Final Performance Report
SC State Wildlife Grant T-42-R-1
Use of GIS to Assess the Demographic Isolation of Red-cockaded Woodpecker Groups in SC
10/01/2008—03/31/2010

GRANT OBJECTIVE:

To determine demographic isolation criteria for South Carolina red-cockaded woodpeckers and apply to known locations of RCWs to determine if isolated groups are present.

ACTIVITY OVERVIEW:

Please see the attached Clemson University document attached below as the final activity report.

ESTIMATED FEDERAL COST: $22,009.00

RECOMMENDATIONS:

SCDNR plans to use the DIG information gained in this project to make decisions about future strategies related to the RCW Safe Harbor Program.

Preliminary Analysis of a Technique Using a Geographic Information System (GIS) to Determine Demographic Isolation of Red-cockaded Woodpecker (*Picoides borealis*) Groups in South Carolina

Jason Brett Craig, MFR and J. Drew Lanham, PhD, Principal Investigator
Ralph Costa (USFWS, ret.) and Robert Baldwin, PhD, Consultants

Department of Forestry and Natural Resources, Clemson University, SC, 29634 USA

A Draft Report
Submitted to:
Laurel Barnhill
Bird Conservation Coordinator
South Carolina Department of Natural Resources

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Jason Brett Craig, MFR candidate and J. Drew Lanham, PhD, Principal Investigator

Department of Forestry and Natural Resources, Clemson University, SC, 29634 USA

ABSTRACT

Red-cockaded Woodpeckers (RCW; *Picoides borealis*) have been studied intensively in the southeastern United States. As with many sensitive species, population persistence of this longleaf pine (*Pinus palustris*) specialist in fragmented landscapes is a major concern since isolation in habitat "islands" may affect essential components of its demography, including dispersal. The study was conducted to determine if Demographically Isolated Groups (DIG) of RCWs currently occur in South Carolina. Using Geographic Information Systems (GIS) analyses coupled with an understanding of population status obtained from South Carolina Department of Natural Resources (SCDNR) and US Fish and Wildlife Service (USFWS) databases, we placed a 8 km (5 mi) and 25 km (15.5 mi) radius around known active and inactive clusters and developed predictions of where we believe DIG may occur in the state using each. From these analyses we conclude here that South Carolina contains 20 isolated clusters using an 8 km (5 mi) radius; six active and 14 inactive and three isolated clusters when using the 25 km (15.5mi) radius; one active cluster and two inactive clusters.

Keywords: dispersal, red-cockaded woodpecker, *Picoides borealis,* RCW, isolation, demographic, South Carolina, endangered

INTRODUCTION

Rare species often exist as small populations in habitat patches that are situated within a matrix of unsuitable habitat. The principles of island biogeography (MacArthur and Wilson 1967) forward the following: (1) large reserves are better than small reserves, (2) a single large reserve is better than a group of small ones of equivalent total area, (3) reserves close together are better than those far apart, (4) a compact cluster of reserves is better that a linear configuration of reserves, (5) circular reserves are better that long thin ones, and (6) reserves connected by a corridor are better than reserves not connected by a corridor (Lindenmeyer and Franklin 2002). Coupling the widely acknowledged ideas of island biogeography to metapopulation theory (Levins 1968) and source-sink dynamics (Pulliam 1988), one might surmise that disjunct habitats may be problematic for small population persistence as they create barriers to dispersal, decrease the probability of genetic exchange among populations and for species with narrow habitat requirements or area sensitivities, reduce the amount of available habitat for long term survival. Barriers to RCW dispersal in South Carolina may include large early successional forest areas, agriculture fields, hardwood forest, large bodies of water, and continuous areas of urban development. Mitigation may be possible for isolated groups in accordance with the incidental take section of the Endangered Species Act of 1973 as amended (ESA).

The federally endangered red-cockaded woodpecker (RCW; *Picoides borealis*) is one of the most intensively studied bird species in the Southeast (Costa et al. 1996, Costa and Daniels 2004). As this rare species relies on an increasingly disappearing and fragmented habitat, mature longleaf pine (*Pinus palustris*) forest, many of the demographic issues associated with small population size in habitat islands may come to fore. The majority of the demographic behavior research on the RCW has been conducted on large persistent populations and limited research has investigated smaller isolated populations. Clusters within these small populations are dynamic and may transition from active to inactive with changing local or landscape level habitat conditions or demographic uncertainly. From a logistical standpoint, fragments of habitat are often viewed as islands and are managed accordingly, therefore without an understanding of the effects of habitat matrix context and proximity to other habitat islands. This may lead to disparities in conservation management as large populations in higher valued habitats might receive more attention while smaller but persistent habitats are ignored. Conversely, if small, ephemeral populations in unsuitable habitat are not feasible options to include in management directives. Understanding where best to re-direct efforts at more manageable situations may create more effective and sustained recovery for the species, avoiding the pitfall of the Concorde fallacy (a.k.a. sunk cost dilemma)-investing time and resources in situations which are likely to never return the investment and in fact may devalue the larger effort. According to the SCDNR, South Carolina may have some small but persistent RCW populations. Some populations are managed in a way to prevent population declines, but others are not managed due to the difficulty of accessibility to improve these habitats.

Landscape modifications by humans, primarily deforestation, are the most significant factors of habitat loss for many species (Saunders et al. 1987; Groombridge 1992). Habitat loss is implicated in at least 80% of the world’s endangered or threatened birds declining statuses (Temple 1986). If one can explicitly enclose the life requisites (e.g. breeding, foraging, dispersal) of a species within a given area and then understand how that area lies in the landscape with respect to other suitable habitat areas and populations within a less suitable matrix, then perspectives on patch dynamics and species ecology/management may be better understood. Crowder et al. (1998) developed an individual-based spatially explicit model to analyze viability of RCW groups and concluded that small populations within a 16 km (9.9 mi) square area had a low probability of persistence and the groups not maximally aggregated would almost certainly be extirpated. However, as a better understanding of RCW dispersal has emerged in conjunction with land use changes that have modified many formerly suitable habitats to unsuitable status, this buffered distance may necessarily increase. Dispersal distance of RCWs are much lower than other avian species, median dispersal distance of females is only two territories from the natal site (Daniels 1997, Daniels and Walters 2000). Seventy percent (70%) of males become breeders on or adjacent to their natal territory. (Daniels 1997). Male and female dispersal occurs to search for a territory to become a breeder. Males may also remain on their natal territory as a helper until a breeding vacancy on their or an adjacent territory becomes available. Twenty-four percent (24%) of dispersing females move long distances (3 or more territories) and 29% join a neighboring group. Dispersal distances of males are similar to those observed among females (Walters et al 1988). Emigrations from small populations into large ones are more common than immigration from large to small populations therefore contributing little to demography. In order to maintain genetic substructure within populations dispersal distances of both sexes are sufficiently short. Populations of RCWs are believed to function as closed populations, depending completely on within-population demography (USFWS 2003). The Southern Range Translocation Cooperative (SRTC) uses 8 km (5 mi) to designate separate subpopulations. If aggregates of active clusters are separated by 8 km (5 mi) or more the aggregates are considered a subpopulation and become eligible to receive translocated birds. Within the SRTC if the distance of 8 km (5 mi) or more separates “populations” then demographic assistance is needed for population survival (R. Costa, per. comm. 2009). Dispersal distances become greater when population density is decreased (Daniels 1997). Delotelle et al. (2004) suggest an alternative estimate for demographic isolation for RCWs is 25 km (15.5 mi) from another group; this estimation was compiled from dispersal distances recorded throughout the RCW range and is suggested to provide a more conservative estimate of demographic isolation and therefore of population persistence.

STUDY AREA

South Carolina is located on the southeast Atlantic seaboard and is bordered by North Carolina to the north, Georgia (across the Savannah River) to the west and south and the Atlantic Ocean to the east. South Carolina is divided into three major physiographic regions with the largest coastal plain province (including the Sand Hills and Atlantic Coastal Plain) lying south of the Fall Line that runs from Augusta, Georgia through Colombia, South Carolina to Cheraw, near the North Carolina border. The areas north of the Fall line include the Piedmont and Blue Ridge Physiographic Provinces. Since the historic range of optimal RCW habitat (mature longleaf pine *Pinus palustris* forest) occurs predominantly along the southeast coastal plain, this area served as the focus of our efforts. Properties investigated for this study included industrial and non-industrial private landowners as well as federal and state managed areas (Figure 1).

MATERIALS AND METHODS

The location of all known RCW cavity tree clusters in South Carolina was obtained using Global Positioning System (GPS) technology by landowners, managers and researchers. All locations (i.e., clusters) were categorized by property owners, managers, or government agency, and activity (active/inactive). We obtained shapefile, decimal degrees and degrees/ minutes/seconds information and compiled them into a GIS map. These datasets were transferred in electronic shapefiles or XY coordinates for trees. Some shapefiles were directly inserted into ArcGIS while others required additional research to determine the coordinate system. By assigning the correct coordinate system to the shapefiles the shapefiles were projected correctly to the basemap (state of South Carolina). Data transferred in XY coordinates, the XY coordinate and other information (activity and ownership) were placed in an excel file. The excel file was added to the basemap in ArcGIS and the option “Add XY Data” under the Tool option was used to convert the data to a shapefile, then the correct coordinate system correlated to the XY coordinates was defined to allow the shapefile to align correctly. To obtain a center point for all clusters, each cluster was transformed into a different shapefile using manual selection and the mean center tool. The cluster center was the only parameter used for the analysis. We were able to conduct the DIG analysis on 80 properties (Figure 1), which contained 1416 clusters. To determine if clusters were demographically isolated, an 8 km (5mi) and a 25km (15.5mi) radius buffer were placed around each cluster center (Figure 2 and Figure 3 respectively). RCW cluster isolation was defined when the buffer did not overlap any other cluster center. In addition to this analysis we separated clusters by status, active or inactive, in order to prioritize an action for the outcome of the model. A habitat suitability map (Figure 4) was developed to display habitat types (optimal, suboptimal, marginal and unsuitable) for RCWs. The four habitat types were defined as; (1) optimal = nesting and roosting habitat, (2) suboptimal = foraging habitat, (3) marginal = habitat that RCWs would use for corridors and (4) unsuitable = areas that have no characteristics that the RCW uses. To develop the map we used United States Geological Survey, Gap Analysis Program data (USGS GAP data) for South Carolina; this raster is a $30m^2$ grid. The GAP data uploaded contained 54 land cover types. We reclassified this data in order to reduce these land cover types to only four habitat types using the Reclass tool under the Spactial Analysis toolbox; the cover type code was changed to reflect our desired habitat types (Figure 4). With the habitat suitability map (Figure 5) future research could show the landscape permeability for RCWs which will illustrate how much energy is required for isolated populations to disperse and the likelihood of individuals reaching other populations. A validation of the habitat suitability map and all active clusters was performed to clarify the accuracy. The validation was completed by using the Extract Values to Points in the Spactial Analysis Toolbox, Extractions. When the validation was completed each point was assigned a suitability classification, these classifications were then averaged to calculate the percentage of points within each habitat classification.

RESULTS , MANAGEMENT IMPLICATIONS & FUTURE CONSIDERATIONS

The 8 km (5 mi) radius buffering exercise showed that there are 20 RCW clusters in South Carolina that are demographically isolated from the nearest viable population (Figure 5). Of the 20 clusters deemed isolated six are active; Kershaw, Georgetown, Berkeley, Colleton, and two in Jasper county, all of which are privately owned. Of the fourteen inactive clusters thirteen are Heritage Trust managed by SCDNR located in; Kershaw, Horry, Florence, Georgetown, Williamsburg, Richland, Clarendon, Orangeburg, Berkeley, Jasper, Lee and two in Aiken county, the other inactive cluster is owned by International Paper in Marion county (Figure 6).

The 25 km (15.5 mi) radius analysis showed that there are only three RCW clusters in South Carolina that are demographically isolated from the nearest viable population (Figure 7). To some degree, each of these isolated populations is near the periphery of the species' range in the state. Only one of the three isolated clusters, located at Big Survey Plantation in Colleton County, is active. The other two, an International Paper tract in Marion County and a SCDNR Heritage Trust property in Aiken County, are inactive (Figure 7).

In regards to future management decisions, the inactive clusters may present marginal opportunities for RCW management unless their status changes (via inputs of relocation or immigration). In such instances, managers may wish to consider the relocation of an isolated group to a larger more viable population that is not demographically isolated. Regarding isolated groups, we suggest that the time, effort and money might be better invested in a population that is more likely to persist for a significant time rather than in one whose viability seems uncertain at best and potentially bound for extirpation. However, as two options are presented in this report, we caution that the complex issues of logistics (time, funding, personnel) also come into play as factors in the ultimate decision-making process. Our intent here is simply to present those options for consideration. We also caution that while the information presented in this report provides a baseline for understanding the demography of RCW groups relative to one another, there were some constraints encountered that may have produced slightly different results. These constraints include outdated, incomplete, unusable or undefined (activity status undefined and presumed inactive) data.

The outcome of the habitat suitability validation showed that 62% of all active clusters fell in the optimal habitat classification category, 5% within the suboptimal class, 6% in marginal, and 27% in the unsuitable habitat classification category. According to the outcome of the validation approximately two-thirds of active clusters fall within the classification “optimal habitat” and approximately one-third are within the “unsuitable habitat”, with smaller percentages in the suboptimal and marginal categories. One might expect to see a declining occurrence trend from optimal to suboptimal to marginal to unsuitable, instead of the trend we observed.. The reason for this error is unknown, but a more accurate habitat suitability map (e.g., smaller scale with more discrete habitat classifications –stand type, age, condition etc…) might offer better resolution that would help explain the counter-intuitive trends.

The "effective isolation" of habitat patches can be significantly influenced by habitat matrix, thus demographic isolation might be more or less isolated than simple distance (Euclidean distance). The distance between habitat patches and the presence of travel corridors influence the "connectivity" of landscape or landscape resistance (Ricketts 2001). A resistant-kernal estimator, which uses a least cost path may be used to understand landscape resistance for RCWs in South Carolina. The resistant kernel would use RCW clusters as polygon centers and create a habitat kernel. The kernel estimator which is commonly used for home range analysis produces a three-dimensional surface using two-dimensional data, representing the probability distribution. The least cost path analysis can be used to find the shortest distance between two points. A resistant value, decided by dividing potential habitat value by land-use intensity, assuming land-use intensity degrades the current value, would be assigned to each cover type in the land-use map (Figure 4) representing the expected dispersal through that cover type (Baldwin and deMaynadier 2009, Compton et al. 2007).

ACKNOWLEDGEMENTS

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LITERATURE CITED

Baldwin, R. F., and P. G. deMaynadier. 2009. Assessing threats to pool-breeding amphibian habitat in an urbanizing landscape. Biological Conservation 142:1628-1638.

Compton, B. W., K. McGarigal, S. A Cushman, and L.Gamble. 2007. A resistant-kernal model of connectivity for amphibians that breed in vernal pools. Conservation Biology 21:788-799.

Costa, R., and S. J. Daniels, editors. 2004. Red-cockaded woodpecker: road to recovery. Hancock House Publishers, Blain, Washington, USA.

Costa, R., E. E. Stevens, N. T. McKay, and R. T. Engstrom. 1996. A current bibliographic resource for the red-cockaded woodpecker. Red-cockaded Woodpecker Field Office, Clemson, South Carolina, USA, and National Fish and Wildlife Foundation, Washington, D.C., USA.

Crowder, L. B., J. A. Priddy, and J. R.Walters. 1998. Demographic isolation of red-cockaded woodpecker groups: a model analysis. Project final report. Duke Univ., Nicholas School of the Environment, Beaufort, N.C. 17pp.

Daniels, S. J. 1997. Female dispersal and inbreeding in the red-cockaded woodpecker. M.Sc. thesis, Virginia Polytechnic Institute and State University, Blacksburg VA.

Daniels, S. J., and J. R. Walters. 2000. Inbreeding depression and its effects on the natal dispersal of red-cockaded woodpeckers. Condors 102:482-491.

Delotelle, R. S., R. J.Epting, D. L.Leonard Jr., and R. Costa. 2004. Management strategies for recovery of red-cockaded woodpecker populations; a metapopulation proposal. Pages 77-89 Red-cockaded woodpecker: road to recovery. Hancock House, Blaine Washington, USA.

Groombridge, B., ed. 1992. IUCN red list of threatened animals. IUCN, Gland, Switzerland.

Levins, R. 1968. Evolution in Changing Environments, Princeton University Press.

Lindenmayer, D. B., and J. F. Franklin. 2002. Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach. 1st ed. Washington, DC: Island Press.

MacArthur, R. H. and E. O. Wilson. 1967. The Theory of island Biogeography. Princeton Univ. Press. Princeton, NJ.

Pulliam, R. H. 1988. Sources, sinks and population regulation. Am. Nat. 132:652-661.

Ricketts, T. H. 2001. The matrix matters: effective isolation in fragmented landscapes. The American Naturalist 158:87-99.

Saunders, D. A., G. W. Arnold, A. A. Burbridge, and A. J. Hopkins, eds. 1987. Nature conservation: The role of remenants of native vegetation Chipping Nortan, Australia Surrey Beatty and Sons.

Temple, S. A. 1986. The problems of avian extinction. Current Ornithology 3:483-485.

U.S.Fish and Wildlife Service. 2003. Recovery plan for the red-cockaded woodpecker (*Picoides borealis*): second revision. U.S. Fish and Wildlife Service, Atlanta, GA. Pp 12 and 23.

Walters, J. R., P. D. Doerr, and J. H. Carter III. 1988. The cooperative breeding system of the red-cockaded woodpecker. Ethology 78:275-305.

Figure 1: Locations and Properties of RCW clusters considered in the DIG analysis(locations provided by SCDNR and USFWS).

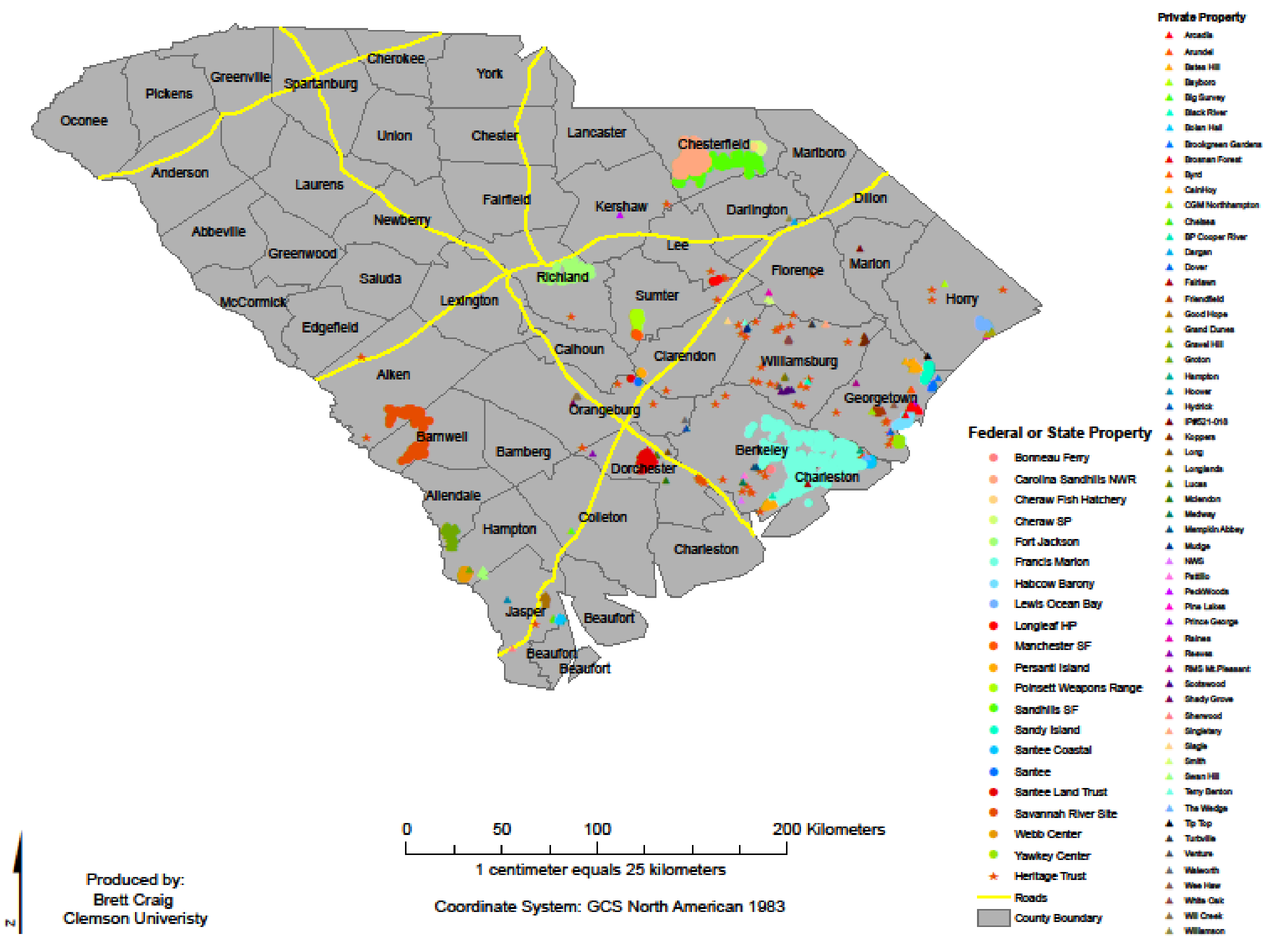

Figure 2: All South Carolina RCW clusters drawn with an 8 kilometer radius buffering each cluster to illustrate demographic isolation.

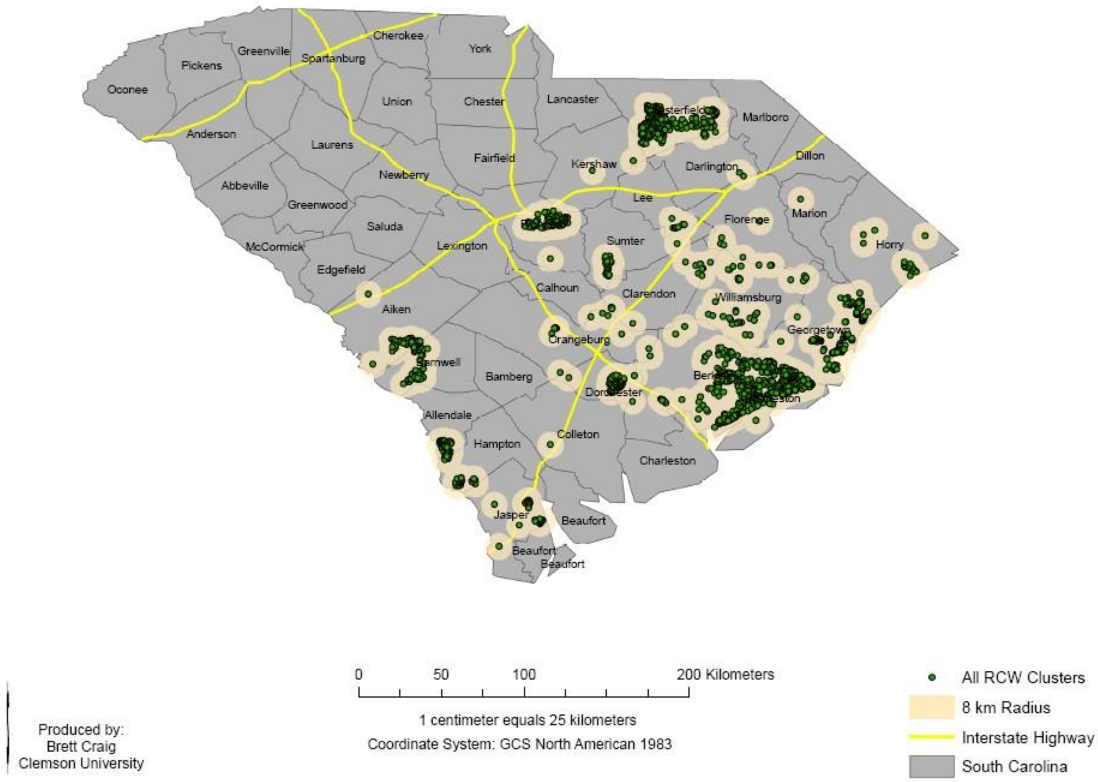

Figure 3: All South Carolina RCW clusters drawn with a 25 kilometer radius buffering each cluster to illustrate demographic isolation.

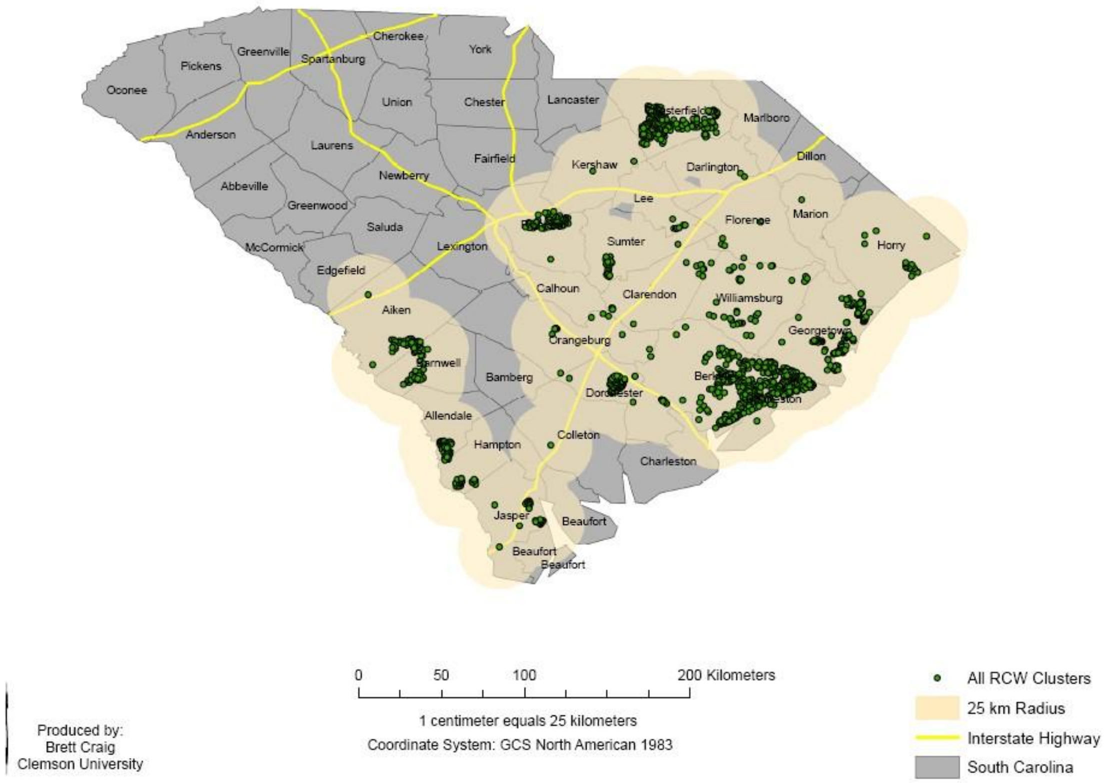

Figure 4: Land cover types provided by USGS GAP data and RCW habitat types associated with each.

Fresh water	Unsuitable	Floodplain forest	Marginal
Marine water	Unsuitable	Wet maritime forest	Marginal
Fresh water marsh/emergent wetland	Unsuitable	Estuarine salt flat/salt shrub thicket	Unsuitable
Pocosin	Unsuitable	Wet pinewoods	Suboptimal
Swamp/bottomland hardwood forest	Unsuitable	Salt and brackish marsh	Unsuitable
Wet soil	Unsuitable	Swamp/bottomland type 14	Unsuitable
Wet scrub/shrub thicket	Unsuitable	Swamp/bottomland type 15	Unsuitable
Dry scrub/shrub thicket	Unsuitable	Swamp/bottomland type 16	Unsuitable
Sandy bare soil	Unsuitable	Swamp/bottomland type 17	Unsuitable
Open canopy/recently cleared forest	Unsuitable	Swamp/bottomland type 18	Unsuitable
Rock outcrop	Unsuitable	Swamp/bottomland type 19	Unsuitable
Aquatic vegetation	Unsuitable	Mud/sand flat	Unsuitable
Closed canopy evergreen forest/woodland	Optimal	Beach	Unsuitable
Needle-leaved evergreen mixed forest/woodland	Optimal	Spoil deposit/impoundment	Unsuitable
Pine woodland	Optimal	Intertidal beach	Unsuitable
Dry deciduous forest/woodland	Marginal	Narrow stream valley forest	Unsuitable
Mesic deciduous forest/woodland	Marginal	Coastal upland mixed forest	Marginal
Dry mixed forest/woodland	Suboptimal	Piedmont bottomland forest	Unsuitable
Mesic mixed forest/woodland	Suboptimal	Dry basic deciduous forest/woodland	Marginal
Grassland/pasture	Unsuitable	Mesic basic deciduous forest/woodland	Marginal
Cultivated land	Unsuitable	Mesic basic mixed forest/woodland	Suboptimal
Urban development	Unsuitable	Ridgetop/upper slope evergreen woodland	Unsuitable
Urban residential	Unsuitable	Rocky shoals	Unsuitable
Low density residential	Unsuitable	Montane riparian forest	Unsuitable
Wet evergreen	Suboptimal	Deciduous rich/acidic cove forest	Unsuitable
Lowland maritime forest	Marginal	Montane evergreen forest	Unsuitable
Maritime shrub complex	Unsuitable	Eastern hemlock ravine forest	Unsuitable

Figure 5: RCW habitat suitability map containing all active clusters and thenatlve range of longleaf pine *(Pinuspalustris).*

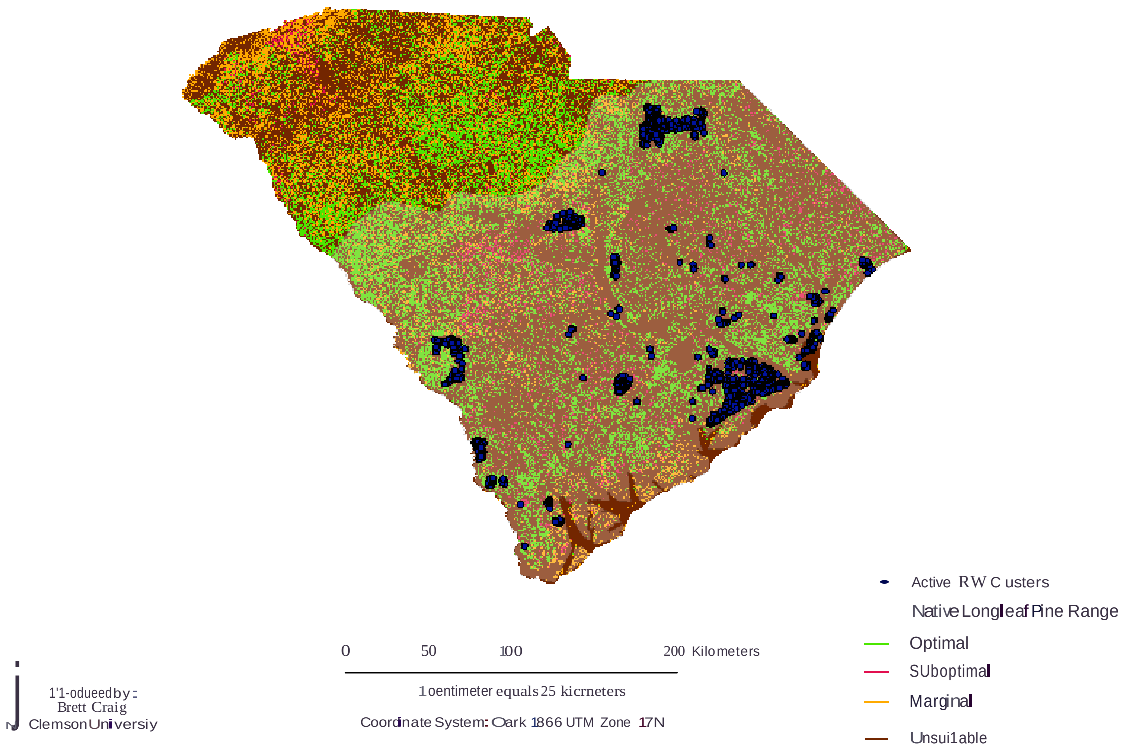

Figure 6: Demographically isolated RCW clusters in South Carolina provided with an 8km radius (clusters are designated as demographically isolated when one 8km radius [i.e., cluster] does not contact another cluster).

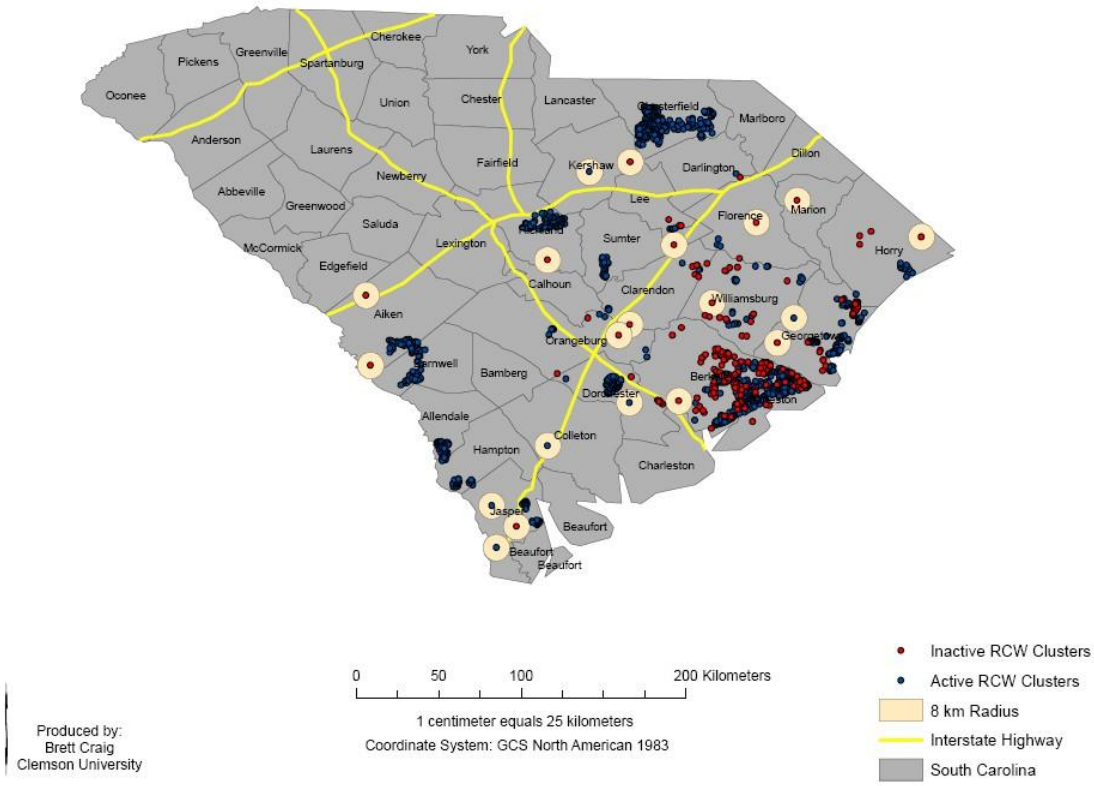

Figure 7: Demographically isolated RCW clusters in South Carolina provided with a 25km radius (clusters are designated as demographically isolated when one 25km radius [i.e., cluster] does not contact another cluster).