# Analyses of Terrestrial Small Mammal Data and Overlap of Select Species of Greatest Conservation Need from Regions Under Consideration for American Marten (*Martes americana*) Reintroduction in Pennsylvania

*Submitted to the*
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***Background***

In March of 2022, staff from the Western Pennsylvania Conservancy's (WPC) Pennsylvania Natural Heritage Program (PNHP) were contracted by the Pennsylvania Game Commission (PGC) to spatially evaluate the terrestrial small mammal prey base as well as the overlap with select Species of Greatest Conservation Need (SGCN) in portions of Pennsylvania with modeled suitable habitat for American Marten (*Martes americana* - MAAM) in ArcGIS Pro 2.9.2. The results of the analyses were needed by the end of April so that a draft assessment could be reviewed internally and presented to the PGC Board of Commissioners in July 2022. The short turn-around for these analyses required us to use data from previously conducted terrestrial small mammal surveys, primarily intended to document species of concern. While these data were collected using standardized and repeatable methods to detect target species, the survey design was not intended to provide robust analyses of small mammal abundance. With that in mind, the intent of this project is restricted to providing analyses of relative abundance and species richness of the potential terrestrial small mammal prey species for MAAM. For the SGCN portion of the project, PNHP used the existing dataset for the Conservation Opportunity Areas Tool (COA) for a select suite of mammal and bird SGCN which have been documented as prey items for MAAM or are suspected to be prey items based on diet analyses from established MAAM populations. The results of these analyses are not intended to identify areas suitable or not suitable for MAAM reintroduction, rather to inform PGC's consideration of areas for reintroduction efforts.

***Methods***

With a draft of the modeled MAAM habitat and compiled GIS layers of terrestrial small mammal survey locations in hand, PNHP worked with PGC Furbearer Biologist, Tom Keller, to evaluate several options to spatially delimit units for the potential MAAM reintroduction analyses. PNHP and PGC agreed on selected Hydrologic Unit Code 10 (HUC10) watersheds since these boundaries aligned reasonably with modeled habitat suitable for MAAM. Using the HUC10 watersheds as compartmentalized survey units allowed for the most robust analyses of potential prey abundance while considering the best available data from documented terrestrial small mammal surveys.

Data used were collected from terrestrial small mammal surveys conducted from 1984-2018 which targeted small mammals using Museum Special (Woodstream Corp., Lititz, PA) and FSI Museum (Forestry Suppliers Inc., Jackson, MS) snap traps, as well as pitfall traps (Kirkland & Sheppard 1994) and Sherman live traps (Tomahawk Live Trap, LLC, Hazelhurst WI). Those surveys were conducted with a particular target species in mind, and therefore focused on specific microhabitats. Additionally, the methods used are effective at capturing shrews, mice, and voles, but tend to be less effective at capturing other species that could potentially serve as MAAM prey. With that, PNHP acknowledges that the results of the surveys used in these analyses are inherently biased and do not provide a thorough evaluation of small mammal population. Despite these biases and limitations, the survey results offer the best available view of terrestrial small mammal richness and relative abundance in those areas predicted to have high suitability for MAAM.

Initially, Mr. Keller conducted a thorough literature review which compiled and summarized diet analyses from 13 different studies on MAAM that clearly demonstrated small mammals make up a large frequency of occurrence in MAAM diet (68.2%; Fig. 1). PNHP grouped the results of available mammal datasets by specific species or similar guilds to mimic the prey categories summarized by the published studies Mr. Keller reviewed; Soricid shrews (*Sorex spp.*), Northern Short-tailed Shrew (*Blarina brevicauda*), Family Sciuridae (squirrels, flying squirrels, chipmunks), *Peromyscus* mice (*Peromyscus spp.*), Red-backed Vole (*Myodes gapperi*), Woodland Jumping Mouse (*Napaeozapus insignis*), and other less-frequently encountered terrestrial small mammals (e.g. moles, mice, voles).

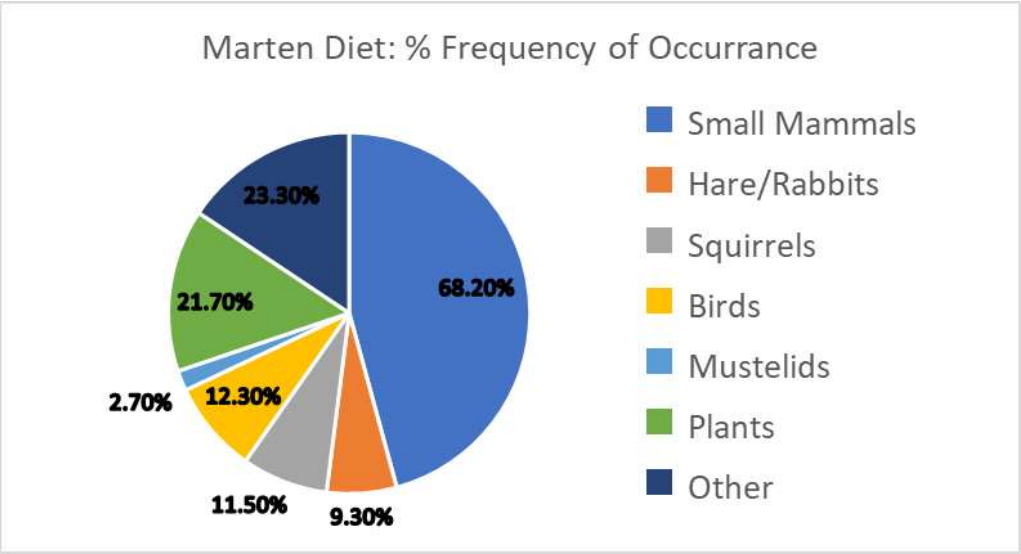


**Figure 1. Percent frequency of occurrence of guilds of prey items from diet analysis of American Marten from 13 studies complied by PGC.**

Additionally, PNHP conducted spatial analysis to provide maps of small mammal prey abundance and richness as well as assess potential conflict areas with a suite of SGCN. Maps are shown at statewide scale, but analysis was restricted to 55 watersheds at the HUC10 level, which represented the MAAM feasibility study area. Data includes summarization at the HUC10 scale in addition to site level spatially interpolated data.

Relative abundance (0-1) was calculated across the feasibility study area for each of seven small mammal species and guilds. These relative abundance values were determined at the HUC10 watershed level as well as the site level. Relative abundance for each small mammal species or group was mapped across the 55 watersheds in the study area. Total mammal abundance in terms of total mammal catch was mapped in the same way across the HUC10 watersheds.

Site level relative abundance was mapped using inverse distance weighted (IDW) interpolation in ArcGIS. IDW is a mathematical or deterministic exact interpolation method used to predict values of a spatial surface in between known values. IDW assumes that closer values are more similar to each than values that are farther apart. Therefore, spatial autocorrelation is used in the mathematics of this interpolation method. Input values nearer to predicted values have greater influence on those predicted values than those which are a greater distance apart. As an exact interpolation method, the resulting raster surface included the exact maximum and minimum values as the input data range and will only occur at measured data points. IDW is a straightforward method for spatial interpolation and useful in this application despite other more complex interpolation methods resulting in more robust models with precited error values (e.g. kriging). PNHP produced IDW predicted relative abundance rasters for each of the seven mammal species/guilds and total mammal capture to represent “heat maps” showing areas of high or low predicted abundance across the study area.

PNHP mapped small mammal richness across the study area using the same methods as described above for abundance. Small mammal richness (number of species) was summarized by HUC10 watershed and mapped across all 55 watersheds. IDW interpolation was used to create a raster of small mammal predicted richness based on the 387 site level richness values.

Another facet of the project was to spatially represent hot spots of SGCN which are known or suspected prey species of MAAM to help identify areas where MAAM could negatively impact SGCN. Through discussions with Mr. Keller and his correspondence with colleagues at PGC, there was particular concern for a handful of SGCN, including Northern Goshawk (*Accipiter gentilis*), Ruffed Grouse (*Bonasa umbellus*), Allegheny Woodrat (*Neotoma magister*), Northern Flying Squirrel (*Glaucomys sabrinus*), Rock Vole (*Microtus chrotorrhinus*), and Appalachian Cottontail (*Sylvilagus obscurus*). To determine regions within the feasibility study area that might result in prey conflicts with SGCN species, PNHP obtained occurrence data from the Conservation Opportunity Areas Tool (COA). Data used to populate the COA tool for the afore mentioned SGCN were taken from multiple sources which include: Pennsylvania Breeding Bird Atlas point counts; eBird = free bird sighting database administered by Cornell Lab of Ornithology (ebird.org); iNaturalist = (www.inaturalist.org); PGC data; PNHP Biotics = Pennsylvania Natural Heritage Program database of unique, threatened or endangered species that is linked with NatureServe, (http://www.natureserve.org/conservation-tools/biotics-5); Bird data from Pennsylvania State University research lab; SGCN data contributed by the Allegheny National Forest. Records for the SGCN used in this analysis range from 1983 to 2021.

Maps were generated at statewide scale, but analysis was restricted to those select 55 HUC10 watershed scale in addition to site level spatially interpolated data. SGCN occurrence data were dissolved across species and scaled up using a 1,000-acre hexagon grid, which was also subsequently dissolved. Upscaling was used to preserve sensitivity for some species included in the analysis. This resulting spatial layer represents potential conflict zones within the MAAM feasibility study area. The final component of this analysis included overlays with both the predicted total small mammal abundance map and the predicted small mammal richness maps to highlight regions where although there may be prey feasibility there also may exist potential SGCN conflicts.

***Results***

Terrestrial small mammal survey results were available from 55 HUC10 watersheds containing a high percentage of suitable modeled MAAM habitat. Across those HUC10 watersheds, 387 surveys were used for the analyses, and those surveys captured 8,368 mammals of 20 species, and were conducted between 1984 and 2018.

The guilds of *Peromyscus* mice and the Southern Red-backed Vole made up a majority of captures from the surveys (60%), similar to the majority (39.6%) summarized from the 13 studies analyzed by PGC (Fig. 2).

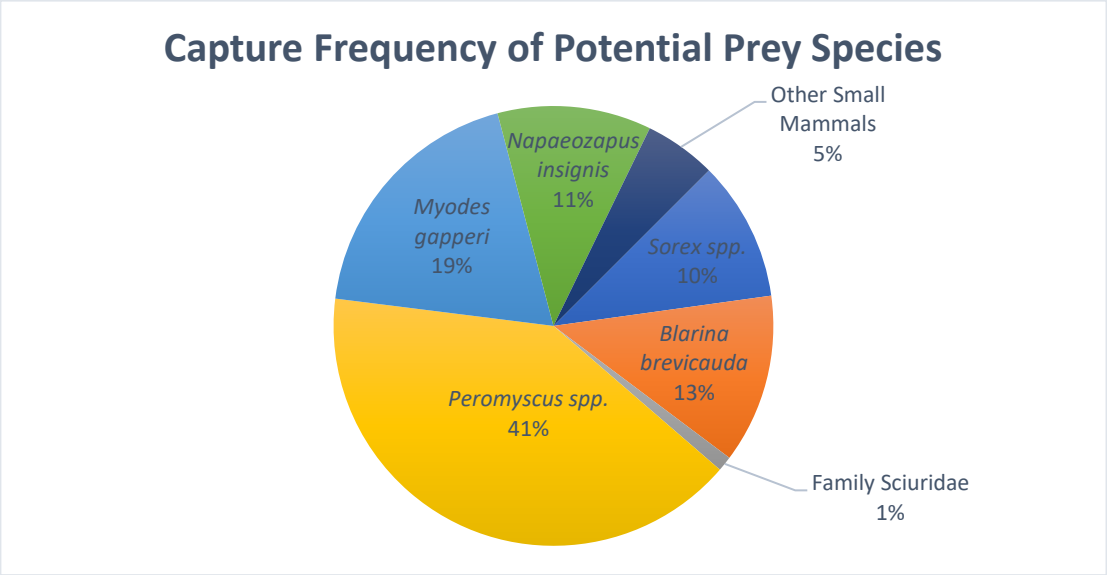


**Figure 2. Percent frequency of occurrence of guilds of terrestrial small mammals from 387 terrestrial small mammal surveys conducted in Pennsylvania between 1984-2018 in modeled suitable habitat for American Marten.**

Patterns of relative abundance by HUC10s and site (Appendix A,B) for Peromyscus mice and Southern Red-backed Voles are not evident. Likewise, we find no clear patterns of species richness (Appendix C) across the HUC10s used in these analyses. Tabular abundance data can be viewed in Appendix D.

There were 3,441 occurrence features for the six SGCN within the study area, and these occurrence features are distributed across nearly the whole study area (Appendix E).

***Discussion***

Although the short timeframe for these analyses precluded use of more current data, 200 of the 387 surveys were from a recent active decade of mammal sampling (2009-2019) because of several survey initiatives including the Cameron County Natural Heritage Inventory (CNHI), the Pennsylvania Mammal Atlas, two projects focused on the American Water Shrew, inventories of data gaps for the Bureau of Forestry, an inventory the Clermont Tract (District 13 - Elk State Forest), WPC studies of areas in the shale gas region, and general PNHP Natural Heritage inventory surveys. Also, given the inherent survey bias by targeting specific microhabitats, the results are not necessarily indicative of the entire small mammal community outside of those habitats. Despite these biases, we feel confident stating that a healthy terrestrial small mammal prey base is present in those HUC10s considered for these analyses. The lack of clear patterns in species richness and relative abundance of the Peromyscus mice and Southern Red-backed Vole, (the two guilds making up the majority of MAAM prey base from other studies), suggest the terrestrial small mammal prey base would not be a limiting factor for MAAM prey base in the HUC10 watersheds considered in these analyses. Rather, the resulting differences between HUC10s are likely due to the overall limited survey effort for terrestrial small mammals in the state.

Across the 55 HUC10s used in these analyses, the frequency of occurrence of species guilds available as potential prey resembles those in the MAAM diet analysis from the 13 studies summarized by Mr. Keller (Fig.

1), suggesting the terrestrial small mammal prey availability is compatible with the breakdown of small mammal prey preferences from previous research on established MAAM populations.

The predicted total abundance of terrestrial small mammals depicted in figure B8 show a high abundance in north central Clearfield County, undoubtably due to some intensive survey efforts by PGC at Parker Dam State Park. These surveys included a mix of snap traps and pitfall traps. Since pitfall traps capture multiple individuals and are more effective at capturing all terrestrial small mammals, caution should be used to not read too much into the predicted abundance. Trap efforts at Parker Dam State Park had high yield because of the survey length and methods used.

Keep in mind that hares/rabbits, squirrels, birds, insects, and plants also make up a significant portion of MAAM diet, and efforts should be made to quantify these prey items as well.

A number of the SGCN used in this exercise are highly sensitive, and it's likely best for PGC to hone in on the susceptibility of individual Element Occurrences (EOs) and evaluate the threats at the site level as reintroduction plans take shape. Should plans for MAAM reintroduction proceed in discrete areas, studies to monitor these SGCN should be prioritized to help inform species management efforts.

***Recommendations***

As mentioned previously, we acknowledge that the data limitations hampered our ability to develop more comprehensive evaluation of small mammal populations related to a MAAM prey base. Consider as well that some of the data used for these analyses are nearly 40 years old. The Mammal Survey of Pennsylvania (1946-1951) conducted by the PGC in cooperation with the Carnegie Museum of Natural History (CMNH) provided a statewide assessment of mammal distributions and status. The six regional summary reports from the Mammal Survey house the first comprehensive species-by-species assessment of the Commonwealth's mammals, and despite being over 70 years old, for many of our mammal species this remains the best information available.

Through personal communiqué with CMNH staff familiar with the data collected during the survey and still housed at the museum, we've learned that notes for each survey exist including detailed location, habitat descriptions, and quantified survey effort. These data are not provided in the six regional summary report of the Mammal Survey but would be very useful analyses of mammal populations from that five-year period. We recommend that a project be developed to digitize the data from the Pennsylvania Mammal Survey project so that this information is available to use for in analyses, such as this effort, and in order to gain historical perspective of the mammal populations from that era.

More recently, PGC initiated a 10-year term Pennsylvania Mammal Atlas aimed at providing a contemporary assessment of all of Pennsylvania's mammal species. Although a pilot atlas study was initiated, the project's support has waned, and it is largely inactive. Efforts to reinvigorate this effort are needed so that species abundance data are available to the PGC and scientific community.

Finally, although there is good coverage of mammal surveys across much of the modeled suitable MAAM habitat, there remain a number of HUC10s where no terrestrial small mammal data is available. Should MAAM reintroduction be considered, efforts to fill some of these data gaps would be prudent.

***Datasets and works referenced***

Kirkland G.L. and P.K. Krim. 1994. Proposed standard protocol for sampling small mammal communities. Pgs. 277-283 *in* Merritt, J.F, G.L. Kirkland, and R.K. Rose. Advances in the Biology of Shrews. Carnegie Museum of Natural History, special publication No. 18. Pittsburgh, PA. 458 pp.

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PGC-PFBC (Pennsylvania Game Commission and Pennsylvania Fish & Boat Commission). 2015. Pennsylvania Wildlife Action Plan, 2015-2025. C. Haffner and D. Day, editors. Pennsylvania Game Commission and Pennsylvania Fish & Boat Commission, Harrisburg, Pennsylvania.

PNHP's terrestrial small mammal surveys (those not included in the PGC's Terrestrial Small Mammal Database

Western Pennsylvania Conservancy, 1993. A Survey of Shrews in Allegheny National Forest, Pennsylvania with emphasis on water shrew, *Sorex palustris* and Long-tailed Shrew *Sorex dispar*. Western Pennsylvania Conservancy: Pittsburgh, PA. 117 pp.

**Appendix A.**

Relative Abundance of Potential Prey Terrestrial Small Mammal Species by 55 select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania from 387 terrestrial small mammal surveys conducted between 1984-2018.

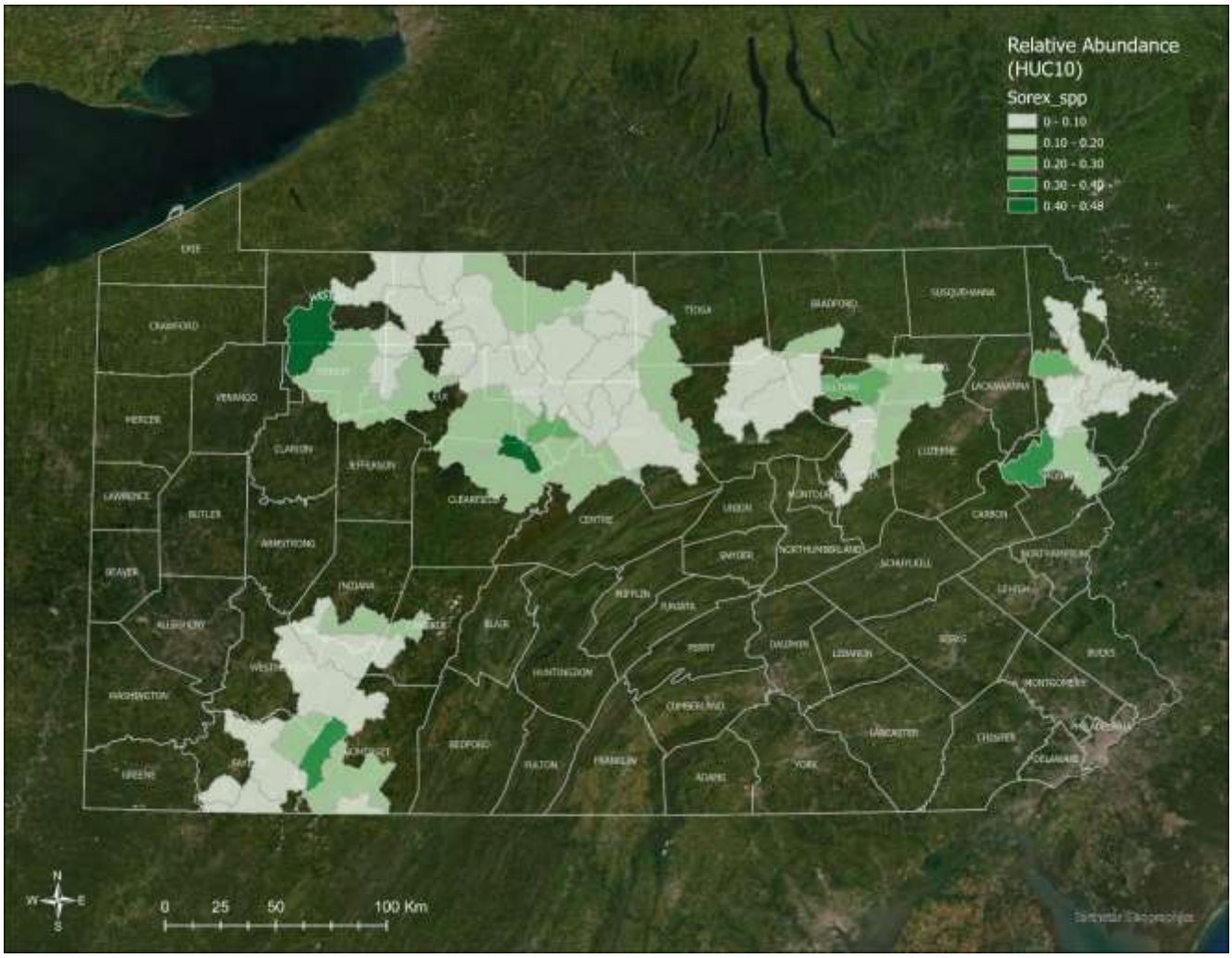


**Figure A1**. Relative abundance of shrews from the genus *Sorex* from select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018. Species include the Masked Shrew (*Sorex cinereus*), Big-tailed Shrew (*Sorex dispar*), Maryland Shrew (*Sorex fontinalis*), Smoky Shrew (*Sorex fumeus*), Pygmy Shrew (*Sorex hoyi*), and American Water Shrew (*Sorex palustris*).

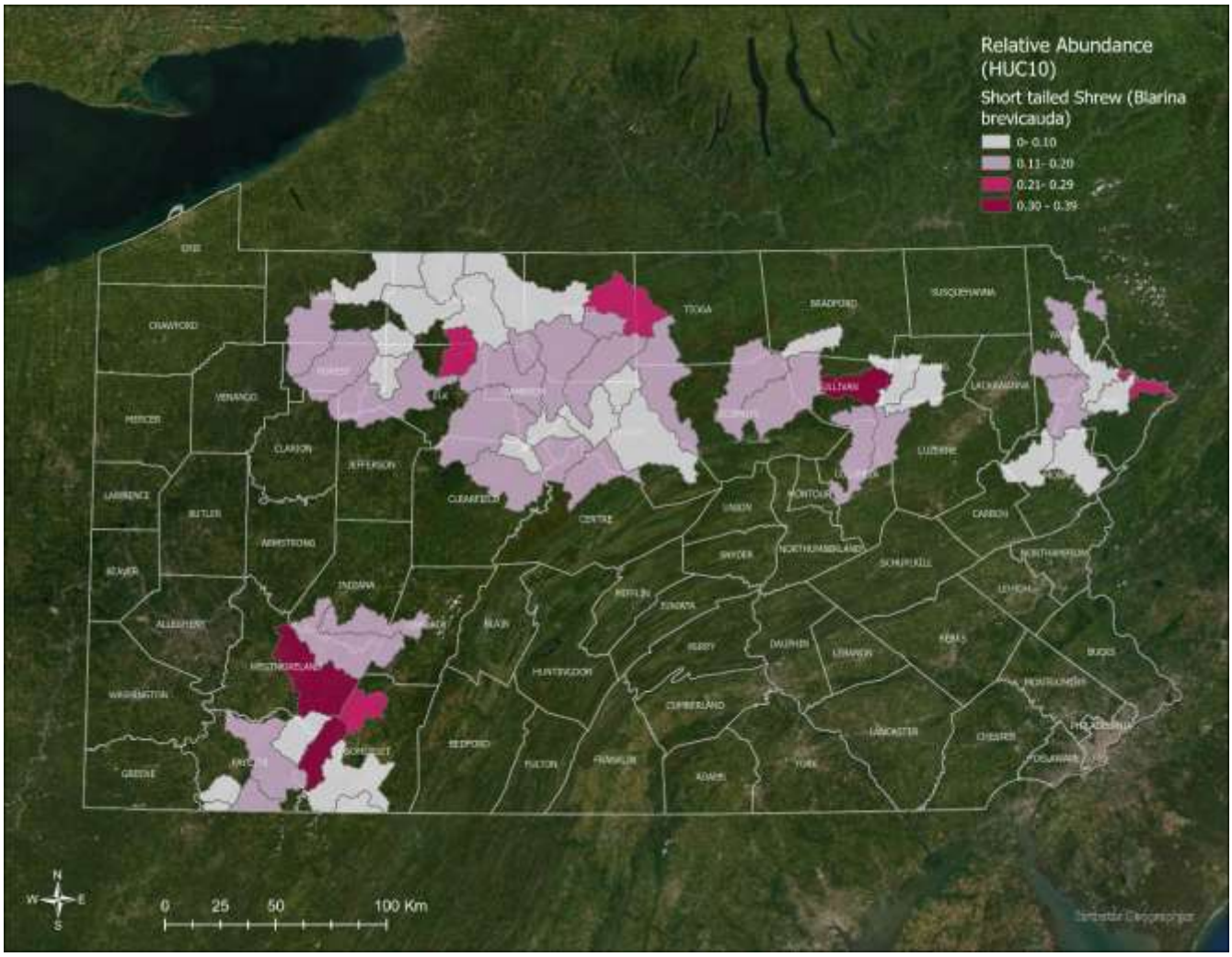


**Figure A2**. Relative abundance of the Northern Short-tailed Shrew (*Blarina brevicauda*) by Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018.

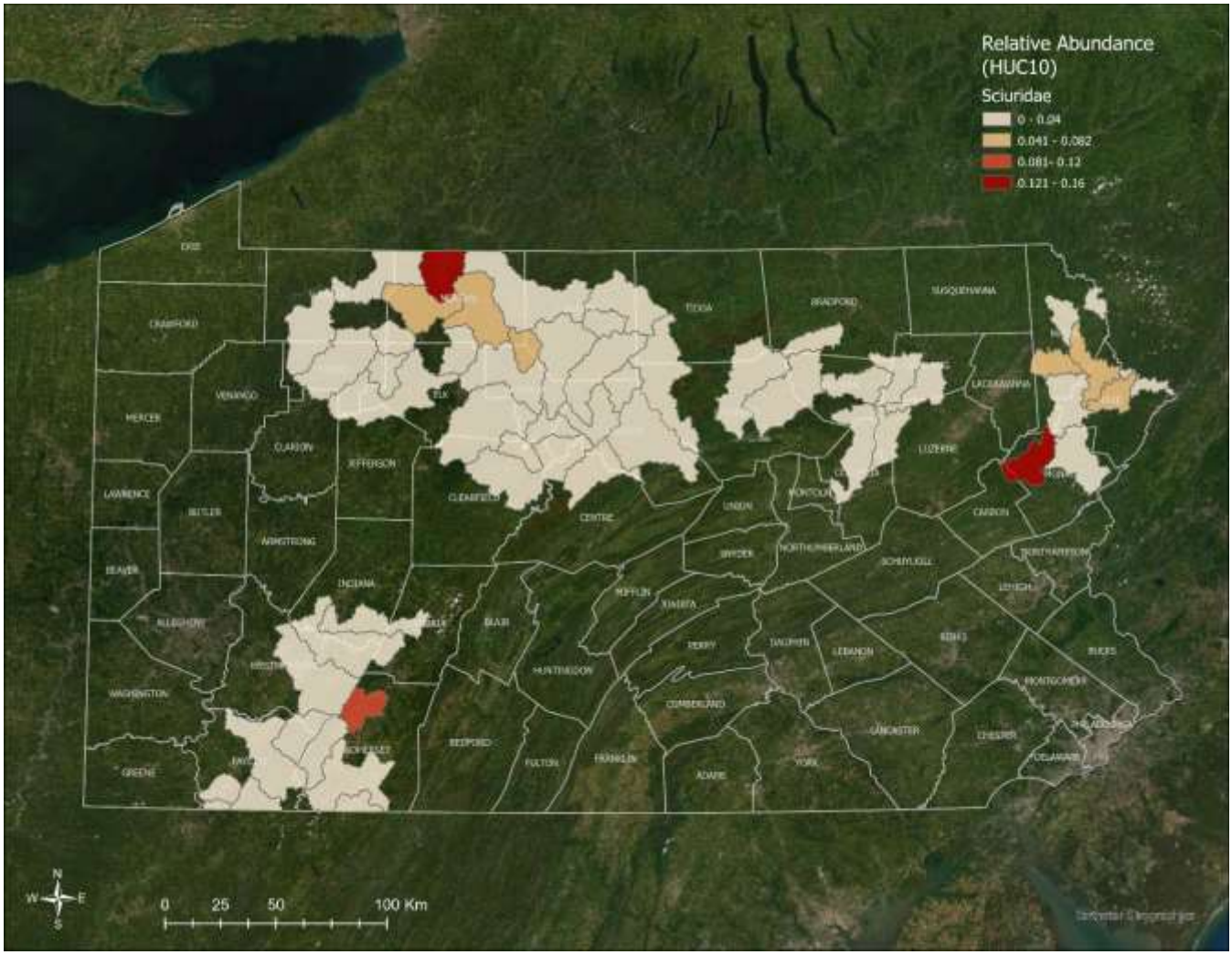


**Figure A3.** Relative abundance of Sciurid species by Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018. Species include the Eastern Chipmunk (*Tamias striatus*), American Red Squirrel (*Tamiasciurus hudsonicus*), and Southern Flying Squirrel (*Glaucomys volans*).

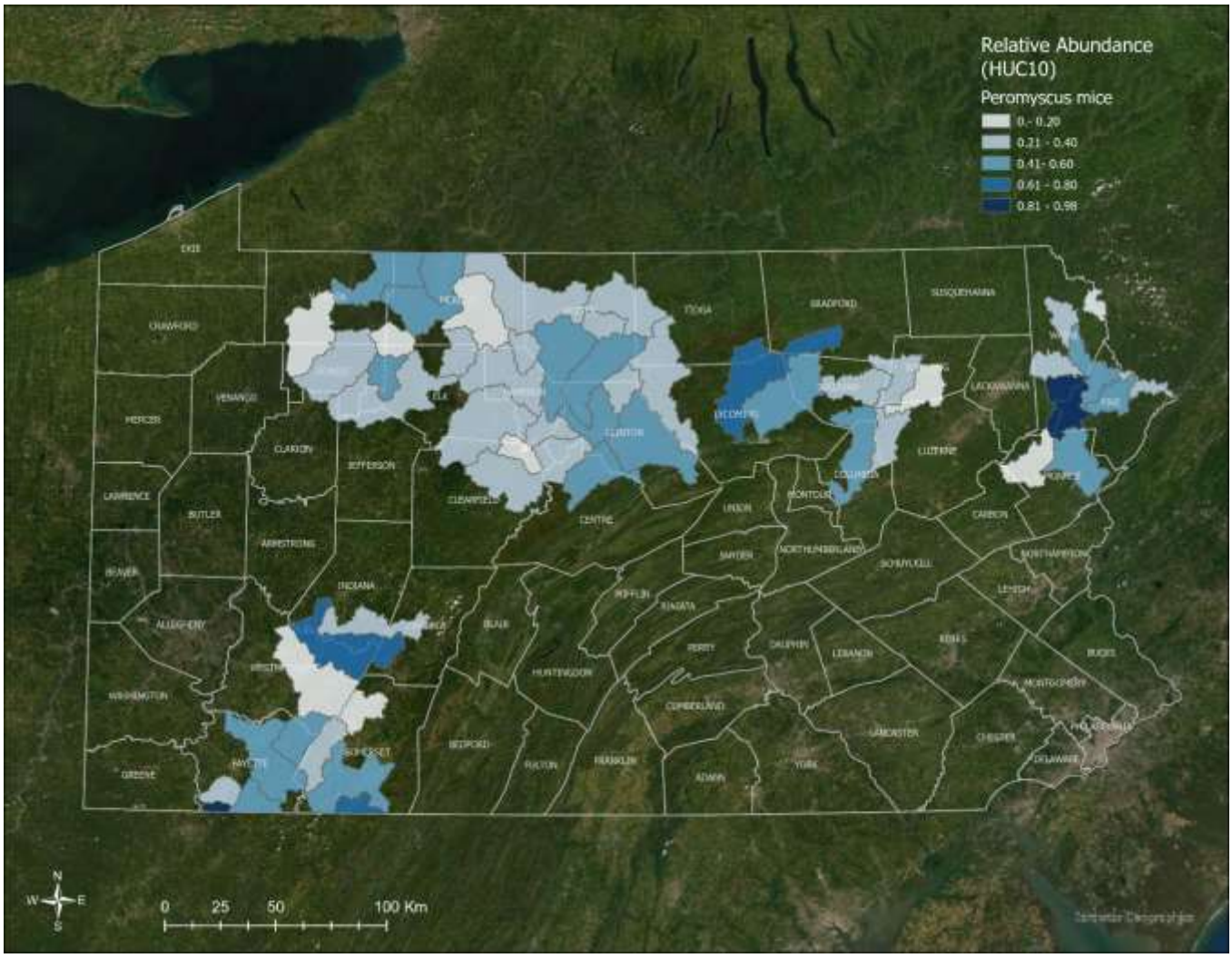


**Figure A4.** Relative abundance of mice from the genus *Peromyscus* by Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018. Species include White-footed Mouse (*Peromyscus leucopus*) and Deer Mouse (*Peromyscus maniculatus*).

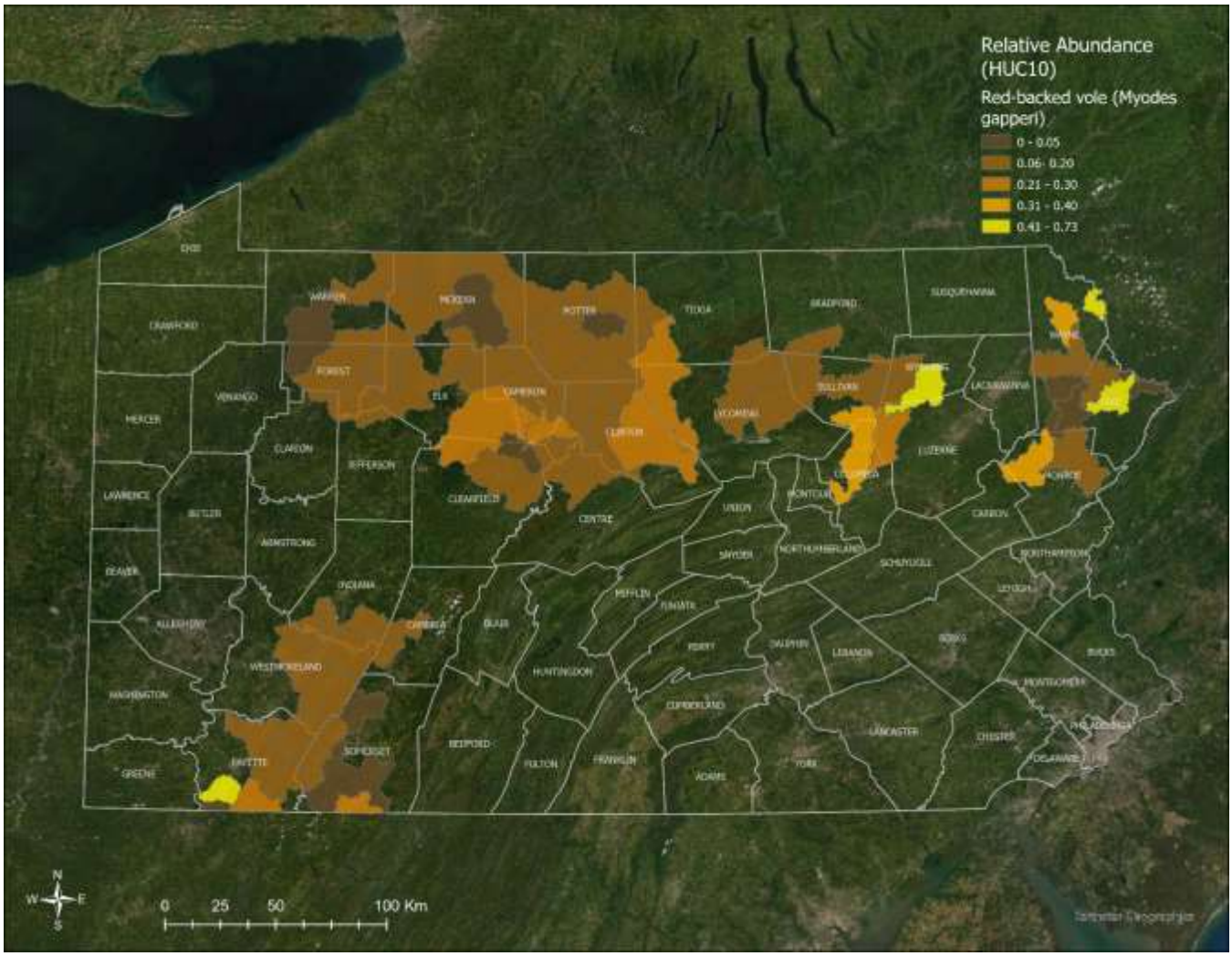


**Figure A5.** Relative abundance of the Southern Red-backed Vole (*Myodes gapperi*) by Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018.

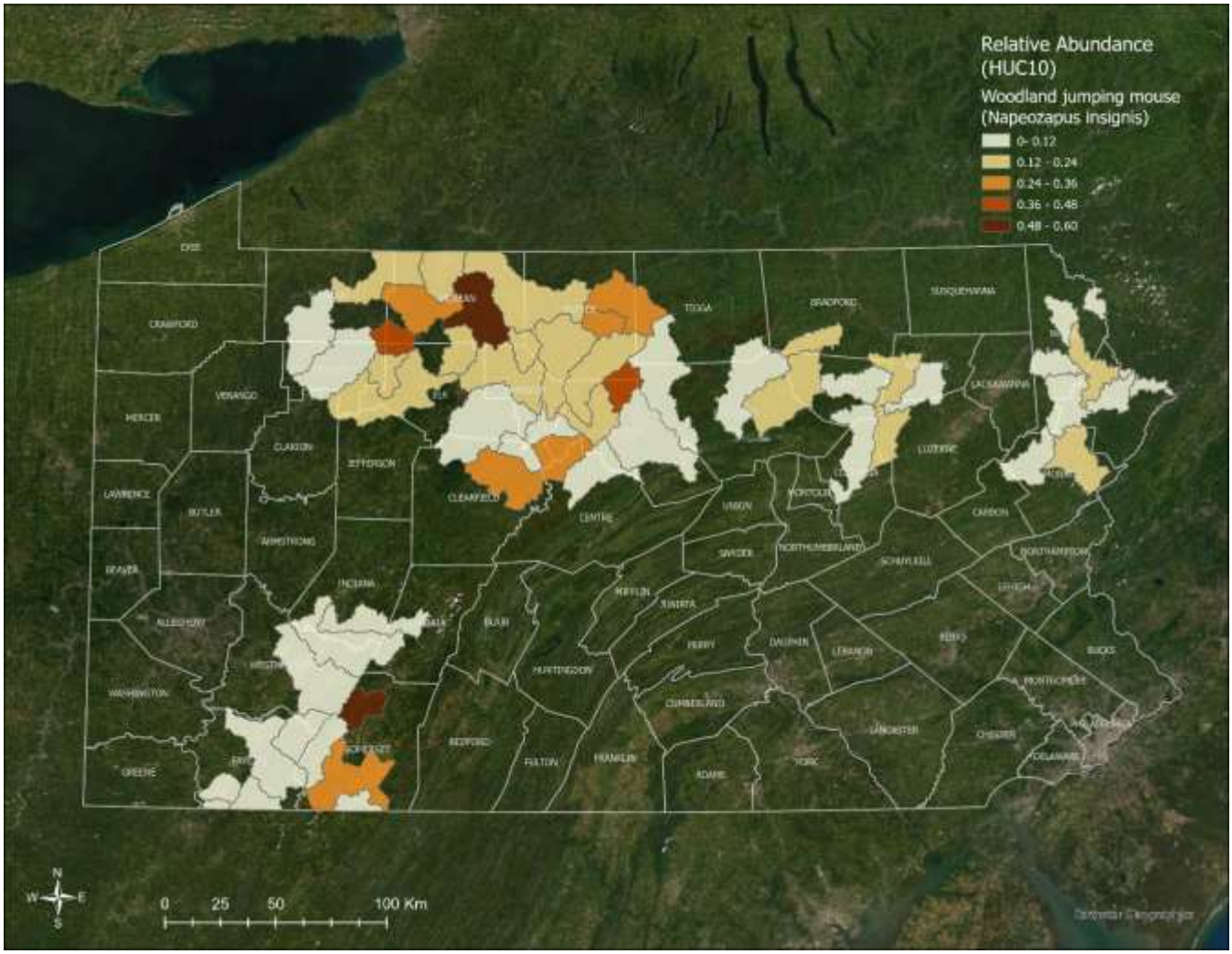


**Figure A6.** Relative abundance of the Woodland Jumping Mouse (*Napaeozapus insignis*) by Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018.

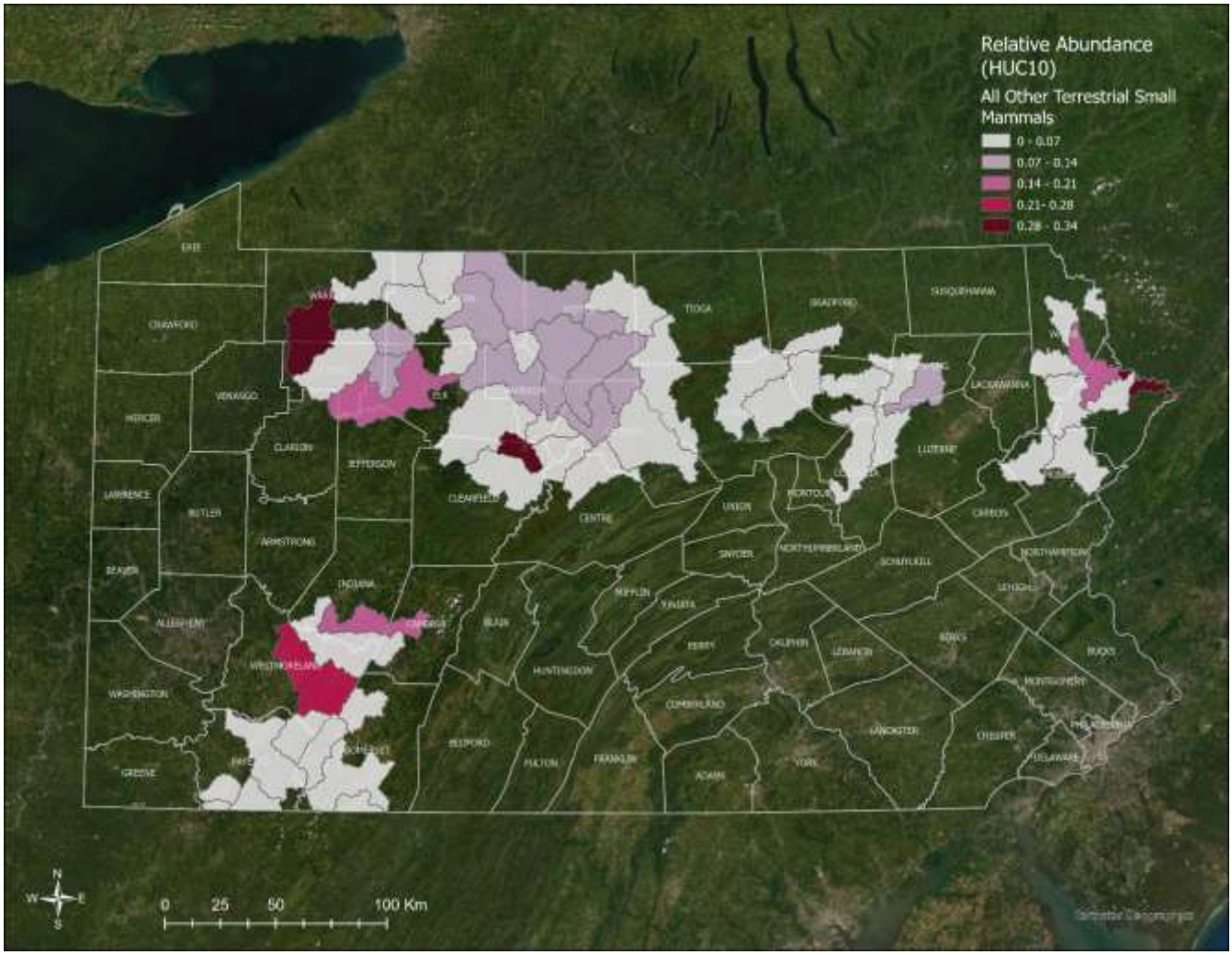


**Figure A7.** Relative abundance of all other terrestrial small mammals from the datasets used for the prey analysis by Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018. Species include Star-nosed Mole (*Condylura cristata*), Rock Vole (*Microtus chrotorrhinus*), Meadow Vole (*Microtus pennsylvanicus*), Woodland Vole (*Microtus pinetorum*), Southern Bog Lemming (*Synaptomys cooperi*), and Meadow Jumping Mouse (*Zapus hudsonicus*).

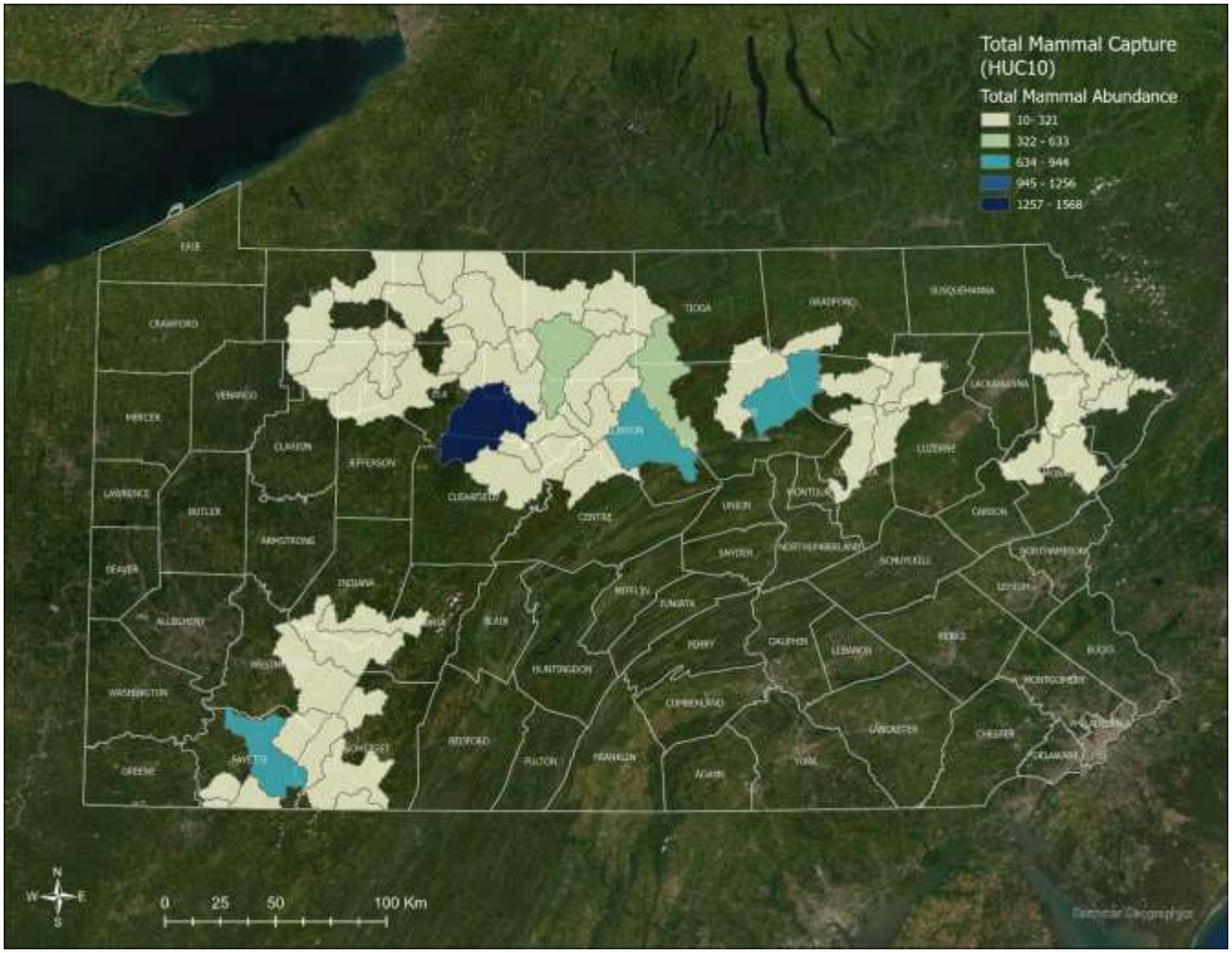


**Figure A8.** Relative abundance of all potential prey species from the dataset by Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018.

**Appendix B.**

Predicted Relative Abundance of Potential Prey Species by Inverse Distance Weighted (IDW) Interpolation from 55 select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania from 387 terrestrial small mammal surveys conducted between 1984-2018.

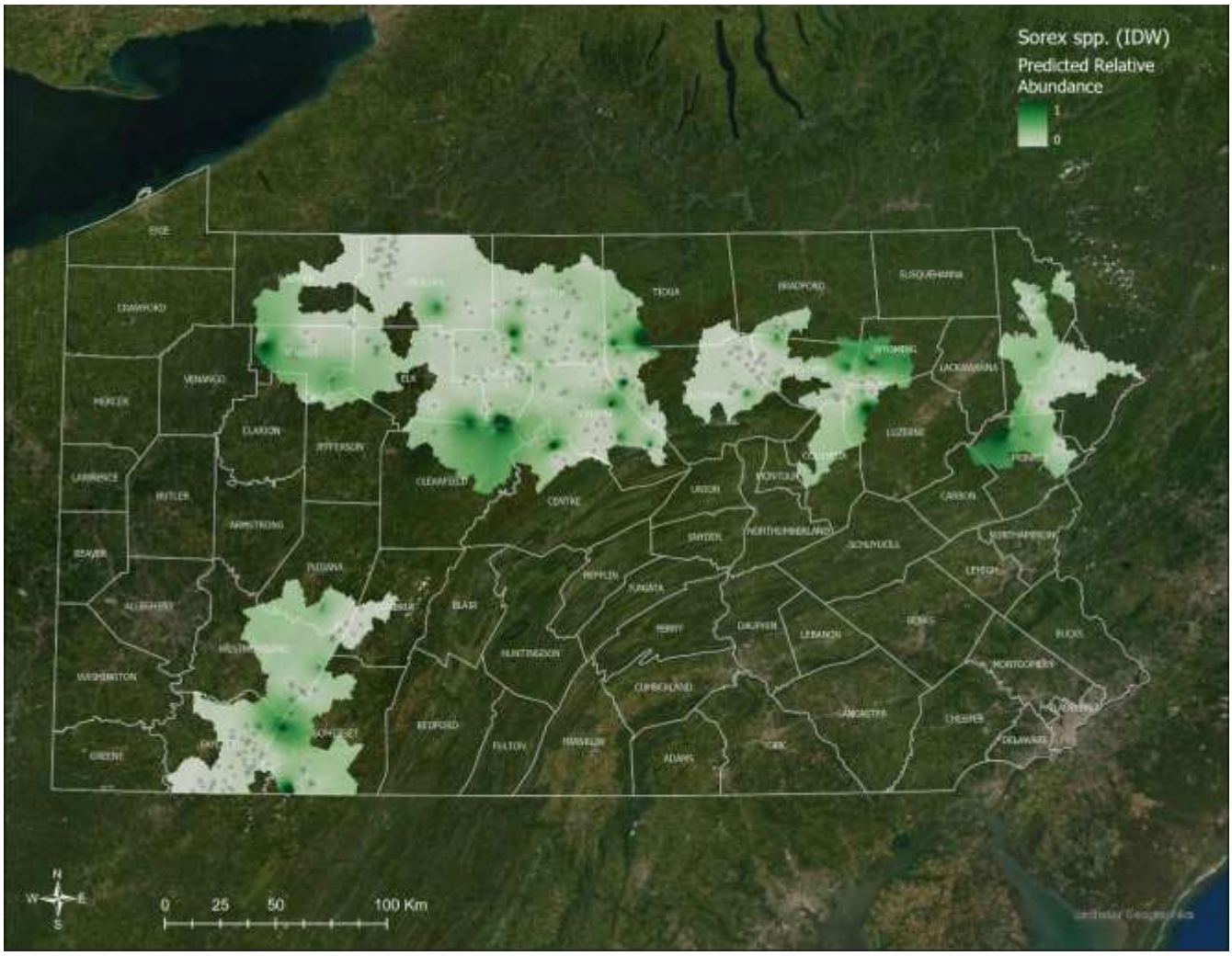


**Figure B1**. Predicted relative abundance of shrews from the genus *Sorex* by inverse distance weighted interpolation from select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018. Species include the Masked Shrew (*Sorex cinereus*), Big-tailed Shrew (*Sorex dispar*), Maryland Shrew (*Sorex fontinalis*), Smoky Shrew (*Sorex fumeus*), Pygmy Shrew (*Sorex hoyi*), and American Water Shrew (*Sorex palustris*).

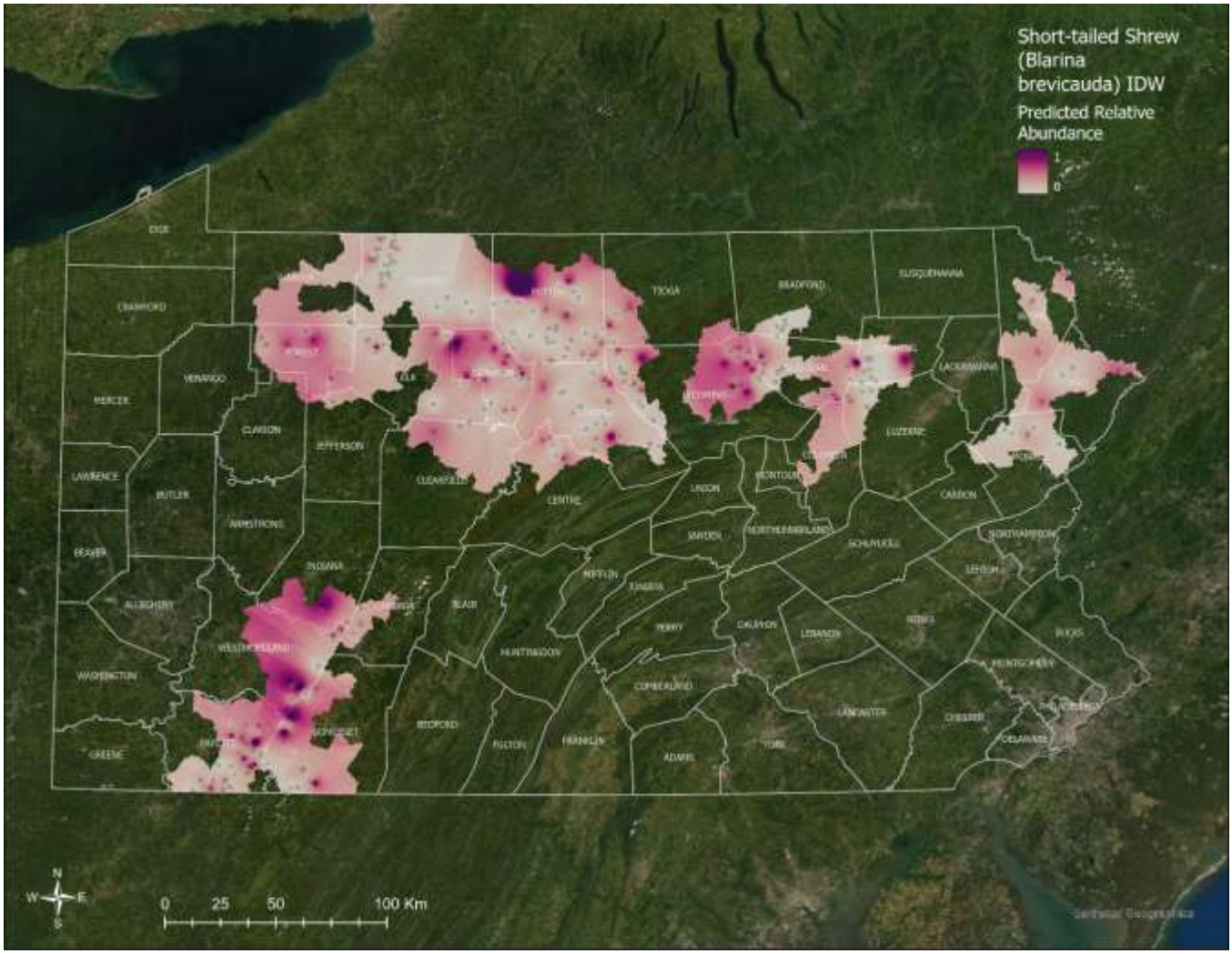


**Figure B2**. Predicted relative abundance of the Northern Short-tailed Shrew (*Blarina brevicauda*) by inverse distance weighted interpolation from select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018.

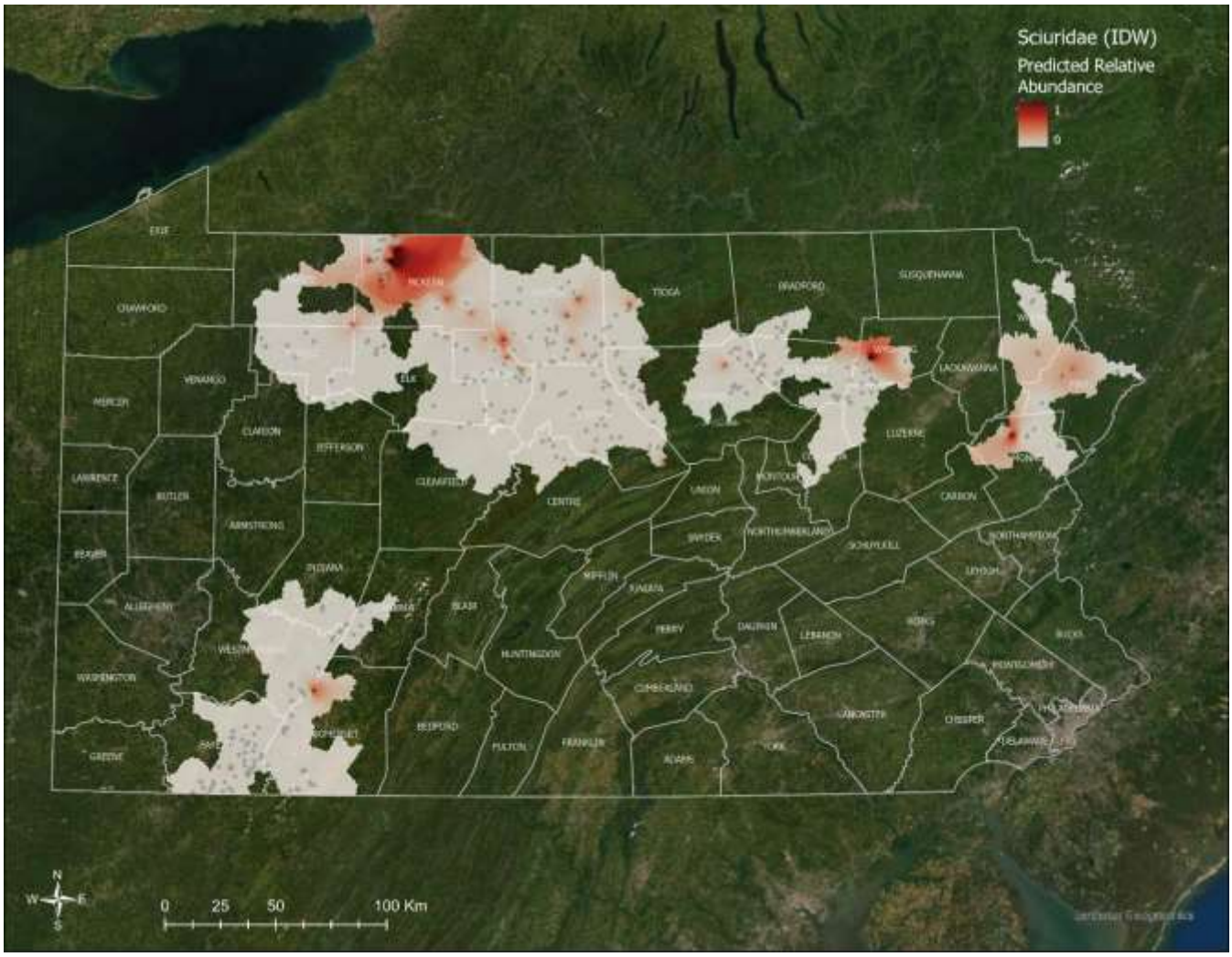


**Figure B3**. Predicted relative abundance of Sciurid species by inverse distance weighted interpolation from select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018. Species include the Eastern Chipmunk (*Tamias striatus*), American Red Squirrel (*Tamiasciurus hudsonicus*), and Southern Flying Squirrel (*Glaucomys volans*).

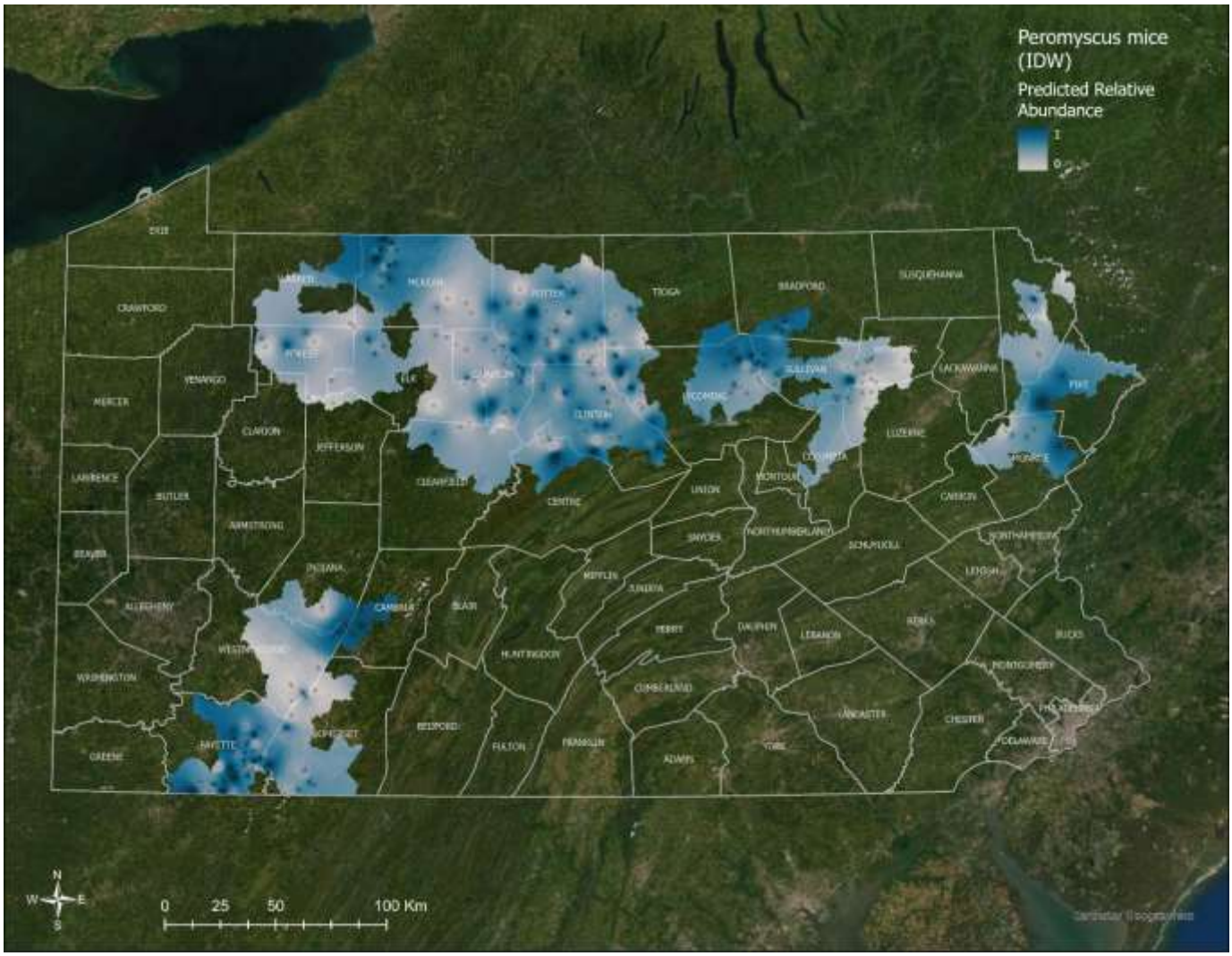


**Figure B4**. Predicted relative abundance of mice from the genus *Peromyscus* by inverse distance weighted interpolation from select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018. Species include White-footed Mouse (*Peromyscus leucopus*) and Deer Mouse (*Peromyscus maniculatus*).

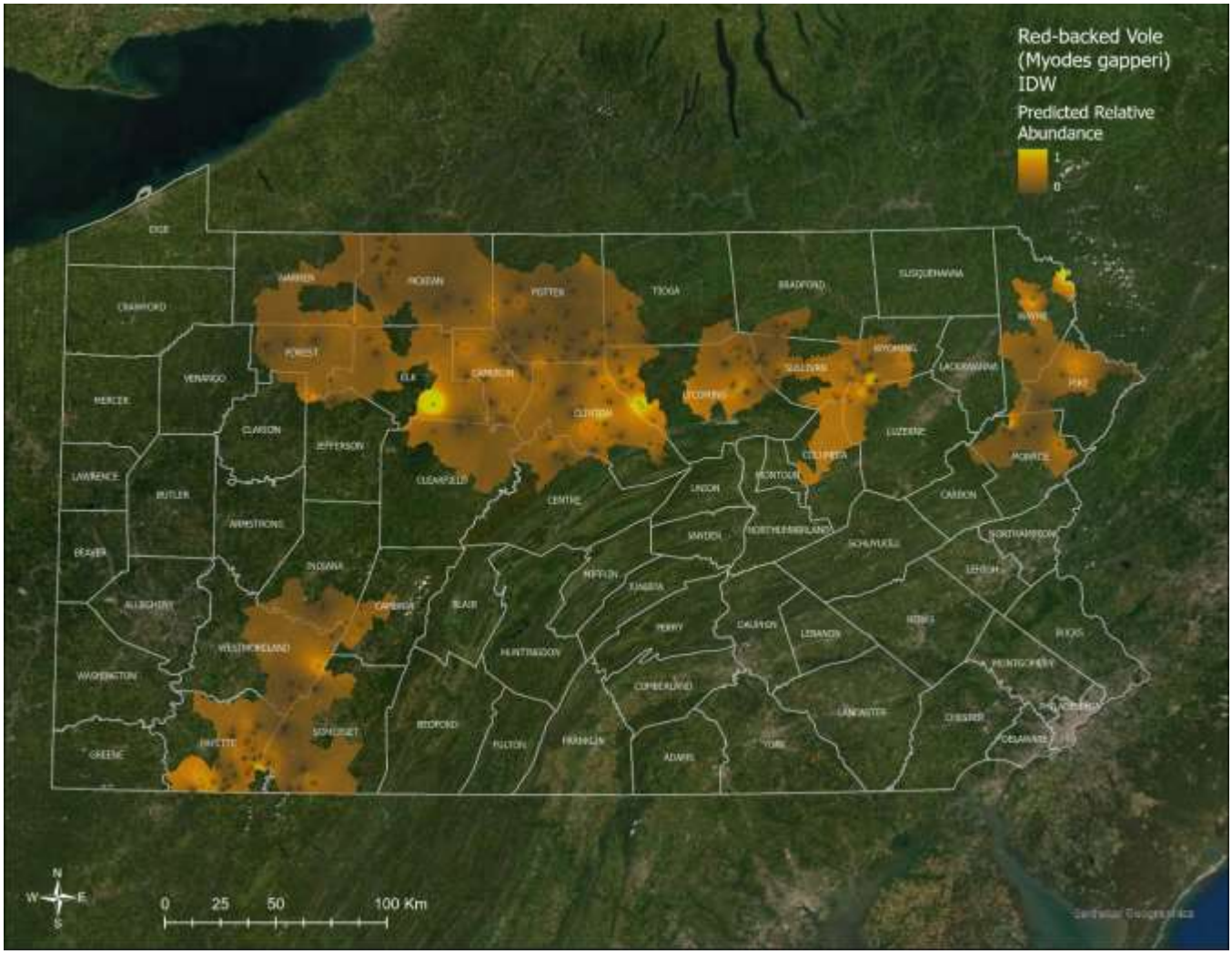


**Figure B4.** Predicted relative abundance of the Southern Red-backed Vole (*Myodes gapperi*) by inverse distance weighted interpolation from select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018.

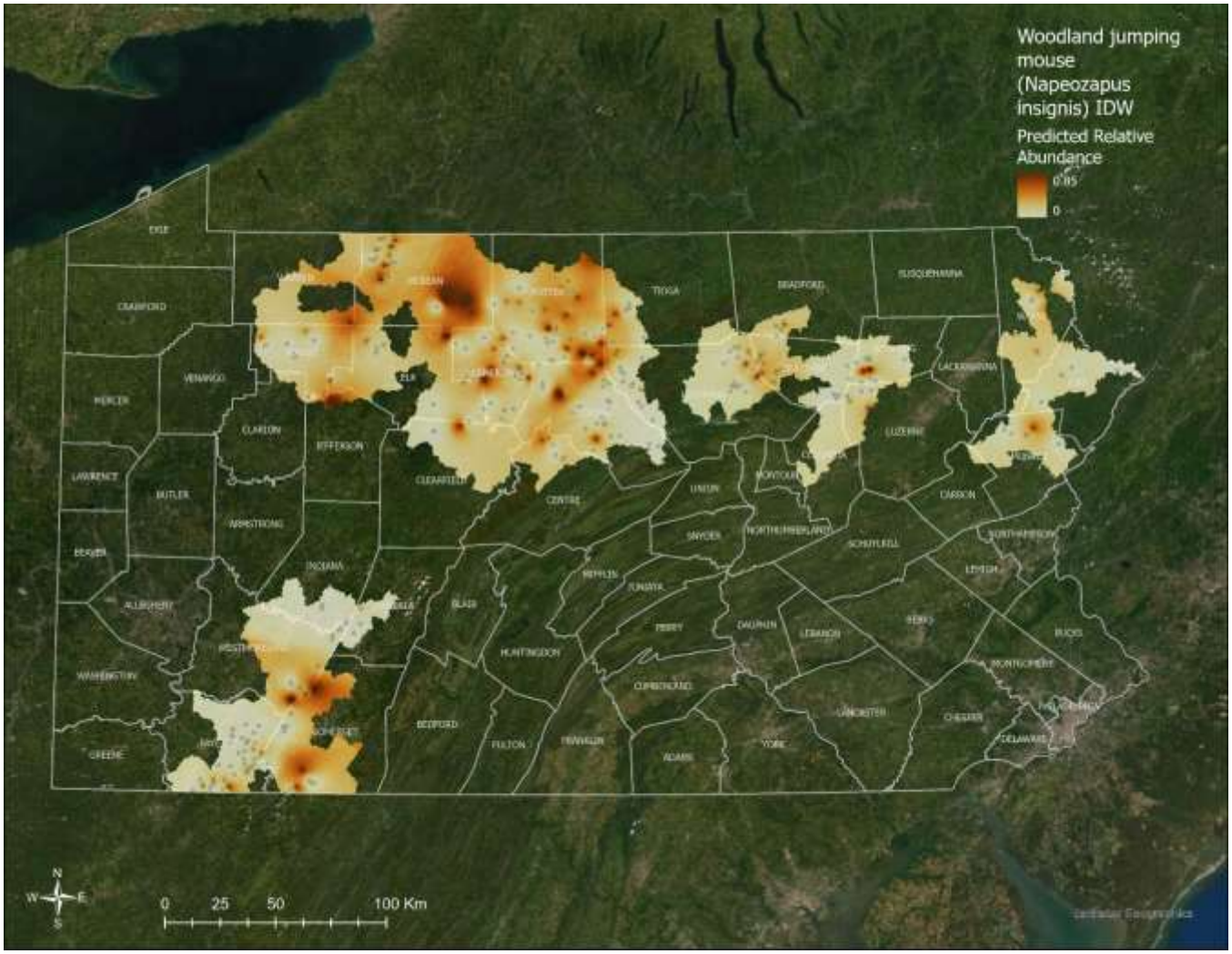


**Figure B6**. Predicted relative abundance of the Woodland Jumping Mouse (*Napaeozapus insignis*) by inverse distance weighted interpolation from select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018.

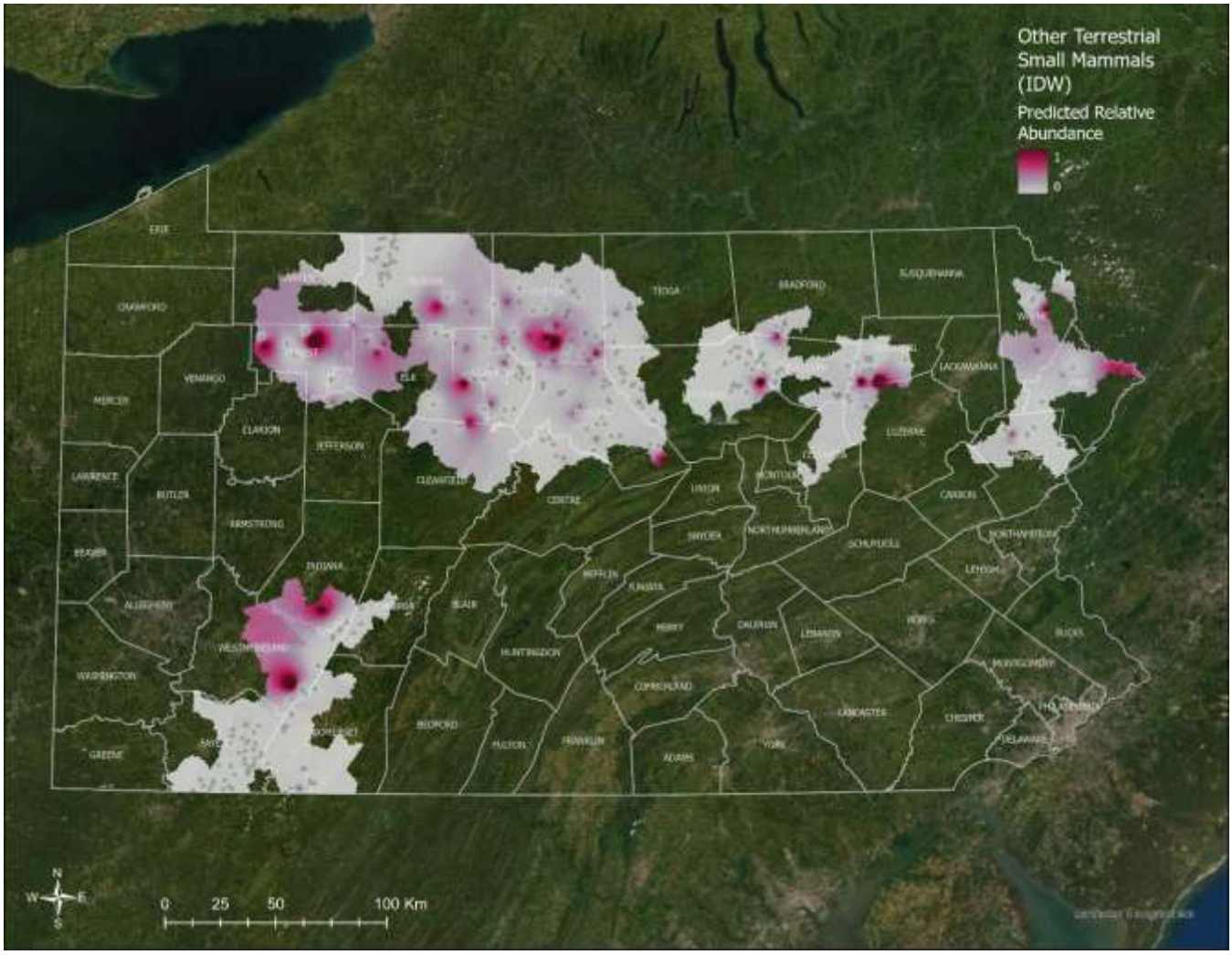


**Figure B7**. Predicted relative abundance of all other terrestrial small mammals from the dataset used for the prey analysis by inverse distance weighted interpolation from select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018. Species include Star-nosed Mole (*Condylura cristata*), Rock Vole (*Microtus chrotorrhinus*), Meadow Vole (*Microtus pennsylvanicus*), Woodland Vole (*Microtus pinetorum*), Southern Bog Lemming (*Synaptomys cooperi*), and Meadow Jumping Mouse (*Zapus hudsonicus*).

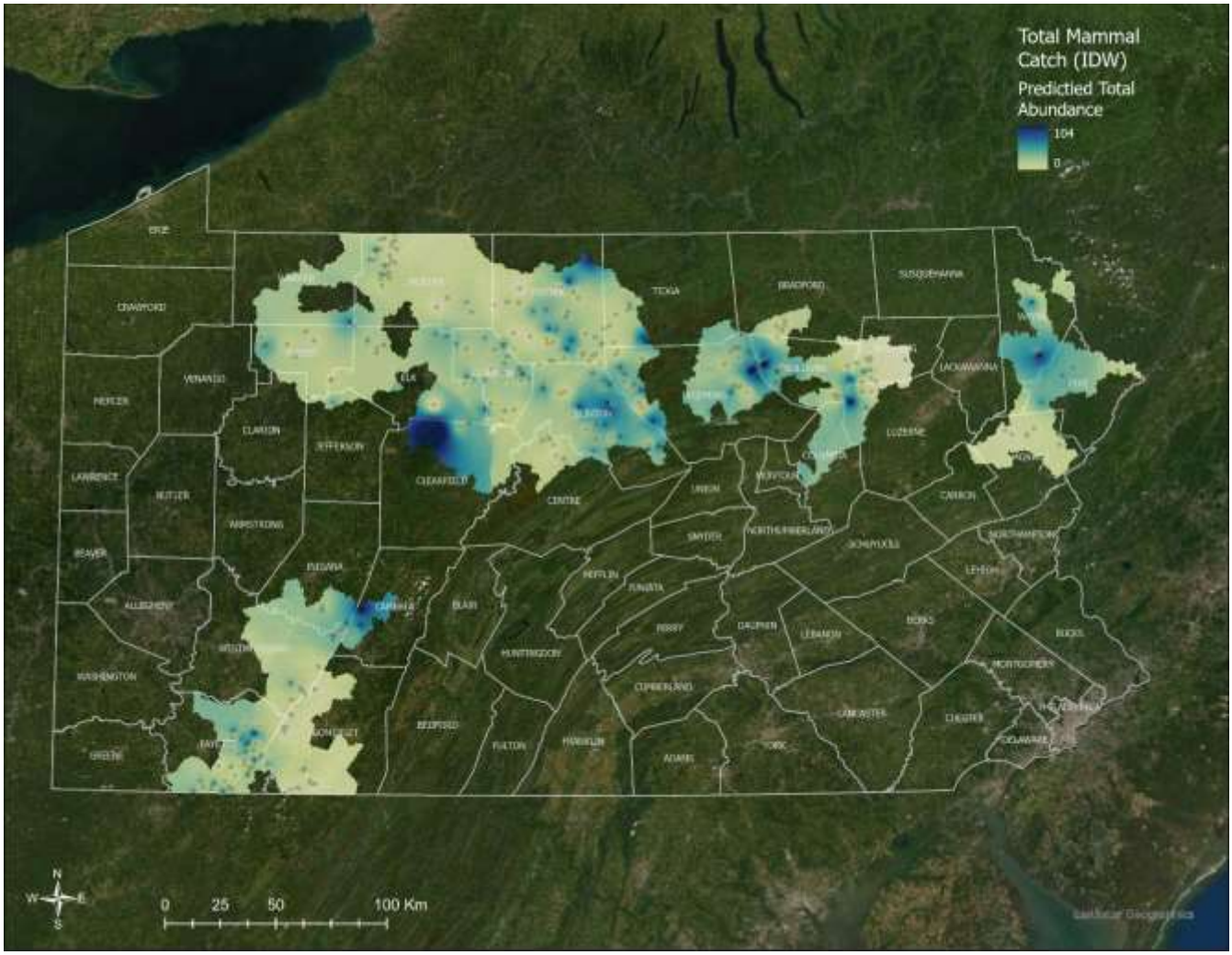


**Figure B8.** Predicted relative abundance of all other potential terrestrial small mammal prey species by inverse distance weighted interpolation from select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018.

**Appendix C.**

Terrestrial Small Mammal Species Richness and Predicted Relative Abundance of Potential Prey Species by Inverse Distance Weighted (IDW) Interpolation in 55 select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania from 387 terrestrial small mammal surveys conducted between 1984-2018.

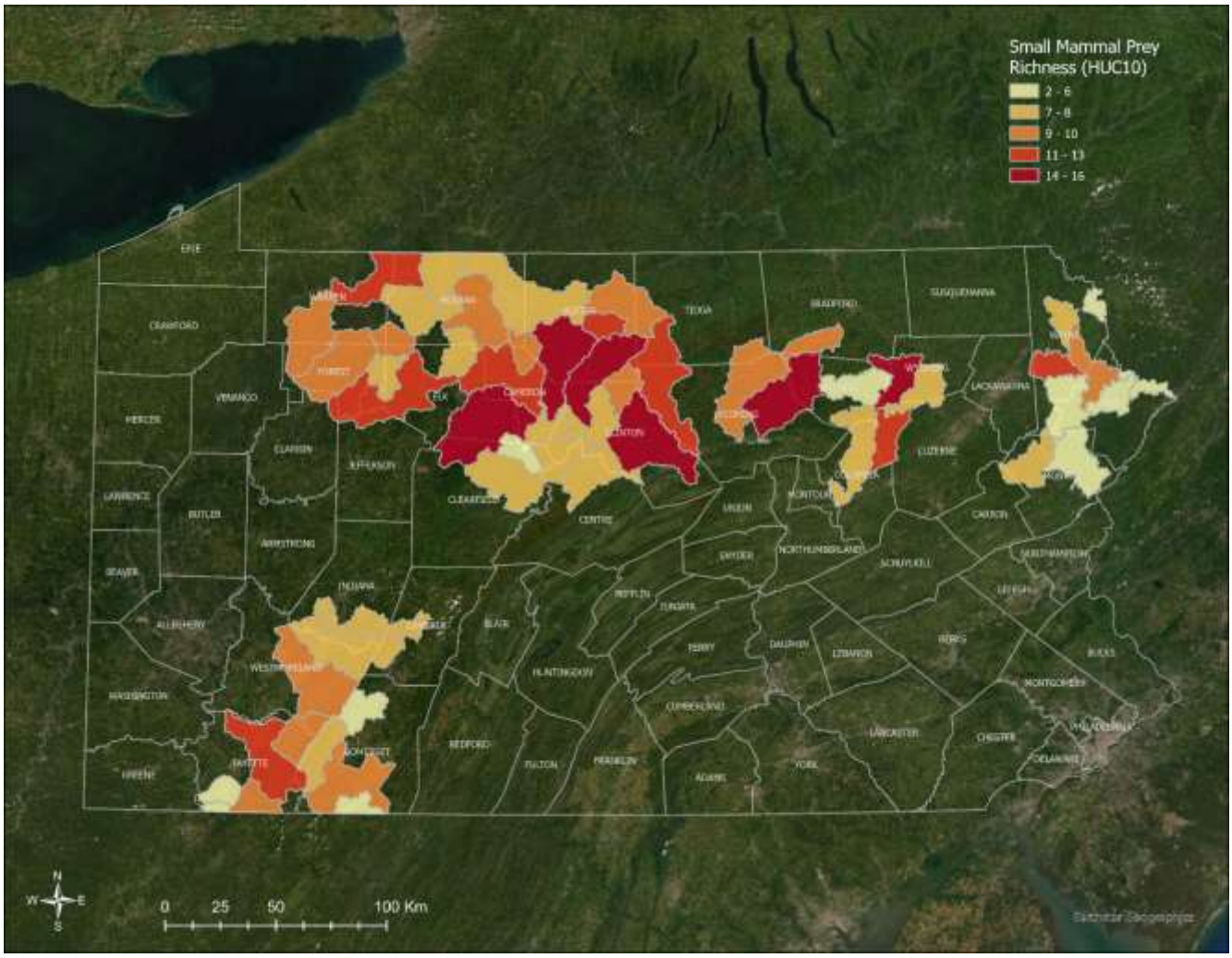


**Figure C1**. Species richness of potential terrestrail small mammal prey species from 387 surveys conducted between 1984-2018 from select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania.

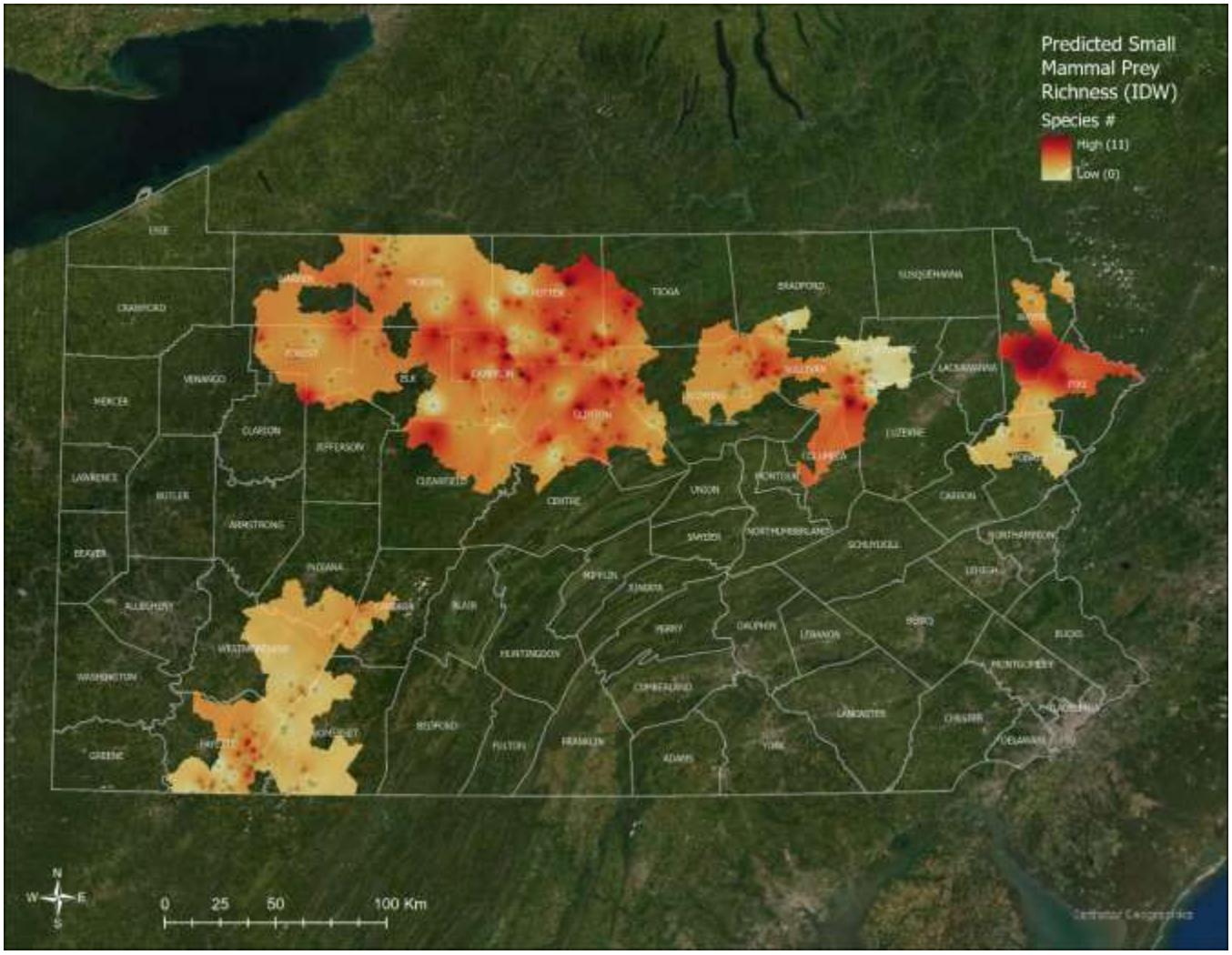


**Figure C2.** Predicted species richness of potential terrestrail small mammal prey species from 387 surveys conducted between 1984-2018 from select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania.

**Appendix D.**

Relative Abundance of Potential Prey Species by HUC10 Watersheds

**Table D.** Relative abundance of 20 species of terrestrial small mammals that could serve as potential prey for the American Marten and species richness listed by HUC10 watersheds that lie within suitable habitat as predicted by PGC modeling.

| Name (HUC10) | *Sorex spp.** | *Blarina brevicauda* | Family Sciuridae** | *Peromyscus spp.*† | *Myodes gapperi* | *Napaeozapus insignis* | Other Small Mammals †† | Species Richness |
|---|---|---|---|---|---|---|---|---|
| **Beech Creek (205020402)** | 0.12 | 0.16 | 0.00 | 0.48 | 0.08 | 0.12 | 0.04 | 8 |
| **Bennett Branch Sinnemahoning Creek (205020203)** | 0.16 | 0.17 | 0.01 | 0.32 | 0.28 | 0.01 | 0.05 | 16 |
| **Big Sandy Creek (502000406)** | 0.03 | 0.10 | 0.00 | 0.53 | 0.24 | 0.10 | 0.00 | 9 |
| **Birch Island Run-West Branch Susquehanna River (205020107)** | 0.16 | 0.16 | 0.00 | 0.27 | 0.11 | 0.30 | 0.00 | 7 |
| **Blacklick Creek (501000709)** | 0.10 | 0.18 | 0.00 | 0.39 | 0.09 | 0.05 | 0.18 | 8 |
| **Bowman Creek (205010613)** | 0.17 | 0.08 | 0.00 | 0.13 | 0.50 | 0.00 | 0.13 | 7 |
| **Broadhead Creek (204010409)** | 0.19 | 0.07 | 0.00 | 0.48 | 0.10 | 0.17 | 0.00 | 6 |
| **Callicoon Creek-Delaware River (204010105)** | 0.09 | 0.18 | 0.00 | 0.00 | 0.73 | 0.00 | 0.00 | 3 |
| **Conemaugh River (501000710)** | 0.02 | 0.13 | 0.00 | 0.65 | 0.18 | 0.02 | 0.00 | 8 |
| **Driftwood Branch Sinnemahoning Creek (205020202)** | 0.06 | 0.17 | 0.03 | 0.25 | 0.18 | 0.24 | 0.08 | 12 |
| **Drury Run-West Branch Susquehanna River (205020302)** | 0.09 | 0.04 | 0.00 | 0.47 | 0.11 | 0.20 | 0.10 | 8 |
| **Dyberry Creek (204010302)** | 0.07 | 0.11 | 0.00 | 0.32 | 0.39 | 0.09 | 0.02 | 8 |
| **East Branch Clarion River (501000501)** | 0.04 | 0.20 | 0.00 | 0.28 | 0.20 | 0.24 | 0.04 | 7 |
| **First Fork Sinnemahoning Creek (205020204)** | 0.07 | 0.12 | 0.01 | 0.43 | 0.09 | 0.22 | 0.07 | 14 |
| **Fishing Creek (205010707)** | 0.07 | 0.15 | 0.00 | 0.42 | 0.32 | 0.00 | 0.05 | 7 |
| **Georges Creek (502000502)** | 0.03 | 0.08 | 0.00 | 0.40 | 0.50 | 0.00 | 0.00 | 5 |
| **Halfway Brook-Delaware River (204010405)** | 0.10 | 0.20 | 0.00 | 0.40 | 0.00 | 0.00 | 0.30 | 6 |
| **Headwaters Allegheny River (501000103)** | 0.13 | 0.03 | 0.00 | 0.35 | 0.16 | 0.19 | 0.13 | 8 |
| **Huntington Creek (205010705)** | 0.15 | 0.10 | 0.02 | 0.30 | 0.27 | 0.13 | 0.04 | 13 |
| **Indian Creek (502000608)** | 0.16 | 0.07 | 0.00 | 0.55 | 0.12 | 0.09 | 0.01 | 9 |
| **Kettle Creek (205020301)** | 0.07 | 0.10 | 0.01 | 0.47 | 0.11 | 0.15 | 0.08 | 14 |
| **Kinzua Creek (501000109)** | 0.04 | 0.02 | 0.08 | 0.50 | 0.10 | 0.26 | 0.00 | 8 |
| **Lackawaxen River (204010306)** | 0.08 | 0.00 | 0.05 | 0.46 | 0.10 | 0.15 | 0.15 | 9 |
| **Laurel Hill Creek (502000606)** | 0.31 | 0.34 | 0.00 | 0.22 | 0.09 | 0.03 | 0.00 | 7 |

| Name (HUC10) | *Sorex spp.** | *Blarina brevicauda* | Family Sciuridae** | *Peromyscus spp.*† | *Myodes gapperi* | *Napaeozapus insignis* | Other Small Mammals †† | Species Richness |
|---|---|---|---|---|---|---|---|---|
| **Lower Allegheny River (501000112)** | 0.04 | 0.08 | 0.02 | 0.48 | 0.13 | 0.21 | 0.03 | 13 |
| **Lower Casselman River (502000607)** | 0.11 | 0.05 | 0.01 | 0.41 | 0.05 | 0.35 | 0.01 | 10 |
| **Lower Cheat River (502000407)** | 0.00 | 0.00 | 0.00 | 0.98 | 0.02 | 0.00 | 0.00 | 2 |
| **Lower Loyalsock Creek (205020605)** | 0.04 | 0.14 | 0.01 | 0.44 | 0.15 | 0.17 | 0.05 | 14 |
| **Lower Pine Creek (205020506)** | 0.18 | 0.11 | 0.01 | 0.39 | 0.23 | 0.07 | 0.02 | 13 |
| **Loyalhanna Creek (501000801)** | 0.08 | 0.32 | 0.00 | 0.16 | 0.11 | 0.09 | 0.23 | 9 |
| **Lycoming Creek (205020602)** | 0.03 | 0.15 | 0.01 | 0.61 | 0.12 | 0.09 | 0.00 | 9 |
| **McElhattan Creek-West Branch Susquehanna River (205020304)** | 0.08 | 0.08 | 0.00 | 0.45 | 0.28 | 0.05 | 0.06 | 15 |
| **Mehoopany Creek (205010609)** | 0.19 | 0.03 | 0.01 | 0.39 | 0.08 | 0.23 | 0.07 | 14 |
| **Middle Creek (204010303)** | 0.26 | 0.13 | 0.04 | 0.28 | 0.13 | 0.09 | 0.07 | 13 |
| **Middle Youghiogheny River (502000609)** | 0.05 | 0.12 | 0.01 | 0.57 | 0.19 | 0.06 | 0.00 | 11 |
| **Mosquito Creek (205020106)** | 0.48 | 0.07 | 0.00 | 0.10 | 0.00 | 0.00 | 0.34 | 4 |
| **Potato Creek (501000101)** | 0.06 | 0.00 | 0.04 | 0.15 | 0.04 | 0.60 | 0.11 | 10 |
| **Quemahoning Creek (501000701)** | 0.10 | 0.20 | 0.10 | 0.00 | 0.00 | 0.60 | 0.00 | 4 |
| **Schrader Creek (205010602)** | 0.13 | 0.02 | 0.00 | 0.61 | 0.09 | 0.14 | 0.02 | 10 |
| **Shohola Creek (204010404)** | 0.00 | 0.04 | 0.08 | 0.44 | 0.44 | 0.00 | 0.00 | 5 |
| **Sinnemahoning Creek (205020205)** | 0.26 | 0.09 | 0.00 | 0.32 | 0.21 | 0.12 | 0.00 | 7 |
| **Sinnemahoning Portage Creek (205020201)** | 0.08 | 0.19 | 0.06 | 0.29 | 0.13 | 0.19 | 0.06 | 10 |
| **South Branch Tionesta Creek (501000302)** | 0.07 | 0.06 | 0.02 | 0.14 | 0.18 | 0.43 | 0.10 | 10 |
| **Spring Creek (501000505)** | 0.08 | 0.06 | 0.00 | 0.45 | 0.18 | 0.16 | 0.08 | 7 |
| **Tionesta Creek (501000304)** | 0.15 | 0.17 | 0.00 | 0.39 | 0.13 | 0.09 | 0.07 | 10 |
| **Tobyhanna Creek (204010601)** | 0.31 | 0.00 | 0.13 | 0.19 | 0.31 | 0.00 | 0.06 | 8 |
| **Tunungwant Creek (501000106)** | 0.01 | 0.03 | 0.16 | 0.49 | 0.07 | 0.22 | 0.00 | 8 |
| **Upper Allegheny River (501000301)** | 0.41 | 0.10 | 0.00 | 0.10 | 0.04 | 0.06 | 0.29 | 9 |
| **Upper Casselman River (502000604)** | 0.06 | 0.09 | 0.00 | 0.62 | 0.23 | 0.00 | 0.00 | 6 |
| **Upper Clarion River (501000506)** | 0.15 | 0.10 | 0.01 | 0.21 | 0.15 | 0.21 | 0.16 | 12 |

| Name (HUC10) | *Sorex spp.** | *Blarina brevicauda* | Family Sciuridae** | *Peromyscus spp.*† | *Myodes gapperi* | *Napaeozapus insignis* | Other Small Mammals †† | Species Richness |
|---|---|---|---|---|---|---|---|---|
| **Upper Loyalsock Creek (205020603)** | 0.22 | 0.39 | 0.00 | 0.26 | 0.13 | 0.00 | 0.00 | 4 |
| **Upper Pine Creek (205020502)** | 0.10 | 0.20 | 0.00 | 0.23 | 0.10 | 0.32 | 0.05 | 10 |
| **Wallenpaupack Creek (204010305)** | 0.00 | 0.19 | 0.00 | 0.81 | 0.00 | 0.00 | 0.00 | 3 |
| **West Branch Pine Creek (205020501)** | 0.08 | 0.12 | 0.03 | 0.34 | 0.03 | 0.29 | 0.11 | 12 |
| **Young Womans Creek (205020303)** | 0.03 | 0.04 | 0.00 | 0.27 | 0.11 | 0.41 | 0.13 | 9 |

*Species from the genus *Sorex* include Masked Shrew (*Sorex cinereus*), Big-tailed Shrew (*S. dispar*), Maryland Shrew (*S. fontinalis*), Smoky Shrew (*S. fumeus*), Pygmy Shrew (*S. hoyi*), and American Water Shrew (*S. palustris*).

**Species from the family Sciuridae include Eastern Chipmunk (*Tamias striatus*), American Red Squirrel (*Tamiasciurus hudsonicus*), and Southern Flying Squirrel (*Glaucomys volans*).

†Species from the genus *Peromyscus* include White-footed Mouse (*Peromyscus leucopus*) and Deer Mouse (*P. maniculatus*).

††All other small mammals include Star-nosed Mole (*Condylura cristata*), Rock Vole (*Microtus chrotorrhinus*), Meadow Vole (*M. pennsylvanicus*), Woodland Vole (*M. pinetorum*), Southern Bog Lemming (*Synaptomys cooperi*), and Meadow Jumping Mouse (*Zapus hudsonicus*).

**Appendix E**

Overlap of select Species of Greatest Conservation Need in select Hydrologic Unit Code 10 (HUC10) watersheds having high suitability for modeled American Marten habitat.

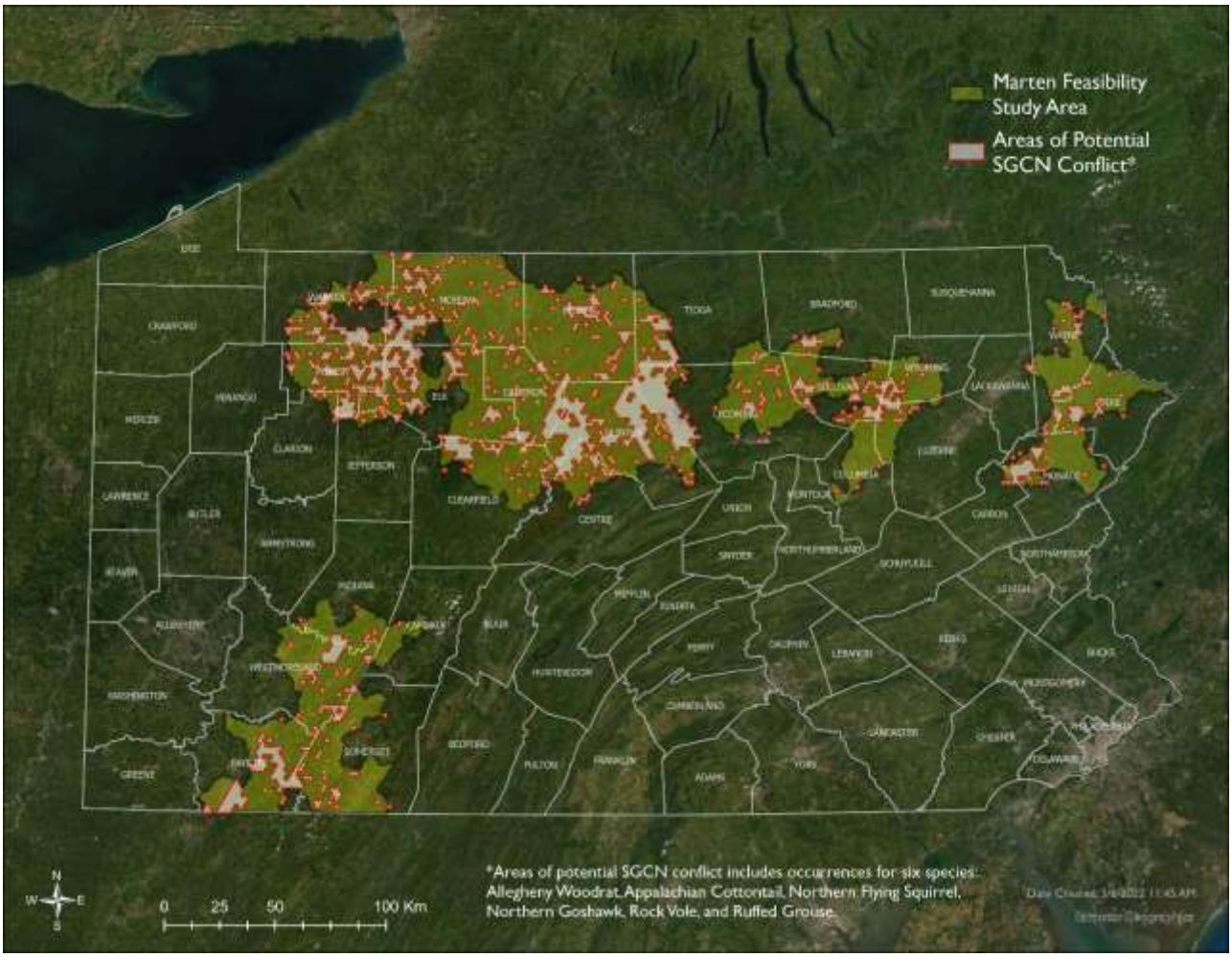


**Figure E1.** Overlap of select Species of Greatest Conservation Need from select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania having high-suitability modeled habitat for American Marten.

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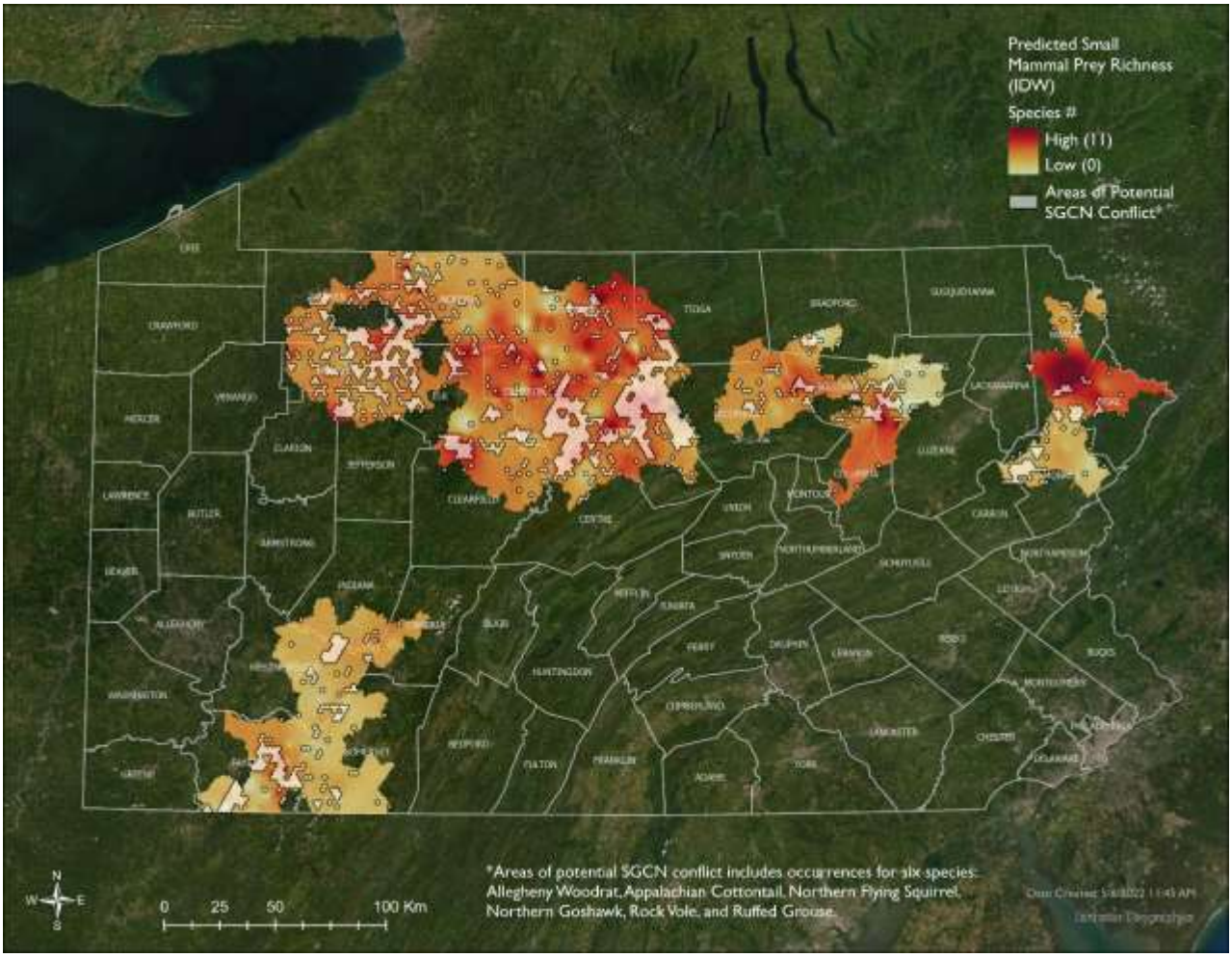


**Figure E2.** Overlap of select Species of Greatest Conservation Need from select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania having high-suitability modeled habitat for American Marten and the predicted small mammal richness analyzed from 387 terrestrial small mammal surveys conducted between 1984-2018.

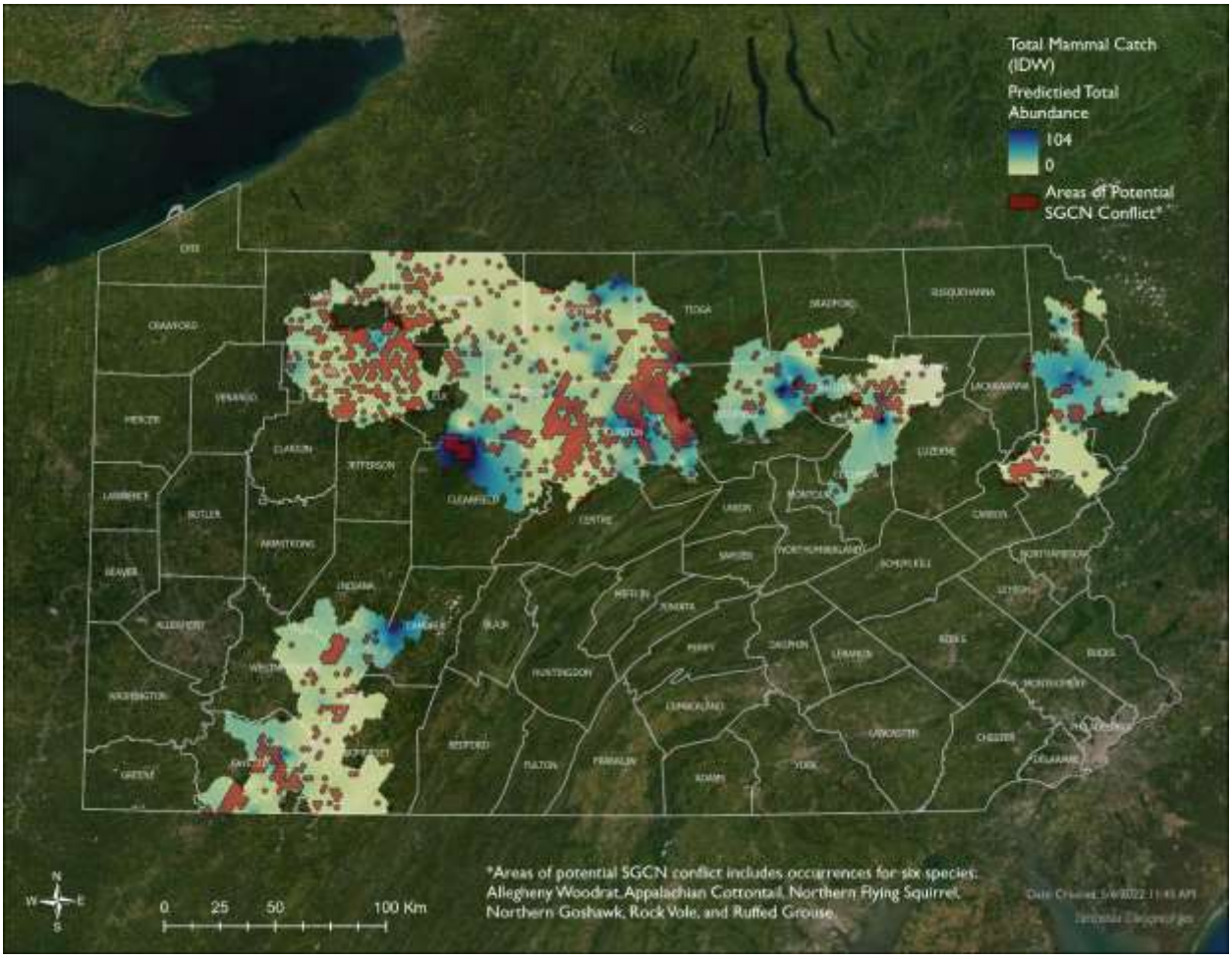


**Figure E2.** Overlap of select Species of Greatest Conservation Need from select Hydrologic Unit Code 10 (HUC10) watersheds in Pennsylvania having high-suitability modeled habitat for American Marten and the total catch from 387 terrestrial small mammal surveys conducted between 1984-2018.