Assessing the Potential Utility of Select State-owned Lands for Vertebrate Conservation

by

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Abstract

With limited resources available for conservation, it is imperative that efficient state conservation plans be developed to protect species of greatest conservation need (GCN species). Through the Inventory and Conservation Planning (ICP) project, the Alabama Department of Conservation and Natural Resources and the Alabama Cooperative Fish and Wildlife Research Unit have collected data on GCN species and habitat on select state-owned lands. Using this information, we proposed development of decision support tools that will provide a spatial depiction of the most useful areas for conservation of each vertebrate GCN species and a relative conservation utility of each study area for the conservation of GCN species. We first determined which species occurred on ICP lands and where it would be ecologically appropriate to manage for them. Alabama GAP Analysis Project (AL-GAP) data were used to identify potential habitat in the Southeastern Plains ecoregion of Alabama. We then identified those areas where appropriate management actions for these species are feasible. Finally, we used the availability and arrangement of resources on the landscape to determine the relative utility of each property for each species. Each of these objectives was incorporated into a geographic information system which was analyzed using kernel density estimation to generate estimates of potential conservation utility. Through this research, we intend to provide land managers and conservation decision makers with additional information to augment field data and other resources used to make conservation decisions.

Acknowledgments

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Introduction:

The state of Alabama has one of the highest species diversity rankings in the continental United States (Stein 2002). However, Alabama also ranks second in the nation in species extinctions and fourth in the nation in the percentage of species facing extinction (Stein 2002). With limited resources available for conservation, it is imperative that efficient state conservation plans be developed to protect species of greatest conservation need (GCN species). The state of Alabama owns and manages 109,668 hectares of protected land, 89% of which is managed by the Alabama Department of Conservation and Natural Resources (Silvano *et al.* 2008). Furthermore, per capita conservation and management funding by the state is less than would be expected based on the state's natural resources as well as demographic and political characteristics (Adelaja *et al.* 2007). However, Adelaja et al. (2007) do not provide the exact values resulting from their analysis. The Alabama Department of Conservation and Natural Resources (ADCNR) hopes to address some of these concerns through the Inventory and Conservation Planning (ICP) project which will result in the production of inventories of GCN species on select state lands as well as conservation plans for these sites (ADCNR 2010).

Successful conservation strategies necessitate broad scale questions often asked by the landscape ecologist (Gutzwiller 2002). However, these questions are inherently complex as landscape ecology is a discipline focused on heterogeneity in both time and space (Turner *et al.* 2001). This spatial heterogeneity is often dealt with in terms of patches, which Forman and Godron (1981) defined as “communities or species assemblages surrounded by a matrix with a dissimilar community structure or composition.” Patch characteristics like size, shape, connectivity and arrangement are therefore some of the metrics of spatial heterogeneity. Not surprisingly, these characteristics are also important to the process of conservation (Shafer 1997). Patch size is obviously an important characteristic to conservation of biodiversity as larger patches typically harbor more species diversity (Schoener 1976). However, characteristics like patch arrangement (Murphy *et al.* 1990) and patch quality (Moilanen and Hanski 1998) may supersede patch size when conserving specific species because of differing species’ needs. Connectivity is another well studied landscape metric pertinent to conservation, as connectivity is typically correlated with population persistence (Fahrig and Merriam 1985).

Aside from spatial heterogeneity, landscape ecology is also characterized by a concern with scale (Turner *et al.* 2001). Many have noted effects of differing temporal and spatial scales on analyses of spatial heterogeneity (Turner *et al.* 1989, Benson and MacKenzie 1995), and processes or features observed at one scale may not translate to another scale. The same phenomenon has been observed in organismal studies as well (Holland *et al.* 2004, Thogmartin and Knutson 2007), and it is therefore critical to determine the appropriate scale at which conservation strategies must be implemented.

Geographic information systems (GIS) have become a commonly used tool in the field of conservation (Santos *et al.* 2006, Friedlander *et al.* 2007, Brito *et al.* 2009, *etc.*), as they are particularly helpful in addressing the broad scale issues facing conservationists and natural resource managers. We wanted to consider the conservation utility of patches according to the following four characteristics: site suitability, potential habitat, management potential and landscape context.

First we wanted to examine site suitability, which we defined as sites where it would be ecologically appropriate to manage for a certain species. Ecological appropriateness was determined by species range as well as abiotic factors such as soil suitability. We hypothesized that it was important to distinguish suitable sites from unsuitable sites for a number of reasons. First, establishment of habitat on unsuitable sites could lead to range expansions of native flora and fauna, a first step in becoming an unwanted invader (Tolley *et al.* 2008, Campos-Krauer and Wisely 2010). Additionally, introduction and management of a species outside its historic range can compromise genetic integrity of species when a closely related species or subspecies occurs within the area of this range expansion (Storfer 1999, Delibes-Mateos *et al.* 2008). Finally, debate continues over the use of assisted migration as a possible solution to conservation problems posed by climate change (McLachlan *et al.* 2007, Ricciardi and Simberloff 2009, Minteer and Collins 2010), but translocation outside historic home range has been linked with decreased translocation success in reptiles and amphibians (Germano and Bishop 2008) as well as birds and mammals (Wolf *et al.* 1996). For these reasons, we hypothesized that conservation utility would be maximized in areas within the range of target species as they would avoid the costly mitigation actions associated with these pitfalls.

The next characteristic which we felt needed to be identified was potential habitat, which we defined as the biotic conditions of a site. Though potential habitat may not have been occupied by target species, it represented a management opportunity because of its potential contribution to cost minimization. Westphal and Possingham (2003) noted the maximization of conservation value of a given area was dependent upon the cost of restoration of particular sites within that area. If seeking to maximize the conservation utility of our conservation lands, we should obviously attempt to minimize our management costs. In identifying biotic conditions on a site, we hoped to introduce an element of cost minimization into our decision support tools. Though not traditionally within the scope of conservation research, many researchers have recently recognized the importance of minimizing costs and maximizing conservation utility obtained from these expenses in light of the limited resources available for conservation (Murdoch *et al.* 2007, Goldstein *et al.* 2008).

Management potential was defined as the economic, social, and political feasibility of management actions requisite for the persistence of a certain species. For example, many species of longleaf pine ecosystems depend on frequent fires for maintenance of their preferred habitat type (Brennan *et al.* 1998, Russell *et al.* 1999). However, sites in close proximity to urban areas or with high road densities may not be burned for safety reasons and would therefore have poor management potential for a species like Bachman’s sparrow, which requires frequent fire (Tucker *et al.* 2004). The association between longleaf pine ecosystems and fire is a particularly appropriate example for discussing management potential, as research indicates that restoration of longleaf pine forests requires the use of fire (Outcalt and Brockway 2010). Though fire surrogates such as disking and herbicide treatment may be used to create and maintain some habitat characteristics similar to those of a burned stand (Harrington and Edwards 1999, Freeman and Jose 2009), the life cycles of some species found in this endangered ecosystem require the use of fire (Norden and Kirkman 2004). Another example of a landscape feature that might determine management potential would be topography, which can also influence management options available for use on a site. For example, if a site is characterized by steep slopes, it may not be feasible to conduct some management practices like forest thinning or extensive clearing. These sites would therefore have poor management potential for a species like the eastern kingsnake which prefers open habitat (Means 2004).

As previously discussed, successful conservation strategies must consider broad scale problems. It was therefore imperative that we consider the landscape context of our study sites. It is important to note that pertinent landscape features varied depending upon the species selected, and context analysis was therefore dependent upon the species. In general, patches of potential habitat within the state represented one of three possibilities: the same as the majority of the habitat in the region (i.e. matrix), an isolated patch, or a patch integrated into a habitat mosaic.

The final stage of our analysis was determination of the relative utility for conservation of a given species. To accomplish this, we developed species' models that equated utility to resource concentration. When developing these models, there were both limiting factors and compensatory factors. Limiting factors were prohibitive in that their absence resulted in the exclusion of a particular species from a given area. Site suitability and management potential, in most cases, were considered limiting factors in the proposed models as their absence would result in unsuccessful management of a given species. Compensatory factors were not prohibitive and high values in one can compensate for low values in another. Potential habitat and landscape context, in most cases, were considered compensatory factors in our models. By combining these factors using kernel density estimation (Silverman 1986), we developed our estimates of relative conservation utility.

Our objective was to determine the conservation utility for each vertebrate, terrestrial GCN species occurring in the Southeastern Plains ecoregion (Griffith *et al.* 2001, see figure 1.1) of Alabama through the development of predictive models incorporating landscape scale parameters.

Methods:

We derived the model parameters for our analysis from numerous sources including expert opinion, available literature and land cover data. Several of these parameters were generated during the Alabama Gap Analysis Project (AL-GAP). Land cover data and information on study area boundaries were obtained from AL-GAP. Range information for each species was also generated through expert opinion during the AL-GAP and was used in this analysis to inform our models on the suitability of a site. The range data for one species, the American black bear (*Ursus americanus*), was generated in an ad hoc manner because the AL-GAP information was unsatisfactory for our purposes. AL-GAP range maps for black bear indicated the current distribution is mostly concentrated in the southwest portion of the state. Considering the historic distribution of the species (see figure 1.2), we felt it would be ecologically appropriate to manage for the species anywhere in the state. Habitat models were also generated for each species known to breed in Alabama during the AL-GAP, and these models were used as indicators of potential habitat. Other sources were used for development of additional data parameters. The soil survey geographic (SSURGO) database was used to generate all soil parameters, and a landform layer generated by Southeast Gap Analysis Project (McKerrow *et al*. Forthcoming) was used to determine additional site suitability characteristics. Wetland parameters were derived from National Wetland Index data.

Many species of concern in the Southeastern Plains ecoregion of Alabama are associated with sandy soils because they engage in fossorial behaviors (Mirarchi *et al.* 2004). To predict potential species use, we needed to incorporate soil data into our modeling. SSURGO data were used to obtain information on the suitability of a site by distinguishing appropriate soils for each species. We initially wanted to use soil texture, which we thought would be a very quantifiable feature, as our indicator of suitability. However, soil analyses for gopher tortoises (*Gopherus polyphemus*) have traditionally been conducted using soil series instead of texture values (McDearman 2005), and we were encouraged by scientists in the field to approach our analysis in the same way (Guyer Pers. Comm.). The United States Fish and Wildlife Service has developed a three-tiered ranking system for soil series that is used to assess habitat for gopher tortoise projects (McDearman 2005). This system ranks soil types as priority, suitable or marginal based on expert opinion of the quality of habitat provided by a certain soil type considering its texture, composition, depth, permeability and drainage (McDearman 2005). We augmented this system by incorporating information from Herman *et al.*

(2002) and a classification conducted by Val Johnson, Craig Guyer and Sharon Hermann (Guyer Pers. Comm.; see Table 1.1 for full list of soils and rankings). Since many fossorial species of concern are often associated with gopher tortoise burrows (Landers and Speake 1980), we assumed that appropriate soils for gopher tortoises were appropriate for associated species such as Eastern indigo snake (*Drymarchon couperi*), gopher frog (*Rana capito*), *etc.* as well. We ranked each soil group as priority, suitable or marginal based on the previously described ranking system. The resulting data layer was submitted to two experts for review, and the ranking of one region was changed to reflect their knowledge of gopher tortoise presence.

Several of the species we modeled also have particular landform requirements. For example, some species make burrows underground and therefore are unlikely to use areas that flood regularly. Other species are typically found in wetlands; therefore it was important that we differentiate between such features on the landscape. As previously discussed, we used a landform layer generated by the SE-GAP to obtain data on the location of particular landform parameters. This layer had 16 classifications ranging from steep slopes to moist flats and open water. We used these classifications to generate information representing bottomlands and uplands by demarcating the boundary between moist and dry flats. We then used these parameters to predict site suitability for a given species.

We also felt that many habitat models for these species would benefit from a parameter incorporating patch size requirements (see Appendix B). For those species for which we could find explicit information on patch size requirements, we incorporated another parameter in the model to display these data. The potential habitat layers for these species were analyzed in ArcMap® (ESRI, Inc., use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement) using the Region Group tool to determine the contiguous patch size of potential habitats. Any patch below the minimum patch requirement was excluded for this parameter, resulting in a layer that we hypothesized would identify potential source populations and potential reintroduction sites.

In general, the following process was performed to create parameters usable in this analysis. First, all layers were rasterized and processed to have a cell size of 30 meters by 30 meters. Layers were subsequently clipped to the ecoregion of interest (Southeastern Plains) in Alabama (Griffith *et al*. 2001). We then converted these layers to ASCII so they could be read as matrices in MATLAB (Mathworks, Inc. ®, does not imply endorsement). Within MATLAB, we created models based on literature review intended to generate utility maps based on species' habitat needs (see Appendix A). This information was acquired from literature review and expert opinion. We then used MATLAB to perform kernel density estimation for the models we created by layering our ASCII files over one another (Bearday and Baxter 1996). The outputs from these analyses were in a text format which was read back into ArcGIS to create maps of relative conservation utility.

Results:

Since many species models incorporated the same parameters, many of the species associated with certain habitat characteristics displayed similar trends. For this reason, we will discuss species in groups based on habitat associations. All of the maps resulting from our analysis are available in Figures 1.4 – 1.36. The first group we will discuss are sandy soil specialists. As previously noted several of the GCN species in this analysis are fossorial during at least one phase of their lives and are therefore dependent on friable soils. This group included the following species: black pine snake (*Pituophis melanoleucus lodingi*), Eastern coral snake (*Micrurus fulvius*), Eastern diamondback rattlesnake (*Crotalus adamanteus*), Eastern indigo snake (*Drymarchon couperi*), flatwoods salamander (*Ambystoma cingulatum*), Florida pine snake (*Pituophis melanoleucus mugitus*), gopher frog (*Rana capito*), gopher tortoise (*Gopherus polyphemus*), Southeastern pocket gopher (*Geomys pinetis*) and Southern hognose snake (*Heterodon simus*). In our models, this group was highly influenced by the soil classification parameter. Priority soils were concentrated predominantly in the southern and southeastern portion of the Southeastern Plains, and conservation utility was as well. Many of these species' current ranges within Alabama were confined to thin slivers on the southern border with Florida; however, several species' models displayed high relative values in areas outside these ranges. In addition, most of these species had high conservation utility north of the Blackland Prairies (Griffith *et al*. 2001, see Figure 1.1), areas traditionally outside of the range of all of these species in the most generous historical range maps. Many of these species' models displayed high conservation utility in the large public land holdings of the southern portion of the state, particularly Conecuh National Forest, Fort Rucker and Barbour County Wildlife Management Area. One notable exception was the black pine snake model, which displayed areas of high conservation utility on private lands west of the Tombigbee River. Floodplains of major rivers were the areas of lowest conservation utility for most of these species.

Species associated with hardwood forests were another prominent group from our analysis that displayed similar results. These species included: Kentucky warbler (*Oporonis formosus*), Swainson's warbler (*Limnothlypis swainsonii*), wood thrush (*Hylocichla mustelina*) and worm-eating warbler (*Helmitheros vermivorus*). The models for these species identified bottomland areas in the southern part of the state as high utility areas. In addition to these bottomlands, larger areas of the Fall Line Hills region (Griffith *et al*. 2001, see Figure 1.1) of the Southeastern Plains were also given relatively high values. However, one species (Swainson's warbler) did not have higher utility in the Fall Line. All of these species' peak utility values were found at the confluence of the Alabama and Tombigbee Rivers in bottomland hardwoods of the Mobile Delta. Lowest utilities for all of these species were found in upland areas of the southern portion of the state.

Riverine and floodplain species were another group that displayed similar patterns of high conservation utility. As expected, high utilities for these species were centered on areas with many rivers and large bottomland areas. These species included: alligator snapping turtle (*Macrochelys temminckii*), least bittern (*Ixobrychus exilis*), long-tailed weasel (*Mustela frenata*), river frog (*Rana heckscheri*) and rainbow snake (*Farancia erytrogramma erytrogramma*). The long-tailed weasel and river frog models both display higher utility outside of floodplains. As with the species associated with hardwood forests, most of these species' models highest values were found around the confluence of the Alabama and Tombigbee Rivers, though some also displayed high conservation utility in an area of the Alabama River floodplain directly west of Montgomery. Low values were generally found in upland areas, particularly in the southern part of the state, though some (like the rainbow snake model) displayed low utility in upland habitats across the entire state.

Two other catchall groups can also be discussed though they do not portray similar conservation utility patterns. The first group, upland generalists, includes species such as the American black bear, American kestrel (*Falco sparverius*), eastern kingsnake (*Lampropeltis getula getula*), eastern spotted skunk (*Spilogale putorius*), southeastern five-lined skink (*Eumeces inexpectatus*) and speckled kingsnake (*Lampropeltis getula holbrooki*). These species generally had elevated conservation utilities across larger areas and were characterized by high conservation utilities on public lands. Another group would be the species dependent on longleaf pine ecosystems that are not dependent on specific soil types. Models for species such as red-cockaded woodpecker (*Picoides borealis*) and Henslow's sparrow (*Ammodramus henslowii*) had some similarities with the soil dependent group, but these models also displayed high values within the Oakmulgee Ranger District of the Talladega National Forest. However, the red-cockaded woodpecker model also displayed areas of high conservation utility outside of public lands in rural areas flanking the Mobile Delta.

Discussion:

Several of the patterns observed in our outputs were expected prior to our analysis. The highest relative utilities for the suite of species associated with sandy soils, for example, were found in the southern half of the state because the highest densities of these soils are found in that region. We also expected that conservation utility would be low for these species in floodplain areas given the flooding in these areas would not be conducive to fossorial lifestyles. However, we did not expect that areas north of the

Blackland Prairie would have such high conservation utility for these fossorial species. These northern areas fall outside of the natural range of all of the species within this group, with the possible exception of the southern hognose snake, depending on which range map is used (Jensen 2004, Silvano *et al.* 2008, etc.). These high values in the Fall Line Hills region reflect the predominantly sandy soils found in the area (Shaw *et al.* 2004). The black pine snake model also displayed a conservation utility distribution unlike others in this group. Many of the species have high values in the large public land holdings in the eastern part of the Southeastern Plains. However, black pine snake utility was highest to the west of the Tombigbee River. This difference is to be expected since the black pine snake's range is more limited than other species in this group.

Species associated with hardwood forests also displayed some expected trends. They had relatively high values in the northern part of the state because of the large area of hardwood forests there and high values in the bottomlands of the southern portion of the state because of the predominantly hardwood canopy in these bottomlands. Swainson's warbler, despite sharing many similarities with other species in this group, did not show the increased conservation utilities that were observed for other species in the northern uplands of the Southeastern Plains. This can probably be attributed to the high affinity of Swainson's warbler for floodplain forests and associated cane stands (Graves 2002, Brown *et al.* 2009). One interesting result of the patch size parameter can be observed from differences in the wood thrush, worm-eating warbler and Swainson's warbler models. All three species are found across the state and have similar habitat preferences, though Swainson's warblers are more attracted to floodplains. Despite these similarities, the utility maps for these species are different because of their different patch size requirements.

The trends we observed with the riverine and floodplain associated species were some of the most predictable. As would be expected, highest conservation utilities were concentrated around large wetlands and the confluences of major rivers. The two species' models that did display higher values outside of floodplains (long-tailed weasel and river frog) were less restrictive in their dependence on bottomlands, having considerable areas of potential habitat disassociated from floodplains. As previously mentioned, most of these species' highest values were found around the confluence of the Alabama and Tombigbee Rivers. This area undoubtedly represented the highest density of potential habitat for this species while also benefitting from an increase in utility because of some smaller public land holdings in the region.

Though the rest of the species were not easily characterized as a single group, there were several notable features of these outputs. The American black bear model displayed high utility in the Southwestern portion of the state where large patches of potential habitat in their current distribution increased conservation utility. Another of these species' models that displays high conservation utilities enhanced by our patch size parameter is the red-cockaded woodpecker. In this case, the large patches of existing habitat located in Conecuh and Talladega National Forests are quite obvious on our outputs, but other large patches are apparent flanking the Tombigbee River in the Southwestern part of the state. Two other species' models are good examples of one problem with our analysis, though they present the same problem in different ways. The eastern spotted skunk model is characterized by relatively high values across most of the state and particularly high values on public lands. In contrast, the little grass frog model displays almost exclusively low utility across most of the state with high values on public lands. Both of these utility distributions can be linked to a lack of information on habitat associations, distributions, *etc*. Whenever information on a species' habitat associations was lacking, the resulting models tended to generalize utility across the state (either high or low) and increase the value of public lands.

Despite the relatively successful application of the model, there are several areas in which we could improve. Range maps are important components of these types of analyses because without them, our models could indicate high utility for a species in an area where it would be totally inappropriate to manage for them. However, many range maps are highly contentious and some of the range maps we used do not necessarily represent a consensus. As previously mentioned in the case with the southern hognose snake, there are occasionally multiple range maps available in the literature. Since our model incorporates species range as a component of conservation utility, it is possible that more restrictive range maps may depress the value of certain lands. We also encountered problems when historic ranges differed drastically from current distributions. As previously described, we felt it was necessary for us to generate a new potential habitat layer for the American black bear model since the species historically ranged across the entire state (Laliberte and Ripple 2004). Other species, such as the Southern hognose snake, have experienced range contractions (Gibbons et al. 2000) presenting problematic questions over where it is ecologically appropriate to manage for them. These factors could contribute uncertainty to our statewide estimates by restricting or expanding the areas we deemed appropriate for management. We therefore recommend that inclusive range maps be used in future analyses such as this.

Though public conservation lands should be an important component of conservation utility, some models tended to overvalue public land. As previously noted, this typically resulted when there was little information available to inform our models on a species' habitat associations or other mappable parameters. For example, the coal skink (*Plestiodon anthracinus*), flatwoods salamander and little grass frog (*Pseudacris ocularis*) models incorporated few parameters and consequently had very little relative utility outside of the boundaries of public lands. This effect is compounded, particularly in the case of the flatwoods salamander and little grass frog, by restrictive range maps that did not allow for much potential habitat data. Alternatively, there could be situations where additional parameters become extraneous, particularly if there are redundant parameters. This situation could result in artificially elevated utility estimates in some areas while simultaneously suppressing utility estimates on public lands. For these reasons, parameters should not be thrown into these models without justification, but incorporation of several pertinent parameters should provide the most explicit indications of utility.

One final potential problem is the use of GAP data, which has come under scrutiny from several sources for its inherent assumptions and shortcomings, most of which revolve around issues of scale and assumed accuracy of data (Conroy and Noon 1996, Flather *et al.* 1997). It has also been noted that broad scale analyses often cannot account for certain fine scale features and that fine scale management resulting from broad scale analyses may sometimes be somewhat misguided (Conroy and Noon 1996, Rouget 2003). Considering the broad extent at which this analysis was conducted, it is quite possible that decisions based solely on this information could be misguided due to scaling issues. Regardless of the implications of these assumptions, at the time of this research, the satellite imagery used to develop AL-GAP data is over ten years old. Undoubtedly, many landscape features have changed since these data were generated, introducing unwanted uncertainty into our analysis.

Keeping these caveats in mind, this method presents an attempt to use available data to generate relative conservation utility estimates across a fairly broad extent. Future analyses would absolutely benefit from more current land cover data and better information on species specific habitat preferences and habitat quality indicators. However this information would require further quantitative estimates of habitat use, studies on the cost and effectiveness of management techniques and newer land cover analyses. These models appear to work best when parameters such as habitat associations and ranges are well understood and well documented.

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Figure 1.1: Level IV Ecoregions of the Southeastern Plains of Alabama, From Griffith *et al*. 2001

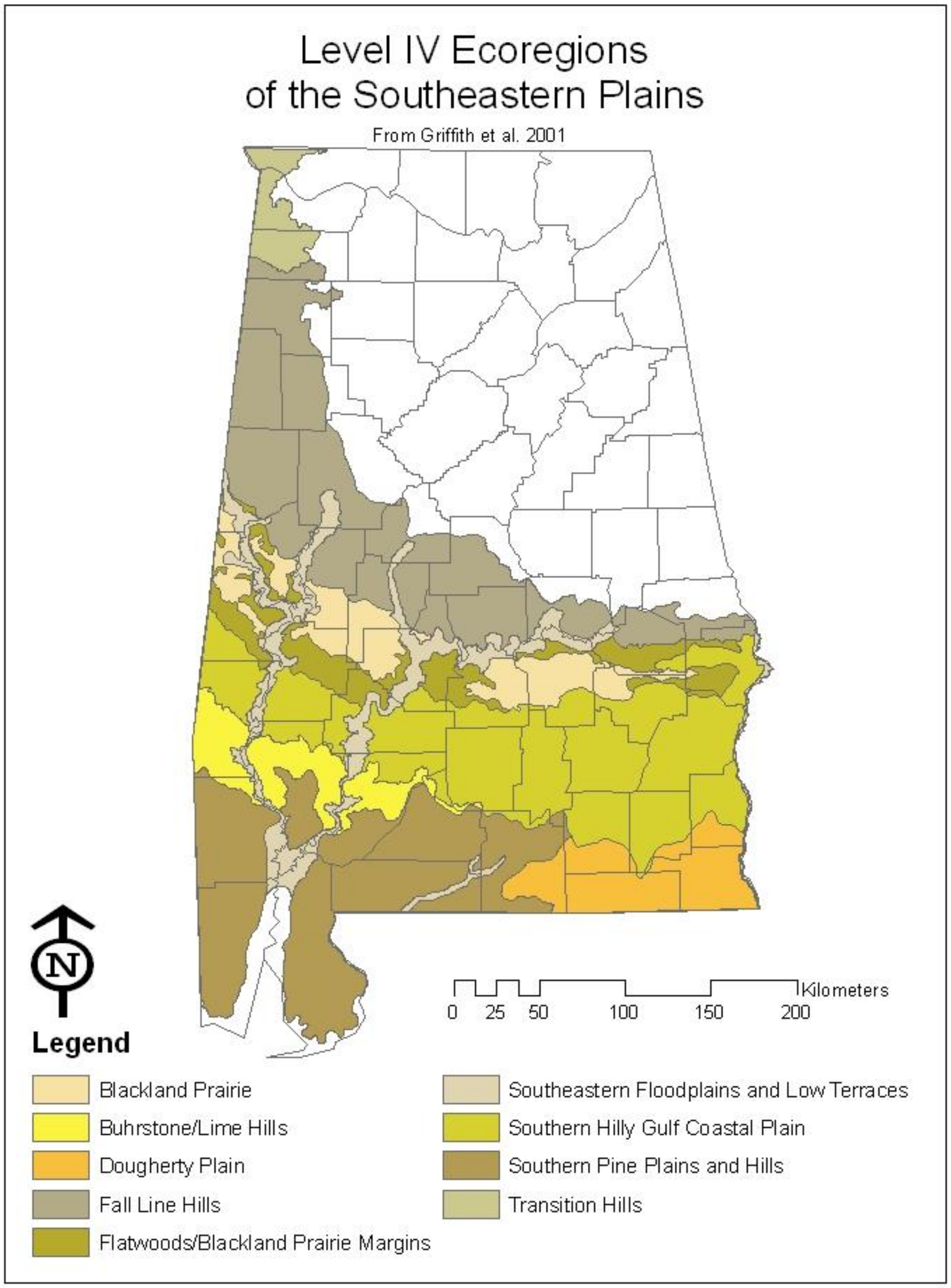


Figure 1.2: Current and historic distribution of American black bears in Alabama

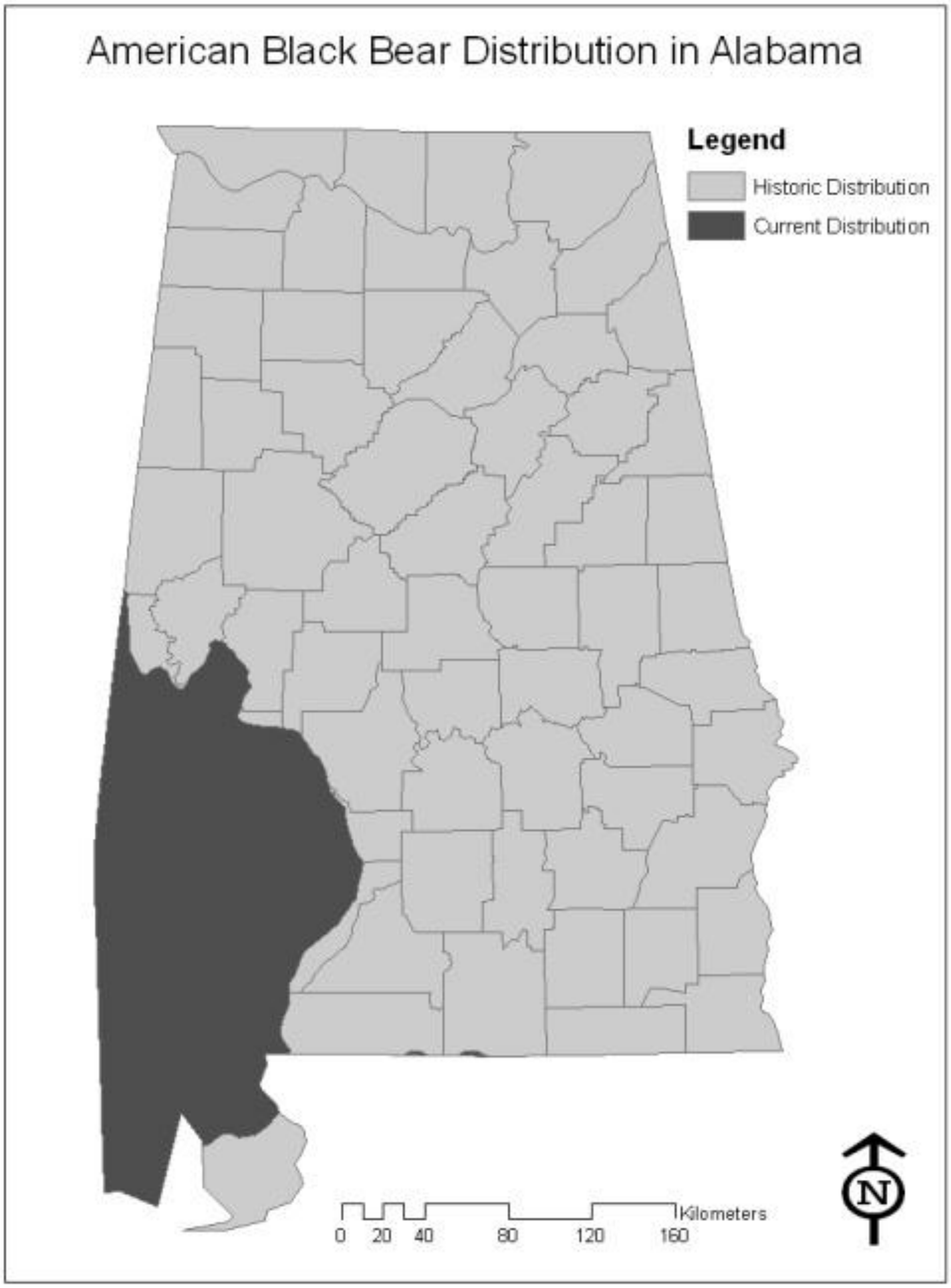


Figure 1.3: Maps of the parameters used as inputs in our models

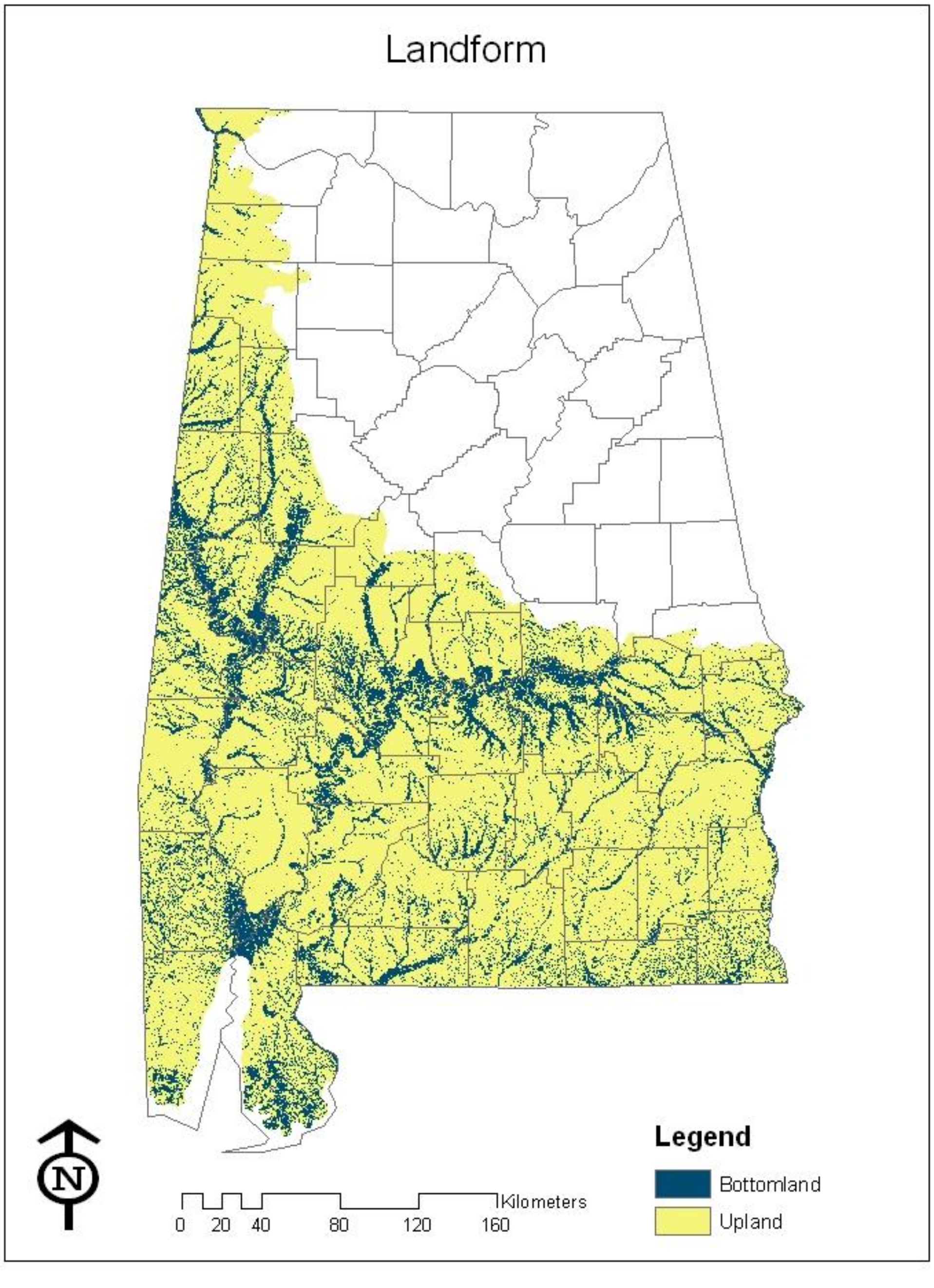


Figure 1.3: Maps of the parameters used as inputs in our models

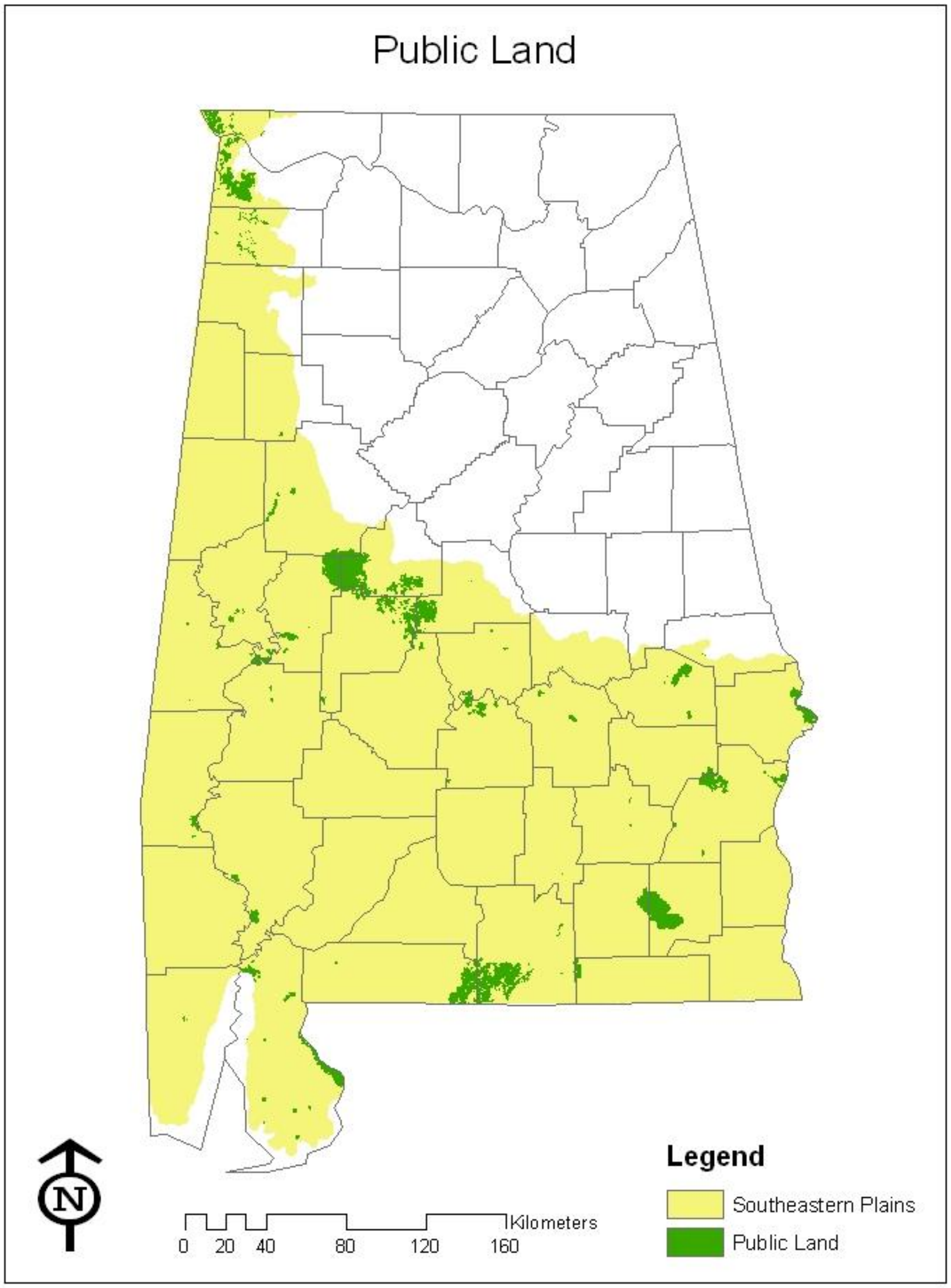
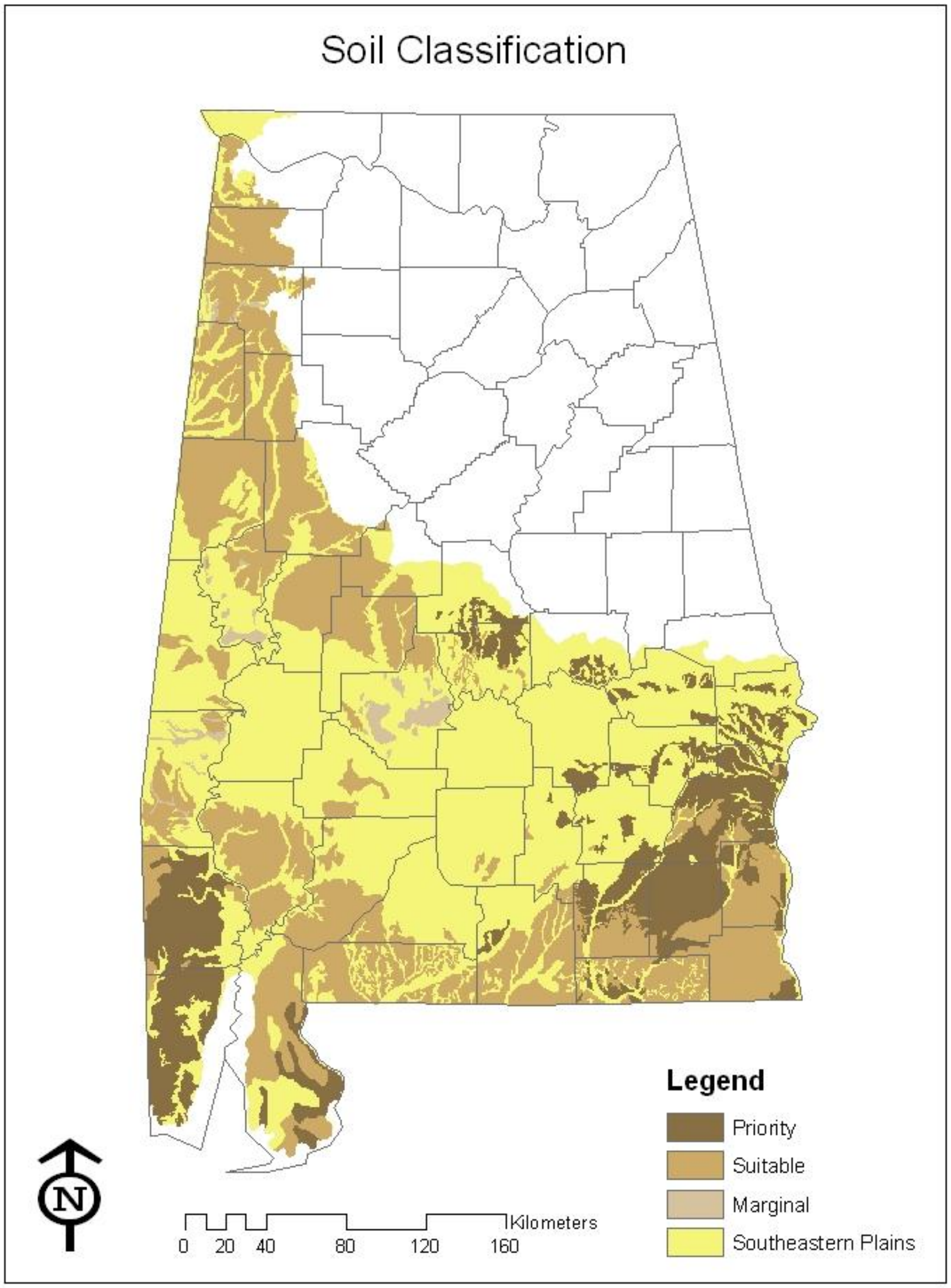


Figure 1.3: Maps of the parameters used as inputs in our models



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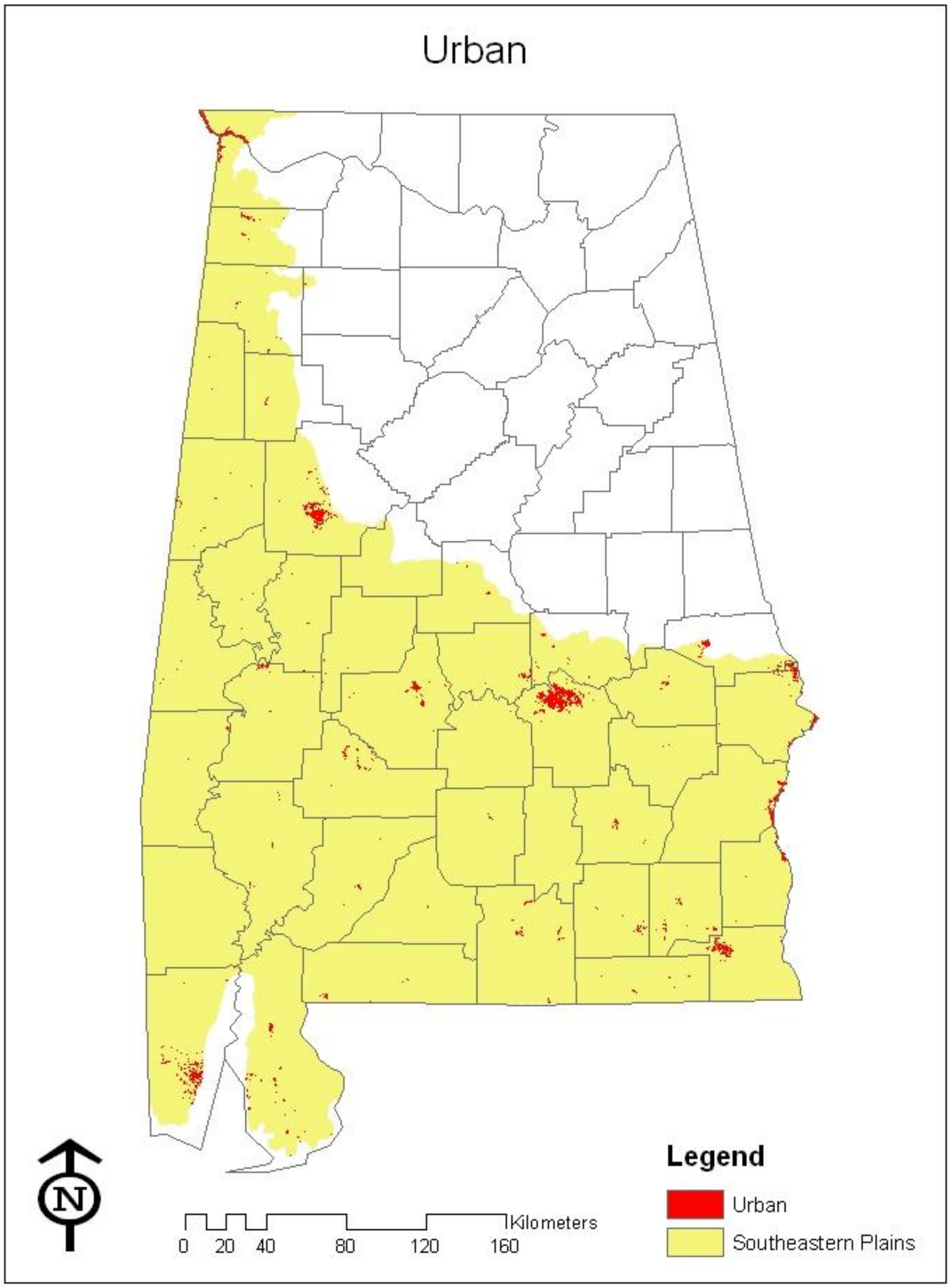

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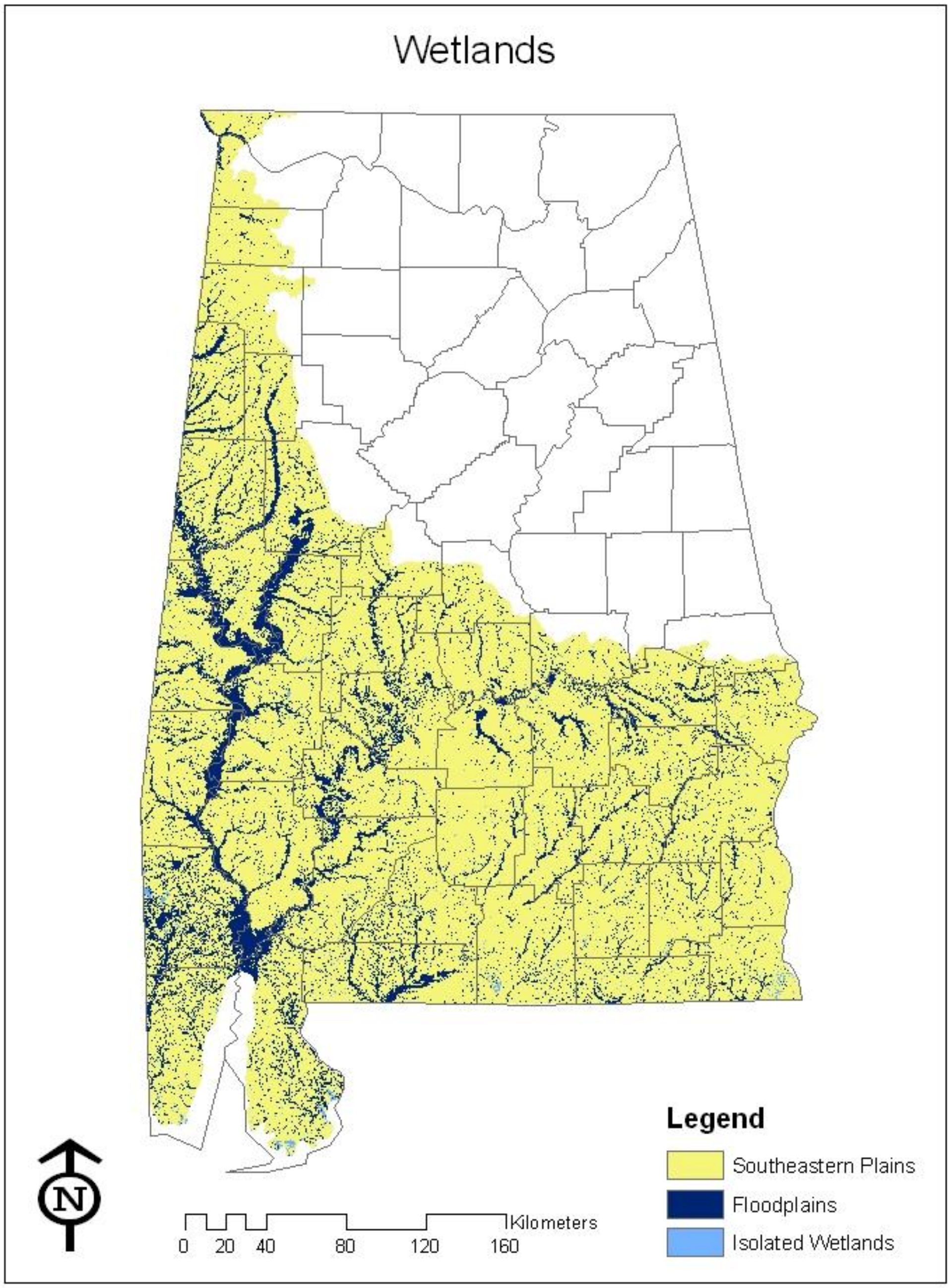

Figure 1.4: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for alligator snapping turtle. For mean value across study extent, see Table 2.1.

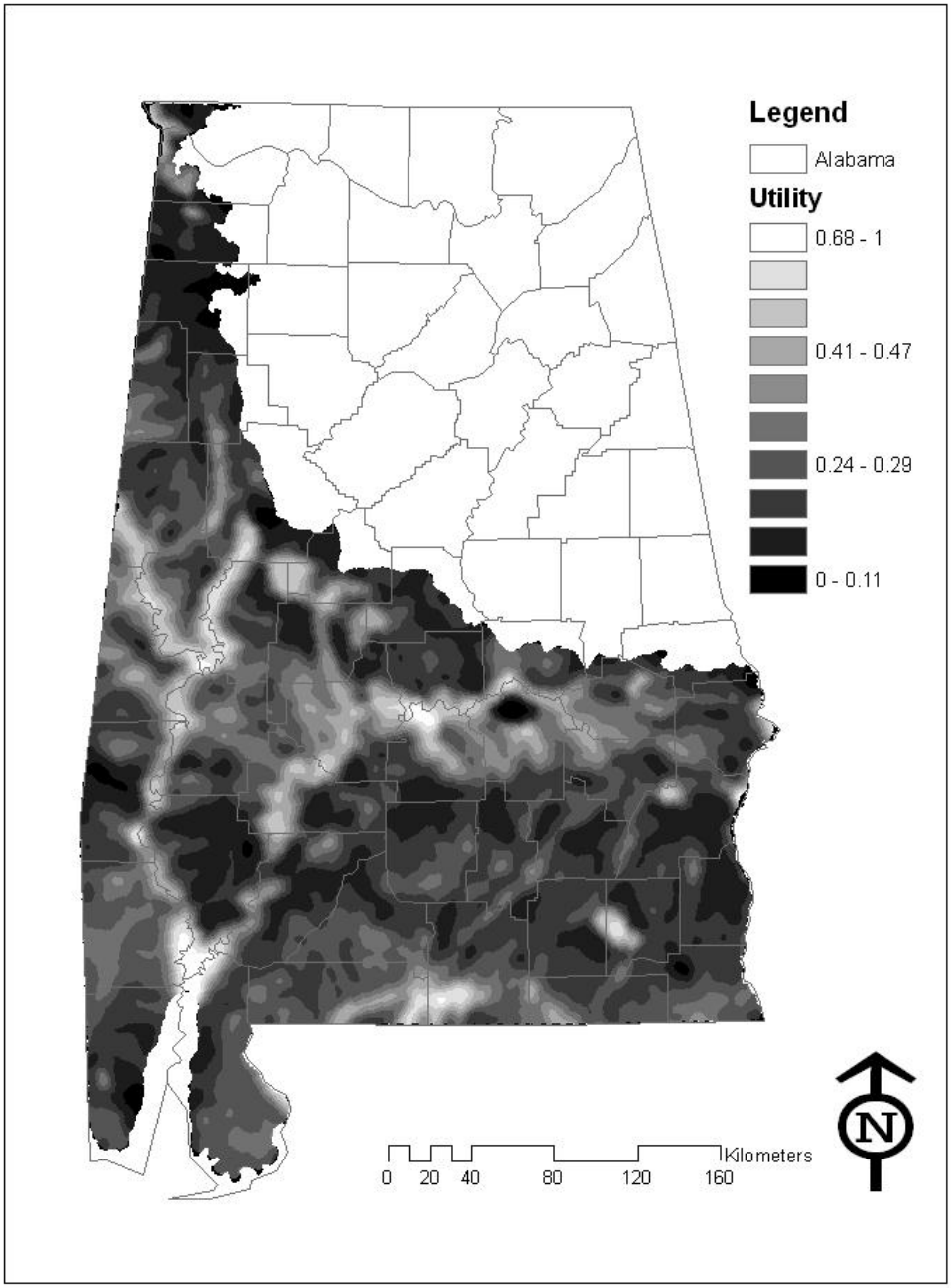

Figure 1.5: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for American black bear. For mean value across study extent, see Table 2.1.

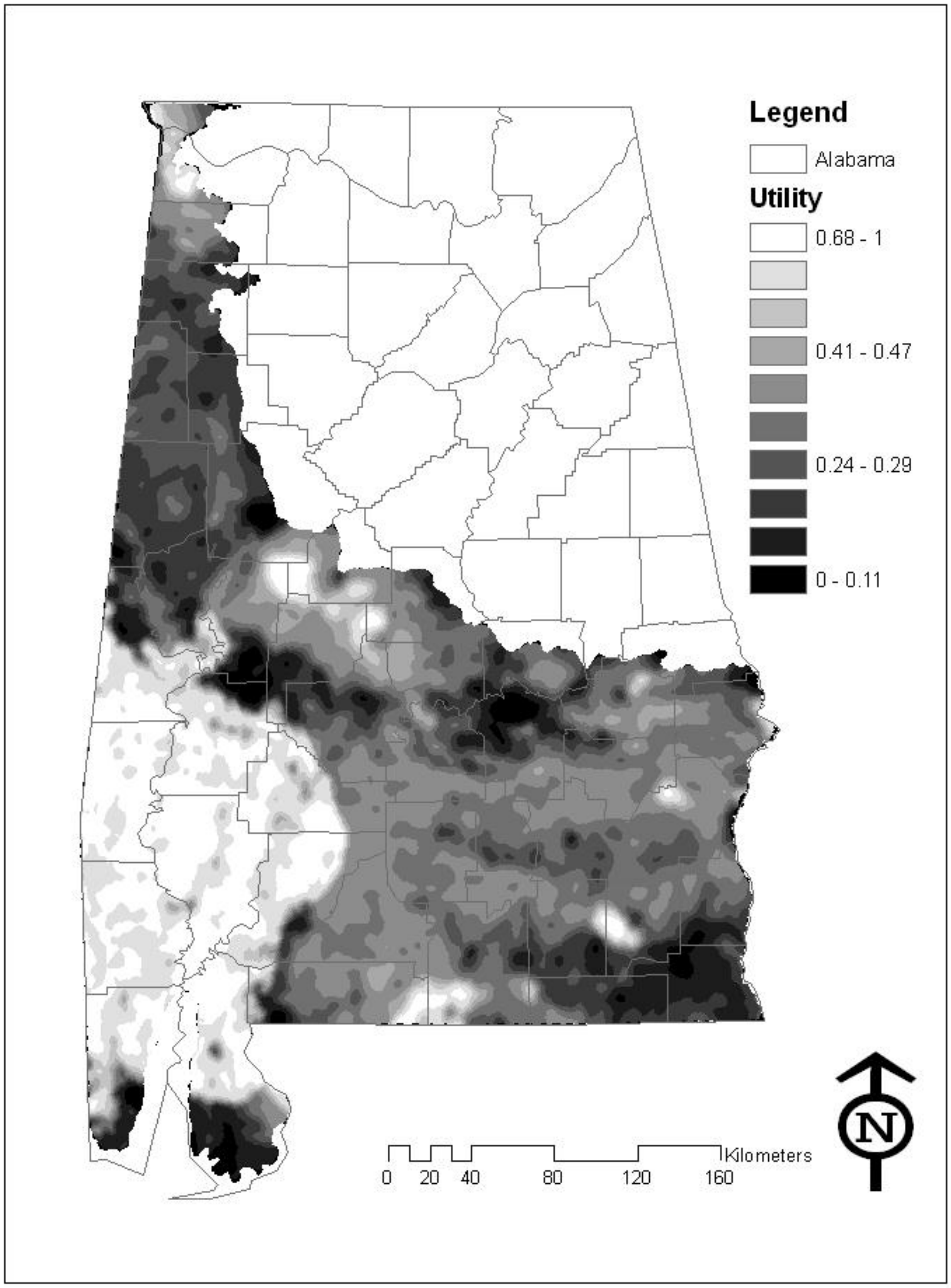

Figure 1.6: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for American kestrel. For mean value across study extent, see Table 2.1.

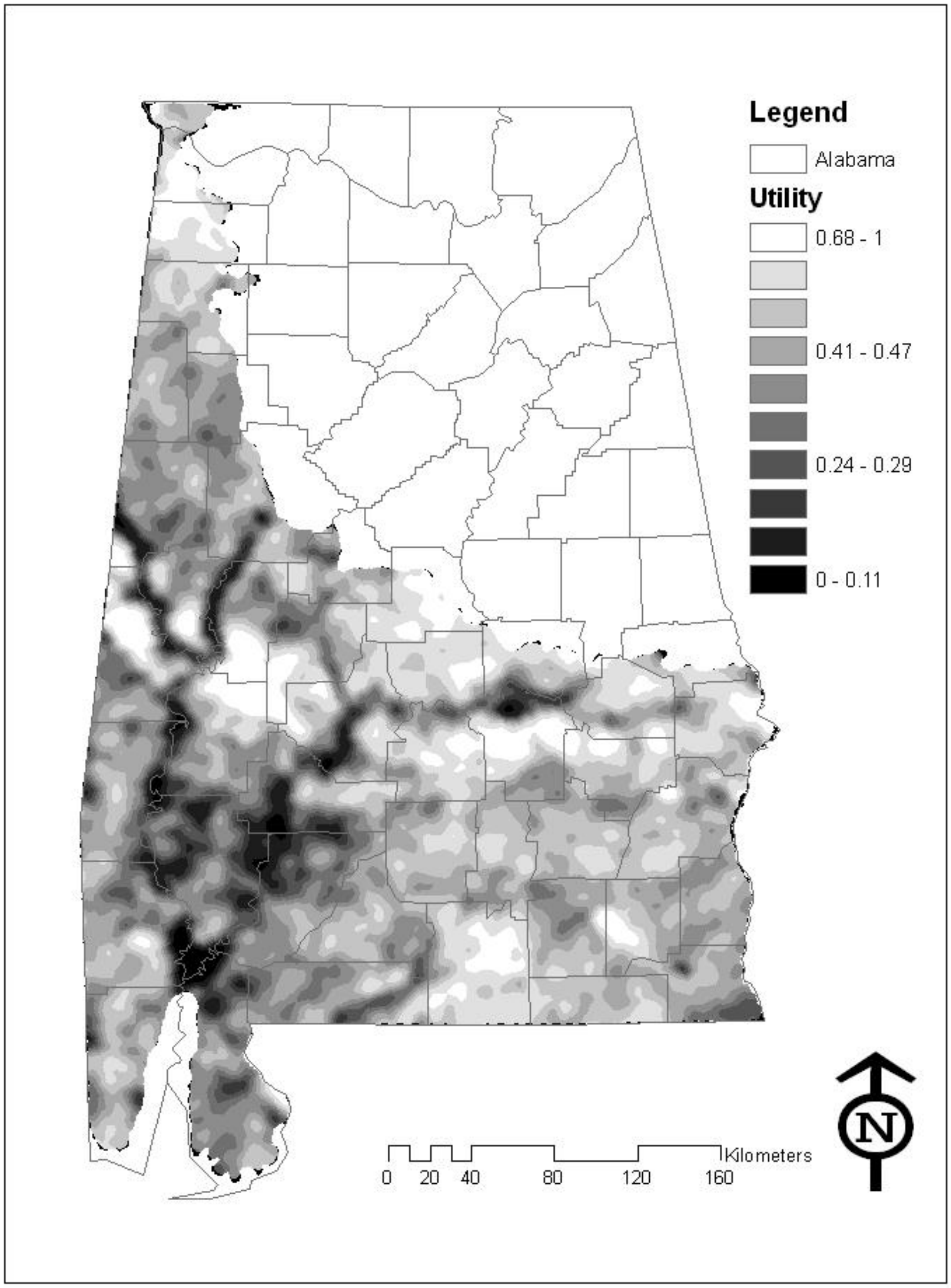

Figure 1.7: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for American woodcock. For mean value across study extent, see Table 2.1.

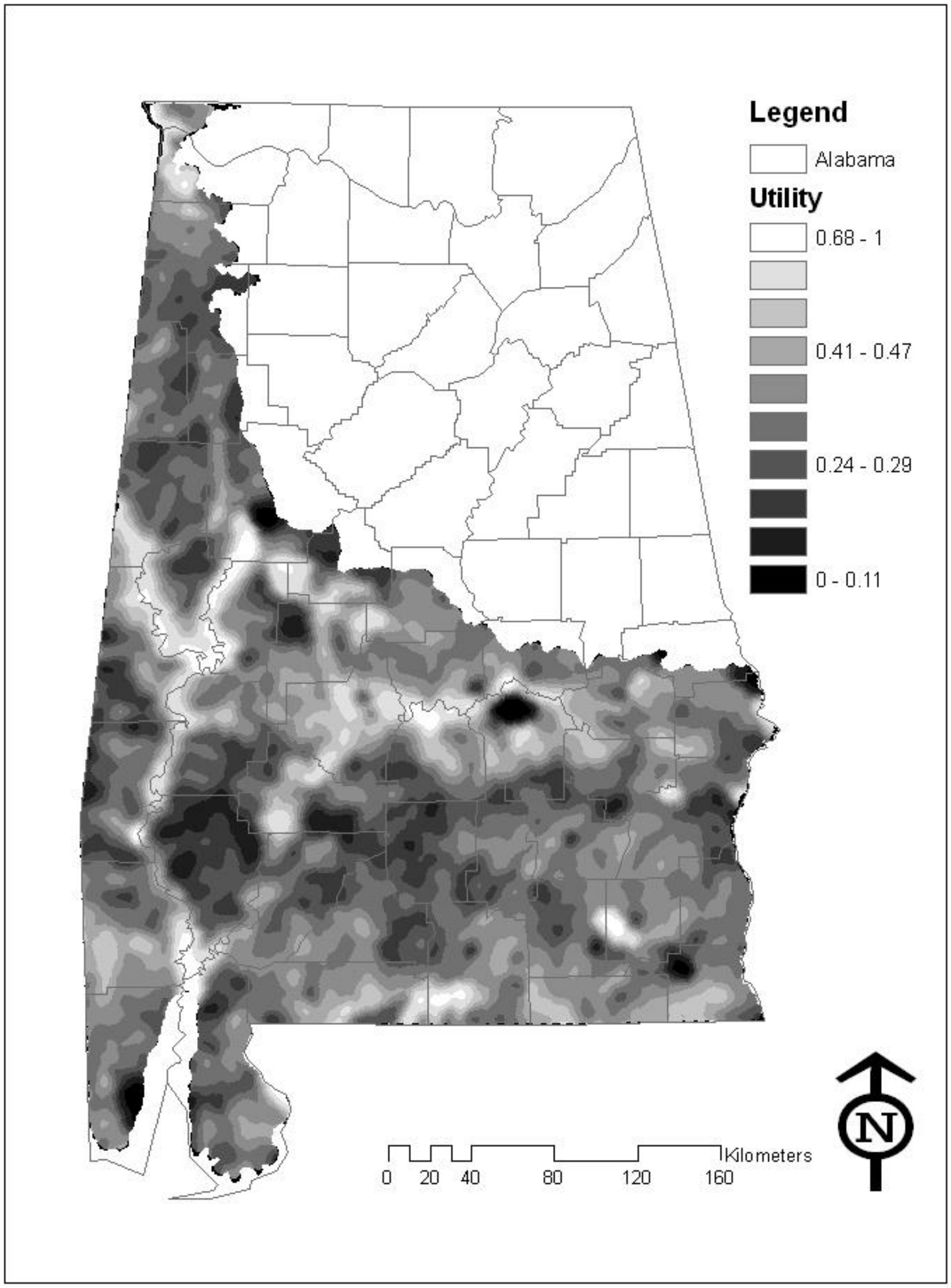

Figure 1.8: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for Bachman’s sparrow. For mean value across study extent, see Table 2.1.

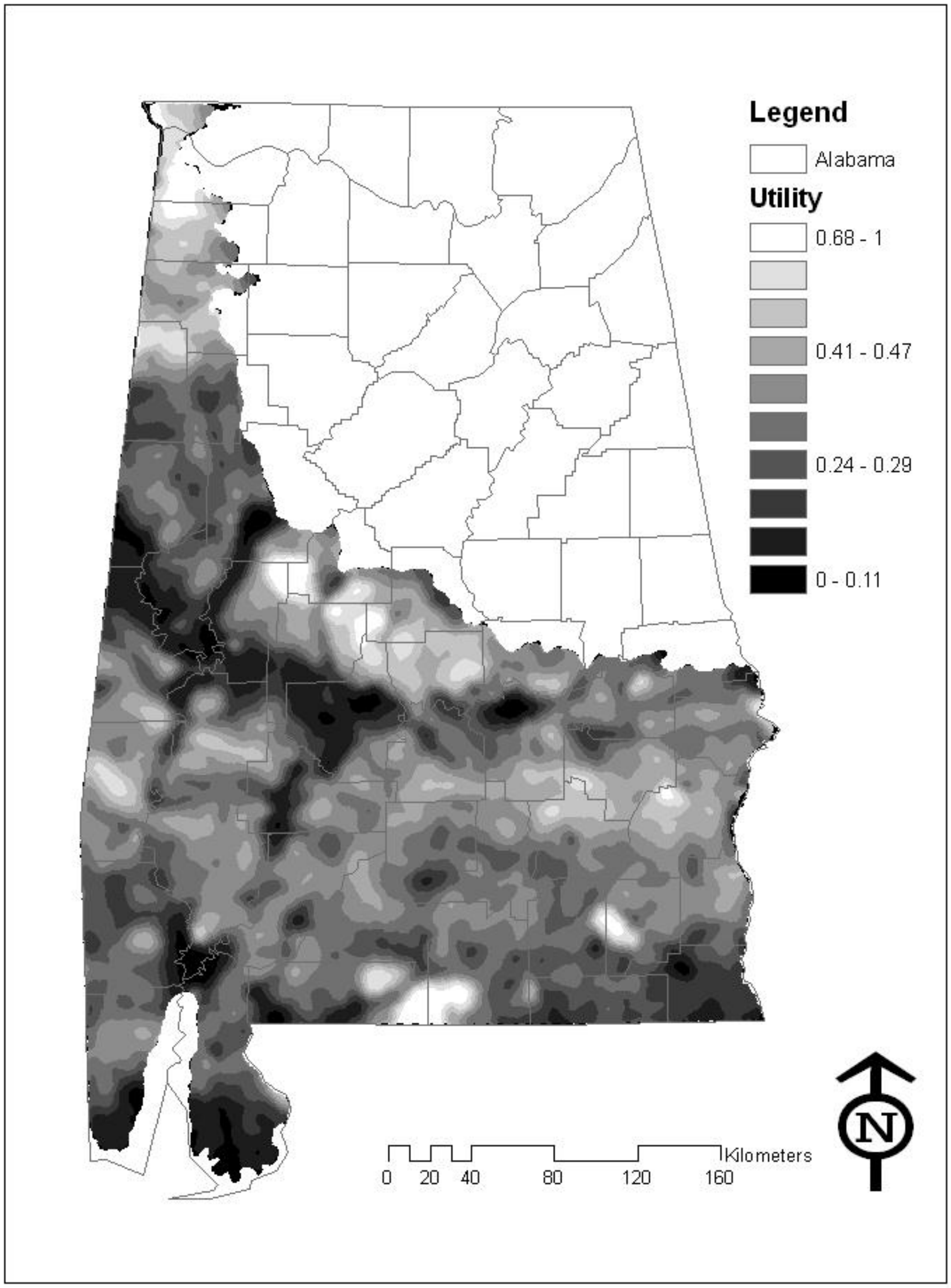

Figure 1.9: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for black pine snake. For mean value across study extent, see Table 2.1.

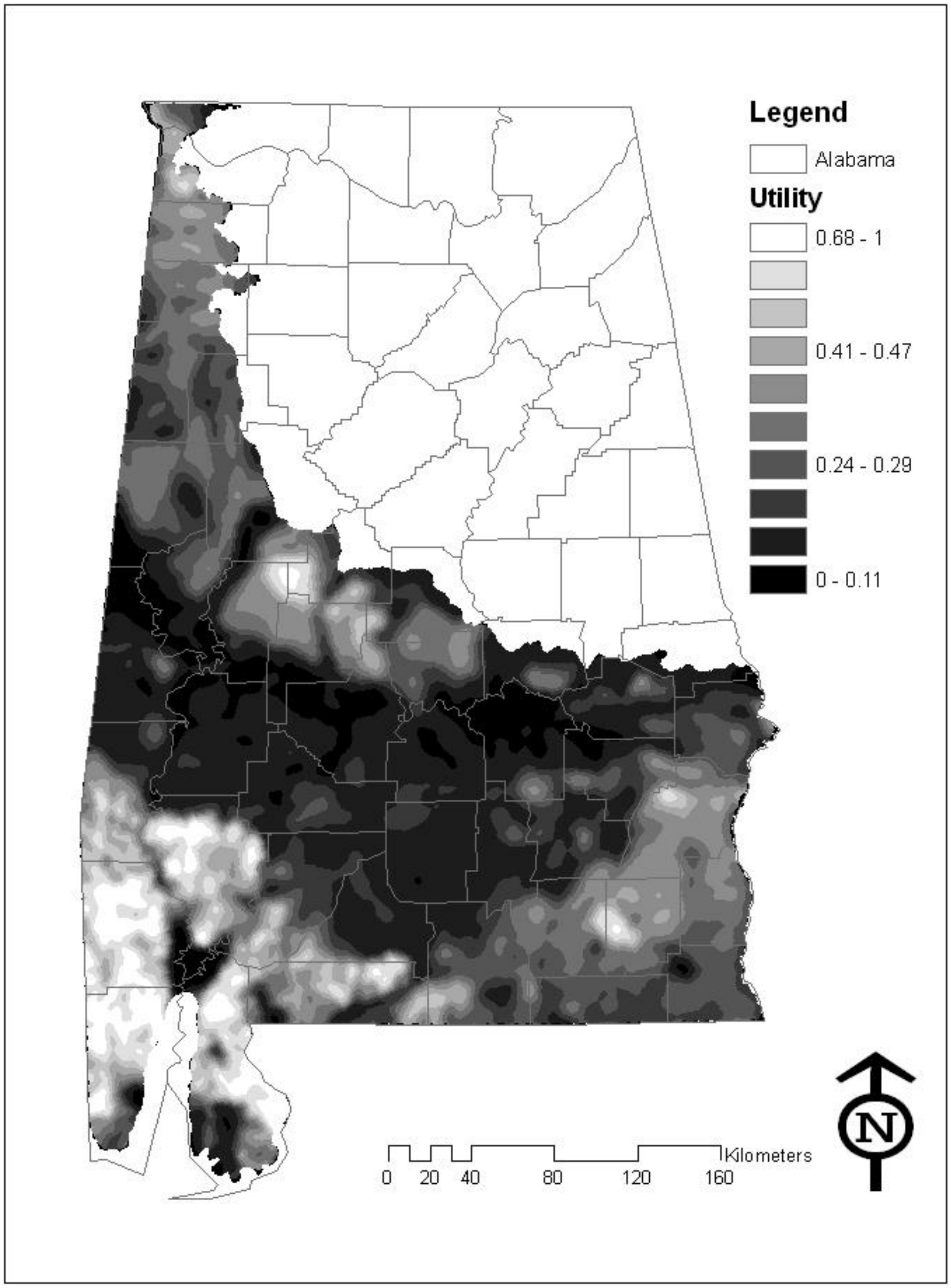

Figure 1.10: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for coal skink. For mean value across study extent, see Table 2.1.

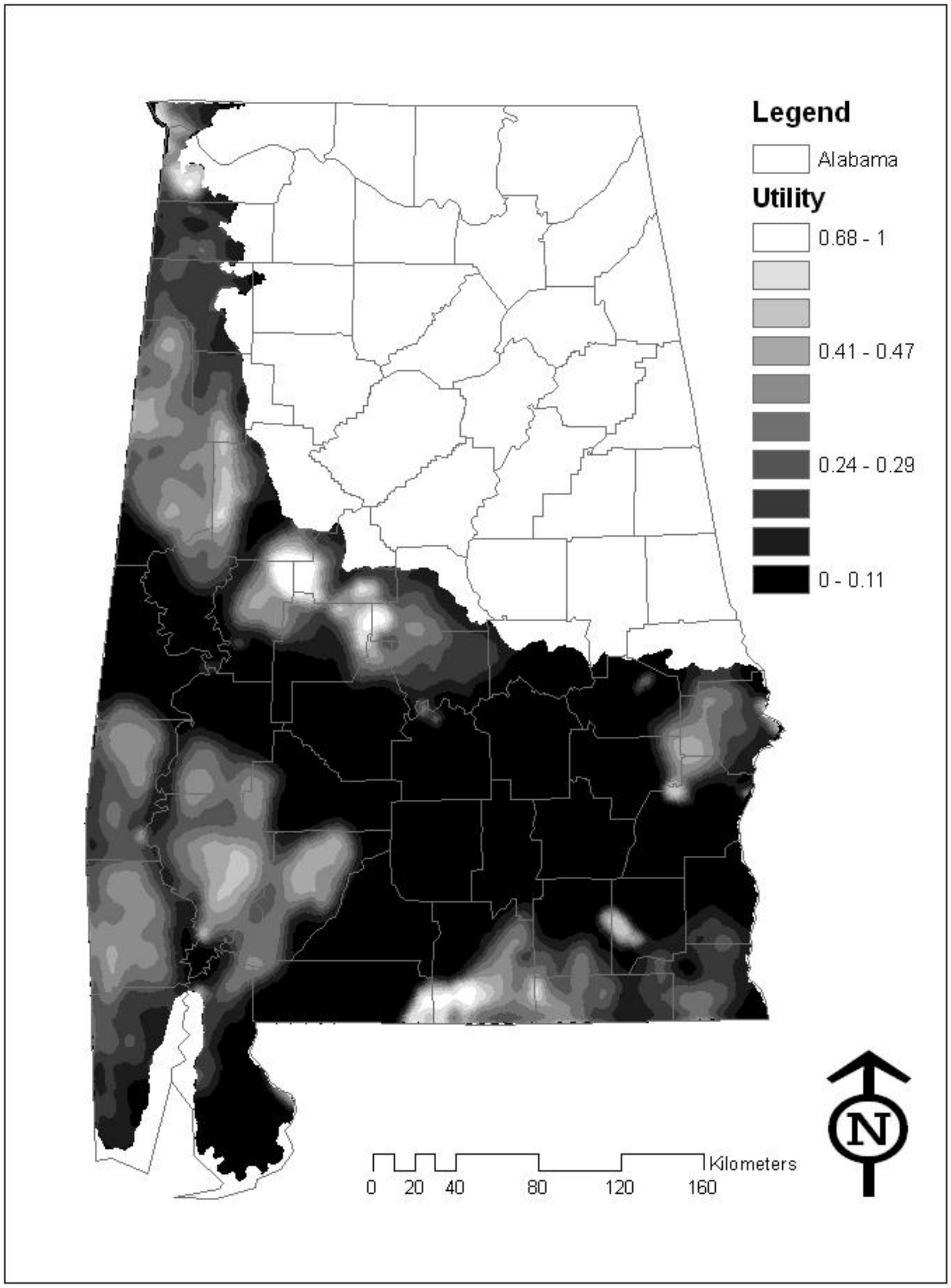

Figure 1.11: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for Eastern coral snake. For mean value across study extent, see Table 2.1.

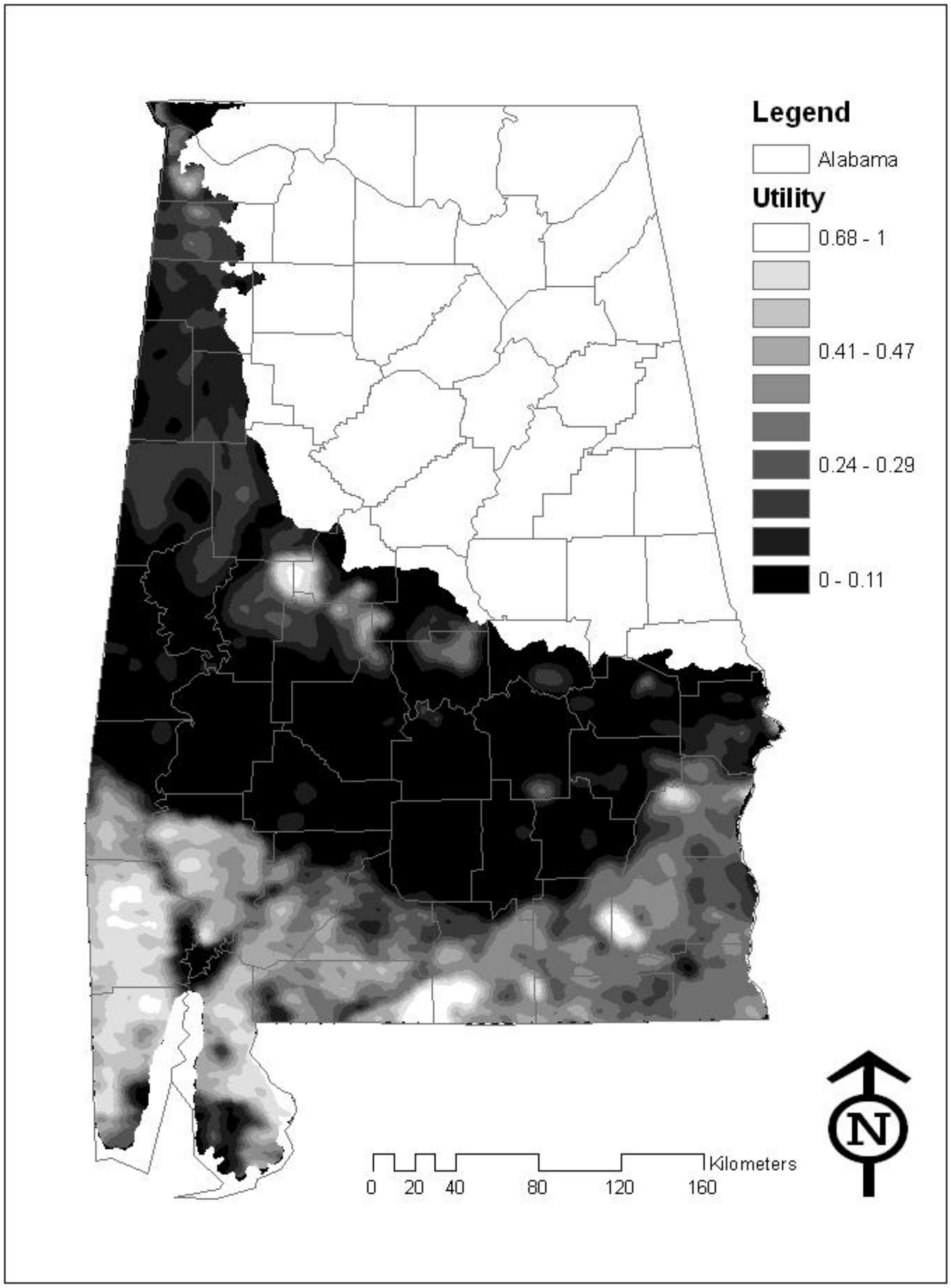

Figure 1.12: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for Eastern diamondback rattlesnake. For mean value across study extent, see Table 2.1.

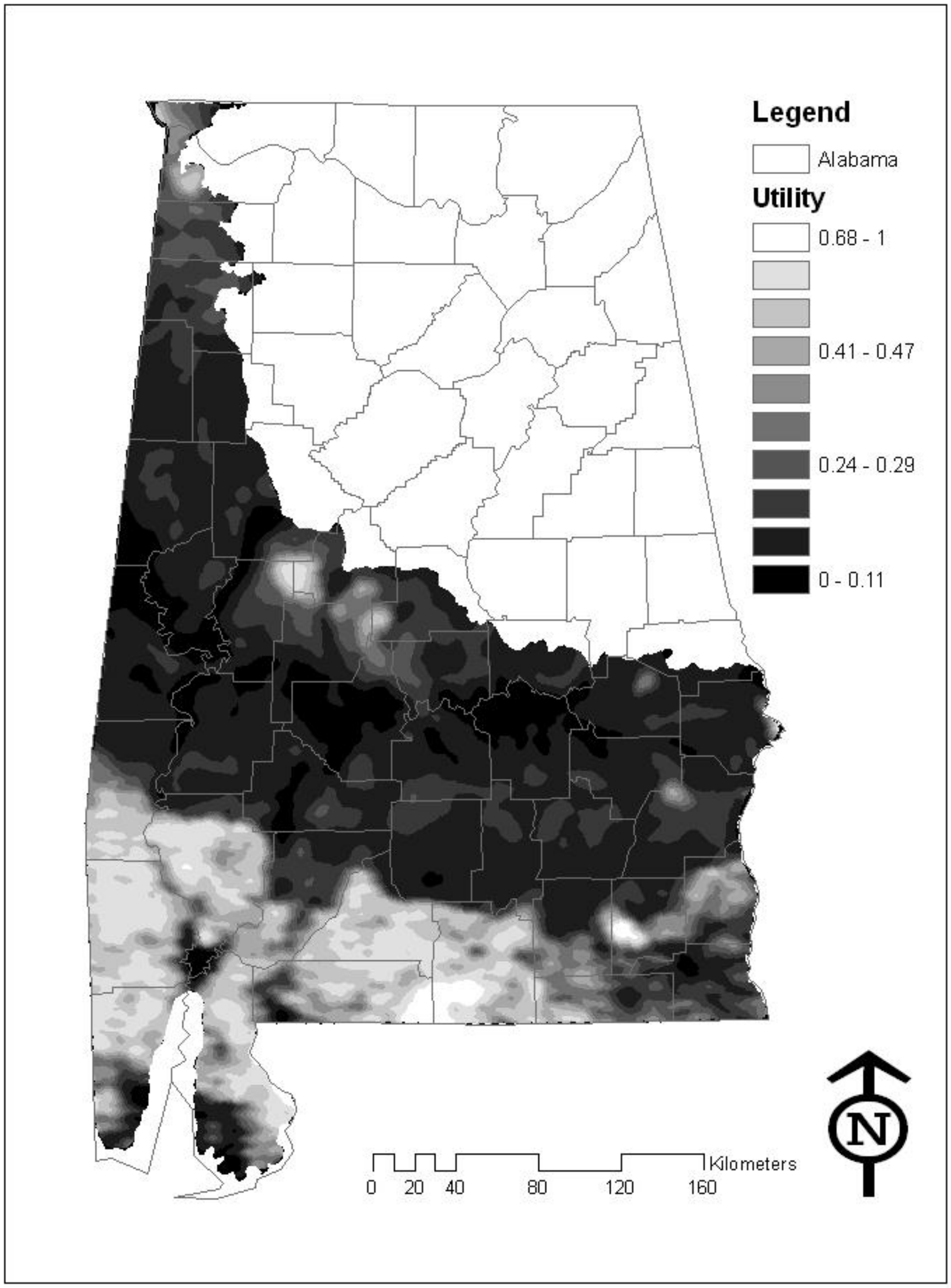

Figure 1.13: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for Eastern indigo snake. For mean value across study extent, see Table 2.1.

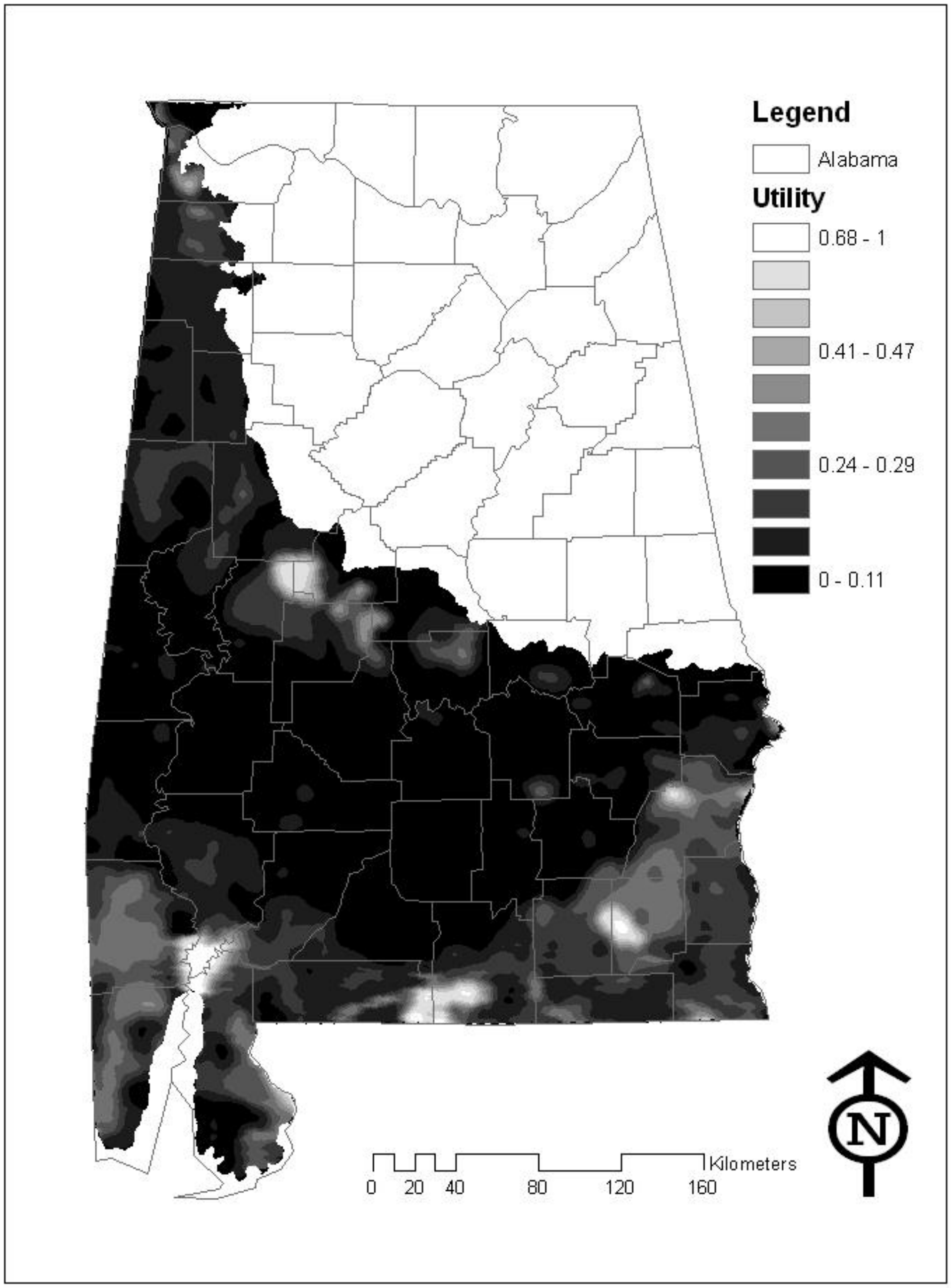

Figure 1.14: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for Eastern kingsnake. For mean value across study extent, see Table 2.1.

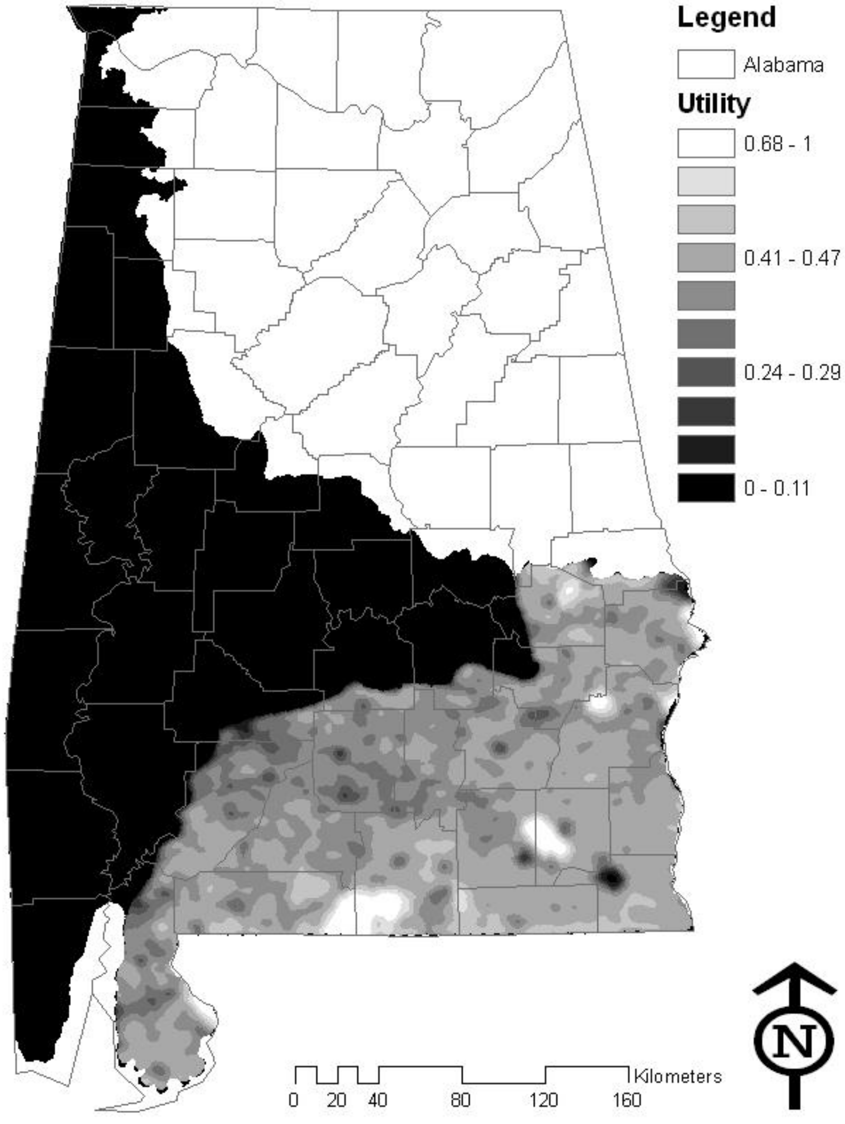

Figure 1.15: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for Eastern spotted skunk. For mean value across study extent, see Table 2.1.

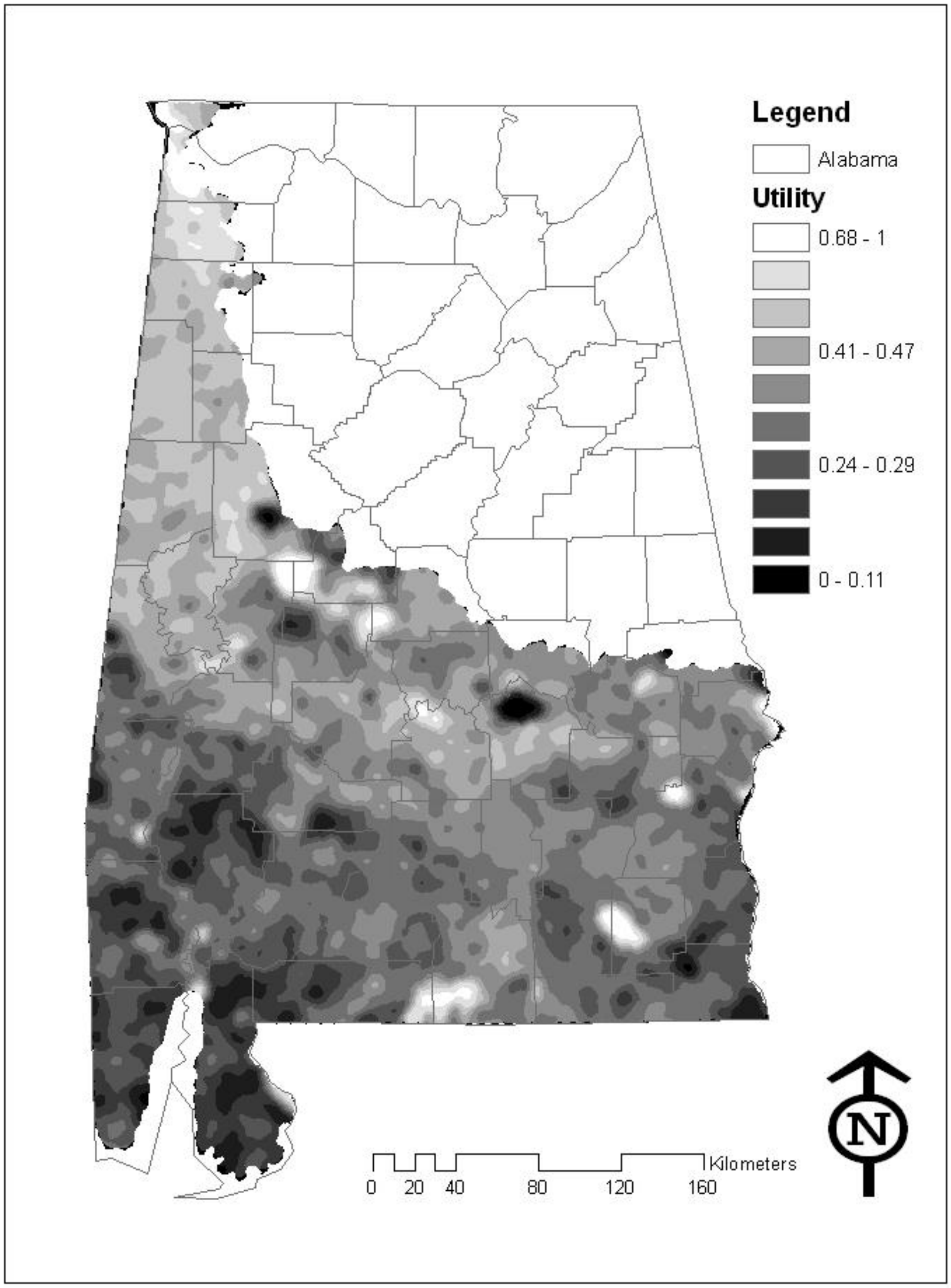

Figure 1.16: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for flatwoods salamander. For mean value across study extent, see Table 2.1.

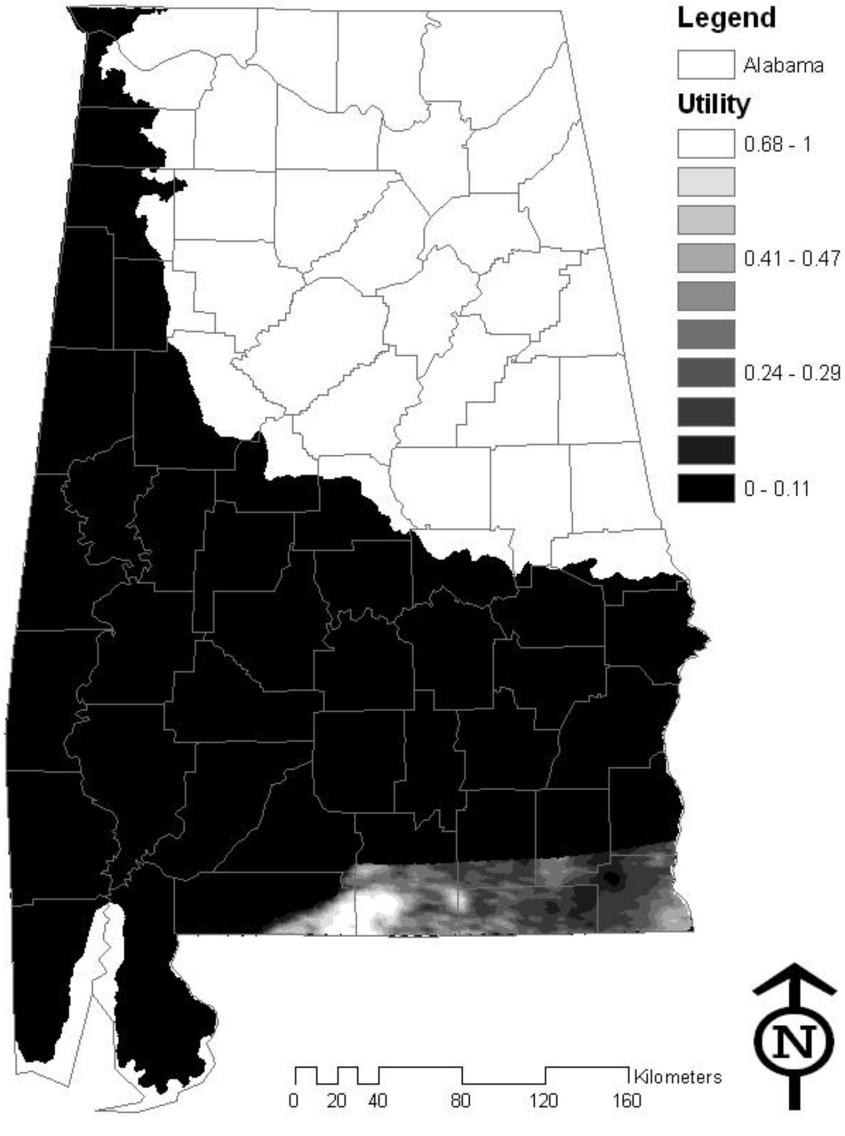

Figure 1.17: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for Florida pine snake. For mean value across study extent, see Table 2.1.

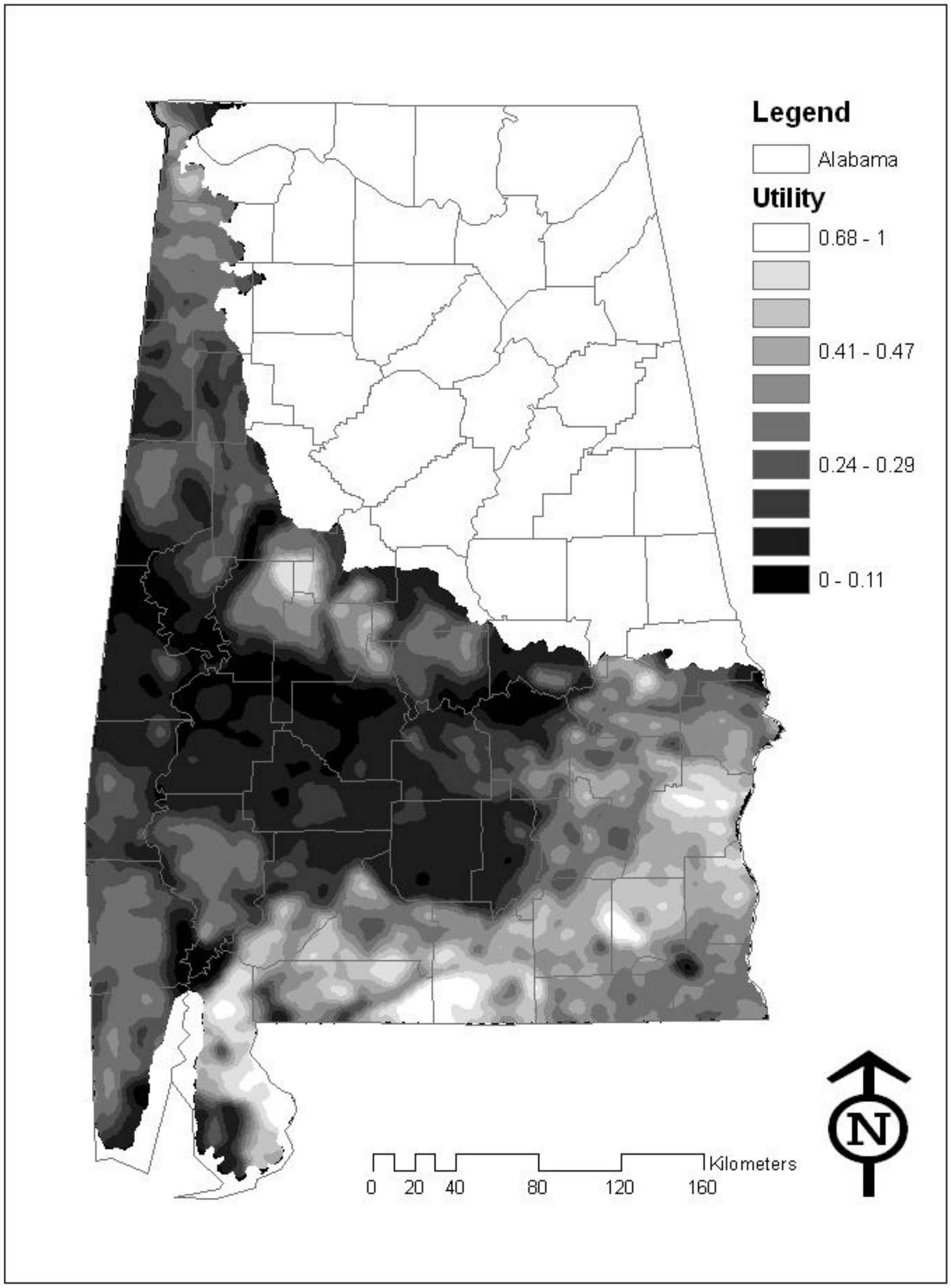

Figure 1.18: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for gopher frog. For mean value across study extent, see Table 2.1.

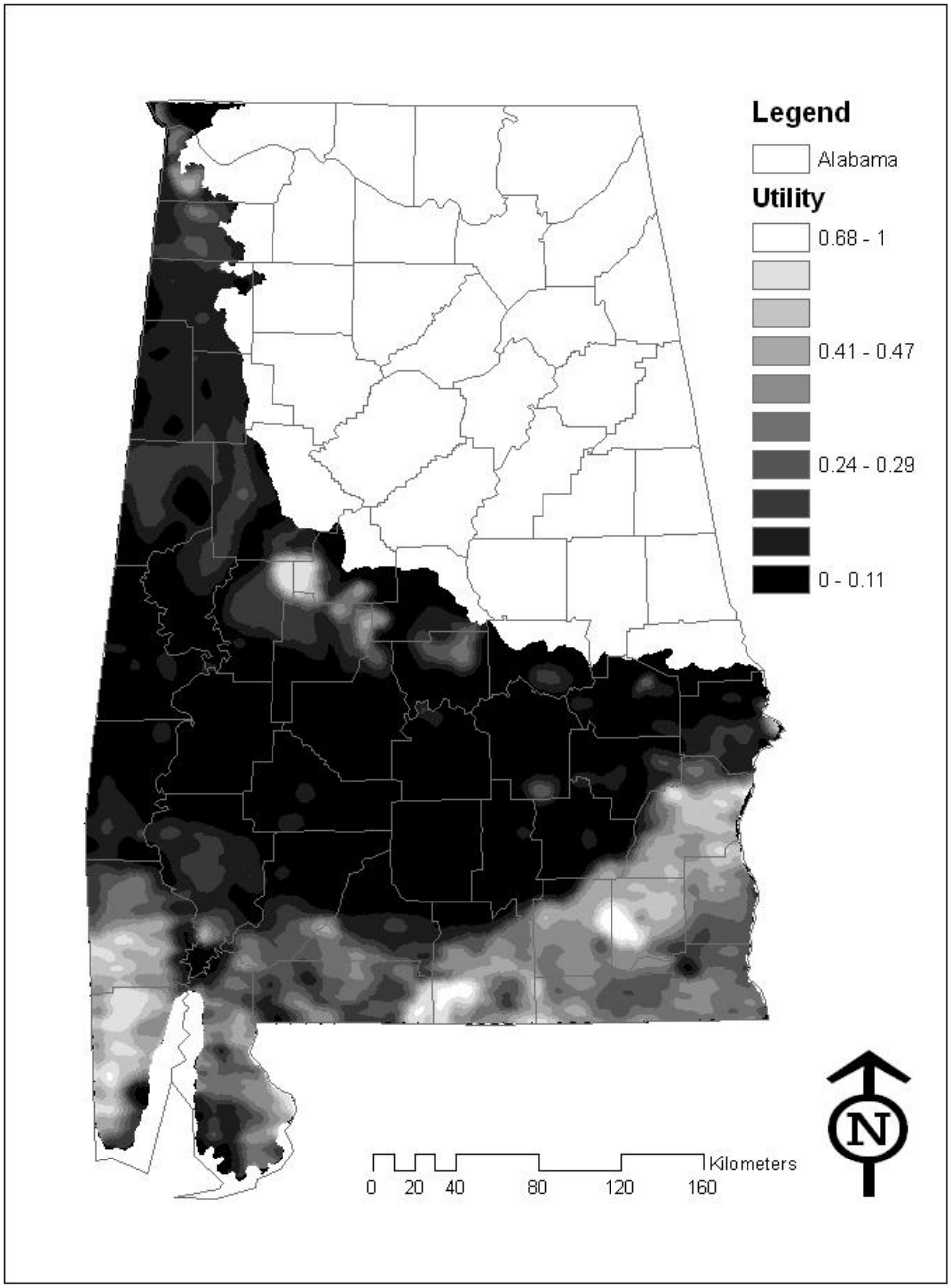

Figure 1.19: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for gopher tortoise. For mean value across study extent, see Table 2.1.

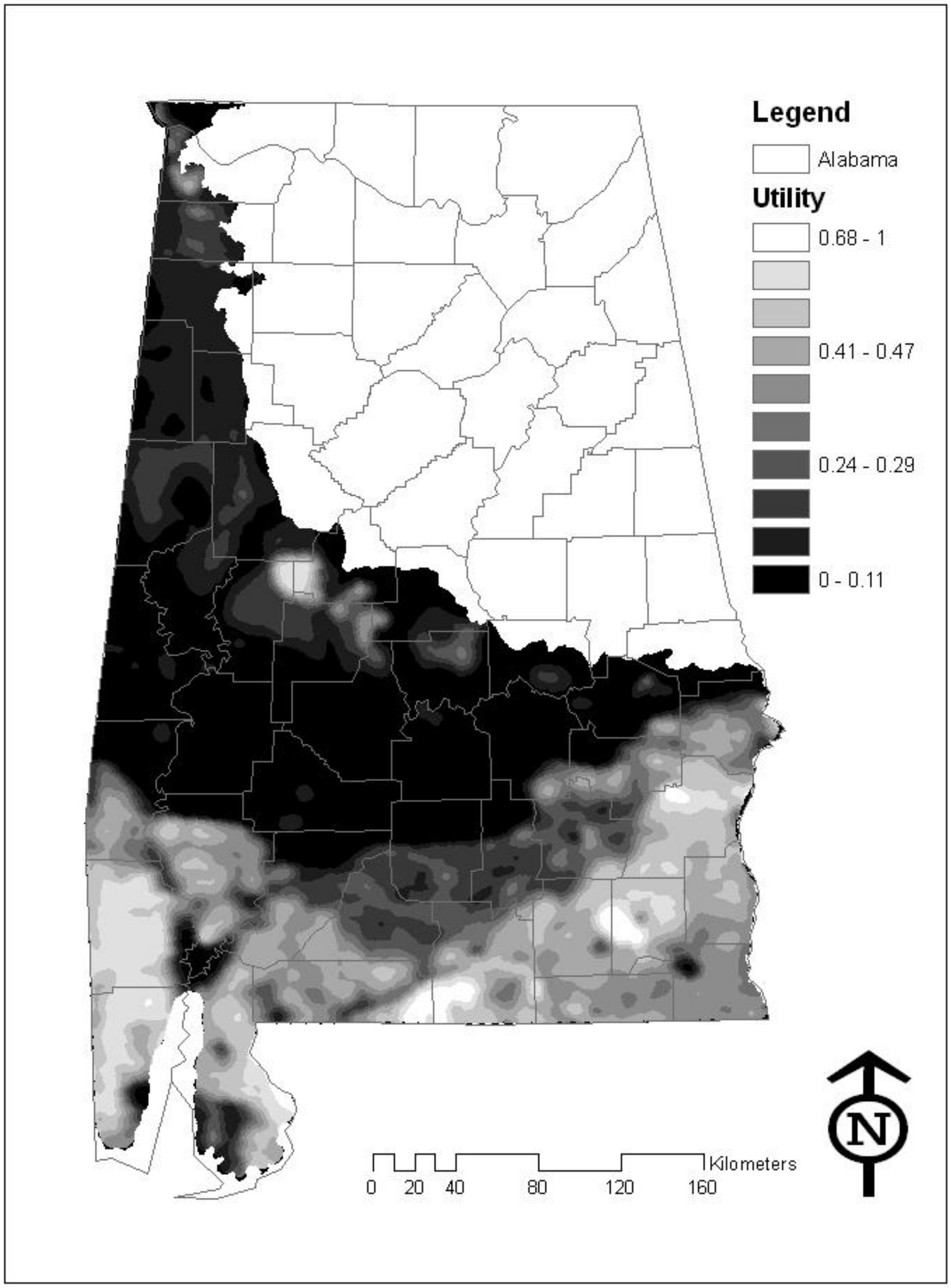

Figure 1.20: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for Henslow's sparrow. For mean value across study extent, see Table 2.1.

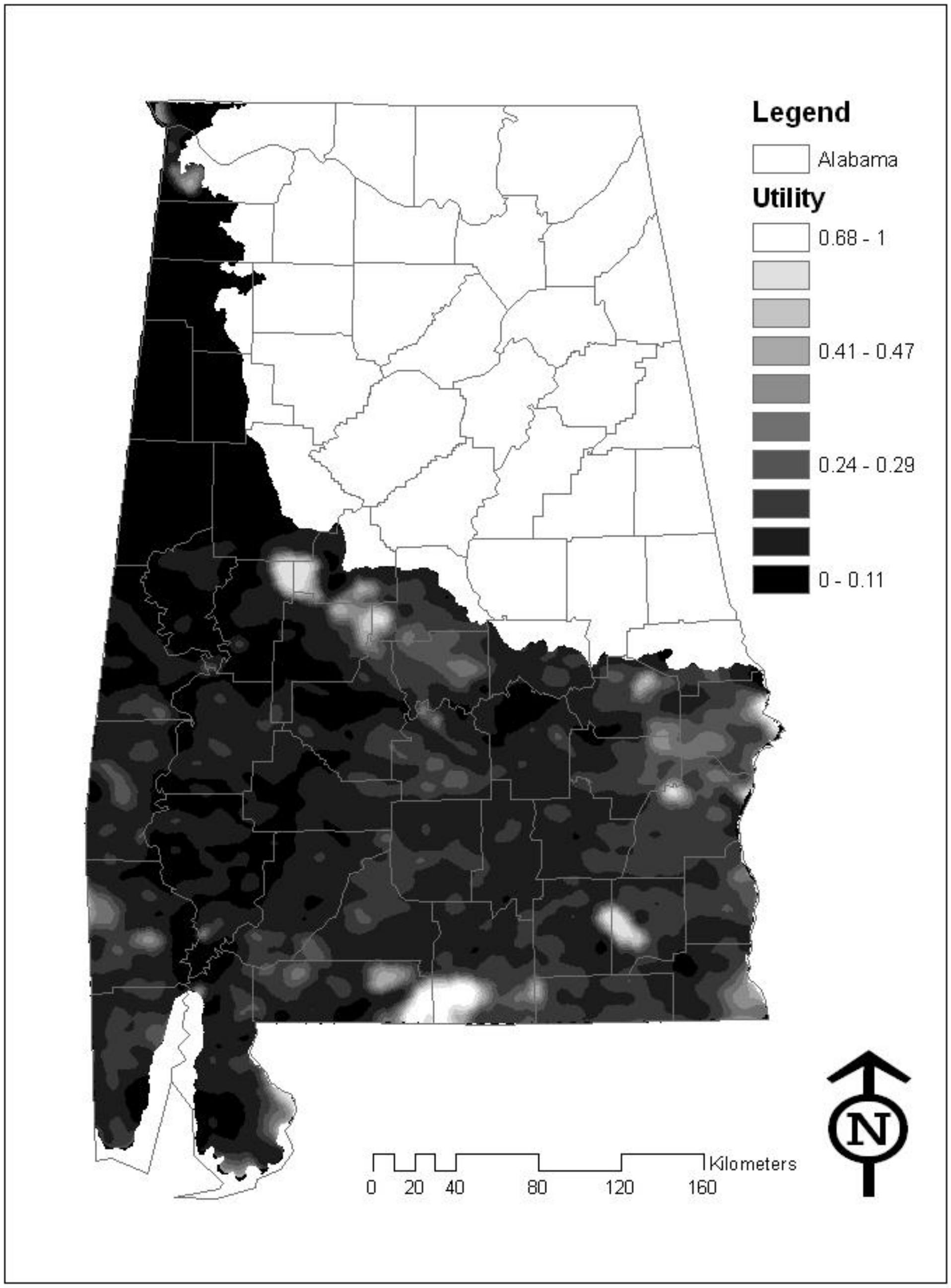

Figure 1.21: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for Kentucky warbler. For mean value across study extent, see Table 2.1.

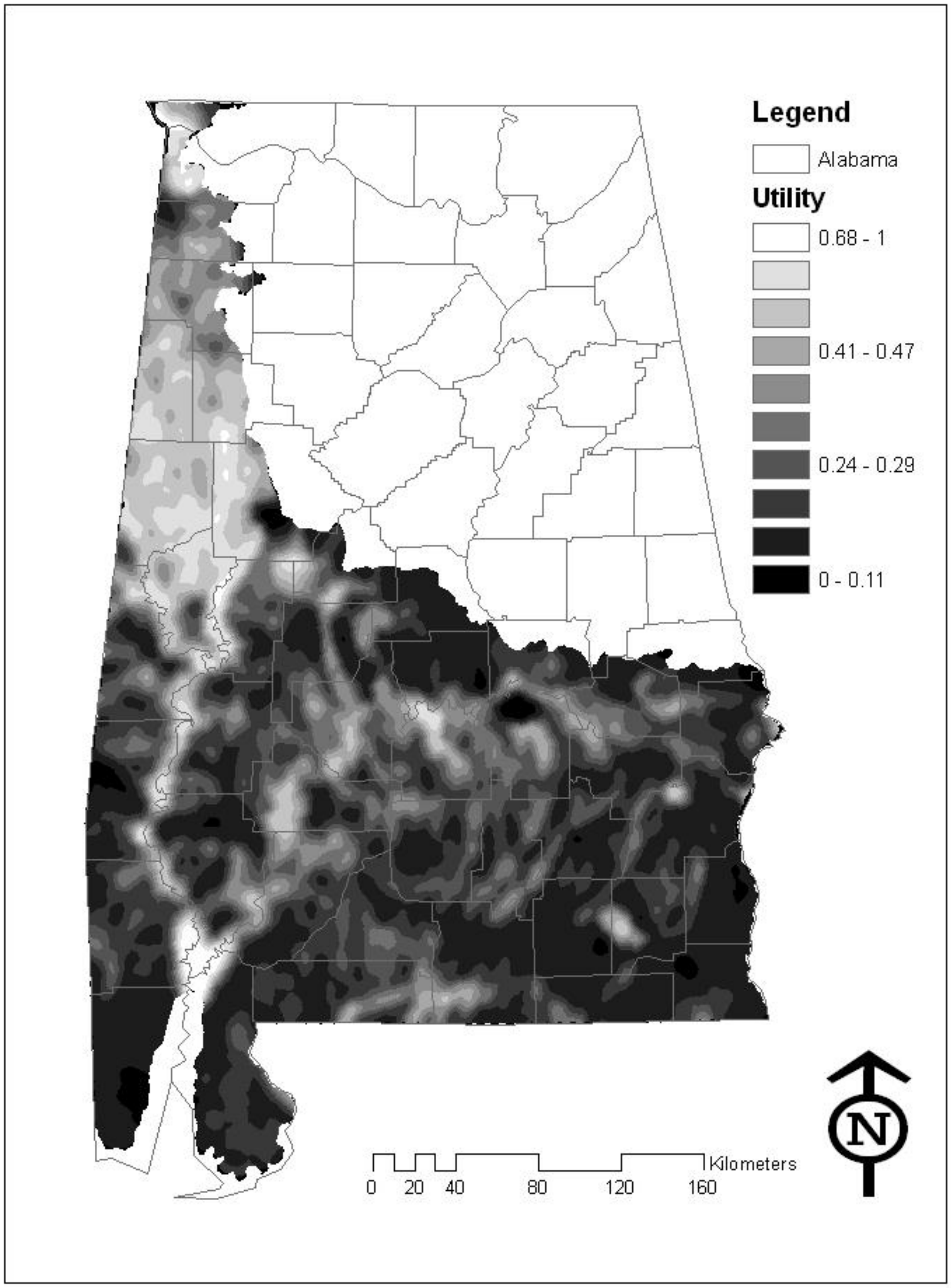

Figure 1.22: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for least bittern. For mean value across study extent, see Table 2.1.

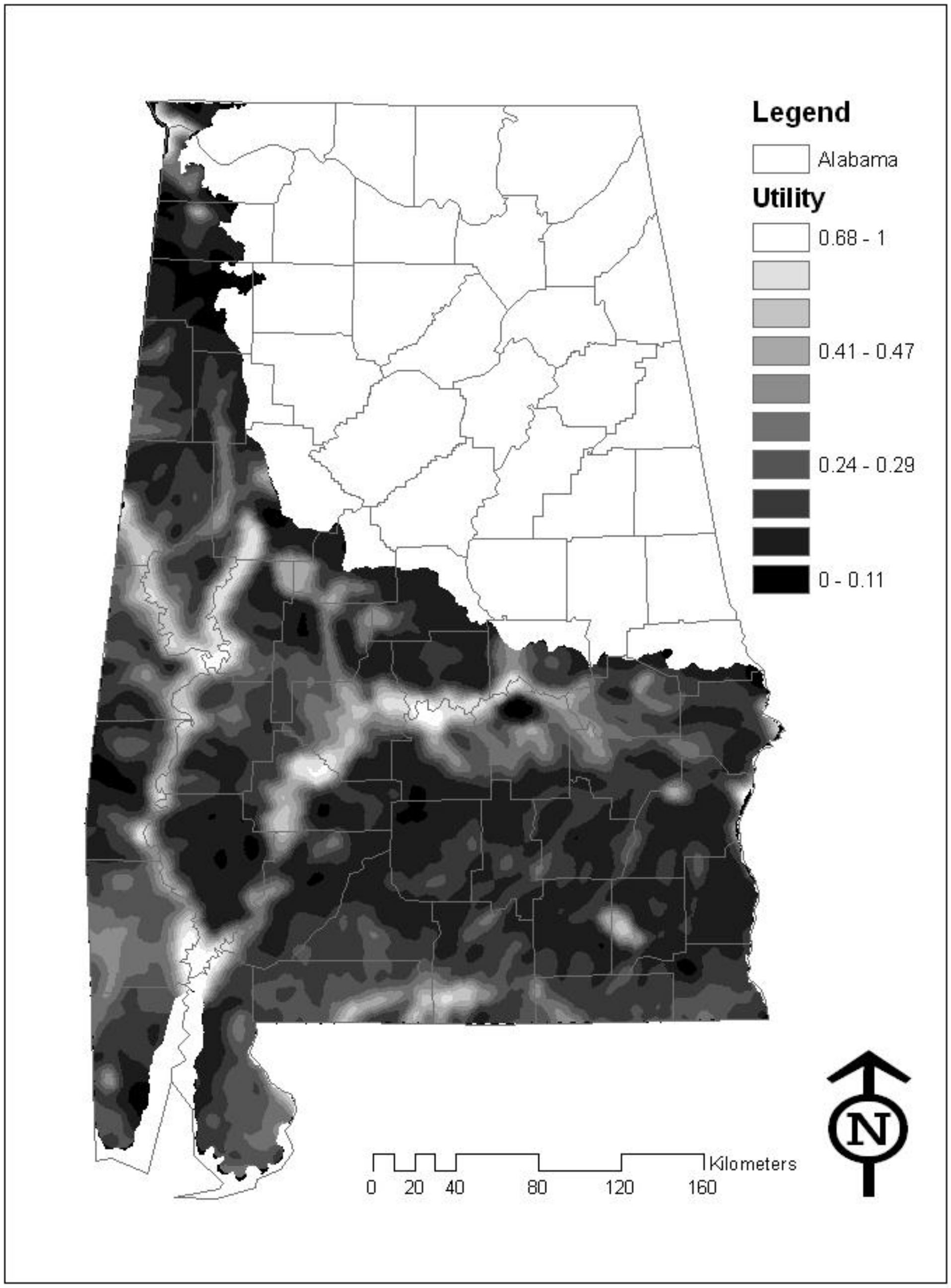

Figure 1.23: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for little grass frog. For mean value across study extent, see Table 2.1.

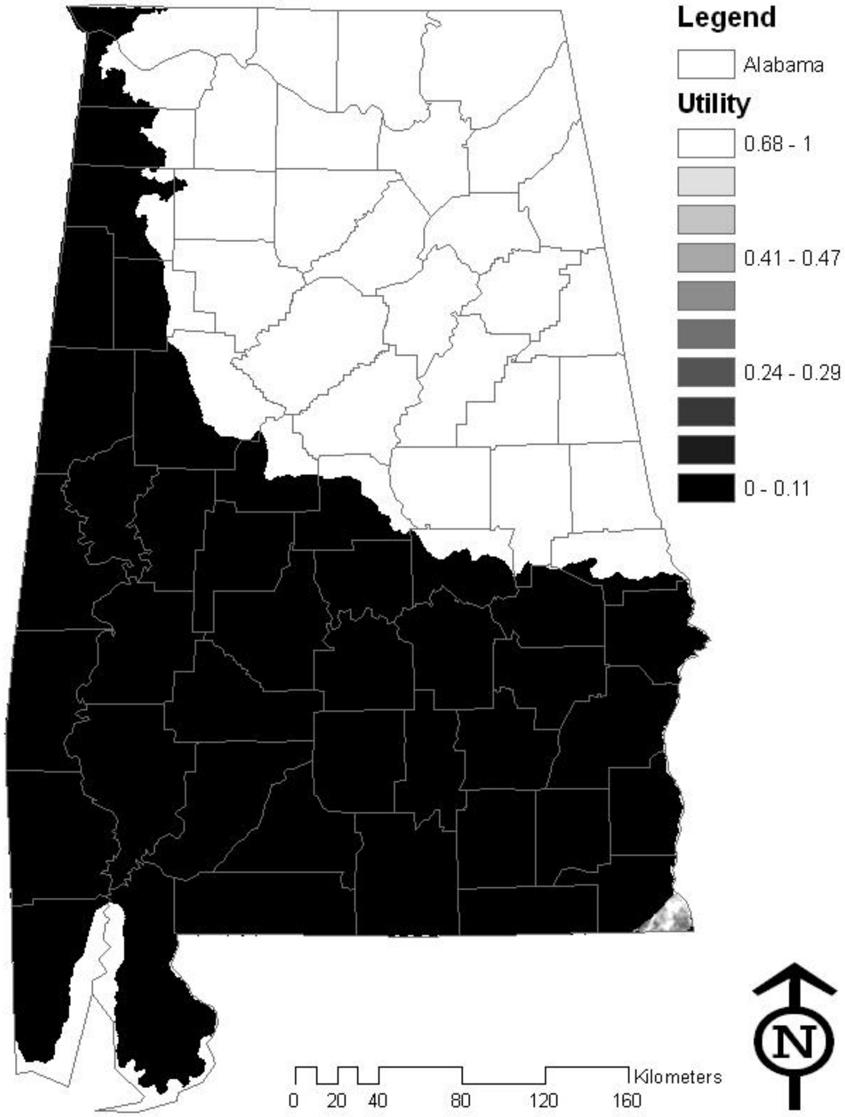

Figure 1.24: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for long-tailed weasel. For mean value across study extent, see Table 2.1.

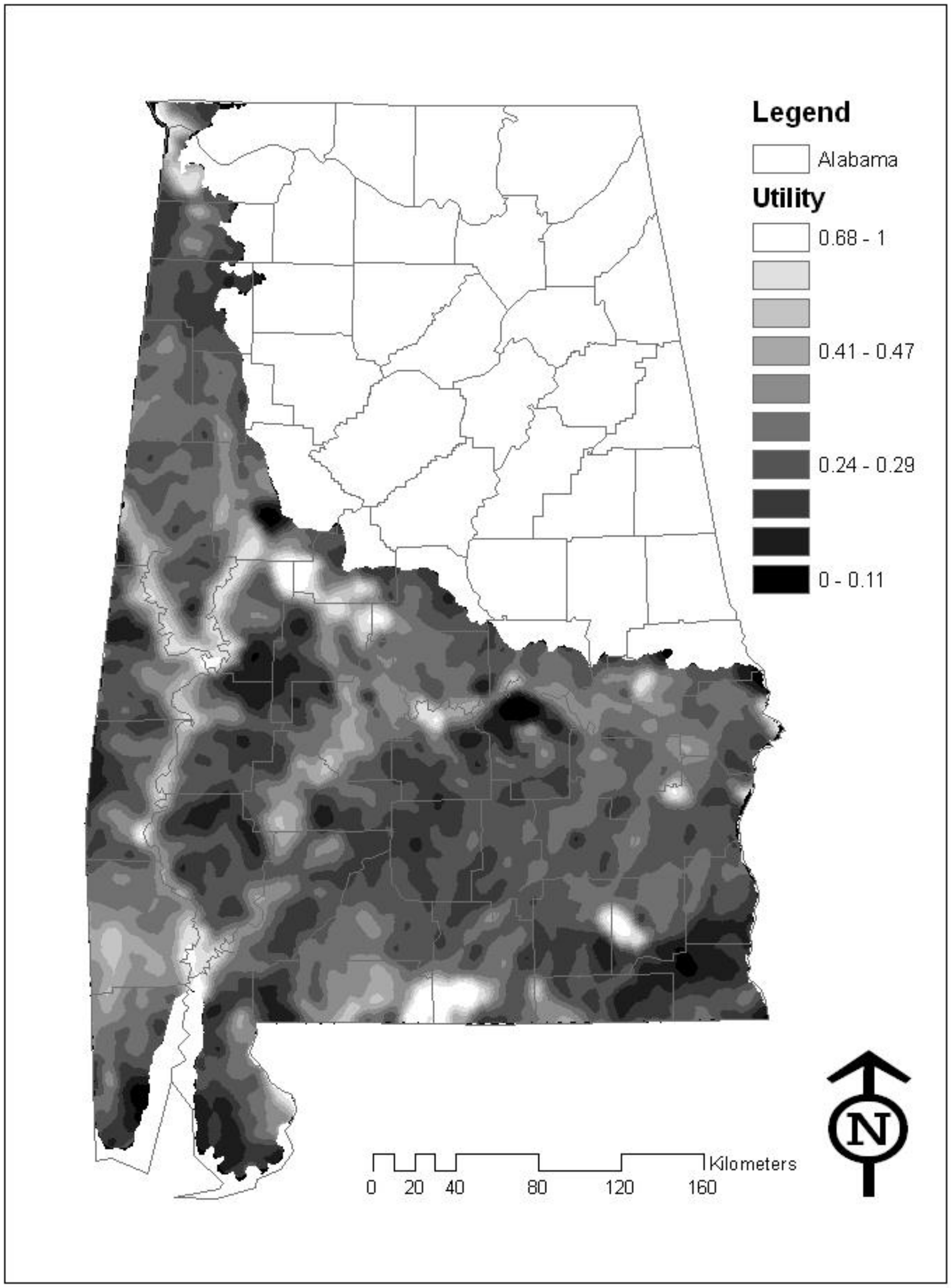

Figure 1.25: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for mimic glass lizard. For mean value across study extent, see Table 2.1.

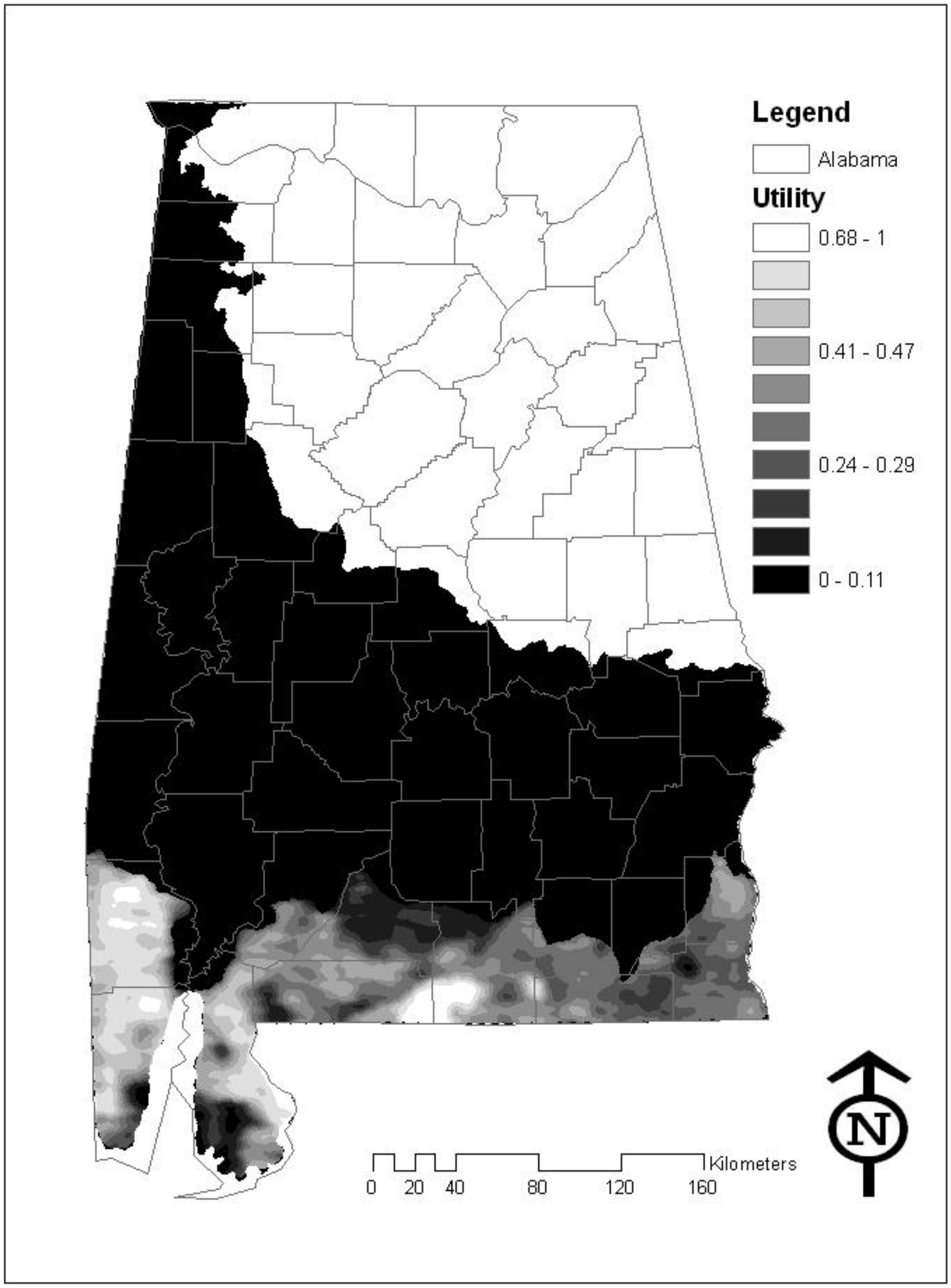

Figure 1.26: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for pine barrens treefrog. For mean value across study extent, see Table 2.1.

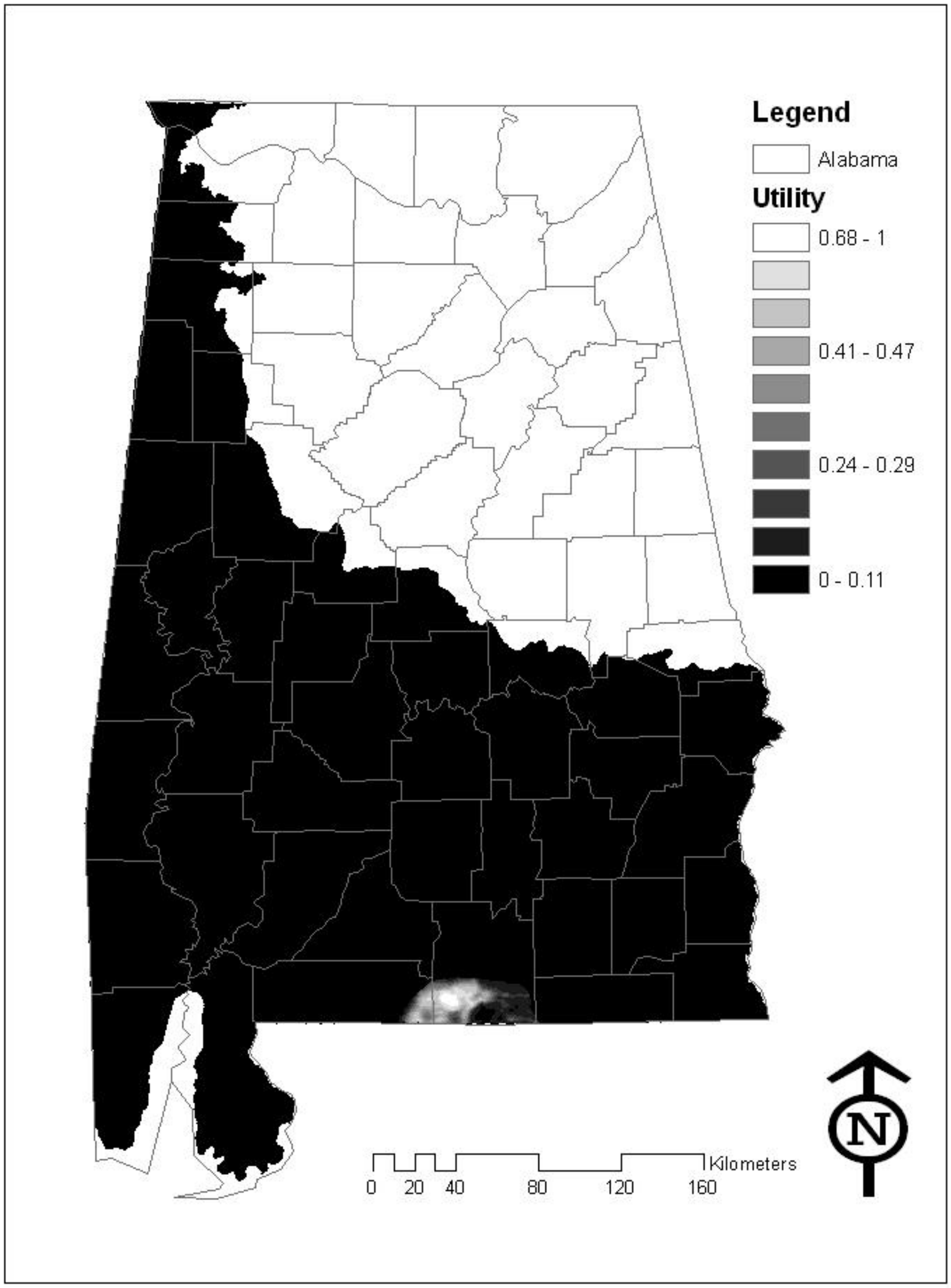

Figure 1.27: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for rainbow snake. For mean value across study extent, see Table 2.1.

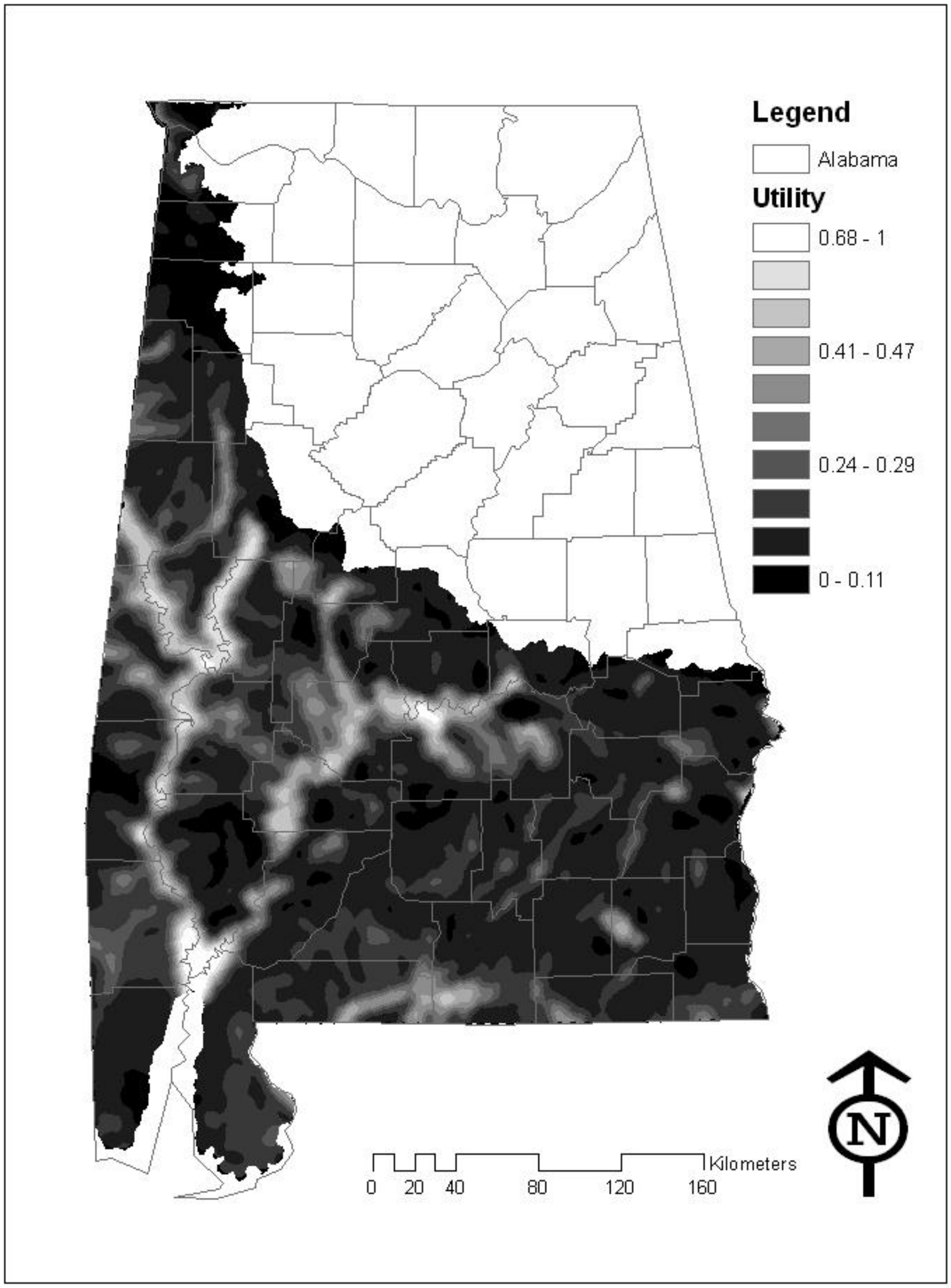

Figure 1.28: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for red-cockaded woodpecker. For mean value across study extent, see Table 2.1.

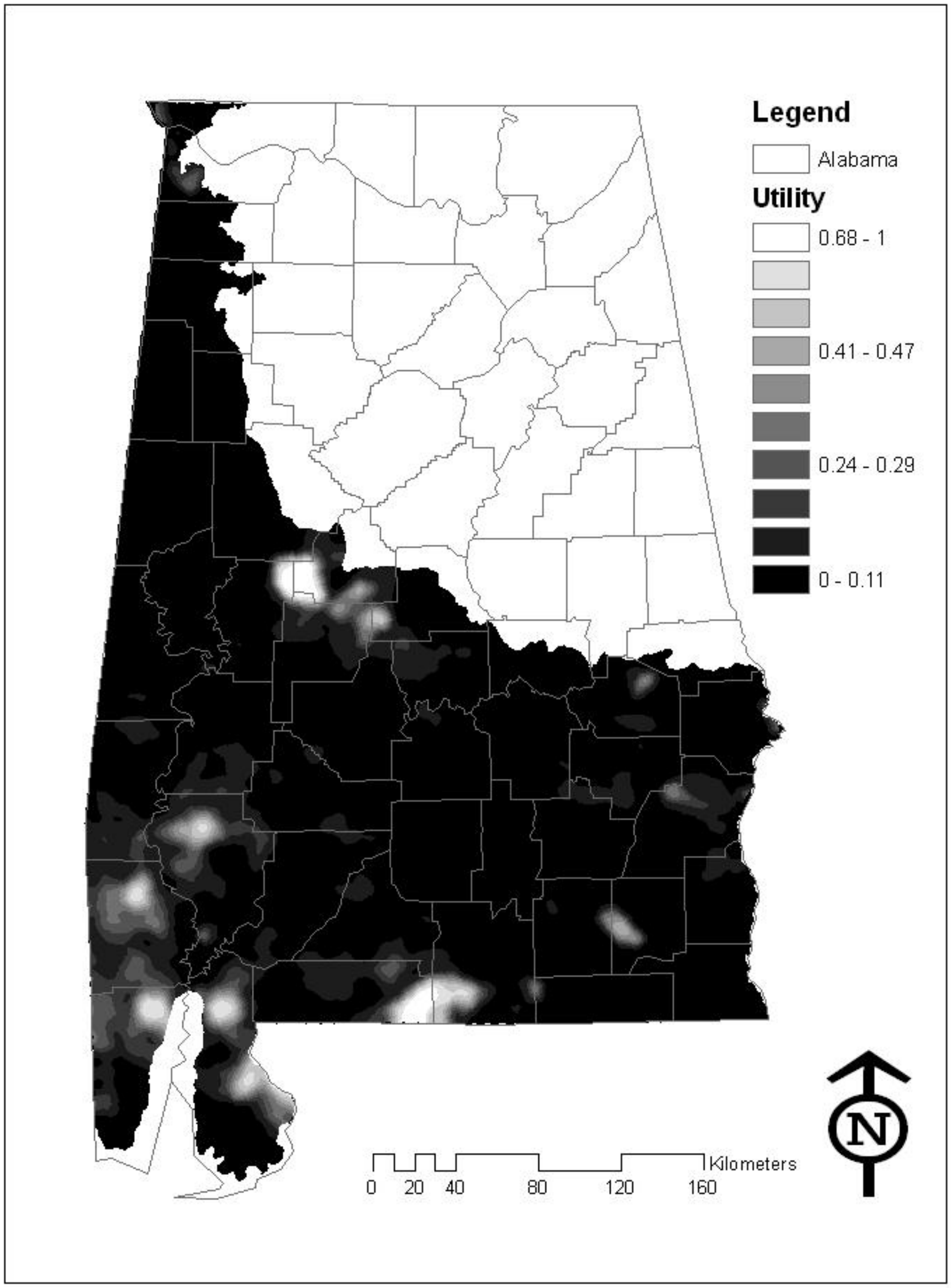

Figure 1.29: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for river frog. For mean value across study extent, see Table 2.1.

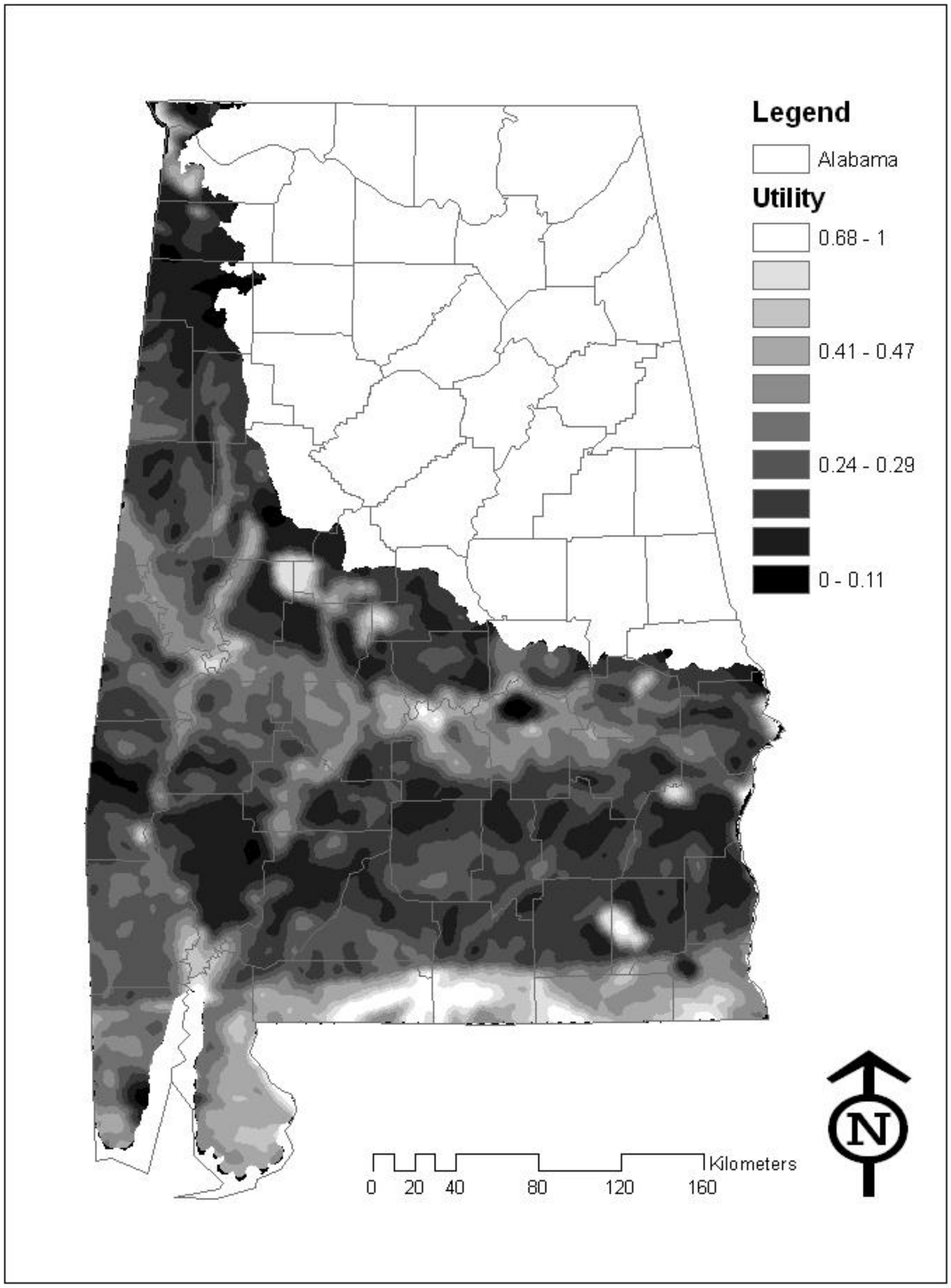

Figure 1.30: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for Southeastern pocket gopher. For mean value across study extent, see Table 2.1.

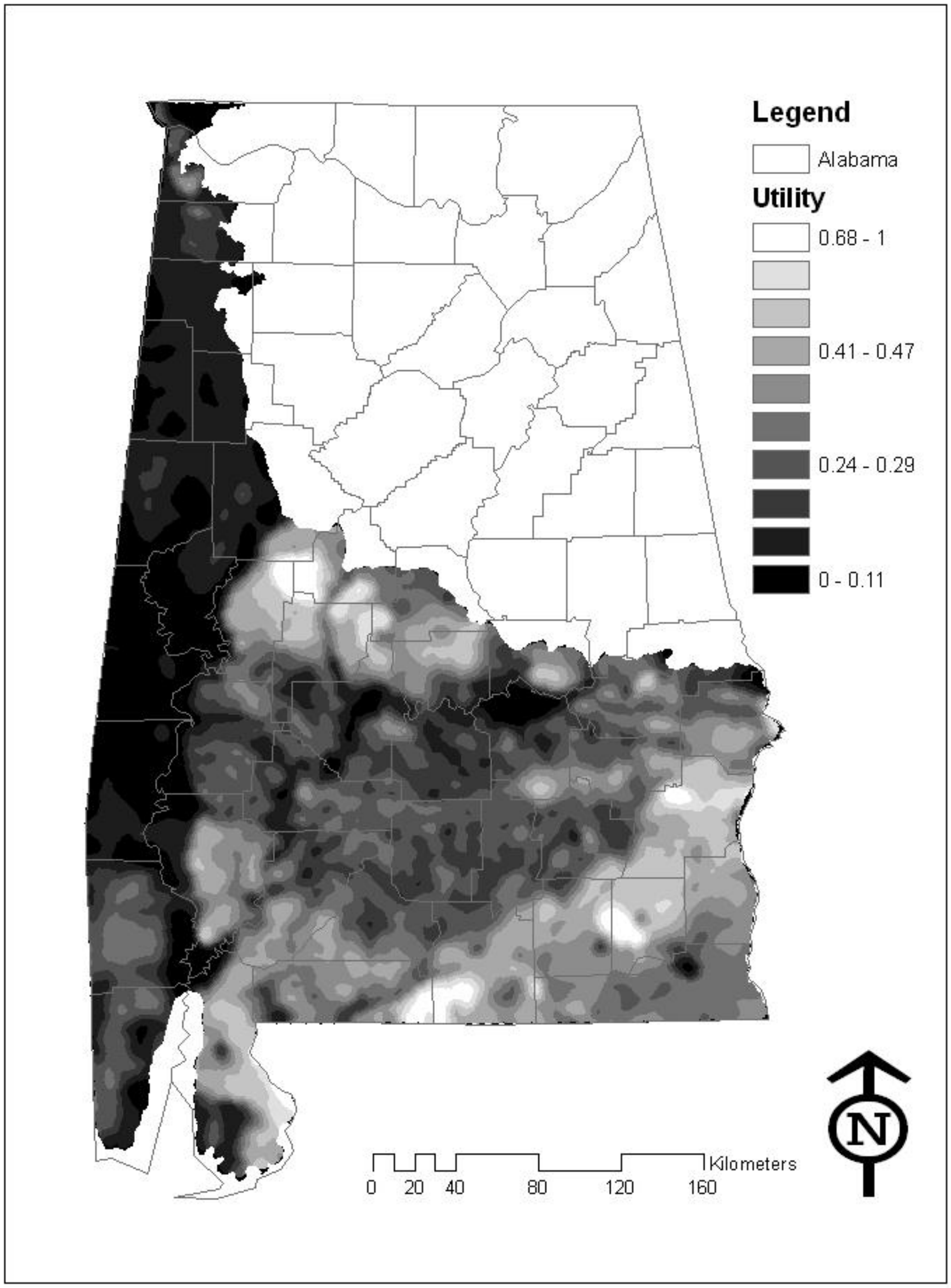

Figure 1.31: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for Southern dusky salamander. For mean value across study extent, see Table 2.1.

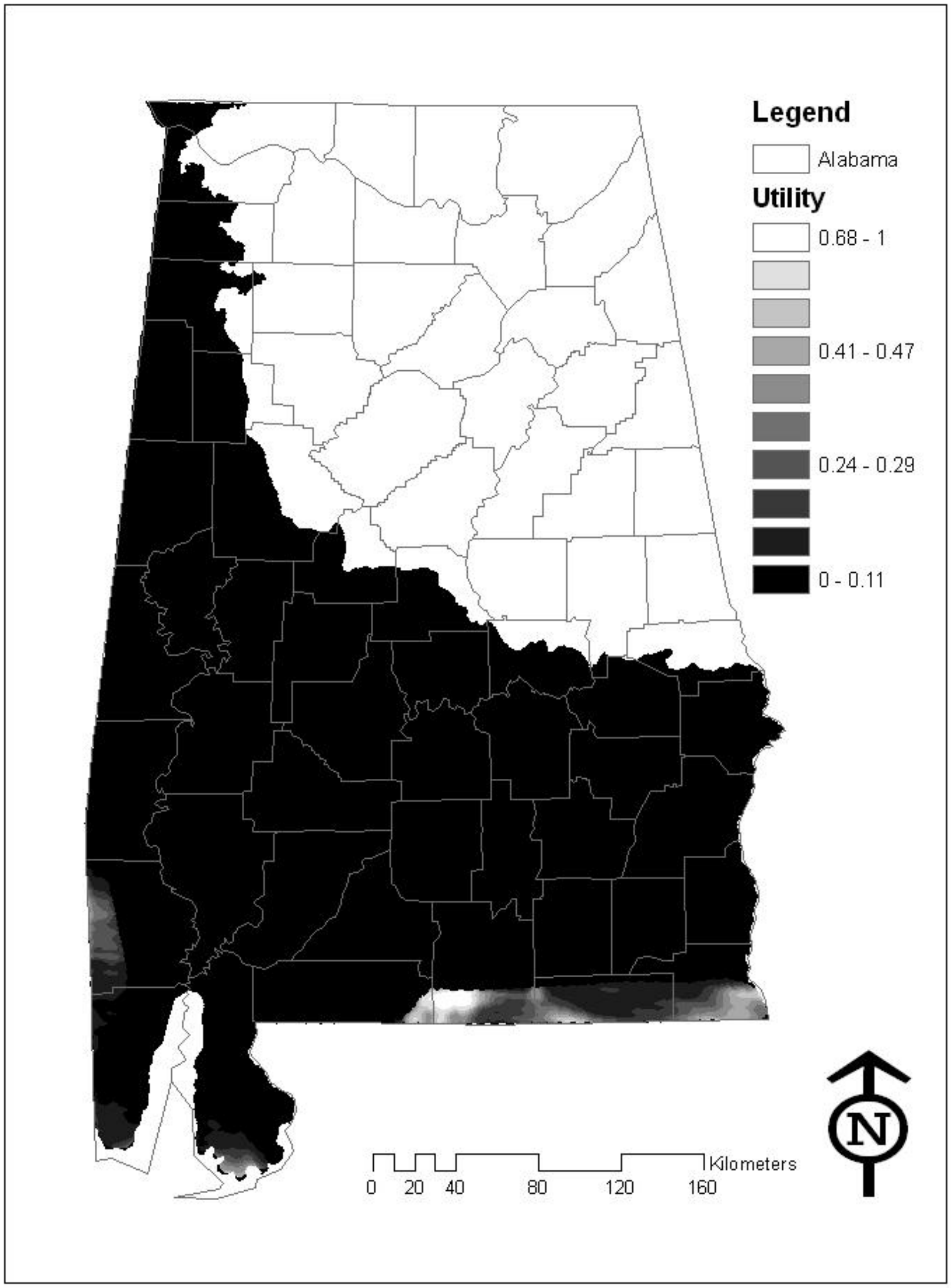

Figure 1.32: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for Southern hognose snake. For mean value across study extent, see Table 2.1.

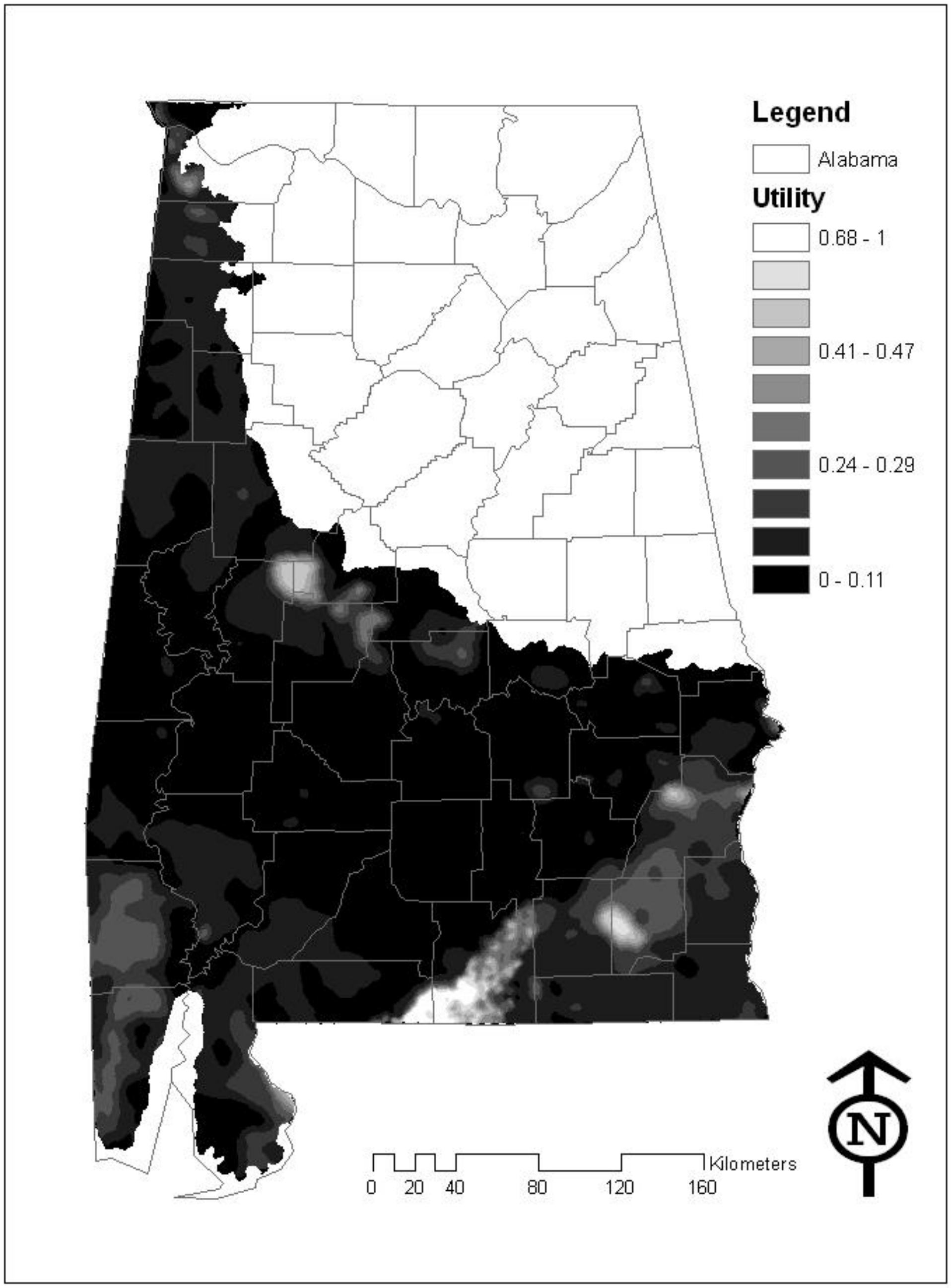

Figure 1.33: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for speckled kingsnake. For mean value across study extent, see Table 2.1.

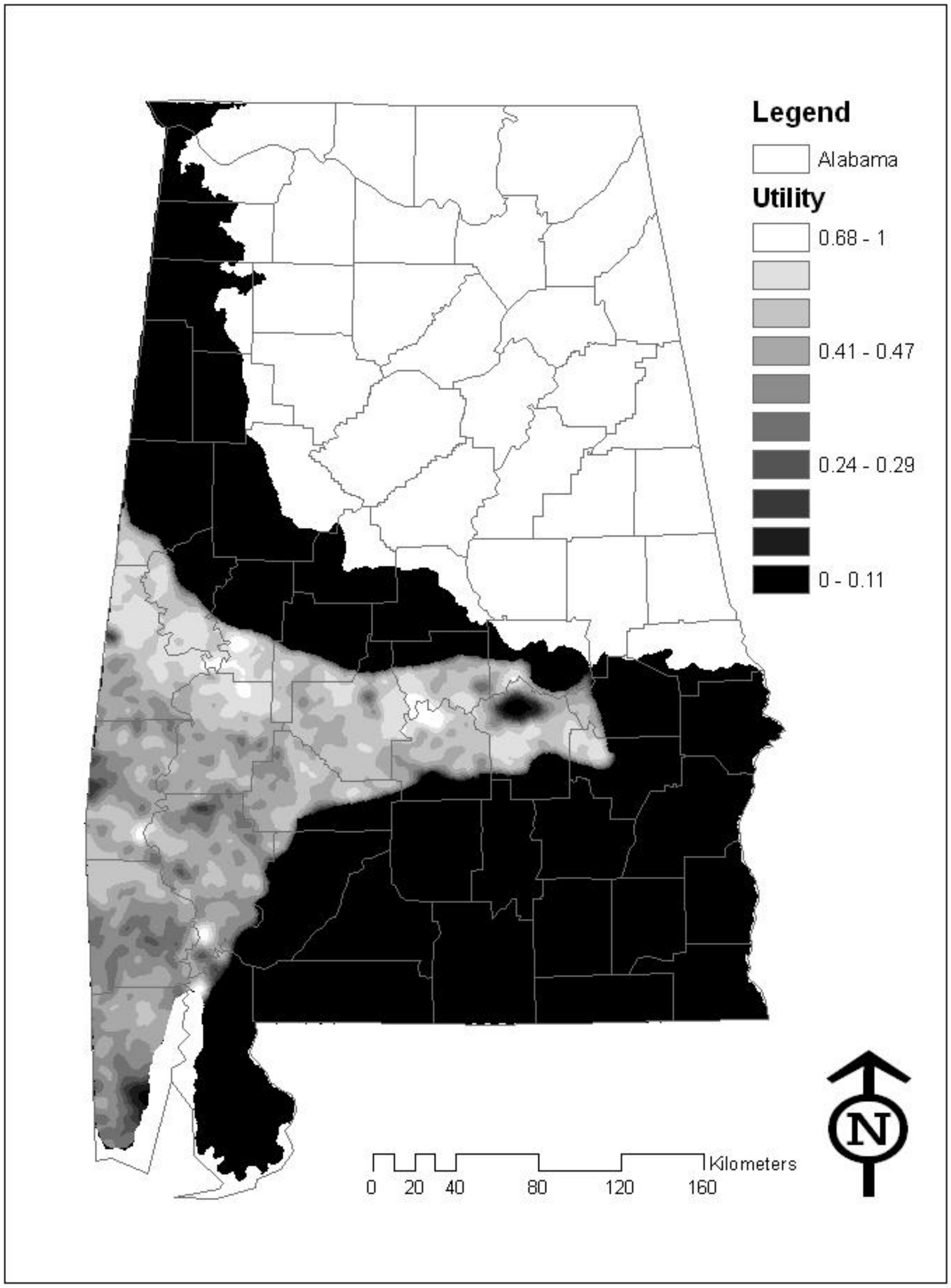

Figure 1.34: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for Swainson's warbler. For mean value across study extent, see Table 2.1.

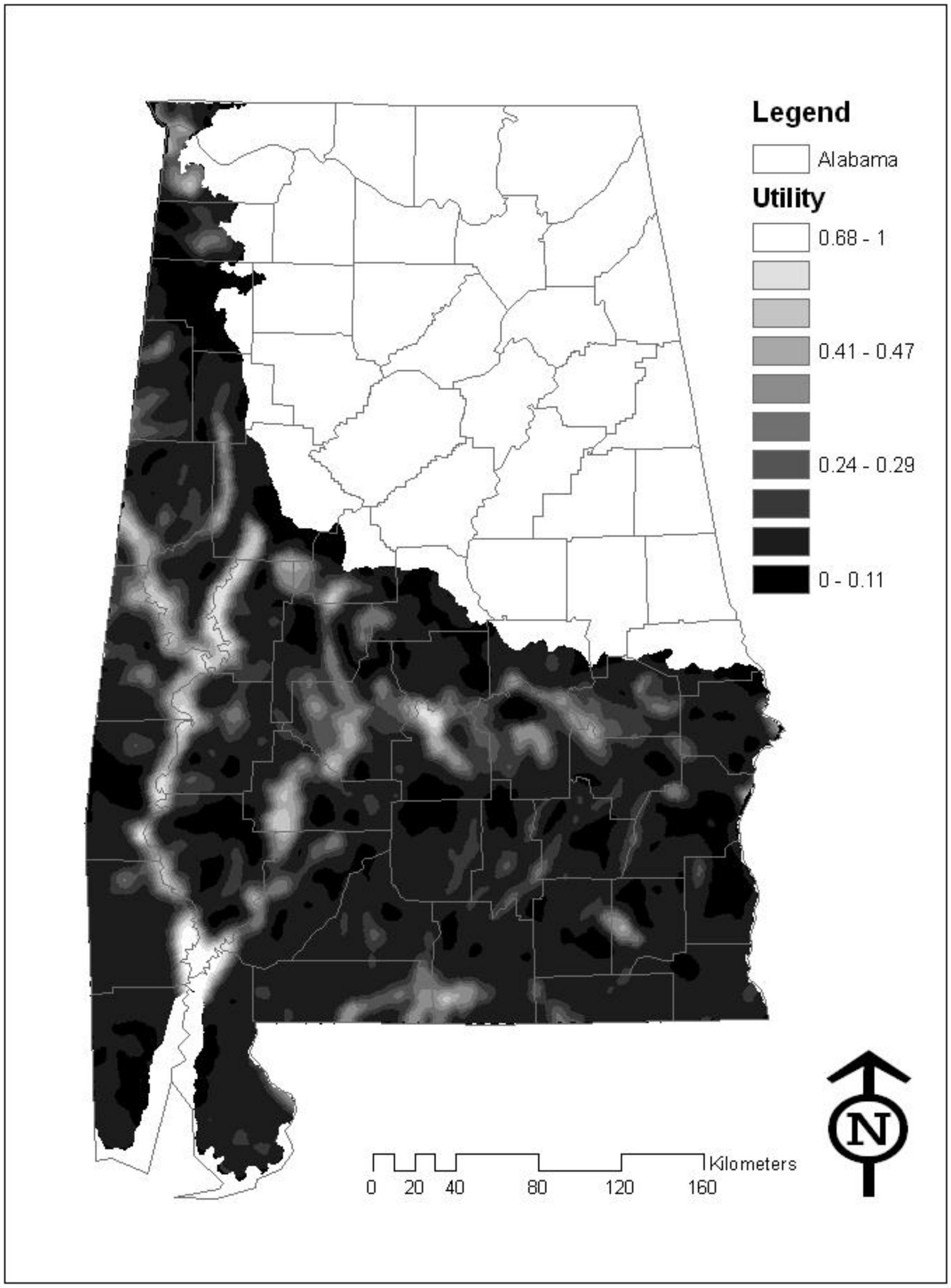

Figure 1.35: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for wood thrush. For mean value across study extent, see Table 2.1.

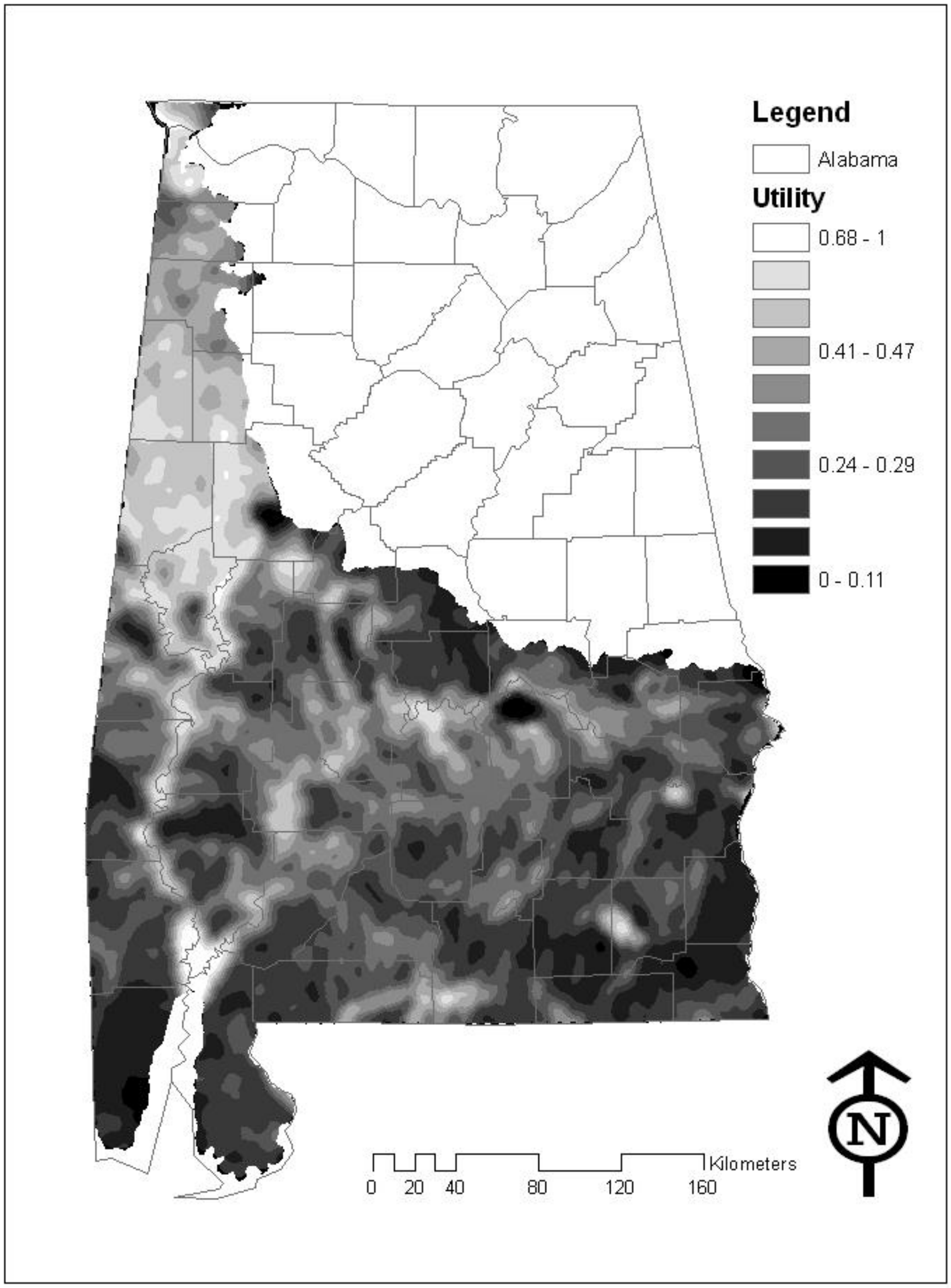

Figure 1.36: Map of conservation utility across the Southeastern Plains ecoregion of Alabama for worm-eating warbler. For mean value across study extent, see Table 2.1.

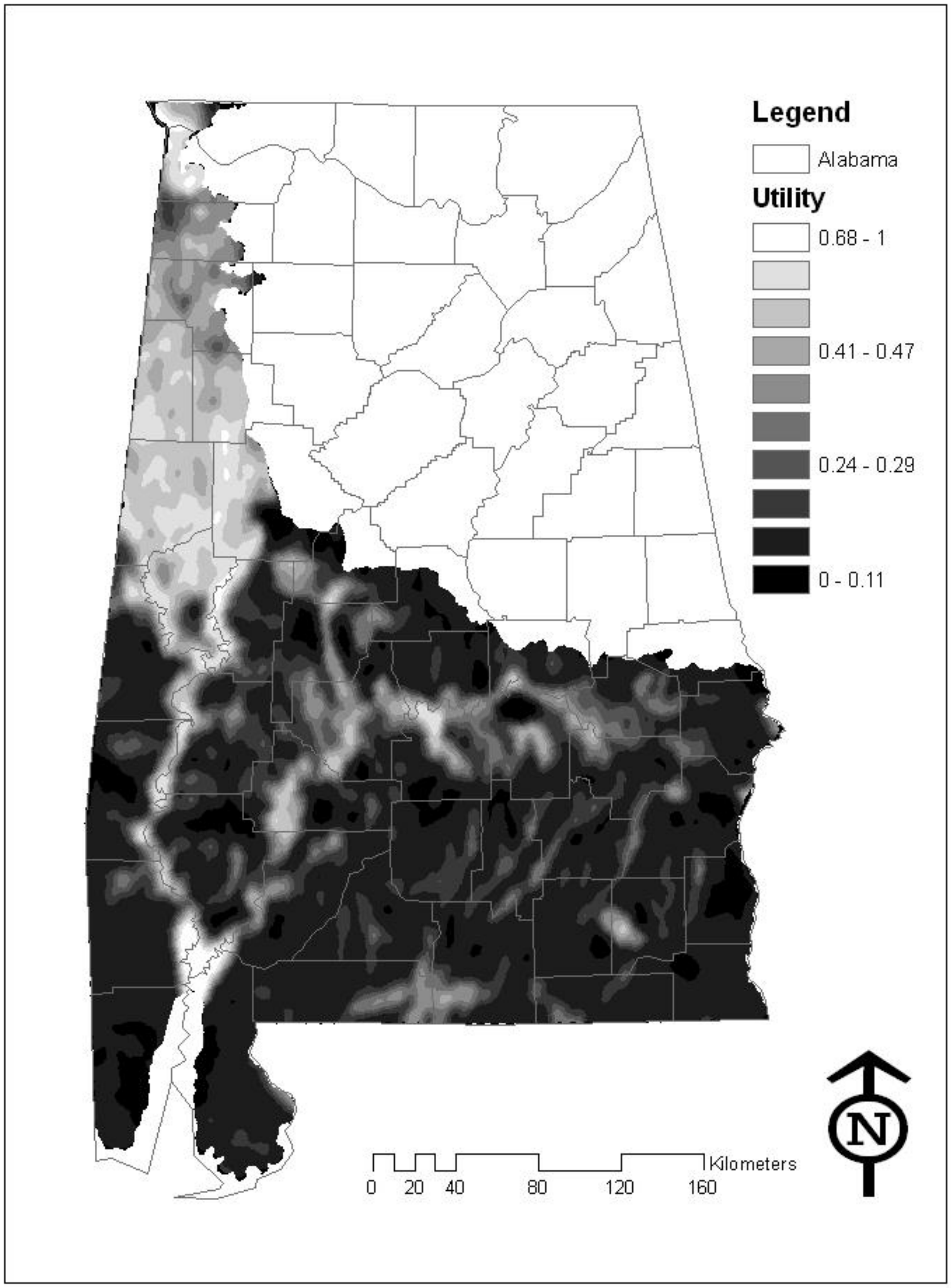

Table 1.1: Soil classification to determine site suitability for gopher tortoise and other fossorial herpetofauna. Unless otherwise noted, soil class from McDearman (2005).

Priority	Suitable		Marginal	
Alaga	Bama	Lucedale	Alapaha *	Petal
Alpin *	Benndale	Lucy	Basin *	Poarch
Bigbee	Bonneau *	Maxton †	Baxterville	Prentiss
Blanton *	Carnegie †	McLaurin *	Bibb *	Quitman *
Eustis	Chisolm †	Nankin †	Boswell	Saucier
Lakeland	Cowarts †	Norfolk *	Falkner *	Savannah
Lakewood *	Cuthbert*	Orangeburg *	Freestone	Susquehanna
Troup *	Dothan *	Ruston	Grady *	
Wadley	Esto †	Shubuta	Leefield *	
	Faceville *	Smithdale	Lorman	
	Florala *	Stilson †	Lynchburg *	
	Fuquay *	Suffolk *	Malbis	
	Greenville †	Sunsweet *	Mashulaville *	
	Harleston *	Tifton †	Myatt *	
	Heidel	Varina †	Ocilla *	
	Izagora *	Wadley *	Osier *	
	Kershaw †	Wagram *	Pelham *	

* From Guyer Pers. Comm. 2010

† From Herman *et al*. 2002

Chapter 2: Relative Conservation Utility of State-owned Lands for Species of Greatest Conservation Need

Introduction:

Publicly owned conservation lands are frequently the primary focus of conservation efforts, though private lands can often prove to be valuable contributors to species conservation (Wallace *et al*. 2008, Wilson *et al*. 2010). Most reserve networks are composed of public lands designed to contribute to the conservation of all species (Rodrigues *et al*. 2004, Tognelli *et al*. 2008). However, the contribution of reserve networks to biodiversity targets is greatly affected by privately owned areas surrounding the reserves (Hansen and DeFries 2007, Ewers and Rodrigues 2008). Management of public lands should consider the conservation contributions of surrounding areas, as some species may be low priorities if their populations are adequately maintained by management on private lands. Conversely, some species may not choose to occupy a site within a reserve if landscape cues, such as forest or non-forest area, water, *etc.*, are absent (Bergin 1992, McLoughlin *et al*. 2004, Lagory *et al*. 2009). Thus, landscape context is an important consideration when managing for species conservation, though its significance often depends on the species of interest (Gagné and Fahrig 2007, Hedenås and Ericson 2008). This suggests that managers may have to make trade-offs among species, especially in regions with high species diversity.

The state of Alabama has one of the highest species diversity rankings in the continental United States (Stein 2002). However, Alabama has also ranked second in the nation in species extinctions and fourth in the nation in the percentage of species facing extinction (Stein 2002). With limited resources available for conservation, it is imperative that efficient state conservation plans be developed to protect species of greatest conservation need (GCN species) as designated in the state wildlife conservation strategy. The state of Alabama owns and manages 109,668 hectares of protected land, 89% of which is managed by the Alabama Department of Conservation and Natural Resources (Silvano *et al.* 2008). Furthermore, per capita conservation and management funding by the state is less than would be expected based on the state's natural resources as well as demographic and political characteristics (Adelaja *et al.* 2007). Despite the fact that many GCN species once ranged extensively in the state, many, like the Southern hognose snake (Jensen 2004) and flatwoods salamander (Means 2004), have not been encountered in Alabama for over twenty years (Mirarchi *et al*. 2004). Furthermore, conservation practitioners in the state face knowledge gaps regarding the locations of populations, habitat associations and other key features of many GCN species. The Alabama Department of Conservation and Natural Resources (ADCNR) hopes to address some of these concerns through the Inventory and Conservation Planning (ICP) project which will result in the production of inventories of GCN species and conservation plans on select public lands (ADCNR 2010).

Successful conservation plans necessitate a broad perspective (Gutzwiller 2002). However, this broad perspective leads to inherently complex questions as it incorporates increasing spatial heterogeneity as the extent broadens (Turner *et al.* 2001). Spatial heterogeneity is often dealt with in terms of patch characteristics like size, shape, connectivity and arrangement. Not surprisingly, these characteristics are also important to the process of conservation network design (Shafer 1997). Aside from spatial heterogeneity, broad perspectives require increased attention to scale (Turner *et al.* 2001). Processes or features important to a species at one scale may not be pertinent at another scale, and it is therefore critical to determine the appropriate scale at which conservation strategies must be implemented. Furthermore, broad scale conservation planning has the ability to increase management efficiency (Kark *et al*. 2009). In an effort to address many of these issues, geographic information systems (GIS) have become a commonly used tool in the field of conservation (Santos *et al.* 2006, Friedlander *et al.* 2007, Brito *et al.* 2009, *etc.*) because they are particularly helpful in addressing the broad scale issues facing natural resource managers.

Through this research, we sought to assess the conservation utility of managing ICP lands in the Southeastern Plains of Alabama for GCN species. Unlike other studies that only focus on the utility or value of individual parcels of land, we assessed the value of ICP lands within a neighborhood. This allowed us to measure the management potential of each ICP property relative to other properties, the surrounding neighborhood and the entire Southeastern Plains ecoregion for the conservation of vertebrate species. Our method required development of multiple GIS data layers pertinent to the conservation of each species. Site suitability was determined to gauge ecological appropriateness of managing for a species on a certain site. This objective determined if a certain species should be managed on a site and was gleaned from available literature, soil maps, species range maps, *etc*. Potential habitat was determined to identify areas where biotic conditions required for a particular species could potentially be met. For the purposes of this analysis, biotic conditions on a site predominantly focused on the distribution and arrangement of land cover types. Land cover was assessed using data provided by the Alabama GAP Analysis Project (AL-GAP) (Silvano *et al.* 2008). We sought to inform decisions related to the management of study areas for GCN species by accomplishing two objectives. First, we wanted to determine the relative utility of each area for GCN species given the distribution and abundance of requisite resources within the state. Second, we wanted to determine the relative utility of each ICP property for GCN species given the distribution and abundance of requisite resources within the areas surrounding the properties. This analysis will provide information to assist managers in confronting the inherent trade-offs in conserving biodiversity.

Methods

Study Areas

Our study focused on public lands within the Southeastern Plains ecoregion of Alabama (Griffeth *et al*. 2001, see Figure 2.1). As part of the larger ICP project, a steering committee identified study areas that represented the highest diversity of GCN species on properties in excess of 1200 hectares. After this initial cut, the committee was left with 27 properties which were further reduced to include only areas for which the state had little information. From the remaining 13 properties that were used for the ICP project, we selected four study areas for our research: Barbour Wildlife Management Area, the Perdido River tracts, the Sipsey River tracts and Stimpson Wildlife Sanctuaries. For the sake of clarity, these study areas will henceforth be referred to as Barbour, Perdido, Sipsey and Stimpson respectively. These properties are managed for a variety of objectives and outputs. Unless otherwise noted, all management objectives were obtained from ADCNR (ADCNR 2010), and all ecoregion classifications were obtained from Griffith *et al.* (2001). Barbour included the Barbour Wildlife Management Area (WMA) and the adjacent Wehle tract of the state's Forever Wild program encompass 8,187 hectares and are located within Barbour and Bullock Counties on the Southern Hilly Gulf Coastal Plain ecoregion. The WMA is managed for big and small game hunting, and the Wehle tract is managed for habitat conservation. Perdido consisted of the Perdido River Longleaf Hills tracts, the adjacent Forever Wild Perdido Nomination and the Nature Conservancy's Perdido River parcel, which are all located along the Perdido River in Baldwin County within the Southern Pine Plains and Hills ecoregion of Alabama. Comprising 7,333 hectares, the state-owned portions of these properties are managed for habitat conservation and big and small game hunting. The timber rights on these properties are owned by a private corporation. Sipsey was composed of the Sipsey Sullivan, Sipsey Robertson and Sipsey Randolph tracts of the state's Forever Wild Program and are found along the floodplain of the Sipsey River in the Fall Line Hills ecoregion. The specific management goals for this 1,379 hectare area are habitat conservation, outdoor recreation and scientific research and education. Stimpson was made up of Fred T. Stimpson Sanctuary and the nearby Upper State Sanctuary and was located along the Tombigbee River in Clark County, Alabama. Together, the sanctuaries encompass 2,943 hectares, providing both timber production and wildlife sanctuaries. Since the 1970s, Stimpson has been the source for many translocated game animals (Stimpson Pers. Comm.).

Model Development

We derived the model parameters for our analysis from numerous sources including expert opinion, available literature and land cover data (see Chapter 1 for more information and Appendix A for a full list of species models). For this analysis we used a GIS consisting of the utility values for species of greatest conservation need in the Southeastern Plains of Alabama that were expected or observed to occur on our study areas. A map of the study area boundaries was derived from the AL-GAP stewardship layer (Silvano *et al*. 2008). Layers were subsequently clipped to the ecoregion of interest (Southeastern Plains) in Alabama and exported as binary ASCII format. We then used MATLAB® (Mathworks, Inc., use of trade product or firm name is for descriptive purposes and does not imply endorsement) to estimate a kernel density surface from the binary data (Bearday and Baxter 1996). Because density indicated where the resources important to species conservation were concentrated, we used it as an indicator of the conservation value of a site. We then combined the density surfaces using a model that treated each surface as either limiting or compensatory to the utility of a site for each species. The outputs from these analyses were imported back into ArcGIS to create maps of relative conservation utility. Statistical analyses were then conducted on these maps using the Zonal Statistics tool of the Spatial Analyst toolbox in ArcGIS. All ICP study areas of interest were buffered by 20 kilometers to determine value within a "neighborhood" surrounding the property. Utility of each study area and the surrounding neighborhood was determined by summing the values within the area of interest. We determined the elasticity of our utility estimates for all 33 species by incrementally increasing the extents and calculating the percentage change in utility relative to the percentage change in area. Finally, because our choice of neighborhood size was arbitrary, we examined relative changes in utility at several different neighborhood (buffer) sizes by determining the change in utility in proportion to the change in neighborhood area. Three species were selected for this analysis to represent wide ranging species (wood thrush), intermediately ranging species (gopher tortoise and narrowly ranging species (Eastern kingsnake).

Results

All of the maps resulting from our analysis are available in Figures 2.2 – 2.34. Average utility values for each property and neighborhood are also available in Table 2.1, and Relative values are available in Table 2.2. Statewide conservation utility varied considerably among species, though in general values were fairly low across the state when compared to local areas of high resource concentration. American kestrel (*Falco sparverius*), American black bear (*Ursus americanus*), Eastern spotted skunk (*Spilogale putorius*) and American woodcock (*Scolopax minor*) had the highest statewide utilities. Conversely, little grass frog (*Pseudacris ocularis*), Pine Barrens treefrog (*Hyla andersonii*), Southern dusky salamander (*Desmognathus auriculatus*) and flatwoods salamander (*Ambystoma cingulatum*) had negligible utilities across the state. Other species, such as Southern hognose snake (*Heterodon simus*) and red-cockaded woodpecker (*Picoides borealis*), displayed fairly low average utility across the state compared with other species. Our results also indicate that though all species included in this analysis had value within the extent of the Southeastern Plains, no ICP study areas in our analysis were appropriate for flatwoods salamander, little grass frog and Southern dusky salamander because all of the study properties are located outside the current distributions of these species.

At the considerably smaller extent of ICP study areas, several species displayed higher average utility values than others (see Table 2.1). As would be expected, the species with the highest utility values within a property often had high utility in the surrounding neighborhood, though there were a few notable exceptions. Within Barbour, Southeastern pocket gopher (*Geomys pinetis*), gopher tortoise (*Gopherus polyphemus*), Eastern kingsnake (*Lampropeltis getula getula*) and American kestrel had the highest utility values. These species all had high neighborhood values as well, though Florida pine snake (*Pituophis melanoleucus mugitus*) and Bachman's sparrow (*Aimophila aestivalis*) both displayed high neighborhood values despite mid-range values within the property. Southeastern pocket gopher, mimic glass lizard (*Ophisaurus mimicus*), gopher tortoise, Florida pine snake, Eastern coral snake (*Micrurus fulvius*) and black pine snake (*Pituophis melanoleucus lodingi*) had the highest average conservation utility values in Perdido. Again, these species had the highest utility values in the surrounding neighborhood, but conservation utility values for Eastern diamondback rattlesnake (*Crotalus adamanteus*) and river frog (*Rana hecksheri*) were among the highest in the neighborhood. Only American black bear and speckled kingsnake (*Lampropeltis getula holbrooki*) displayed high utility values within the Stimpson Sanctuaries, and only the black bear maintained those high values in the surrounding neighborhood. Within Sipsey, utility values were highest for wood thrush (*Hylocichla mustelina*), worm-eating warbler (*Helmitheros vermivorus*) and Kentucky warbler (*Oporornis formosus*), and these species maintained high utilities in the neighborhood.

Several species displayed high utility values relative to the surrounding neighborhood and state on multiple properties (see Table 2.2). Red-cockaded woodpecker displayed particularly high relative values on all ICP study areas but Stimpson. Southern hognose snake also had high relative utility on both Barbour and

Perdido. Other species had high relative values on only one property. The models for mimic glass lizard and coal skink both indicated high relative utility on Perdido. In general, Sipsey and the Stimpson did not provide high relative utility for any species and most species highest relative utility values were located on either Barbour or Perdido. One notable exception to that generalization is red-cockaded woodpecker which had its highest relative utility in Sipsey.

Elasticity analysis revealed that most utility estimates were fairly close to unit elastic (see Table 2.3). There were, however, a few notable exceptions. Less than one percent increase in area resulted in approximately four percent increase in utility for mimic glass lizard and coal skink in the Stimpson and Barbour neighborhoods, respectively. Similarly, less than one percent increase in area resulted in approximately two percent increase in utility for Eastern kingsnake in the Stimpson neighborhood. State-wide utility for all species was particularly insensitive to increases in area size, though little grass frog proved most sensitive at this extent. The fact that the frog's range barely extends into the state presumably contributed heavily to the fact that less than one percent increase in area resulted in approximately one percent increase in utility. Several species ranges did not extend into some neighborhoods, resulting in exclusion of these species from sensitivity analysis on those neighborhoods.

Our examination of changes in neighborhood size revealed similar results (See Table 2.4). Most species (including the narrowly ranging species in most neighborhoods) were either fairly inelastic or close to unit elastic; that is, the change in utility was either less than or proportionate to the change in neighborhood area. However, as with our initial elasticity analysis, there were exceptions. Eastern kingsnake utility estimates were extremely elastic (i.e., change in utility was greater than proportionate change in area) when the neighborhood size was increased to a 50 km buffer around Stimpson. Alternatively, there was no utility for Eastern kingsnake calculated in the neighborhood when the buffer was reduced to 5 km. These results are what we would expect with areas close to the edge of a species' range: large increase in relative utility as the size of the neighborhood increases when there is little to no utility within the property.

Discussion

Utility estimates across the Southeastern Plains ecoregion reflect the availability of resources that are potentially important to the conservation of GCN species at a broad extent. These estimates could, therefore, be used to prioritize conservation effort among species within the region. Decisions based on these utility values would be affected by the accuracy of the range maps we used. If our range maps over-predicted the actual range of a species in the state, then we will have over-estimated the value of the region to the overall conservation of that species and vice versa. Fortunately, our sensitivity analysis indicates that range inaccuracies would not significantly alter those statewide estimates for most species as elasticity was negligible for most species models at the extent of a species' range. For prioritizing actions at local extents, however, the inaccuracy of range maps could have caused us to assign value to study areas that were outside of the actual range of some species and to assign no value to study areas that were actually within the range of others. This was most likely to occur when study areas were on the margins of a species' range. These observations highlight the significance of the range maps used in analyses like this and suggest that one way of making better informed decisions using this tool would be by developing more accurate range maps. It is also important to note that, since range map inaccuracies would affect utility estimates differently, decisions at broad extents should use our statewide estimates while decisions at more local levels should incorporate additional information.

Utility estimates at the neighborhood level indicate the available resources immediately surrounding our ICP study areas. These estimates could therefore be used to choose between competing conservation needs on a more local scale. For instance, high utility values in the neighborhood adjacent to a study area might be helpful in identifying potential land acquisitions. If accompanied by stable populations on ICP study areas, high neighborhood utility might also indicate an opportunity for existing populations to act as source populations that could colonize neighboring suitable habitat. However, if low or unstable population numbers accompany high neighborhood values, that could indicate that either our potential habitat models are inadequate or habitat resources are not being managed appropriately. Low neighborhood values could also be important in guiding conservation decision making. Low neighborhood values for a species with a large or stable population on an ICP study area might indicate a study area that is very important to the conservation of that particular species. However, ICP study areas with a small, unstable population of a particular species with low utility in the surrounding area could represent an area that might be better used by devoting its resources to other species, particularly if that species is well represented elsewhere in the state’s reserve system. A key point to remember from each of these examples is that without the context provided by population vital rates, population viability analyses, or inventories, interpretation of neighborhood utility can be misleading. However utility estimates could prove quite informative when paired with the appropriate contextual data.

Utility estimates on ICP study areas reflect concentrations of important resources for the conservation of GCN species in areas that will be managed for the preservation of those species in perpetuity. This continuity gives these study areas added utility because most private lands cannot offer the same stability. According to our models, Barbour and Perdido presented the most conservation utility for fossorial GCN species such as black pine snake, Florida pine snake, gopher tortoise and Southeastern pocker gopher. Considering the large area encompassed by each of these properties, they could prove to be very valuable for the conservation of these species within their region over a long period of time. In some cases, one part of a study area might have high utility for a particular species or suite of species, while having low utility for these species in other parts of the study area. For example, consider the situation of the Florida pine snake on Barbour. According to our estimates, the southeastern portion of Barbour harbors the highest concentration of resources needed by Florida pine snake in the area (see Figure 2.15). This information could be used to justify concentrating management and resources for that species in the southeastern portion of the property while managing other species elsewhere in Barbour.

Of course, conservation management should never take place in a vacuum, as indeed we have noted that surrounding lands can contribute to conservation. This point highlights the significance of our relative utility values which indicate the conservation utility for a given species found on a particular study area relative to the utility available in the state and neighborhood. Though these estimates are all quite small, they vary greatly between species and between ICP study areas. Thus, they can be used to inform decisions when multiple species are in competition with one another for resources (money, management effort, area, etc.) on a particular property. These estimates can also be used to compare the relative importance of each study area for a particular species. However, estimates of relative conservation utility can seem confusing without context. For example, our red-cockaded woodpecker model indicated that the Sipsey had high relative utility for red-cockaded woodpecker. These findings make little sense considering the fact that the property does not meet the species' minimum patch size requirement (see Appendix B) and does not seem to provide suitable habitat. However, we suspect that since all conservation lands received positive value in our models, even public lands with little to no appropriate habitat could have higher utility than the surrounding neighborhood. In such a case, that property would represent a high proportion of the utility in that area relative to what is available in the neighborhood without actually being very important to a particular species. This appears to be the case with our red-cockaded woodpecker model on Sipsey. This situation highlights the fact that these relative values should not be considered alone. Our relative values should always be informed by population models and other contextual information when available.

For the species we examined, the choice of neighborhood sizes from the area 5 – 50 km surrounding each study area had little effect on wide or moderately wide-ranging species. However, for species with restricted distributions, and those whose range extents were largely outside of our region of interest the results were equivocal or misleading. Thus the results of this type of analysis should be viewed with caution in those cases.

Considering these guidelines, it becomes possible for us to make some conclusions about the importance of each study area for the conservation of GCN species. According to our estimates, Barbour and the Perdido have high relative utility for red-cockaded woodpecker (see Table 2.26). There simply are not many properties of this size within the state, and our models indicate that because of this these two properties could be very important for the conservation of red-cockaded woodpecker across the region and within their neighborhood. Additionally, because both study areas have similar soil qualities, our models indicate that both Barbour and Perdido have high utility for many of the fossorial GCN species, particularly Florida pine snake, gopher tortoise and Southeastern pocket gopher on Barbour and black pine snake, Eastern coral snake, Florida pine snake, mimic glass lizard and Southeastern pocket gopher on Perdido (see Table 2.1). The neighborhood values for these species and properties are also fairly high, resulting in rather low relative utility (see Table 2.2). This indicates that the importance of these properties for these particular species may not be very high within the region or the neighborhood, but they still represent excellent opportunities to manage for these threatened species.

Because of its smaller size, interpreting our relative utility estimates on Stimpson is difficult. In our example with the red-cockaded woodpecker, smaller properties with low values in both the study area and the surrounding neighborhood can result in unexpectedly high relative utility. However, by checking relative utility estimates against study area and neighborhood utility values, the interpretation becomes clearer. For example, our estimates indicated fairly high relative utility for speckled kingsnake on Stimpson (see Table 2.2) because, contrary to our red-cockaded woodpecker example from this property, the available utility for speckled kingsnakes is actually fairly high (see Table 2.1). For this reason, our models indicate that Stimpson could be an important property for speckled kingsnakes within the region as well as the surrounding neighborhood. We should also point out we found very high utility values for American black bear on Stimpson. Though high neighborhood values for the species diminish the relative utility of the property, Stimpson could prove to be an important stepping stone for black bears attempting to disperse from their current stronghold in the southeastern portion of the state.

Sipsey is another case where relative utility estimates are best used when informed by our study area and neighborhood utility estimates. Our models indicate that the property represents fairly high relative utility for Swainson's warbler and a few other species (see Table 2.2). However, Swainson's warbler is the only species with fairly high study area utility estimates (see Table 2.1), indicating that the property is likely important for this warbler but not the other species. Study area utility estimates are also particularly high for Kentucky warbler, worm-eating warbler and wood thrush. As with the black bear on Stimpson, neighborhood values for these species are also high and the relative importance of the property is somewhat low across the region. However, these maps indicate that Sipsey represents an excellent management opportunity for these species.

One potential shortcoming of this research is the use of GAP data, which has come under scrutiny from several sources for its inherent assumptions and shortcomings most of which revolve around issues of scale and assumed accuracy of data (Conroy and Noon 1996, Flather *et al.* 1997). Conroy and Noon (1996) also point out that the uncertainty associated with these assumptions should always be explained to resource managers. Finally, it has been noted that broad scale analyses often cannot account for certain fine scale features and that fine scale management resulting from broad scale analyses may sometimes be somewhat misguided (Conroy and Noon 1996, Rouget 2003). In our study, there were several resources important to the management of GCN species that could not be mapped. For example, though information on long-tailed weasels is scarce, some sources indicate that prey density is a good indicator of long-tailed weasel habitat (Mitchell and Sievering 2004). We were unable to model prey density because those data were not available at the time of our analysis. Plentovich *et al*. (1999) found that Henslow's sparrows in Alabama preferred pitcher plant bogs, a habitat feature that is below the spatial resolution of our data and therefore could not be mapped for our analysis. These issues could result in difficulty when attempting to scale down our findings for on-the-ground management actions. Regardless of the implications of these assumptions, at the time of this research, the satellite imagery used to develop AL-GAP data are over ten years old. Undoubtedly, many landscape features have changed since these data were generated, introducing unwanted uncertainty into our analysis.

This study focused on vertebrate GCN species occurring in the Southeastern Plains of Alabama, but there is no reason it could not be extended to encompass other regions or other states. In fact, the neighborhood estimates conducted in this analysis could be quite helpful in any number of conservation situations. Furthermore, this type of analysis could be useful with other species, not just species of greatest conservation need. Management decisions are made regarding common species as well as GCN species, and our utility estimates could easily be used to inform those decisions. That being said, we would probably not recommend that these types of analyses take place across several ecoregions because it might become difficult to accurately apply our utility estimates to a decision making process across such varied landscapes.

Acknowledgements:

First and foremost, we thank Dr. Mark MacKenzie for initiating and inspiring this research. We would like to thank Max Post – Van der Burg for his contributions to earlier drafts. Will McDearman, Eric Soehren, Val Johnson and Craig Guyer are all greatly appreciated for their input on soil classifications. We thank Kevin Kleiner and Tyler Krepps for their assistance during the GIS components of this project. This research was funded through the Alabama State Wildlife Grants Program as part of the Inventory and Conservation Planning project coordinated by the Alabama Cooperative Fish and Wildlife Research Unit. The ALCFWRU is a partnership between the U.S. Geological Survey, the Wildlife Management Institute, the Alabama Department of Conservation and Natural Resources, Auburn University and the U.S. Fish and Wildlife Service.

Figure 2.1: ICP study areas in the Southeastern Plains of Alabama

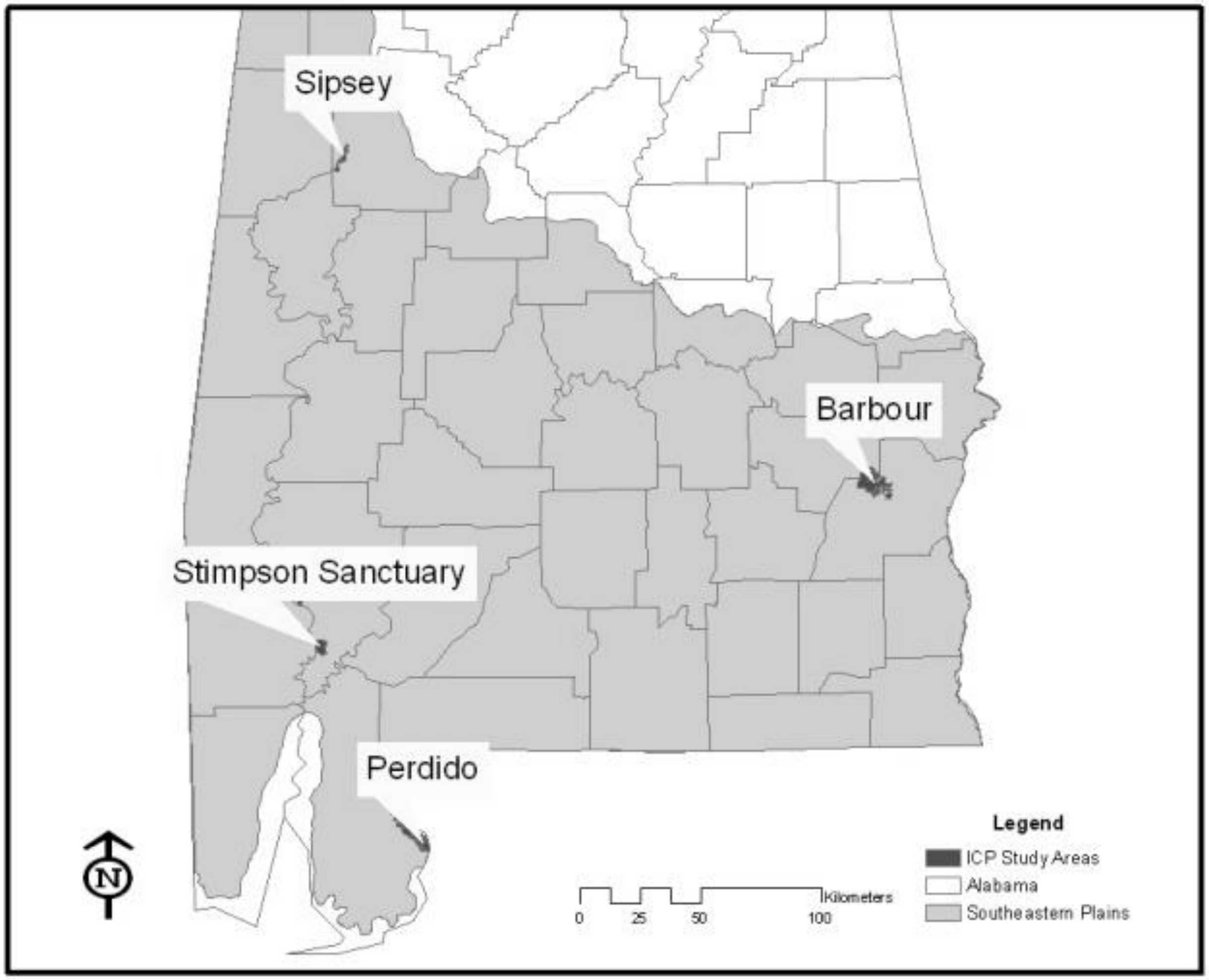

Figure 2.2: Utility Maps for alligator snapping turtle on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

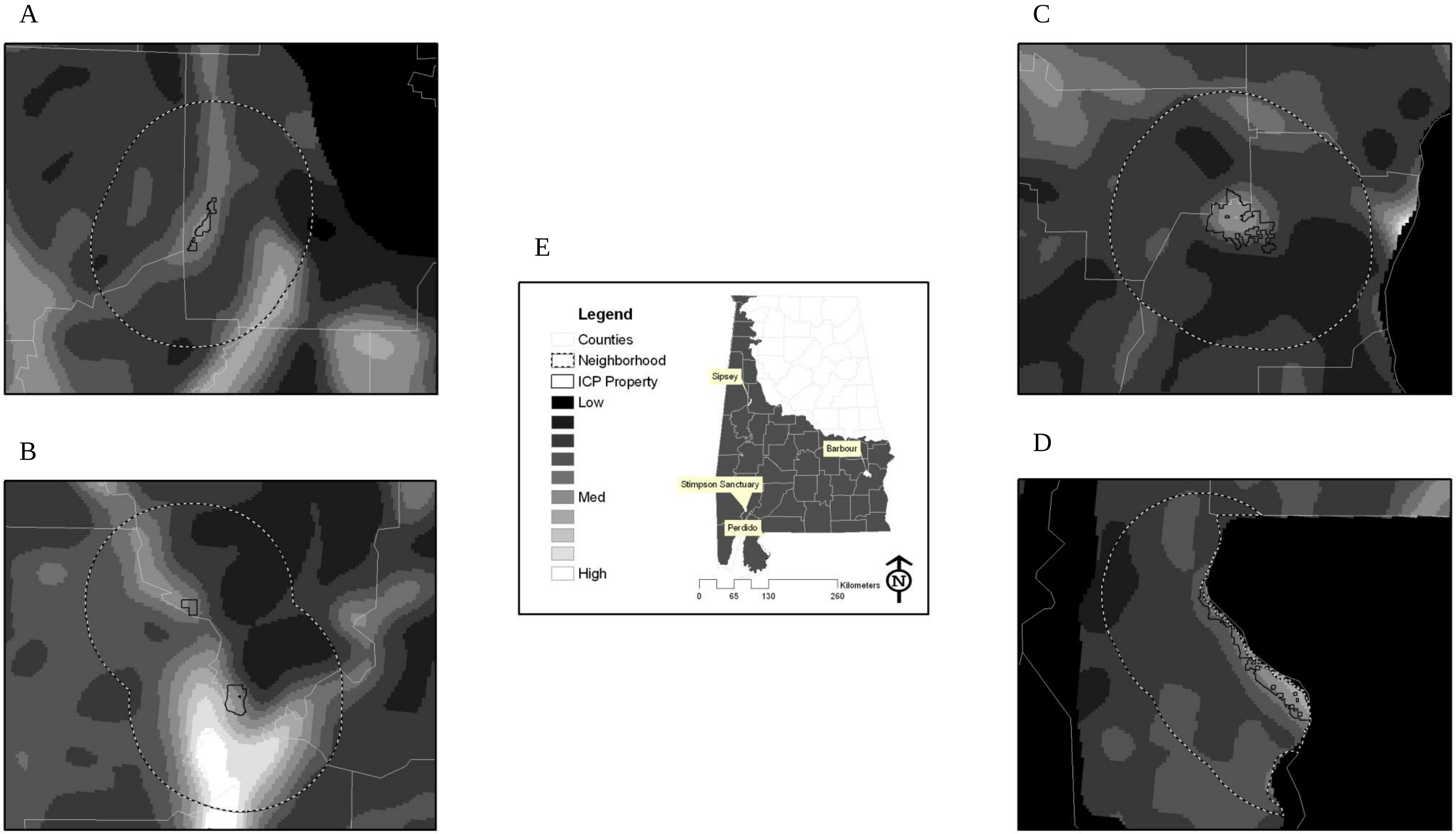

Figure 2.3: Utility Maps for American black bear on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

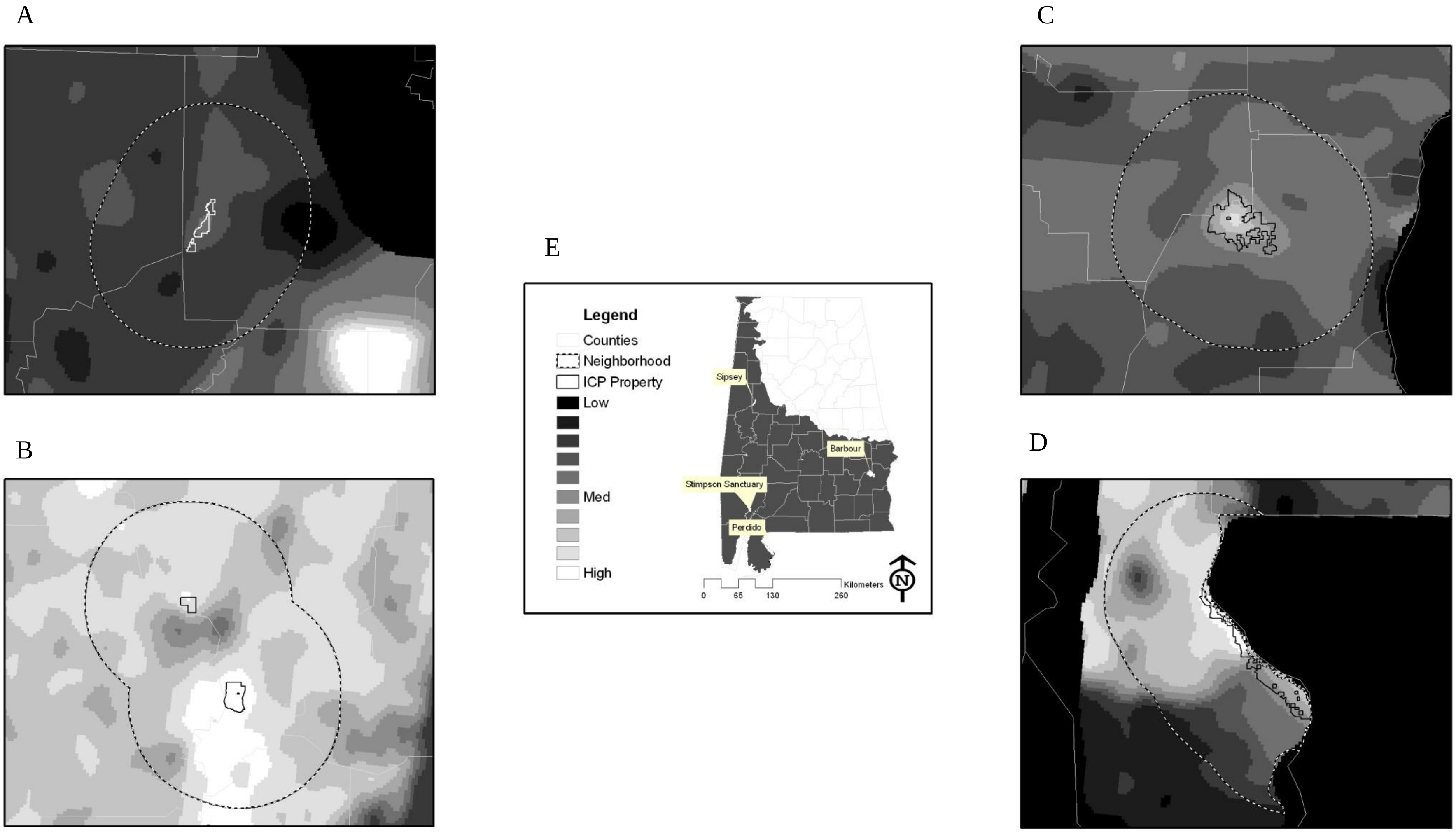

Figure 2.4: Utility Maps for American kestrel on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

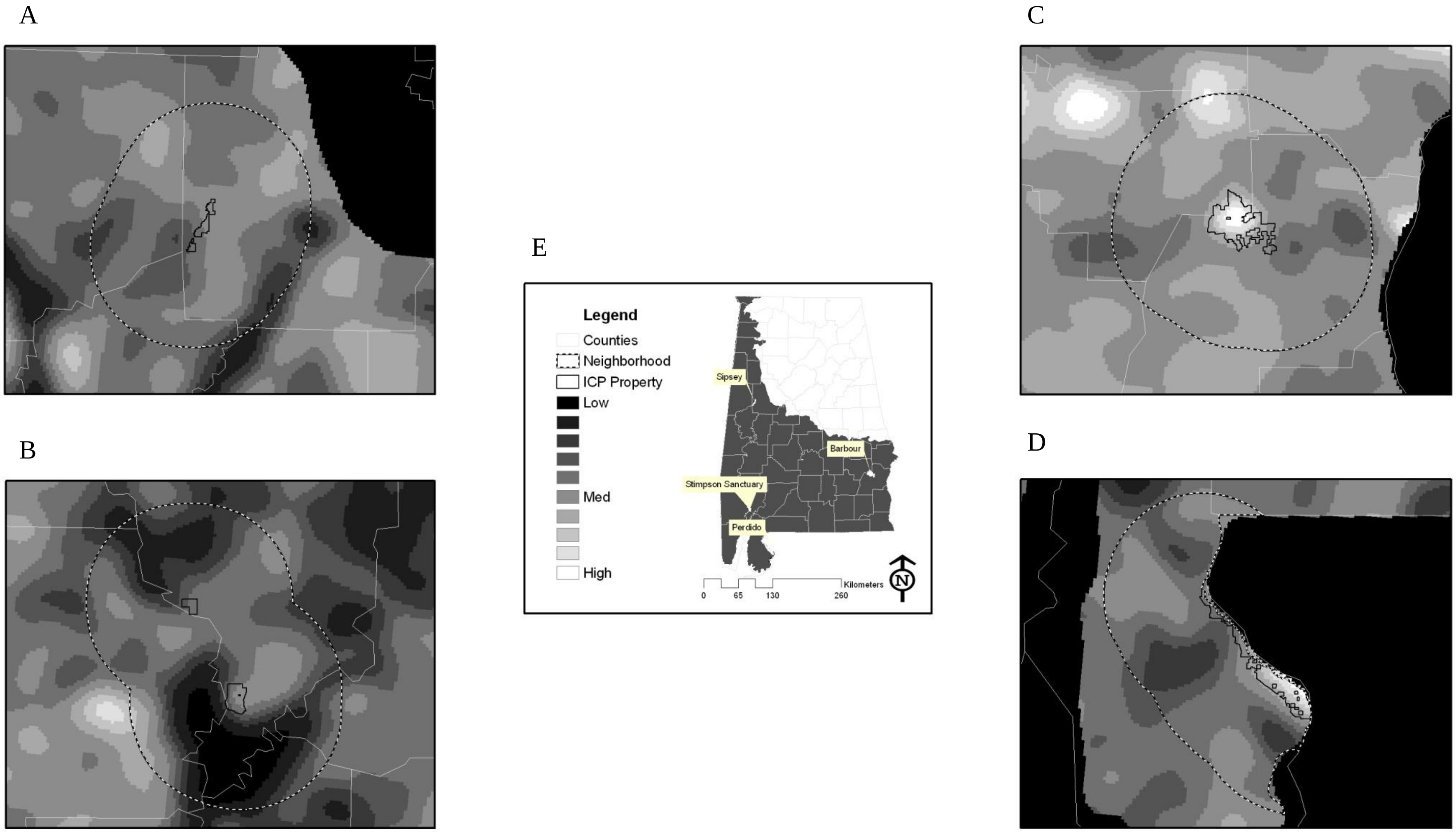

Figure 2.5: Utility Maps for American woodcock on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

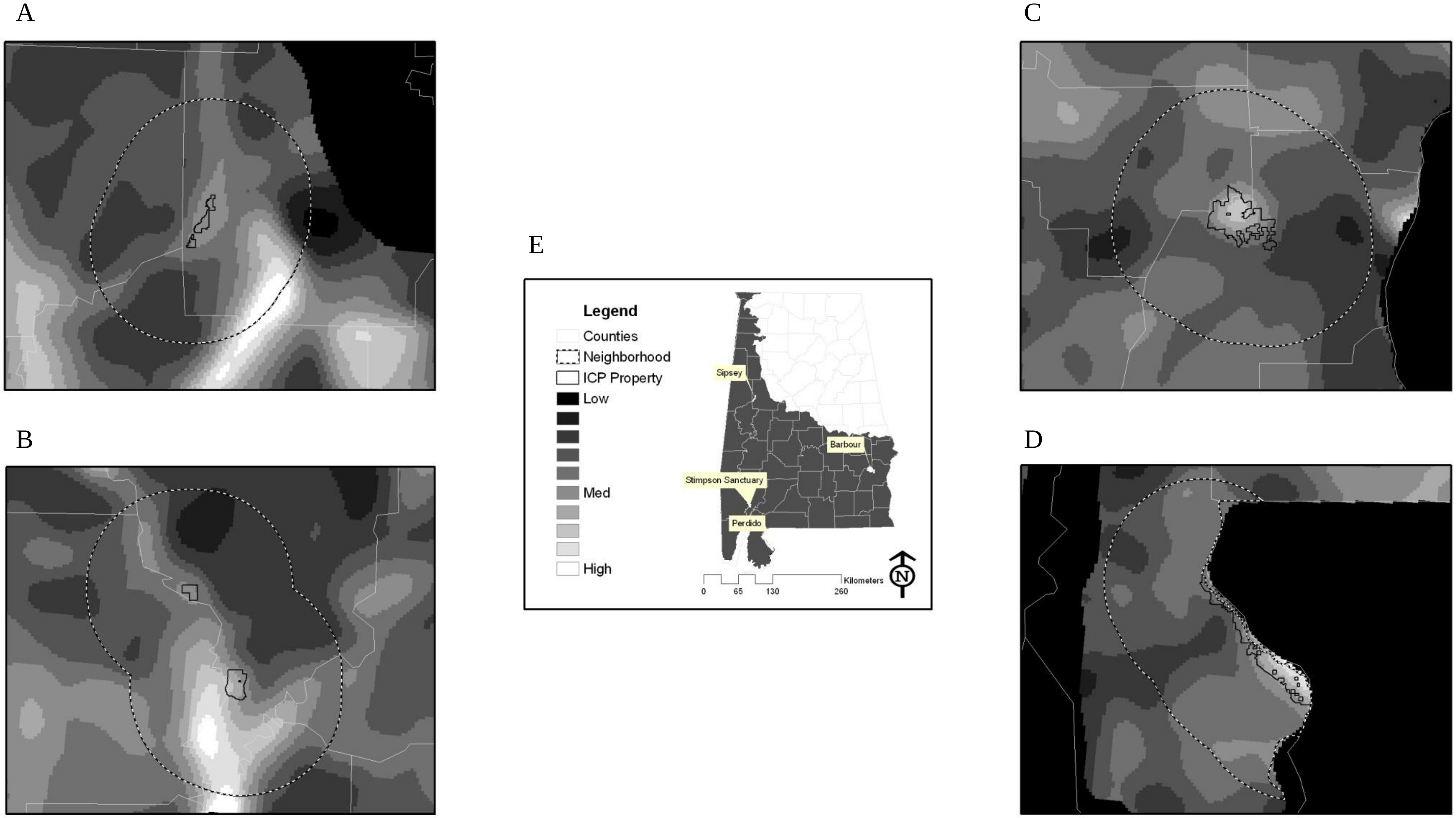

Figure 2.6: Utility Maps for Bachman's sparrow on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

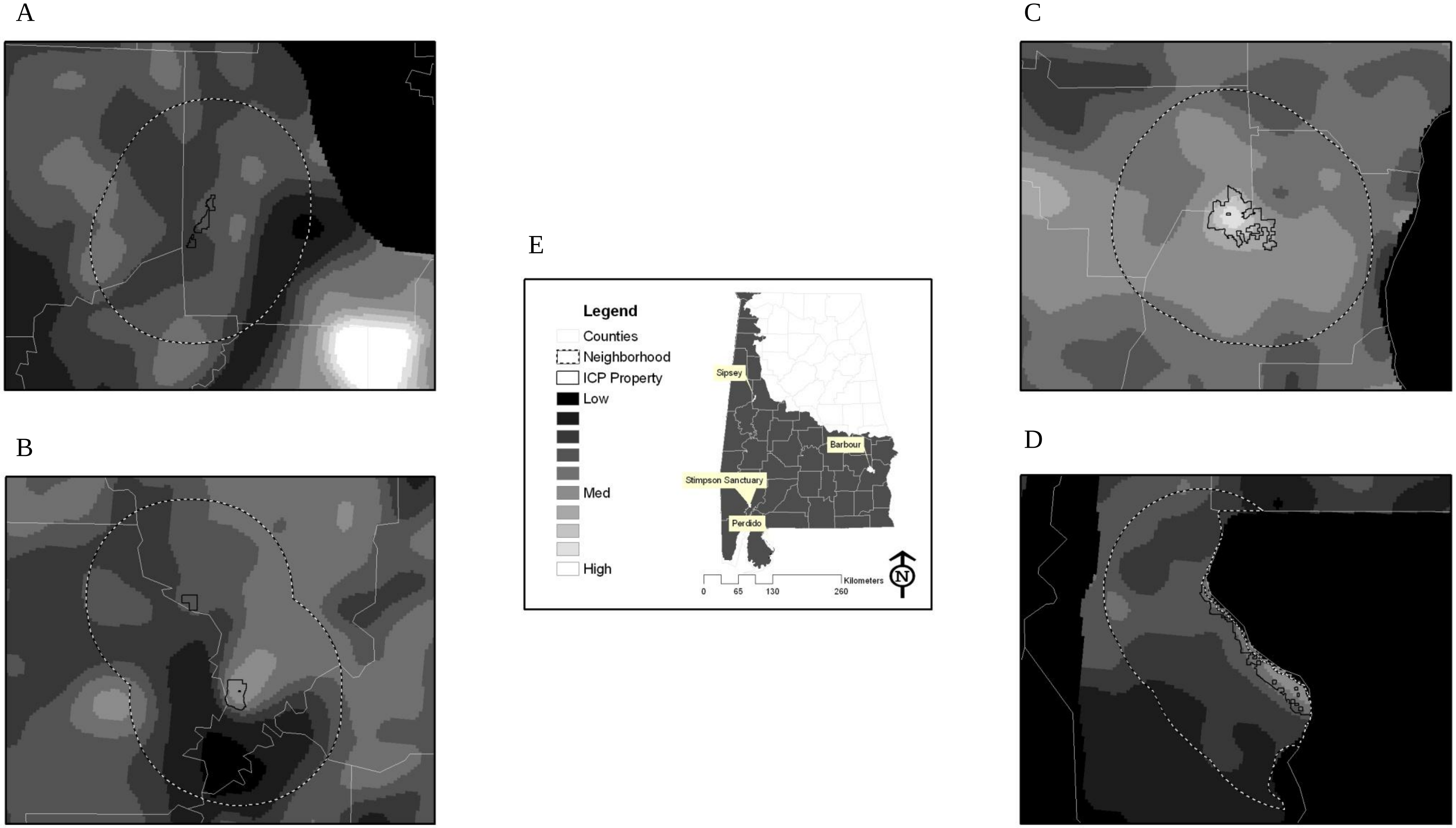

Figure 2.7: Utility Maps for black pine snake on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

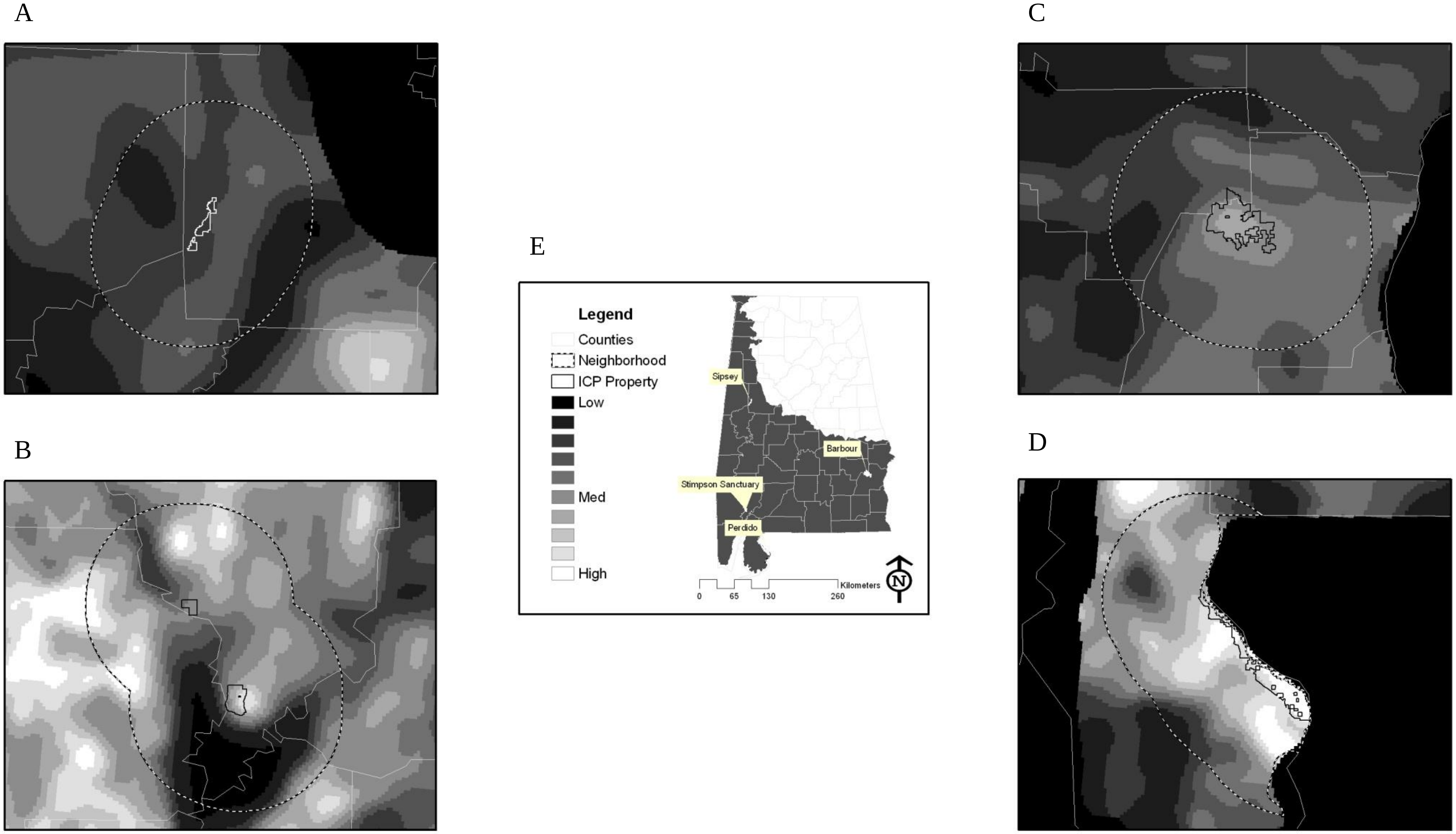

Figure 2.8: Utility Maps for coal skink on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

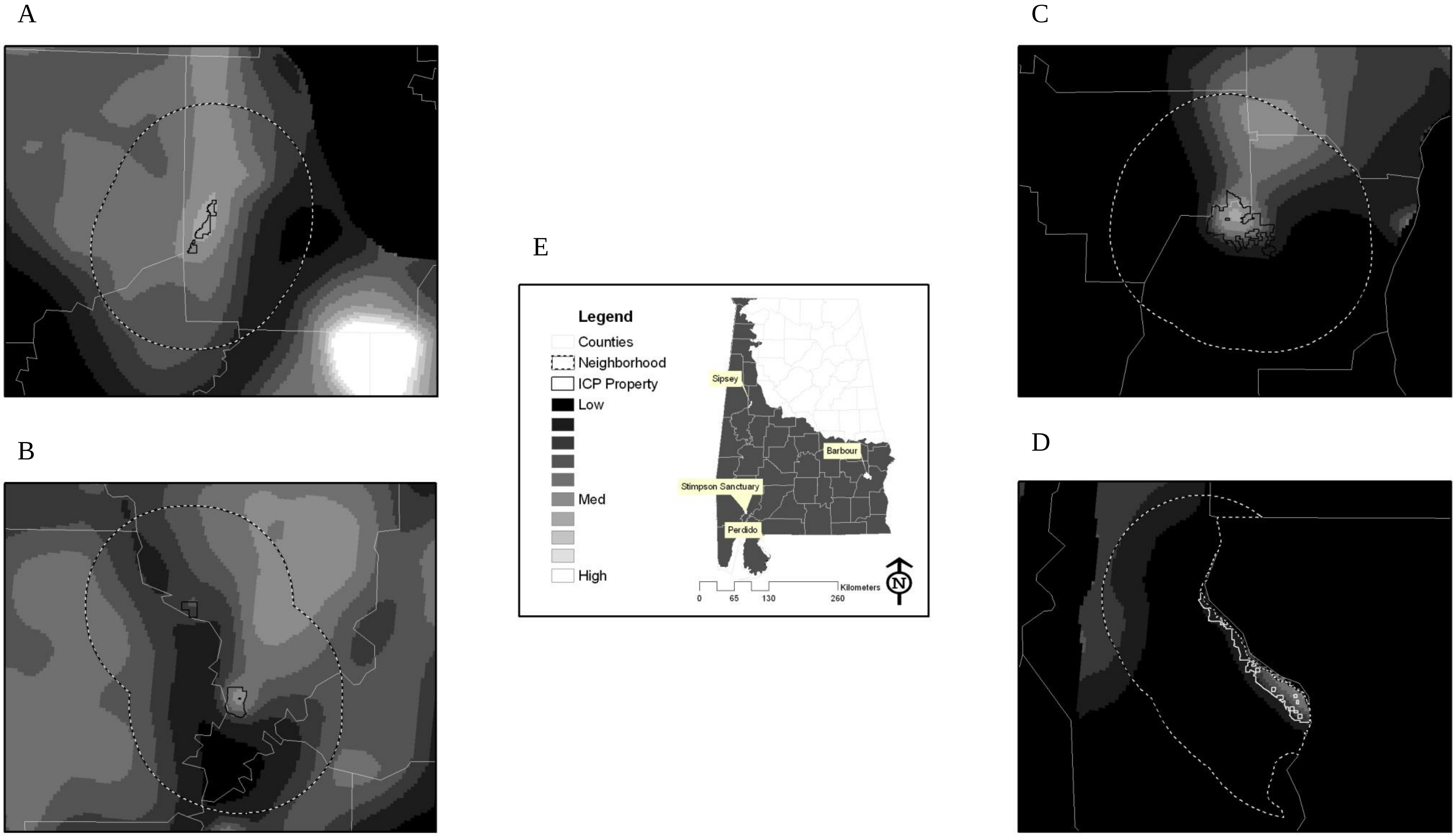

Figure 2.9: Utility Maps for Eastern coral snake on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

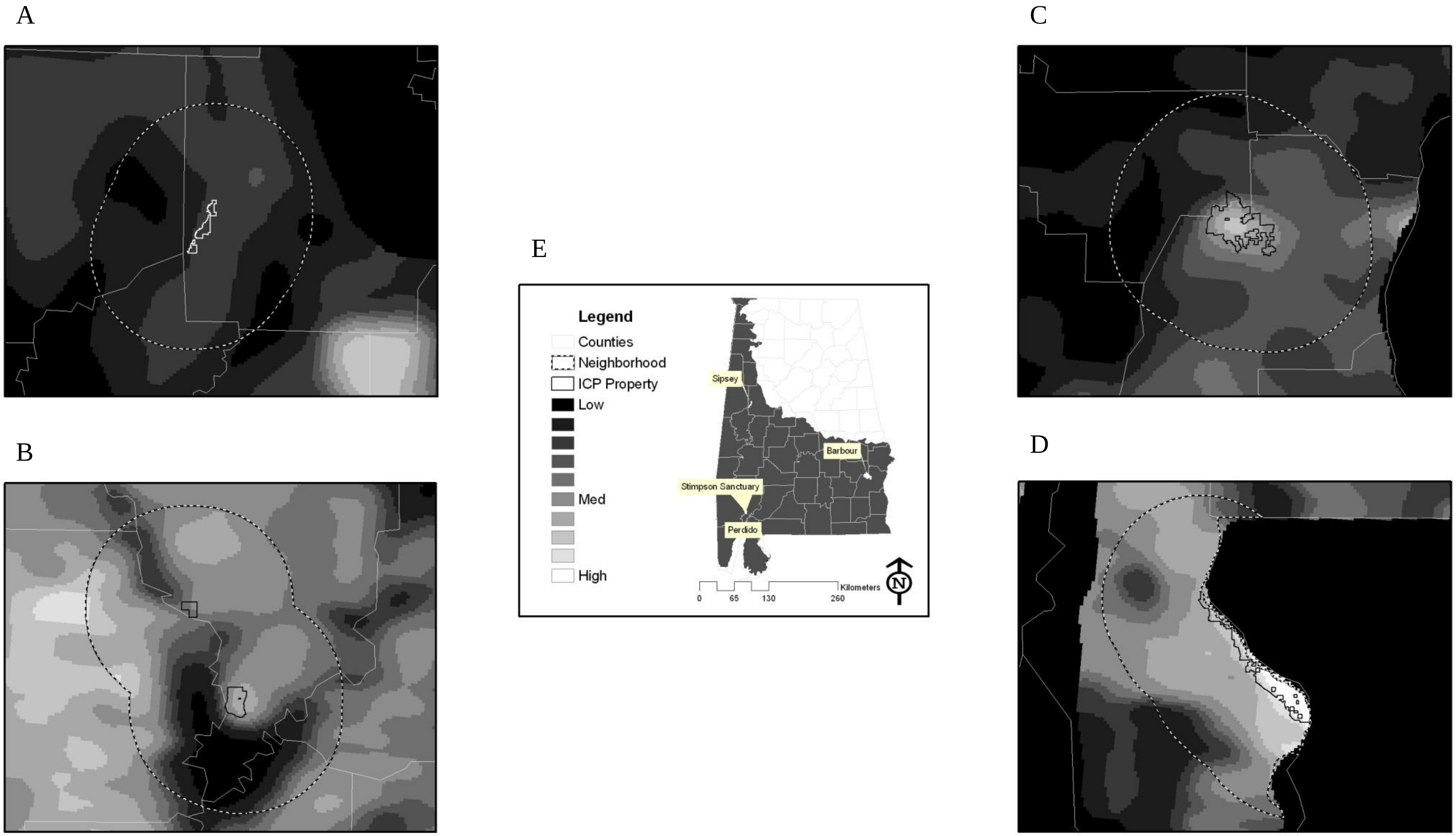

Figure 2.10: Utility Maps for Eastern diamondback rattlesnake on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

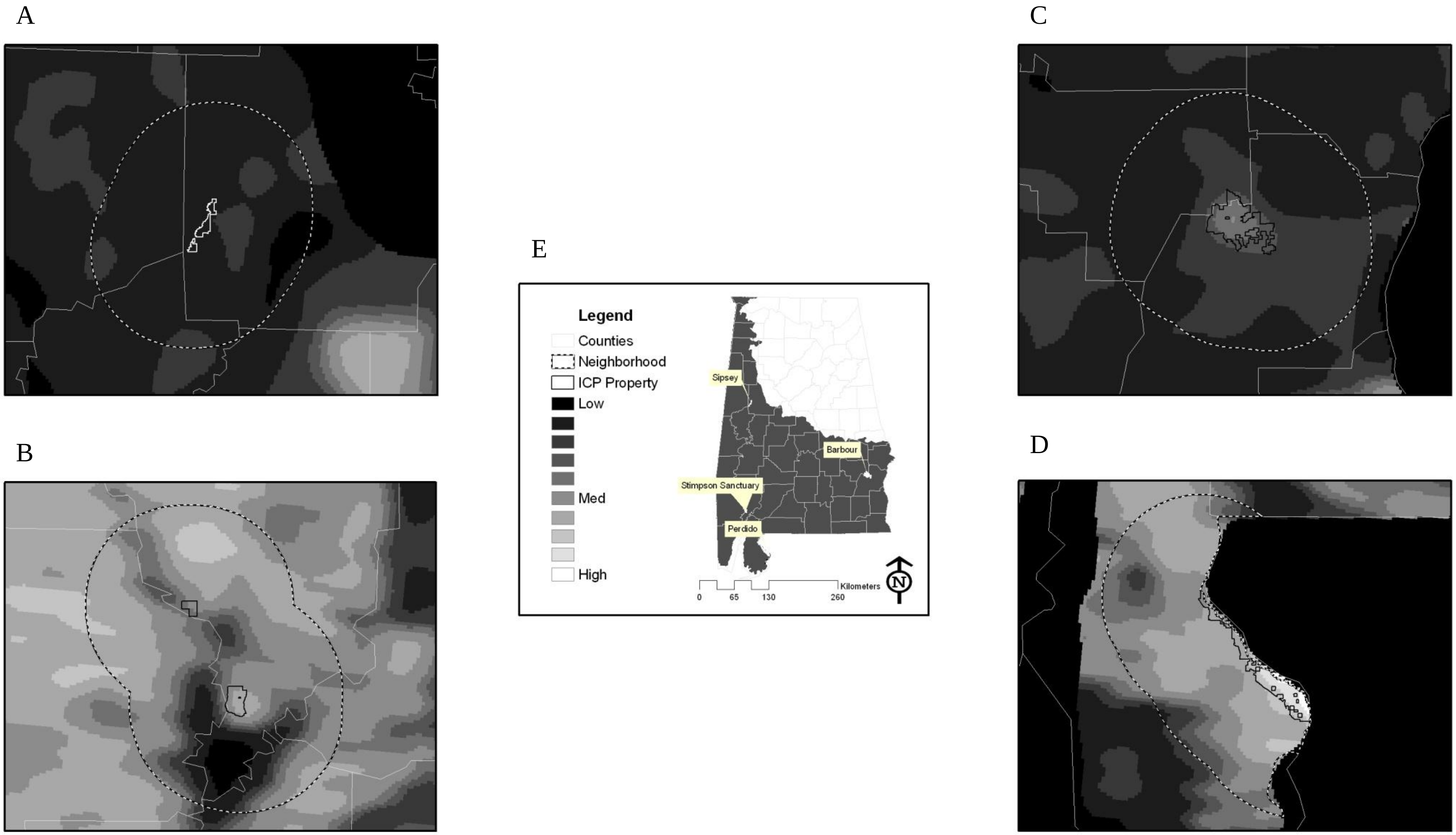

Figure 2.11: Utility Maps for Eastern indigo snake on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

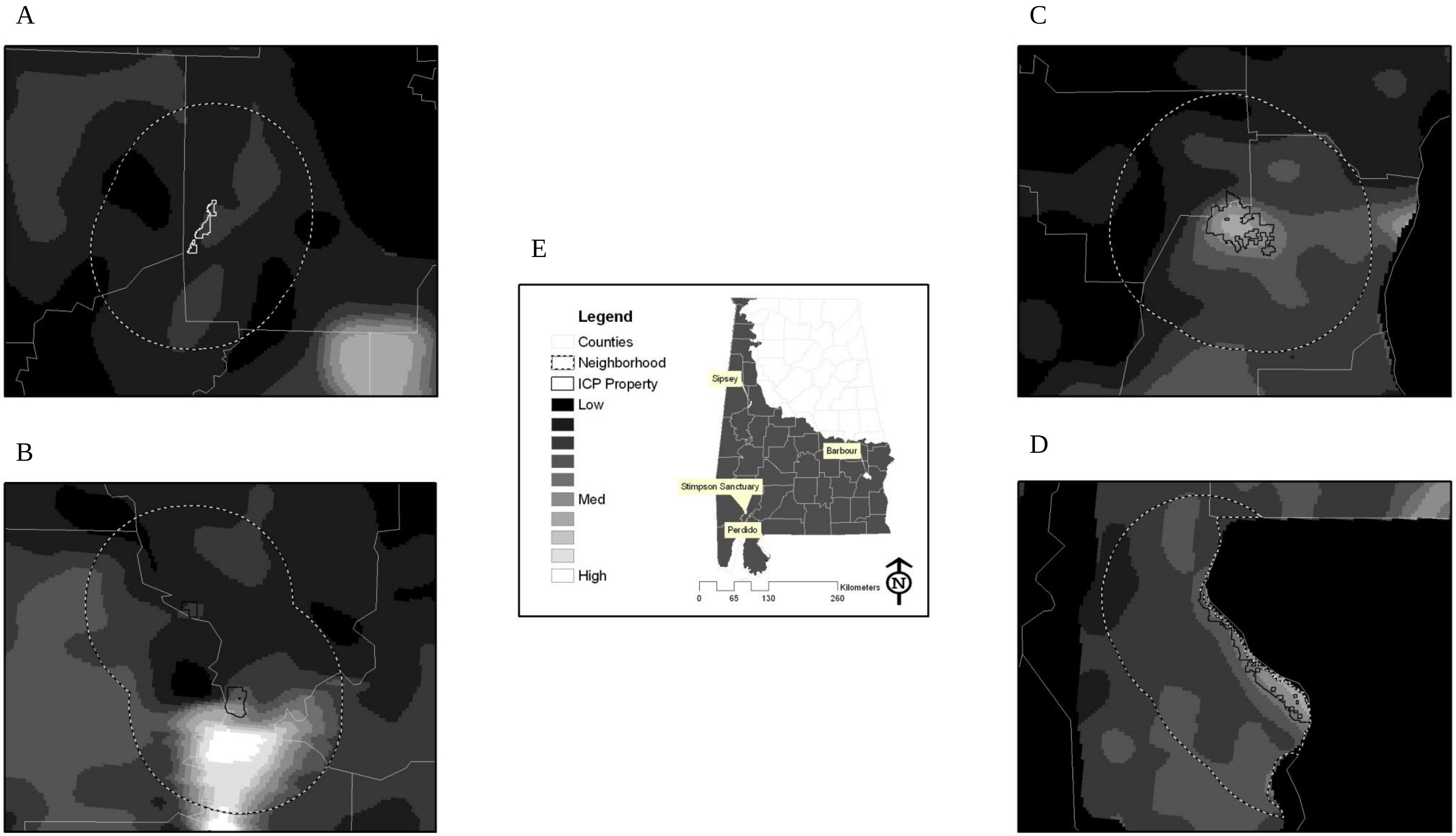

Figure 2.12: Utility Maps for Eastern kingsnake on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

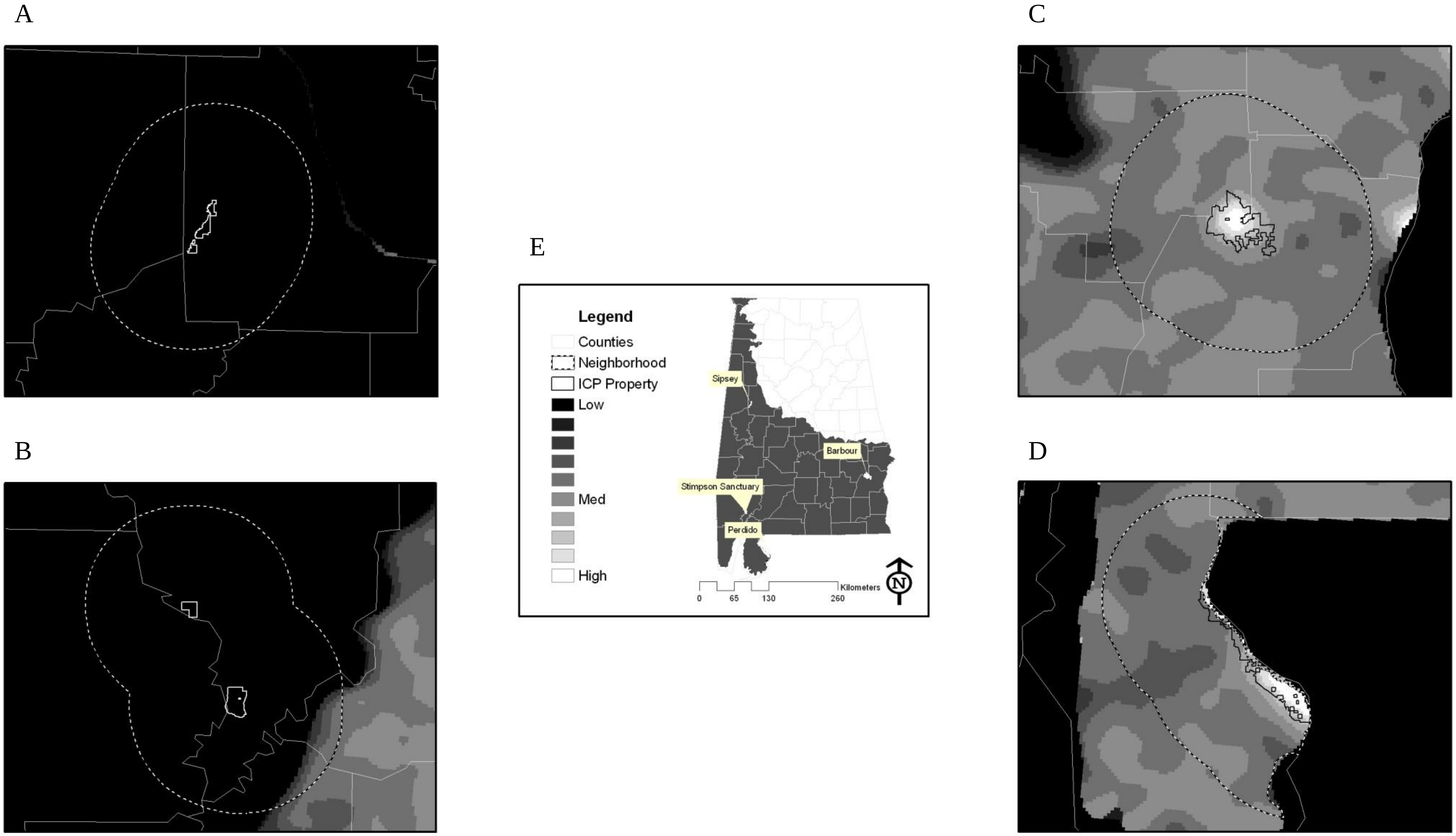

Figure 2.13: Utility Maps for Eastern spotted skunk on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

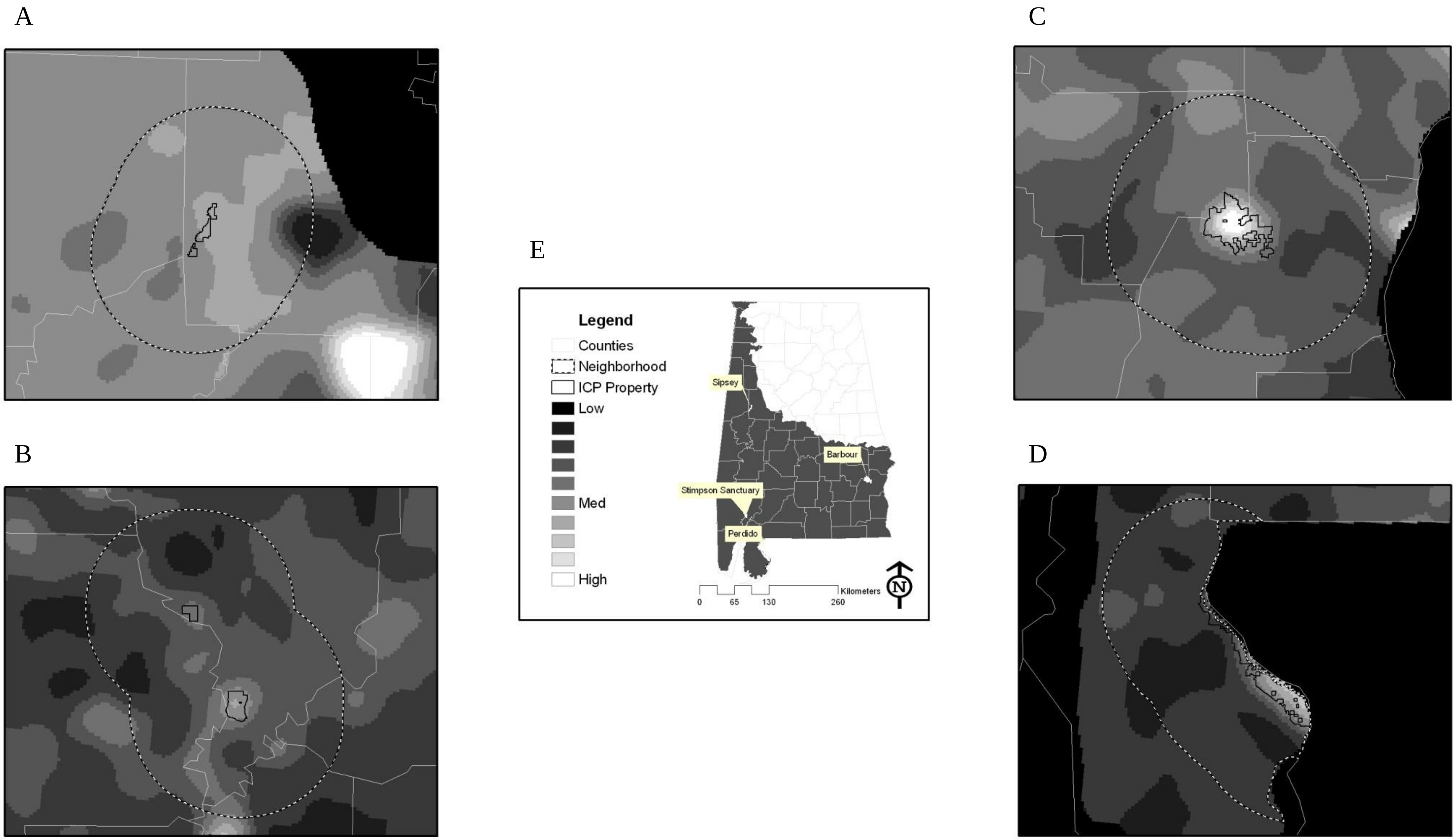

Figure 2.14: Utility Maps for flatwoods salamander on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

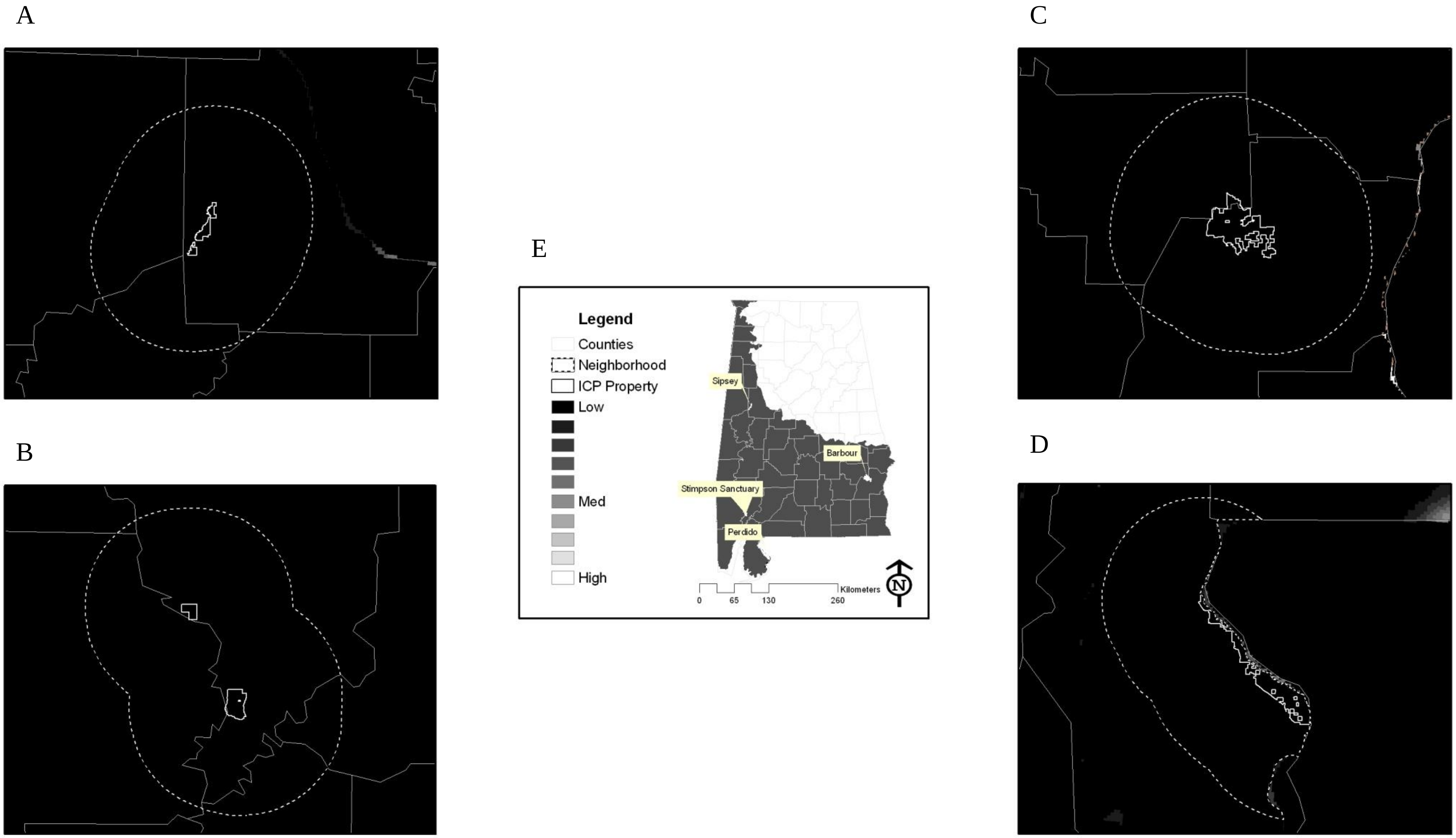

Figure 2.15: Utility Maps for Florida pine snake on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

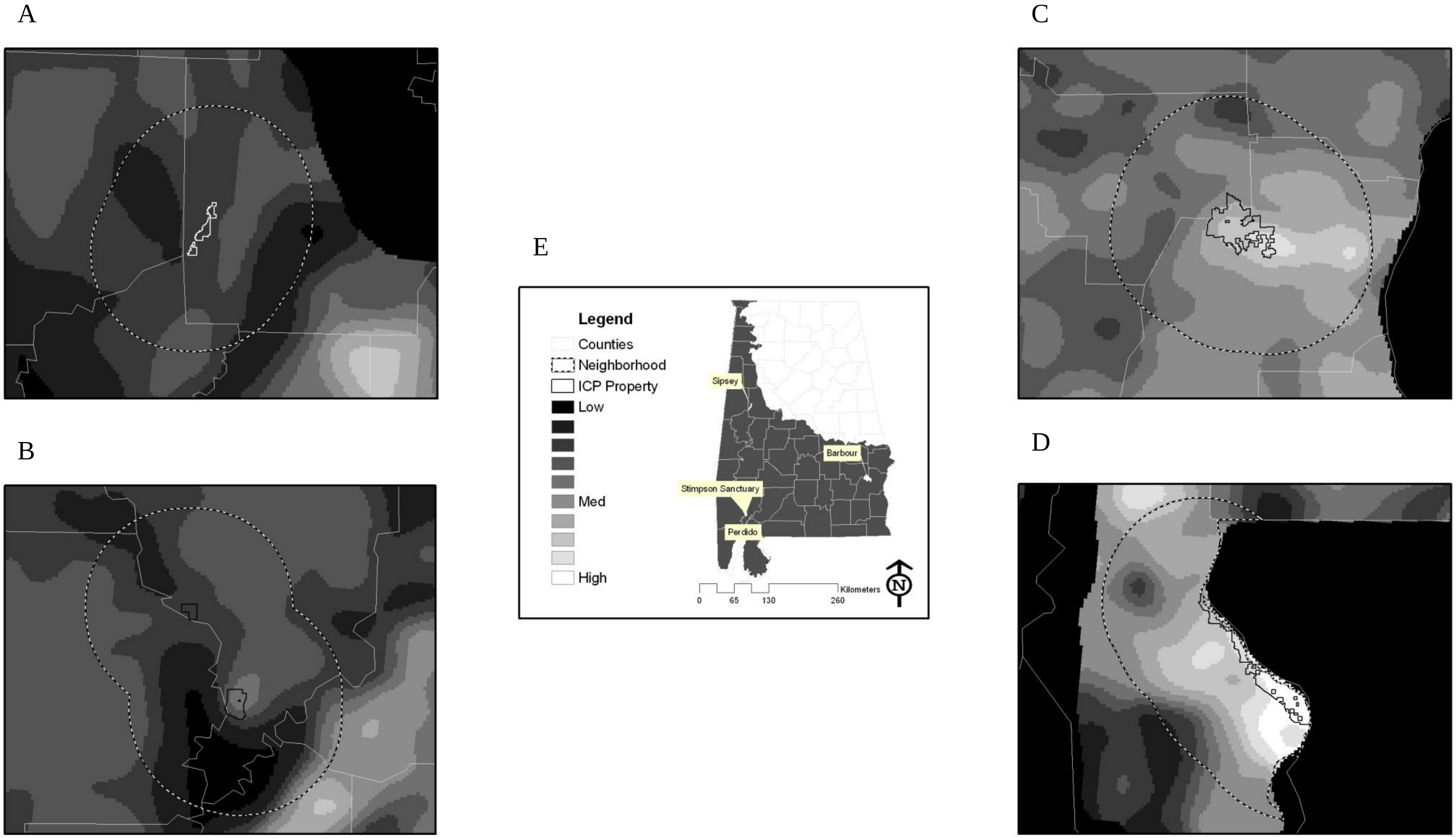

Figure 2.16: Utility Maps for gopher frog on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

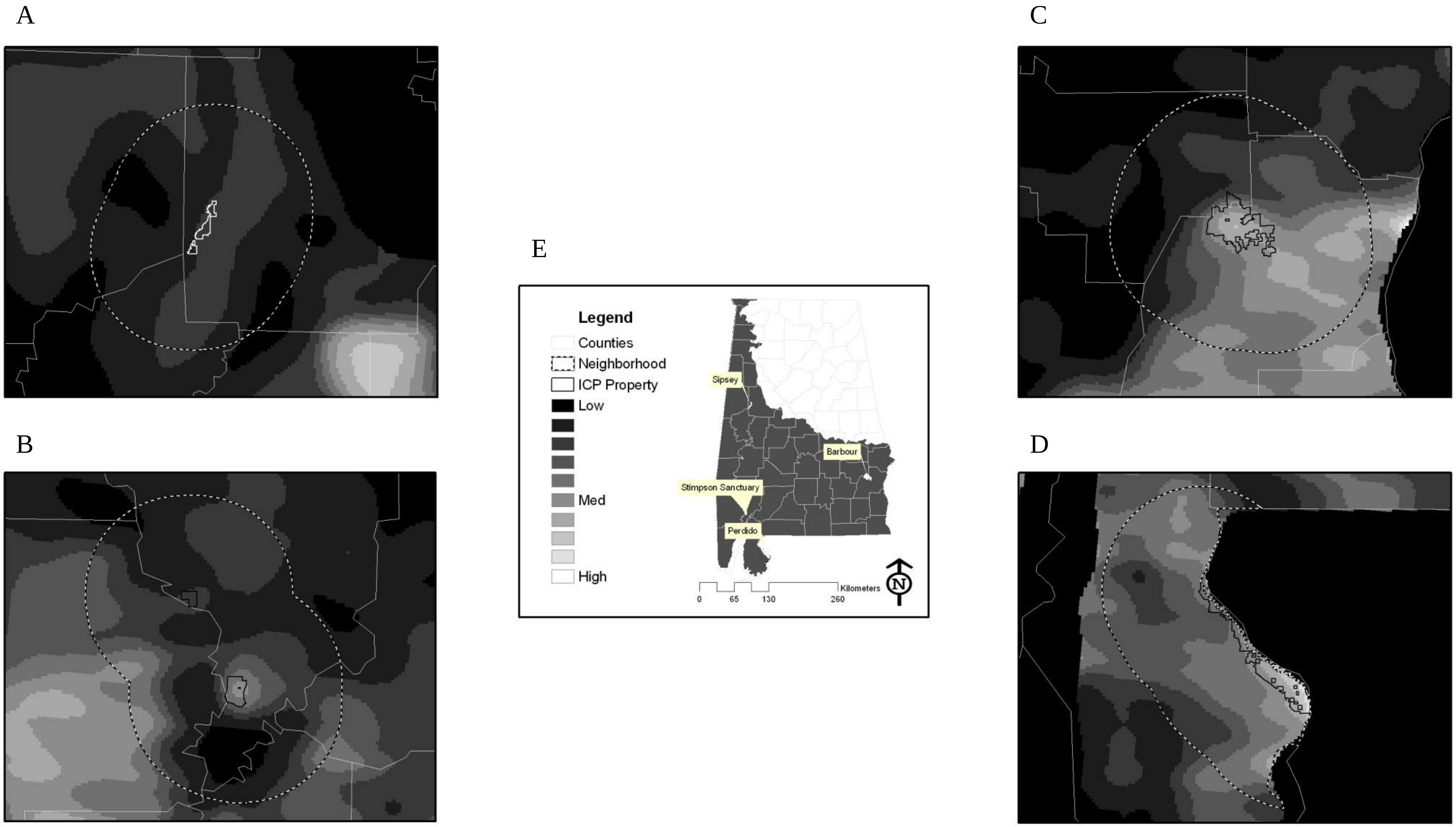

Figure 2.17: Utility Maps for gopher tortoise on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

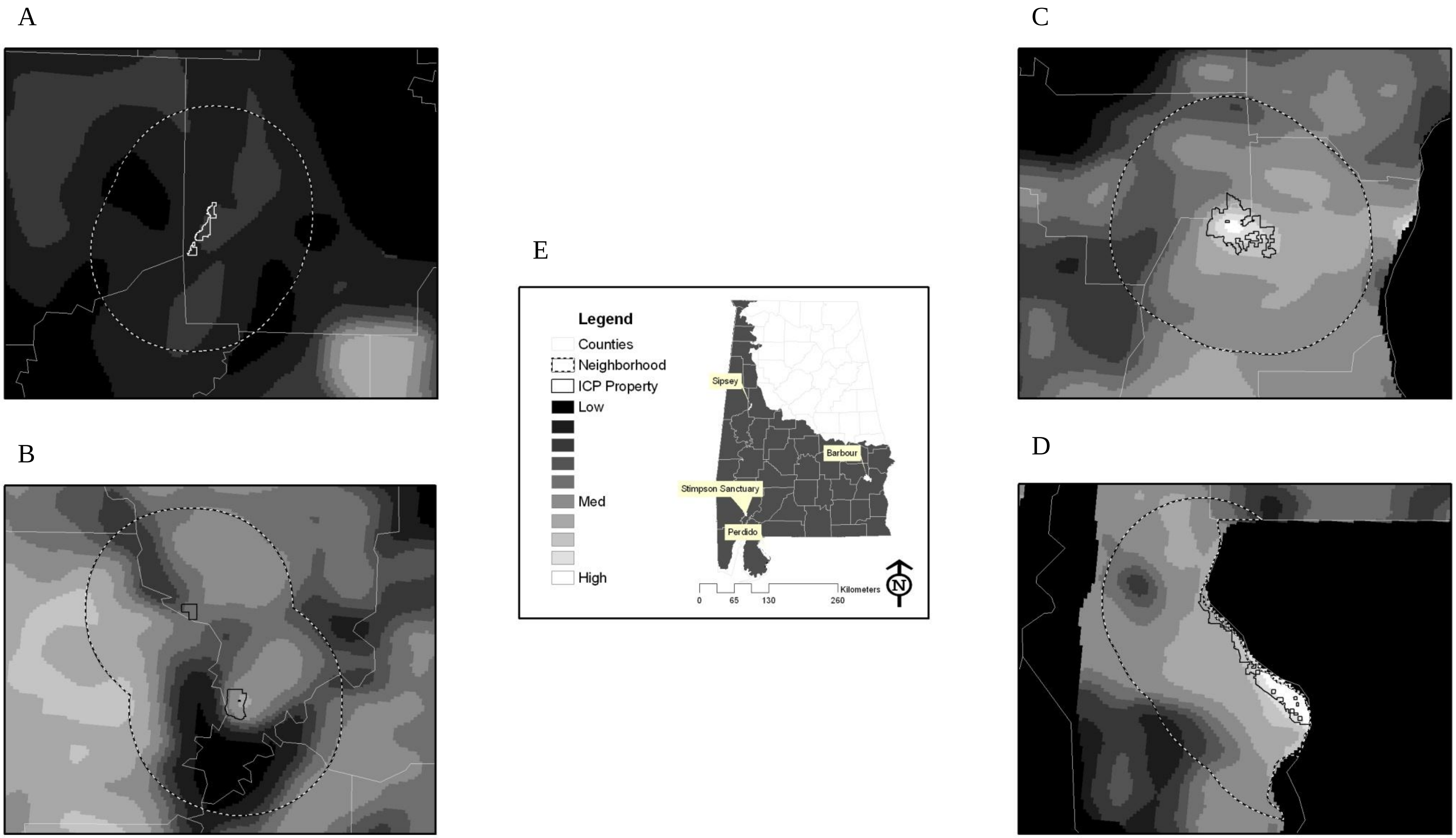

Figure 2.18: Utility Maps for Henslow's sparrow on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

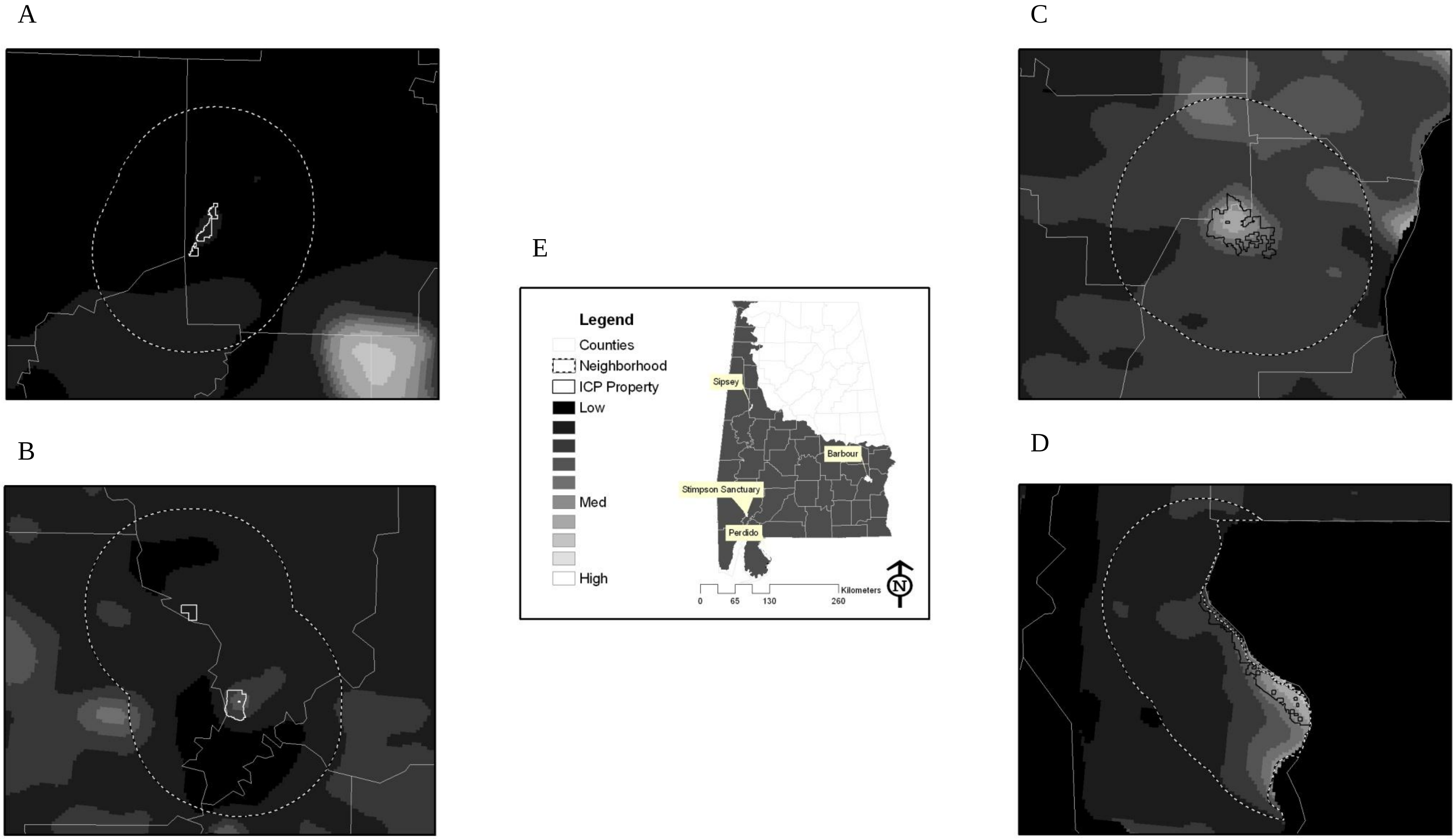

Figure 2.19: Utility Maps for Kentucky warbler on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

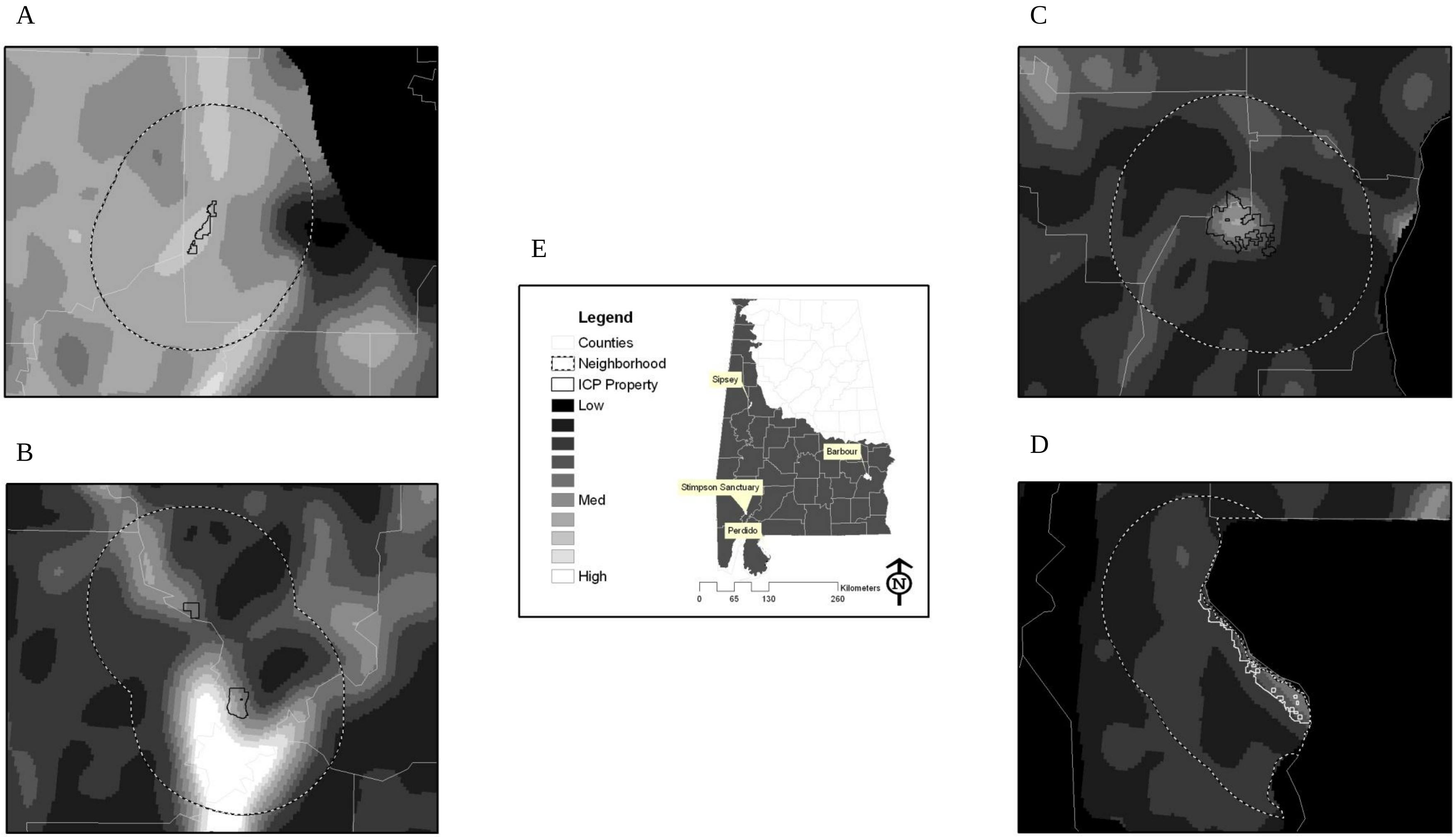

Figure 2.20: Utility Maps for least bittern on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

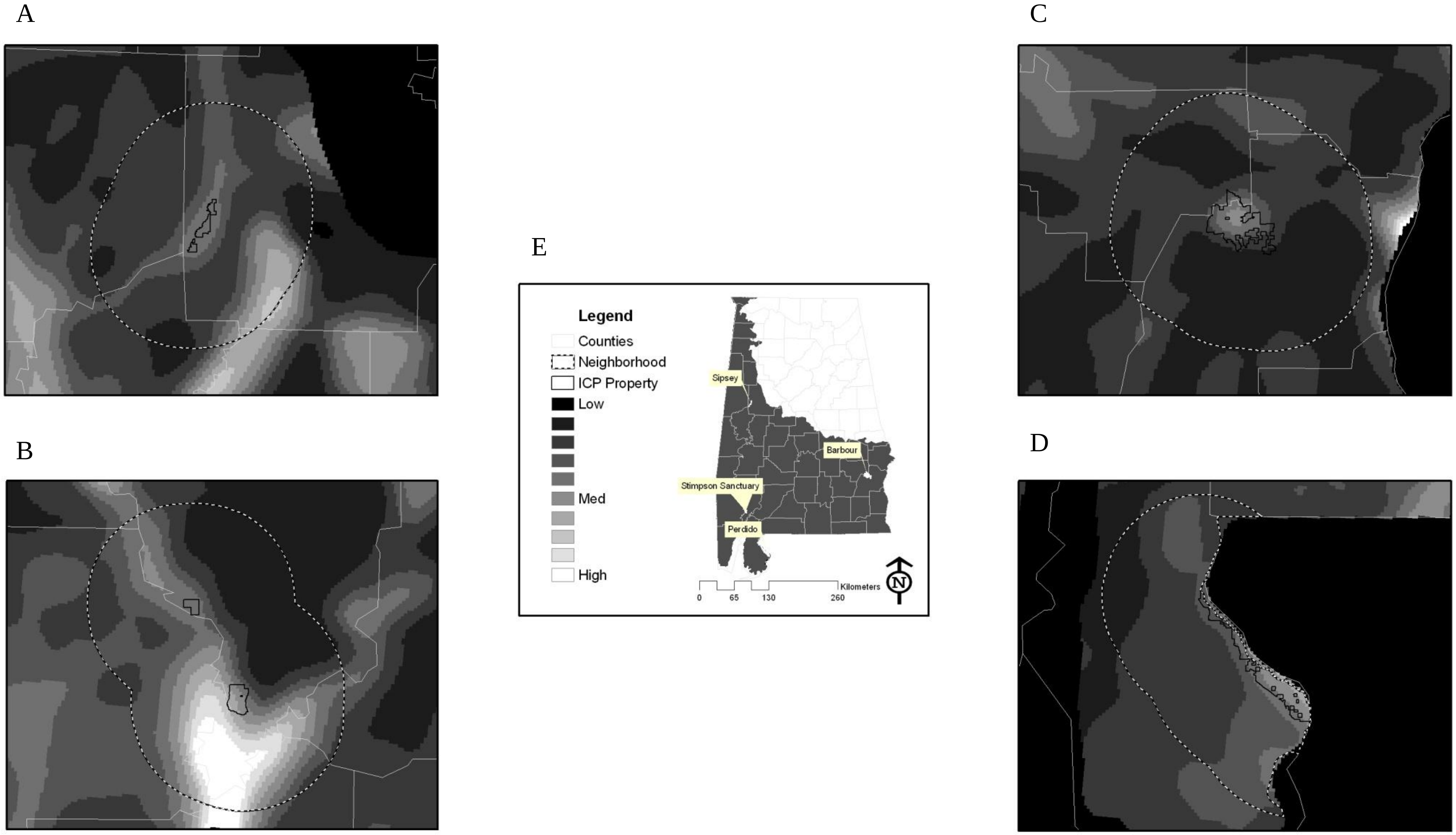

Figure 2.21: Utility Maps for little grass frog on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

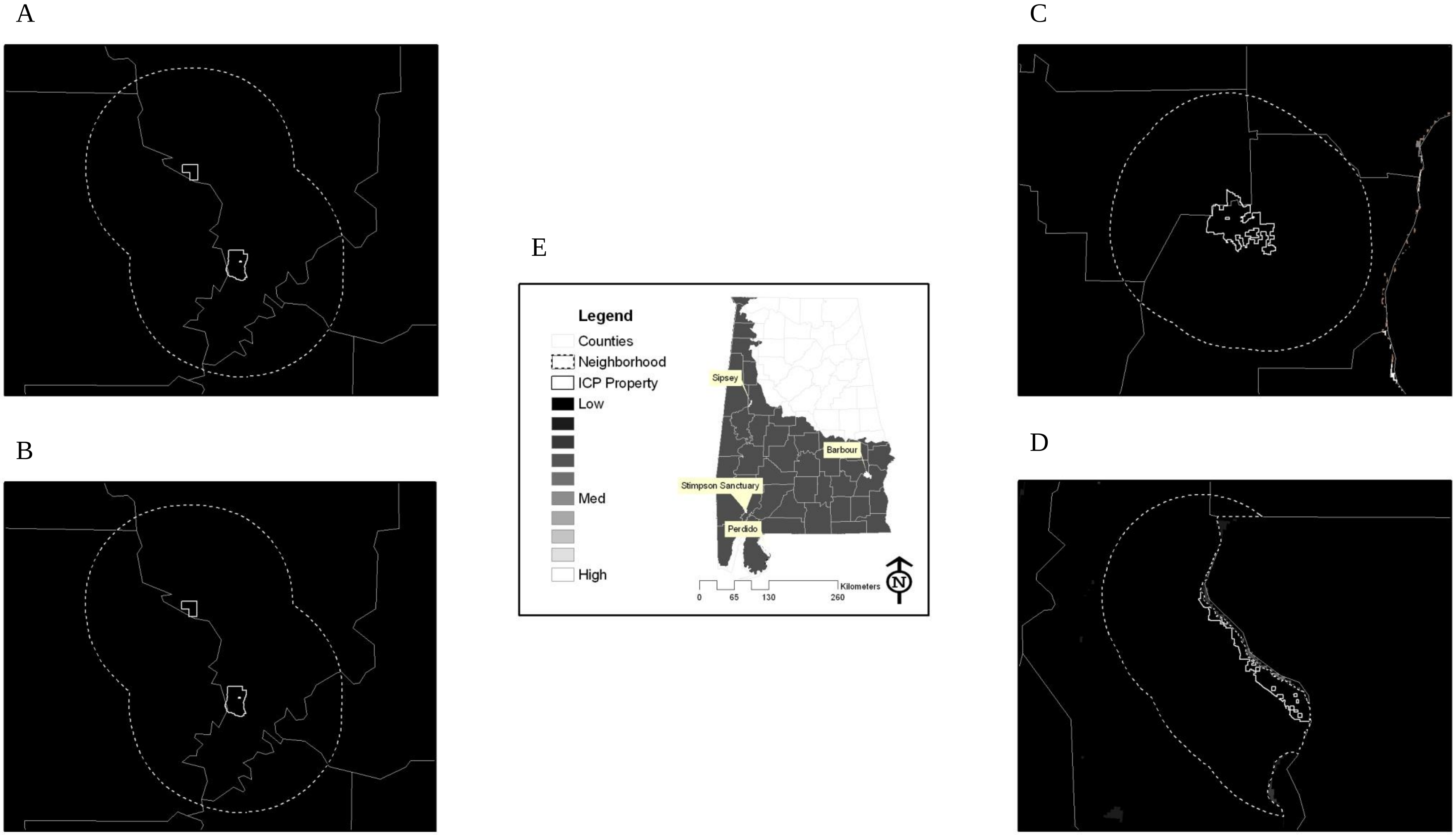

Figure 2.22: Utility Maps for long-tailed weasel on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

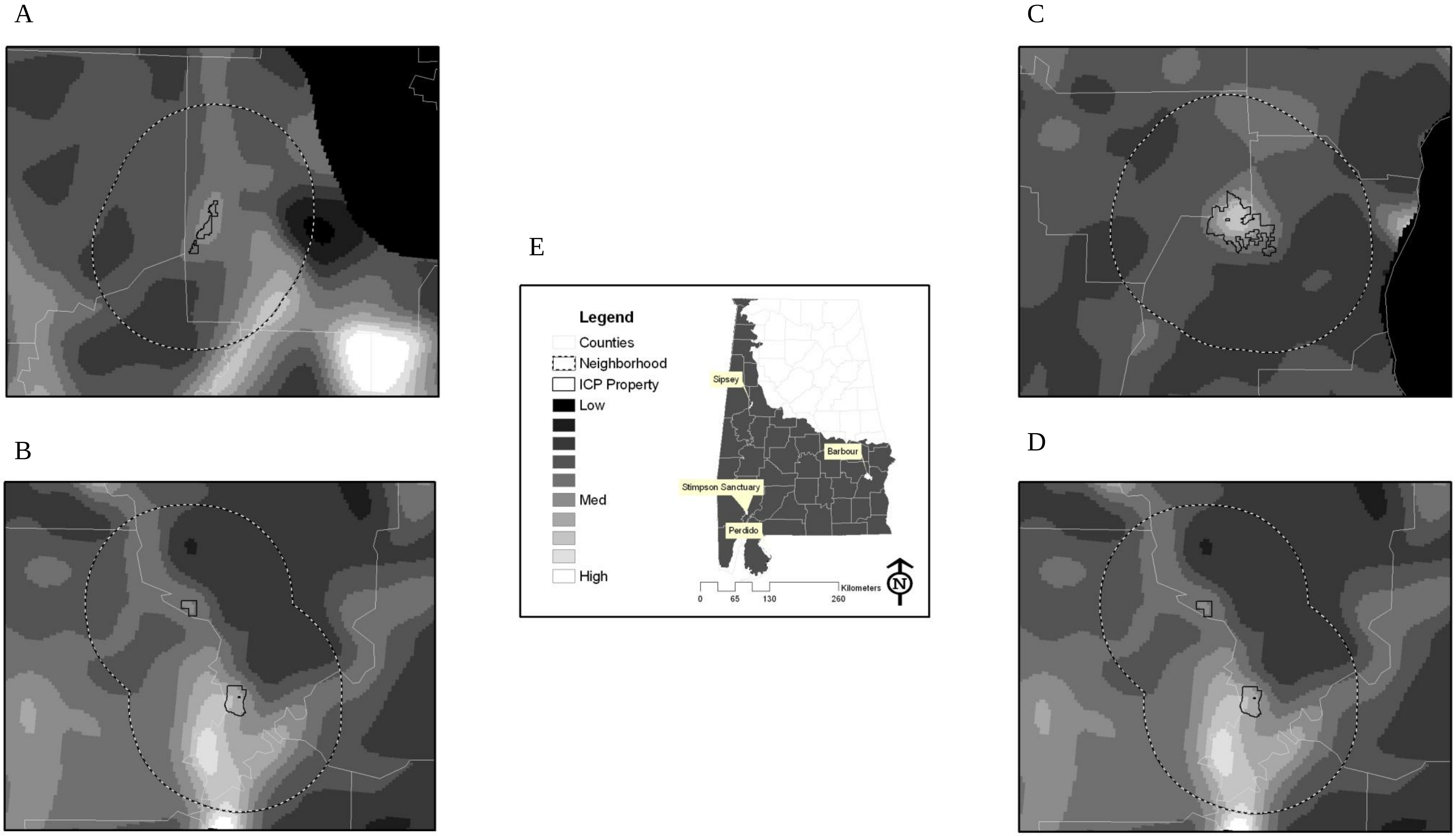

Figure 2.23: Utility Maps for mimic glass lizard on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

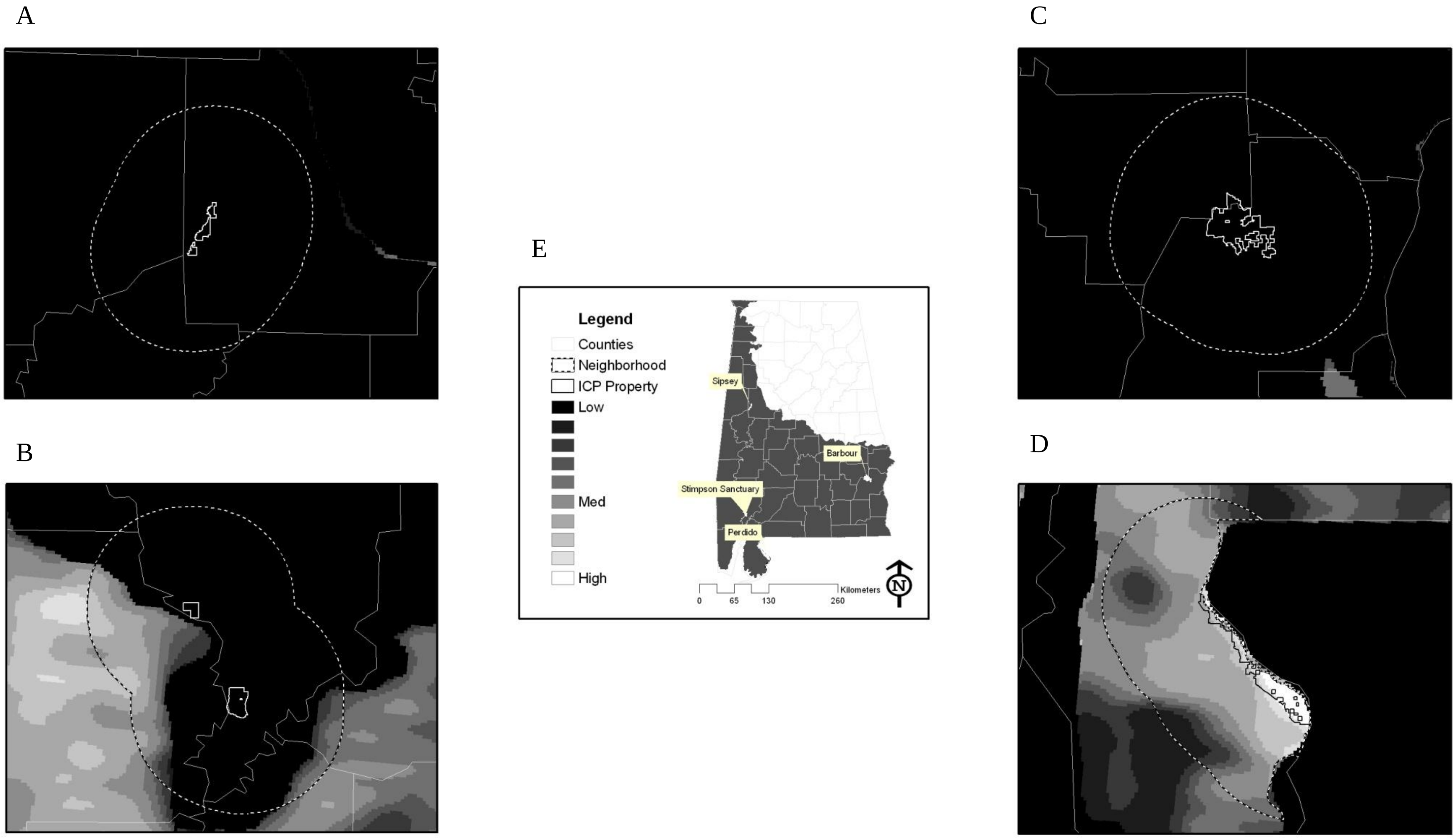

Figure 2.24: Utility Maps for pine barrens treefrog on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

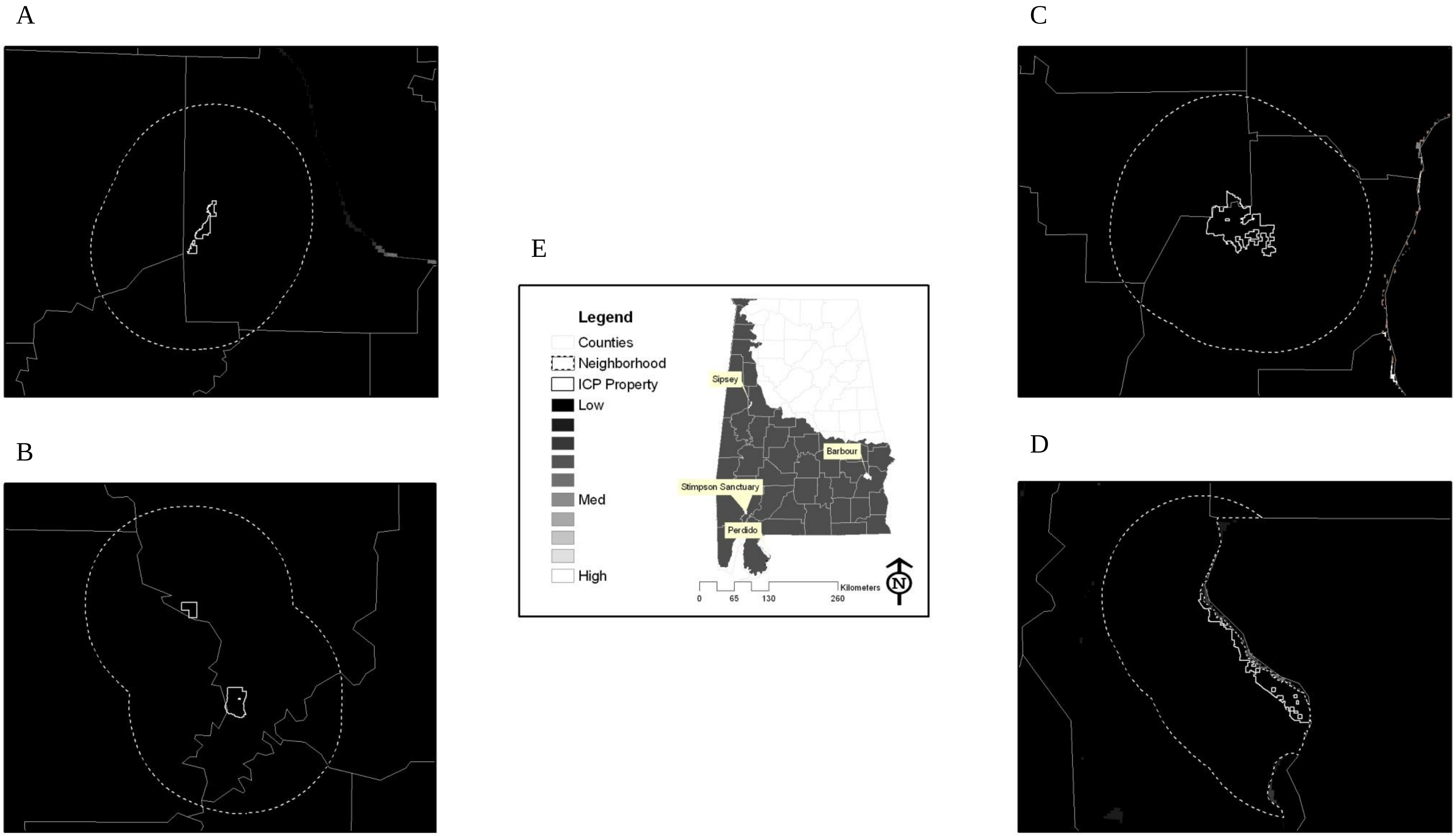

Figure 2.25: Utility Maps for rainbow snake on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

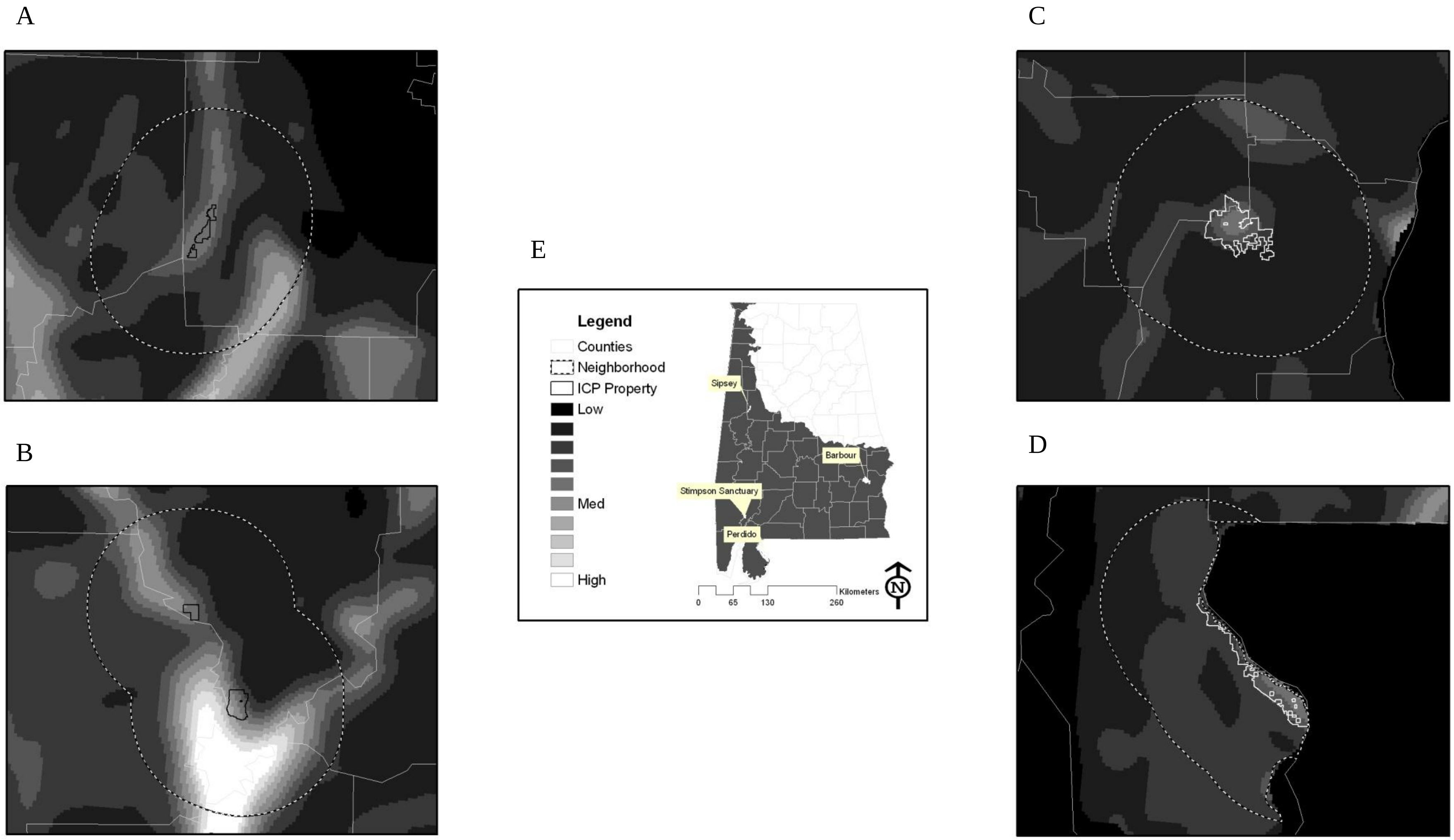

Figure 2.26: Utility Maps for red-cockaded woodpecker on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

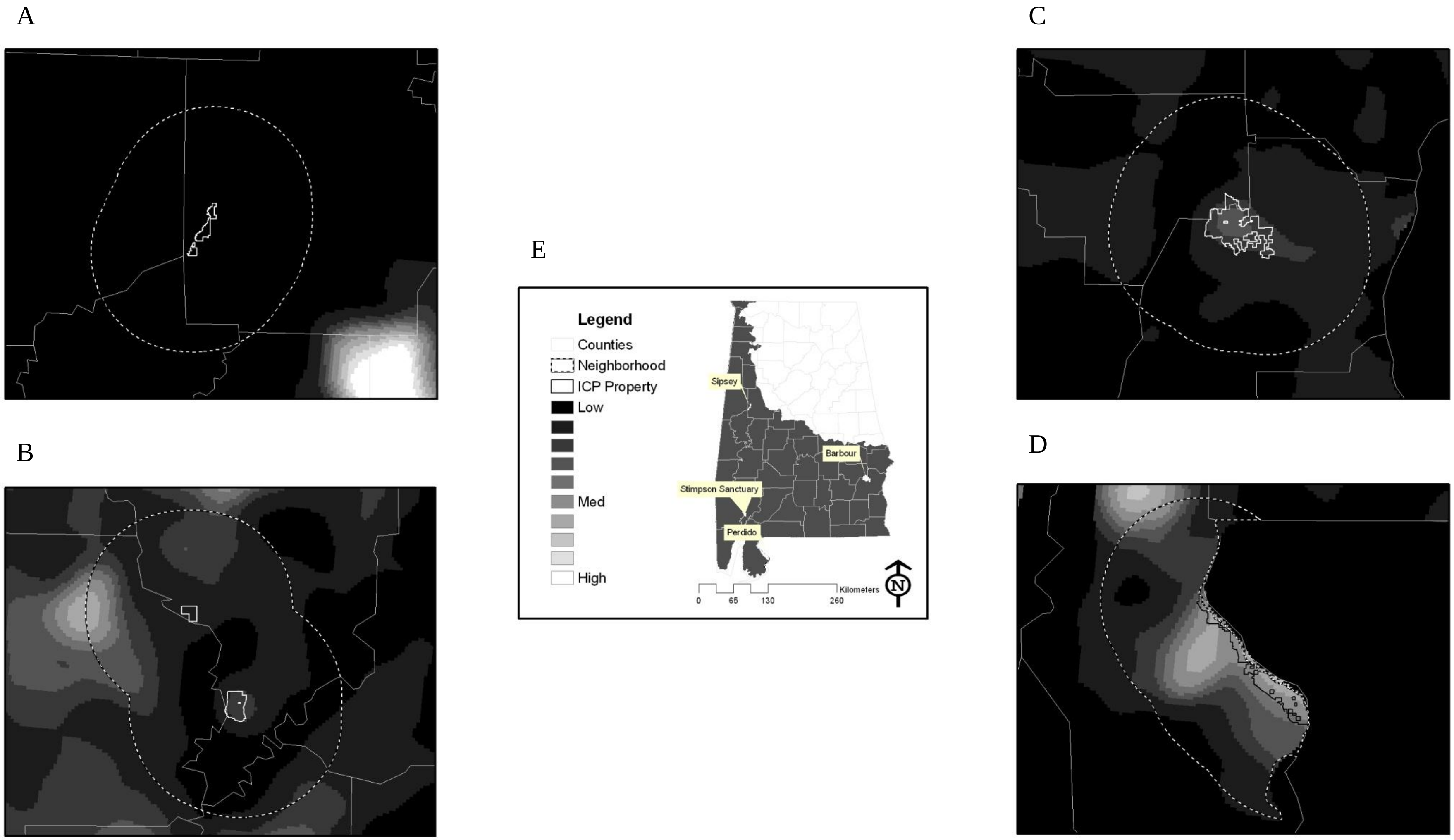

Figure 2.27: Utility Maps for river frog on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

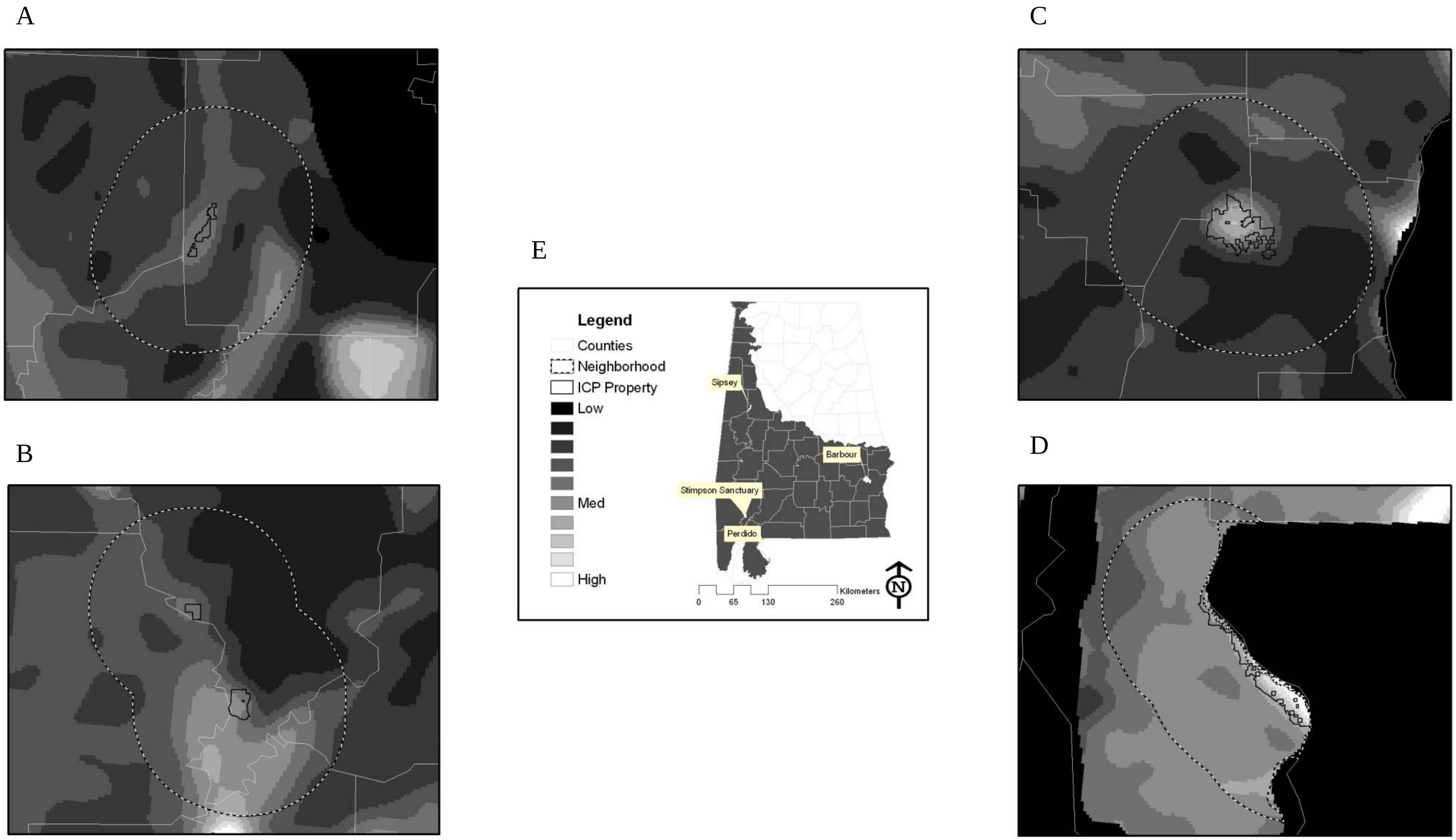

Figure 2.28: Utility Maps for Southeastern pocket gopher on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

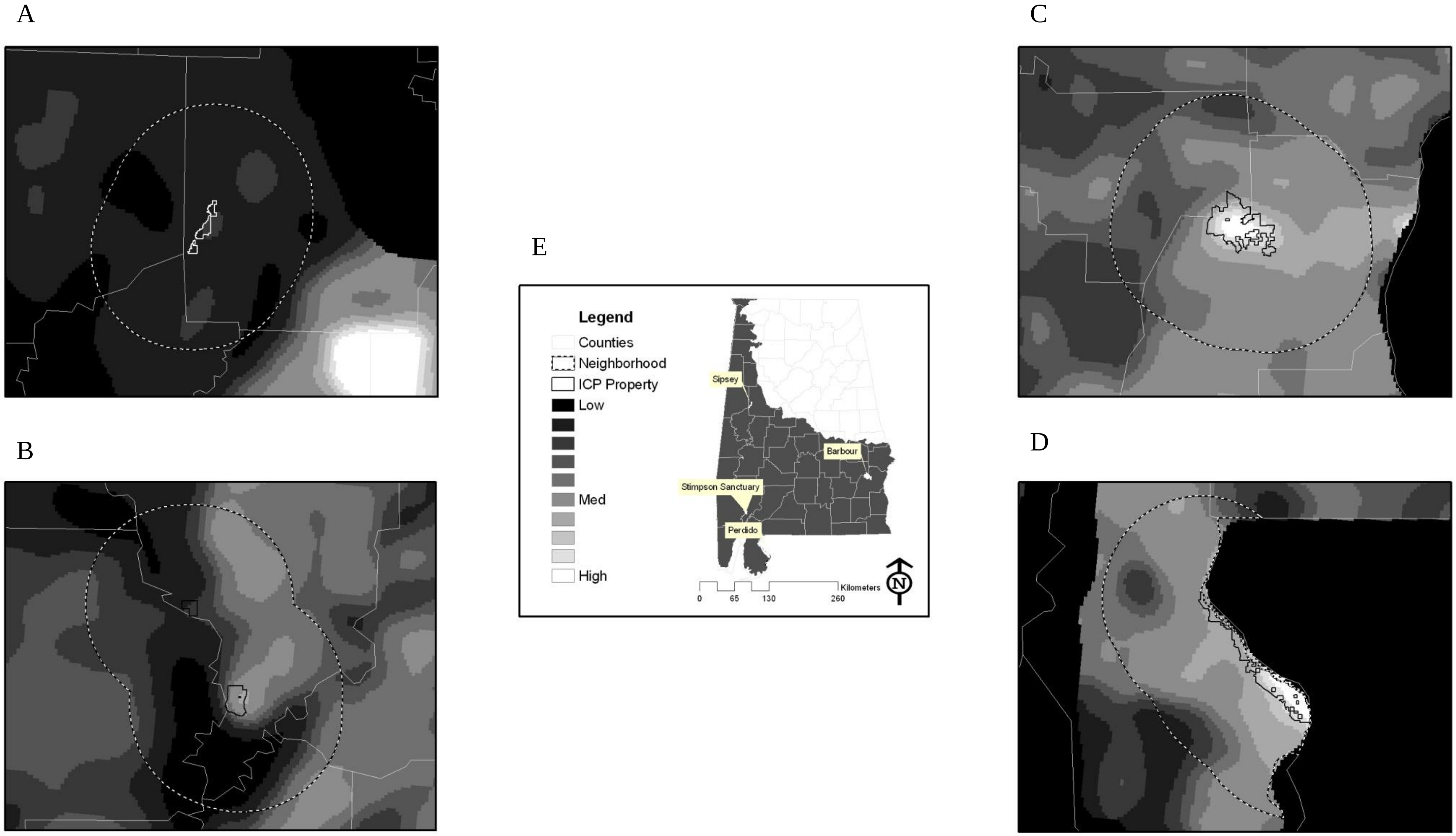

Figure 2.29: Utility Maps for Southern dusky salamander on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

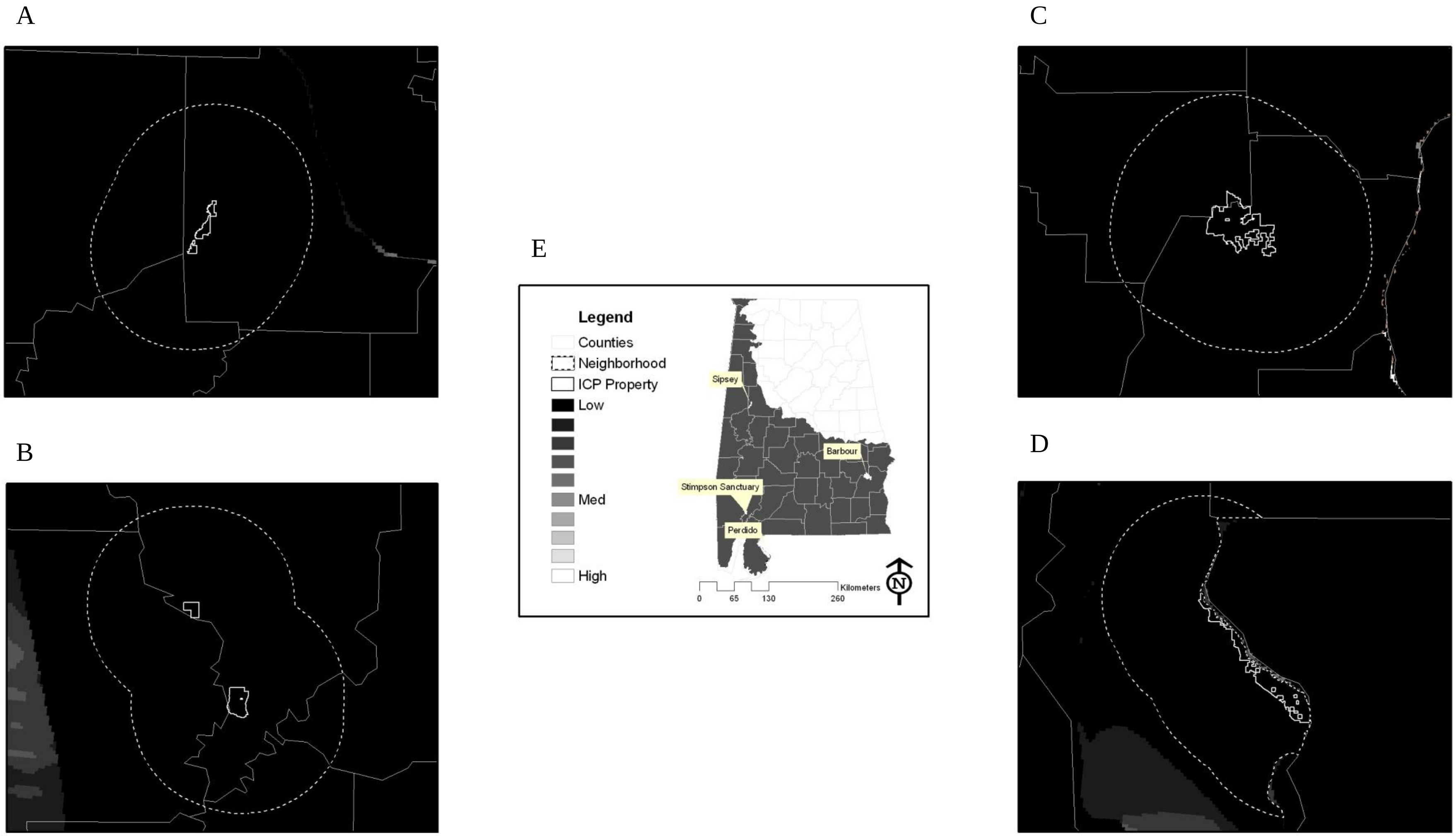

Figure 2.30: Utility Maps for Southern hognose snake on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

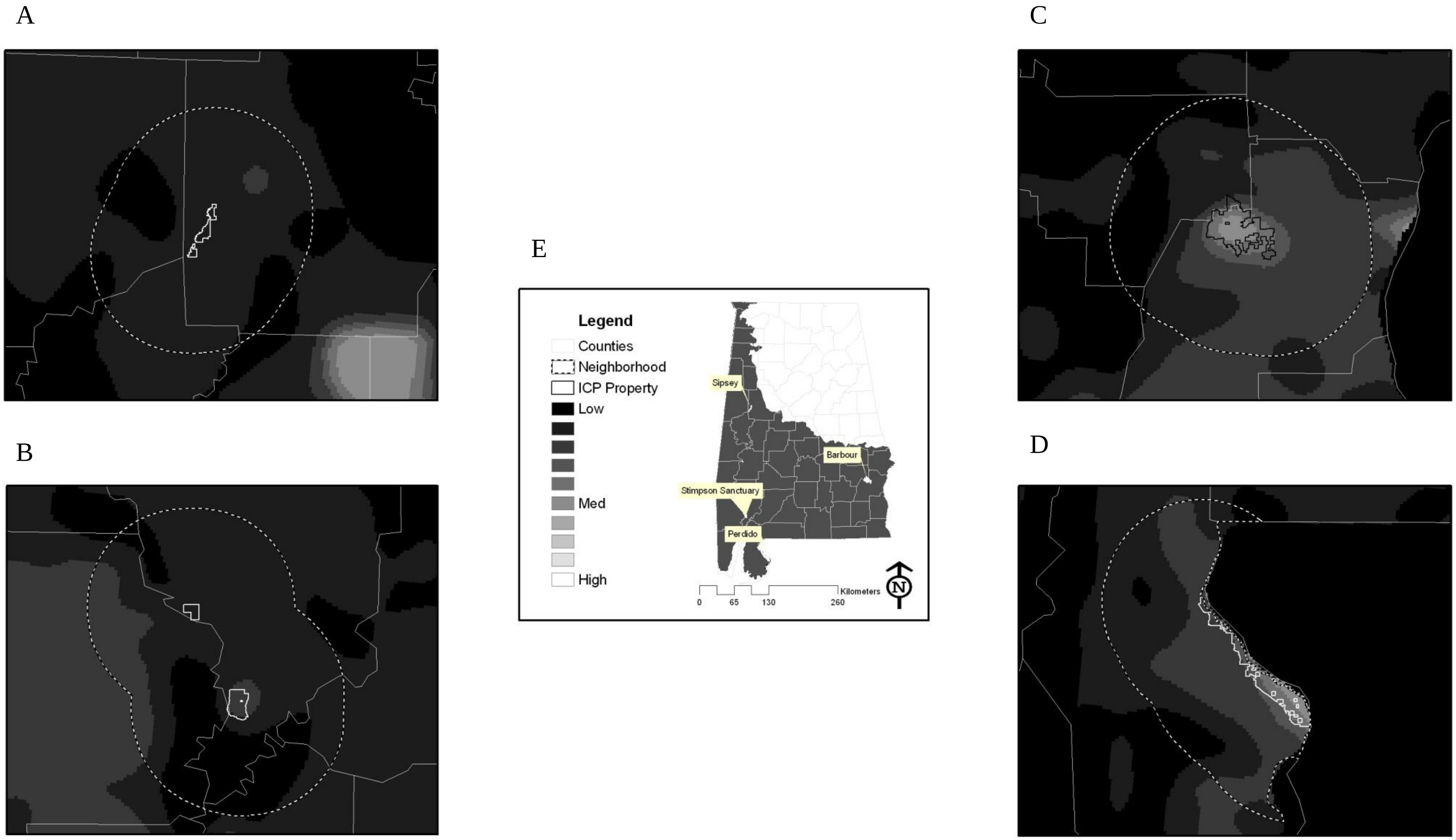

Figure 2.31: Utility Maps for speckled kingsnake on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

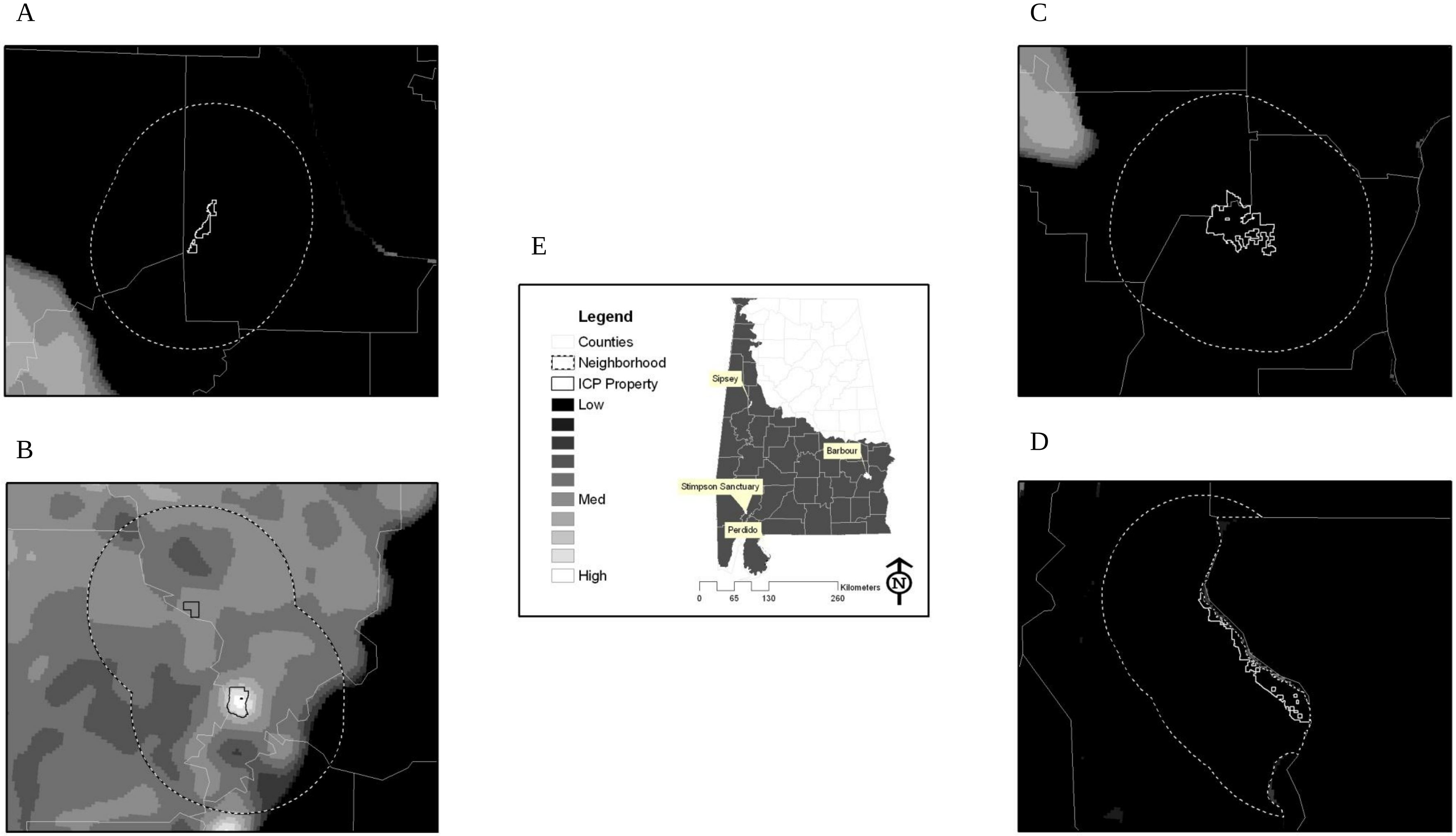

Figure 2.32: Utility Maps for Swainson's warbler on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

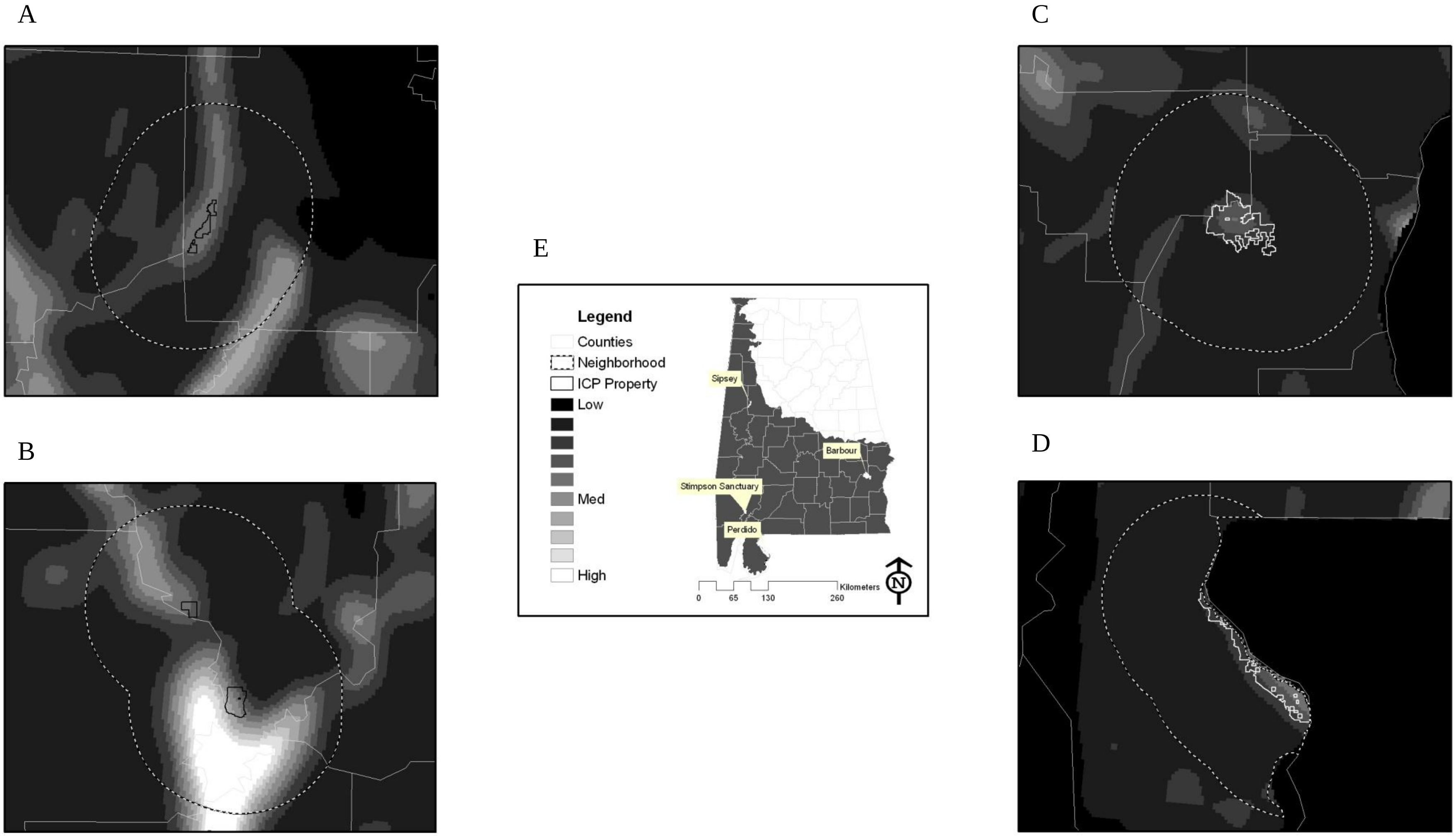

Figure 2.33: Utility Maps for wood thrush on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

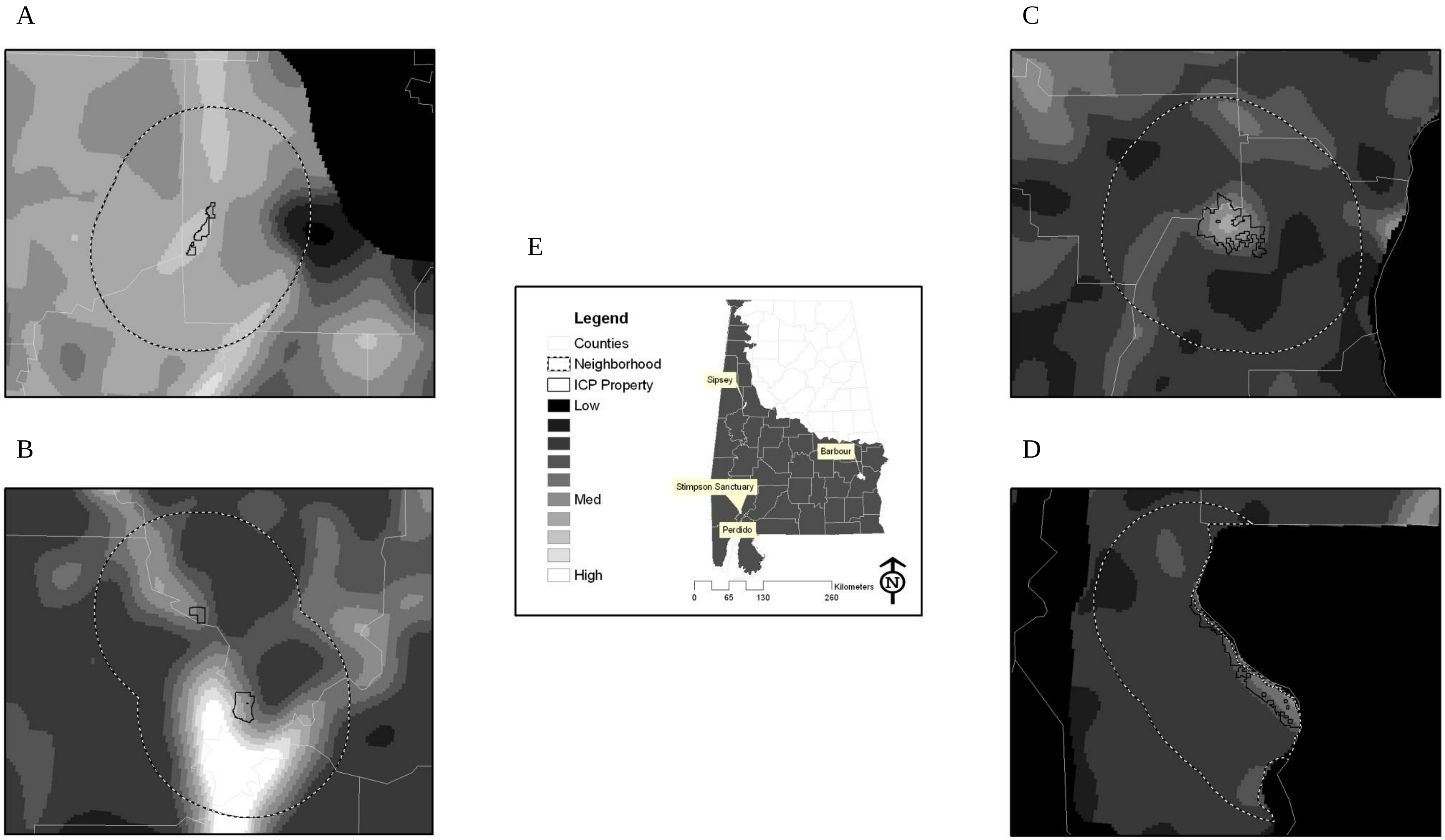

Figure 2.34: Utility Maps for worm-eating warbler on A) the Sipsey Tracts, B) Stimpson Sanctuaries, C) Barbour Wildlife Management Area and D) Perdido Tracts and neighborhoods with E) legend. Neighborhood boundaries represented by dotted line.

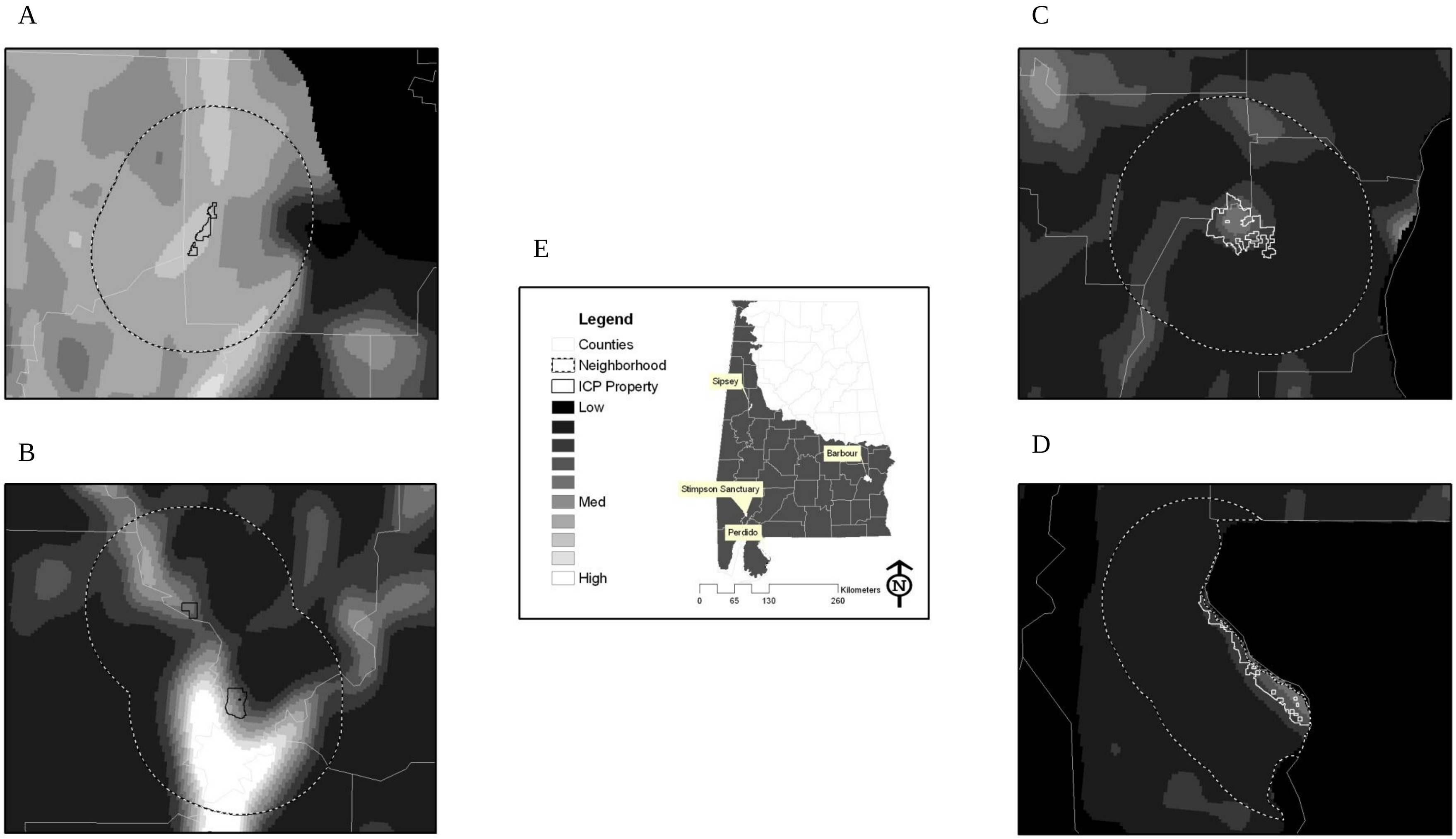

Table 2.1 Mean conservation utility for each species within each study area and the surrounding neighborhood

	State	Barbour	Barbour Neighborhood	Perdido	Perdido Neighborhood	Sipsey	Sipsey Neighborhood	Stimpson	Stimpson Neighborhood
Alligator Snapping Turtle	0.2640	0.4058	0.2309	0.4522	0.2730	0.4514	0.3695	0.4173	0.2825
American Black Bear	0.3922	0.5950	0.3635	0.6151	0.5163	0.8477	0.7004	0.3323	0.2394
American Kestrel	0.4552	0.6605	0.4954	0.6058	0.3842	0.3918	0.2801	0.4278	0.3967
American Woodcock	0.3513	0.5270	0.3332	0.5782	0.3545	0.5244	0.3875	0.4803	0.3528
Bachman’s Sparrow	0.3324	0.6313	0.4365	0.4004	0.2553	0.4231	0.2587	0.2798	0.2702
Black Pine Snake	0.2758	0.5216	0.3252	0.8043	0.5529	0.5615	0.4037	0.2538	0.2436
Coal Skink	0.1630	0.3746	0.1129	0.2594	0.0566	0.3630	0.2580	0.5438	0.3244
Eastern Coral Snake	0.2013	0.5337	0.2435	0.7918	0.4940	0.5081	0.3633	0.2192	0.1622
Eastern Diamondback Rattlesnake	0.2605	0.3519	0.1961	0.6770	0.4908	0.5152	0.4273	0.1693	0.1552
Eastern Indigo Snake	0.1289	0.4719	0.2153	0.4520	0.2411	0.3418	0.2817	0.1938	0.1434
Eastern Kingsnake	0.1808	0.6648	0.4261	0.6792	0.4082	0.0000	0.0141	0.0000	0.0000

Table 2.1 Mean conservation utility for each species within each study area and the surrounding neighborhood

	State	Barbour	Barbour Neighborhood	Perdido	Perdido Neighborhood	Sipsey	Sipsey Neighborhood	Stimpson	Stimpson Neighborhood
Eastern Spotted Skunk	0.3570	0.6470	0.3477	0.4736	0.2368	0.4610	0.2783	0.5445	0.4841
Flatwoods Salamander	0.0259	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Florida Pine Snake	0.2852	0.6406	0.4747	0.7911	0.5545	0.3231	0.2253	0.2367	0.2272
Gopher Frog	0.1693	0.5169	0.2954	0.5473	0.3467	0.3610	0.2048	0.2069	0.1531
Gopher Tortoise	0.2339	0.6936	0.4640	0.7602	0.4920	0.4522	0.3438	0.1957	0.1448
Henslow’s Sparrow	0.1619	0.4478	0.2479	0.4560	0.2004	0.2466	0.1132	0.0840	0.0396
Kentucky Warbler	0.2730	0.3985	0.2066	0.3181	0.2054	0.4699	0.3780	0.6490	0.5353
Least Bittern	0.2436	0.3428	0.2003	0.4370	0.2682	0.4589	0.3658	0.3866	0.2778
Little Grass Frog	0.0018	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Long-tailed Weasel	0.3017	0.5407	0.3026	0.5690	0.3202	0.5385	0.3755	0.4478	0.3334
Mimic Glass Lizard	0.0979	0.0000	0.0000	0.7889	0.4905	0.0000	0.1121	0.0000	0.0000
Pine Barrens Treefrog	0.0048	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 2.1 Mean conservation utility for each species within each study area and the surrounding neighborhood

	State	Barbour	Barbour Neighborhood	Perdido	Perdido Neighborhood	Sipsey	Sipsey Neighborhood	Stimpson	Stimpson Neighborhood
Rainbow Snake	0.2065	0.2903	0.1693	0.3201	0.2040	0.4107	0.3513	0.3815	0.2400
Red-cockaded Woodpecker	0.0815	0.2613	0.0989	0.4945	0.2452	0.2156	0.1373	0.0528	0.0042
River Frog	0.2783	0.4693	0.2329	0.6693	0.4483	0.4066	0.2983	0.3832	0.2638
Southeastern Pocket Gopher	0.2733	0.7200	0.4474	0.7185	0.4609	0.4037	0.2246	0.1847	0.1389
Southern Dusky Salamander	0.0172	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Southern Hognose Snake	0.1052	0.3974	0.1813	0.3656	0.1811	0.2165	0.1191	0.1632	0.1208
Speckled Kingsnake	0.1585	0.0000	0.0000	0.0000	0.0000	0.6871	0.3902	0.0000	0.0000
Swainson’s Warbler	0.1846	0.2564	0.1446	0.2970	0.1610	0.4063	0.3307	0.3897	0.2117
Wood Thrush	0.3079	0.4349	0.2480	0.3383	0.2356	0.4876	0.4006	0.6467	0.5408
Worm-eating Warbler	0.2416	0.2957	0.1697	0.2983	0.1615	0.4040	0.3421	0.6540	0.5383

Table 2.2: Conservation utility for each species within each property relative to the utility in the state and surrounding neighborhood

	Barbour	Perdido	Sipsey	Stimpson
Alligator Snapping Turtle	1.294E-06	1.492E-06	2.376E-07	2.859E-07
American Black Bear	8.112E-07	7.223E-07	1.503E-07	1.906E-07
American Kestrel	5.693E-07	8.224E-07	1.006E-07	1.899E-07
American Woodcock	8.751E-07	1.104E-06	1.646E-07	2.380E-07
Bachman’s Sparrow	8.457E-07	1.122E-06	1.323E-07	3.040E-07
Black Pine Snake	1.131E-06	1.254E-06	1.604E-07	3.116E-07
Coal Skink	3.957E-06	6.686E-06	4.369E-07	5.334E-07
Eastern Coral Snake	2.116E-06	1.893E-06	2.852E-07	4.293E-07
Eastern Diamondback Rattlesnake	1.340E-06	1.259E-06	1.778E-07	2.859E-07
Eastern Indigo Snake	3.305E-06	3.458E-06	4.453E-07	5.814E-07
Eastern Kingsnake	1.678E-06	2.188E-06	0.000E+00	0.000E+00

Table 2.2: Conservation utility for each species within each property relative to the utility in the state and surrounding neighborhood

	Barbour	Perdido	Sipsey	Stimpson
Eastern Spotted Skunk	1.013E-06	1.332E-06	1.338E-07	2.867E-07
Flatwoods Salamander	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Florida Pine Snake	9.198E-07	1.189E-06	1.551E-07	3.107E-07
Gopher Frog	2.008E-06	2.216E-06	3.389E-07	6.430E-07
Gopher Tortoise	1.242E-06	1.570E-06	2.453E-07	3.474E-07
Henslow's Sparrow	2.169E-06	3.343E-06	5.566E-07	8.310E-07
Kentucky Warbler	1.373E-06	1.349E-06	1.886E-07	2.813E-07
Least Bittern	1.366E-06	1.591E-06	2.427E-07	3.182E-07
Little Grass Frog	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Long-tailed Weasel	1.151E-06	1.400E-06	1.890E-07	2.936E-07
Mimic Glass Lizard	0.000E+00	3.905E-06	0.000E+00	0.000E+00

Table 2.2: Conservation utility for each species within each property relative to the utility in the state and surrounding neighborhood

	Barbour	Perdido	Sipsey	Stimpson
Pine Barrens Treefrog	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Rainbow Snake	1.614E-06	1.807E-06	3.268E-07	3.498E-07
Red-cockaded Woodpecker	6.295E-06	5.881E-06	6.582E-06	1.190E-06
River Frog	1.403E-06	1.271E-06	2.210E-07	3.016E-07
Southeastern Pocket Gopher	1.144E-06	1.356E-06	2.066E-07	4.061E-07
Southern Dusky Salamander	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Southern Hognose Snake	4.049E-06	4.562E-06	5.455E-07	1.067E-06
Speckled Kingsnake	0.000E+00	0.000E+00	0.000E+00	6.862E-07
Swainson’s Warbler	1.867E-06	2.376E-06	4.234E-07	4.112E-07
Wood Thrush	1.107E-06	1.109E-06	1.650E-07	2.443E-07

Table 2.2: Conservation utility for each species within each property relative to the utility in the state and surrounding neighborhood

	Barbour	Perdido	Sipsey	Stimpson
Worm-eating Warbler	1.402E-06	1.818E-06	2.136E-07	3.020E-07

Table 2.3: Elasticity of each species model for the ecoregion and each neighborhood. No value indicates an area where the species did not occur.

	State	Barbour	Perdido	Sipsey	Stimpson
Alligator Snapping Turtle	1.0011	1.0097	1.0002	1.0049	1.0043
American Black Bear	1.0012	1.0057	1.0004	1.0057	1.0041
American Kestrel	1.0013	1.0066	1.0002	1.0063	1.0043
American Woodcock	1.0012	1.0069	1.0002	1.0050	1.0042
Bachman’s Sparrow	1.0012	1.0027	1.0003	1.0071	1.0049
Black Pine Snake	1.0013	1.0039	1.0003	1.0063	1.0041
Coal Skink	1.0013	1.0406	1.0003	1.0074	1.0092
Eastern Coral Snake	1.0013	1.0041	1.0002	1.0066	1.0083
Eastern Diamondback Rattlesnake	1.0012	1.0012	1.0002	1.0064	1.0041
Eastern Indigo Snake	1.0013	1.0039	1.0000	1.0048	1.0040
Eastern Kingsnake	1.0011	1.0042	1.0003	1.0246	-

Table 2.3: Elasticity of each species model for the ecoregion and each neighborhood. No value indicates an area where the species did not occur.

	State	Barbour	Perdido	Sipsey	Stimpson
Eastern Spotted Skunk	1.0013	1.0062	1.0002	1.0061	1.0050
Flatwoods Salamander	1.0015	-	-	-	-
Florida Pine Snake	1.0012	1.0022	1.0002	1.0070	1.0041
Gopher Frog	1.0013	1.0043	1.0001	1.0059	1.0083
Gopher Tortoise	1.0012	1.0022	1.0001	1.0065	1.0083
Henslow’s Sparrow	1.0013	1.0106	1.0004	1.0063	1.0029
Kentucky Warbler	1.0012	1.0072	1.0001	1.0049	1.0040
Least Bittern	1.0012	1.0111	1.0002	1.0046	1.0043
Little Grass Frog	1.0096	-	-	-	-
Long-tailed Weasel	1.0012	1.0073	1.0003	1.0051	1.0042
Mimic Glass Lizard	1.0014	-	1.0001	1.0391	-

Table 2.3: Elasticity of each species model for the ecoregion and each neighborhood. No value indicates an area where the species did not occur.

	State	Barbour	Perdido	Sipsey	Stimpson
Pine Barrens Treefrog	1.0008	-	-	-	-
Rainbow Snake	1.0011	1.0087	1.0002	1.0045	1.0042
Red-cockaded Woodpecker	1.0012	1.0046	1.0007	1.0057	1.0021
River Frog	1.0012	1.0095	1.0001	1.0049	1.0041
Southeastern Pocket Gopher	1.0012	1.0024	1.0001	1.0078	1.0070
Southern Dusky Salamander	1.0014	-	-	-	-
Southern Hognose Snake	1.0013	1.0039	1.0000	1.0060	1.0040
Speckled Kingsnake	1.0009	-	-	1.0052	-
Swainson’s Warbler	1.0011	1.0078	1.0002	1.0045	1.0043
Wood Thrush	1.0012	1.0074	1.0001	1.0050	1.0040

Table 2.3: Elasticity of each species model for the ecoregion and each neighborhood. No value indicates an area where the species did not occur.

	State	Barbour	Perdido	Sipsey	Stimpson
Worm-eating Warbler	1.0012	1.0080	1.0002	1.0046	1.0040

Table 2.4: Elasticity of three species models to extreme changes in neighborhood size surrounding each study area. No value indicates an area where the species did not occur.

	Study Area	50 km Buffer	5 km Buffer
	Barbour		
Eastern Kingsnake		0.9277	1.1531
Gopher Tortoise		0.7469	1.2201
Wood Thrush		1.0198	1.2038
	Perdido		
Eastern Kingsnake		0.8370	1.1867
Gopher Tortoise		0.7800	1.2368
Wood Thrush		1.0635	1.0907
	Sipsey		
Eastern Kingsnake		-	-
Gopher Tortoise		1.0338	1.1950
Wood Thrush		0.9079	1.1084
	Stimpson		
Eastern Kingsnake		6.8060	-
Gopher Tortoise		1.1240	0.9926
Wood Thrush		0.7377	1.1439

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Appendix A: Models used to predict conservation utility

Species	Model
Alligator Snapping Turtle	= (Expected Habitat + Public Land + Bottomland)*Urban
American Black Bear	= (Expected Habitat + Minimum Patch + Public Land)*Urban
American Kestrel	= (Expected Habitat + Minimum Patch + Public Land)*Urban
American Woodcock	= (Expected Habitat + Public Land + Wetlands)*Urban
Bachman's Sparrow	= (Expected Habitat + Minimum Patch + Public Land + Upland)*Urban
Black Pine Snake	= (Expected Habitat + Minimum Patch + Public Land + Upland + Sandy Soils)*Urban
Coal Skink	= (Expected Habitat + Public Land)*Urban
Eastern Coral Snake	= (Expected Habitat + Public Land + Sandy Soils)*Urban
Eastern Diamondback Rattlesnake	= (Expected Habitat + Minimum Patch + Public Land + Upland)*Urban
Eastern Indigo Snake	= (Expected Habitat + Minimum Patch + Public Land + Sandy Soils)*Urban
Eastern Kingsnake	= (Expected Habitat + Public Land)*Urban
Eastern Spotted Skunk	= (Expected Habitat +Public Land)*Urban

Appendix A: Models used to predict conservation utility

Species	Model
Flatwoods Salamander	= (Expected Habitat + Public Land + Isolated Wetlands + Sandy Soils)*Urban
Florida Pine Snake	= (Expected Habitat + Minimum Patch + Public Land + Upland + Sandy Soils)*Urban
Gopher Frog	= (Expected Habitat + Public Land + Sandy Soils)*Urban
Gopher Tortoise	= (Expected Habitat + Public Land + Sandy Soils)*Urban
Henslow's Sparrow	= (Expected Habitat + Public Land + Isolated Wetlands)*Urban
Kentucky Warbler	= (Expected Habitat + Minimum Patch + Public Land + Bottomland)*Urban
Least Bittern	= (Expected Habitat + Public Land + Wetlands)*Urban
Little Grass Frog	= (Expected Habitat + Public Land + Isolated Wetlands)*Urban
Long-tailed Weasel	= (Expected Habitat + Public Land + Wetlands)*Urban
Mimic Glass Lizard	= (Expected Habitat + Public Land + Sandy Soils)*Urban
Pine Barrens Treefrog	= (Expected Habitat + Public Land + Isolated Wetlands)*Urban
Rainbow Snake	= (Expected Habitat + Public Land + Bottomland)*Urban

Appendix A: Models used to predict conservation utility

Species	Model
Red-cockaded Woodpecker	= (Expected Habitat + Minimum Patch + Public Land)*Urban
River Frog	= (Expected Habitat + Public Land + Bottomland)*Urban
Southeastern Pocket Gopher	= (Expected Habitat + Public Land + Sandy Soils)*Urban
Southern Dusky Salamander	= (Expected Habitat + Public Land + Isolated Wetlands)*Urban
Southern Hognose Snake	= (Expected Habitat + Minimum Patch + Public Land + Sandy Soils)*Urban
Speckled Kingsnake	= (Expected Habitat + Public Land)*Urban
Swainson's Warbler	= (Expected Habitat + Minimum Patch + Public Land + Bottomland)*Urban
Wood Thrush	= (Expected Habitat + Minimum Patch + Public Land + Bottomland)*Urban
Worm-eating Warbler	= (Expected Habitat + Minimum Patch + Public Land + Bottomland)*Urban

Appendix B: Minimum patch size requirements for select species. If a species is not on this list, minimum patch was not incorporated into its model because the information was unavailable in literature.

Species	Minimum Patch	Source
American Kestrel	250 ha	Smallwood et al. 2009
Wood Thrush	80 ha	Rittenhouse et al. 2007
Worm-eating Warbler	150 ha	Rittenhouse et al. 2007
Swainson's Warbler	350 ha	Eddleman et al 1980
American Black Bear	1000 ha	Rudis and Tansey 1995
Eastern Indigo Snake	1000 ha	Hallam et al. 1998
Eastern Diamondback Rattlesnake	8500 ha *	Timmerman 1989
Kentucky Warbler	500 ha	Gibbs and Faaborg 1990
Eastern Kingsnake	4900 ha *	Linhan et al. 2010
Southern Hognose Snake	5000 ha #	Plummer and Mills 2000
Black Pine Snake	4800 ha *	Duran 1998
Florida Pine Snake	5700 ha *	Franz 2005
Bachman's Sparrow	2000 ha	Silvano et al. 2008
Red-cockaded Woodpecker	80000 ha †	US Fish and Wildlife Service 2003

* home range size multiplied by population of 100 individuals

home range size of similar subspecies multiplied by 100 individuals

† home range size on "sites of low productivity" multiplied by 100 individuals