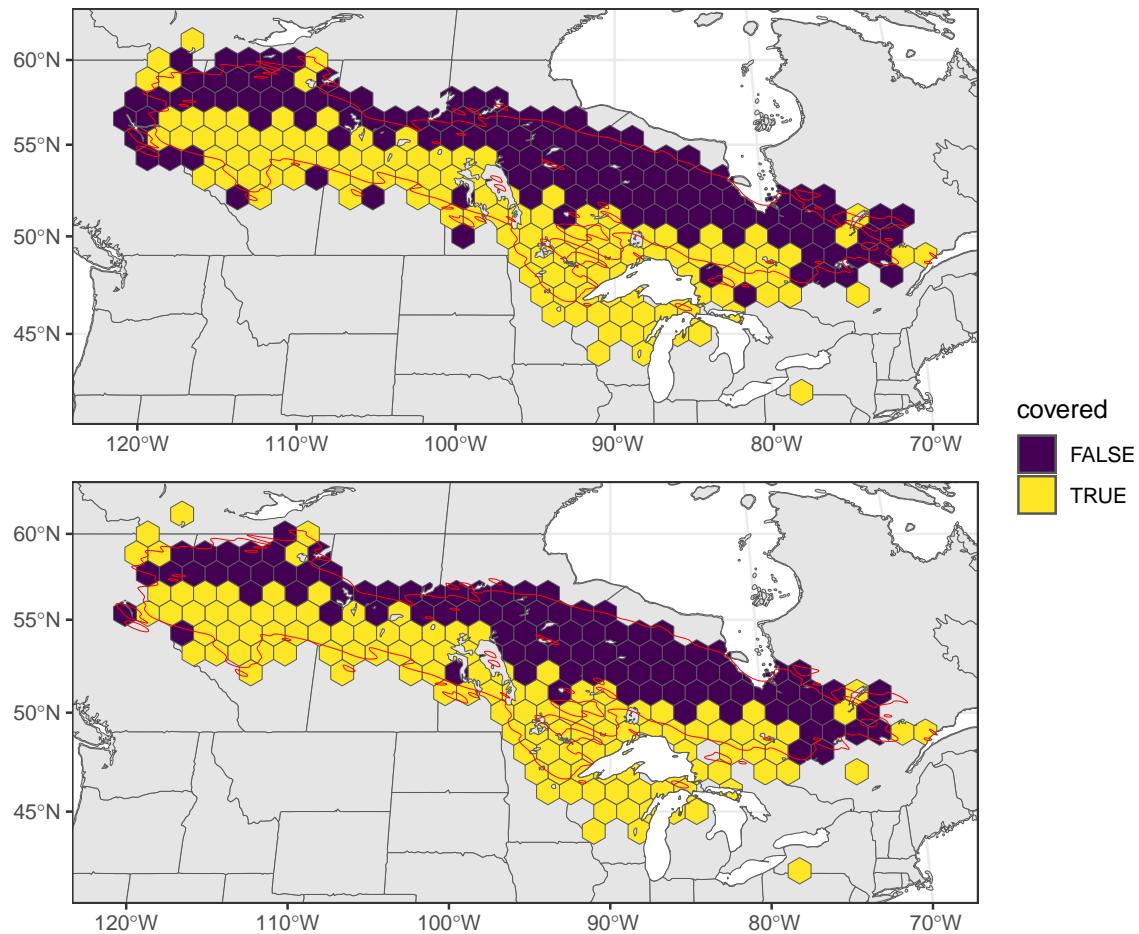


Figure 4: Connecticut Warbler coverage: The top panel considers any grid cells that overlap the species' range polygon as being part of the range. The bottom panel excludes any grid cell with less than 25% of its area overlapped by the range polygon.

Range outside of North America

The hexagonal grid extends across all of the western hemisphere, which is particularly useful for estimating coverage of North American monitoring efforts conducted during the non-breeding season (wintering waterfowl, Christmas Bird Count, migrating shorebird surveys). However, it also raises some questions about the breeding season coverage for species with very broad breeding season ranges that extend into South America. This approach allows us to calculate the hemispheric coverage, but for some assessments, a smaller scope may be desired.

Approximately 37.2% of the species' hemispheric range is covered by the BBS. Whereas, 94.6% of range in the USA and 54.3% of the range in Canada is covered.

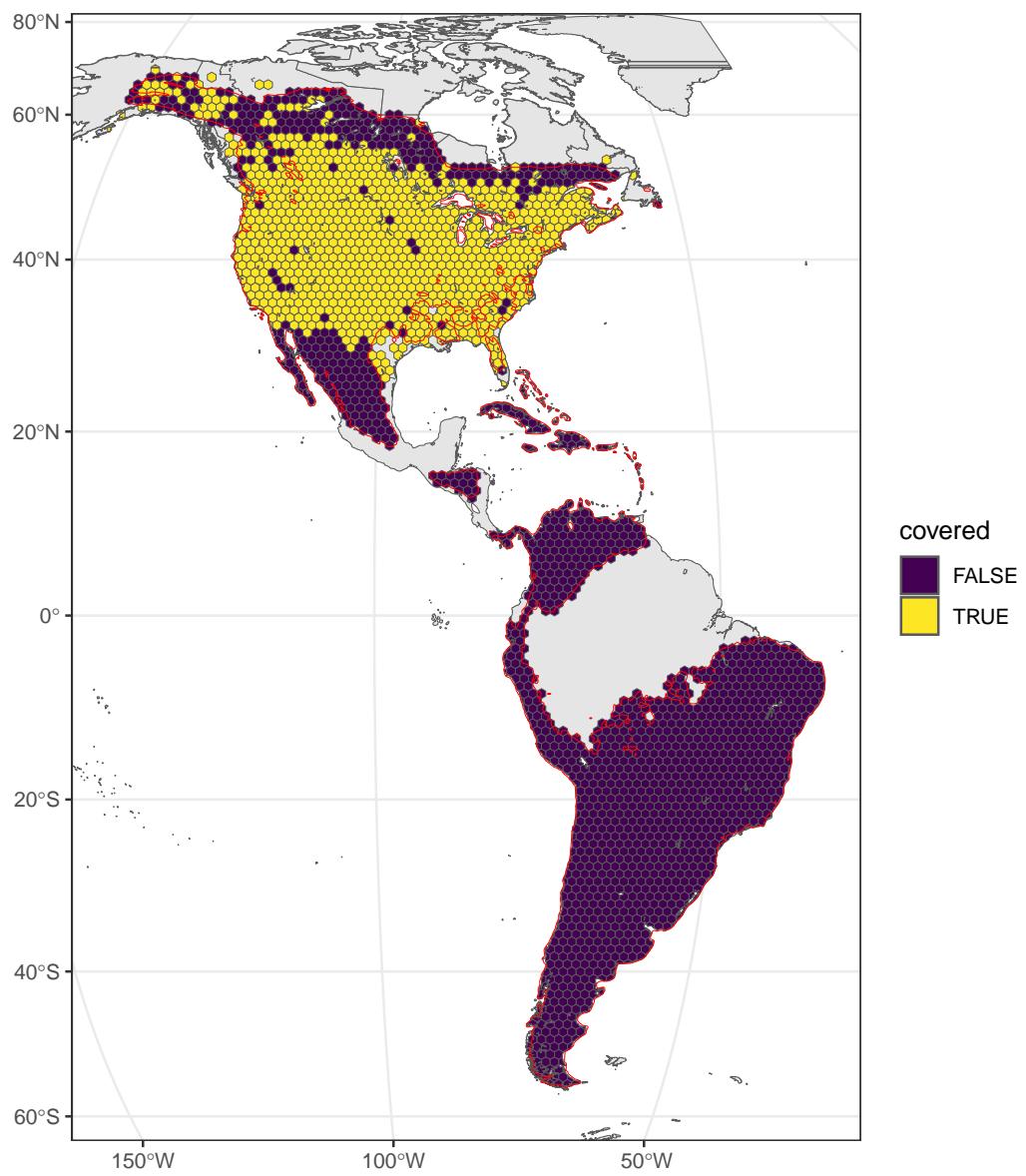


Figure 5: American Kestrel coverage of hemispheric range by BBS

Complex range boundaries highlight the importance of spatial grain

Some species have relatively complex range boundaries. In these cases, the general approach here still works, but the size of the grid cells and the decisions about minimum overlapping range of grid cells become particularly important. Caspian Tern provides an interesting example, where there are relatively many cells with monitoring data that do not overlap the range polygons, and also many small isolated patches of range that are too small to meet the minimum threshold overlap of 25%.

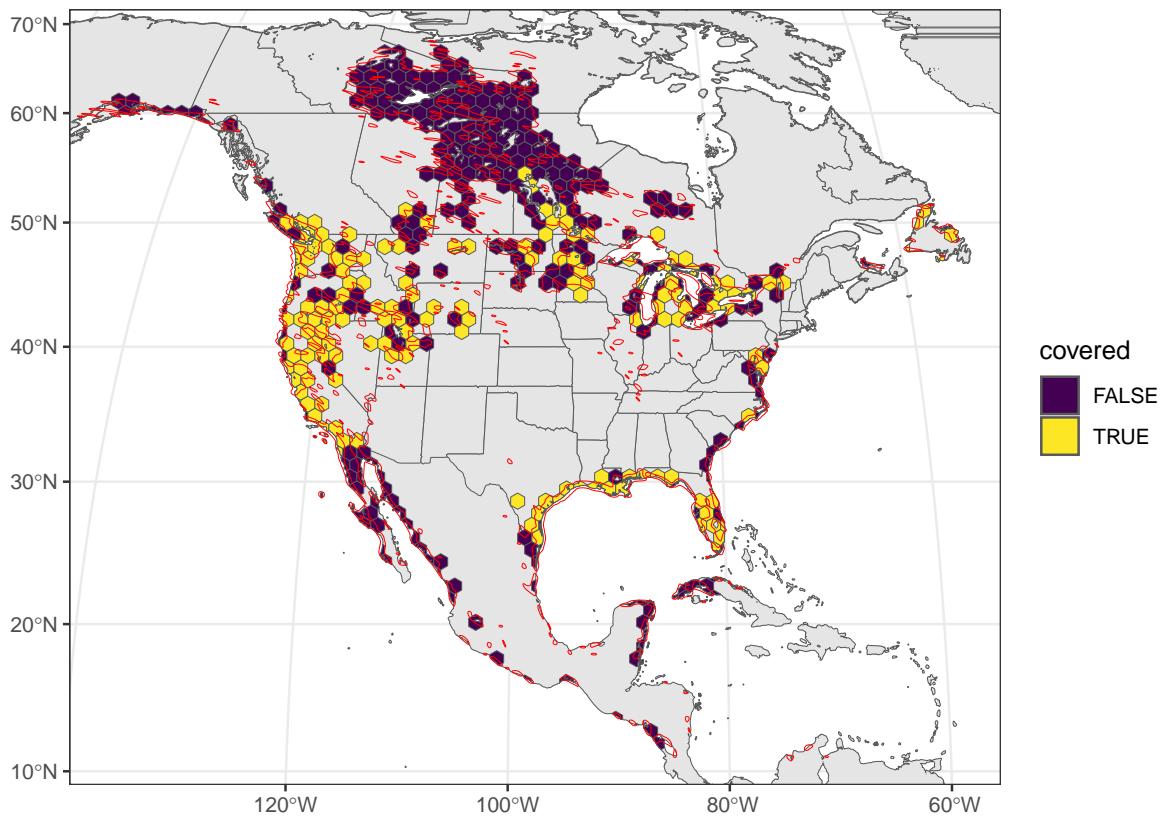


Figure 6: Caspian Tern coverage of complex range by BBS, using a hexagonal grid approximately 120km in size, and requiring a minimum of 25% overlap with the range polygon in order to consider a non-monitored grid cell part of the species' range.

Temporal variation in monitoring

An added complication to assessing the spatial coverage of a monitoring program is that for many programs, the spatial coverage has changed over time. For example, the spatial coverage of the BBS for American Robin in the 2010s (41%) is larger than it was in the 1970s (56.3%).

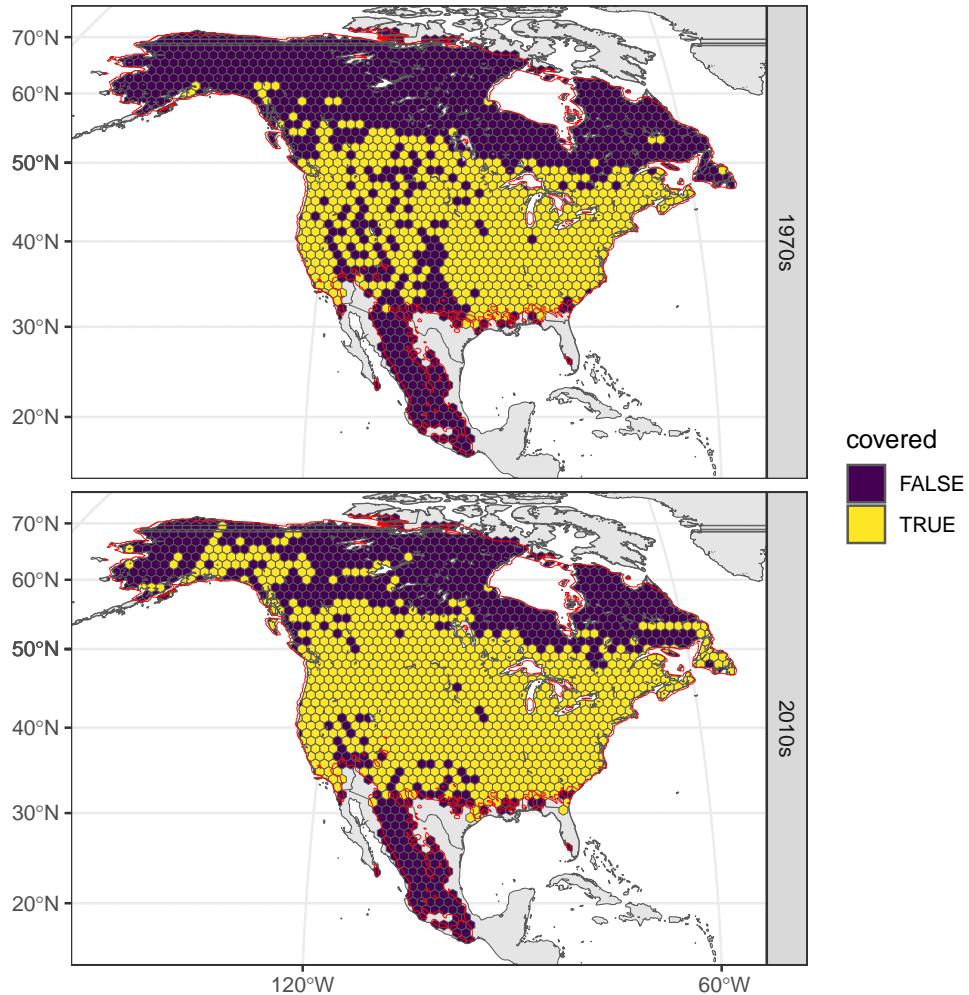


Figure 7: BBS coverage of American Robin range in the 1970s and the 2010s

Spatial variation in abundance

For monitoring coverage, we could expand the inferential goal beyond the spatial coverage of a species' range, to consider the relative abundance of the species across its range. For example if a particular grid cell includes 5% of a species population, monitoring coverage within that grid cell is likely more important than monitoring coverage within a grid cell that includes 0.1% of the species' population. The map below shows the BBS coverage of Barn Swallow overlayed on the eBird relative abundance surface. Accounting for the spatial variation in relative abundance, 77.5% of the species' population is covered by BBS, whereas using range information 69.5% of the species' range is covered.

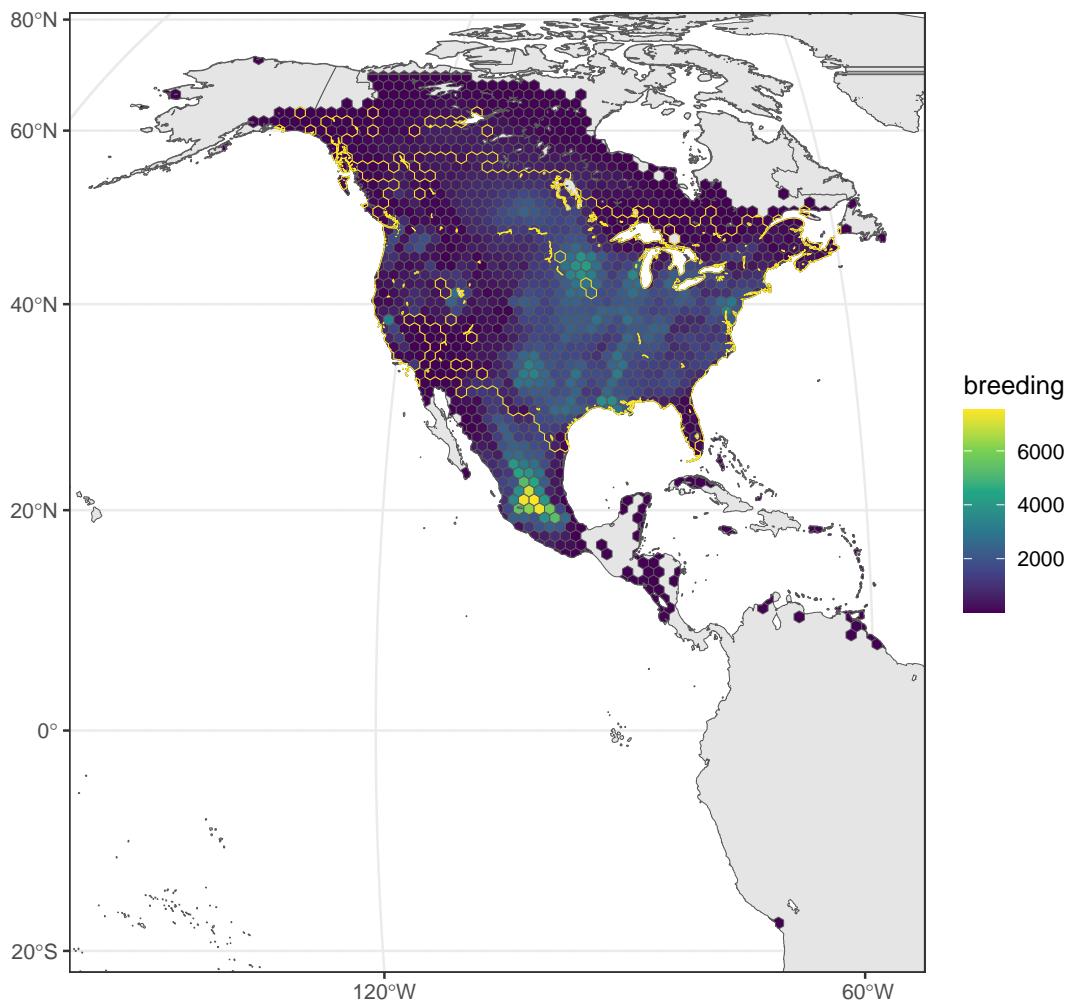


Figure 8: BBS coverage of Barn Swallow relative abundance. The cell colours are scaled to the eBird estimated breeding population relative abundance in each grid cell. Yellow-outlined cells are covered (i.e., have some BBS monitoring data for Barn Swallow)

References

Strimas-Mackey, Matthew, Shawn Ligocki, Tom Auer, and Daniel Fink. n.d. “Ebirdst: Access and Analyze eBird Status and Trends Data Products.”