THE WILDLIFE SOCIETY

Remotely Wild

Newsletter of the Spatial Ecology & Telemetry Working Group

Issue 32 Summer 2016

From the Working Group Chair

Welcome to the 2016 Summer edition of Remotely Wild, the newsletter of the Spatial Ecology & Telemetry Working Group of the Wildlife Society (SETWG). I hope you are having a productive season of field work and spatial data analyses. We have some great articles in this edition, and this year is proving to be an exciting one for the Working Group as we gear up for the annual Wildlife Society conference in Raleigh, North Carolina this October. We'll continue to keep you up to date.

*Last year was an exciting one for SETWG! We sponsored a symposia at the 2015 Wildlife Society conference in Winnipeg as well as the "Rhr: a package for home range estimation with a graphical user interface" workshop led by Rhr R-package authors Johannes Signer and Dr. Niko Balkenhol that was a sold-out success (see page 4). This year we are pleased to again be able to offer travel awards for students to attend the 2016 conference. SETWG is also excited to be sponsoring a half-day workshop '**Modeling & Visualizing Wildlife Spatial Behaviors in 3D**' led by the mkde R-package authors Dr. Jeff Tracey and myself (see preview on page 6). Given the popularity of previous spatial ecology workshops and the increasing use of R in our field we expect similar high demand for this 3D R tutorial, so get in early!*

Thanks to those who submitted articles for this issue of our newsletter - and thanks to the SETWG membership for your continued support and interest in the Working Group. If you would like your research published in Remotely Wild, please feel free to email us your work for consideration.

Best regards, *James K. Sheppard*

In this issue:

TWS Spatial Ecology & Telemetry Working Group

Treasurer's Report: 2016

Balance as of 1/1/2015	$5,839.63
2015 Total Income	$788.10
2015 Total Expenses	$2,010.10
Balance as of 12/31/2015	$4,617.63
Current balance	$5,105.63
Membership	176

SETWG Executive team update:

SETWG is pleased to announce that **Alex Wolf** has joined our executive team as Secretary. Alex graduated with a BS in Evolution, Ecology & Behavior from Beloit College in 2006 and an MS from the Cooperative Wildlife Research Lab at Southern Illinois University in 2012. His professional experience includes two years working with invasive pythons in the Everglades for the University of Florida and National Park Service before graduate school and three years with the Missouri Dept of Conservation. Alex has recently accepted a position at the Cary Institute of Ecosystem Studies in NY.

WHERE IN THE WORLD ARE SETWG MEMBERS..?

2016 Student & Young Professional Travel Awards

The Spatial Ecology and Telemetry Working Group of the Wildlife Society is soliciting applications for $500 travel awards to attend the Wildlife Society's Annual 2016 Conference in Raleigh, NC. A total of four awards will be provided in the following three categories:

2 Graduate Student awards: Must be a current graduate student or have graduated in 2016.

1 Undergraduate Student award: Must be a current undergraduate student or have graduated in 2016.

1 Young Professional award: Must have graduated from undergraduate or graduate school within the previous 2 years.

Award guidelines:

Individual applicants must be a member of The Wildlife Society at the national level. Membership of the Spatial Ecology and Telemetry Working Group is not required (although it is encouraged!). Graduate student and young professional applicants must be presenting a poster and/or oral presentation at the conference. Preference will be given to applicants whose research emphasizes GIS, remote sensing, or telemetry. Undergraduate applicants are not required to present but should have research interests or experience in the areas of GIS, remote sensing or telemetry. Travel awards will not be presented to applicants who have already received a travel award from the Wildlife Society or another working group in 2016. As a condition of the travel award, recipients will be asked to write a short article describing their research for our SETWG newsletter. How to apply:

Applicants must send a copy of their presentation abstract (graduate and young professional applicants) or a description of their research interests (undergraduate applicants), a brief 1-page CV, and a 1-page letter stating their professional interests and why they should be considered for the award to SETWG Chair: James Sheppard (spatialecologist@gmail.com). Make sure to mention which travel grant you are applying for.

The application deadline is **August 5, 2016.** Award recipients will be notified by August 19, 2016.

WORKSHOP RECAP:

Rhr: a package for home range estimation with a graphical user interface

Johannes Signer and Dr. Niko Balkenhol

22nd Annual TWS Meeting, Winnipeg (2015)

Rapid developments in wildlife biotelemetry technologies have enabled the collection of large high-resolution location datasets, which have been matched by advances in spatial analytical techniques and computing power - wildlife professionals increasingly recognize the value of modeling skills for optimizing the management and analysis of spatial data . Recognizing this, SETWG sponsored a sold-out workshop at the 2015 Wildlife Society conference on the "***Rhr***" package available for the R software, which offers functions and methods to enable wildlife professionals to successfully conduct spatial analysis and modeling of their telemetry data.

The ***Rhr*** workshop was led by the R-package authors, Johannes Signer and Dr. Niko Balkenhol, University of Goettingen

Home ranges are often used to analyze tracking data originating from GPS telemetry. Unfortunately, the variety of methods available for home range estimation also makes it difficult to objectively evaluate published results of many home range studies. This is because results and parameter values of home range analyses are often not reported adequately, and important analytical steps are often missing (Laver and Kelly 2008). Consequently, Laver and Kelly (2008) urged researchers to conduct certain analytical steps before actual home range analyses, and requested minimum editorial standards for reporting home range analyses. For the estimations of home ranges several software products and extensions for Geographic Information Systems (GIS) are available. However, current software solutions are often closed-source and require commercial licenses or require programming skills, which not every wildlife manager or student has. To improve the current situation and to provide a software platform implementing the recommendations of Laver and Kelly (2008), we present a new R package, *rhr* (reproducible home ranges; Signer and Balkenhol 2015), that enables users to perform home range analyses using the most common estimators and keep track of all analytical steps, parameter values, and results.

The *rhr* package runs entirely within program R and provides a graphical user interface that runs within the web browser. At the moment the rhr package provides access to asses site fidelity and time to statistical independence, estimate home ranges with minimum convex polygons, kernel density estimation, local convex hulls, Jennerich-Turner Ellipses, Brownian Bridge Movement model and an area independent estimation of core areas. In addition, the *rhr* package has some data management capabilities, e.g., the user can select among different animals which ones to include in an analysis, temporal and spatial subsets can be performed and the coordinate reference system of relocations can be adjusted. Finally the *rhr* package produces a report at the end of each analysis with a summary of the main finding and all parameter values used during the analyses. Spatial results (e.g., Shape files of home-range isopleths or rasters with utilization distributions) are written automatically to a temporary or use specified directory and can be used for further processing in other Geographic Information Systems.

To use the package, R (Version 3.1 or higher) and a modern inter browser is required. Detailed instructions how to install and use the package are available on the package website: http://rhr.spamwell.net

Once the package is installed and loaded into R, the graphical user interface can be started with a single command. Data on the relocation of animals can than be loaded from deliminator separated text files (e.g., csv files).

A mailing is available (https://listserv.gwdg.de/mailman/listinfo/rhr-discussion) for further discussion, bug reports and feature requests.

Literature cited

Laver, P. N., and M. J. Kelly. 2008. A critical review of home range studies. Journal of Wildlife Management 72:290–298.

Signer, J., and N. Balkenhol. 2015. Reproducible home ranges (rhr): A new, user-friendly R package for analyses of wildlife telemetry data. Wildlife Society Bulletin in press.

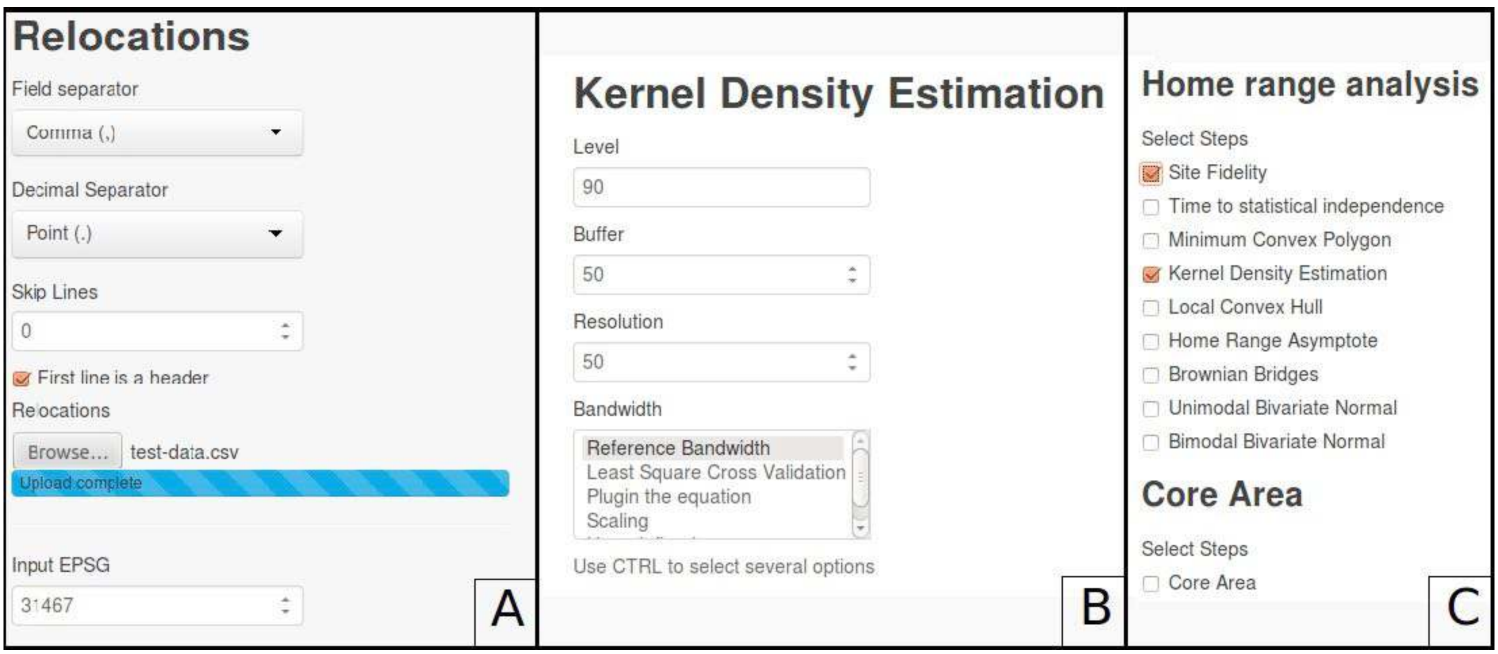


Figure 1: The user can upload deliminator separated text files and specify field separators among other things (panel A). Each analytical method has set of options that can be set (kernel density estimation is shown as an example in B). Finally the user can select which analytical steps to include in one run (panel C).

WORKSHOP PREVIEW

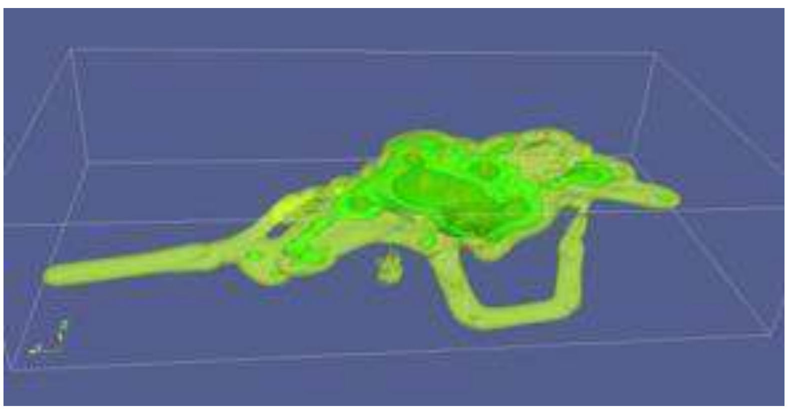
Modeling & Visualizing Wildlife Spatial Behaviors in 3D

Dr. Jeff Tracey[1] & Dr. James Sheppard[2]

23rd Annual TWS Meeting, Raleigh NC (October 15 – 19, 2016)

1. U.S. Geological Survey, San Diego Field Station, Western Ecological Research Center

2. San Diego Zoo Institute for Conservation Research



Advances in digital biotelemetry technologies are enabling the collection of bigger and more accurate data on the movements of free-ranging wildlife in space and time. The coevolution of biologgers with home range estimators is bringing inferences on animal space use closer to biological reality. However, current estimators fail to capitalize on the 3D profiles offered by modern GPS biotelemetry datasets. Animal space-use is multi-dimensional and can be characterized within two x and y planar spatial dimensions, as well as a z-dimension representing altitude (for flying or arboreal species), elevation (for terrestrial species), or depth (for aquatic species). Although many biotelemetry devices record 3D location data with x, y, and z coordinates from tracked animals, the third z coordinate is typically not integrated into studies of animal spatial use. Disregarding the z dimension greatly limits our understanding of the vertical component of animal ranging patterns and restricts our ability to define and predict how animals move through landscapes and select and use habitats. Traditional 2D home range estimators may also misrepresent the space use of animals that occupy habitats with a strong vertical component.

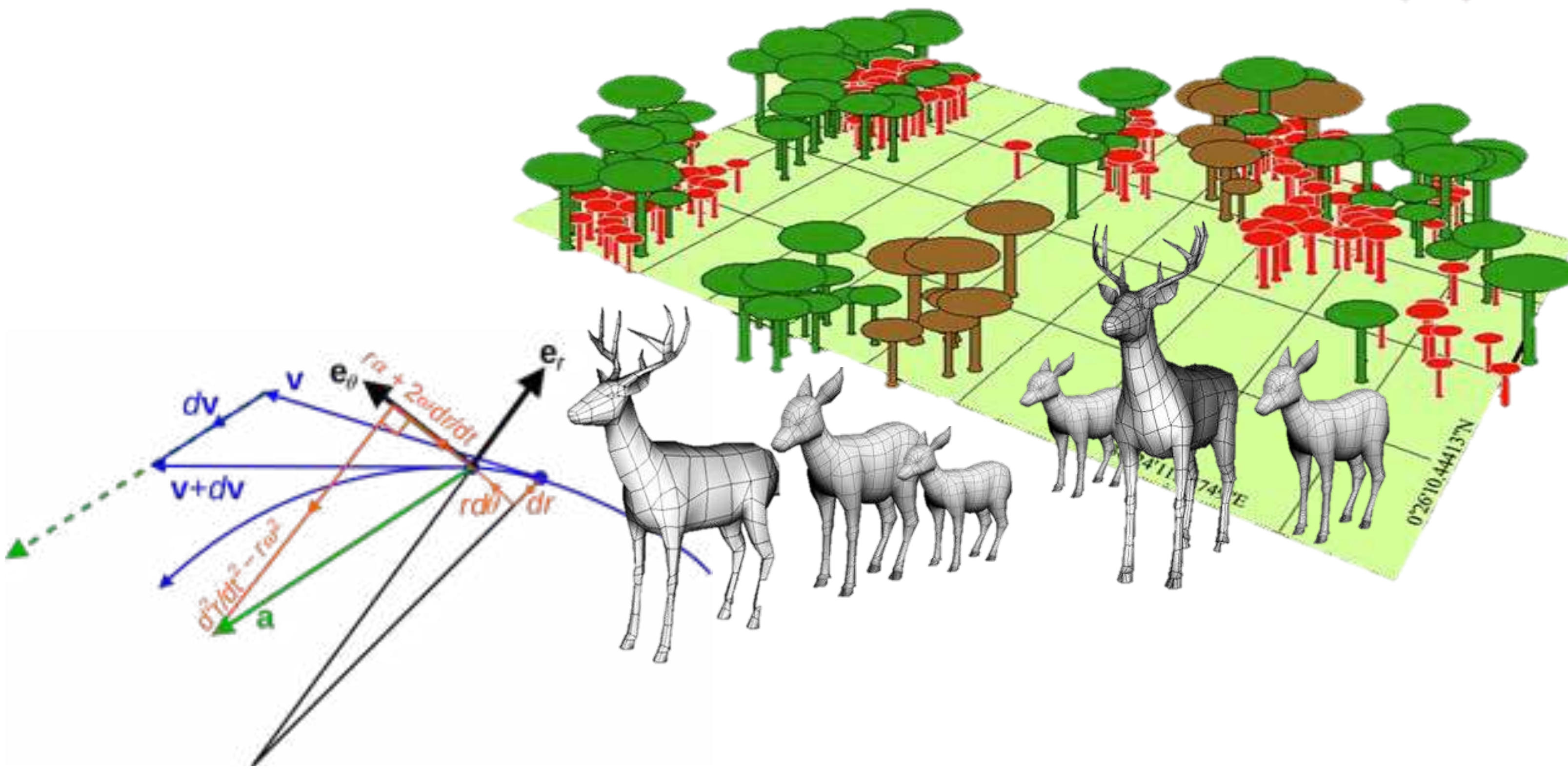
This workshop will present novel 3D movement-based kernel density estimators and computer visualization tools for generating and exploring wildlife 3D home ranges based on biotelemetry location data. The application and value of these estimators will be demonstrated using biotelemetry data acquired from endangered animals that occupy aerial, terrestrial, and aquatic spatial domains. The workshop will explain how these 3D methods work, discuss their pros and cons relative to other methods, and go step-by-step through the freely available *mkde* package for R. https://cran.r-project.org/web/packages/mkde/index.html

Case studies will be used to demonstrate the ecological insights and conservation management benefits provided by 3D home range estimation and visualization for terrestrial, aquatic, and avian wildlife research. This is not a statistics or modeling workshop, but will provide wildlife professionals with hands-on tools and skills to facilitate enhanced 3D visualization and analysis of wildlife biotelemetry data.

Keep up to date with conference workshops at the Wildlife Society 2016 conference website:

http://www.twsconference.org/workshops/

SETWG Awards 2016



The Spatial Ecology and Telemetry Working Group is excited to announce the 2016 recipients of **SETWG Awards** that recognize professionals in the field of GIS or Telemetry who have made significant contributions to the field of wildlife biology.

Award recipients do not need to be wildlife biologists or even involved in any environmental research or management. They only need to have written or produced something, or provided some service that has substantially improved our ability to do our job and enabled us to do things we may not have been able to do before. Although our awards do not include any kind of cash prize, they are a way for us, as a professional society, to say thank you to these individuals for the help they have given us.

All individuals listed below have been awarded Certificates of Appreciation from our working group, and sent letters thanking them for the tremendous service they have provided to our profession. Thank you to those members who nominated this year's winners - If you would like to nominate a individual or organization that you feel should be considered for recognition by SETWG we would love to hear from you. Please send all nominations to the working group awards committee chair Alex Wolf (wolfa@caryinstitute.org).

Join us in congratulating the following 2016 SETWG awardees!

ArcMET: Movement Ecology Tools for ArcGIS®

Jake Wall

Colorado State University

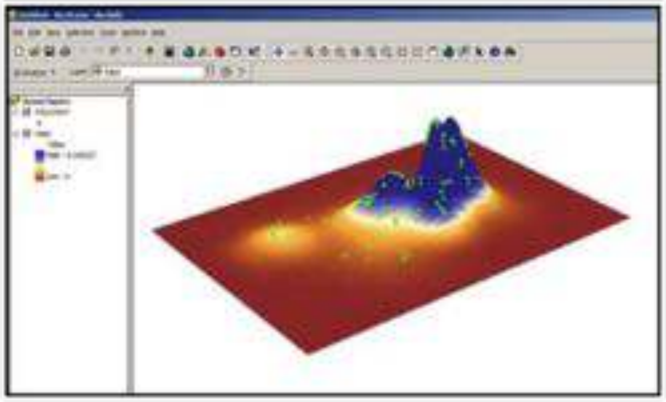
Department of Fish, Wildlife and Conservation Biology

http://www.movementecology.net

ArcMET (Movement Ecology Tools for ArcGIS) is a package of tools for analyses within the fields of movement ecology and wildlife conservation. At present, these tools comprise 6 major categories:

1. Filter: tools for filtering and temporal segmentation of movement data
2. Trajectory: tools that operate on or calculate aspects of an animal's trajectory
3. Range: tools for calculating the range of an animal based on its sampled trajectory
4. UD: tools for calculating the utilization distribution of an animal based on its sampled trajectory
5. Covariate: tools for linking movement data with covariate information
6. Utilities: various utility tools

HRT: Home Range Tools for ArcGIS®



A.R. Rodgers, J.G. Kie, D. Wright, H.L. Beyer, and A.P. Carr

Centre for Northern Forest Ecosystem Research, Ontario Ministry of Natural Resources

http://flash.lakeheadu.ca/~arodgers/hre/

The HRT is an extension for ArcGIS to analyze animal home ranges developed by Arthur R. Rodgers at the Ontario Ministry of Natural Resources and a group of collaborators. In addition to home range calculations using several methods, the program supports calculation of other movement statistics and has a data animation tool.

The HRT contains software that extends ArcGIS to analyze home ranges of animals. The ability to use large data sets and carry out all required home range analyses within a single software environment were the primary reasons for developing the HRT for ArcGIS. The programs have been written for novice GIS users who already understand basic wildlife telemetry issues and who are familiar with the concept of a "home range".

The HRT include 2 home range analysis models: minimum convex polygons (MCPs) and kernel methods. The HRT for ArcGIS provides raster output and batch processing of kernel analyses for multiple animals.

Hard travelin' down the Prairie: within-season breeding dispersal in a declining grassland songbird

Emily J. Williams[1,2] & W. Alice Boyle[1]

1. Division of Biology, Kansas State University

2. Email: ejwillia@ksu.edu

Zipping across the world, a single country, or even a specific region, the diversity of topography and spatial change is outstanding: we're witness to shifts from the aquatic to the terrestrial, stream to river delta, mountain to valley, forest to grassland, urban to rural. Then zoom into a very specific fragment of a place – say, a 10-km slice of California – you'll still find tremendous spatial complexity, with patches of cropland, emergent marsh wetland, Redwood forest, and the foothills of the Sierras, all intricately entwined within an urban-metropolitan matrix. A central theme in wildlife biology is how the spatial patterns of a landscape – at a myriad of scales – can affect the behavior, survival, and reproduction of wildlife. One of the most common and perhaps, most challenging ways of answering spatial ecology questions is to study animal movement behavior. When faced with ecotone shifts, hard edges, and human development, how do animals cope? How might corridors facilitate movement and access to habitat or food resources that would otherwise be unavailable? These and countless other questions are at the forefront of landscape ecology and largely remain as some of the most difficult questions to answer in highly mobile species of wildlife.

Fig. 1 (left): Emily Williams (Masters student at KSU) collecting a feather sample from a female Grasshopper Sparrow at Konza Prairie Biological Station, KS.

Fig. 2 (above): Color-banded male Grasshopper Sparrow perched on a fence line. This individual is known as "YY-SK." Photo by Dave Rintoul.

One relatively well-studied animal movement behavior is breeding dispersal, or the movement an adult makes between successive breeding attempts. The ability of animals to return to a breeding area, or site faithfulness, is a well-documented trait among many species of birds and mammals (Greenwood 1980). One of the most remarkable examples of this is in migratory birds: many species travel thousands of kilometers in a single year, but then return back to the same territory, the same tree, or even to the same infinitesimal depression of lichen and bearberry on the tundra.

The benefits of site faithfulness are manifold: the territorial sex often can secure a higher quality territory, can more easily climb the social hierarchy, reap the benefits of past experience in knowing the area, and save energy, as moving to a new site is energetically costly and has inherent unknown risk. The idea that individuals would be faithful to their breeding site is no surprise; the fitness payoffs often outweigh the risks of moving to a new territory or breeding area. However, although site fidelity may be the paradigm in the bird world, there are many cases of individuals doing the exact opposite. Some birds disperse to a new breeding area within a single breeding season, or travel to a new site the following year. Provided that site fidelity is so common, the individuals not performing this "normal" behavior make them the odd ones, and prompt the question, "why?!"

Birds that occupy stable habitats within-season and across years are frequently highly site-faithful, such as Black-throated Blue Warblers breeding in the mixed deciduous woodlands of New Hampshire (Cline et al. 2013), Piping Plovers breeding along river sandbars in southeast South Dakota (Friedrich et al. 2015), or Pacific Golden Plovers breeding in the lowland tundra of northern Alaska (Colwell 2010). Although all of these habitats face seasonal changes in temperature, precipitation, and leaf-out, the structure and composition of the plant community and the substrates upon which birds nest changes little. In contrast, growing evidence for site infidelity is coming from birds that breed in areas characterized by great spatial and temporal variability. These patterns suggest that the inherent variability that typify these landscapes influences avian inhabitants to capitalize on multiple breeding areas, as a particular location can radically change over space and time.

Variability is a defining feature of grasslands. They are landscapes that can dramatically change over the course of the breeding season, and from year to year. Grasslands are characterized by incredible variability in climate, with high and strong seasonal patterns of annual rainfall (CV=25%) (Knapp 1998). Grasslands also experience interannual variability in precipitation (Nippert et al. 2006). Coupled with inter- and intra-annual changes climate, the interactive effects of fire and grazing create a dynamic landscape that changes considerably from early to late season (Fig. 3) (Fuhlendorf et al. 2009).

Fig. 3: A) ungrazed pasture burned early Spring, B) same pasture in late Summer C) grazed pasture one year since burn in early Spring D) same pasture in late Summer. Images taken at Konza Prairie Biological Station, KS.

The effects of grazing, burning, and seasonal changes in climate can have profound effects on the settlement and nesting decisions of birds that rely upon variable landscapes. Anecdotal evidence suggests that grassland birds adopt a more mobile strategy in the face of constant flux: the Eurasian Hoopoe, which breeds across savanna and steppe environments across Europe, Asia, and North Africa (Bötsch et al. 2012), the Red-billed Quelea, which breeds within the savanna and steppe of Sub-Saharan Africa (Jaeger et al. 1986), and the Sedge Wren, which breeds within shortgrass marsh and tallgrass prairie across the eastern half of the United States (Robbins 2015). For each of these species, published descriptions of their breeding movement patterns include potential evidence for having “dual-breeding ranges,” as the distances between successive breeding attempts are vast. Our own study of Grasshopper Sparrows within the Flint Hills region of eastern Kansas now reveals that many individuals shift territories and sometimes disperse over smaller distances of up to 9 km between breeding attempts within the same breeding season (Williams and Boyle, in prep). This intriguing pattern of movement led us to ask the questions, “what affects the decision to disperse, and the decision on where to settle next?”

To answer these questions, we hypothesized that dispersal and subsequent settlement decisions may be shaped by spatial and temporal variation in predation or nest parasitism risk, food availability, and nest microhabitat quality. To test these hypotheses, we studied Grasshopper Sparrows between May – August 2013-15 at the Kansas State University (KSU) Konza Prairie Biological Station and Experimental Range Unit (Fig. 4), located in the northern Flint Hills of eastern Kansas. Konza Prairie is a 3,487-ha tract of tallgrass prairie co-owned by Kansas State University and The Nature Conservancy. The Konza is experimentally managed with varying grazing and burning treatments, where grazing varies by bison, cattle, or no grazing treatments, and prescribed burns occur on an annual to every 2, 3, 4, and 20-year basis. The KSU Experimental Range Unit is composed of six 24.3-ha pastures managed with “intensive early stocking,” where pastures are burned in late April and heavily stocked with cattle (Owensby et al. 1988).

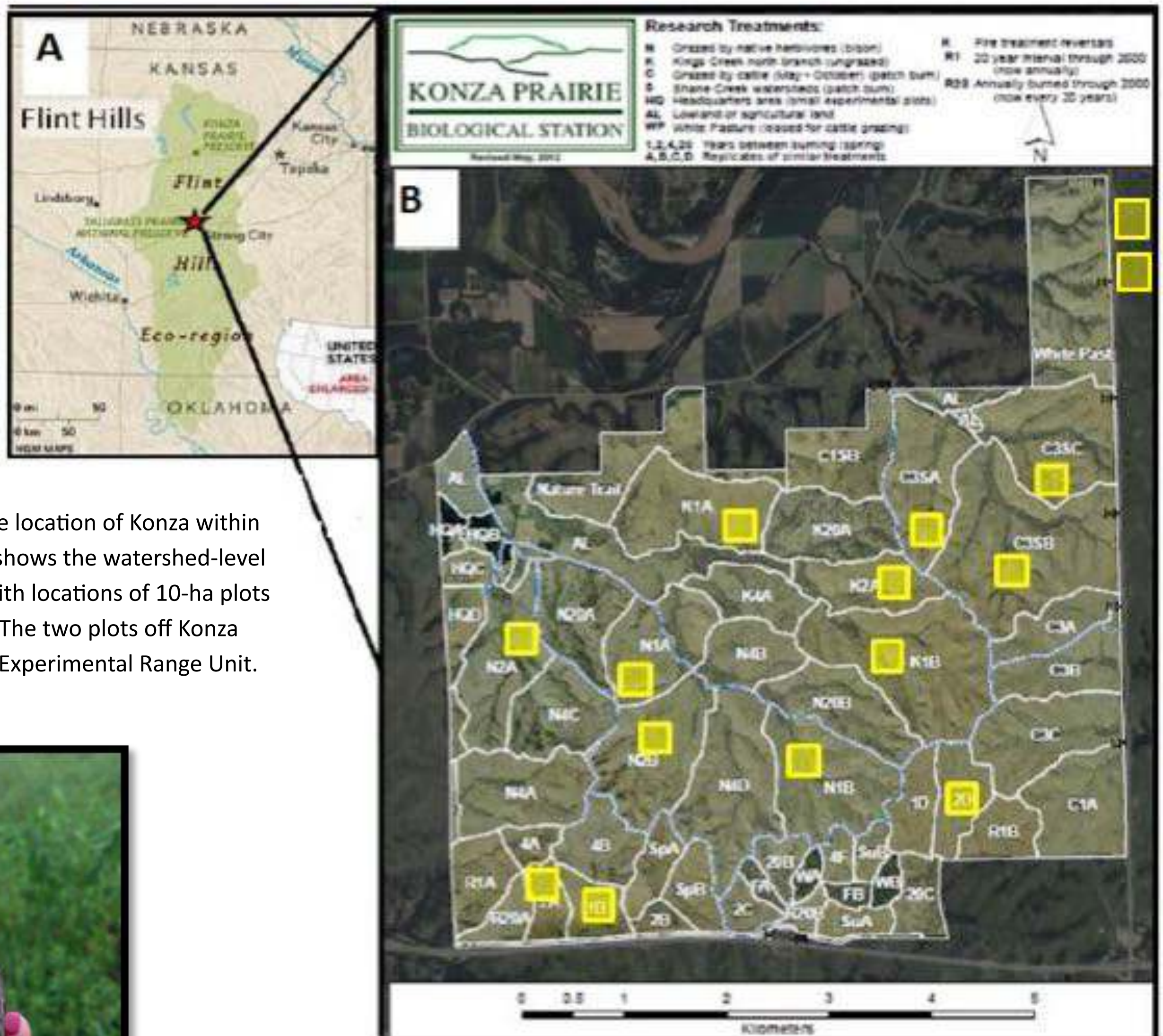


Figure 4: Panel A shows the location of Konza within the Flint Hills, and panel B shows the watershed-level treatments on the Konza with locations of 10-ha plots marked by yellow squares. The two plots off Konza are located within the KSU Experimental Range Unit.

Figure 5: Male Grasshopper Sparrow fitted with a radio-transmitter.

We captured, color-banded, and monitored Grasshopper Sparrows in a randomly-located 10-ha plot within 18 watersheds in replicated combinations of a) grazing or no grazing, b) annual spring burns or two-year burns, c) intensive early stocking and d) “patch-burn” plots managed with a three-year rotational burn regime in combination with warm-season cattle grazing (Fig. 4). We searched for nests 2-4 days/week by using behavioral observations and rope dragging to flush females off of nests, and monitored nests every 2 days until the nest failed or fledged. To monitor dispersal events and measure dispersal distances, we mapped territories of all individuals every 7-14 days within each watershed, and conducted radio-telemetry on males at nests for which we had strong confidence were the nest fathers. We considered sparrows as dispersed if they a) displayed territorial behavior >100m away from their original territory or nest location, or b) were not resighted at their initial territory ≥1-week after nest completion. Grasshopper Sparrow territories range in size from 0.36ha – 0.81ha across their breeding range, and are ~0.16ha in tallgrass prairie – so our 100m cutoff is well outside the range of sparrow territories encountered at the Konza Prairie.

From May-July 2013-2015, we color-banded a total of 779 adult Grasshopper Sparrows (males=647, females=132) and radio-tagged 20 individuals between May-July 14-15. We observed 148 dispersals, with most instances of dispersal recognized by resight surveys (N=139, telemetry = 9). Dispersal distances ranged from 0.101 – 8.94km from first and second territories or nests (Fig. 6). Data from 2014 indicate that territory densities in watersheds managed differently exhibit different temporal trajectories (Fig. 7). We observed consistent seasonal shifts in habitat selection, with higher densities of sparrows on cattle-grazed plots (e.g., patch-burn and early-intensive stocking) than in ungrazed or bison-grazed watersheds. In general, cattle-grazed plots had consistently higher densities than ungrazed or bison-grazed watersheds throughout the entire season across years. These patterns of dynamic habitat selection agree with recent published studies indicating higher Grasshopper Sparrow abundances in areas managed with fire and grazing (Hovick et al. 2014).

Throughout this study, our objectives are: 1) to provide the first comprehensive description of the spatial and temporal patterns of within-season breeding dispersal in a grassland bird, and to 2) investigate the ecological causes and potential adaptive consequences of within-season breeding dispersal, by explaining the factors that shape the initial decision to disperse and subsequent settlement decisions following dispersal. Although our study will provide the first detailed, population-level description of within-season breeding dispersal in a grassland bird, this within-season movement, despite the dearth of published evidence, may be more common than we might expect. Within several life history accounts of grassland-obligate migratory birds, including the Sedge Wren, Cassin's Sparrow, and Henslow's Sparrow, these species are often characterized as having "fluid" territories and have "erratic" habits that inevitably result in large gaps in their annual life cycle (Dunning et al. 1999, Herkert et al. 2001, Herkert et al. 2002). It's likely these species have developed a more mobile strategy to adapt to the constantly changing environmental conditions; a requisite in temporally and spatially variable environments such as grasslands.

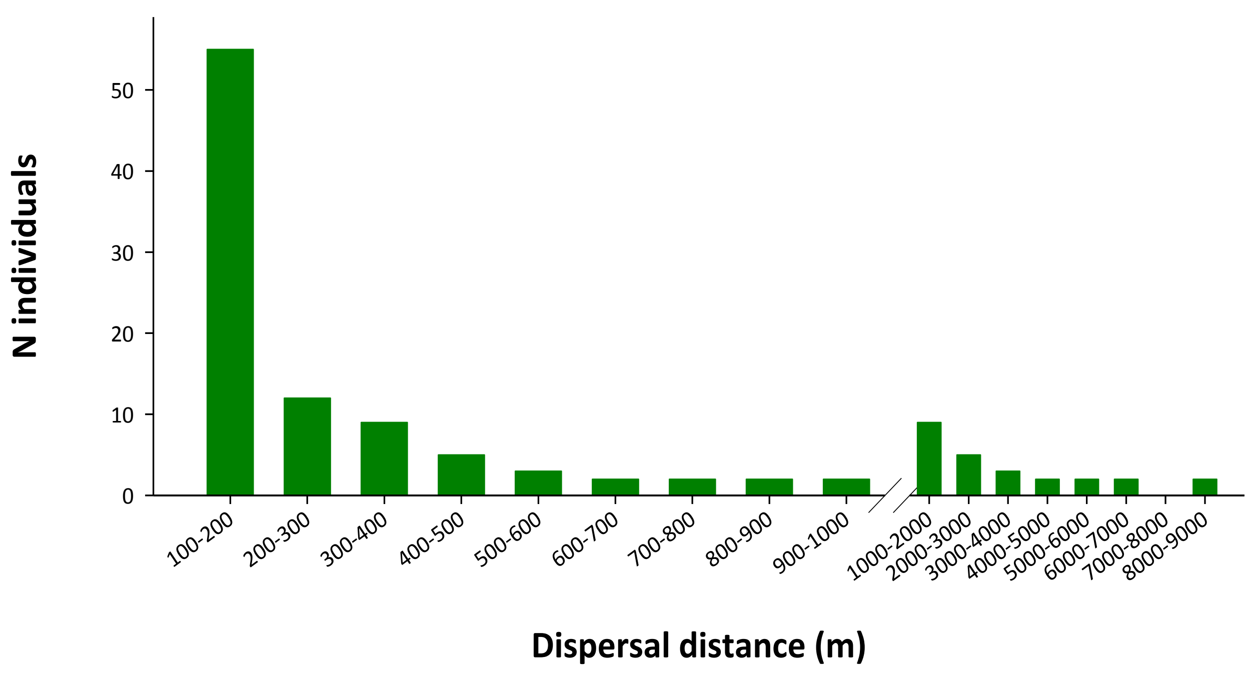


Figure 6: Range of dispersal distances of Grasshopper Sparrows at Konza and the KSU Experimental Unit.

We currently know relatively little of whether within-season breeding dispersal occurs within these species, and further, lack even basic knowledge of the patterns and explanations for this behavior. Without this spatial information, we cannot investigate the ecological and evolutionary basis for within-season breeding dispersal behavior, nor can we construct complete demographic models necessary for estimating survival, identifying life stages responsible for declines, and projecting future population trajectories. Since grassland birds have suffered the largest declines out of any other avian guild (Sauer et al. 2014), identifying the instances, patterns, and causes of within-season breeding dispersal decisions of these species is thus critically important to effectively manage them and preclude further declines.

On the whole, to answer those tough questions in wildlife biology can be incredibly challenging, especially when it involves following highly mobile animals that have a tendency to be site faith-*less* and unpredictable. Nonetheless, studying breeding dispersal – or some other kind of animal movement – is one step closer to greater understanding of how wildlife react and respond to spatial patterns that are constantly changing over time. Although complexity brings with it some formidable challenges, variability is what makes it interesting. After all, *variation is the spice of life*! (Kruglyak and Nickerson 2001).

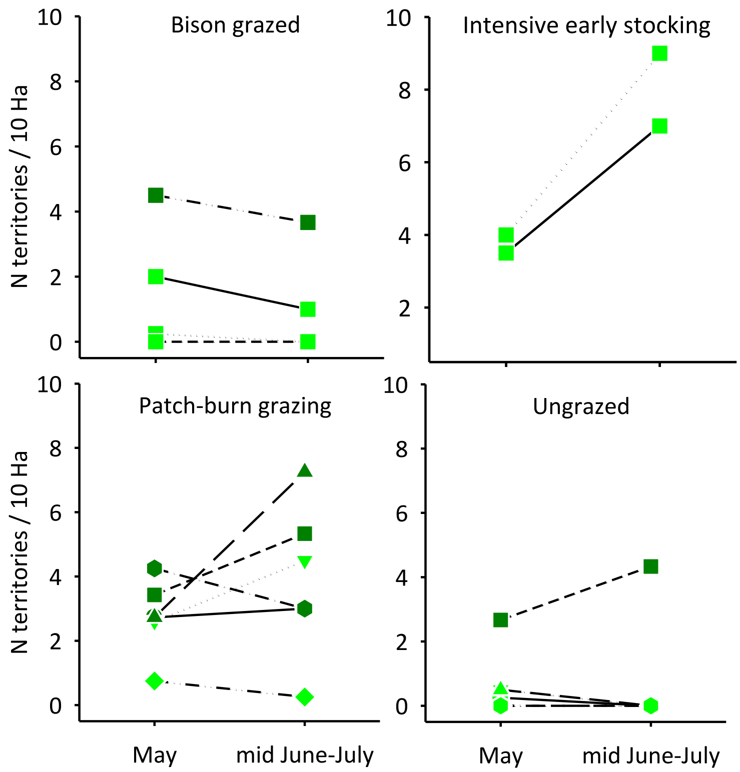


Figure 7: Changes in density of territorial Grasshopper Sparrows within watersheds from early (May) to late season (mid June – July).

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An autonomous GPS geofence alert system to curtail avian fatalities at wind farms

James K. Sheppard[a], Andrew McGann[b], Michael Lanzone[b], Ronald R. Swaisgood[a]

a. San Diego Zoo Global, Institute for Conservation Research

b. Cellular Tracking Technologies LLC, Somerset, Pennsylvania, United States of America

Email: jsheppard@sandiegozoo.org

Wind energy developments continue to proliferate globally as nations seek clean and renewable alternative energy sources to fossil fuels. However, wind farms do not come without environmental costs [1]. A growing literature is documenting the serious impacts that wind farms can have on resident and migratory avifauna populations through mortalities from direct collisions with turbines [2, 3]. Recent estimates indicate that wind farms in North America are responsible for up to 368,000 bird fatalities annually [4]. Consequently, the development and implementation of effective measures to reduce wind energy impacts on wildlife is recognized as a top priority by biologists, conservation organizations, regulators and the private sector (see reviews by [5-7]). We developed a new geofence-based biotelemetric system to minimize collision risks, particularly for threatened and endangered bird species whose ranges overlap with current and future wind farm sites.


M. Mirinha/STRIX Nature doi:10.1038/nature.2012.10214

A geofence is a virtual boundary delineated around an area of interest that triggers: 1) A cue to the telemetered animal (e.g. electric shock); 2) a change in the location fix rate attempted by the unit, or; 3) an alert to managers whenever the animal crosses the boundary edge. Geofences are increasingly recognized as an effective platform to enhance the spatiotemporal flexibility of wildlife management. For example, geofences have been successfully integrated into the management of mammalian populations that come into conflict with or are disturbed by human activities, such as elephants and wolves (see review by [8]). However, until now geofence alert technology has been prohibitively too large or too complex to incorporate into avian biotelemetry.

We developed an autonomous alert system that successfully miniaturizes and integrates virtual geofence capability into solar-powered biotelemetry devices used to track species of large birds currently impacted by wind farms, such as cranes and raptors. These units combine a GPS receiver with a GSM communications system that transmits acquired high-resolution location data via cellular networks in near real-time. Custom sized geofences can be placed around wind farms. When a telemetered bird ingresses one of these virtual boundaries the GPS location fix rate decreases from 15-min to 30-sec and an SMS alert is automatically transmitted to a user group within 2-min. When the bird egresses the geofence zone, a second alert is sent and the fix rate returns to 15-min to conserve transmitter energy and data acquisition costs.

Combining: 1) GPS level accuracy; 2) high location fix sampling rates; 3) location data received in near real time, and: 4) automated SMS alerts into an integrated and flexible geofence biotelemetry system will provide conservation managers and wind farm operators with sufficient warning and time to implement appropriate mitigative actions to prevent avian collision mortalities associated with wind turbine collisions. The flexibility of this system will enable users to customize the locations and dimensions of their geofences and associated alert settings to meet the management challenges specific to each wind energy development and the movement behaviors of species of concern.

Fig. 1: Solar powered GSM-GPS geofence avian transmitter. Telemetry device is attached to the wing of a free-ranging California condor via patagial mount with an ID tag.

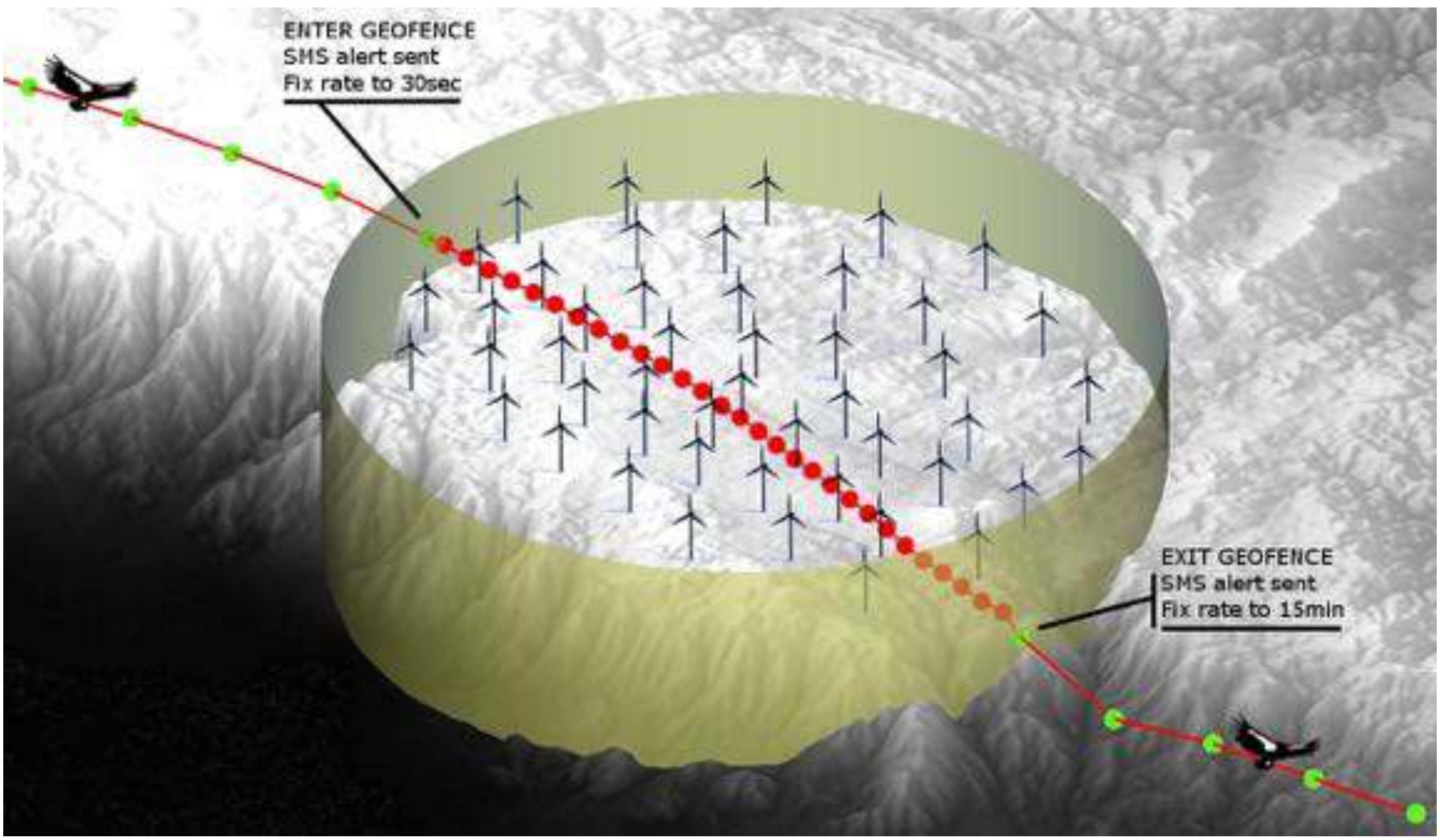

Fig. 2: Demonstration of the geofence alert system placed around a hypothetical wind farm. A telemetered bird ingresses the geofence boundary (top left), triggering an SMS alert and increasing the GPS fix rate from 15 minutes (green dots) to 30 seconds (red dots). When the bird egresses the geofence zone (lower right) a second SMS alert is broadcast and the fix rate returns to the standard 15 minutes.

Users must carefully consider the location and dimensions of their geofences if the system is to provide reliable alerts. For example, geofences deployed to provide alerts of fast flying eagles will have to be set apart at greater distances around a wind farm than those set to provide alerts of slower flying cranes. Current limitations to this alert system include its weight (which precludes its deployment on bats and small birds), the solar power system (which generally restricts operation to daytime without long periods of inclement weather) and the necessity of having to capture birds to fit them with the biotelemetry system and recapture birds whose telemetry units need replacing.

The performance of the system may also be impeded if GSM network coverage in remote regions where the units are deployed is very patchy, although additional coverage is often installed around wind energy sites during construction. Much of the technology that has been developed and incorporated into this geofence system is cutting-edge and novel, so its performance will not be able to be truly gauged until it has been successfully deployed across multiple species and field settings. Despite these limitations, we feel it offers a highly promising cost-effective solution to mitigating avian collisions with wind turbines.

A copy of the open access journal paper describing the geofence alert system can be downloaded here:

http://animalbiotelemetry.biomedcentral.com/articles/10.1186/s40317-015-0087-y

A demo video of the geofence alert system can be viewed here:

https://www.youtube.com/watch?v=2oWodZpmbHo

Recent media coverage of the geofence alert system:

http://wildtech.mongabay.com/2016/02/can-a-virtual-fence-help-protect-birds-from-human-structures/

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Foraging habitat characteristics, prey diversity and detectability of breeding Rusty Blackbirds: implications for land and wildlife management in the Northern Forest

Amanda Pachomski[1] & Stacy A. McNulty[2]

SUNY College of Environmental Science and Forestry

Syracuse, NY

[1] Email: amandapachomski@gmail.com

[2] Email: smcnulty@esf.edu

The Rusty Blackbird (Euphagus carolinus, RUBL) is a migratory songbird that breeds in and near the boreal wetlands of northern New England and Canada. It is listed as Vulnerable on the IUCN Red List and the US Fish and Wildlife Service has listed the RUBL as a Focal Species of Birds of Management Concern. Our objective was to model single-season RUBL occupancy as a function of site covariates, including aquatic invertebrate diversity and abundance. We assessed breeding RUBLs' use of both active and inactive beaver-influenced wetlands in Coos County, New Hampshire and Oxford County, Maine. This study is the first research to model RUBL occupancy in this area and the first to include prey availability as a covariate. From May to July, 2014, we visited 60 sites three times teach to collect RUBL detection/non-detection site histories and habitat data. Following each 30 minute RUBL survey, we surveyed aquatic invertebrates and recorded puddle presence/absence, percent open water, and detection/non-detection of current beaver activity. Later, we used a GIS to digitize each wetland as a polygon, calculate wetland size, and measure percent softwood cover within a 500 meter buffer of each site. All wetland delineations were based on the most recent orthoimagery available and then checked by a regional expert. Using Program Presence, we calculated RUBL detectability and determined which site covariates best predict RUBL use of wetlands in our study area. Umbagog National Wildlife Refuge will use our results to develop a RUBL habitat assessment and monitoring plan.

Male RUBL foraging. *Photo by Devon Cote.*

The Rusty Blackbird (Euphagus carolinus, RUBL) is considered a “poster child” for boreal avian species decline. Although the Rusty Blackbird was once common, the species has declined by an estimated 90% since the 1960’s (Greenberg et al. 2010). The cause of this decline is not known; climate change (McClure et al. 2012), mercury contamination (Edmonds et al. 2010), hematozoa infections (Barnard et al. 2010), and timber harvest (Powell et al. 2010) have been suggested as possible factors. The southeastern limits of the bird’s breeding range appear to have retreated northward and inland coincident with the population decline (McClure et al. 2012). Thus, it is important to monitor RUBLs to detect further population changes or range shifts.

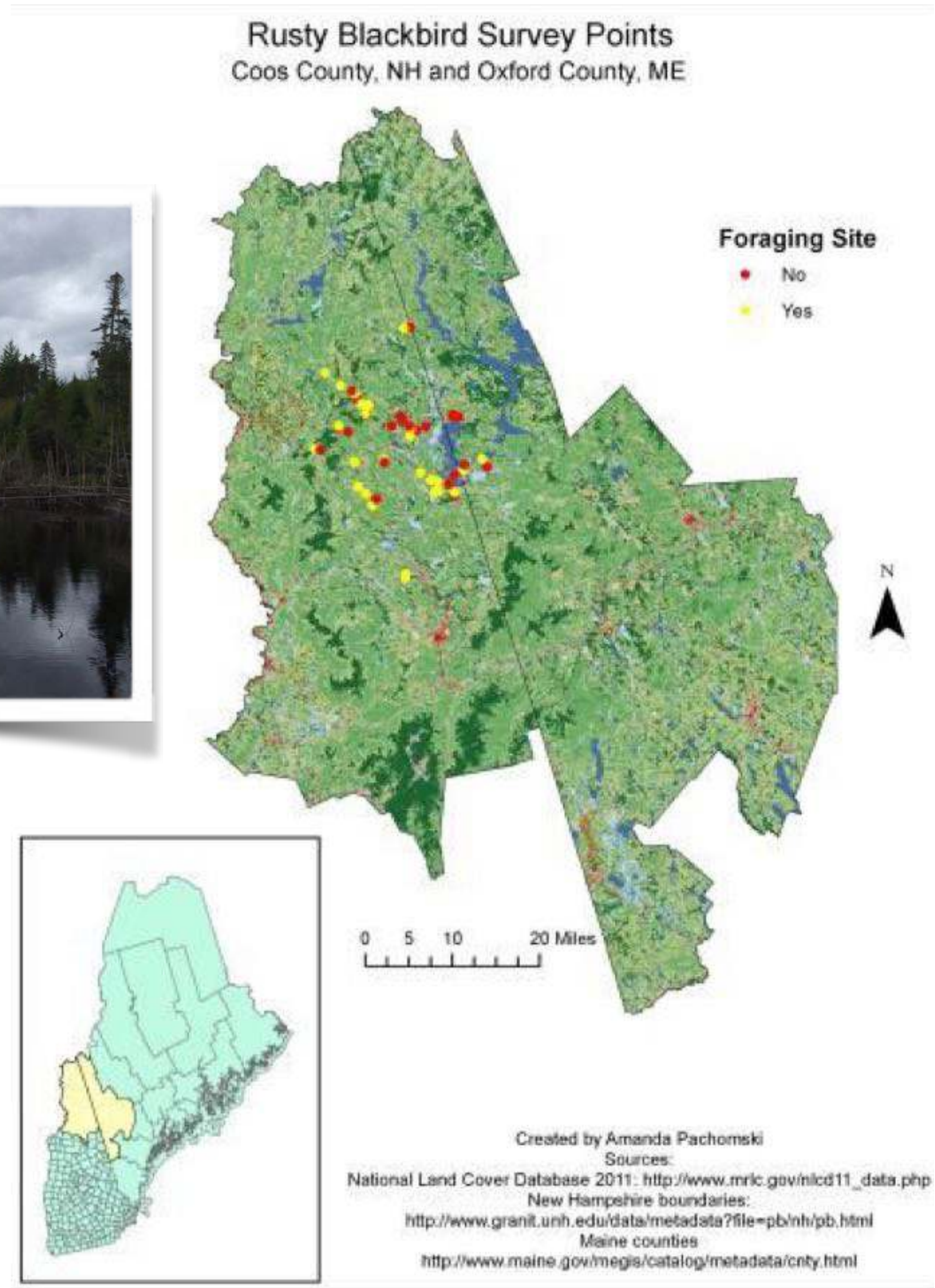
RUBLs breed in and near boreal wetlands from northern New England and the Maritime Provinces west to Alaska. RUBLs select nest sites with minimal canopy cover and high basal area of young conifers in New England (Buckley 2015). RUBLs nest in both wetland and upland habitat types, typically in live spruce or fir trees that are surrounded by regenerating conifer stands or sometimes in alder patches at wetland sites. Occasionally, they nest in snags or isolated conifers in wide-open areas. Nesting trees are small, with an average height of 2.47 m and an average DBH of 4.14 cm in New Hampshire (Buckley 2013).

In recent years, important research has been conducted on RUBL productivity and nest habitat. But, few studies have focused on the species’ foraging ecology. As breeding RUBLs’ diet consists mostly of aquatic macroinvertebrates (Avery 1995), they are a wetland obligate species. In northern New England, RUBLs prefer sites with high wetland cover and high young softwood cover (Buckley 2015). Recent research has also shown that RUBLs prefer wetlands that are currently occupied by American beavers (Castor canadensis) (Powell et al. 2014). These ‘ecosystem engineers’ create ephemeral impoundments of water that RUBLs use for foraging. However, the specifics of RUBL diet and foraging ecology are largely unknown. This is the first effort to study prey availability for breeding RUBLs.

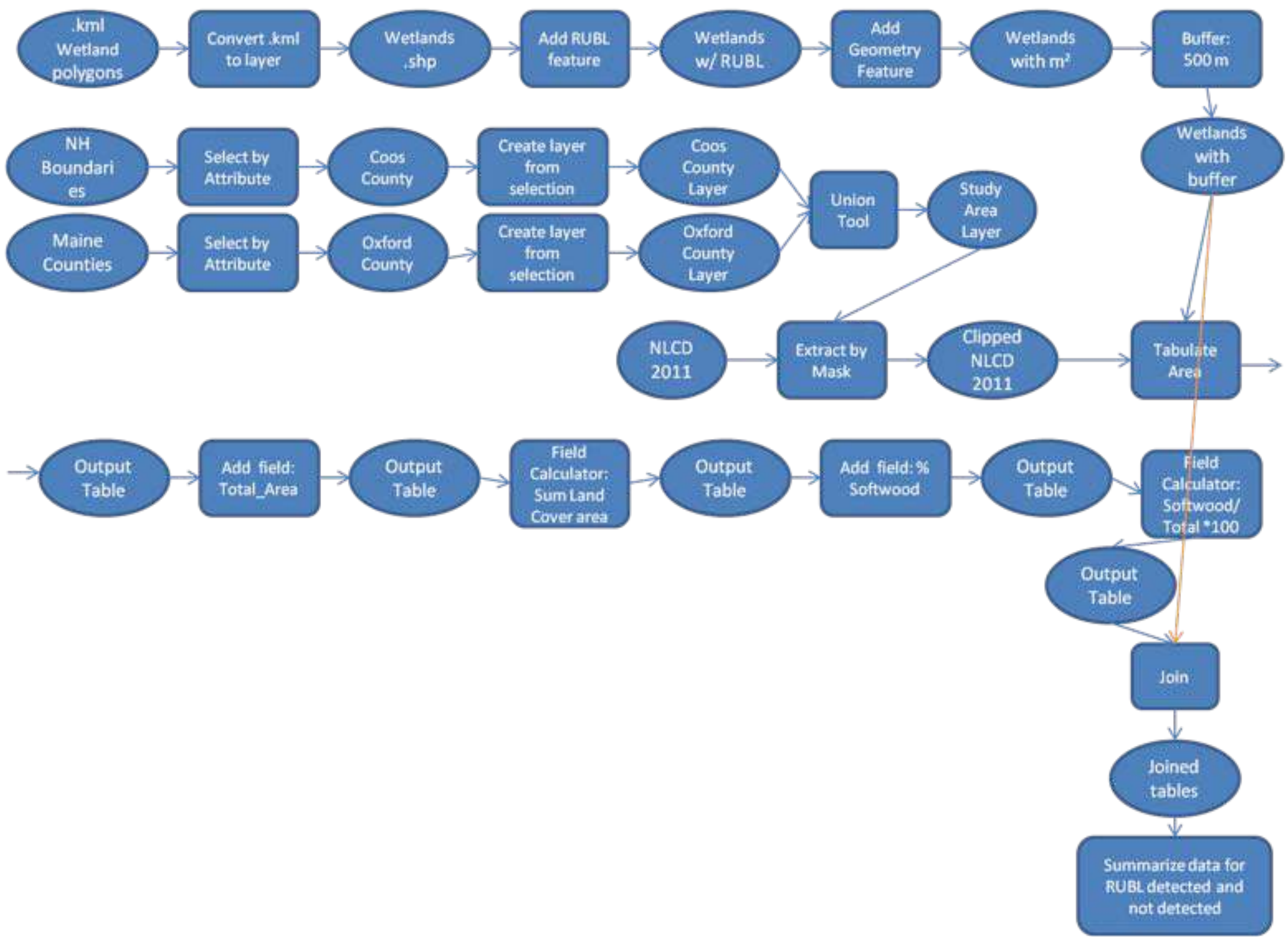
Traditional avian point-counts are not sufficient for accurately detecting Rusty Blackbirds within their remote and inaccessible breeding grounds (Greenberg et al. 2010). Since detectability is low in the Northern Forest region (Glennon 2010) and the RUBL is both rare and often cryptic, it is important for researchers to quantify our limited ability to document RUBL presence and absence. Occupancy survey methods can account for missed detections of secretive and rare species (MacKenzie et al. 2002).

Study objectives, methods, and results

Our goal was to use occupancy modeling to model single-season RUBL use of wetlands as a function of site covariates, including aquatic invertebrate diversity and abundance. Powell et al. (2014) conducted the first study to model RUBL occupancy of wetlands in New England. We aimed to build upon that study by adjusting survey methods, adding in prey availability and abundance, and conducting the surveys in a different area. We assessed breeding RUBLs' use of both active and inactive beaver-influenced boreal wetlands in Coos County, New Hampshire and Oxford County, Maine. Sites were either on Federal land owned by Umbagog National Wildlife Refuge or were privately owned and managed by Wagner Forest Management, Ltd. This remote area of New England is heavily managed, with active logging operations occurring near most of our sites. The wetlands we surveyed were often surrounded by spruce and fir trees; other sites were in speckled alder swamps or were within a mixed forest.



Originally, we wanted to model occupancy in three foraging habitat types: beaver-influenced wetlands, acidic swamps, and acidic basin fens. We had wanted to use the TNC Northeast Habitat Classification maps to select from these three habitat types. However, we found that the map of our study area only identified a few swamps and fens. As this would not have given us a large enough sample size, we reduced our site selection to just beaver-influenced wetlands. Also, we found that some known wetlands weren't mapped as any kind of wetland habitat in the TNC classification, or were mapped as larger or smaller than they appear in orthoimagery and are on the ground. We also found that this was true for National Landcover Data and National Wetlands Inventory maps. While these geospatial databases offer an immense amount of habitat information and are incredibly useful, we needed more detailed and field matched data for our study purposes. Since boreal wetlands in our study area change over time, especially with the influence of beavers, we found that the best way to map our sites was to digitize our own wetland polygons.



Using our prior knowledge of the survey area and orthoimagery, we identified beaver-influenced wetlands of potentially suitable habitat. We used ArcMap to select 60 sites from 263 wetlands within 500 meters of a road and within a 25 km radius of the town center of Errol, NH. Some sites were known to be occupied by RUBLs in previous years. We wanted to randomly select all sites. But, because we only had one field vehicle, we had to survey nearby sites in pairs. If a randomly site selected site didn't have another selected site nearby, we added another relatively nearby wetland to make it logistically possible to survey 60 sites. Upon arrival to our field station, we discovered that some of the dirt logging roads that we needed to travel on were no longer passable. These access issues caused us to drop some previously selected sites and replace them with new randomly selected wetlands, and then manually select sites to make pairs if necessary. In total, we non-randomly selected 21 of the 60 sites. We had previously surveyed 18 of the 60 sites for our pilot study in 2013.

From May to July, 2014, we visited 60 wetlands three times each to collect RUBL wetland site use and habitat data. To measure within-season changes in RUBL probability of detection, we conducted surveys in two week intervals that align with stages in the breeding season: incubation (May 14 to May 27), nesting (May 28 to June 10), and fledging (June 11 to June 24). We conducted passive (without playback) detection/ non-detection surveys for RUBLs. Although previous research found that the use of acoustic playback increased RUBL detectability (Powell et al. 2014), we chose to use passive surveys because we wanted to record the behavior of RUBLs and didn't want our presence to further influence their behavior.

During each 30 minute RUBL survey, we recorded RUBL detection history, sex of detected RUBLS, and whether or not the birds had bands. We recorded survey specific variables, such as wind speed and time of day, which may have impacted our ability to detect RUBLs. Following each RUBL survey, we sampled aquatic invertebrates and recorded puddle presence/absence, percent open water, percent exposed mud, and detection/non-detection of beaver activity. Later, we used a GIS to digitize each wetland, calculate wetland size, and measure percent softwood cover within a 500 meter buffer of each site using 2011 National Land Cover. We used the 9/18/2013 Google Earth orthoimagery to digitize each wetland as a polygon, using visual vegetative changes and on the ground survey experience as a guide.

Using Program Presence, we calculated RUBL detectability and determined which site covariates best predict RUBL use of wetlands in our study area. We detected RUBLs at over half of our sites (Naive occupancy estimate = 0.5833). Adjusting for imperfect detections, we found that RUBLs were present in 61.55 % of our sites (occupancy estimate= 0.6155 ± 0.0689 (95% CI: 0.4750, 0.7391). Preliminary results suggest that probability of RUBL occupancy increases with the presence of puddles in comparison with the base model of no puddles. As percentage of exposed mud increases, occupancy decreases. Although the variable "percent open water" was not included in our top models, our results suggest a preference for water over mud. Probability of detection was best explained by survey period (top model) and Julian day (delta AIC <2). We expected this result, as RUBLs tend to be very cryptic during nesting but more vocal and defensive while rearing nestlings. We are in the process of reanalyzing our data using Unmarked in Program R. We will publish our final results in the fall of 2016.

I am so grateful to have received a 2015 Spatial Ecology and Telemetry Working Group Travel Award, which allowed me to give my first conference presentation at TWS 2015 in Winnipeg, Canada. Thank you to my steering committee: Carol Foss, Shannon Farrell, and especially Stacy McNulty, my major professor, for your advice and support. Thank you to Jonathan Cohen and Brian Underwood for help with my data analysis. Thank you to the entire RUBL field crew for your help and advice. Thank you to Devon Cote, Kelsey Schumacher, Amasa Fiske-White, Thomas Ruland, Donald Arthur and Katelyn Zonneville for helping me collect data in the field and process invertebrate samples.

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BOBCAT HABITAT SELECTION IN A FREQUENTLY-BURNED PINE SAVANNA

Andrew R. Little[1], L. Mike Conner[2], Michael J. Chamberlain[1], Robert J. Warren[1]

[1] Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA 30602, USA
[2] Joseph W. Jones Ecological Research Center at Ichauway, Newton, Georgia, 39870, USA

Longleaf pine (Pinus palustris) savannas are one of the most biologically diverse systems in North America and commonly support hundreds of species of flora and fauna (Alavalapati et al. 2002). This ecosystem historically occupied over 30 million ha in the southeastern United States (Brockway et al. 2005, Van Lear et al. 2005). However, today approximately 1.2 million ha of longleaf pine savannas exist in isolated patches (Van Lear et al. 2005), primarily due to land use change (e.g., conversion to agriculture and establishment of intensively-managed pine plantations were the primary goal is timber production). Likewise, these unique systems were historically maintained by fire ignited by natural and anthropogenic sources but government policies were developed to encourage landowners to exclude fire from their properties (Alavalapati et al. 2002). Today, over 30 plant and animal species endemic to longleaf pine savannas are now considered to be threatened or endangered (Landers et al. 1995). For example, the endangered red-cockaded woodpecker (Picoides borealis) commonly found in longleaf pine savannas prefer the open, park-like conditions created by frequent prescribed fire (≤ 3 years; Alavalapati et al. 2002). Fortunately, natural resource professionals recognized the diversity of flora and fauna in longleaf pine savannas (Barnett 1999, Alavalapati et al. 2002) and subsequently implemented restoration efforts to convert altered landscapes back to longleaf pine savannas (Brockway et al. 2005). An important mesopredator found in longleaf pine savannas is the bobcat (Lynx rufus). Currently, a knowledge gap exists in our understanding of bobcat habitat selection in these ecologically diverse systems and research is warranted to direct our future management decisions.

Historically, red wolves (Canis rufus) and mountain lions (Puma concolor) occupied many parts of the southeastern United States. Today, these species occupy a small percentage of their historical range (Ripple et al. 2014). This void provided mesopredators, such as bobcats, an opportunity to fill this open niche. Bobcats are considered the most widely distributed wild cat in North America and continue to increase in many parts (Roberts and Crimmins 2010). Bobcat space use is influenced by many different factors including prey abundance, season, breeding behaviors, and intraspecific relationships (Chamberlain et al. 2003). Bobcats commonly select mature pine, young pine, hardwood, and agriculture habitat types (Conner and Leopold 1996, Chamberlain et al. 2003, Godbois et al. 2003a). Prey abundance has been found to be a driver of their habitat selection patterns (Miller and Speake 1978, Conner and Leopold 1996, Chamberlain et al. 2003, Godbois et al. 2003a, Godbois et al. 2003b). Hardwoods are commonly used by bobcats for refugia (i.e., den sites, cover, and protection from summer heat; (Hall and Newsome 1976, Godbois et al. 2003a) or travel corridors between foraging patches (Godbois et al. 2003a). In addition, roads are also considered important travel corridors for bobcats (Lovallo and Anderson 1996).

To improve our knowledge of bobcat habitat selection in longleaf pine savannas, we conducted our study in a longleaf pine-dominated landscape located in Baker County, Georgia. The study area was 11,735-ha in size and was privately owned by the Joseph W. Jones Ecological Research Center at Ichauway (hereafter, Jones Center; Fig. 1). The Jones Center was comprised of approximately 31.2% mixed-pine hardwood, 31.1% mature pine (>20 years old), 11.2% agriculture/food plot, 9.8% young pine (<20 years old), 9.8% hardwoods, 2.6% open water, 1.8% wetlands, 1.5% shrub/scrub, and 0.9% urban/barren (Fig. 2). Wiregrass and old-field grasses (e.g., Andropogon spp.) were the dominant understory habitat in the pine and pine/hardwood stands (Goebel et al. 1997). However, >1,000 vascular plant species occur on the site (Drew et al. 1998). Road density was 5.48 km/km2 (Fig. 3).

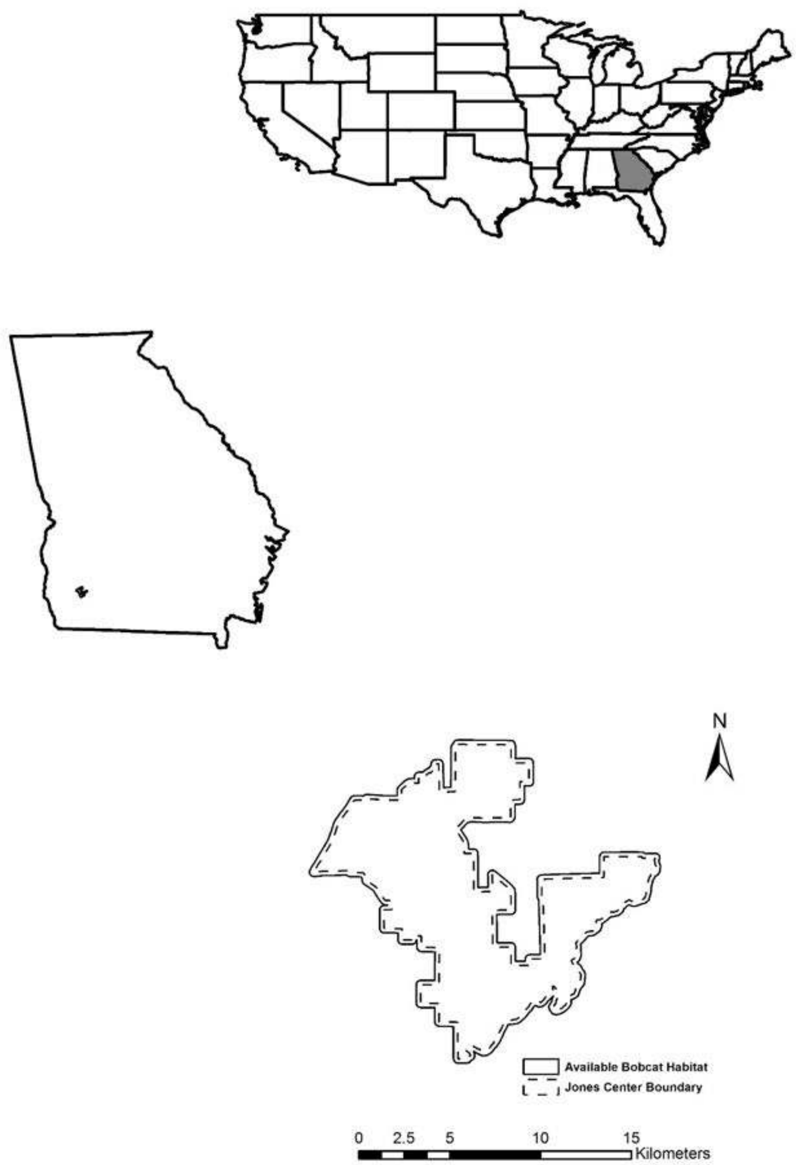

Figure 1: Study area, Joseph W. Jones Ecological Research Center at Ichauway located in Baker County, Georgia, USA.

We examined habitat selection by bobcats at the study area and home range scale. Bobcats consistently moved off the study area during the study period. Therefore, to assess study area habitat selection we calculated the median linear distance of all bobcat locations occurring outside of the Jones Center boundary to the boundary line, which resulted in a median distance from the study area boundary of 237-m. We then buffered the Jones Center boundary by 237-m (i.e., available habitat; see Figure 1 solid line) and removed all locations occurring outside of this boundary. To assess home range habitat selection, we calculated 95% fixed kernel utilization distributions in the Adehabitat Package (Calenge 2006) for program R (R Core Team 2013). To investigate the influence of habitat type and roads on habitat selection of bobcats, we used a geographic information system (ArcGIS® 10.2, Environmental Systems Research Institute Inc., Redlands, CA, USA) to map 6 habitat types available on the study area: mature pine (>20 years old), young pine (<20 years old), mixed pine/hardwood, hardwood, shrub/scrub, and agriculture/food plot. To evaluate the influence of roads as travel corridors, we classified roads on the study area into 2 categories based on traffic-levels: 1) primary roads (county and primary); and 2) secondary roads (secondary and tertiary).

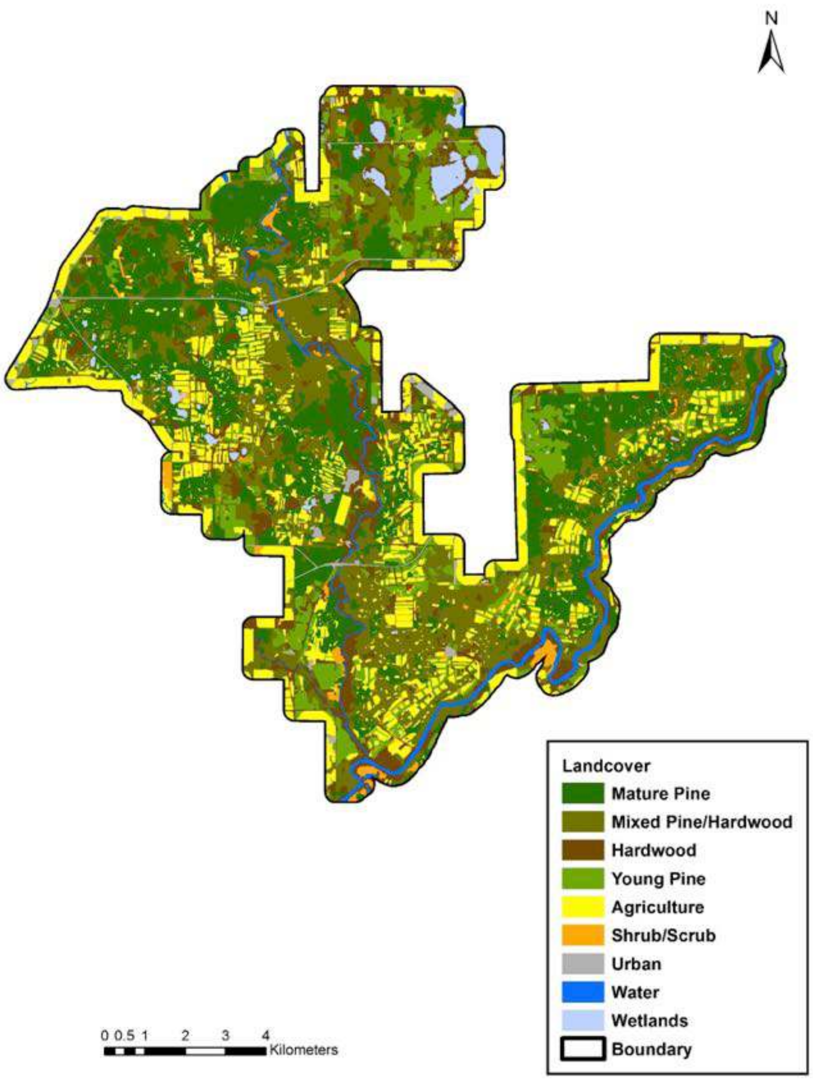

Figure 2: Habitat composition during our study (2001-2007) at the Joseph W. Jones Ecological Research Center at Ichauway located in Baker County, Georgia, USA.

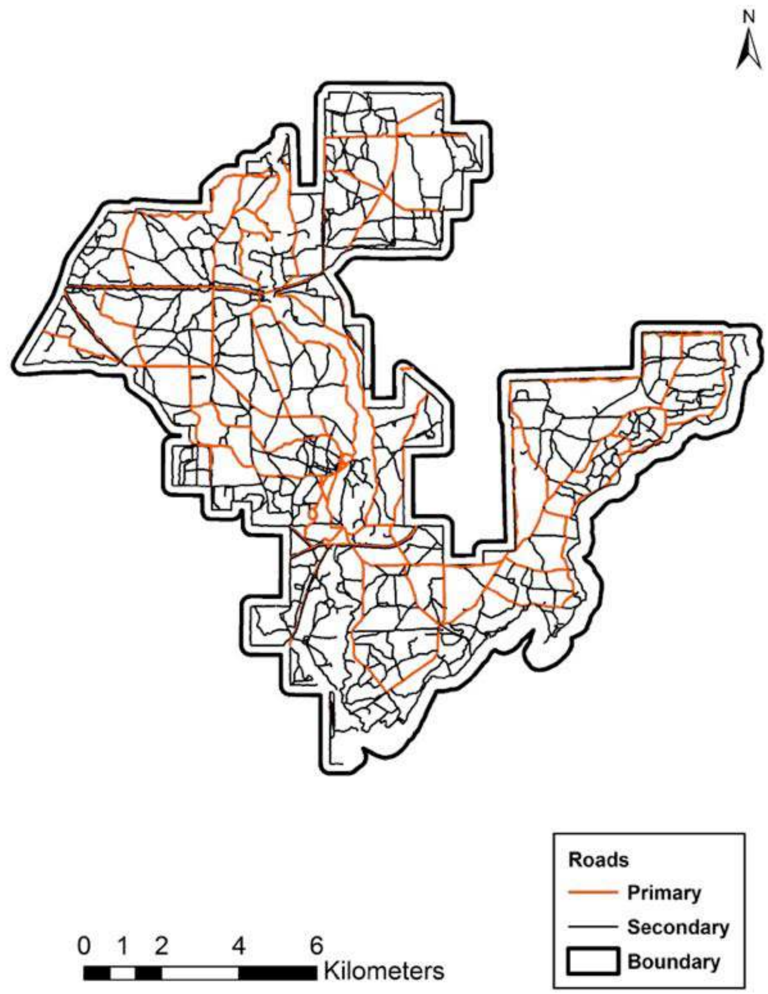

Figure 3: Primary (paved, graded, and dirt) and secondary (harrowed, mowed, and firebreaks) roads at the Joseph W. Jones Ecological Research Center at Ichauway located in Baker County, Georgia, USA.

We developed resource selection functions (RSFs) to examine relationships between landscape features and bobcat establishment of home ranges on the landscape (study area selection) and examined relationships between landscape features and bobcat use within their home ranges (home range selection). We evaluated bobcat habitat selection using a Euclidean distance-based approach. We performed a logistic regression analysis using a generalized linear mixed effects model in the lme4 package (Bates et al. 2007) in program R to quantify landscape features that influence bobcat habitat selection. We used a binomial approach to estimate habitat selection by comparing characteristics of used (bobcat) locations to an equal number of random locations within the study area boundary and within bobcat home ranges (Manly et al. 2002). We included random intercepts for individual bobcats to account for correlation of habitat use within individuals, account for unequal sample sizes among individuals (minimum: 42 locations and maximum: 309 locations), and aid in improved model fit (Gillies et al. 2006).

Results

We captured and monitored 63 bobcats (27 males and 36 females) during 2001-2007. After removal of bobcats with < 40 locations during a given year and < 6 months of telemetry locations, our final data set contained 45 bobcats (16 males and 29 females). From this data set, we constructed 144–95% home ranges. At the study area scale, bobcats were closer to mature pine, mixed pine/hardwoods, hardwoods, agriculture/food plots, shrub/scrub, and primary roads but farther from young pines. Distance to secondary roads was not statistically significant. Primary roads were 13.3 times more important than secondary roads and mixed pine/hardwoods were 1.8 times more important than hardwoods for bobcat home range establishment. Using the coefficient estimates, we developed a study area resource selection map to depict areas of lowest to highest relative probability of resource selection (Fig. 4).

At the home range scale, bobcats were closer to mature pine, mixed pine/hardwoods, hardwoods, agriculture/food plots, shrub/scrub, primary roads, and young pines. Distance to secondary roads was not statistically significant. Agriculture/food plots were 6.4 times more important than young pine and hardwoods were 2.4 times more important than mixed pine/hardwoods for bobcat use within their home range. Using the coefficient estimates, we developed a home range resource selection map to depict areas of lowest to highest relative probability of resource selection (Fig. 5).

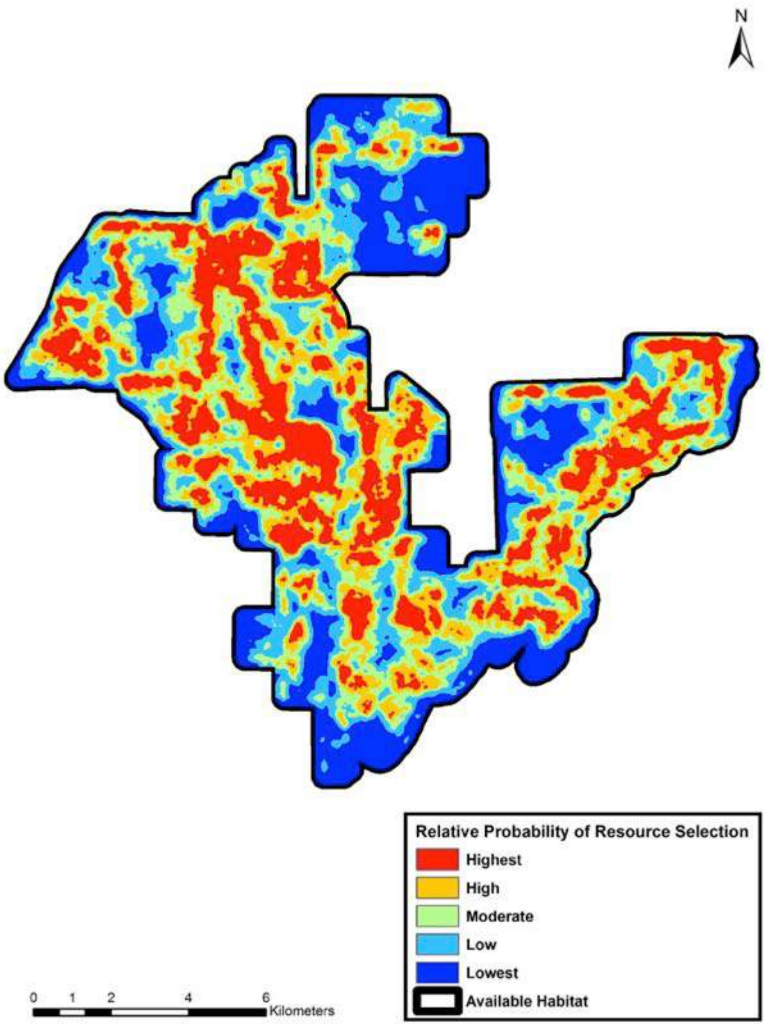

Figure 4: Relative probability of study area resource selection for bobcats (Lynx rufus) during 2001-2007 at the Joseph W. Jones Ecological Research Center at Ichauway located in Baker County, Georgia, USA.

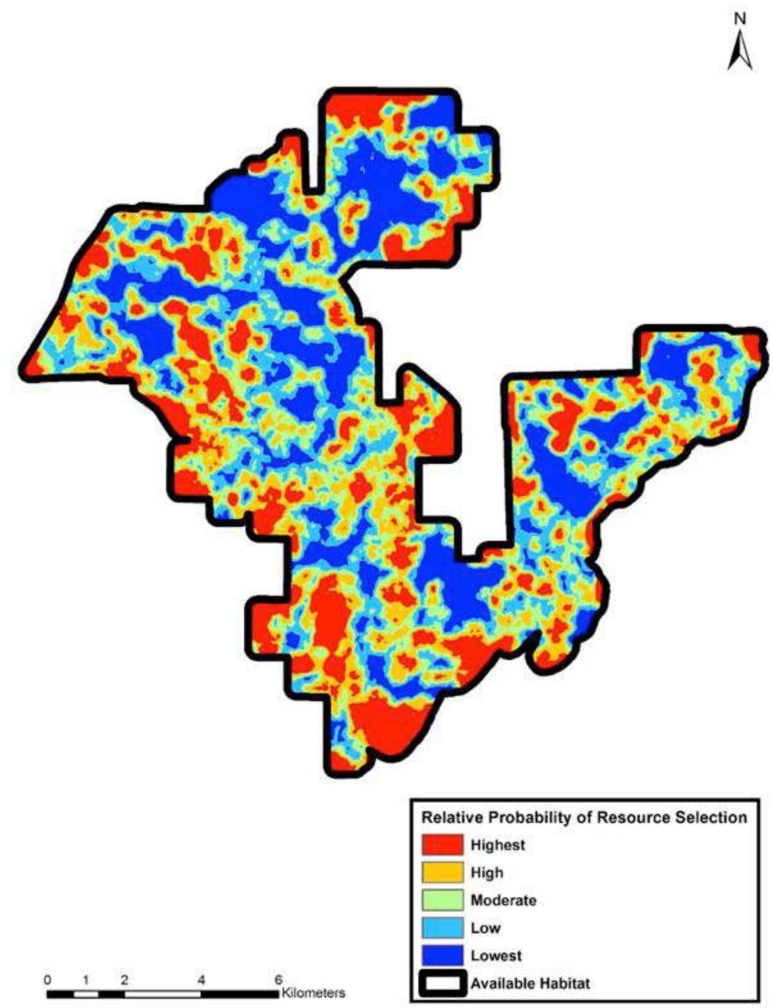

Figure 5: Relative probability of home range resource selection for bobcats (Lynx rufus) during 2001-2007 at the Joseph W. Jones Ecological Research Center at Ichauway located in Baker County, Georgia, USA.

Discussion

Our findings demonstrate the generalist nature of bobcats. We observed bobcats selecting mature pine and mature pine-hardwood stands managed by frequent fire, but also selecting for other important habitat types such as hardwoods, agriculture/food plots, and shrub/scrub. We also observed differential habitat selection across spatial scales. For example, hardwoods were of greater importance at the home range scale than the study area scale, suggesting that land managers need to recognize and potentially incorporate the effects of spatial scale into their management programs depending on their goals and objectives.

Our study site consisted of 72% fire-maintained, pine-dominated forest with frequent fire return intervals (≤ 2 years). Our findings were consistent with previous work that found mature pine and mixed pine/hardwoods to be important to bobcats in a fire-maintained forest (Godbois et al. 2003a). Bobcats were also generally closer to agricultural/food plots, shrub/scrub, and hardwoods habitats. Small mammal populations have been found to be most abundant in areas with dense herbaceous ground cover interspersed with shrubs (Golley et al. 1965, Schnell 1968), which are characteristic of shrub/scrub habitat types juxtaposed to agriculture/food plots on our study area. Hardwoods were also found to be important to bobcats. Hardwood stands may serve as travel corridors between forage patches (Godbois et al. 2003a). Likewise, selection of hardwood stands may also serve as important locations for refugia (i.e., den sites, cover, protection from summer heat; Hall and Newsome 1976, Godbois et al. 2003a) in pine-dominated systems. Additional research is needed to evaluate potential seasonal differences in habitat selection and evaluate the influence of time-since-fire on bobcat selection patterns. For example, bobcats may quickly occupy a recently burned patch to exploit potential resources, thus affecting the predator-prey dynamics in a frequently-burned landscape.

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Spatial Ecology & Telemetry Working Group

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Upcoming Events

- 2016 Wildlife Society Annual Conference, Raleigh, NC: October 15-19, 2016. http://www.twsconference.org
- SCGIS Conference, Jun 22 to Jun 25, 2016, Asilomar Conference Grounds, Pacific Grove, CA. http://www.scgis.org/conference
- ESA 101th Annual Meeting, August 7-12, 2016, in Fort Lauderdale, FL. http://www.esa.org/esa/meetings/annual-meeting/
- Spatial Ecology & Conservation 4, University of Birmingham (UK), 12 to 14 July 2016 .http://www.ert-conservation.co.uk/sec4-introduction.php
- Interaction workshop @ UT-Austin Nov 10-11, 2016: https://sites.utexas.edu/interaction/