**Framework for Implementing CHJV Forest and Woodland Habitat Objectives**

**Overview**

The Central Hardwoods Joint Venture (CHJV) is a partnership of state and federal government agencies and non-governmental organizations who work together to ensure the long-term viability of native bird populations within the Central Hardwoods Bird Conservation Region (CHBCR). The CHJV pursues this mission by striving towards 2 primary goals: (1) implement conservation actions based on sound science and principals of adaptive management, and (2) target landscapes with the greatest ecological and socioeconomic potential to support viable populations of priority birds.

In pursuit of the first goal, CHJV staff worked with the CHJV Technical Committee and university partners to develop a suite of decision support tools that fall in 4 main categories. Habitat Assessment tools include Habitat Suitability Index (HSI) models for assessing the relative suitability of habitat conditions at local and landscape scales for individual species, and a General Productivity Index model for assessing the potential impact of habitat fragmentation on avian productivity. Population-Habitat Linkage tools are a set of density and demographic estimates that can be used to convert suitability estimates to population impacts. Future Expectation tools identify conservation opportunities and threats and include an Ecological Potential Vegetation (EPV) model for identifying habitat restoration opportunities and targets, and an Urban Growth model that predicts where increased housing density is likely to occur. Finally, a pair of spreadsheet-based Simulation tools has been developed to tie the other decision tools together in a way that provides a rapid assessment of the likely impacts of a future scenario on a species, as well as the potential tradeoffs among species that are inherent in any conservation design. More rigorous assessment of promising conservation designs can be conducted using the Habitat Assessment tools and/or the recently-developed Landscape-based Population Viability model. This simulation tool combines the Habitat Assessment and Population-Habitat Linkage tools with a dispersal model in a metapopulation framework and has been parameterized for 3 priority species (Wood Thrush, Prairie Warbler, and Worm-eating Warbler).

CHJV staff have used the HSI models, density linkages, EPV model, and the 2 spreadsheet-based simulation tools to estimate the amount of restored habitat (i.e. habitat objectives) needed to sustain populations of priority forest and woodland birds at desired levels (i.e. our population objectives). These restoration objectives have been allocated among State sub-regions of the CHBCR, as well as to conservation partners within those regions, based on the proportion of the overall (CHBCR-wide) restoration opportunity they encompass (Population & Habitat Objectives report available upon request). The restoration objectives provide CHJV partners with an idea of the magnitude of effort (a range of acreages) required to sustain species at goal and their relative responsibility for achieving that goal. However, there is great uncertainty in the allocation process because there are unforeseen constraints and a myriad of ways the partners might come together to overcome those constraints and achieve the overall habitat targets. As a hypothetical example, partners in Illinois might already have projects planned, underway, or completed that would exceed Illinois' allocation for floodplain forests (i.e. bottomland hardwoods and riparian areas), whereas Illinois' allocation of barrens may be out of reach due to socio-economic constraints. The shortfall in barrens allocation might be compensated for by opportunities in another State sub-region, or we may find that we need to re-allocate bird populations among other useable habitat types.

Uncertainty in the process of allocating habitat objectives requires that we take an iterative and adaptive approach to designing landscapes capable of sustaining bird populations at desired levels. The current allocation of habitat objectives represents a "top-down" approach that demonstrates it is (at least mathematically) possible to sustain bird populations at desired levels without managing every acre of the CHBCR. However, it lacks some realism relative to the capacity constraints of partner organizations and the socio-economic constraints within particular landscapes. Thus, we need to develop a "bottom-up" strategy that recognizes conditions on the ground. Conservation designs that result from this bottom-up approach can be analyzed with the CHJV models to assess their potential to meet our population objectives. Through iterative comparisons of top-down and bottom-up designs we can arrive at strong, well-supported vision for CHBCR landscapes.

This document recommends a framework for using the CHJV decision support tools to accomplish the second goal of the CHJV partnership – targeting conservation actions towards landscapes with the greatest potential to sustain populations. This framework attempts to bring our knowledge and science to bear so that we make decisions about where to focus our conservation efforts in the most transparent, defensible, and strategic way possible. It is structured as a series of questions and shows how CHJV tools can be used to answer those questions. Additional sources of information can be incorporated into the framework to reduce uncertainty for any decision point (i.e. multiple lines of evidence make for better supported decisions). Similarly, if higher resolution or better quality information exists in a state, it may be substituted for the CHJV information provided it allows comparison of conservation designs and objectives among partners and State sub-regions.

It should be noted that this framework is focused on priority bird species that require trees or shrubs as part of their breeding habitat & that it assumes that the habitat needs of these species are best met by restoration of native forest and woodland community types included in the EPV model. Therefore, other management practices that may provide suitable habitat conditions (e.g. clearcuts) do not contribute to the overall objective because of their ephemeral nature.

**Framework for Targeting and Designing Sustainable Forest and Woodland Landscapes**
For habitat modeling purposes, the CHJV has used Bailey's ecological subsections as the primary landscape unit. There are 57 subsections within the CHBCR, some of which encompass portions of multiple states. For practical reasons, the CHJV has split those 57 subsections into 80 landscapes (i.e. planning units) based on CHBCR, subsection, and State boundaries (Figure 1). Very small portions of subsections that intersect a state were combined with neighboring subsections to reduce the number of planning units & eliminate impractical divisions. Similarly, the small Kansas and Ohio portions of the BCR were analyzed separately but combined with other states (Oklahoma and Kentucky, respectively) for purposes of this document.

There are many potential conservation actions that can be targeted within a single landscape. This framework aims to help identify 1 of 4 primary actions for a landscape by enabling planners to classify landscapes into 1 of 4 categories:

1. Priority birds are abundant, has lots of high quality habitat, and is protected
    a. Maintenance is primary need
    b. "Do no harm"
2. Birds are abundant, has lots of high quality habitat, but is unprotected
    a. Protection is primary need (Maintenance is also necessary)
    b. "Keep it intact"
3. Birds are present & could be increased/concentrated & has good restoration potential/opportunity (protected or not)
    a. Enhancement is primary need (Protection may also be necessary)
    b. "Bring it back"

4. Birds are rare or absent (could be reintroduced), but has good restoration potential/opportunity, & is protected
    a. Restoration is primary need
    b. "Build it & they will come"

This framework is structured as a series of 7 questions to help identify Steps to ID targeted landscapes

1. Which priority bird group are we focusing on?
2. How are they currently distributed? (Where is the habitat currently most suitable?)
3. Are current distributions protected?
4. Where are communities currently restored or in good condition?
5. Where are restoration opportunities concentrated?
6. What are the stressors?
7. Where do these qualities intersect?

**Question 1:** Priority Bird Group
The CHJV has emphasized natural community restoration as the preferred mechanism for sustaining priority species populations at desired levels over time. There are many reasons for taking this approach, but one of the primary reasons is that these communities are adapted to specific soil and edaphic conditions. By identifying where these conditions are throughout the BCR, we have identified where the most appropriate (and likely least cost) places are for managing & maintaining those communities (http://www.chjv.org/newchjv/modeling.html). Because our planning units are ecological subdivisions of the BCR, each unit has its own mixture of current landscape conditions and the set of natural communities that can potentially be restored. Similarly, units will differ as to the relative benefit restoration efforts will provide to bird species and communities. Because of this, every planning unit presents conservation opportunities of some sort. A useful first step then is to decide which bird(s) should be the lens through which we assess our options.

The CHJV has developed individual habitat models for a suite of forest and woodland species that are capable of assessing current and projected or desired landscape and local habitat conditions (Tirpak et al. 2009a). The justifications for which species were selected are documented in the Population and Habitat Objectives report (available upon request). We chose to develop individual species models (as opposed to assessing diversity or richness) to enable an assessment of the tradeoffs among species that are inherent in management and planning decisions. However, for the purpose of targeting landscapes and developing conservation designs, we recognized the need to simplify the decision-making process. Thus, we grouped our priority species into 3 broad habitat groups (Table 1) according to their expected response to restoration based on our habitat models. The Woodlands group includes species expected to benefit from restoration of the open canopy conditions characteristic of savannas, barrens, glade complexes, oak open woodlands, and pine-bluestem open woodlands. Depending on management regime (e.g. fire frequency) these communities should provide habitat for shrub-dependent species (e.g. bobwhite). The Forest group includes species expected to benefit from restoration of more closed-canopy conditions characteristic of oak closed woodland, pine-oak closed woodlands, and mesic forests. The Riparian group includes species that prefer forest conditions associated with streams, floodplains, or bottomlands. Whereas no classification scheme is perfect (some species necessarily fall in more than 1 group), these designations will hopefully help stimulate thinking about the targets and goals of conservation actions.

**Question 2:** Bird Group Distribution

Another useful step is to determine how birds and their habitat are currently distributed. Working from a premise of multiple lines of evidence, we have developed 2 tools to help answer this question. The first uses our habitat models to show how habitat is distributed across the BCR. The second uses BBS data to indicate where populations are currently clustered.

Weighted Ensemble Models – Based on the bird group designations described above, we combined the spatially-explicit, "reduced" versions of our validated HSI models (i.e. those that form the basis of the spreadsheet tool and the habitat objectives allocation). Model outputs for each group of birds were added together on a pixel-by-pixel basis after a 3-step process. First we converted HSI model outputs to carrying capacities by multiplying the HSI score times the maximum density for a given subsection (Population & Habitat Objectives report available upon request). Next we scaled carrying capacity by the relative productivity of landscapes by multiplying the carrying capacity times the General Productivity Index (see Question 4 below) and re-scaled outputs to a 0-1 scale. Finally, we weighted each species' capacity-productivity scores based on its relative priority (Table 1), with Watch List species receiving full weight, Stewardship species receiving two-thirds (0.667), and BCR Priorities receiving one-third (0.333). The resulting maps (Figures 2, 3, & 4) show the relative score of each location in the BCR, with higher numbers indicating either suitability of that site for more species or for higher priority species. The raw data maps were summarized at the planning unit scale by simple averaging across all pixels in the unit. Units were ranked by their average score with the highest mean score receiving a rank of 1 and the lowest a rank of 80 (map insets in Figures 2-4; Table 2). We caution against interpreting the raw data maps too literally. Although we used only models that had been validated for use at the subsection scale (Tirpak et al. 2009b), these "reduced" versions are still being tested for accuracy. Further, although the models indicate that local and landscape conditions are suitable for a given species, this does not necessarily ensure that the species are using that location. Habitat selection is impacted by non-structural factors that cannot be assessed from remotely sensed data.

BBS Abundance Ranks – Another limitation of the habitat ensemble approach is that we don't have validated models for all the species we are concerned about, especially in the Woodland group. To fill this gap, we analyzed BBS grid data (i.e. USGS model extrapolations of BBS route abundance data for 2006-2010) to determine where species are concentrated in the BCR. This analysis borrows from work done in the Prairie Pothole JV (K. Doherty, personal communication) that assesses which BBS grid cells have the highest densities for a species compared to all the grid cells in its range. Here we restrict the "range" to the BCR. Again, rather than show individual model results, we combine species according to groups and show the number of species for which a particular grid cell is in the top 25% of densities (Figures 5-8). Figures 5 and 6 show the difference between restricting this analysis to validated models versus all priority species in the Woodland group. Illinois "lights up" in the all priority species version because of its importance to Northern Bobwhite and Brown Thrasher among others. Maps for the Forest (Figure 7) and Riparian (Figure 8) groups are based upon birds with validated models only because there are fewer birds without validated models in those groups and the results were not appreciably different. Caution should be used in interpretation of these maps as well because the BBS does not sample all landscapes or species equally, and due to the course resolution of the cells.

**Question 3:** Level of Protection

Commonly referred to as a gap analysis, assessment of the degree to which species are "covered" by protected lands is a staple of conservation planning because public lands can provide large areas of relatively secure conservation investments. Here we used the CHJV's public land database to represent protected lands (Figure 9), and planning units are ranked simply by the amount of land under protection with the highest receiving a rank of 1 and the lowest a rank of 80 (map inset in Figures 9; Table 2). Caution should be used in interpretation of this information for 3 reasons. First, this data was pulled together in 2006 from a variety of inputs. Thus, current boundaries may not be accurate and recent acquisitions will not be represented. Second, long-term & permanent conservation easements on private lands are a substantial and important part of the Conservation Estate, but are not included here due to the difficulty in pulling that data together. Finally, we included all public lands without regard to management status or purpose. General categories of protection level are available via the Protected Areas Database produced by USGS. The CHJV partnership will need to assess if that level of classification are sufficient or if more detailed information is warranted.

**Question 4:** Landscape & Habitat Conditions
The EPV model defines what communities should be where across the BCR. We can use this information to assess the current state of BCR landscapes by assessing their relative departure from desired conditions. We have examined this from 4 slightly different perspectives. The first 2 approaches examine the relative amount and fragmentation of forested lands within the BCR. The third examines landscape condition on a pixel-by-pixel basis using the concept of naturalness. The fourth examines departure of current vegetation from desired (i.e. EPV model) for each patch.

Forest Proportion – The amount of forested land is a simple and straightforward comparison of the value of planning units for forested birds. We created a simple forest/non-forest binary map by reclassifying the 2006 NLCD (Figure 10), where forest classes included deciduous, evergreen, mixed, shrub, or woody wetland. Planning units were ranked by the proportion (%) of land in forest land covers with the highest receiving a rank of 1 and the lowest a rank of 80 (map inset in Figure 10; Table 2). The primary caveat to interpretation of this map is that it does not include any information about forest type or condition.

General Productivity Index – The productivity of forest and woodland birds is impacted by forest fragmentation. The General Productivity Index is based on a synthesis of the data reported by Robinson et al. (1995) and was derived from aforementioned forest/non-forest binary map. It is made up of 2 components: the proportion of land within a 10-km radius of a pixel that is classified as forest, and the distance from the pixel to the nearest non-forest edge. The components are combined giving greater weight (2/3) to the proportion of forest (Figure 11). Planning units were ranked based on the mean GPI value of forested lands (non-forested pixels = 0) with the highest receiving a rank of 1 and the lowest a rank of 80 (map inset in Figure 11; Table 2). We are currently working towards an assessment of this tool, thus it is best interpreted as a measure of forest fragmentation.

Naturalness Index – We adapted a Degrees of Naturalness classification scheme used by Ferrari et al. (2008) to assess the relative restorability of pixels within the BCR under the assumption that higher degrees of naturalness would indicate locations that easier and less costly to restore and maintain. In increasing order of naturalness (decreasing order of cost), the classes included:

1. Not Restorable: water and urban
2. Agriculture: crop and pasture
3. Semi-natural: vegetation with spontaneous species composition, but of a different structural type than expected (e.g. woods on a prairie site)
4. Sub-Natural: vegetation which still belongs to right structural type, but of a different class (e.g. deciduous woods on a pine site)
5. Natural: vegetation remains as the expected structural type and class

Pixels were classified based on an overlay of the 2001 NLCD on the EPV model output (Figure 12), and planning units are ranked by the proportion (%) of land in the Natural class with the highest receiving a rank of 1 and the lowest a rank of 80 (map inset in Figure 12; Table 2). Unknown rates of classification error in both maps could impact the raw scores. However, error rates are likely consistent within states.

<u>Patch Condition Map</u> – We developed the patch condition map to assess the extent to which restoration habitat objectives may already be met within State sub-regions and planning units of the BCR. To do this we developed a patch map for the BCR by intersecting a landform map (based off a digital elevation model and used as input to the EPV model) with the 2006 NLCD, and then computing average canopy cover from the 2001 NLCD Canopy Cover product (i.e. an 2001 NLCD product not updated in 2006). This patch map was then compared directly to the EPV model to determine if the current patch had the expected cover type and canopy cover class characteristics. Current landscape patches were classified into 4 classes (Figure 13):

1. In Character: land cover type and canopy range consistent with EPV model
2. Out of Character: same land cover type as EPV but diff canopy range or Mixed forest in any range (with exception of closed Pine-Oak)
3. Altered: land cover type is inconsistent with EPV model
4. Converted: Agricultural, Urban, or Water land cover classes

Planning units were ranked by the proportion (%) of land in the In Character class with the highest receiving a rank of 1 and the lowest a rank of 80 (map inset in Figure 13; Table 2). Unknown rates of classification error in both maps could impact the raw scores. However, error rates are likely consistent within states.

**Question 5:** Restoration Opportunities
The EPV model (Figure 14) was produced by asking community ecologists in each State to assign natural communities to combinations of land form and land type association (i.e. the step below subsection in Bailey's ecological hierarchy), assuming natural disturbance regimes. This map has alternately been interpreted as historic (i.e. pre-settlement) vegetation or desired conditions, but perhaps the best interpretation is as a map of restoration opportunities. The EPV model can be used to assess the appropriate community to restore a given parcel of land within the BCR and these opportunities can be summarized in terms of area (e.g. acreage) for any ownership. Rather than produce maps and subsection ranks for each community type, we summarized the amount of restoration opportunity on public lands for each community type by planning unit for each State (see Table 2 in each State document). The caveat to interpreting those summaries is that they assume that areas classified as a forested land cover are the only "restorable areas". Areas in other land uses were assumed to be too costly.

Another potential approach to assessing restoration opportunities using the EPV model might be to create a cluster analysis of communities needed by priority bird group to identify opportunity areas. Alternatively, the National Bobwhite Conservation Initiative's Biologists Ranking Index includes assessments of the entire BCR by local managers and biologists as to the potential for particular types of actions including woodland restoration.

**Question 6:** Stressors
Two major forces impacting the amount and quality of forest and woodland habitat have been identified for the BCR: anthropogenic impacts and climate change. Datasets are available that allow us to examine anthropogenic impacts both retrospectively (forest loss) and prospectively (expected urban growth). Downscaled clime predictions are becoming available for the BCR, but have yet to be analyzed.

Forest Loss – The USGS has used consistent methodology for development of the 2001 and 2006 NLCD products that is based on identifying and reclassifying areas of land cover change. We extracted areas that converted from a forest class (deciduous, evergreen, mixed, shrub, or woody wetland) to a non-forest class (Figure 15). Planning units were ranked by the proportion (%) of forest land converted with the lowest receiving a rank of 1 and the highest a rank of 80 (map inset in Figure 15; Table 2). The primary caveat to interpretation of this data is that the drivers of change are not known.

Urban 2030 – Human population growth and the concurrent urban expansion not only converts habitat to non-habitat but also impacts our ability to manage. National forests within the BCR and across the nation have been hampered by public concern over their land management practices. As human populations grow, surrounding and potentially isolating public lands, managers are likely to come under greater scrutiny by a public that has been taught every tree is sacred. To capture this, we assumed that human population thresholds identified by Wear et al. (1999) that indicated a difference in the ability of land managers to apply clearcuts in Virginia was a good proxy for our ability to use thinning and burning to restore & maintain forests and woodlands for conservation. We applied these thresholds to data on current & projected housing density data developed by the Silvis Lab at the University of Madison Wisconsin and classified partial block group census polygons into 5 categories (Figure 16):

1. Very Low: Human populations are below $20/mi^2$ and are expected to stay below that threshold<br>Low: Human populations are below $20/mi^2$ but are expected to rise above that threshold
2. Moderate: Human populations are between $20/mi^2$ and $70/mi^2$ are expected to stay within that range
3. High: Human populations are between $70/mi^2$ and $150/mi^2$ are expected to stay within that range
4. Very High: Human populations are above $150/mi^2$ and are expected to stay above that threshold

Planning units were ranked by the proportion (%) of land within the Very Low class with the highest receiving a rank of 1 and the lowest a rank of 80 (map inset in Figure 16; Table 2). The primary caveat to interpretation of this data is the assumption that public attitudes towards clearcuts in Virginia are a good proxy for public attitudes towards thinning and burning in the BCR. Over an area this large, public attitudes likely vary considerably. Thus, the assumption may hold in some areas and not others. Another important caveat is whether the population thresholds are reasonable for defining rural and urban areas. Wear et al. (1999) considered the range between $20/mi^2$ and $70/mi^2$ to be the transition zone between rural and urbanizing landscapes where there was the greatest uncertainty in public attitudes.

Climate Change – Data are becoming available that the CHJV can use in its planning process. Currently the CHJV Science Coordinator is cooperating on a project that will combine climate, tree establishment, forest growth and management, habitat suitability, and population viability models to forecast likely future impacts of climate change. Results should be available in 2016. Preliminary data and expert opinion suggests that the BCR will experience hotter and drier conditions overall, and that these conditions will favor woodland conditions and disfavor mesic forest conditions. Further, analysis of nest success in Missouri suggests that higher temperatures have a negative impact regardless of the level of landscape fragmentation. Downscaled climate data could be used now to help the planning process, but decisions need to be made regarding which variables are most helpful in making decisions (e.g. annual vs. breeding season precipitation).

**Question 7:** Overlap

The final step in this framework is to combine the rankings developed in questions 2-6 for a priority bird group(s) selected at step 1. The process for selecting which data sets are used to answer questions 2-6 and how those rankings are combined (e.g. weighted by perceived importance) needs to be developed by the partnership. CHJV staff envision the development of this process occurring within State sub-regions through discussions between formal CHJV partners and other conservation organizations. This would generate a "bottom-up" approach to conservation design that can be analyzed with the CHJV models to assess their potential to meet our population objectives. Regardless of what process develops within the State sub-regions, documentation of decisions at each step in the process will be vital to producing target landscapes in transparent & defensible way.

**Notes on Implementing the Framework**

This framework is intended for determining what actions are needed in which landscapes to conserve birds ("where to do what"). As such, we have avoided topics such as identifying desired structural conditions for a forest or woodland community, identifying management techniques to generate those conditions, identifying funding sources or programs to get these communities restored, or designing monitoring protocols to evaluate restoration success. These kinds of materials are in development and will be made available on the CHJV website as they become available. In the interim, contact CHJV staff for guidance.

For some partners, the tables and maps produced in this document and the companion State documents will be sufficient to produce an implementation plan for their geography. Others will want to examine the underlying data more closely, recognizing that ranks may obscure large differences in the values used to produce them. The summarized data for each planning unit, as well as the underlying raster and polygon datasets are freely available by contacting CHJV Science Coordinator Todd Jones-Farrand at (573) 875-5341 extension 226, or at david_jones-farrand@fws.gov. Todd will be happy to help with application or interpretation questions for these datasets or to discuss producing additional decision support tools where needed. He and the rest of the CHJV staff are here to help in any way they can, including facilitating sub-regional meetings to develop plans.

CHJV staff are continually working to improve the quality of scientific information used by the partnership. As mentioned above, several products are currently being evaluated. Updates and improvements to underlying datasets may alter the relative rank of planning units. Recognizing the potential problems this could cause, CHJV staff recommend updating the framework at regular intervals (e.g. every 5 years when new land cover are available). In future updates, every effort will be made to separate changes due to process (e.g. how ranks are calculated) from changes due to biological or socio-economic conditions (e.g. land use change).

**Cited and Supporting Literature**

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Table 1. Habitat groupings of the Central Hardwoods Joint Venture's priority species. Birds are listed according to their Partners in Flight priority classification.

| Class | Species [a] | AOU Code | % Global Pop in BCR | CHJV Objectives | Habitat Group Woodland | Forest | Riparian |
|---|---|---|---|---|---|---|---|
| *Continental Priorities (Watchlist)* | Bachman's Sparrow | BACS | 0.0% | Increase 100% | **XX** | | |
| | Bell's Vireo | BEVI | 0.7% | M/I | XX | | |
| | Blue-winged Warbler | BWWA | 16.8% | Increase 100% | **XX** | | |
| | Brown-headed Nuthatch | BHNU | 0.0% | Increase 50% | **XX** | | |
| | Cerulean Warbler | CERW | 11.6% | Increase 100% | | **XX** | x |
| | Kentucky Warbler | KEWA | 27.8% | Maintain | | **XX** | |
| | Painted Bunting | PABU | 0.5% | Maintain | **XX** | | |
| | Prairie Warbler | PRAW | 14.9% | Increase 100% | **XX** | | |
| | Prothonotary Warbler | PROW | 4.0% | Maintain | | | **XX** |
| | Red-cockaded Woodpecker | RCWO | 0.0% | None | X | | |
| | Red-headed Woodpecker | RHWO | 7.5% | Increase 100% | XX | | |
| | Swainson's Warbler | SWWA | 0.0% | Maintain | | | X |
| | Swallow-tailed Kite | STKI | 0.0% | None | | | X |
| | Wood Thrush | WOTH | 7.2% | Maintain | | **XX** | x |
| | Worm-eating Warbler | WEWA | 21.4% | M/I | | **XX** | |
| *Stewardship Species* | Acadian Flycatcher | ACFL | 14.4% | Maintain | | x | **XX** |
| | Brown Thrasher | BRTH | 7.5% | Increase 50% | XX | | |
| | Chuck-will's-widow | CWWI | 10.4% | M/I | X | | |
| | Hooded Warbler | HOWA | 2.0% | Maintain | | **XX** | |
| | Louisiana Waterthrush | LOWA | 19.6% | Maintain | | | **XX** |
| | Mississippi Kite | MIKI | 0.3% | Maintain | | X | x |
| | White-eyed Vireo | WEVI | 7.5% | M/I | XX | | |
| | Yellow-throated Vireo | YTVI | 10.9% | Maintain | x | **XX** | |
| | Yellow-throated Warbler | YTWA | 16.5% | Maintain | | **XX** | |
| *BCR Priorities* | Bewick's Wren | BEWR | 1.1% | Need Info | XX | | |
| | Blue-gray Gnatcatcher | BGGN | 13.1% | M/I | x | x | |
| | Carolina Chickadee | CACH | 11.1% | Maintain | x | x | |
| | Chimney Swift | CHSW | 9.8% | Maintain | x | x | x |
| | Eastern Wood-pewee | EAWP | 19.0% | Increase 100% | x | x | x |
| | Field Sparrow | FISP | 21.6% | Increase 100% | **XX** | | |
| | Loggerhead Shrike | LOSH | 1.5% | Increase 100% | X | | |
| | Northern Bobwhite | NOBO | 7.6% | NBCI | XX | | |
| | Orchard Oriole | OROR | 11.2% | M/I | XX | | |
| | Summer Tanager | SUTA | 13.2% | Maintain | X | | |
| | Whip-poor-will | WPWI | 26.6% | Increase 100% | X | | |
| | Yellow-billed Cuckoo | YBCU | 13.1% | Increase 100% | x | x | **XX** |
| | Yellow-breasted Chat | YBCH | 11.8% | M/I | **XX** | | |
| | Wild Turkey | WITU | 5.0% | Maintain | X | x | |

[a] Font color indicates status of habitat models as either validated for use at the subsection scale (black), currently being revised (red), or under development (blue).
[b] Population Objectives set by the CHJV Technical Committee in 2010. Objectives follow Partners in Flight categories. M/I indicates an objective to maintain or increase the population. NBCI indicates the committee defaulted to objectives being set by the Northern Bobwhite Conservation Initiative.
[c] Primary habitat group is indicated by a capital 'X' whereas other used habitats are indicated by 'x'. Multiple X's indicate the species was included in either the ensemble habitat models (**XX**) or in the BBS abundance analysis (XX).

Table 2. The 80 planning units (i.e. landscapes) within the Central Hardwoods Bird Conservation Region and their relative rank based on attributes relevant to conservation planning. Units are ranked from "1" (best) to "80" (worst) relative to conservation perspective. A composite rank will not be calculated until partners determine which attributes are most important.

| Plan Unit | Subsection | Short Name | ST | Public [a] | Naturalness [a] | In Condition [a] | Forest Proportion [a] | GPI [a] | Forest Loss ('01-'06) [a] | Urban 2030 [a] | Ensemble Model Scores [a] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Woodland | Forest | Riparian |
| 1 | 223Ao & Ak | MS River Alluvial | IL | 39 | 31 | 65 | 62 | 55 | 4 | 1 | 76 | 60 | 59 |
| 2 | 223Aq | IL Ozarks | IL | 32 | 16 | 22 | 36 | 39 | 18 | 6 | 58 | 41 | 47 |
| 3 | 223Db | Lower OH Alluvial | IL | 64 | 29 | 55 | 57 | 56 | 12 | 4 | 62 | 15 | 2 |
| 4 | 223Dh | Gr. Shawnee Hills | IL | 15 | 8 | 10 | 16 | 15 | 17 | 13 | 55 | 17 | 23 |
| 5 | 223Di | Lsr. Shawnee Hills | IL | 27 | 19 | 24 | 31 | 31 | 7 | 23 | 47 | 32 | 27 |
| 6 | 223Gb | Mt. Vernon Hills | IL | 20 | 59 | 36 | 71 | 71 | 25 | 10 | 64 | 68 | 68 |
| 7 | 223Gc & Ge | Wabash Alluvial | IL | 67 | 69 | 69 | 79 | 79 | 11 | 5 | 79 | 79 | 77 |
| 8 | 223Gd | Wabash Uplands | IL | 77 | 67 | 48 | 76 | 78 | 32 | 8 | 78 | 74 | 73 |
| 9 | 231Hf | OH and Cache Alluvial | IL | 38 | 41 | 50 | 60 | 60 | 27 | 9 | 73 | 59 | 52 |
| 10 | 231Hg | Cretaceous Hills | IL | 41 | 49 | 7 | 55 | 54 | 13 | 22 | 56 | 56 | 54 |
| 11 | 223Ba | Brown County Hills | IN | 11 | 1 | 54 | 7 | 7 | 5 | 46 | 69 | 6 | 31 |
| 12 | 223Bc & Bd | Mitchell Karst Plains | IN | 35 | 47 | 51 | 47 | 47 | 33 | 68 | 49 | 48 | 61 |
| 13 | 223Db | Lower OH Alluvial | IN | 58 | 79 | 79 | 74 | 74 | 59 | 36 | 72 | 66 | 64 |
| 14 | 223Dc | Outer W. Coalfields | IN | 56 | 76 | 72 | 65 | 65 | 66 | 41 | 75 | 78 | 79 |
| 15 | 223De | Crawford Uplands | IN | 6 | 17 | 6 | 17 | 17 | 10 | 42 | 37 | 12 | 30 |
| 16 | 223Df | Crawford Escarpment | IN | 33 | 23 | 15 | 15 | 16 | 22 | 72 | 2 | 21 | 38 |
| 17 | 223Fc | W. Bluegrass | IN | 65 | 51 | 67 | 49 | 48 | 62 | 43 | 46 | 40 | 22 |
| 18 | 223Fd | Northern Bluegrass | IN | 69 | 7 | 52 | 18 | 18 | 3 | 70 | 28 | 20 | 16 |
| 19 | 223Fe | Muscatatuck Flats | IN | 25 | 35 | 76 | 45 | 45 | 6 | 59 | 11 | 45 | 43 |
| 20 | 223Ff | Scottsburg Lowland | IN | 44 | 54 | 73 | 63 | 62 | 56 | 49 | 65 | 54 | 49 |
| 21 | 223Gc | Wabash Alluvial | IN | 50 | 53 | 70 | 67 | 67 | 43 | 14 | 53 | 33 | 8 |
| 22 | 223Ge | SW IN Glaciated Lowlands | IN | 34 | 78 | 78 | 72 | 72 | 50 | 38 | 68 | 72 | 72 |
| 23 | 223Fd | Northern Bluegrass | OH | 47 | 11 | 80 | 33 | 33 | 48 | 55 | 57 | 51 | 51 |
| 24 | 221Ej | E. Knobs Transition | KY | 59 | 3 | 29 | 32 | 32 | 73 | 77 | 61 | 49 | 63 |
| 25 | 223Bb | Brush Creek Hills | KY | 72 | 4 | 20 | 9 | 9 | 2 | 80 | 12 | 3 | 1 |
| 26 | 223Bc | Mitchell Karst Plains | KY | 48 | 57 | 58 | 53 | 53 | 47 | 67 | 52 | 55 | 57 |
| 27 | 223Bd | W. Knobs | KY | 16 | 10 | 18 | 24 | 23 | 46 | 51 | 39 | 30 | 26 |
| 28 | 223Da | Interior W. Coalfields | KY | 61 | 80 | 39 | 69 | 69 | 39 | 45 | 71 | 65 | 65 |
| 29 | 223Db | Wabash Alluvial | KY | 54 | 77 | 61 | 75 | 77 | 67 | 20 | 77 | 75 | 74 |
| 30 | 223Dc | Outer W. Coalfields | KY | 21 | 48 | 3 | 26 | 26 | 40 | 48 | 26 | 28 | 10 |
| 31 | 223Dd | Marion Hills | KY | 71 | 68 | 14 | 34 | 35 | 23 | 21 | 32 | 44 | 32 |
| 32 | 223Dj & De | N. Dripping Springs | KY | 42 | 26 | 31 | 27 | 27 | 9 | 73 | 21 | 37 | 39 |

| Plan Unit | Subsection | Short Name | ST | Public [a] | Natural-ness [a] | In Condition [a] | Forest Proportion [a] | GPI [a] | Forest Loss ('01-'06) [a] | Urban 2030 [a] | Ensemble Model Scores [a] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Woodland | Forest | Riparian |
| 33 | 223Dg | S. Dripping Springs | KY | 31 | 45 | 30 | 29 | 29 | 16 | 52 | 33 | 36 | 34 |
| 34 | 223Di | Lsr. Shawnee Hills | KY | 73 | 66 | 33 | 43 | 42 | 19 | 34 | 24 | 42 | 50 |
| 35 | 223Ea | E. Highland Rim | KY | 40 | 28 | 17 | 41 | 40 | 30 | 76 | 10 | 43 | 35 |
| 36 | 223Eb | E. Karst Plain | KY | 30 | 6 | 19 | 40 | 37 | 78 | 56 | 41 | 35 | 33 |
| 37 | 223Ec | Outer Nashville Basin | KY | 66 | 5 | 35 | 8 | 8 | 8 | 61 | 4 | 5 | 3 |
| 38 | 223Eg | W. Pennyroyal Karst Plain | KY | 14 | 38 | 63 | 23 | 22 | 20 | 26 | 50 | 29 | 37 |
| 39 | 223Eh | Pennyroyal Karst Plain | KY | 46 | 73 | 59 | 73 | 73 | 44 | 58 | 67 | 77 | 78 |
| 40 | 223Fa | Outer Bluegrass | KY | 37 | 36 | 16 | 46 | 46 | 24 | 74 | 5 | 50 | 42 |
| 41 | 223Fb | Inner Bluegrass | KY | 63 | 74 | 46 | 80 | 80 | 64 | 64 | 70 | 73 | 71 |
| 42 | 223Fc & Ff | W. Bluegrass | KY | 62 | 64 | 23 | 58 | 58 | 74 | 71 | 45 | 57 | 56 |
| 43 | 223Fd | N. Bluegrass | KY | 68 | 20 | 12 | 38 | 38 | 52 | 62 | 34 | 34 | 41 |
| 44 | 231Hf | OH and Cache Alluvial | KY | 45 | 72 | 66 | 59 | 61 | 69 | 28 | 59 | 62 | 58 |
| 45 | 223Ea | E. Highland Rim | TN | 78 | 13 | 1 | 19 | 19 | 37 | 78 | 8 | 27 | 15 |
| 46 | 223Eb | E. Karst Plain | TN | 28 | 34 | 27 | 50 | 50 | 65 | 57 | 54 | 52 | 44 |
| 47 | 223Ec | Outer Nashville Basin | TN | 29 | 27 | 11 | 37 | 36 | 54 | 65 | 25 | 39 | 46 |
| 48 | 223Ed | Inner Nashville Basin | TN | 43 | 63 | 60 | 51 | 51 | 76 | 69 | 42 | 58 | 60 |
| 49 | 223Ee | Highland Rim | TN | 70 | 50 | 42 | 66 | 66 | 38 | 79 | 74 | 70 | 70 |
| 50 | 223Eg | W. Pennyroyal Karst Plain | TN | 10 | 9 | 2 | 11 | 11 | 80 | 35 | 35 | 11 | 20 |
| 51 | 223Eh | Pennyroyal Karst Plain | TN | 19 | 32 | 25 | 30 | 30 | 45 | 60 | 19 | 25 | 4 |
| 52 | 223Ee | Highland Rim | AL | 76 | 55 | 44 | 61 | 63 | 75 | 75 | 60 | 61 | 55 |
| 53 | 223Ef | Tennessee-Gasper Valley | AL | 26 | 60 | 43 | 70 | 70 | 79 | 31 | 66 | 64 | 62 |
| 54 | 223Eg | W. Pennyroyal Karst Plain | AL | 79 | 42 | 28 | 39 | 41 | 61 | 63 | 16 | 14 | 17 |
| 55 | 231Cd | Sandstone Mountain | AL | 55 | 46 | 32 | 28 | 28 | 77 | 53 | 31 | 26 | 14 |
| 56 | 231Ce | Moulton Valley | AL | 74 | 61 | 47 | 52 | 52 | 71 | 66 | 51 | 69 | 66 |
| 57 | 223Aa | St. Francois Knobs | MO | 12 | 22 | 5 | 5 | 5 | 31 | 11 | 48 | 10 | 21 |
| 58 | 223Ab | Central Plateau | MO | 18 | 62 | 38 | 35 | 34 | 51 | 32 | 1 | 46 | 53 |
| 59 | 223Ac | Osage River Hills | MO | 9 | 33 | 37 | 13 | 14 | 34 | 33 | 9 | 16 | 18 |
| 60 | 223Ad | Gasconade River Hills | MO | 8 | 37 | 4 | 10 | 10 | 42 | 12 | 7 | 9 | 11 |
| 61 | 223Ae | Meramac River Hills | MO | 5 | 18 | 8 | 2 | 2 | 35 | 25 | 18 | 4 | 12 |
| 62 | 223Af | Current River Hills | MO | 1 | 15 | 9 | 1 | 1 | 28 | 2 | 44 | 2 | 7 |
| 63 | 223Ag | White River Hills | MO | 3 | 40 | 40 | 14 | 13 | 53 | 17 | 14 | 13 | 13 |
| 64 | 223Ah & An | Elk River Hills | MO | 57 | 24 | 26 | 22 | 24 | 49 | 50 | 3 | 24 | 40 |
| 65 | 223Ai | Prairie Ozark Border | MO | 60 | 70 | 62 | 68 | 68 | 26 | 16 | 40 | 71 | 67 |
| 66 | 223Aj | Inner Ozark Border | MO | 49 | 25 | 13 | 25 | 25 | 15 | 39 | 17 | 22 | 19 |
| 67 | 223Ak & Ao | Outer Ozark Border | MO | 36 | 44 | 34 | 48 | 49 | 36 | 29 | 29 | 47 | 36 |
| 68 | 223Al | Black River Ozark Border | MO | 7 | 30 | 21 | 6 | 6 | 14 | 24 | 30 | 18 | 28 |
| 69 | 223Am | Springfield Plain | MO | 23 | 71 | 71 | 64 | 64 | 58 | 40 | 20 | 63 | 69 |

| Plan Unit | Subsection | Short Name | ST | Public [a] | Naturalness [a] | In Condition [a] | Forest Proportion [a] | GPI [a] | Forest Loss ('01-'06) [a] | Urban 2030 [a] | Ensemble Model Scores [a] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Woodland | Forest | Riparian |
| 70 | 223Ap | MO River Alluvial | MO | 51 | 56 | 45 | 78 | 75 | 72 | 3 | 80 | 80 | 80 |
| 71 | 251Ea | Scarped Osage Plains | MO | 52 | 75 | 74 | 77 | 76 | 55 | 19 | 63 | 76 | 76 |
| 72 | 223Ab | Central Plateau | AR | 53 | 43 | 68 | 20 | 20 | 63 | 18 | 6 | 23 | 24 |
| 73 | 223Ag | White River Hills | AR | 13 | 21 | 56 | 12 | 12 | 57 | 27 | 15 | 8 | 5 |
| 74 | 223An&Ah&Am | Springfield Plateau | AR | 17 | 39 | 49 | 44 | 44 | 70 | 37 | 36 | 31 | 29 |
| 75 | M223Aa | Boston Mountains | AR | 4 | 2 | 53 | 3 | 3 | 29 | 7 | 38 | 1 | 9 |
| 76 | M223Ab | Boston Hills | AR | 2 | 14 | 64 | 4 | 4 | 68 | 15 | 43 | 7 | 6 |
| 77 | 223Am & Ah | Springfield Plain | OK | 75 | 58 | 57 | 56 | 59 | 41 | 54 | 23 | 67 | 75 |
| 78 | 223An | Springfield Plateau | OK | 24 | 52 | 41 | 42 | 43 | 60 | 44 | 27 | 38 | 48 |
| 79 | M223Ab | Boston Hills | OK | 22 | 12 | 75 | 21 | 21 | 21 | 30 | 13 | 19 | 25 |
| 80 | 223Am | Springfield Plain | KS | 79 | 65 | 77 | 54 | 57 | 1 | 47 | 22 | 53 | 45 |

[a] Attributes are defined as the quantity of protected lands (Public), overall landscape conditions (Naturalness), extant forest community conditions (In Condition), quantity of forested (i.e. restorable) lands (Forest Proportion), forest fragmentation / avian productivity (GPI), forest loss from 2001-2006 (Loss), urbanization threat (Urban 2030), and current capacity-productivity weighted ensemble model scores for suites of birds. Full definitions are available in the companion Framework document.

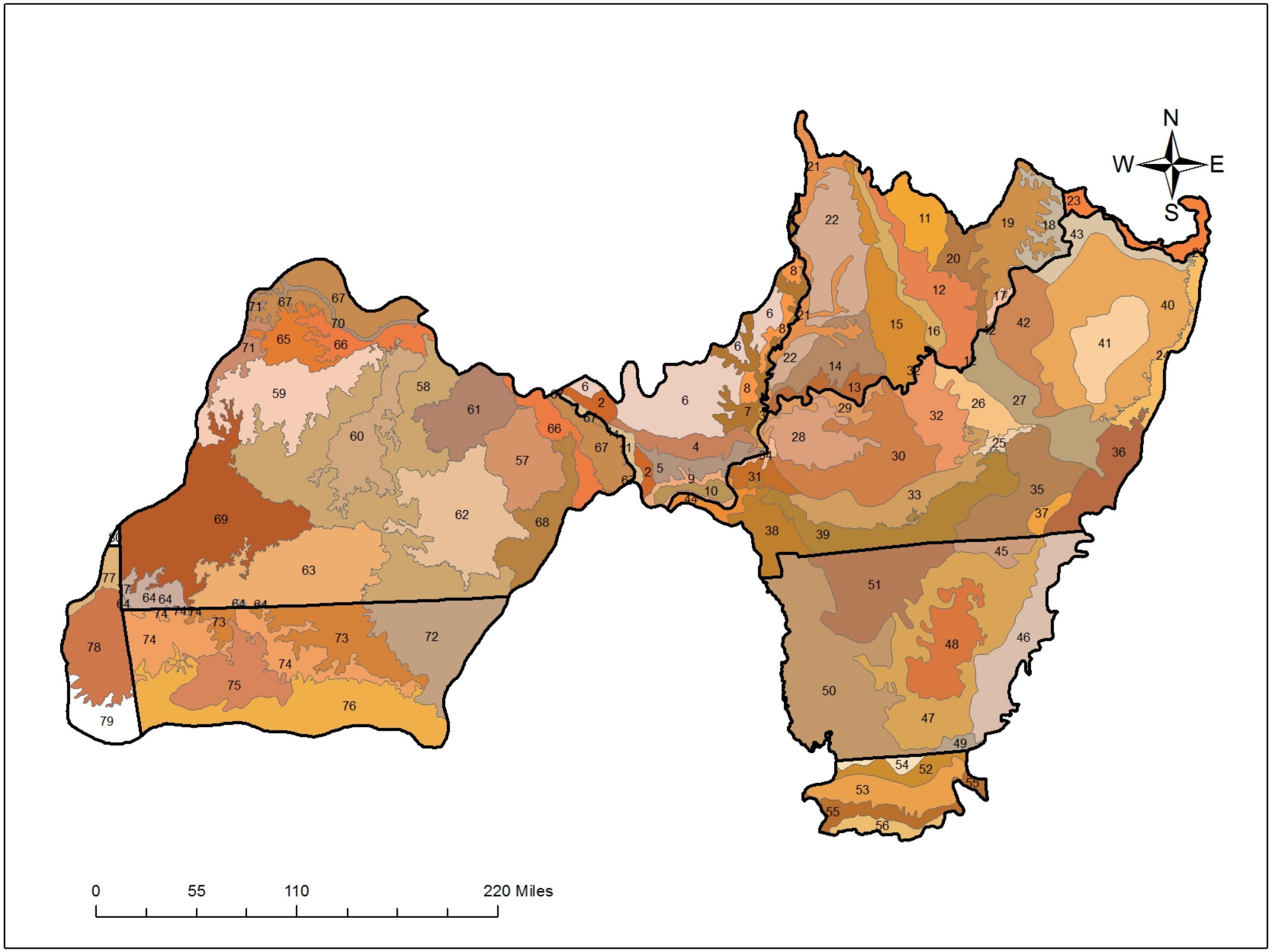


Figure 1. Location of the 80 planning units in the Central Hardwoods Bird Conservation Region. Planning units are defined by the intersection of State boundaries with Bailey's ecological subsections.

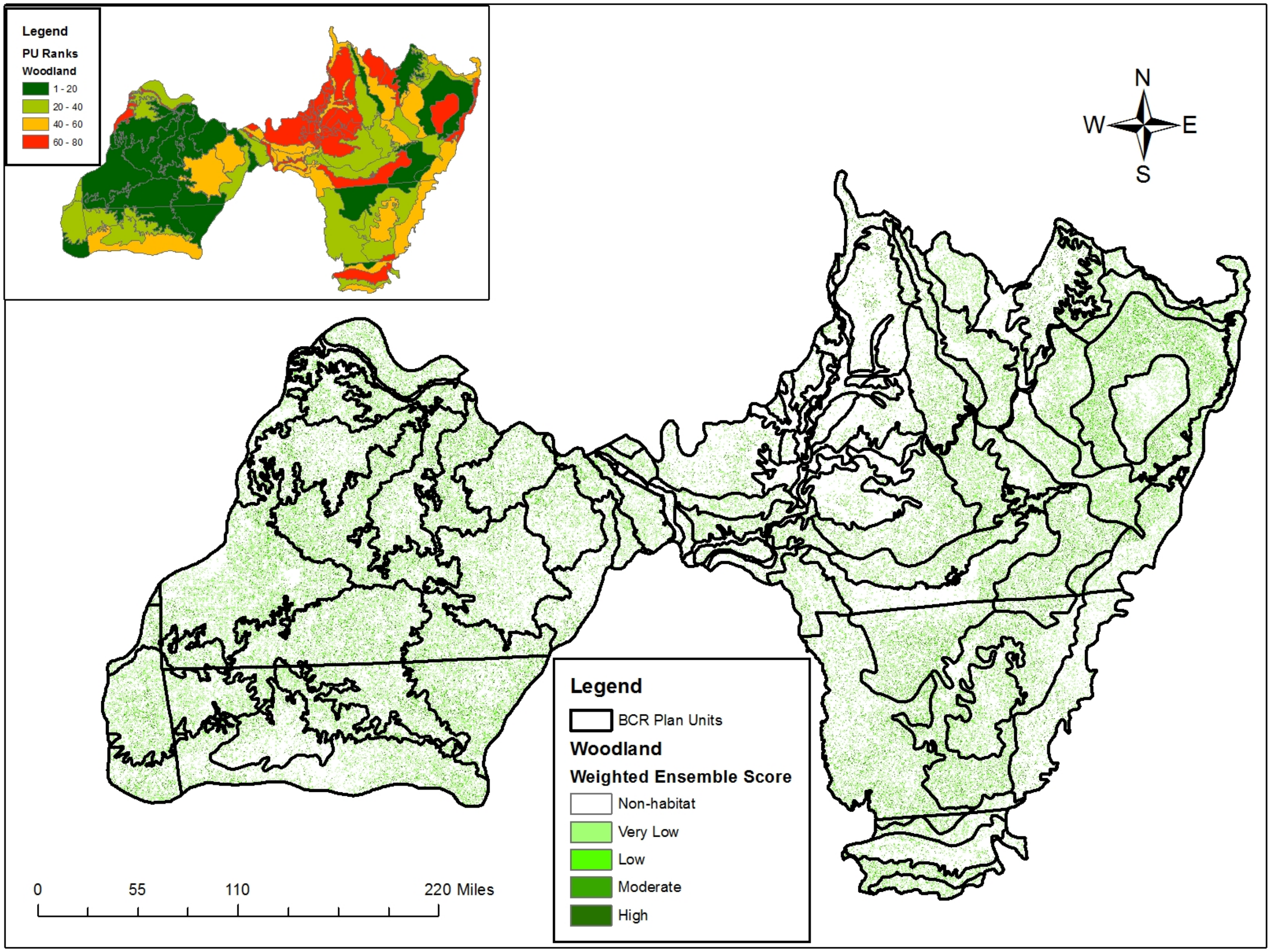


Figure 2. (Q2) Raw scores from the combination of Woodland species habitat models (n=7) weighted by the priority class of each species. Mean scores for each planning unit were used to produce ranks (inset) from high (1) to low (80).

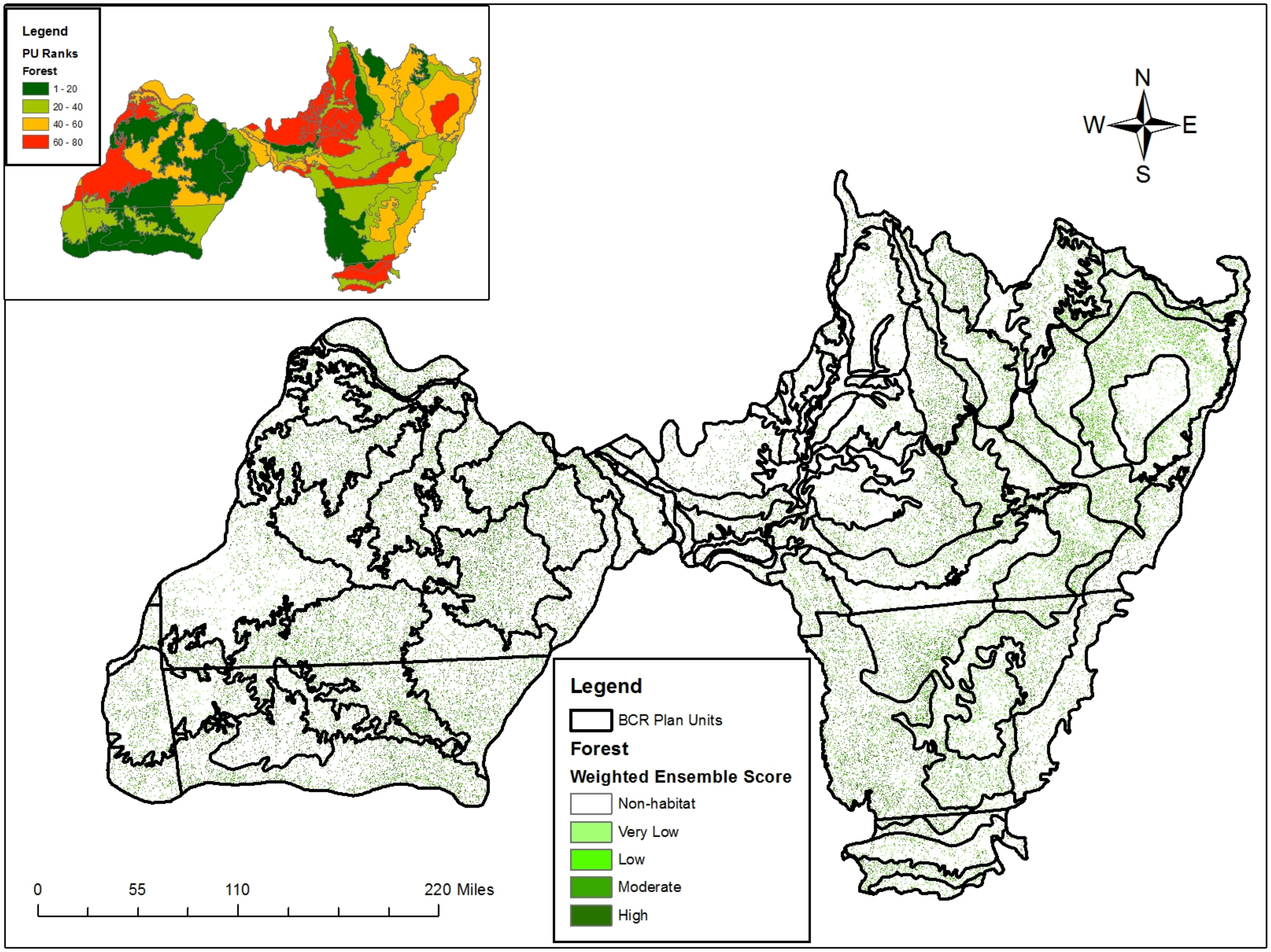


Figure 3. (Q2) Raw scores from the combination of Forest species habitat models (n=7) weighted by the priority class of each species. Mean scores for each planning unit were used to produce ranks (inset) from high (1) to low (80).

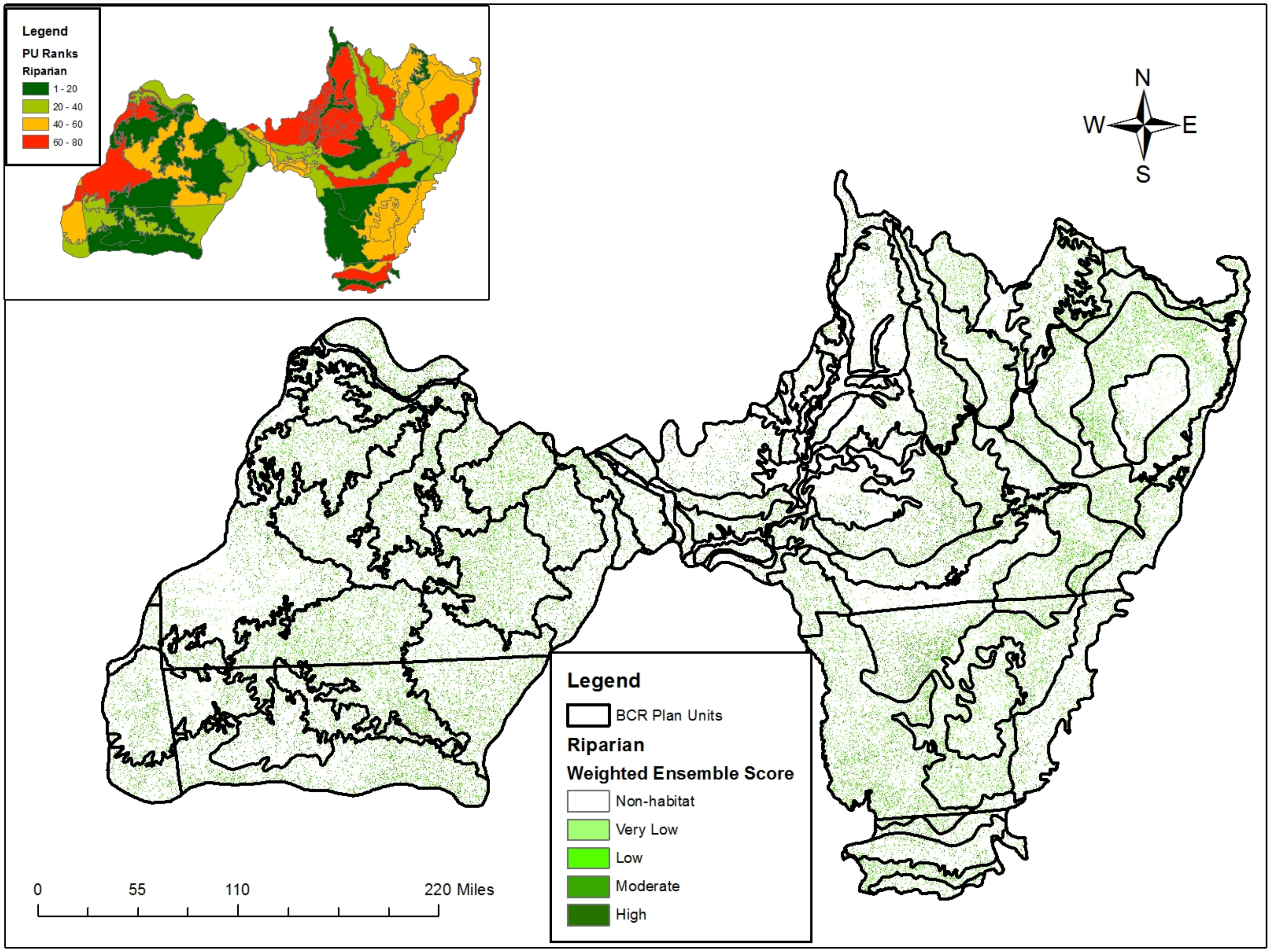


Figure 4. (Q2) Raw scores from the combination of Riparian species habitat models (n=4) weighted by the priority class of each species. Mean scores for each planning unit were used to produce ranks (inset) from high (1) to low (80).

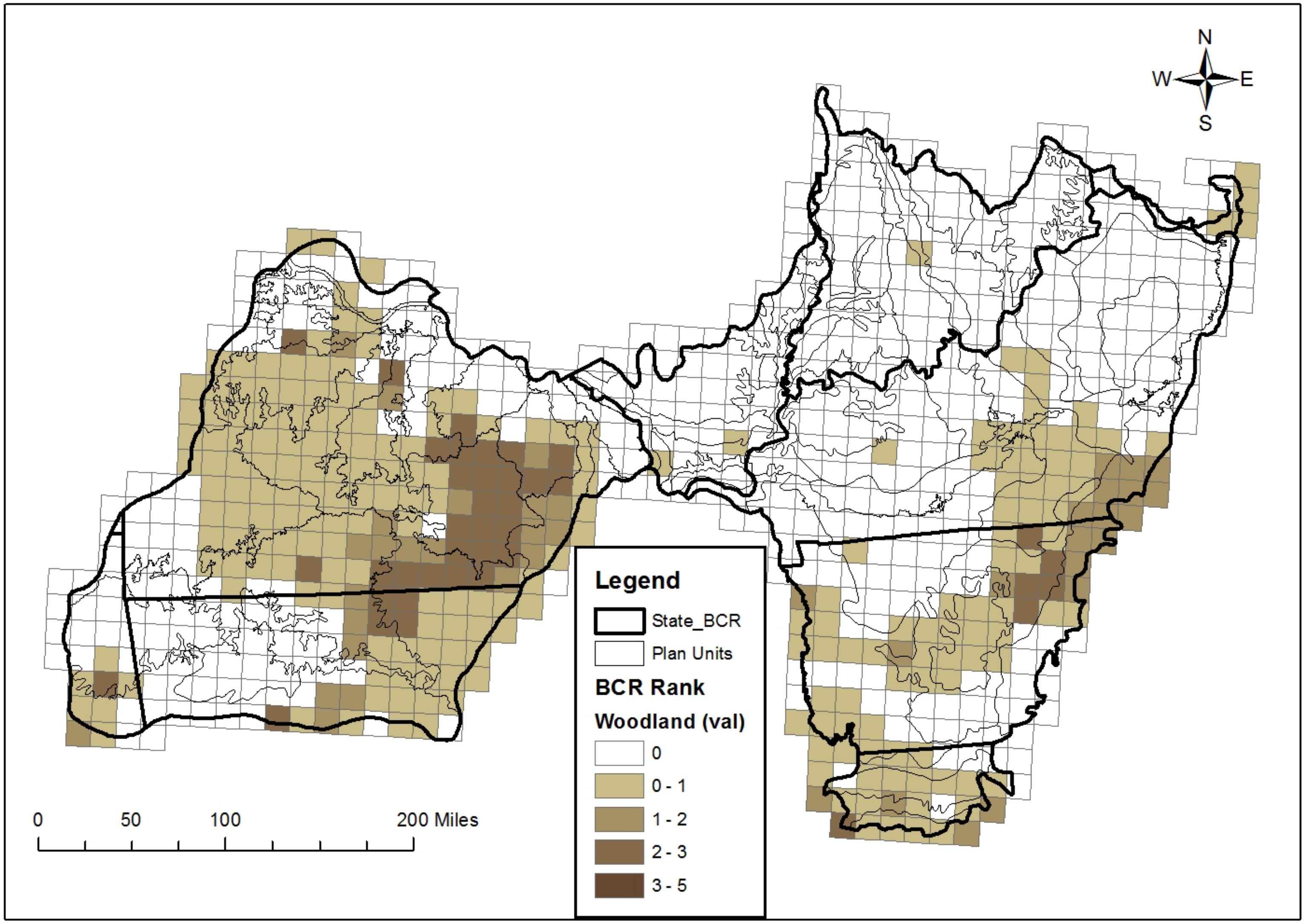


Figure 5. (Q2) The number of Woodland species with validated Habitat Suitability Index models for whom each Breeding Bird Survey grid cell contains the top 25% of the species' densities in the Central Hardwoods Bird Conservation Region. See Table 1 for the list of species included.

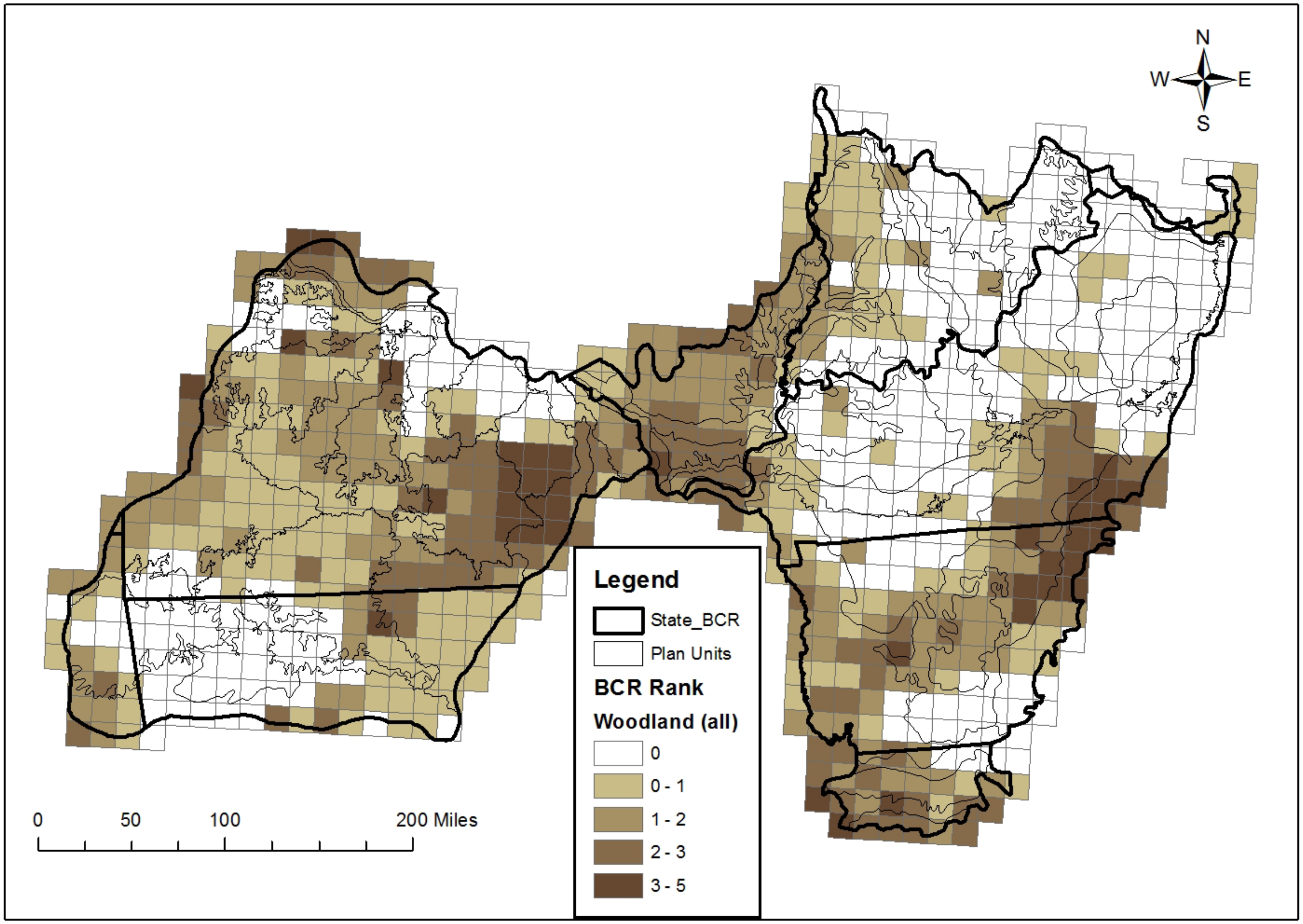


Figure 6. (Q2) The number of Woodland species for whom each Breeding Bird Survey grid cell contains the top 25% of the species' densities in the Central Hardwoods Bird Conservation Region. See Table 1 for the list of species included.

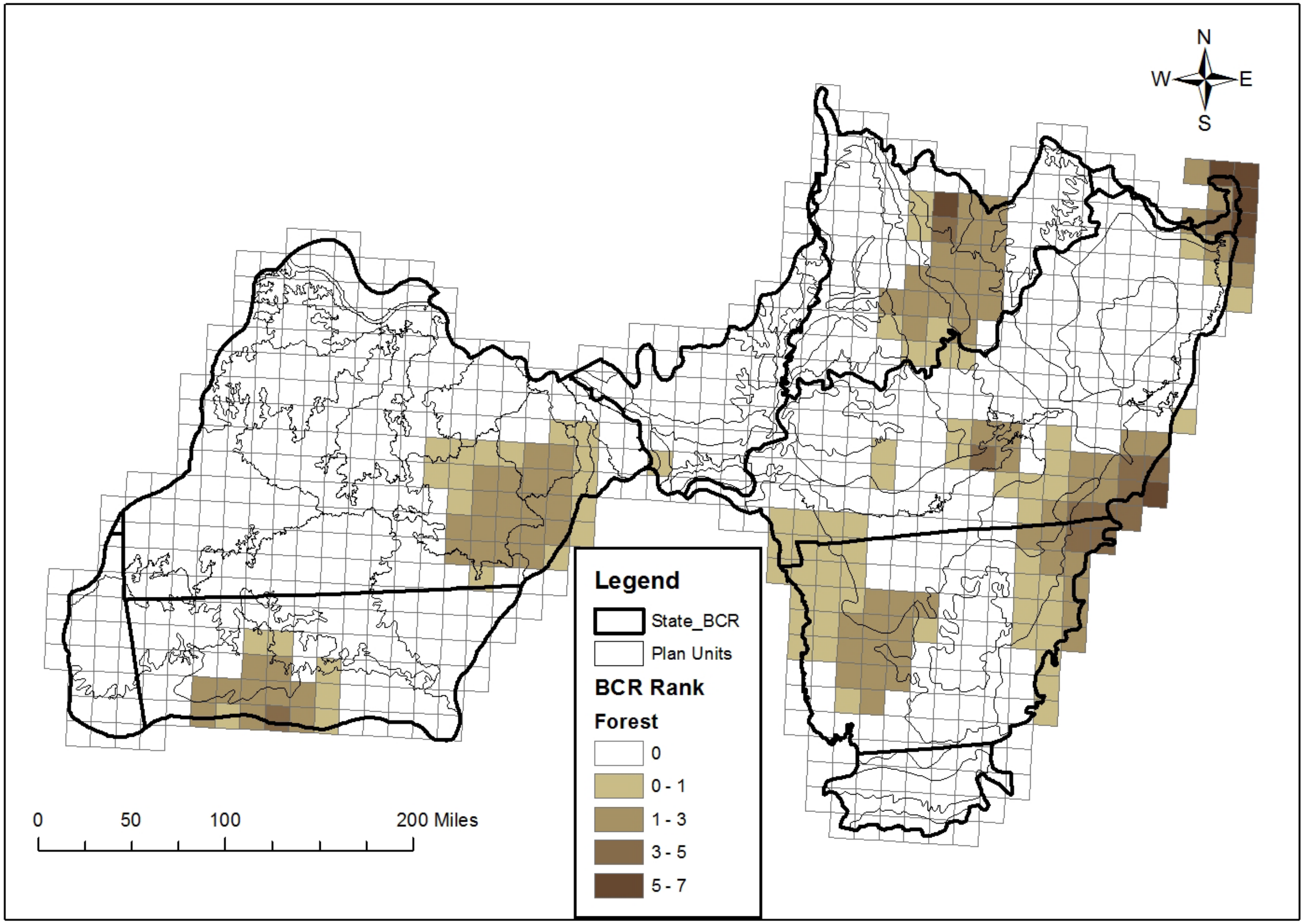


Figure 7. (Q2) The number of Forest species with validated Habitat Suitability Index models for whom each Breeding Bird Survey grid cell contains the top 25% of the species' densities in the Central Hardwoods Bird Conservation Region.  See Table 1 for the list of species included.

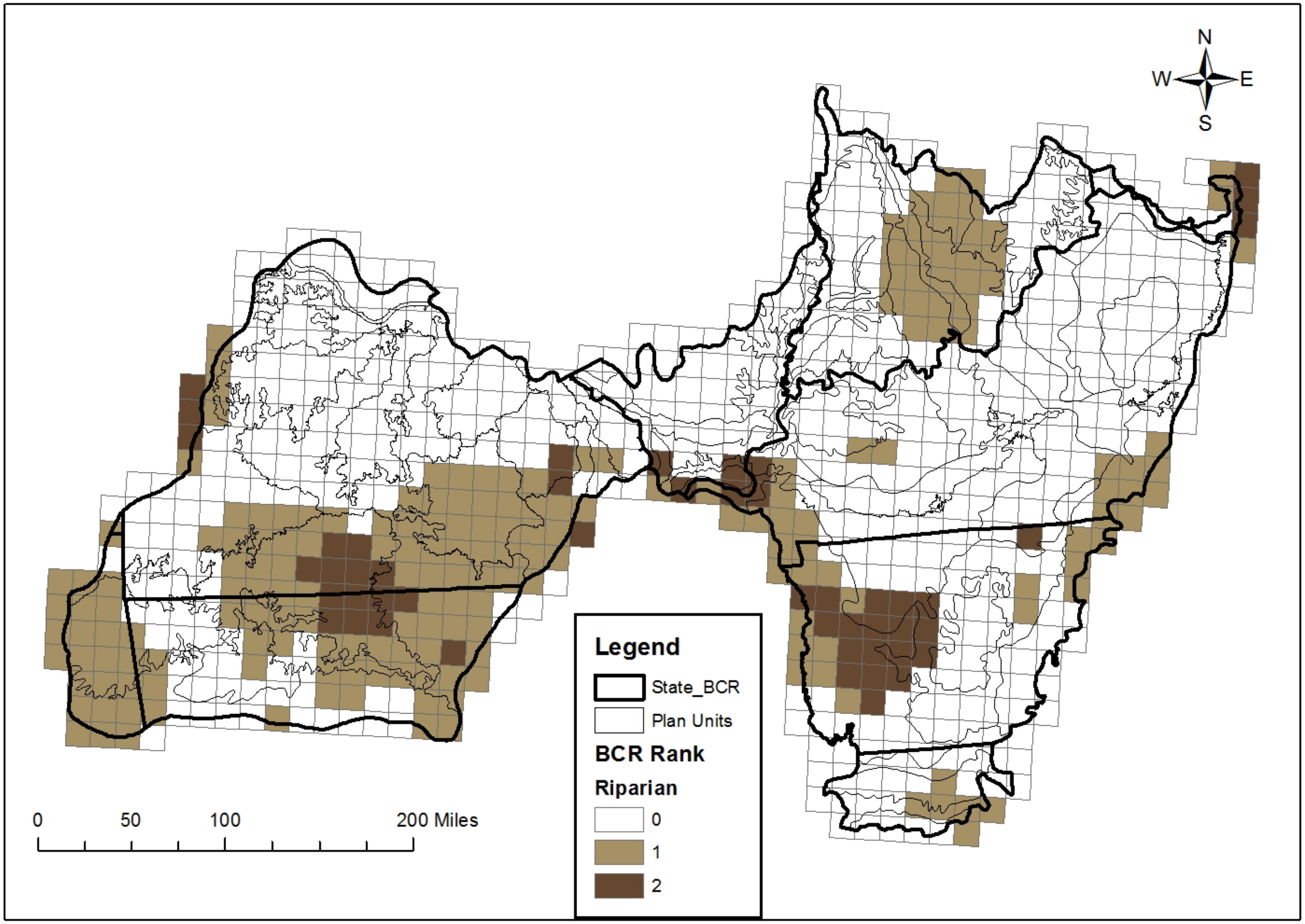


Figure 8. (Q2) The number of Riparian species with validated Habitat Suitability Index models for whom each Breeding Bird Survey grid cell contains the top 25% of the species' densities in the Central Hardwoods Bird Conservation Region. See Table 1 for the list of species included.

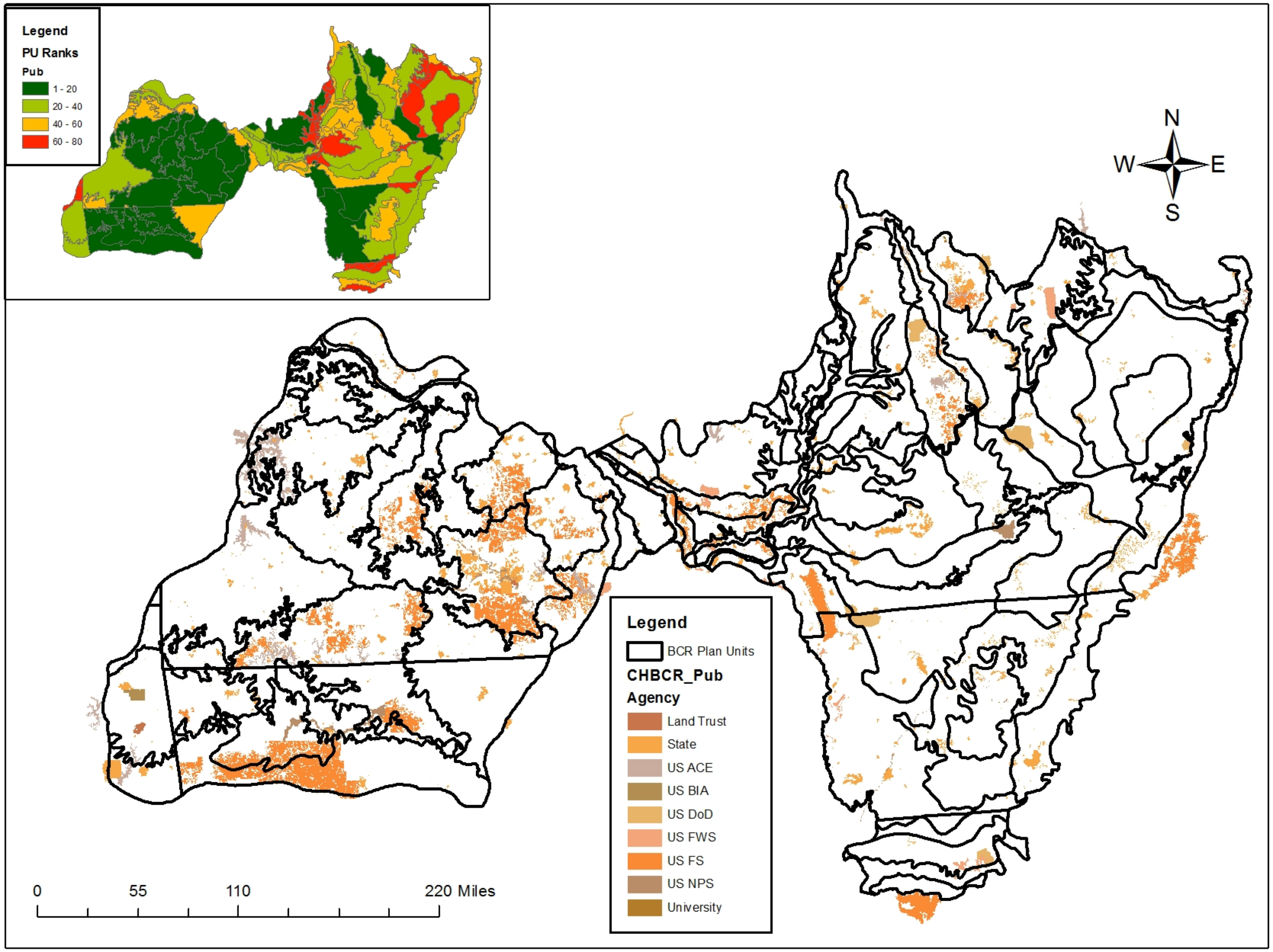


Figure 9. (Q3) Distribution of public lands within the Central Hardwoods Bird Conservation Region by agency or organization. Total area of public ownership for each planning unit was used to produce ranks (inset) from high (1) to low (80).

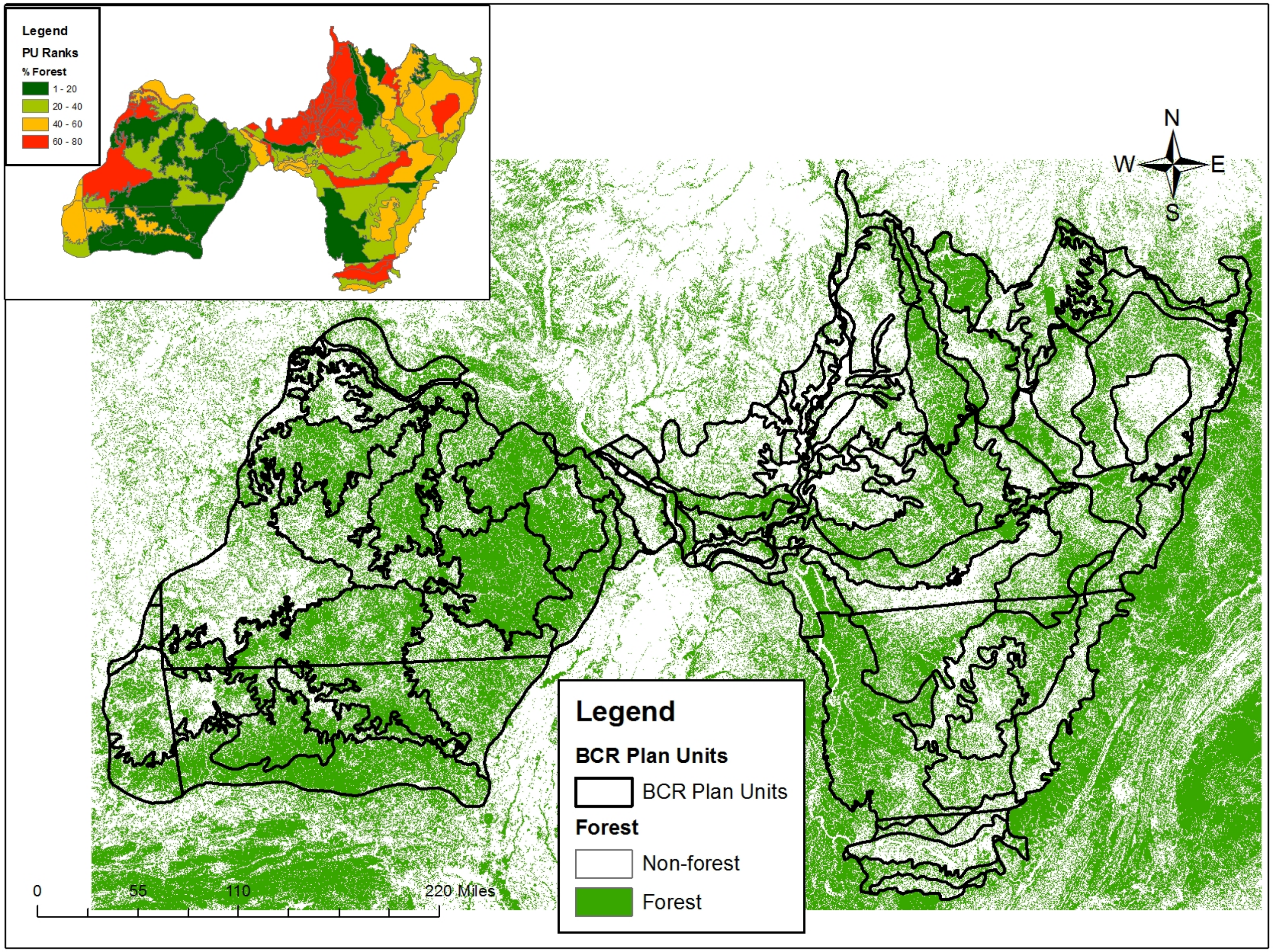


Figure 10. (Q4) Distribution of lands classified as a forested type within the Central Hardwoods Bird Conservation Region by the 2006 NLCD. Proportion of forested land for each planning unit was used to produce ranks (inset) from high (1) to low (80).

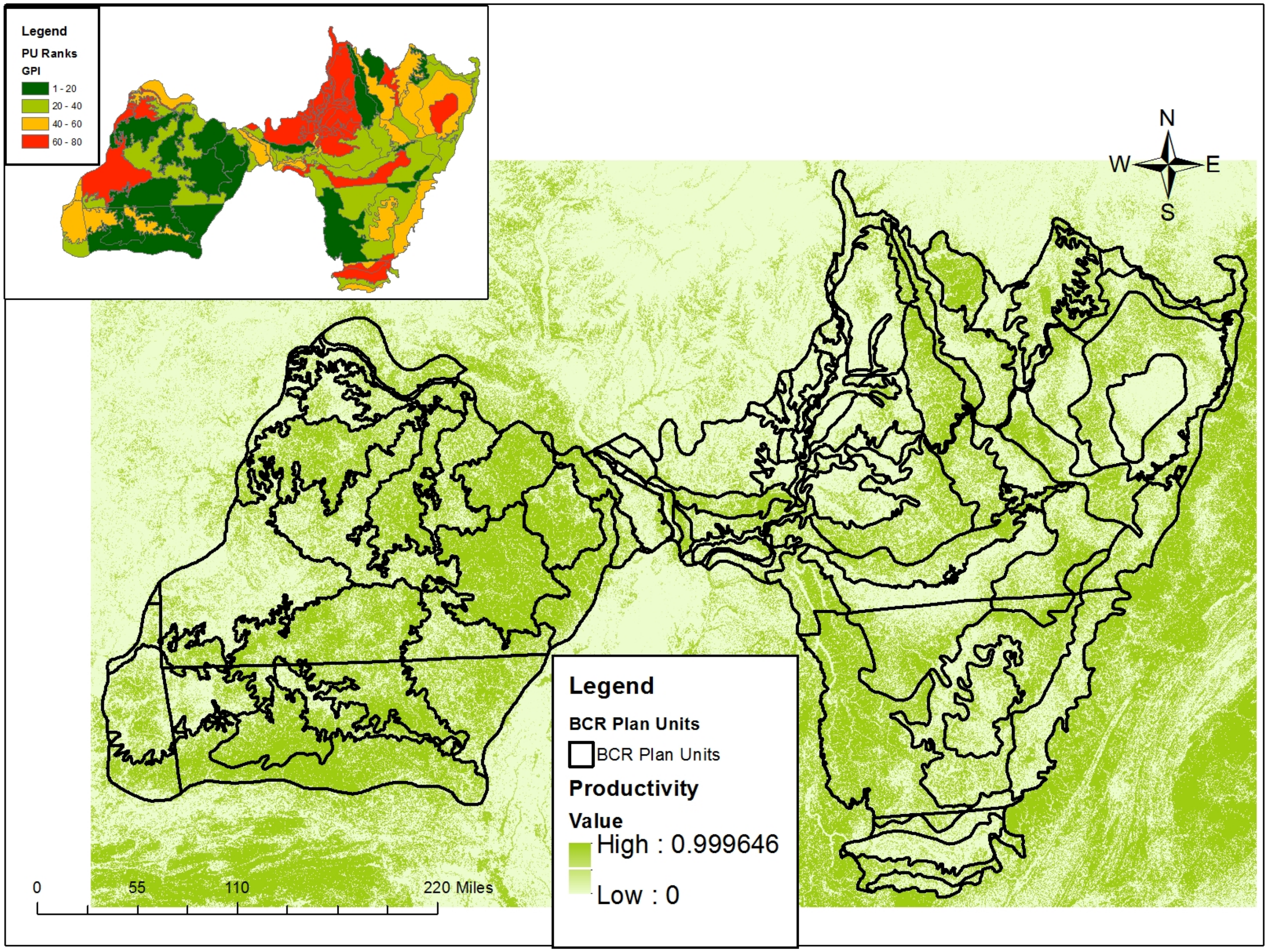


Figure 11. (Q4) Fragmentation of forested lands as measured by the General Productivity Index within the Central Hardwoods Bird Conservation Region. Mean index score on forested lands for each planning unit was used to produce ranks (inset) from high (1) to low (80).

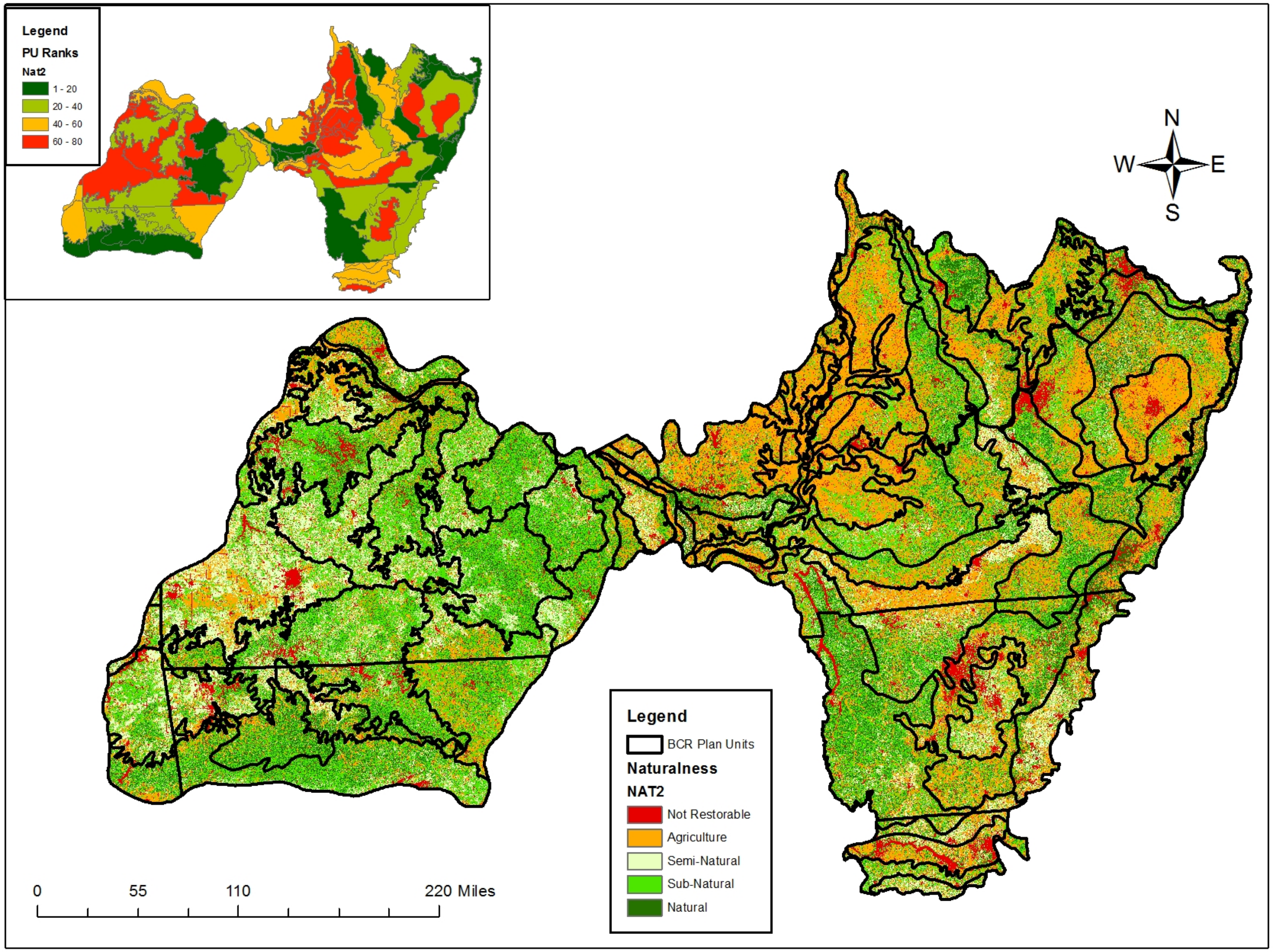


Figure 12. (Q4) Classification of the relative naturalness of lands within the Central Hardwoods Bird Conservation Region following Ferrari et al. 2008. Proportion of each planning unit in the "Natural" class was used to produce ranks (inset) from high (1) to low (80).

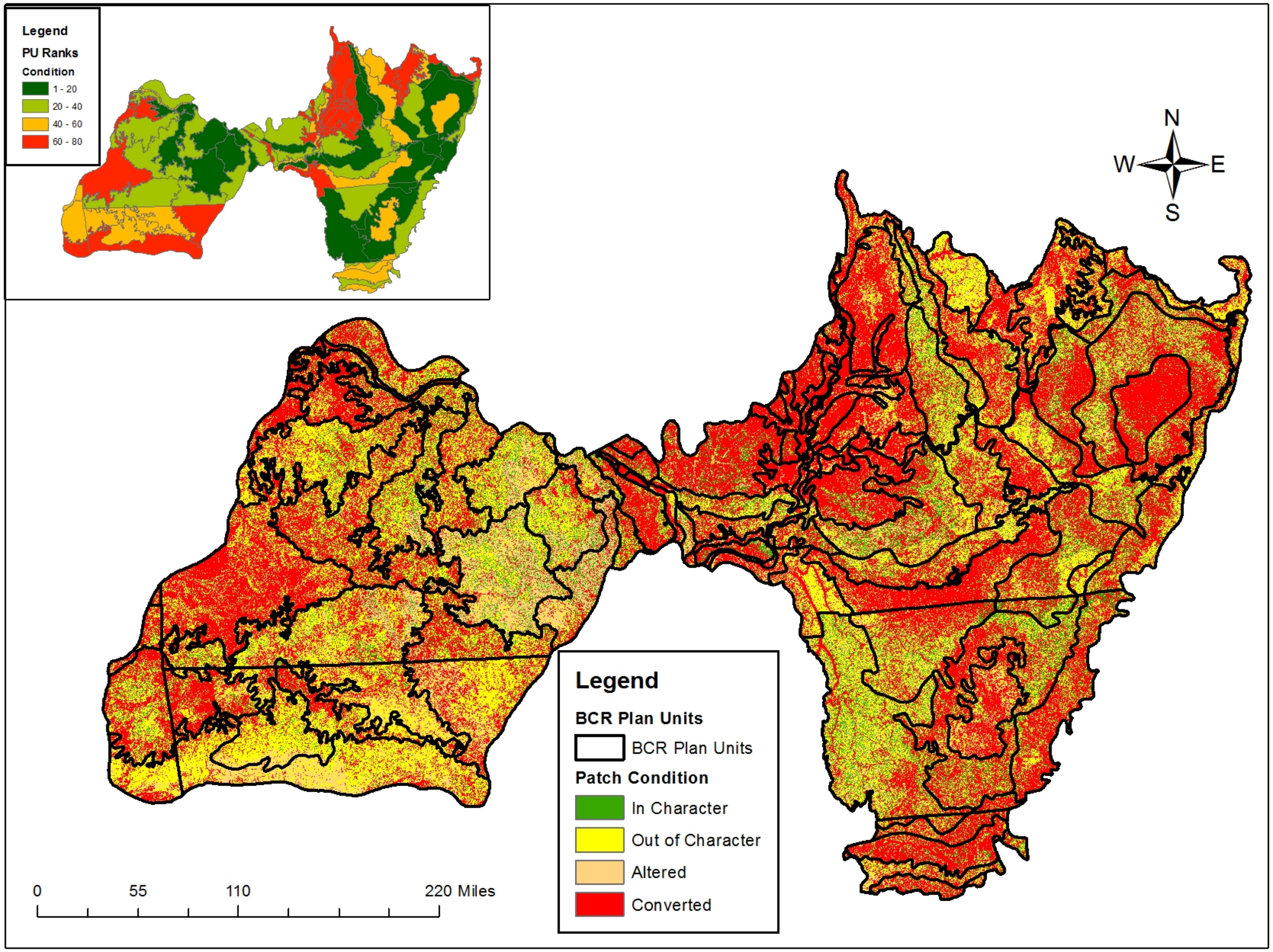


Figure 13. (Q4) Comparison between current and expected landscape patch conditions within the Central Hardwoods Bird Conservation Region. Proportion of each planning unit in the "In Character" class was used to produce ranks (inset) from high (1) to low (80).

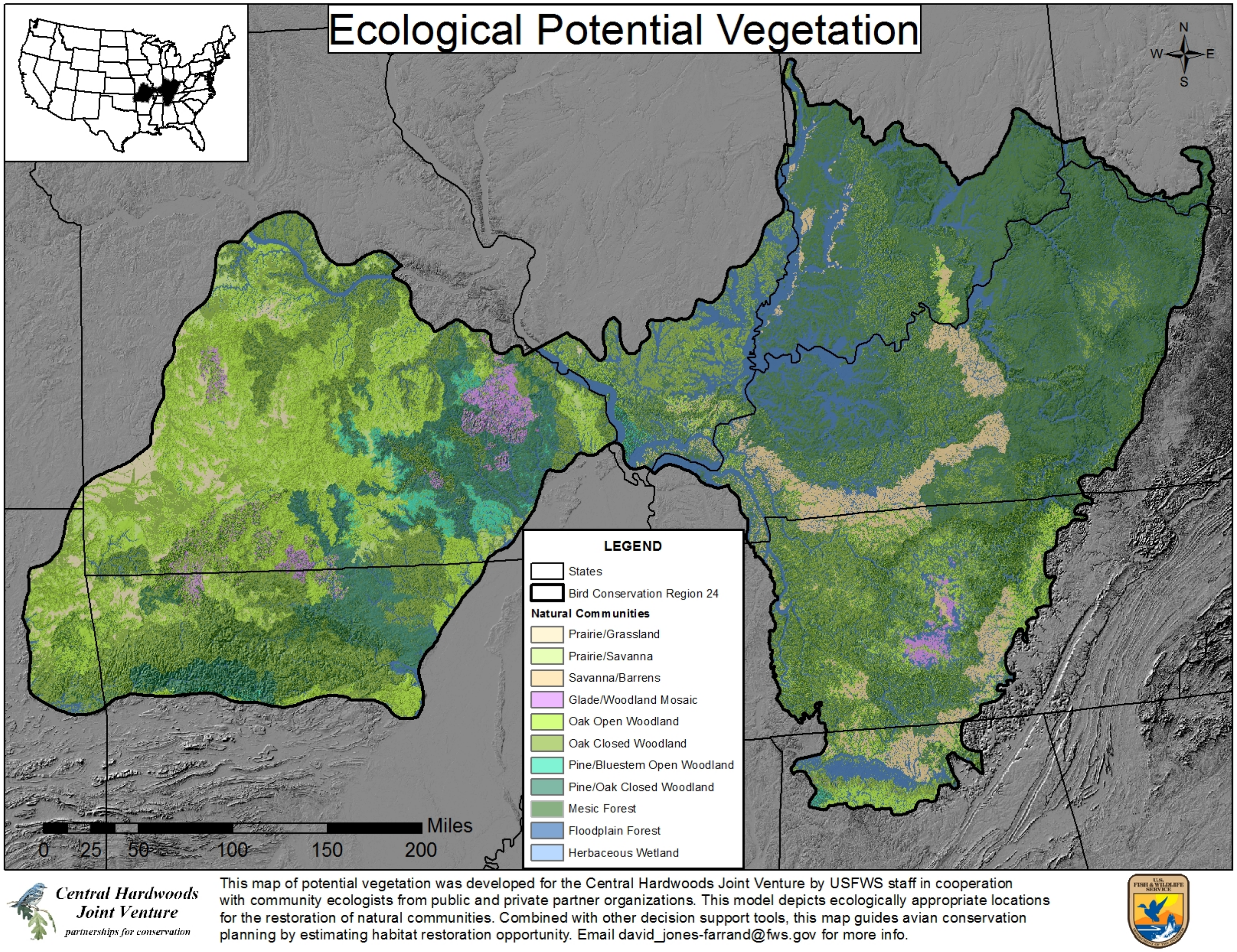


Figure 14. (Q5) The Ecological Potential Vegetation model showing restoration opportunities for the Central Hardwoods Bird Conservation Region.

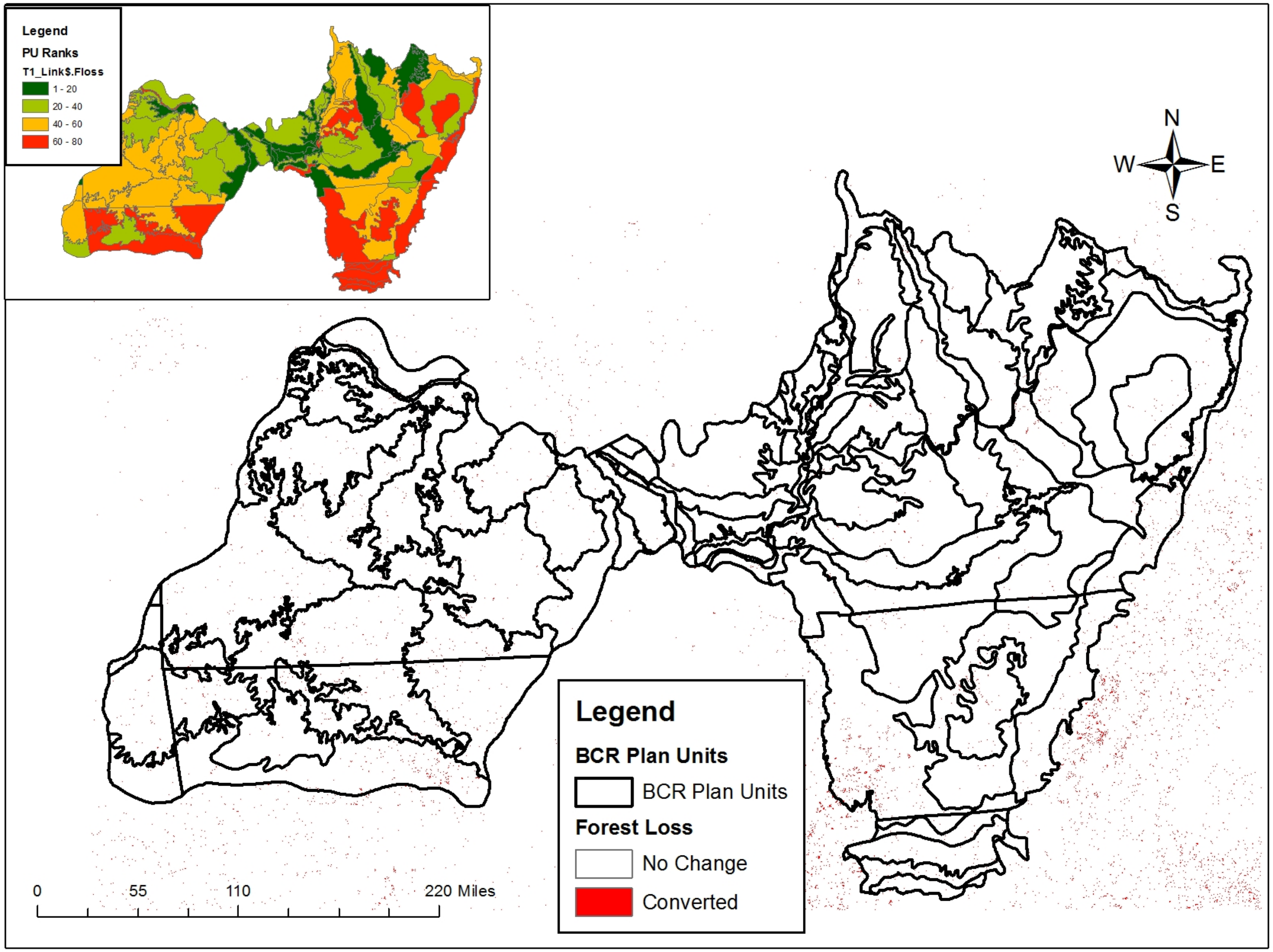


Figure 15. (Q6) Locations where land cover classification changed from a forest type to a non-forest type in 2006 within the Central Hardwoods Bird Conservation Region. Proportion of forest converted in each planning unit was used to produce ranks (inset) from low (1) to high (80).

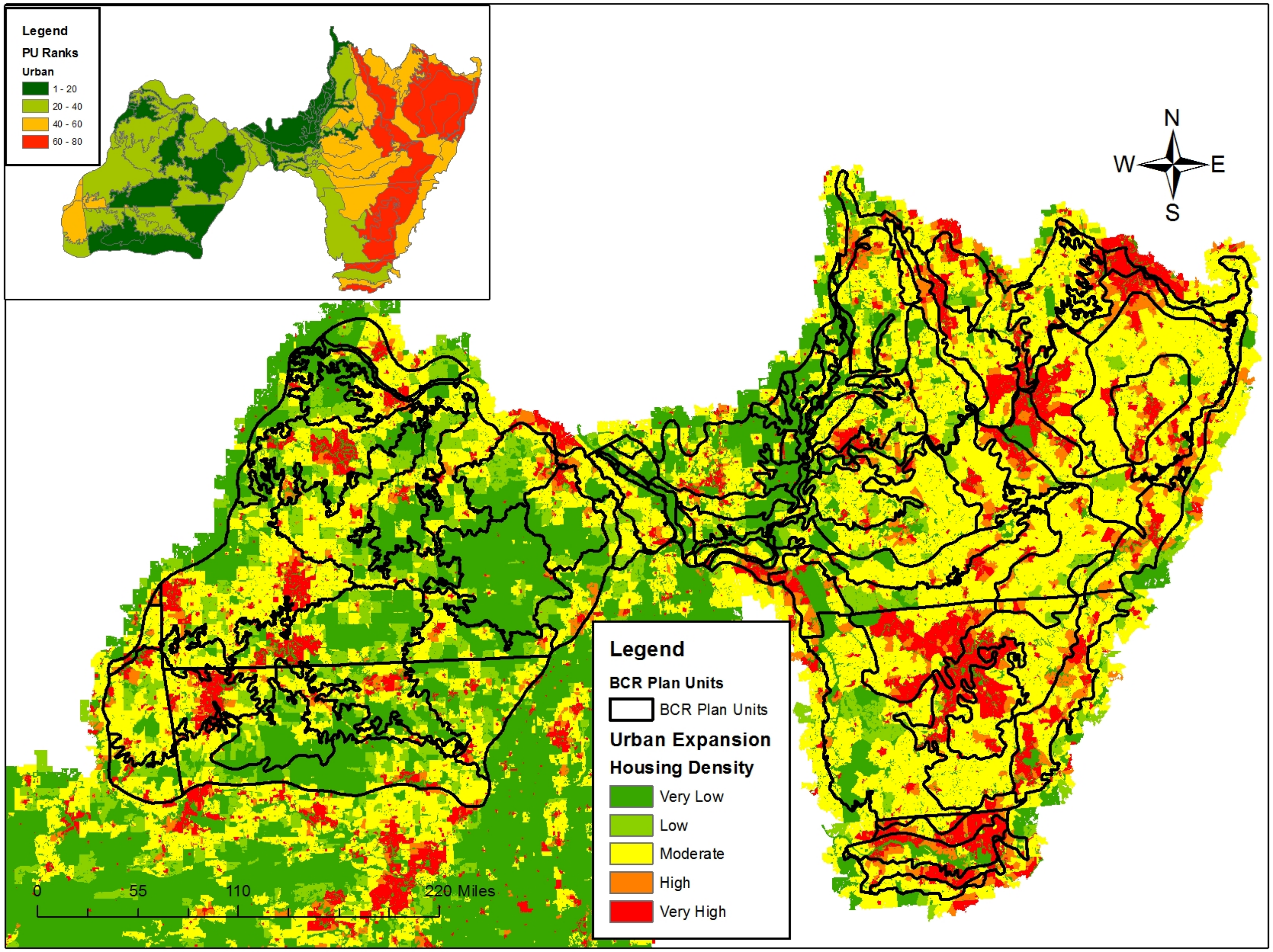


Figure 16. (Q6) The relative impact of current and projected housing density on management actions within the Central Hardwoods Bird Conservation Region. Proportion of each planning unit in the "Very Low" class was used to produce ranks (inset) from high (1) to low (80).