T H E W I L D L I F E S O C I E T Y

Remotely Wild

Newsletter of the Spatial Ecology & Telemetry Working Group

Issue 30: Spring 2014

From the Working Group Chair

Welcome to the 2014 spring 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 Pittsburgh this October. We'll continue to keep you up to date.

Last year was a challenging one for SETWG with the Government shutdown, budget cuts and the extreme weather affecting activity. However, our our executive officers and committees have have still been busy behind the scenes! SETWG sponsored three symposia at the 2013 Wildlife Society conference in Milwaukee as well as the "Adehabitat Skills Workshop" led by Adehabitat author Dr Clément Calenge that was a sold-out success. This year we are pleased to again be able to offer travel awards for students to attend the 2014 conference and we will make an announcement regarding travel grant opportunities later this year. SETWG is also excited to be sponsoring a half-day workshop on the T-LoCoH method for calculating animal home ranges using location data led by the T-LoCoH R-package author Dr Andy Lyons (see article on page 7). Given the popularity of previous spatial ecology workshops and the increasing use of R in our field we expect similar high demand for the T-LoCoH 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. SETWG will also be announcing elections for executive positions later this year for any members who would like to get involved with the Working Group.

Best regards, James K. Sheppard (spatialecologist@gmail.com)

In this issue:

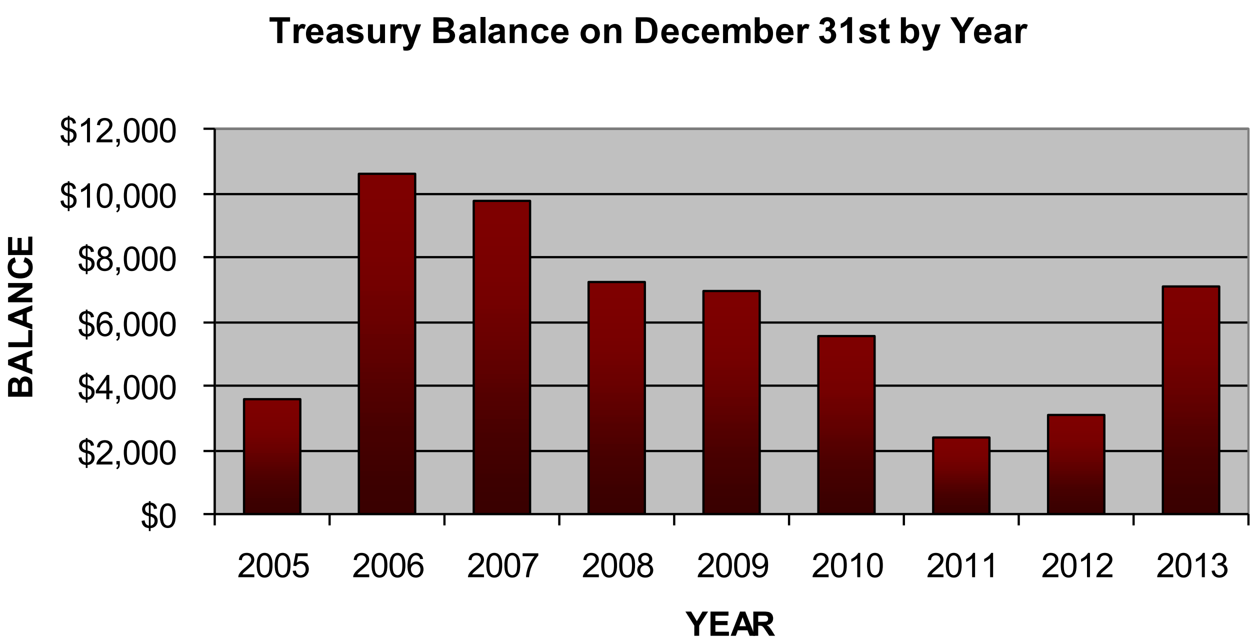
SPATIAL ECOLOGY & TELEMETRY WORKING GROUP

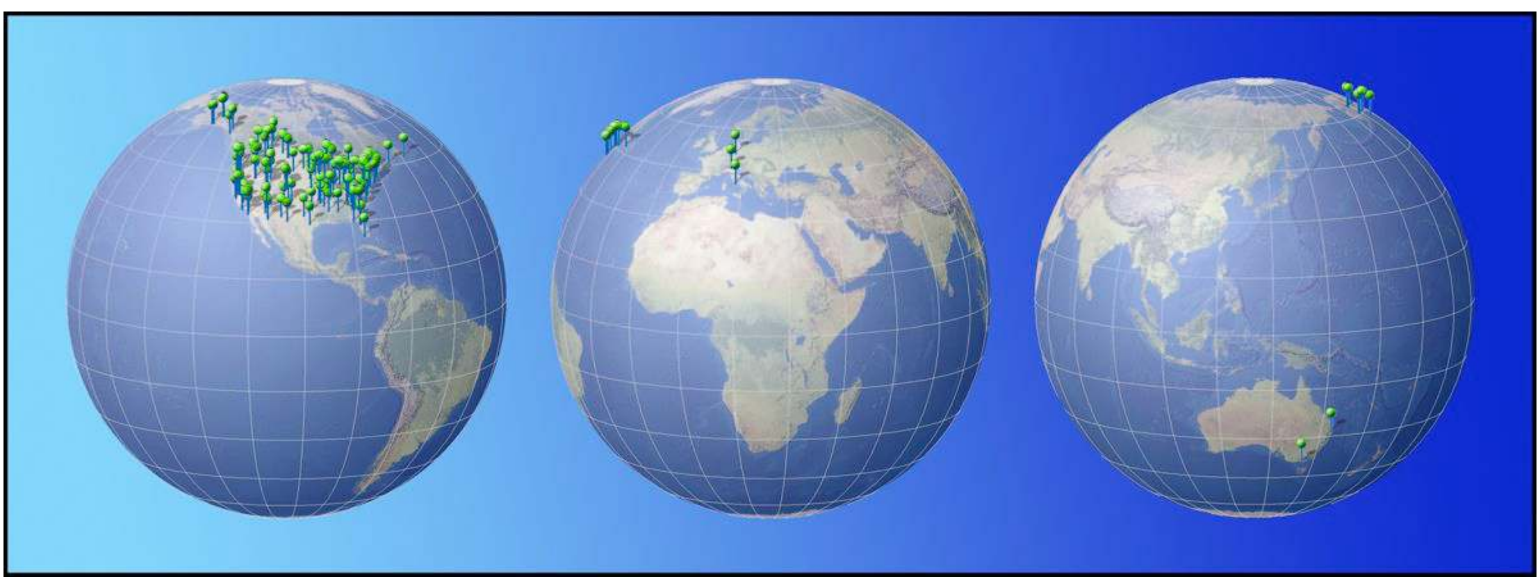
The Spatial Ecology and Telemetry Working Group provides an opportunity for TWS members to address issues of concern to the GIS community and to advance their own skills and understanding of GIS, remote sensing, and telemetry technologies. The Working Group functions as a clearinghouse of information and expertise in the area of GIS, remote sensing, and telemetry for The Wildlife Society Council, TWS sections and chapters, and individual TWS members.

TWS Spatial Ecology & Telemetry Working Group

Treasurer's Report: 2013

2013 Income	$4948.00
2013 Expenses	$800.00
Current Balance	$7075.79
Current Membership	214





WHERE IN THE WORLD ARE SETWG MEMBERS..?

WORKSHOP RECAP:

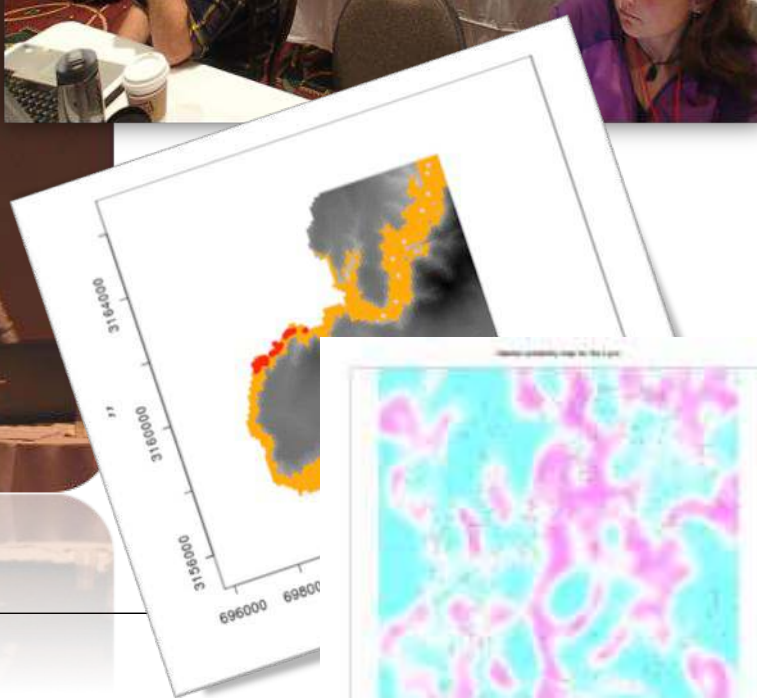
Analyses of Wildlife Spatial Behaviors & Habitat Use with 'Adehabitat' R Packages

20th Annual TWS Meeting, Milwaukee, Wisconsin (2013)

The practical analysis of space use and habitat selection by animals is often a problem due to the lack of well-designed programs. Recognizing this, SETWG sponsored a sold-out workshop at the 2013 Wildlife Society conference on the 4 "***adehabitat***" packages available for the R software, which offers 250 GIS (Geographic Information System) functions and methods to analyze biotelemetry data and habitat selection by wildlife, and interfaces with other R packages. These tools can be downloaded freely on the Internet (http://adehabitat.r-forge.r-project.org). Because the functions of these packages can be combined with other functions of R, "*adehabitat*" provides a powerful environment for the analysis of animal space and habitat use.

The adehabitat workshop was lead by the author, Dr Clément Calenge, Office National de la Chasse et de la Faune Sauvage, France. Clément covered four main themes as they pertain to the four adehabitat packages for R: i) spatial operations (**adehabitatMA**), ii) home-range estimation (**adehabitatHR**), (iii) animal movements (**adehabitatLT**), and iv) habitat selection (**adehabitatHS**). The skills-based component of the workshop focused on quantifying spatial relationships among objects, geometry manipulation and conversion, a wide range of sampling tools, characterizing data at multiple scales, movement modeling and space-use estimation, and habitat selection exploration.

For a copy of the annotated workshop tutorial with updated commands, please contact Dr Calenge at: clement.calenge@oncfs.gouv.fr



SETWG Awards 2013

The Spatial Ecology and Telemetry Working Group is excited to announce the 2013 recipients of awards that recognize professionals in the field of GIS, Spatial Ecology, Remote Sensing & Biotelemetry 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 and to the SETWG awards committee!, especially Jeff Jenness and Stephen L. Webb.

Join us in congratulating the following 2013 SETWG awardees!

CIRCUITSCAPE

Brad McRae: *The Nature Conservancy, North America Region, bmcrae@tnc.org*

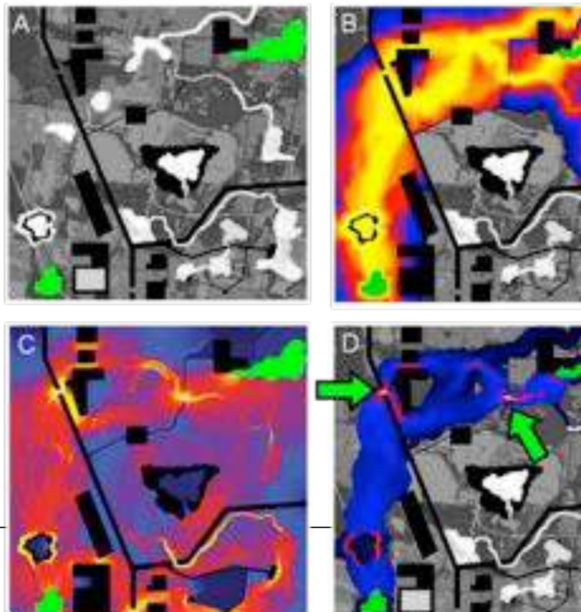
Viral Shah: *Interactive Supercomputing & the University of California, Santa Barbara, viral@mayin.org*

(Contributions from Tanmay Mohapatra)

http://www.circuitscape.org/home

Circuitscape is an open-source program that uses circuit theory to predict connectivity in heterogeneous landscapes for individual movement, gene flow, and conservation planning. Circuit theory offers several advantages over common analytic connectivity models, including a theoretical basis in random walk theory and an ability to evaluate contributions of multiple dispersal pathways. Landscapes are represented as conductive surfaces, with low resistances assigned to habitats that are most permeable to movement or best promote gene flow, and high resistances assigned to poor dispersal habitat or to movement barriers. Effective resistances, current densities, and voltages calculated across the landscapes can then be related to ecological processes, such as individual movement and gene flow method.

(For more, see article on page 20)



SETWG Awards 2013

unmarked

Models for Data from Unmarked Animals

Ian Fiske: Ignite, Jacksonville, FL, *ianfiske@gmail.com*

Richard Chandler: *Warnell School of Forestry and Natural Resources, University of Georgia rchandler@warnell.uga.edu*

Andy Royle: *USGS Patuxent Wildlife Research Center, Laurel, MD, aroyle@usgs.gov*

David Miller: *USGS Patuxent Wildlife Research Center, Laurel, MD, dxm84@psu.edu*

Marc Kéry: *Swiss Ornithological Institute, Switzerland, marc.kery@vogelwarte.ch*

(*Richard Chandler maintains the R site and documentation*)

R Package DOWNLOAD: *http://cran.case.edu/web/packages/unmarked/index.html*

Google Groups Forum: *http://groups.google.com/group/unmarked*

Google site: *https://sites.google.com/site/unmarkedinfo/home*

github: *https://github.com/ianfiske/unmarked*

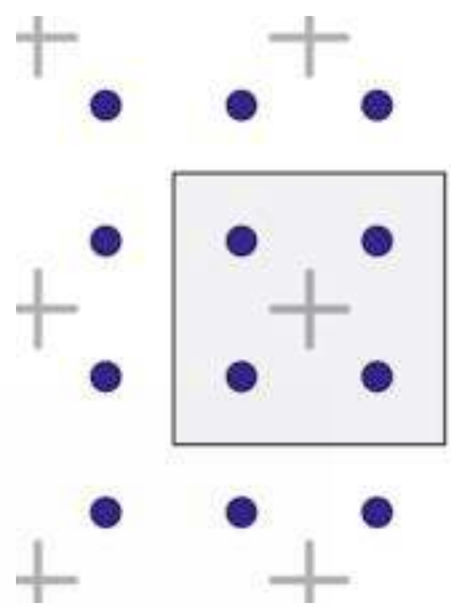
5-hour introductory tutorial: *http://www.pwrc.usgs.gov/Royalvideo.cfm*

Unmarked aims to be a complete environment for the statistical analysis of data from surveys of unmarked animals.

Unmarked is an R package for analyzing ecological data arising from several popular sampling techniques. The sampling methods include point counts, occurrence sampling, distance sampling, removal, double observer, and many others.

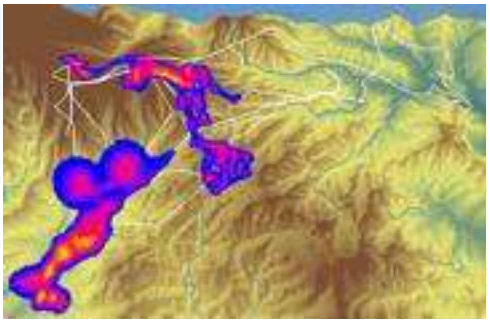
Unmarked uses hierarchical models to incorporate covariates of both the level of the latent abundance (or occupancy) and imperfect detection process.

Unmarked provides methods to estimate site occupancy, abundance, and density of animals (or possibly other organisms/objects) that cannot be detected with certainty. Unmarked uses S4 classes to store data and metadata in a way that allows for easy data manipulation, summarization, and model specification.



SETWG Awards 2013

Analyzing Animal Movements Using Brownian Bridges



Jon S. Horne, *Idaho Dept. of Fish and Game, Lewiston, ID, jhorne@uidaho.edu*

Edward O. Garton, *College of Natural Resources, University of Idaho, ogarton@uidaho.edu*

Stephen M. Krone, *Department of Mathematics, University of Idaho Moscow, ID, krone@uidaho.edu*

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Ryan Nielson, *WEST, Inc., Cheyenne, WY, rnielson@west-inc.com*

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Trent McDonald, *WEST, Inc., Cheyenne, WY, tmcdonald@west-inc.com*

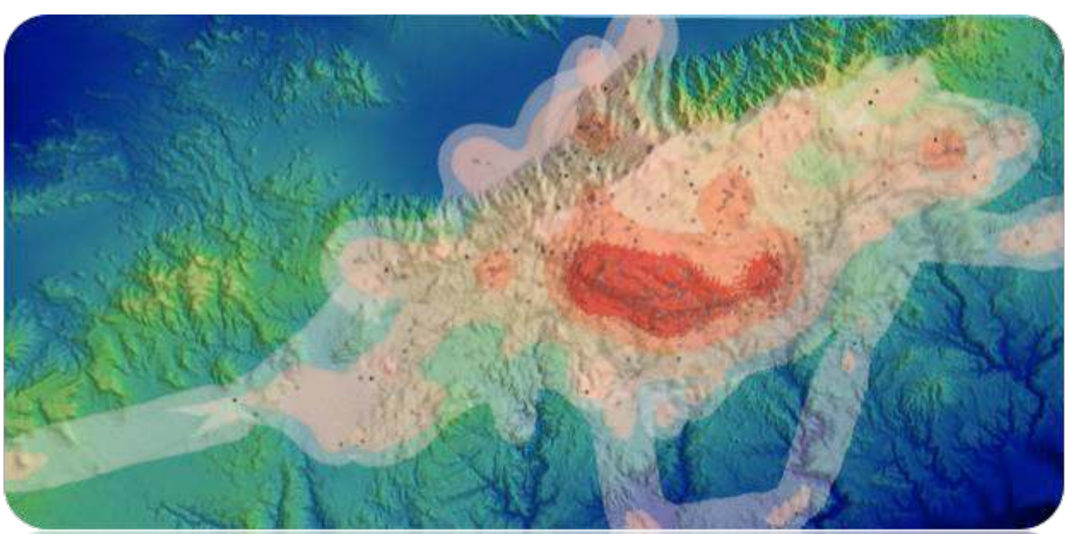
By studying animal movements, researchers can gain insight into many of the ecological characteristics and processes important for understanding population-level dynamics. The Brownian bridge movement model (BBMM) was developed for estimating the expected movement path of an animal, using discrete location data obtained at relatively short time intervals.

The BBMM is based on the properties of a conditional random walk between successive pairs of locations, dependent on the time between locations, the distance between locations, and the Brownian motion variance that is related to the animal's mobility.

After the BBMM is fitted to location data, an estimate of the animal's probability of occurrence can be generated for an area during the time of observation.

Manuscript: http://webpages.uidaho.edu/~krone/BrownianBridge_Ecology.pdf

Implementation in R: Module BBMM: http://cran.r-project.org/web/packages/BBMM/BBMM.pdf



T-LoCoH

A spatiotemporal home range estimator for GPS data

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By incorporating time into the spatial analysis of location data, TLoCoH produces home ranges that highlight temporal as well as spatial partitions of habitat use, and reveal the connections between space and time use.

As the capabilities of animal tracking hardware improve and costs drop, the demand for new analytical tools continues to grow. Fortunately, the tool bag of spatial analysis methods has never been fuller.

T-LoCoH (Time Local Convex Hull[1]) is one of the newer methods for analyzing location data. It joins the ranks of methods like the kernel method that generate utilization distributions—or maps that show intensity of space use—based on a set of observed locations. The contour which represents 95% of predicted habitat use is frequently labeled an individual's 'home range', while the contour that represents 50% of the most heavily used areas is conventionally called the 'core'. Whether or not these somewhat arbitrary definitions are helpful, and the choice of method used to estimate these areas from the raw data, depends a lot on the data and research objective.

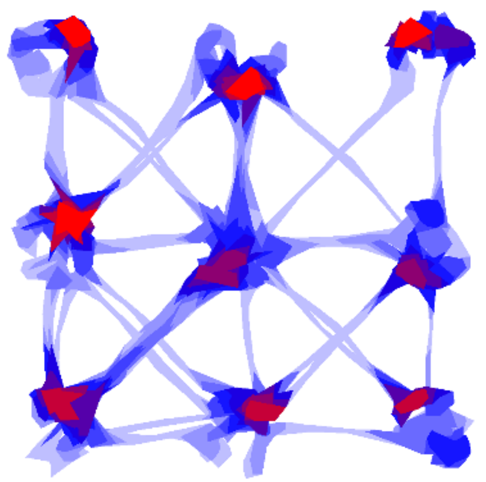
One of the earliest home range estimators is the minimum convex polygon (MCP), a simple geometric method comparable to stretching a rubber band around all of the observed locations. TLoCoH builds upon the venerable MCP but with a twist. Instead of drawing a single MCP around all of the points, T-LoCoH constructs little MCPs around each and every point, and then starts to union them together. By merging these local hulls smallest to largest, you wind up with a series of nested polygons that reflect the relative density of locations. In other words, a utilization distribution.

T-LoCoH adds another twist that distinguishes it from its predecessor, classic LoCoH[2]. In classic LoCoH, local MCPs (or hulls) are created by connecting the dots around each point and several of its nearest neighbors (exactly how many nearest neighbors is a detail we'll skip for now). TLoCoH follows this same approach, but provides an option to incorporate time into how we define the 'distance' between any two points. The result are hulls that are local in both space and time, with the balance between space and time determined by a parameter that represents the spectrum between "space rules" and "time rules".

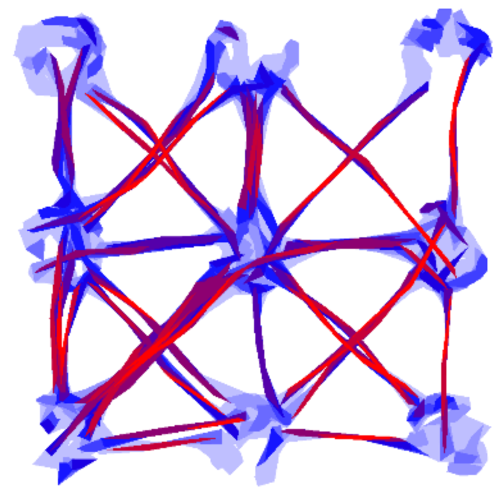
So what's the result of incorporating time into a space-use model? Actually, several interesting things emerge. First, like classic LoCoH, utilization distributions generated by T-LoCoH do a pretty good job in delineating hard edges in the habitat. Other home range methods such as the popular kernel methods often 'bleed over' hard edges created by fences, water bodies, or steep terrain. In addition to respecting spatial edges, the inclusion of time in T-LoCoH home ranges captures temporal partitioning of space. Imagine for example the intersection of two paths an animal uses. Home range methods that ignore time may represent the intersection as one big blob, but T-LoCoH contours will pick out the different pathways.

A workshop on T-LoCoH will be offered at the 21st Annual Conference of The Wildlife Society in Pittsburgh, PA, October 2014.

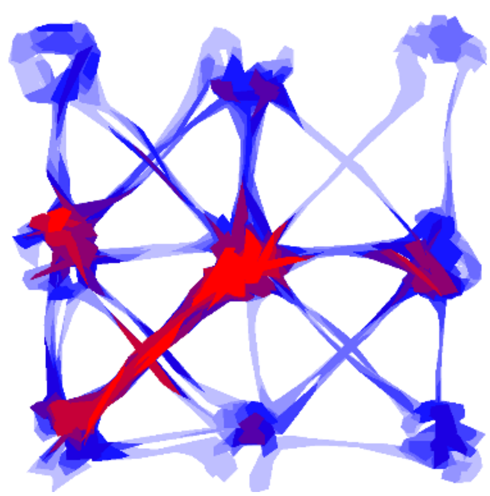
Because T-LoCoH hulls are localized in both space and time, we can also use them as cookie cutters to explore different behavioral patterns. The density of points in a hull is a good proxy for how intensely an area was used, which is why sorting the hulls by point density results in a utilization distribution. The geometric properties of hulls can also reveal something about behavior in that area, such as whether movement was directional or searching. The figure below shows different space use models created by the same set of hulls generated from the movement of a virtual animal traveling between nine resource patches. Depending how you sort the hulls prior to merging them, you can highlight different characteristics of how the animal uses space.



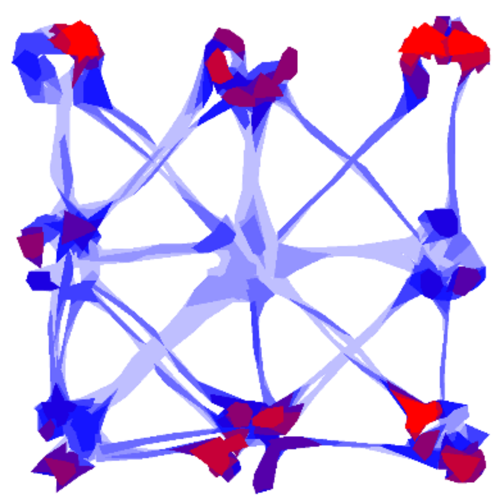
Sorting hulls by point density then merging produces a conventional utilization distribution. In this map, red represents the most densely used areas.



Sorting hulls by their perimeter:area ratio instead highlights areas of directional travel.

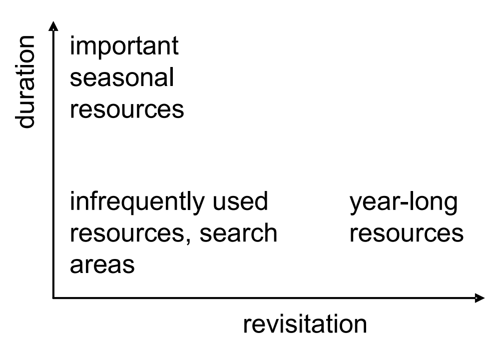


Sorting hulls by revisitation rate highlights areas frequently travelled pathways.

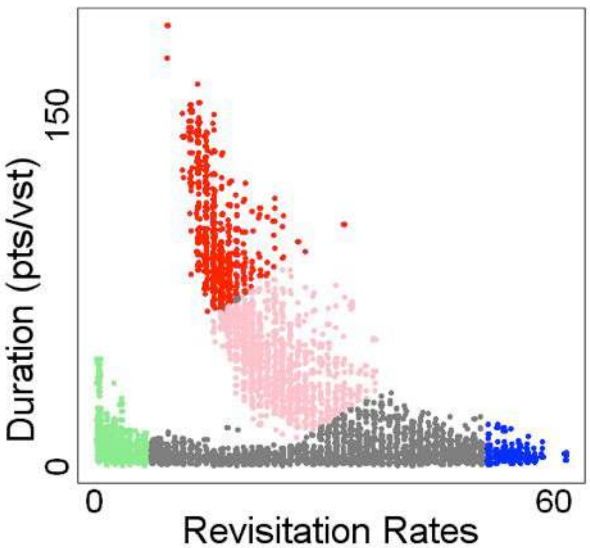


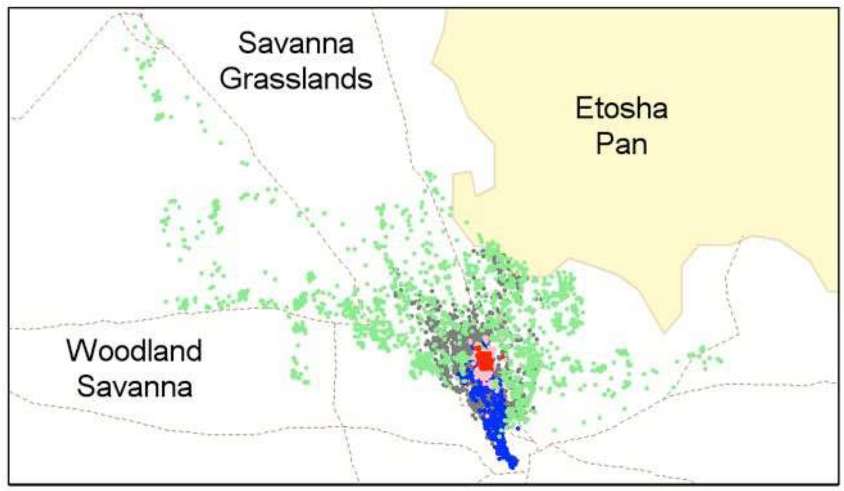
Sorting hulls by the amount of time spent per visit highlights areas of long duration.

As shown in the figure above, local hulls can also be used to quantify time-use patterns, for example by counting how many times an individual returned to an area, or how long it stayed each time it was there (a "visit" is defined by the amount of time that must pass between different visits). These two metrics of time use, revisitation and duration, represent two dimensions of time that can be used to classify habitat and behavior.



The figure below a scatterplot of the rates of revisitation and duration for hulls generated from the movement a male springbok antelope in Etosha National Park in Namibia. What is striking about this distribution is the spur of hulls in the center, with relatively high rates of revisitation and moderately high periods of duration. Coloring the interesting areas on the scatterplot and using it as a map legend reveals a tight cluster of hulls on the landscape—the male's defended territory. This 'territorial spur' in time-use space has been observed in data for both ungulates and carnivores, suggesting a temporal as well as spatial signature for territorial behavior. This example illustrates also how hulls can be more than just the basis for a home range, they can also serve as a derived units of analysis for other types of analysis.





T-LoCoH works with any type of location data, even those without time stamps. But many of its more innovative features presume regularly sampled data, such as those collected by a GPS device. TLoCoH is a good choice when there are edges in the habitat that restrict movement, or the research question demands attention to the temporal dynamics of space use. However as a polygon-based method, T-LoCoH is not well-equipped to model the effects of spatial uncertainty. If that is important, you're probably better off using a method such as the kernel method or Brownian bridges, both of which include parameters for location uncertainty.

T-LoCoH is currently available a package for R[3]. Because the algorithm and underlying mathematics are relatively simple, it can chug through large datasets. The workflow is well-described in a tutorial, but it isn't a one-click solution and the method isn't yet integrated into any GIS packages. In addition to constructing hulls and utilization distributions, the R package has a number of general purpose utility functions for cleaning data, producing animations, creating scatterplots of hull metrics, and exporting results into standard tabular and spatial data formats. Power users can dig into the data structure and create hull metrics of their own.

This is a good time for spatial ecology. The increasing availability and diversity of data, from high frequency tracking data to genomics, has thrown open the doors to all kinds of new questions and analysis methods. Methods like T-LoCoH are tailored for modern datasets and extend the traditional concepts of utilization distribution and home range to new forms that can reveal the spatiotemporal patterns in behavior. The analytical toolbox has never been bigger - the trick is, and always will be, finding the right tool for the question.

References

1 Lyons, A., Turner, W.C., and WM Getz. 2013. Home range plus: A space-time characterization of movement over real landscapes. BMC Movement Ecology 1:2, doi:10.1186/2051-3933-1-2.

2 Getz, W., Fortmann-Roe, S., Cross, P., Lyons, A., Ryan, S., & Wilmers, C. 2007. LoCoH: nonparameteric kernel methods for constructing home ranges and utilization distributions. PloS one, 2(2), e207.

3 T-LoCoH Package for R. http://tlocoh.r-forge.r-project.org

A new dimension for spatial ecology:

LiDAR as a tool for improving wildlife habitat models and fostering collaboration

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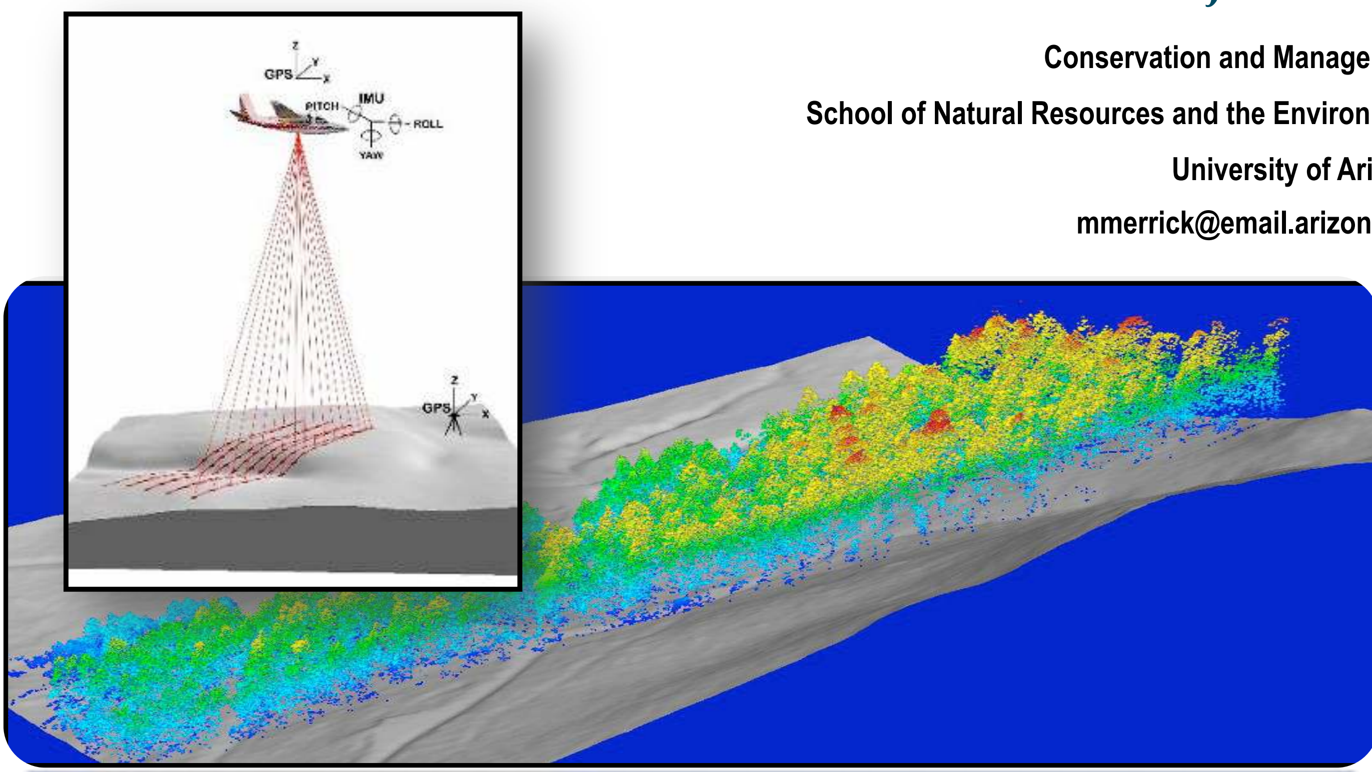

How we model space use and habitat

The locations of animals in space and time, derived from radio or satellite telemetry, survey data, or random sightings, are increasingly used to identify wildlife habitat preferences, landscape features critical to reproduction and survival, potential corridors for connectivity, and to model the probability of animal presence or use based upon the availability of necessary habitat components. Many species-specific physiographic and vegetative features can be characterized with remote sensing data by quantifying the linear relationships among spectral data and ground-based plot measurements, allowing us to create habitat maps and predictive surfaces over large spatial extents.

The majority of habitat variables incorporated in such models are derived from passive sensors intercepting wavelengths of reflected light or heat from the earth's surface. Passive remote sensing products are typically only capable of representing landscape complexity in two dimensions and do not directly measure structure or three-dimensional complexity (Lefsky et al. 2002; Vierling et al. 2008), which limits our ability to accurately describe and predict wildlife-habitat relationships. In reality, animals interact with and select features within a three-dimensional spatial landscape. Active sensor technologies such as light detection and ranging (LiDAR) can improve wildlife habitat models and predictive surfaces by more accurately describing fine-scale, three-dimensional structural features related to animal use, occurrence, and reproductive success (Vierling et al. 2008), and measure these features across entire management units, mountain ranges, or districts with high accuracy (Reutebuch et al. 2005).

Fine-scale space use data is increasingly accessible for a wide variety of species of nearly all size classes as technological advances improve transmitter capabilities and reduce size, increasing our understanding of how landscapes are utilized by animals and which biotic and structural features are important to include in habitat models or predictions of use. High temporal resolution three-dimensional spatial use data obtained via GPS enabled collars and tags are now available for larger animals and some birds. Characterizing and modeling three-dimensional space use is a new frontier in spatial ecology, as animals do not live on planar surfaces; they fly, swim, climb, utilize specific tiers of the canopy, and burrow beneath the ground (Belant et al. 2012). Vertical space itself may be an important habitat component, but is frequently overlooked (Belant et al. 2012). If we are able to model animal space use in three dimensions, realistic habitat models should also include three-dimensional structural components.

LiDAR basics and types

LiDAR conceptually works like a laser range finder – laser pulses are emitted towards the earth's surface and the time it takes for each pulse to return to the sensor is recorded. Pulses hitting tall objects return to the sensor first, pulses hitting the ground take the longest to return. LiDAR data are generally collected via a laser-emitter scanner linked to an accurate global positioning system and inertial measurement unit so that the location at which each pulse hits an object can be mapped (Reutebuch et al. 2005); the resolution and quality of the data depends on both the scanner and the laser pulse density (Reutebuch et al. 2005; Laes et al. 2008; Evans et al. 2009).

LiDAR can be broadly categorized into two classes depending on the type of sensor: large-footprint, lower resolution wave-form data in which the pulse-return intensity over time is digitized (the more "stuff" the pulses run into, the higher the pulse-return intensity; Fig. 1), and small-footprint, higher resolution discrete return data (Fig. 2) in which the spatial coordinates at which each laser pulse intersects an object are recorded (see Lefsky et al. 2002; Reutebuch et al. 2005; Vierling et al. 2008; and Evans et al. 2009 for excellent reviews). There are positives and negatives to each method (Evans et al. 2009), both provide unique structural information not available from spectral or thermal sensor technology, and can greatly improve our ability to classify landscape features and describe how animals relate to them.

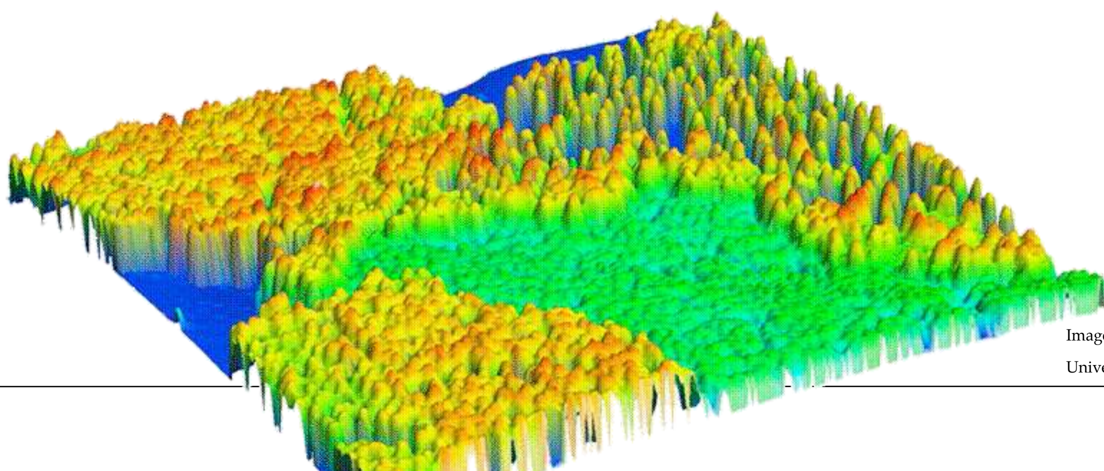

Image: USDA
University of Washington

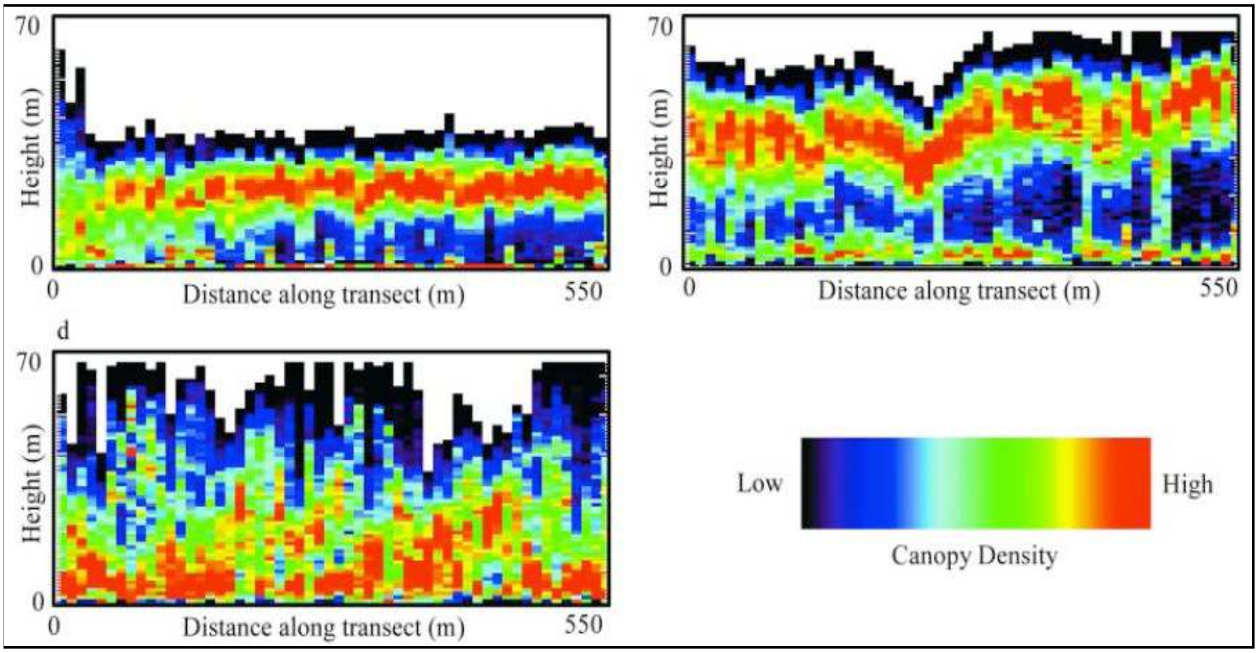

Figure 1. Wave-form LiDAR data visualization, from Lefsky et al. 2002.

How LiDAR can improve our spatial ecology

LiDAR can measure or quantify habitat features that are often highly correlated with wildlife presence, survival, and reproductive success over large spatial scales with high accuracy (Lefsky et al. 2002; Vierling 2008; Mitchell et al. 2012). Many three-dimensional structural variables can be directly measured from the LiDAR point cloud or waveform, including canopy cover, tree or vegetation height, woody debris volume and canopy volume within various height categories. Many other derived variables can be modeled based on linear relationships among plot-based measurements and first-order variables extracted from the LiDAR point cloud or waveform such as basal area, above-ground biomass, woody debris, leaf area index, and abundance of shrubs or snags (Lefsky et al. 2002; Ruetebuch et al. 2005; Vierling et al. 2008; Martinuzzi et al. 2009; see Merrick et al. 2013 for a review). Still other LiDAR-derived variables provide novel information that is difficult to obtain from field-based measurements such as extremely accurate terrain models and secondarily derived metrics of slope, aspect, and rugosity or roughness (a measure of surface height variability). Measures of pulse-return intensity can be used to distinguish among live and dead trees (Bater et al. 2009; Kim et al. 2009) and identify ephemeral wetlands beneath forest canopy cover (Julian et al. 2009).

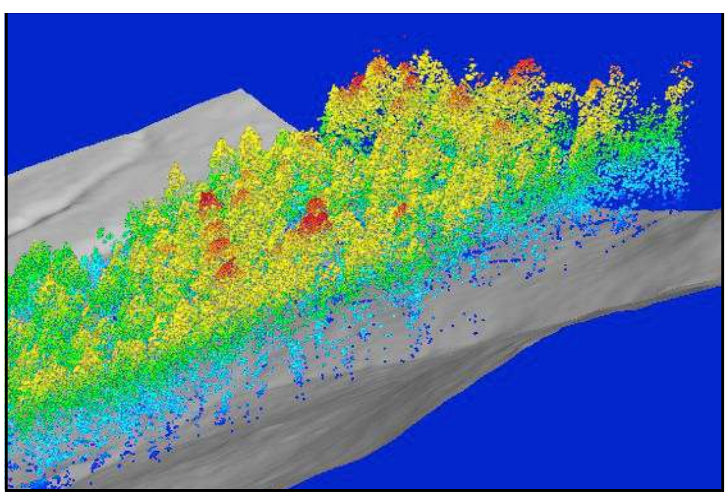

Figure 2. Discrete return LiDAR data visualization, each unique pulse return is digitized in 3-D space.

Because LiDAR data has a vertical component, the point cloud or waveform can be "sliced" to extract data above or below various height thresholds. In this way, one LiDAR data set can be used to construct models specific to many different species, each with distinct habitat requirements and structural affinities (Fig. 3).

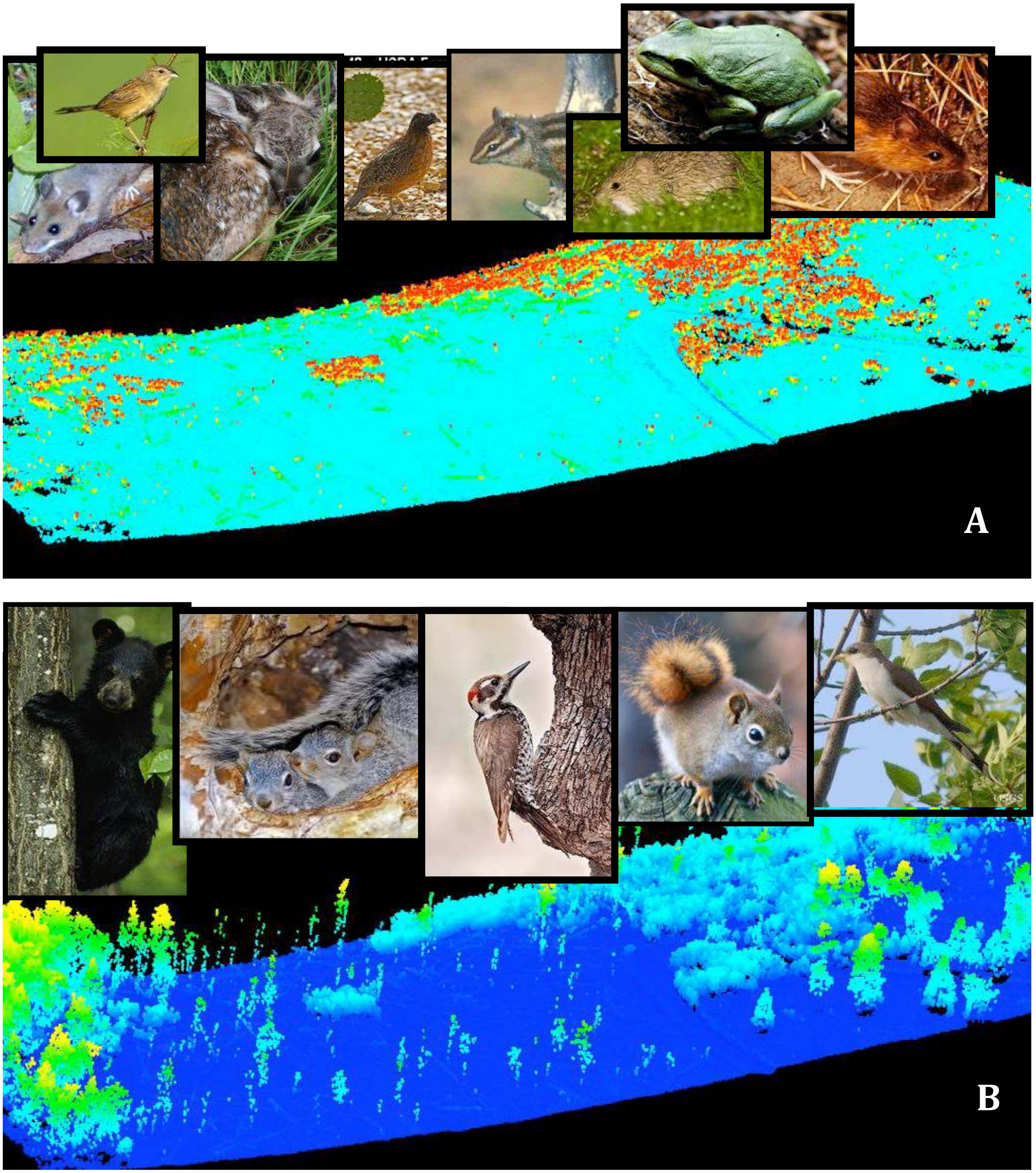

Figure 3. Discrete- return LiDAR point cloud with different heights extracted. **A**. Data ≤ 2m above the ground are extracted and can be used to model habitat and structural affinities of many species associated with woody debris, shrub cover, and meadows. **B**. Data > 2m above ground are extracted and can be used to model habitat and structural affinities of species associated with taller structures, closed canopy, increased stem density and canopy volume, and snags.

Additionally, discrete-return LiDAR acquisition missions generate accurate digital terrain models with much higher spatial resolution than USGS digital elevation models (Fig. 4).

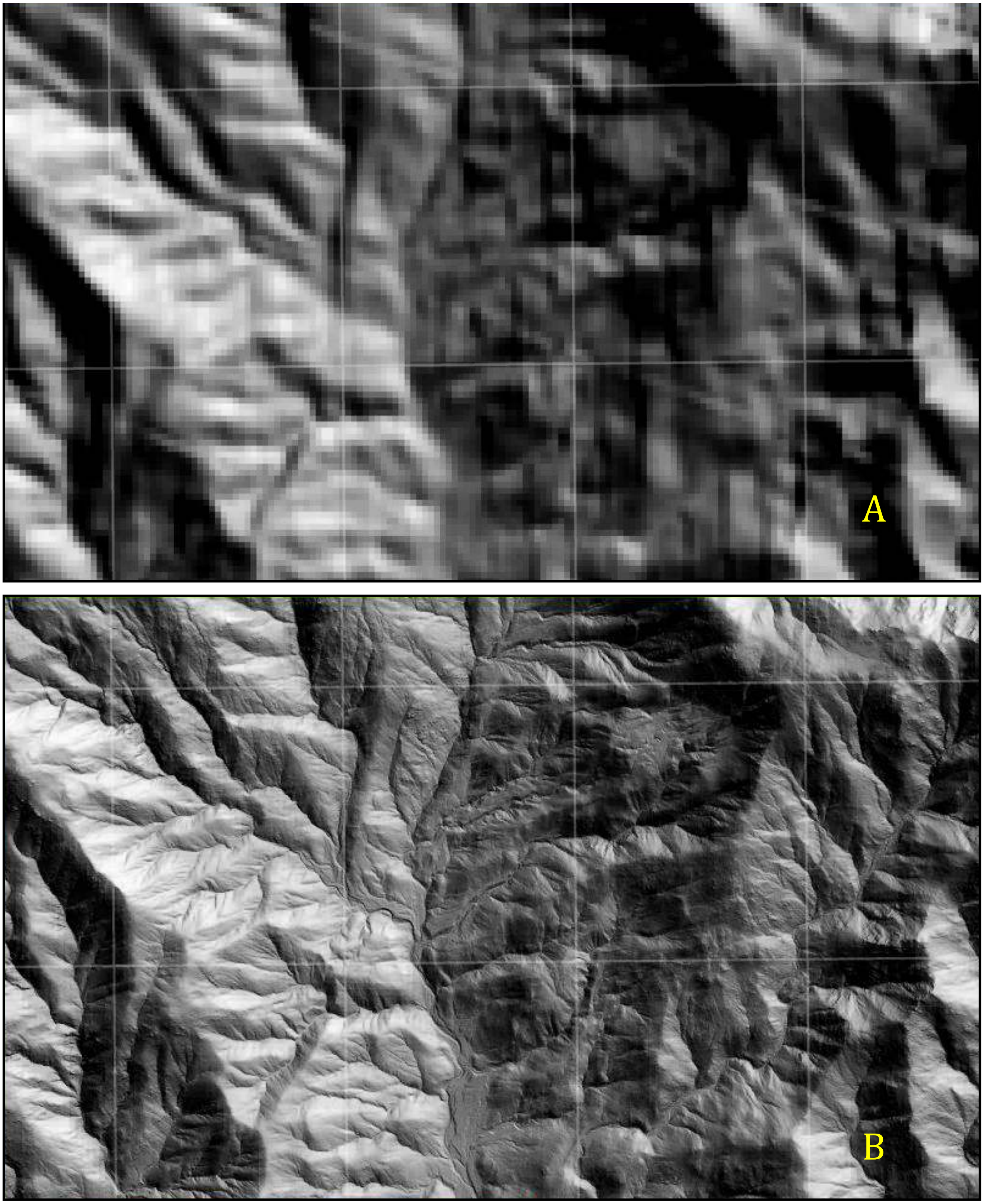

Figure 4. Improved resolution and accuracy from LiDAR-derived digital terrain models at 2m resolution (**B**) compared to 30m resolution USGS digital elevation models (**A**). After Laes et al. 2009.

LiDAR-derived variables can be visualized three-dimensionally in LiDAR-specific software such as FUSION (however ESRI ArcGIS 10.1 allows for visualizing LiDAR data in its native .las or .lda format), or represented two-dimensionally as raster layers in a GIS environment (Fig. 5), which can then be incorporated into specific models predicting use or suitability.

A review of recent ecological and remote sensing literature revealed four main application domains common to wildlife studies that have benefitted from incorporation of LiDAR-derived variables (Merrick et al. 2013). Current application domains include habitat mapping or creating layers used in habitat maps, predicting species presence or use, mapping or predicting correlates of habitat quality such as reproductive success and survival, and mapping or predicting correlates of biodiversity (Merrick et al. 2013).

Many promising applications are emerging or are possible with LiDAR data. Examples of novel applications include:

- The ability to measure canopy closure adjacent to and over streams (Arroyo et al. 2010). Canopy closure contributes to stream temperature and is an important habitat feature for freshwater fishes, aquatic ecosystems, and avian communities associated with riparian corridors.
- Microclimate models over large spatial scales. Microclimates could be modeled via the relationships between discrete temperature measurements, obtained with arrays of temperature loggers, and accurate terrain models. Specific microclimates are important habitat components for ectotherms, nesting birds, neonate mammals, and plants.
- Improved models of roughness. Roughness can be used to predict and map escape terrain important for species such as mountain lions and big horn sheep. It may also be an important component of microclimate/microhabitat models.
- Three dimensional habitat maps or predictive surfaces based on animal locations that include elevation or depth obtained from GPS satellite collars and tags (Belant et al. 2012).

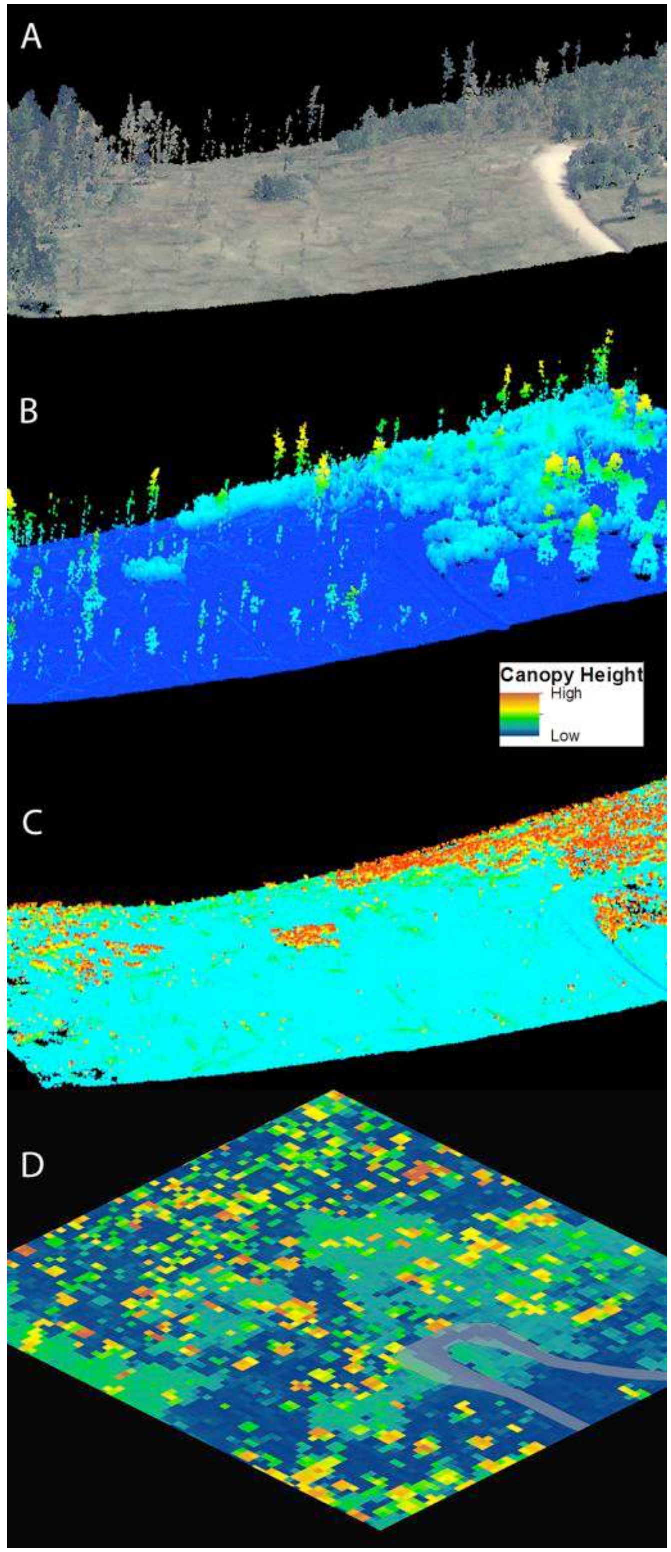

Figure 5. Visualization and representation of discrete, multiple return LiDAR data: (**A**) LiDAR point cloud draped with georeferenced aerial imagery, (**B**) Height of LiDAR pulse returns above the ground showing all vegetation structure and density, (**C**) Height of LiDAR pulse returns ≤ 2 meters above the ground showing shrub/sapling vegetation structure and density, (**D**) raster layer created from mean canopy height surface, 3m pixel resolution. From Merrick et al. 2013.

LiDAR as a collaborative tool

LiDAR data sets are large and relatively expensive, but can also provide a comprehensive snapshot of a landscape in time and generate a wealth of data useful to many interested parties from a variety of disciplines. Increasingly, funding agencies are more apt to fund interdisciplinary collaborative research proposals, and LiDAR acquisition may be a reality given that the data can serve so many for an extended period of time and result in many products like models of hydrological flow, sediment erosion, fuel load, fire behavior, wildlife or plant habitat suitability, presence, or use, and facilitate monitoring efforts such as landscape management and restoration projects, and carbon stores via estimated biomass.

I will briefly use an example I am personally familiar with to illustrate the potential LiDAR datasets have to foster collaboration among agencies and academia. In an effort to inform an ecosystem restoration plan in the Pinaleño Mountains of southeastern Arizona, develop monitoring tools for bark beetle infestation, and improve habitat models for threatened and endangered species like the Mount Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*), the Coronado National Forest in conjunction with the US Forest Service Southwestern Regional Office contracted Watershed Sciences to collect and process discrete-return LiDAR data for the Pinaleño Mountains in 2008 (known as the Pinaleño LiDAR project). The LiDAR coverage area was 34,608 ha, with an average pulse return rate of 7.4 points/m2, with a cost for all deliverables of $105,013.00, or just over $3.00 per hectare (Laes et al. 2009). All data including the raw point cloud and processed deliverables fit on a 500 GB hard drive.

Given that LiDAR data sets are such rich sources of information with countless potential applications, the Coronado National Forest brought together interested parties from the U.S. Forest service, U.S. Fish and Wildlife Service, Arizona Game and Fish Department, and the University of Arizona, invited participation in two, three-day workshops aimed at describing LiDAR processing steps, deliverables, models for derived variables, and providing participants with hands-on instruction and experience working with FUSION software and creating LiDAR-derived products. LiDAR data and deliverables for the Pinaleños were then made available to participants and are currently being used in a variety of ways including creation of variables used in fuel and fire behavior models, forest demography models, monitoring insect defoliators and modeling their spread, and creating habitat variables useful in predicting presence or use of forested areas by Mount Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*) and Mexican spotted owls (*Strix occidentalis lucida*).

As a result of these collaborative efforts, the Coronado National Forest has ensured that one dataset had and continues to have exceptional reach and impact, evidenced by dozens of presentations at local and national meetings to date, several current publications and many more in the planning or preparatory stages, and the development of long-term professional collaborations that did not previously exist.

In summary, LiDAR data provide a way to characterize structural components of wildlife habitat not available from spectral passive sensor technology. Combining LiDAR and multispectral datasets allows us to more fully explore, describe, and model a species' biotic and structural associations, improving our ability to represent the real world that animals inhabit respond to. LiDAR datasets are large and information rich, providing a wealth of direct, derived, and potentially novel variables useful to a variety of research interests, which can facilitate collaboration. Collaborative research projects involving LiDAR data sets may foster new ideas and research directions, increasing the scope and impact of a project far beyond the data itself.

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ZooTracer

Setting a Track Record

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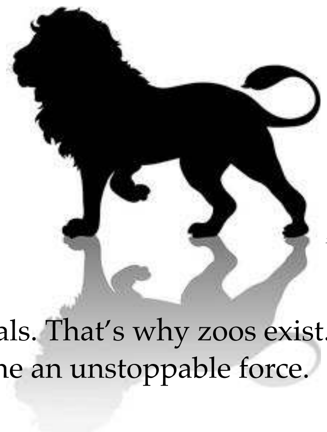
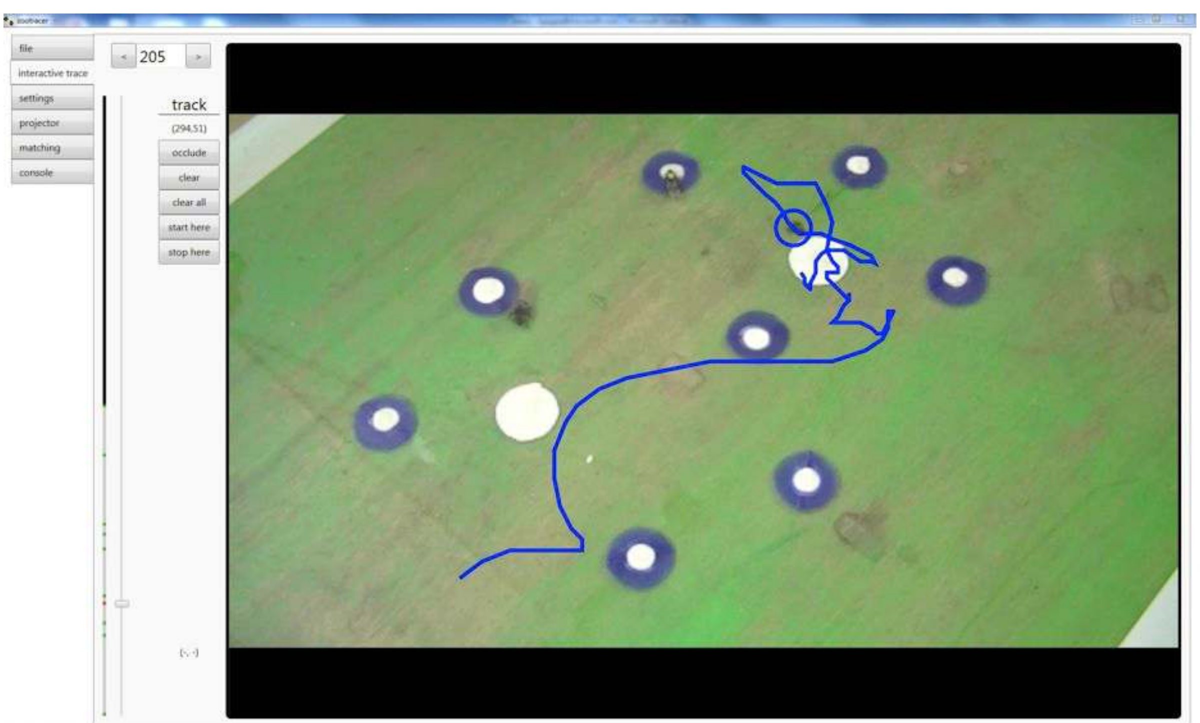


People love to watch animals. That's why zoos exist. That's why photographic safaris command princely sums. That's why cat videos have become an unstoppable force.

I love to watch animals, too, but my motivation includes an additional dimension. As a scientist in the Computational Ecology and Environmental Sciences (CEES) group at Microsoft Research Cambridge, I head the Conservation Science Research Unit, which focuses on my key interests of science, policy, and tools and technology.

Recently, my colleagues and I took a step toward melding a couple of those interests by offering for download ZooTracer, a desktop tool that can be used to trace animal movement by using consumer video equipment. The product of collaboration between CEES and the Computer Vision group at Microsoft Research Cambridge, ZooTracer is easy to use, can take video from anywhere, and the user can quickly modify the results—helping the software learn how to track any object.



ZooTracer

We hope people use it to track animals in video footage. As readers of this newsletter know, tracking animals is an important step in addressing fundamental ecological and environmental problems. Tracking animals can occur across continents, or within a patch of flowers. For example, bee populations are in drastic decline. What plants do they pollinate—and why? That is a question pretty relevant to the production of food for human consumption, but as at least a few of the people reading this newsletter know, actually watching bees fly around and trying to track their plant preferences and the flight paths they take is a pretty difficult task. ZooTracer allows people to collect those data very easily.

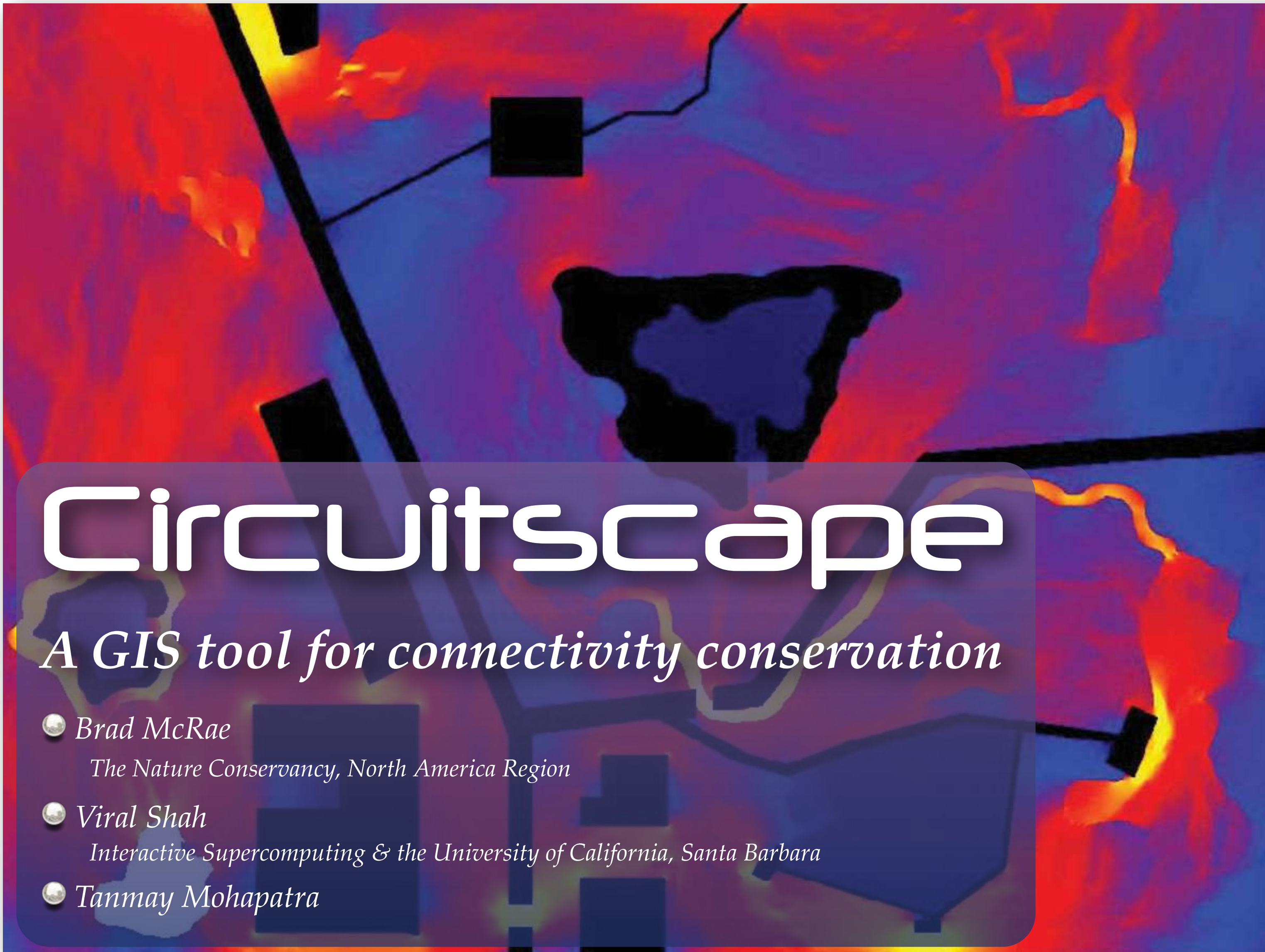
ZooTracer can provide accurate tracking of unmarked, interacting animals in arbitrary video footage. It also can cope with variations in lighting, camera movement, and object appearance—and it does so regardless of the type of recording device or habitat. Most other video-tracking software packages require the user to have thought quite hard about what they were going to do before they did it - for example, using extreme background subtraction algorithms allows for a heavily automated object detection and tracking process. But the actual collection of video footage appropriate for such algorithms can become a trying affair—and it certainly doesn't work for most field biologists!

We have thrown that thinking by the wayside and said that if we allow the user to input a small amount of information about the system, then perhaps we can make a tool significantly more generic than currently exists. So, have some footage taken with your smartphone with shaky hands and a strangely lit background? No problem! ZooTracer should be able to handle it, and if it doesn't, you are able to modify the algorithm's parameters through the user interface to attempt to make it work for you.

We would love for people to download the software and give it a try. It is free to use for scientific work and we are always looking for ways to improve the user experience. Take a look, give it a go, and get back to us with your experiences… we would love to hear from you!

http://research.microsoft.com/en-us/downloads/c54fe194-120d-43e8-b6b6-621e8f9841c3/default.aspx

Microsoft



Circuitscape

A GIS tool for connectivity conservation

Brad McRae

The Nature Conservancy, North America Region

Viral Shah

Interactive Supercomputing & the University of California, Santa Barbara

Tanmay Mohapatra

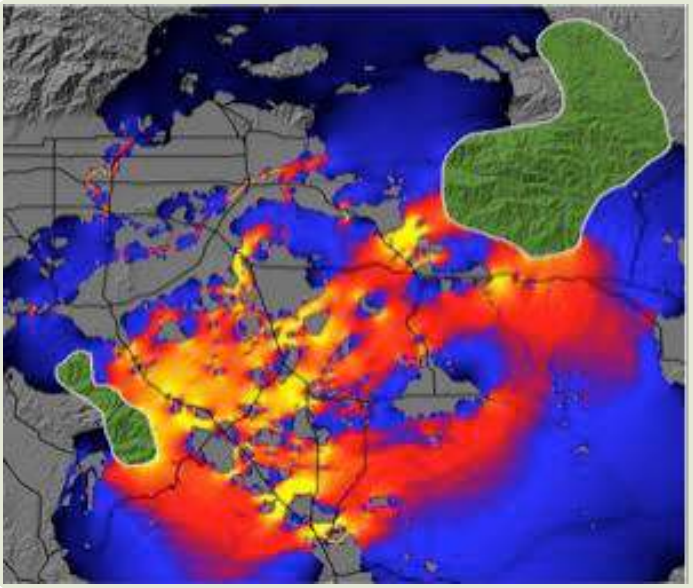
As a growing human footprint fragments natural habitats, managing for well-connected landscapes to conserve processes like dispersal, pollination, and gene flow is becoming a key conservation strategy. Connectivity is particularly important in the face of climate change, because many species will need to shift their ranges as climatic conditions and vegetation patterns change dramatically.

But predicting how different land use, climate change, or reserve design scenarios will affect connectivity is challenging, especially in complex mosaics of natural and converted lands. Processes like dispersal often occur over multiple, diffuse pathways rather than along single, predictable routes. Even if organisms obediently use corridors set aside for them, unpredictable events like wildfires can destroy a corridor overnight. So, building redundancy into connectivity plans is critical if we're going to conserve ecological processes over the long term.

Circuitscape is a connectivity modeling tool borrows concepts and algorithms from circuit theory to help conservation planners meet these challenges. Ecological and electrical networks have a lot in common, right down to the equations that describe how animals and electrons move through them. That means the computational tools we've been using to design and analyze electrical networks for over 150 years can be applied to landscapes, with some nifty advantages. Because these tools incorporate multiple pathways, they provide a great complement to traditional methods when predicting gene flow in complex landscapes.

In conservation planning, circuit theory can be used to quantify redundancy contributed by adding more connections, or to identify "pinch points"—areas critical for connectivity conservation because alternative pathways don't exist—in reserve networks. Remove a corridor, and the whole map changes; think of the loss of a transmission line and the remaining lines becoming more important as the load shifts.

Circuitscape has a large user base, and has been applied to topics as varied as landscape genetics, mapping potential range shift routes in response to climate change, mapping important dispersal routes for conservation, and understanding how different kinds of development affect species of conservation concern. These questions are being asked for species as diverse as army ants, frogs, tigers, and even humans. Researchers are finding new ways to apply Circuitscape for conservation, e.g. in wall-to-wall connectivity analyses, combining results across thousands of species, or modeling the importance of individual habitat patches for keeping a larger habitat networks connected.

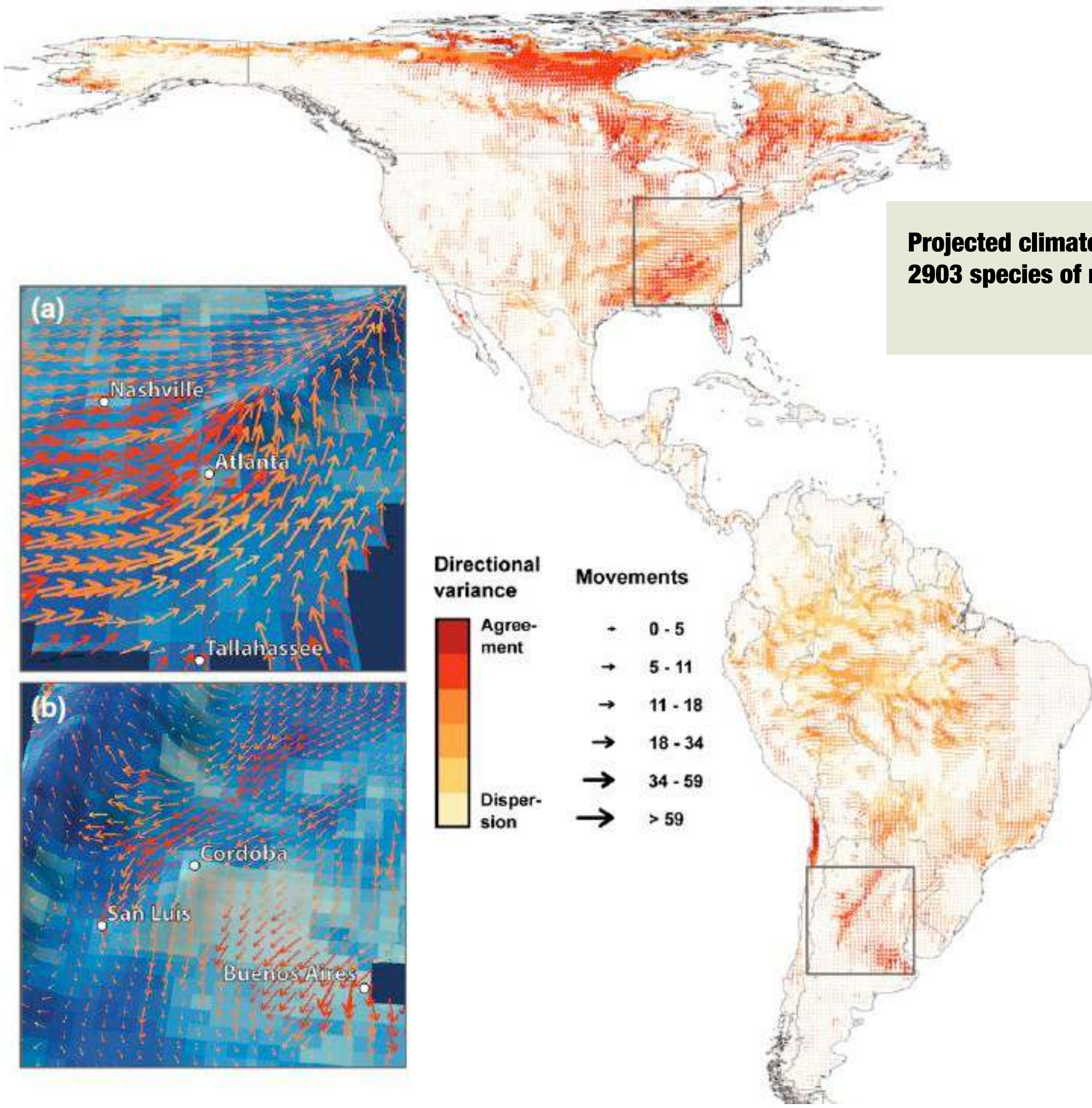


Current map used to predict important connective habitat between core habitat areas (green polygons, entered as focal regions) for mountain lions. Warmer colors indicate areas with higher current density. "Pinch points," or areas where connectivity is most tenuous, are shown in yellow.

Research Collaborators: Brett Dickson and Rick Hopkins.

Circuit theory isn't a replacement for least-cost corridor modeling. Rather, these two approaches represent complementary assumptions about animal movement and connectivity. Whereas least-cost corridor modeling assumes that individuals have the ability to choose a near-optimal path between habitat patches, circuit theory assumes that all pathways to some degree enhance connectivity. Neither is likely to be wholly correct for most species; the optimal pathway may not be at all obvious to a disperser, but at some point the addition of alternative pathways may not contribute to population connectivity either. One way to reconcile these approaches is to hybridize them, which Linkage Mapper now does. It maps least-cost corridors, then runs Circuitscape within them allowing the user to identify pinch points in a corridor or compare levels of redundancy among alternative least-cost corridor designs. Circuitscape and Linkage Mapper can also be used to identify where restoration would most improve connectivity.

We'd be remiss if we didn't point out that the field of connectivity modeling is growing quickly, and that there are many new tools available for connectivity research and planning. Each differs in its conceptual approach, and different tools will be suited to different questions, scales, processes, species, and ways of thinking about connectivity. Websites like Corridor Design, Connecting Landscapes, and Conservation Corridor can help users choose tools that are right for their questions. Whatever tool you use, connectivity modeling involves a great deal of research, data compilation, GIS analyses, and careful interpretation of results. Defining areas to connect, parameterizing resistance models, and other modeling decisions you will need to make are not trivial. Before diving in, we strongly recommend that users first acquaint themselves with the process and challenges of connectivity modeling by consulting published resources (the websites above are a great place to start).



Projected climate-driven movement routes for 2903 species of mammals, birds, and amphibians.

From Lawler et al. 2013.

Circuitscape is freely available at www.circuitscape.org. Recent developments include a toolbox that can run Circuitscape right from ArcGIS, integration with Linkage Mapper, and new tools for resistance and core area modeling. And we're excited to announce Circuitscape 4.0, which sports big speed-ups and new functionality like the ability to analyze graphs (networks), opening up new applications like prioritizing linkages needed to keep larger protected area networks connected. We're now at work testing a web-based version of Circuitscape that can process huge datasets on the cloud.

Spatial Ecology & Telemetry Working Group

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REMOTELY WILD

Spring 2014 – Volume 30

Remotely Wild is a virtual publication issued by the Spatial Ecology and Telemetry Working Group of The Wildlife Society. The newsletter provides information about the working group and its activities, columns and features, information about new technologies, publications and resources of interest to spatially enabled wildlife professionals.

Upcoming Events

- 2014 Wildlife Society Annual Conference, Pittsburgh, PA - October 25 - 30, 2014. http://wildlifesociety.org/
- SCGIS Conference, Jul 11, 2014 to Jul 13, 2014, Asilomar Conference Grounds, Pacific Grove, CA. http://www.scgis.org/conference
- Symposium - Remote sensing for conservation: uses, prospects and challenges, May 22-23, http://www.zsl.org/science/whats-on/symposium-remote-sensing-for-conservation-uses-prospects-and-challenges
- 2014 ESA Annual Meeting, Aug 10th - Aug 15, Sacramento CA. http://esa.org/am/info/
- 2015 ICCB, Montpelier, France, August 2-6, 2015.
- IMCC 3, 14-18 August 2014, Glasgow, Scotland. http://www.conbio.org/mini-sites/imcc-2014
- 5th International Bio-Logging Science Symposium (BLS5), 22-26 September 2014, Strasbourg (France). http://bls5.sciencesconf.org
- Symposium on Animal Movement and the Environment, 5–7 May 2014, Raleigh, North Carolina. http://amovee2014.com
- Spatial Ecology & Conservation 2, University of Birmingham (UK), 17 to 20 June 2014. http://www.ert-conservation.co.uk/sec2.php