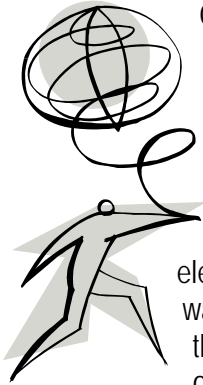


# REMOTELY WILD

The Newsletter of the GIS, Remote Sensing, and Telemetry Working Group  
The Wildlife Society

## Message from the Chairperson



Greetings from the southeast in Gainesville, Florida (29.69N - 82.35W). To those that are unaware, the working group had officer elections during the Wildlife Society meeting in Anchorage. I was elected chair, Robert Kissell was elected secretary, and Tabitha Graves was elected treasurer. Among the three of us, we have a diverse range of expertise in GIS, remote sensing, and telemetry. Among our professions, we also have a good mix of government, academia, and the private sector. I thank Wayne Thogmartin, Dave Olson, and Susan Bernatas for serving as past officers of the working group.

The annual TWS meeting in Anchorage was exciting, interesting, and informative. The working group sponsored three workshops and 1 symposia and I thank the organizers for their efforts. The Wildlife Society has some exciting changes for the website that will positively impact the working group. The Wildlife Society plans to create a website that allows each working group to control their own content all while keeping a similar design with TWS's main page. This will allow for more timely updates to the site and content and allow us to better communicate with our members. The new design is expected to debut sometime in 2007.

Having been elected chair, I am now no longer chair of the website committee for our working group. Our new secretary (Rob Kissell) is now in charge of the website and content updates. If you have a suggestion for the website or something you would like to be added, contact Rob at (kissell (at) uamont.edu). Rob

is also looking for someone to help with content and site updates. Contact Rob if you are interested in serving on the website committee. The newsletter committee is active and well and I thank Nicole Brown, the current newsletter chair, for publishing this issue. The newsletter committee is always looking for content ideas, and people to write articles. Contact Nicole at (nbrown (at) azgfd.gov) if you are interested in helping with the newsletter.

In addition to being elected chair, I was also the recipient of the 2006 student travel award. Each year the working group awards a \$500 travel grant to a current or recently graduated student to attend the TWS annual conference and present their research. I presented some results from my PhD research on landscape-level influence on wetland breeding birds in the Prairie Pothole Region. I have written a summary of my research in another article in this issue of the newsletter. I thank the working group for the award. If you are a current or recently graduated student whose research involves spatial analyses and plan on presenting at the TWS annual conference in Tucson, please watch for the June 2007 issue of our newsletter where details will be released on how to apply for the travel award.

If you work with GIS, Remote Sensing, or Telemetry, I encourage you to become involved with the working group. We all have different areas of expertise and there is much we can all learn from each other's experience. Thank you for your interest in the working group's activities.

*Greg Forcey, Chairperson  
Pandion Systems, Gainesville, FL*

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## GIS for Designing Corridors

By Dan Majka. GIS Analyst/Programmer  
Northern Arizona University

Wildlife need room to move. Species must move through a landscape for a variety of reasons, including daily foraging for food or water, seasonal migrations to different habitats, establishment of new populations via juvenile dispersal, reproduction among meta-populations, and in response to disturbances such as fire, flooding, or climate change. While wildlife have historically been able to move unfettered, habitat loss, transportation networks, and urban development have fragmented the landscape in many places, leaving disjunct habitat patches and populations. Fortunately, these threats can be mitigated by conserving well-connected networks of large wildland areas where natural ecological and evolutionary processes operate over large spatial and temporal scales.

Large habitat blocks connected by corridors can maintain top-down regulation by predators, natural gene flow, pollination, dispersal, energy flow, nutrient cycling, inter-specific competition, and mutualisms. To be successful, a corridor must be planned with the best available biological information, and involvement with the local community, developers, conservation groups, and planning agencies.

In the past 10 years, many groups throughout the United States have been designing corridors, including the [Yellowstone to Yukon \(Y2Y\)](#) project, which is perhaps the most high-profiled corridor study, and was recently featured in a story by the [New York Times](#).

Corridors have been designed using a myriad of methods, ranging from the use of expert-opinion to simply draw corridors on a map, to highly technical methods based on mathematical theory, to quantitative field studies of animal movement, to hybrid approaches combining several techniques. Regardless of the specific corridor modeling approach applied, most techniques employing GIS share the same basic steps in corridor design analysis.

*Step 1: Determine what you are connecting* Corridors are usually designed to connect 2 or more blocks of habitat. In analyses for the Arizona Missing Linkages project, we assumed that the habitat found within large blocks of publicly administered land or privately

owned conservation lands or easements will generally offer some degree of protection.

*Step 2: Determine focal species* Assembling a list of focal species usually involves consultation with regional biologists who know the region you are studying. It is best to select multiple species to capture the breadth of all species habitat needs in the study area. In our analyses, we have modeled 5-25 species per linkage zone. Typical categories of species often modeled include keystone, umbrella, flagship, specialist, and vulnerable species.

GIS data availability can also determine which species should be modeled. Rock-dwelling species, such as some rattlesnakes and lizards, are difficult to model because rock outcrops are not widely available in GIS layers. Riparian species such as fish and frogs are usually only found along specific reaches of streams, washes, or lakes within a study area, and stream conditions or riparian vegetation are not always mapped out precisely enough to model their habitat preferences. While riparian species are often not modeled explicitly, it is important to incorporate their connectivity needs into a corridor design by including any important riparian systems in which they are found.

*Step 3: Create a habitat suitability map for your focal species* Habitat suitability models allow you to better understand the available habitat within the study area, assess the quality of habitat for a species within a modeled corridor, and serve as the required cost layer for least-cost path and corridor analyses. Habitat suitability models are almost always created as a raster layer. They are generally created using one of two techniques which relate a species to raster-based layers such as land use/land cover, elevation, topographic position, human disturbance (e.g. distance from roads, road density, housing density, etc), or any other important factor available as a GIS layer.

If presence-absence data or abundance is available for the species in the study area, then empirical statistical models can be created by relating the

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## Working with large shapefiles

by [Wayne Thogmartin](#), USGS Upper Midwest Environmental Sciences Center  
La Crosse, Wisconsin

Personal geodatabases and vector data layers in ArcMap (Environmental Science Research Institute [ESRI], Redlands, California) are limited to 2 GB. This is a limit imposed by the .dbf file structure. When dBASE, the progenitor of the .dbf file structure, was originally created by Ashton-Tate (Borland Corporation, Cupertino, California), designers were not concerned with files approaching anything close to 2 GB. In today's analytical environment, with its heavy investment in multi-resolution, multi-temporal, and multi-variable datasets, often expressed over large spatial extents, the 2 GB file is all too common. Unfortunately, no software writing to a .dbf file can circumvent this restriction. So, what is a geographic information systems (GIS) analyst to do?

One option is meeting your analytical needs outside of the ESRI computing environment. For instance, Geographic Resources Analysis Support System, aka GRASS GIS, is a free, open source GIS used for data management, image processing, graphics production, spatial modeling, and visualization of data. [GRASS](#) was originally designed by the U.S. Army Construction Engineering Research Laboratories, a branch of the U.S. Army Corp of Engineers. The utility of GRASS in this large dataset quandary is that GRASS can write to a [PostGIS](#) database based on [PostgreSQL](#) (among others). Like GRASS, the PostgreSQL database is free and open source. The maximum size table in this database is 32 TB.

Learning a new GIS and database structure can be intimidating. So, how can one solve this problem of large vector data but remain in the ESRI computing environment? ArcGIS 9.2 utilizes the 'file

geodatabase' in an enterprise database management system. A file geodatabase is a file folder that holds the dataset in a separate file on disk. The file size limit is 1 TB for each dataset, though each file geodatabase can hold many datasets. Each feature class can scale to over 300 million vector features per dataset. Though each file geodatabase is limited to 1 TB, the database management systems underlying the file geodatabase (Microsoft SQL Server, Oracle, IBM Informix, or IBM D2) are capable of handling 4 TB. Because file geodatabases use about one third of the feature geometry storage required by shapefiles and personal geodatabases they allow for quicker handling, a serious consideration when dealing with large file sizes. File geodatabases also allow users to compress vector data to a read-only format that further reduces storage requirements.

These are two options for spatial data analysts. There are many more. The ability to handle large vector datafiles is growing as our demand for access to these large files also grows. The limitations on spatial calculations now seem to have swung toward the pace of calculations rather than in the mass of memory tied up by large file sizes.

*The author wishes to acknowledge the comments of T. J. Fox and J. E. Fallon on an early draft of this document.*

*Dr. Thogmartin is a research scientist working at the nexus of avian ecology, spatial statistics, and spatial analyses, and is currently involved in modeling and mapping rare bird abundance over large spatial extents.*

## TWS Annual Meeting, Sept. 22-26, Tucson, AZ

The Wildlife Society's 14th Annual Conference will be held in Tucson, Arizona from September 22-26, 2007. The theme of this year's conference is Excellence in Wildlife Stewardship through Science and Education. Visit the conference [website](#) for more information.

The GIS/RS/Telemetry Working Group presents a student travel award \$500 for a current or recently graduated student using GIS in his/her research. Application details will be provided in the Summer 2007 newsletter.

Greg Forcey, who recently completed his Ph.D. in Zoology at North Dakota State University, was the thankful recipient of the 2006 student travel award, and contributed the following article briefly describing his research:

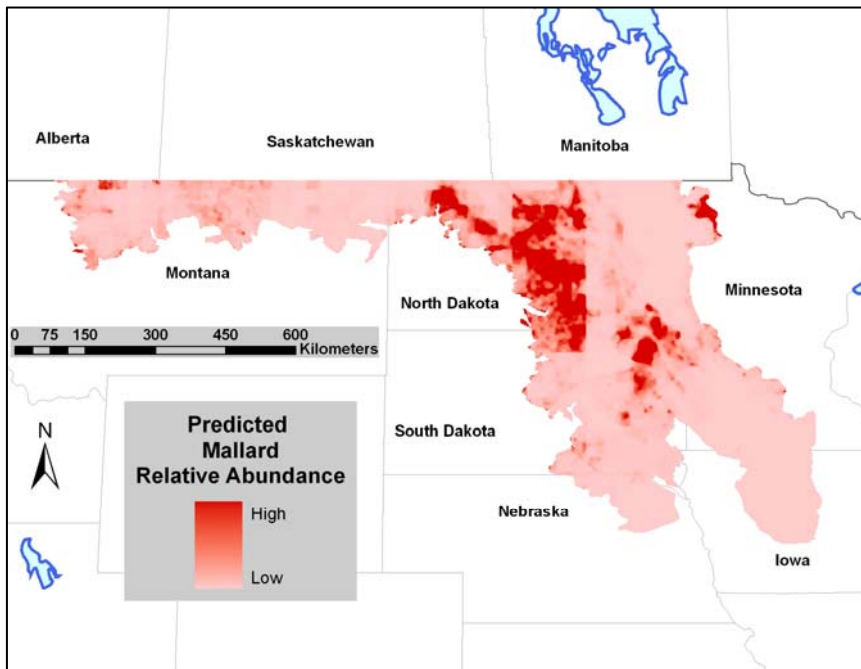
"My research involved examining landscape-level habitat relationships of wetland breeding birds in the Prairie Pothole Region. I used bird abundance data from the North American Breeding Bird Survey (NABBS), land use data from the National Landcover Dataset, and climate data from the National Climate Data Center to model bird abundance as a function of land use and climate. I used ArcGIS 9 in conjunction with FRAGSTATS to quantify land use composition and configuration at different scales surrounding each

NABBS route. I also used the spatial analyst extension in ArcGIS 9 to create a continuous surface of climate data over the Prairie Pothole Region from known information collected at weather recording stations. Climate data were calculated and summarized around each NABBS route at a 100,000 ha scale. Environmental variables were related to bird abundance using a hierarchical modeling approach. Covariates in the model included environmental variables along with nuisance variables, including year, route, and observer effects. These effects were included to accommodate for survey constraints from the NABBS. Models were also "mapped" back into the landscape and used to predict areas of relative abundance across the prairie pothole region. Models were also validated to assess their performance using NABBS data withheld from the original model construction.

Modeling efforts revealed strong influences of climate variables and landscape composition while landscape configuration was less influential. As expected, precipitation, wetland, and water covariates were highly influential on bird abundance in the Prairie Potholes. The influence of other covariates varied among species. Maps of predicted abundance showed that central North Dakota and north-eastern South Dakota were areas of high predicted abundance for most focal species (Fig. 1).

Landscape-level modeling efforts can provide new insights as to how birds are influenced by environmental variables at large scales. Information gleaned from these models can be used in regional conservation planning efforts for birds when identifying areas of high predicted abundance. Identifying areas of high predicted abundance can direct management efforts to those locations which can foster a more efficient use of scarce conservation resources."

Figure 1. Predicted relative abundance for Mallard in the Prairie Pothole Region of the United States



## **Workgroup Meeting Minutes, Sept 11, 2006 Anchorage, Alaska**

### *Members Present*

Rob Kissell	Sindy Eick
Greg Forcey	Tabitha Graves
Mary Ann Cunningham	Bob Weih
Wes Newton	Misty Summer
David Douglas	Susan Bernatas
Miranda Terwilliger	Vivian Queija
Ryan Long	Les Dillard
Niko Balkenhol	Sheila Dufford
Susan Rupp	

This working group provided two work shops during the TWS Annual Meeting in Anchorage. One suggestion for a workshop is developing a landscape-scripting language workshop for characterization analysis.

We would like a more informal location for our next working group meeting. Susan Bernatas, indicated she would find an offsite location for the working group meeting during the Annual meeting in Tucson for approximately 20 people.

The current balance 9/11/2006 is \$5,703.91. The student travel award went to Greg Forcey (\$500.00).

Communication via the TWS central web site is poor since the national level web site doesn't work well. The national office has not suggested when working group web pages would be available and operable. The working group members felt it was worthwhile to develop a separate working group web site. Rob Kissell suggested his college web site within the University of Arkansas, Monticello, could be an option. There was also in interest in setting up a blog on the web site to make it more interactive and timely. There may be an option to fund the cost of the web site from vendor donations.

We proposed a "roundtable" format for discussions on a topic area. This could allow members to casually network to both learn about a topic area and explore new connections. These could be set up during lunch or dinner. It would need to be set up so that people would. One suggested topic is data visualization (i.e., Google earth).

Tom Rider asked if other workers were having similar issues with radio frequency overlap in telemetry collars. He is finding that there is a lot of overlap in frequency in his study area. Has anyone else had similar issues and how was it resolved?

There was some discussion about changing the working group's name since it is so long and may not represent the working group members' interests. Any suggestions on a name change?

We need to set up a mechanism to put the scholarship on the web site to allow more students know it is available.

### Election Results:

Chair: Greg Forcey – Pandion Systems  
Secretary: Rob Kissel. – University of Arkansas at Monticello  
Treasurer: Tab Graves – USGS

We have a great representation across private, university and agency staff. Thanks to Wayne Thogmartin – Chair, Dave Olson – Treasurer, and Susan Bernatas – Secretary for their time and effort.

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species occurrence data to habitat factors. Statistical techniques such as generalized linear or generalized additive models (e.g. logistic or Poisson regression), artificial neural networks, classification and regression trees (CARTs), and genetic algorithms can all be used to create a map of a species probability of occurrence at any pixel in the landscape., which can take a considerable amount of time. With these models, data is typically extracted from the GIS layers, assembled into a site by occurrence matrix, analysed with a statistics package such as [R](#), [S-Plus](#), or [SAS](#), then fed back into the GIS software to create a map. Stand-alone modeling packages such as [Biomapper](#), [openModeller](#), or [DesktopGarp](#) can also be used. While empirical models are probably more accurate than rule-based or literature-review based models, they require gathering a good set of field observations for every species

The more common habitat suitability modeling technique used for corridor modeling is based on literature review and expert opinion, and generally follows the ideas found in the 1981 U.S. Fish and Wildlife Service publication [Habitat Evaluation Procedures Handbook](#). With this technique, anywhere from 1 to  $n$  habitat factors are scored for each species by a biologist who knows the species well. If only a vegetation layer is used, the different classes within the layer (such as pinyon-juniper woodland, desert scrub, wetland, urban, etc), are all given an importance value on a logical scale. The range and magnitude of this scale is not important, as long as it is consistent and makes sense for the species and those performing the modeling. The most common scales range from 0-1, 0-10, 1-10, 0-100, and 1-100. If more than 1 habitat factor is used, each class within each factor is given an importance value, and then the overall influence weight of each factor, such as land cover or elevation, is scored so their sum is 1. For example, land cover might carry 70% of the weight, while topography and road density are each only 15% important ( $.70 + .15 + .15 = 1$ ).

Once different habitat factors are scored and weighted, they are then combined together to form a single habitat suitability map that has a suitability score for each pixel. The two most common methods of combining factors are additive (or arithmetic) mean

and geometric mean models. Details on these models can be found in the [Standards for Development of HSI Models](#) section of the Habitat Evaluation Procedures Handbook.

Within GIS, habitat suitability models are created by reclassifying each habitat factor grid, and then combining the layers using a weighted overlay function (for additive mean models) or map algebra (for either additive or geometric mean models). If many habitat suitability models will be created, it is easiest to automate the process by writing these functions in a scripting language such as Python, AML, or Avenue.

*Step 4: Determine patches of potentially suitable habitat for your species* It is handy to have a map of potential habitat patches for every species within the study area. This is most often accomplished by setting a threshold for habitat suitability, reclassifying everything above (or below, depending upon your modeling framework) the threshold as suitable, and then joining adjacent pixels of suitable habitat together.

For example, I might have a habitat suitability map ranging from 0 to 100, where 0 is absolutely bad habitat, and 100 is absolutely good. If I set a patch suitability score greater or equal to 50 would be threshold of 50, then every pixel with a habitat considered suitable habitat for a patch, while everything less than 50 would be unsuitable. This step is performed using a simple reclassification procedure in ArcGIS. Adjacent pixels of suitable habitat can then be grouped together using the REGIONGROUP function in ArcGIS, and the resultant groups of suitable habitat can then be sorted according to size, and reclassified if necessary into different sizes of potential habitat patch (e.g. breeding patch, population core, etc.).

*Step 5: Perform corridor analysis for species* Three modeling techniques have commonly been applied to model potential corridors species:

**Least-cost path analysis (LCPA)** is available as a function with ArcGIS's [ArcToolbox](#), ArcInfo Grid (function COSTPATH), and as a Map Calculator LCPA creates a 1-pixel wide least-cost path between function within ArcView 3.3 (function COSTPATH). 2  
(continued on p.7)

source patches. Often, this path is buffered by a given distance to widen the corridor beyond the width of a single pixel.

**Least-cost corridor analysis (LCCA)** is also available within [ArcToolbox](#) and ArcInfo Grid (function CORRIDOR), but is not found within ArcView 3.3. LCCA creates a swath of pixels between 2 source blocks. For designing a corridor between just two blocks of habitat, it is often preferred over least-cost path analysis because it allows the analyst to select a corridor wider than a single pixel. Additionally, because LCCA can create multiple corridor strands if two or more areas between habitat blocks are equally permeable. The Arizona Missing Linkages project uses this approach.

**Graph theory approaches** are a flexible way to evaluate the landscape-level connectivity of a network of habitat patches. With these techniques, the robustness of a network of nodes (habitat patches) can be analyzed, as well as the shortest optimal edges (paths) which connect these nodes. Graph theory methods do not come standard within any ESRI GIS package, but are available in some form in the [FunConn Package for ArcGIS](#) and the [ArcRstats package](#), created by Pat Halpin's Geospatial Analysis Program at Duke University.

*Step 6: Combine corridors from multiple species to make multi-species linkage design* After deciding on a final corridor for each species in the analysis, the corridors are typically combined to create a multi-species linkage design. Because some species will have overlapping habitat preferences, combining corridors will usually result in fewer corridor strands than the number of species modeled. Most of the final

linkage designs in the Arizona Missing Linkages project were composed of 2-5 distinct corridor strands.

*Step 7: Evaluate corridor or linkage design* Before a corridor or linkage design can be implemented, it must be evaluated to ensure the species expected to use it are well-served. Within GIS, this step typically involves calculating metrics that measure how 'good' the design is for every species. Typical metrics include average habitat suitability found within the corridor design, distribution of habitat suitability, and distance between potential habitat patches to ensure patches are located within dispersal distance for each species. Following GIS evaluation, field work is performed to determine any barriers such as recent un-mapped urban developments which inhibit the linkage design.

### **CorridorDesigner: Coming to a Computer Near You**

To help others design corridors with GIS, we are programming a ArcGIS 9.x extension to streamline the process. *CorridorDesigner* will provide functions for creating habitat suitability and patch models, running corridor analyses, and creating data layers, as well as an extension for ArcMap that will allow the user to compare and evaluate alternative corridors using metrics such as those described above.

Please visit our [website](#) which will provide in-depth advice on all the modeling and evaluation decisions a user has to make throughout the corridor design process.

Both the tools and the website will be completed by July 1, 2007, but may be available as early as March or April 2007. For more information about designing corridors with GIS, feel free to contact me at [dan@corridordesign.org](mailto:dan@corridordesign.org).

## Where in the World?

Test your photo interpretation skills by identifying this international landmark. Clue: Site of Annie Edson Taylor's famous voyage.



## REMOTELY WILD

Winter 2007

Remotely Wild is a virtual publication issued two times per year by the Geographic Information Systems, Remote Sensing, and Telemetry Working Group of the Wildlife Society. The newsletter provides information about the working group and its activities, regular columns and features, information about new technologies, publications and resources of interest to spatially enabled wildlife professionals.

Remotely Wild encourages its members to submit articles. Please send submissions via email to Nicole Brown, Newsletter Editor, at [nbrown@azgfd.gov](mailto:nbrown@azgfd.gov)

### About Us

The Geographic Information Systems (GIS), Remote Sensing, 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. The Working Group includes, but is not limited to, GIS users, remote sensing specialists, cartographers, and landscape ecologists.

### Current Officers

**Chairperson** [Greg Forcey](#)

Pandion Systems, Inc., Gainesville, FL

**Secretary** [Robert Kissell](#)

University of Arkansas at Monticello

**Treasurer** [Tabitha Graves](#)

USGS Glacier Field Station, West Glacier, MT

**Newsletter Editor** [Nicole Brown](#)

Arizona Game and Fish Dept., Phoenix AZ

Please visit our [website](#).

The Wildlife Society (TWS), founded in 1937, is an international non-profit scientific and educational association dedicated to excellence in wildlife stewardship through science and education. Our mission is to enhance the ability of wildlife professionals to conserve diversity, sustain productivity, and ensure responsible use of wildlife resources for the benefit of society.