TIEE

Teaching Issues and Experiments in Ecology - Volume 8, April 2012

EXPERIMENTS

Drivers of Avian Local Species Richness: Continental-Scale Gradients, Regional Landscape, or Local Land Cover?

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ABSTRACT
Students learn how to test hypotheses related to the local, regional, and continental determinants of local breeding bird species richness, using georeferenced data from standardized point counts and remotely-sensed data, including orthoimages and continental-scale land use and land cover. The exercise is intended as a small-group bounded inquiry. The activity requires a short period of in-class introduction and time for student presentations, but completion of the exercise can be done outside of class.

Point Count Surveys from: Bayou Macon WMA
Point (actual survey site): 1-1
Coordinates: Lat / Lon: 32.8688176 / -91.2789056 UTM zone/x/y: 15 / 661025.0 / 3638057.0
Elev: - **Slope:** - **Aspect:** -
Description:

Survey Summary

Season	First Yr	Latest Yr	~ # Of Surveys
Breeding	2007	2008	2

Point Species List

	Freq. Occurence On Surveys	
Species	2007	2008
Yellow-billed Cuckoo	X	X
Red-bellied Woodpecker	-	X
Downy Woodpecker	-	X
Pileated Woodpecker	-	X
Acadian Flycatcher	X	-
Great Crested Flycatcher	-	X
White-eyed Vireo	-	X
American Crow	X	X
Tufted Titmouse	X	X
Carolina Wren	X	X
Northern Cardinal	X	X
Indigo Bunting	-	X

KEY:
"X"= Found during at least one survey during this year
" - "= Not found during this year's counts

Figure 1. (left) ***Bird point count survey data from one location (source: USGS Bird Point Count Database),*** (right - upper) ***land cover near the point count's location (source: 2006 National Land Cover Data), and*** (right - lower) ***a matching high-resolution image of the point count location (source: Google Earth).***

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KEYWORD DESCRIPTORS

- **Ecological Topic Keywords:** biogeography, bird community structure, environmental gradients, gradient analysis, human impacts, landscape ecology, scale, species diversity

- **Science Methodological Skills Keywords:** data analysis, evaluating alternative hypotheses, formulating hypotheses, graphing data, hypothesis generation and testing, oral presentation, quantitative data analysis, use of spreadsheets, use of graphing programs

- **Pedagogical Methods Keywords:** assessment, bounded inquiry, formal groupwork, group work assessment, peer evaluation, problem based learning (PBL), project-based teaching

CLASS TIME

2 to 3 hours. This includes 30 - 45 minutes for an introduction to the activity, 10 minute check-in sessions on each of two subsequent class periods, and one hour for presentations. Time for presentations depends on class size: each 3-5 person team will do a 7 to 10 minute presentation.

OUTSIDE OF CLASS TIME

5 hours or more per student. The per-student time varies, depending on how well organized teams are and how skilled students are with figuring out unfamiliar computer applications. Allow 2 weeks to complete the out-of-class component of the activity.

STUDENT PRODUCTS

Each student-team submits a worksheet that has a scaffolded set of questions about the exercise. Each team also provides a data table and four graphs that summarize their data collection and analysis. The team makes an oral presentation about their data analysis and conclusions, and they submit the powerpoint slide set as a product.

SETTING

North America, using publically-available data accessed from the internet; patch-scale to landscape-scale data for land use / land cover and species richness.

COURSE CONTEXT

Undergraduate ecology, class of 30 students

INSTITUTION

Small 4-year primarily-undergraduate institution

TRANSFERABILITY

A simplified version of this activity may be appropriate for non-majors or high-school students. The activity is also appropriate for upper-division (junior/senior) undergraduates. The exercise is suitable for most students, including those who cannot easily go into the field. The only students for whom this activity may not be suitable are the visually-impaired.

ACKNOWLEDGEMENTS

This has been developed as part of the *Teaching with Large Datasets Distributed Seminar*, which was a collaboration among NCEAS, ESA, and NEON Inc, with support from NSF. Special thanks Teresa Mourad (ESA), Wendy Graham (NEON Inc.), Stephanie Hampton (NCEAS), Amelia Nuding (NCEAS), Bruce Grant (Widener University) and all of the active collaborators within our working-group, especially Barbara Abraham (Hampton University) and Denny Fernández (University of Puerto Rico at Humacao). My undergraduate students Tiyi Brewster and Rachael Rodriguez provided a perceptive analysis and critique of the exercise. I thank Christopher Beck and the reviewers for suggesting improvements to this exercise.

SYNOPSIS OF THE EXPERIMENT

Principal Ecological Question Addressed

What factors best explain variation in local (alpha) species richness of breeding birds: local habitat, local species pool, regional patterns of land use and land cover, or continental-scale gradients associated with climate?

What Happens

Students are placed in teams of five (or whatever number the instructor considers suitable). The instructor provides a brief introduction to the concepts of gradients in species richness, and local vs. regional patterns of land cover / land use. Student teams generate hypotheses for why bird species richness varies across localities, including hypotheses about local land cover, regional land cover / land use, and continental gradients in climate. Students are provided an excel spreadsheet with avian point count sample data from a longitudinal transect across eastern North America, extracted from the USGS Bird Point Count Data Base (*Transect Data Tables.xlsx*), and a set of example data (*Transect 1 Example Points.pptx*, *Transect 2 Example Points.pptx*, *Transect 3 Example Points.pptx*). Each student samples five points, ideally each at a different location, so a team of five then samples 25 locations spanning 20 -30 degrees longitude from the east coast of North America to the interior of the continent. For each location, students quantify land use at two spatial scales using the National Land Cover Database. The teams then test the predictions of their hypotheses graphically by plotting relevant land use / land cover measures, local species pool or longitude against species richness. Each team then makes a short oral presentation of their study.

Experiment Objectives

(1) Understand how local patterns of species richness can be the function of local, regional, and continental-scale processes.
(2) Understand how anthropogenic changes in land cover and land use can alter natural gradients of species richness.
(3) Learn how measures of land use and land cover patterns vary depending on the spatial scale of the analysis.

Equipment/ Logistics Required

Computer with an internet connection
Up-to-date web browsing software
Following applications installed:
- Spreadsheet program (e.g. Microsoft Excel)
- ImageJ (free download at http://rsbweb.nih.gov/ij/)
- Google Earth (free download at http://www.google.com/earth/index.html)
- Snipping Tool (standard installation on recent Microsoft Operating Systems) or comparable Mac OS utility (see http://www.wikihow.com/Take-a-Screenshot-in-Mac-OS-X)

Following bookmarks marked in browsing software:
- http://www.pwrc.usgs.gov/point/ (Bird Point Count Database)

http://www.google.com/earth/index.html (Google Earth)
http://www.mrlc.gov/ (National Land Cover Database)

The following files provided in the course management website for download (or distributed as emailed attachments

Exercise Introduction
Overview of Data Collection and Analysis Methods
Worksheet
Appendix 1 - USGS Patuxent Wildlife Research Center Bird Point Count Database
Appendix 2 - Google Earth
Appendix 3 - MRLC National Land Cover Data Viewer User Guide
Appendix 4 - Using ImageJ
Appendix 5 - Analyzing Image J data with Excel
Appendix 6 - Student assessment instrument
Transect Data Tables
Transect 1 Example Points
Transect 2 Example Points
Transect 3 Example Points

Summary of What is Due

Each student-team (1) presents a 5 to 7 minute talk on their research. Each team additionally submits (2) one completed activity worksheet, (3) one spreadsheet providing the data on the point count locations used for the analysis, and (4) the powerpoint slide file or other digital resource file used for the oral presentation. (5) The spreadsheet and powerpoint slide file are expected to include four scatterplots with appropriate scaling, labeling, titles, and captions: (a) longitude vs. bird species richness, (b) local species pool vs. point count species richness, (c) local proportion forest cover vs. species richness, and (c) regional proportion forest cover vs. species richness.

DETAILED DESCRIPTION OF THE EXPERIMENT

Introduction

What determines local species richness and composition, meaning the number of coexisting species and the kinds of coexisting species found in one point location? Local species richness and composition, also referred to as alpha diversity, is a function of the regional species pool, at least in part. The regional species pool is partially a function of historical processes of colonization and *in situ* speciation. Regional species pools also reflect regional environmental complexity; for example, topographically complex regions have more species than flat regions. On large spatial scales, in North America there are south to north, coast to interior, and lowlands to highlands gradients of decreasing regional species richness. These gradients are caused by gradients in temperature and precipitation, and the associated climatic effects on primary productivity (Schluter and Ricklefs 1993, Rosenzweig 1995, Gaston 2000, White and Hurlbert 2010).

Local species richness is also a function of habitat availability and distribution. At the most local scale, species richness may increase with the size of a habitat patch; patch shape and orientation may further impact species richness. Size and shape of habitat patches affect species composition too – some species only occur when suitable habitat patches are large, and species that occur in other habitats may 'bleed' into a habitat patch near its edges (Fahrig 2003, Ries et al. 2004).

At a landscape level, metapopulation dynamics are important. The number and distribution of habitat patches and the degree of contrast between the habitat patches and the surrounding landscape matrix impact species richness: the more numerous the habitat patches, the less isolated the patches from each other, and the less severe the matrix contrast between them, the more species that are likely to occur within a given patch (Andren 1994, Fahrig 2003).

Human modification of a landscape caused by land cover conversion to human land uses can affect local species richness, by changing the size and shape of habitat patches, creating new matrix types, and favoring the presence of human-associated native and invasive species. Regionally, human activities may increase or decrease habitat complexity of the landscape. Human modification of a landscape may result in lower or higher species richness than occurred at a location before human presence (Blair 1996).

At what spatial scale do landscape patterns of habitat affect local species richness and composition? In other words, is it just the patch itself and its surrounding matrix, or the neighborhood of habitat patches and the local matrix, or is it habitat patterns over the greater region? There is no general answer to this question – it is important to evaluate a range of spatial scales from very local to the greater region around a patch, and it is indeed possible that patterns of habitat at several spatial scales jointly affect species composition (Fig. 2).

Birds are often used as indicators of species richness of terrestrial biodiversity in general, because bird species richness correlates with species richness of plants and with other animal taxa (Wiens 1989). One standard way to estimate the local species richness of birds and bird species composition is a methodology called the point count (Ralph et al. 1995, Bibby at al. 2000). A point count is a list of species detected (seen or heard) for a defined time (e.g. 10 minutes) and area (e.g. 100 m radius around a surveyor). It is important that the time is defined, since the longer the monitoring period the more species that will be detected. The diameter of the radius is important too – the larger the diameter, the more species that will be detected. In some habitats, birds can be reliably detected at a greater distance than others; one can detect grassland birds on an open prairie at a greater distance than woodland birds in a thick forest. One typical methodology is to list detected birds within radial bands, e.g. within 50 m, 50 – 100 m, greater than 100 m (Fig. 3). This can be used to correct for differential detectability across habitats.

Obviously the timing of the point count matters; typically point counts are done in the breeding season, but some surveys focus on birds during migration or other periods. Since there is day-to-day and other temporal scale variation in detectability (e.g. birds sing less in poor weather), surveys that use point counts often survey a point multiple times within a season (for example, three times at least one week apart), and then sum the results. Of course the more times a point is surveyed, the more species that are likely to be detected.

Literature Cited

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Bibby C.J., N.D. Burgess, D.A. Hill, and S.H. Mustoe. 2000. Bird Census Techniques. Academic Press, San Diego CA.

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Ries, L., R.J. Fletcher Jr., J. Battin, and T.D. Sisk. 2004. Ecological responses to habitat edges: mechanisms, models, and variability explained. Annual Review of Ecology, Evolution, and Systematics 35:491-522.

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Schluter D., and R.E. Ricklefs. 1993. Species diversity: An introduction to the problem. Pp 1-12 in Species Diversity in Ecological Communities (R.E. Ricklefs, S. Schluter, eds.). University of Chicago Press, Chicago IL.

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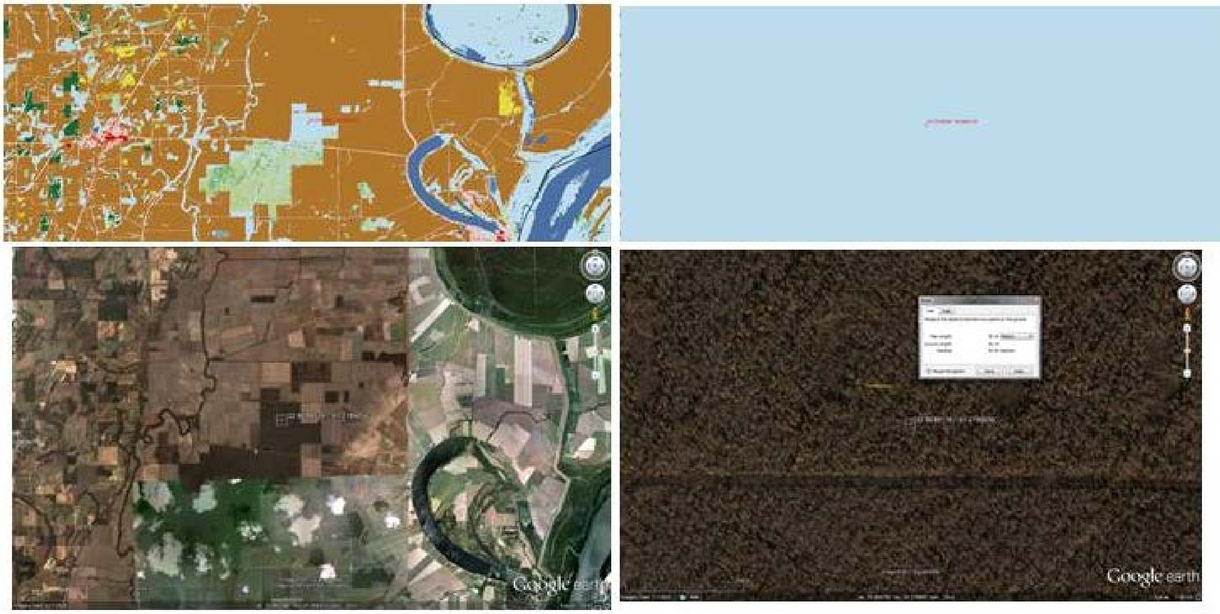
White, R.P., and A.H. Hurlbert. 2010. The combined influence of the local environment and regional enrichment on bird species richness. American Naturalist 175: E35–E43.



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Acadian Flycatcher	X	-
Great Crested Flycatcher	-	X
White-eyed Vireo	-	X
American Crow	X	X
Tufted Titmouse	X	X
Carolina Wren	X	X
Northern Cardinal	X	X
Indigo Bunting	-	X

KEY:
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Figure 2. Local and regional landscape around one point count site at Bayou Macon Wildlife Management Area, Louisiana. The upper two panels are 2006 National Land Cover Data and the middle two panels are digital orthoimagery taken from GoogleEarth.

The lower panel is the point count data, from single-visit point count surveys in 2007 and 2008.

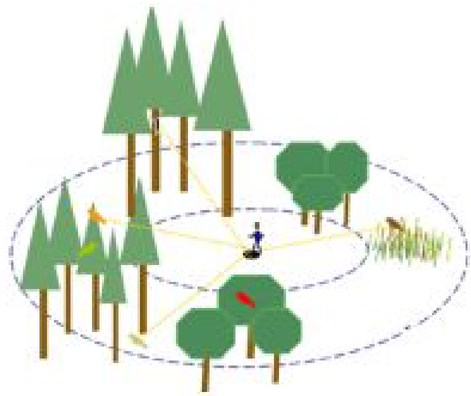

Figure 3. Schematic of a point count, for which detected birds are classified as being within one of three distance classes (under 50 m, 50 – 100 m, greater than 100 m). The distance bands aid in detecting and correcting loss of detectability with distance.

(Image Source: USGS Patuxent Wildlife Research Center Bird Point Count Database. http://www.pwrc.usgs.gov/point)

Materials and Methods

Study Site(s): This activity uses publically-accessible archived point count data available for locations across the United States. The locations are primarily on managed public lands (e.g. National Forests, National Wildlife Refuges, National Parks).

Overview of Data Collection and Analysis Methods:

1. Provide an introduction to the conceptual background to the exercise. See *Comments on Introducing the Experiment to Your Students.*

2. Provide a brief introduction to the exercise. This should include providing an introductory presentation of Google Earth, the National Land Cover Data, the Point Count Database, and ImageJ. Ideally, an instructor should run through steps 2, 3, 5, and 6 of the students' instructions (below), using a different point count location.

3. Divide students up into groups. I prefer groups of five students, because it generates sufficient data for analysis without overburdening students, and groups of five can generate good discussions and divide presentation

tasks well. If an instructor prefers smaller groups, one option is to have all class-members pool the data, then distribute the pooled data to each group to analyze (see ***Comments on the Data Collection and Analysis Methods Used in the Experiment***).

4. Provide each group with a data sheet with a menu of points that represent one longitudinal transect. The file ***Transect Data Tables*** has three worksheets, each worksheet providing a set of point count data for over 75 points along a longitudinal transect starting near the east coast of the US. Also provide an example data file that corresponds to the assigned transect (***Transect 1 Example Points***, ***Transect 2 Example Points***, or ***Transect 3 Example Points***).

5. Make sure that students know where to find the resources they need to complete the exercise (e.g. the class's course management site).

You will be assigned to a small group of students. You will answer the questions to the worksheet as a group.

1. Read the webpage *What is a Point Count?* at the **Bird Point Count Database** (http://www.pwrc.usgs.gov/point/).

2. Using Appendix 1 as a guide, go to ***Patoka River NWR & MA*** (from the home page, click *Search by state > Indiana > Patoka River NWR & MA*). At ***Patoka River NWR & MA***, in the brown box are the methodological details of each point survey – how long each point was surveyed and the distance bands used to control for the decline in detectability with distance. From ***Patoka River NWR & MA***, click ***Inventory*** to see how many species were detected across all point counts. From ***Patoka River NWR & MA***, click ***List of Points with Coordinate,*** then select ***Point 2*** to see the list of species detected at the point, and the geocoordinates of the point. ***Answer Question 1 on the worksheet.***

3. Using **Google Earth** (see Appendix 2), in the ***Fly to*** box paste 38.381316, -87.304142 (latitude 38.381316 degrees N, longitude 87.304142 degrees W). This point corresponds to *Patoka River NWR & MA*: *Point 2*. Look at

the point at the finest local scale that the image resolution will allow, then zoom out to increasingly larger scales, up to an altitude of about 100 km. ***Answer Question 2 on the worksheet.***

4. Next, access the **MRLC National Land Cover Database** (http://www.mrlc.gov/), and read the **NLCD 2006 Product Description**, **Legend**, and **Statistics** (from the home page, click *Finding Data > National Land Cover Database 2006*).

5. Access the **MRLC Consortium Viewer** (http://gisdata.usgs.gov/website/mrlc/viewer.htm). Appendix 3 provides a general guide to using the Viewer; detailed instructions on using the Viewer are at http://gisdata.usgs.gov/website/mrlc/userinstructions.htm .

   Using the **MRLC Consortium Viewer**, find the same point location that you looked at using Google Earth (paste into the xy panel: -87.304142, 38.381316). Look at the location from the finest local scale up to about 1:700,000. ***Answer Question 3 on the worksheet.***

6. Look at the location at a medium scale (around 1:80000 scale). Take a screen-shot (using a screen grabber utility such as Windows **Snipping Tool,** or for the Mac OS see http://www.wikihow.com/Take-a-Screenshot-in-Mac-OS-X), and calculate the proportional land cover around the point count at this spatial scale using **ImageJ** and **Excel** (see document Appendix 4 & Appendix 5). ***Answer Question 4 on the worksheet.***

7. Imagine making a transect of 25 point counts for breeding birds starting at the Atlantic coast of North America and moving west into the continental interior to the approximate center of North America (around 100 degrees west longitude). Pose a set of alternative hypotheses about how ***local land cover patterns*** (e.g. land cover class, proportional land cover, land cover diversity, distance from an edge), ***regional landscape patterns*** (proportional coverage, land cover diversity, degree of habitat fragmentation), ***species pool*** (all of the species of birds that breed in a region, whatever the habitat), and ***continental gradients*** (i.e. the east-west latitudinal gradient from coast to interior) affect breeding bird species

richness, as indicated by a point count. What would each hypothesis predict?

Note that by hypothesis, what is meant is a justifiable scientific conjecture of a cause of spatial variation in bird species richness (i.e. *why is there variation?*), and by prediction what is meant is the pattern of species richness one would predict if the hypothesis were true (i.e. *how does it vary, given the hypothesis?*). For example, one might hypothesize that bird species richness is inversely proportional to the annual variability in climate. If true, species richness of birds should decline as one moves from coastal locations into the interior of the continent, since the climate in the interior of a continent is generally more variable than near its coasts.

Note that it is quite possible that more than one hypothesis would result in the same prediction about patterns of species richness, and it is also possible for more than one hypothesis to be correct. ***Answer Question 5 on the worksheet.***

8. Your instructor will distribute a data sheet of breeding bird point counts extracted from the USGS Patuxent Wildlife Research Center Bird Point Count Database. The points were selected on along a narrow latitudinal band (around 5 degrees) running from the East Coast of North America to the interior of the continent, spanning 20-30 degrees longitude. Three point counts were selected randomly from each **Land Unit** (i.e. the wildlife refuge or other site that was the source of the data). The most recent year's data were recorded for points that had been sampled in multiple years. There was no effort to control for survey effort; point counts from different Land Units may vary somewhat in sampling method (point diameter, how many repeat surveys within the year) and surveyor expertise. The **Inventory** is the total number of species recorded among all point counts at a Land Unit, and is correlated with the regional species pool, but also affected by sampling effort (i.e. number of distinct point counts within the Land Unit, number of years of data) and habitat diversity within the Land Unit.

   Each student within a group should select five point-count locations in a transect starting from the Atlantic into the continental interior, using the excel data sheet of point counts extracted from the USGS Patuxent Wildlife Research Center Bird Point Count Database.

Select points from as many different States and Land Units as you can, taking care to span your longitudinal transect. To provide an example, complete data are provided for three points from one Land Unit. ***Answer Question 6 on the worksheet.***

9. Examine each of your group's points using Google Earth (see Appendix 3). Zoom in as far as possible on the point (the closest you can zoom without the image becoming blurry). You can use the Google Earth ruler utility to visualize a 50 m radius around the point. Describe the land cover / land use of the point-count area as best as you can (e.g. forest, field, wetland), and enter in the Student Data Sheet under **Site Description: Local**. Zoom out to an 'eye altitude' of 20 km. Describe the landscape around the point as best as you can (e.g. farmland with small woodlots, extensive forest), and enter in the Student Data Sheet under **Site Description**: **Landscape**. ***Answer Question 7 on the worksheet.***

10. Examine each of your group's points (5 points per group-member) using the 2006 National Land Cover Data. You will analyze land cover around a point at two spatial scales: local and regional. Using the **MRLC Consortium Viewer** (see Appendix 4), input the x (longitude) and y (latitude) coordinates of the first point you selected from the Point Count Database. Look at ***Scale Information*** to the upper left of the land cover map. The local scale should be defined as a zoom by a factor of 3 larger than the smallest scale option on the Scale Information bar (around 1:300). This represents more-or-less the land cover encompassed by a 50 m radius point-count. The landscape scale can be defined as a factor of 11 larger than the smallest scale option on the Scale Information bar (about 1:90,000). By scrolling the cursor across the Scale Information scale bars, you can see what the factor change in scale is for each bar from the one currently selected (in red); for help, see Appendix 4.

    Depending on the purpose of a study, it is often sensible to aggregate ecologically similar land cover classes in the National Land Cover Database. For this exercise, you will quantify the proportion of a selected area around a point that is forest (including land cover classes *Deciduous Forest*, *Evergreen Forest*, *Mixed Forest*, and *Woody Wetland*).

Select a view at the appropriate scale for land cover analysis (*Local* or *Landscape*, as defined above). Take a screen-shot (using a screen grabber utility such as Windows **Snipping Tool,** or for the Mac OS see http://www.wikihow.com/Take-a-Screenshot-in-Mac-OS-X), and calculate the proportional land cover around the point that is forest, using **ImageJ** and **Excel** (see Appendix 5 and Appendix 6). Calculate the proportion forest for each of the two spatial scales for the points, and enter the results in the Student Data Sheet under **Proportional Land Cover Forest**: **Local** and **Proportional Land Cover Forest**: **Regional**. ***Answer Question 8 on the worksheet.***

11. Examine graphically the relationship between species pool, longitude, or forest cover at the local or landscape scale (independent variables, plotted on the x-axis) versus breeding bird local (point count) species richness (dependent variable, plotted on the y-axis). ***Answer Question 9 on the worksheet.***

12. Discuss with your group what can be concluded, and what additional uncertainties remain. Discuss the limitations of the study, in terms of data availability and data quality. Discuss any alternative ways that the same hypotheses could be tested by analyzing the databases in alternative ways. ***Answer Questions 10 - 12 on the worksheet.***

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Worksheet: *Drivers of Avian Local Species Richness: Continental-Scale Gradients, Regional Landscape, or Local Land Cover?*

This worksheet is to be completed as a group. Only one sheet will be submitted per group. Your group will also submit one completed ***Student Data Sheet****. Your group will also make a 7-10 minute oral presentation. The oral report is due* dd/mm/yr*. The written report is due* dd/mm/yr*. You are asked to document each group member's contribution to the project. Each student needs to understand how all parts of the assignment were done, however.*

	Name	*Contribution to Assignment*
Group Member 1	______________________	______________________
Group Member 2	______________________	______________________
Group Member 3	______________________	______________________
Group Member 4	______________________	______________________
Group Member 5	______________________	______________________

1a. At *Patoka River NWR & MA*, what was the standard point count survey methodology: (i) how much time was spend surveying each point, (ii) what were the distance bands for detections at a point, and (iii) how many times was each point surveyed?

1b. At *Patoka River NWR & MA*, (i) how many total points were surveyed, (ii) how many species in total were detected across all points (the *Inventory*), and (iii) how many species were detected at *Point 2*?

2. How do the relative amounts of forest cover versus agriculture and other land use change around the point as you scroll from an elevation of 1 km to an elevation of about 100 km?

3a. How do the images differ between the Google Earth image and the MRLC National Land Cover Database (NLCD) at the smallest scale?

3b. How do the images differ at the largest scale (100 km altitude for Google Earth, around 1:700000 for NLCD)?

4a. Paste in the screen shot.

4b. What proportion of landscape is forest land cover (including land cover classes *Deciduous Forest*, *Evergreen Forest*, *Mixed Forest, and Woody Wetland*) in your image?

5. Provide at least five alternative hypotheses for why species richness varies among points included in an east-west transect of bird point counts, and a valid prediction based on each hypothesis. Have at least one hypothesis at a local land cover scale, one hypothesis at the landscape scale, and one hypothesis at the east-west latitudinal gradient scale. *For each hypothesis, make sure to note which scale it addresses: local, landscape, or continental.*

6a. What is the latitudinal range of your survey (i.e. the latitude of the most northern and southern point-counts)?

6b. What is the longitudinal range of your survey (i.e. the longitude of the most eastern and western point-counts)?

7. How do land cover and landscapes change along your east to west longitudinal transect?

8. How does the proportion of land cover classified as forest change along your east to west longitudinal transect at the local and landscape scale?

9. What factors are good predictors of local bird species richness, as indicated by a point count's species count? To help answer this, plot the relationship between each predictor and species count.

10. What can you conclude about local, landscape, and continental patterns of bird species richness?

11. What uncertainties, if any, remain about your conclusions? Make sure to discuss any concerns about data quality and data availability.

12. What is at least one alternative way that one of your hypotheses could be tested by analyzing the Point Count Database in a different way?

Questions for Further Thought and Discussion:

1. Why does local species richness of birds (and other taxa) generally decline in North America as you move north in latitude, or move from the edge of the continent to the interior, or from low altitude to high altitude?

2. For bird point counts, like many widely-used survey methods, there is a push to develop a standardized methodology (e.g. sample duration and radius of detection) that all researchers and population monitoring programs should use. Why would this methodological standardization be necessary?

3. Why is only a subset of the regional species pool detected at any one location?

4. Why isn't there just one 'best' spatial scale at which to measure land cover and land use?

5. When using archived data from multiple data sources, why do you have to define criteria about what data to include and exclude from your sample?

6. It is well-known that lowland tropical evergreen forests have many more species of birds than temperate deciduous forests or boreal evergreen forests. However, species comparisons are usually of regional species richness, not local (alpha) species richness. How would it be possible for tropical forests to have higher regional species richness than temperate deciduous or boreal forests, yet have similar local species richness? Using published literature, compare local species richness at representative tropical, temperate, and boreal forest locations surveyed in the same manner. A good start is to read Terborgh et al. (1990).

7. How might local bird species richness vary along an urban – rural gradient? Read and discuss one paper where researchers have measured how local bird species richness changes along a gradient of human land uses. A good start is Blair (1996).

References and Links:

Andren, H. 1994. Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. Oikos 71:355-366.

Bibby C.J., N.D. Burgess, D.A. Hill, and S.H. Mustoe. 2000. *Bird Census Techniques*. Academic Press, San Diego CA.

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Tools for Assessment of Student Learning Outcomes:

Each team is evaluated on (1) the oral presentation and (2) the worksheet and accompanying data table. All team members are expected to contribute equal effort to the project. To assure that each member is properly credited for her/his efforts, each member submits directly to the instructor (by email) an evaluation of relative group effort of each of the group members. In a group of 5, each member is expected to provide 20% of the effort. Students must justify each score that is different from the expectation (lower or higher). I calculate the median of the five evaluations, and the presentation and worksheet scores are weighted up or down by the proportional difference between the expected effort and the observed effort (as indicated by the scores).

Oral Presentation:

All class members in the audience and the instructor provide three ratings on the oral presentation: (1) *Clarity & Style*, (2) *Scientific Content*, and (3) *Overall Presentation Quality*. Presentations are rated using following scale of 1 -10: 10 = outstanding, 9 = very good, 8 = good, 7 = fair, 6 = poor, 5 = very poor. The class member scores are averaged. The team score is based 50% on the class average of *Overall Presentation Quality* and 50% the instructor's rating.

Good presentations (1) provide a clear background for the study, (2) present justified alternative hypotheses and their predictions, (3) explain where the data come from and by what criteria they are selected, (4) provide and explain appropriate graphs that show how species richness varies with the investigated factors, (5) make reasonable conclusions about the hypotheses based on the data, (6) discuss remaining uncertainties, and (7) provide a brief summary of what was concluded and what was learned. Presenters show evidence of having practiced the talk, and speak clearly and confidently. Slides have easy-to-read text and appropriate images. Graphs are easily read and accurately labeled. Presenters clearly explain what the text, images, and graphs mean (e.g. explain the axes on the graph), without resorting to reading the text.

Worksheet:
Each of the 12 questions on the worksheet are scored on a scale of 0 - 4, where 4 = outstanding, 3 = good, 2 = fair, 1 = poor, 0 = not done. The data table is scored 2 points per data point, plus 2 points bonus for completing all assigned data points (i.e. 5 points per group member). Thus the maximum score for the worksheet + data sheet = 100 points. Note: *The number of points per data point and bonus are adjusted depending on the group size so that the total maximum score per worksheet and data sheet = 100 points.*

Quiz:
1. We make an accurate count of the number of butterfly species on our college campus: there are 10 species. Other colleges all across North America do the same and all are accurate. The species number among college campuses varies from 2 to 50 species. What are at least three different, plausible hypotheses to account for the variation in species number across North American college campuses?

2. You are asked '*What is the percentage land cover that is cropland in the region of your college campus?*'. How large a radius around your campus do you measure? Justify and explain why your radius is better than a smaller or larger radius.

3. Provide a plausible hypothesis for why local bird species richness (as indicated by a standardized point count) would vary with geographical latitude. Draw a graph showing the relationship between bird species richness and latitude predicted by your hypothesis.

NOTES TO FACULTY

Comments on Challenges to Anticipate and Solve:

1. Poor team coordination, resulting in members collecting data that lack proper spatial dispersion or which are analyzed in inconsistent ways. This results in much within-team frustration, and extra work to correct errors. A solution is to emphasize the importance of team coordination and planning before starting to collect data, and frequent communication among team members about group progress. An ‘intervention’ meeting between the group and the instructor can be helpful in cases of severe group dysfunction. It may be helpful to have a mid-way session with the class to check on progress, assess the students’ comprehension of the exercise’s objectives, and answer questions.

2. Common group meeting times may be difficult for students, especially for students that are not at a residential college. If so, it may be beneficial for the instructor to set up online work space and chat areas using course management software, so that students can collaborate remotely. If students are not accustomed to out-of-class collaborative team projects, the instructor may wish to allocate some time to discuss the importance of group work, and how to collaborate successfully.

3. Access to computer applications on public computers. Students who have personal computers (most students) can download the applications to their computers. At my institution, students could not use university lab computers, because two applications (Google Earth, ImageJ) were not installed, and students did not have the necessary permissions to install them. Instructors should make sure that computer labs have the needed applications installed before the start of the activity.

   Applications that must be installed on computers that students will use include:

   a) Google Earth http://www.google.com/earth/index.html

b) Image J http://rsbweb.nih.gov/ij/index.html
c) Excel (or similar spreadsheet application)
d) A screen grabber utility (e.g. Windows Snipping Tool)

A good practice is to have a 'shortcut' icon for each of these applications on the computer desktop, so students can easily locate them.

In addition, it would make it easier for students if the following web bookmarks were provided, either in the web browser, as a web links section in a course's course management software, or a hyperlinked document:

a) Bird Point Count Database. http://www.pwrc.usgs.gov/point/
b) National Land Cover Database. http://www.mrlc.gov/

4. Understanding how to graph the data. Many of my sophomore students did not understand that a bivariate plot is preferable to other graphical methods of presenting the data in this exercise, nor that bird species richness is the dependent variable and hence should be plotted on the y-axis. A solution (which I have found is only partially successful) is highlighting appropriate graphs in the course text, and presenting such graphs during the initial presentation of the activity.

5. Some teams may need pointers on how to efficiently manipulate data and create tables using Excel or other spreadsheet applications. I encourage groups to see me for a tutorial if the students needed help.

Comments on Introducing the Experiment to Your Students:

This activity coincides with a course unit on community ecology. I make sure that class members read in their course text the appropriate background on local, regional and continental patterns of species richness (in M.C. Molles Jr. (2010) *Ecology - Concepts & Applications* 5th Edition, students review Chapter 16 *Species abundance and diversity* and Chapter 32 *Geographic ecology*). I also give a lecture on causes of distributional patterns of species at different spatial scales. Students will have already learned about global patterns of primary productivity, global and continental-scale climate patterns, and the distribution of the major terrestrial biomes.

I distribute the exercise instructions and direct students to read it before the next class. I start the next class period with a class discussion / brainstorming session about what factors might cause variation in local species richness. I guide the discussion so that local, regional, and continental – scale hypotheses are elicited. I then go through the activity, and demonstrate using each of the data sources. I present a set of figures showing actual patterns of species richness against latitude, altitude, degree of disturbance etc., from the course text and other literature sources (e.g. Gaston 2000). Next, I announce the teams, and have the students briefly meet to coordinate their out-of-class work. For the next two class periods, I provide some time (5 - 10 minutes) for groups to meet, and to ask me questions about the assignment.

Comments on the Data Collection and Analysis Methods:

I have designed this exercise so that it provides a mostly authentic 'real-world' challenge of using archived data. Such challenges include data gaps, differences in methodology, inconsistent metadata, etc., and the challenge of deciding how to take an unbiased sample that is geographically dispersed. In the original implementation of this exercise, I had student groups select their own criteria for data inclusion, and had them create the longitudinal transect and find the point count data themselves. While my students could successfully complete the project, my assessment data and interviews with the students indicated that this step was difficult and frustrating, without sufficient commensurate learning gains. That is why in the current version of the exercise I provide a data sheet that has a menu of preselected points.

I prefer groups of five students, because it generates sufficient data for analysis without overburdening students, and groups of five can generate good discussions and divide presentation tasks well. Smaller groups provide more assurance that all group members are involved in all tasks; sometime large groups organize into task specialists, and members fail to see the big-picture. With too many groups, however, oral presentations become impractical. If an instructor prefers smaller groups than five, for exampling working in pairs or alone, one option is to have all class-members pool the data, then distribute the pooled datasheet to each group (or each student) to analyze independently.

Finally, in high school or introductory non-majors courses, it might be beneficial to simply show an example of the point count data, and then show the digital orthoimagery and National Land Cover Data at different spatial scales, and have students discuss what they can infer about the site and local and regional landscapes, and how land use / land cover at various scales might affect the number of bird species detected in a point count.

There are internet-accessible data archives for other taxa that can be used for a similar activity as the one presented in this document. An excellent data set is the frog and toad call survey data available at the USGS Patuxent Wildlife Research Center's *North American Amphibian Monitoring Program* http://www.pwrc.usgs.gov/naamp/ .

One suggestion to provide a field component to this activity is to have students conduct point counts using the methodology described in the *Bird Point Count Database* and other resources I have listed under *References and Links*. This presumes that students can accurately identify birds by sight and vocalizations. The students could then analyze the land use / land cover around the points, and compare their results to archived point count data from their region.

In the instructions for students, I do not require any statistical hypothesis testing; students simply produce graphs and interpret the patterns visually. This is because the majority of my students have not yet taken a course in statistics. If students are capable of conducting and interpreting statistical hypothesis tests, it would be appropriate to require it for the exercise, at the level of statistical sophistication appropriate for the students' abilities.

Comments on Questions for Further Thought:

1. *Why does local species richness of birds (and other taxa) generally decline in North America as you move north in latitude, or move from the continent to the interior, or from low altitude to high altitude?*

   Model Answer: *Climatic seasonality becomes more extreme as one goes north in latitude, and as a consequence primary productivity and local plant species richness declines. Local species richness of birds is* *positively correlated with primary productivity and local plant species richness. A similar explanation can account for why, in part, local species richness of birds typically declines with altitude in mountains. The decline in species richness from the coast to continent interior is in part due to higher precipitation near the coast of a continent than its interior, and seasonality that is more extreme in the interior than the coast. Thus primary productivity and local plant species richness are typically higher near the coast that the interior of a continent. Another reason that species richness of birds is higher near a continent's coast than interior is habitat diversity; coastal areas have coastal habitat types such as salt marshes that are not present in the interior of continent, but also have habitat types similar to the interior of the continent. Higher regional species richness, caused by greater habitat diversity, increases local species richness.*

I suggest showing a global map of terrestrial net primary productivity, a global map of plant species richness, and a map of the earth's terrestrial biomes. Presuming that students have some understanding of global climate patterns, and how climate affects global vegetation patterns (as reflected in the distribution of the earth's terrestrial biomes and in patterns of net primary productivity), the students should be able to generate some plausible hypotheses for patterns of bird species richness.

2. *For bird point counts, like many widely-used survey methods, there is a push to develop a standardized methodology (e.g. sample duration and radius of detection) that all researchers and population monitoring programs should use. Why would this methodological standardization be necessary?*

   Model Answer: *Standardization is necessary for two reasons. First, presuming that the standard methodology has been properly validated, standardization helps researchers avoid using methods that are faulty, and lets others who access the data have confidence that the data are valid. Second, standardization of methodology makes it much easier to compare the results of different studies- if all studies are done with the same valid methodology, results that differ among studies are likely to be* *due to more interesting factors than differences in the researchers' methods.*

The *Bird Point Count Database* website has a good short explanation about standardization of point count methods (*What is a Point Count?* http://www.pwrc.usgs.gov/point/index.cfm?fa=pointcount.whatIsAPointCount). This webpage also lists some references about point count methodology. Other sources are listed under *References & Links* (i.e. Ralph et al. 1995, Bibby et al. 2000).

Alternatively, one could take students into the field and have them do some standardized point counts. Afterwards, the instructor could lead a discussion with the students about the challenges of doing accurate surveys by point counts using multiple observers at multiple locations, and how standard methods can address some of those challenges.

3. *Why is only a subset of the regional species pool of birds detected at any one location?*

Model Answer: *There are several reasons. First, most bird species are restricted to certain habitat types, e.g. forest interior, marsh, old field. Thus, a point count in a forest interior will detect forest species, but probably not species in the regional species pool that inhabit other habitat types. A second reason is that some species only inhabit large blocks of habitat, or habitat patches that are remote from human disturbance. Some grassland bird species, for example, only inhabit grasslands that are hundreds of hectares in extent, so a hayfield of only a few hectares will not support these species. A third reason is that some species are very wide-ranging and occur at very low density; they have home ranges much larger than the scale of a point count. These birds, for example many raptor species, although present within the landscape may be very unlikely to be detected at a specified point count location.*

Here, it may be helpful to look at a local landscape using *Google Earth* and the *National Land Cover Data Base*, and lead students into thinking about how many bird species are restricted to particular land cover types or land uses (e.g. grasslands, shrubland, coniferous forest, deciduous forest, marsh, urbanized area), and how some species may be restricted to large patches of habitat, and how some species may be sensitive to anthropogenic disturbance, and how some species may be at low density or wide-ranging enough that likelihood of detection at any given point is low, even in the appropriate habitat. Providing a sample 'species pool' for the locality (i.e. a suitable subset of species from the actual local species pool), and then indicating examples of species that are locally restricted in occurrence for each of these reasons should help students understand the multiple reasons why the entire regional species pool will not be detected at any given point.

Again, an alternative field exercise that will help students grasp the answer to this question is to have them perform a set of point counts at different locations within the same habitat category and another set of point counts in a distinctly different habitat category nearby.

4. *Why isn't there just one 'best' spatial scale at which to measure land cover and land use?*

   Model Answer: *A highly local spatial scale characterizes the land cover within the point count zone. A somewhat larger spatial scale will characterize what the land cover / land use is within the greater vicinity of the point count location. The point count circle may be deciduous forest, but that forested point may be embedded within a vast deciduous forest tract, or may be a tiny forest patch in the middle of a corn field. As one moves to a larger landscape scale, the dominant habitat types and the sizes and shapes of habitat patches become evident. At an even larger regional spatial scale, connections between distinct landscape elements become evident. Local species richness is affected by land cover / use at a survey location and the vicinity of that location, but also by the regional species pool of birds, which is in part a function of the landscape and regional land cover/ land use patterns.*

   Select a point location centered on a locality with which students are familiar (e.g. the college campus). Starting at a very local spatial scale, have students describe the land cover / land use based on the *Google Earth* and the *National Land Cover Data Base*. Keep moving out to a progressively more regional scale, and have students describe the land cover / land use. Ask the students to explain why their description changes as the scale changes. Using birds, challenge students to propose what kinds of questions about the distribution and abundance of birds might be most sensibly addressed by quantifying land cover / land use at the very local scale, and what kinds of questions could be most sensibly addressed at a landscape or regional scale.

5. *When using archived data from multiple data sources, why do you have to define criteria about what data to include and exclude from your sample?*

   Model Answer: *Data sources often vary in their methodologies, and some studies have better descriptions of the methodology and sounder methodology than others. To reduce extraneous variation that risks obscuring interesting patterns in the data, it is a good idea to have explicit criteria for what to include or exclude as data sources, so that there is a minimum of variation due to methodology among included studies, and all studies use methods that provide valid data for the hypotheses to be tested. It is also important to have explicit criteria for data source selection, to avoid bias or suspicion of bias that can result from ad hoc exclusion or inclusion of data sources.*

   One way to approach this question is to have students brainstorm the key features of a good manipulative experiment, especially focusing on the importance of replication and standardization of replicates (good experimental control of extraneous factors). Then have students discuss why archived data from multiple data sources may be less standardized, and what they can do with such data to minimize extraneous ‘noise’.

6. *It is well-known that lowland tropical evergreen forests have many more species of birds than temperate deciduous forest or boreal evergreen forests. However, species comparisons are usually of regional species richness, not local (alpha) species richness. How would it be possible for tropical forests to have higher regional species richness than temperate*

deciduous or boreal forests, yet have similar local species richness? Using published literature, compare local species richness at representative tropical, temperate, and boreal forest locations surveyed in the same manner. A good start is to read Terborgh et al. (1990).

Model Answer: *A point location in a tropical forest might have the same local species richness as a temperate or boreal forest, despite much higher regional bird species richness, if tropical birds would have much more specific habitat requirements than temperate or boreal birds – in effect, dividing up lowland tropical evergreen forest into many finer habitat types than bird species in temperate forests partition theirs. A second reason would be if tropical bird species would have very localized distributions, with similar species inhabiting different localities within the same region.*

In fact, local (alpha) species diversity is higher in lowland tropical forest than temperate or boreal forests. However, regional species richness appears to also be increased by finer habitat partitioning among species and more localized distributions of species within a region.

This question echoes and expands upon *Questions for Further Thought* #3. Once students understand the answers to #3, they should be able to come up with reasons why a tropical forest might have no more species at one point location than a temperate deciduous or boreal evergreen forest, even though it has much higher regional species richness.

It should be relatively easy for students to find appropriate studies in the literature to make a comparison of alpha species richness of forest birds based on latitude – the cited references in Terborgh et al. (1990) is a good start for locating appropriate studies, and a search of the many papers that cite Terborgh et al. (1990) (using *Google Scholar* or *Web of Science*) will indicate appropriate recent papers. Alternatively, there are several web-based data archives listed under *Reference and Links* that provide raw data to answer this question.

7. *How might local bird species richness vary along an urban – rural gradient? Read and discuss one paper where researchers have measured how local bird species richness changes along a gradient of human land uses. A good start is Blair (1996).*

   Model Answer: *There is no simple answer to this question – it really depends on regional patterns of urban – rural transitions, which are a function of local ecology, human history, and human sociology and cultural practices. Core urban areas of cities typically have a relatively low number of bird species, many of which are introduced exotic species (e.g. rock dove* Columba livia*). Suburban regions ringing a city or large city parks may have a very high diversity of plants (native and exotic), abundant water, and bird feeders. As a consequence, suburban areas or urban parks may have more bird species than more rural areas, especially in arid regions where suburban areas and parks have much more verdant vegetation than the surrounding region. Beyond the suburbs, the region may be intensively agricultural, or have native land cover. If intensively agricultural, the species richness may be lower than the suburban belt. Native land cover typically becomes more prevalent the greater the distance from the city (presuming there is not another approaching city), and if so the species richness of birds reaches another peak once native land cover becomes more prevalent than intensive agriculture.*

   It may be helpful to select a city with which students are familiar. Starting at the city center, have students describe the land cover / land use based on the *Google Earth* and the *National Land Cover Data Base*. Keep moving in a linear transect out from the city center through the suburbs and out into the agricultural and native land cover landscapes beyond the outer suburbs. Students should be able to make some valid inferences about how bird communities change and why, including how species richness might change based on the amount and distribution of different types of habitat used by birds.

   It should be relatively easy for students to find appropriate studies in the literature to make a comparison of alpha species richness of birds changes along a gradient of human land uses – the cited references in

Blair (1996) is a good start for locating appropriate studies, and a search of the many papers that cite Blair (1996) (using *Google Scholar* or *Web of Science*) will indicate appropriate recent papers.

Comments on the Assessment of Student Learning Outcomes:

Using my grading scale for oral presentations, there is usually a very good agreement between the class evaluation average of each oral presentation and my evaluation. Students write comments justifying their evaluations, and I distribute these (anonymous) comments along with my own comments to each group. After all oral presentations, I take class time to discuss with students the general strengths and weaknesses, in terms of scientific content and clarity.

My method of evaluating individual effort within groups works well, and I find that students appreciate it. Because I calculate medians of the five ratings, the score is unaffected by outlier judgments. There is usually good agreement among group members in relative allocation of effort, except for an occasional outlier that is submitted by a free-rider: the free-rider will rate his/her effort as equal to others, whereas the other group members will consistently rate the student's effort as low.

Grading of the worksheets is straight-forward, and the worksheets provide a good document (along with the oral presentations) to gage whether students adequately understand the activity's concepts.

Comments on Formative Evaluation of this Experiment:

I provided a short pretest and posttest to students, coded with an individually unique identifier that made the respondent's identity anonymous to me (for the posttest, see Appendix 6; protocol approved under Clarkson IRB certificate of exemption 11-03 E). The pretest was administered immediately before the exercise was distributed to the students, and the posttest was administered immediately after the last oral presentation and all worksheets had been turned in. A similar instrument is currently being used by colleagues at other institutions who are attempting to adapt this exercise to their classes, and will be used by me in the future to assess the effectiveness of modifications of the exercise.

Students were asked to provide short essay responses to two content questions that were derived from the objectives of the exercise:

> (1) *We make an accurate count of the number of butterfly species on our college campus: there are 10 species. Other colleges all across North America do the same and all are accurate. The species number among college campuses varies from 2 to 50 species. What are at least three different, plausible hypotheses to account for the variation in species number across North American college campuses?*
>
> (2) *You are asked what the percentage land use and land cover in the region of you college campus is cropland. How large a radius around your campus do you measure? Justify and explain why your radius is better than a smaller or larger radius?*

The two questions were designed to evaluate students' understanding of the concepts that are the focus of the three objectives of the exercise, without asking questions that were directly extracted from the exercise itself. I chose to use short essay questions because this format more likely to provide a student's reasons for a particular response than would be a multiple-choice format question. Question 1 is intended to address Objective 1 (*Understand how local patterns of species richness can be the function of local, regional, and continental-scale processes*) and Objective 2 (*Understand how anthropogenic changes in land cover and land use can alter natural gradients of species richness*). Question 2 is intended to address Objective 3 (*Learn how measures of land use and land cover patterns vary depending on the spatial scale of the analysis*).

The two questions were scored based on the number of distinct logical hypotheses (Question 1) or justifications (Question 2) and the sophistication of each. Questions were scored (by me) blind as to the subject identifier and the time of administration (pretest or posttest). A spot check showed that the scores were repeatable. There was a significant improvement in the item scores for both Question 1 (paired t-test: $t = 2.7$, one tailed $p = 0.006$, $n = 24$ subjects) and Question 2 ($t = 3.7$, $p = 0.0006$), so the exercise did seem to be effective at improving students' understanding of the concepts stated in the three stated objectives.

For the posttest, I also administered seven questions that were intended to evaluate students' perceptions about the activity. Each item's response was a 5-level Likert scale of subject agreement about a statement, where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4= agree, and 5 = strongly agree. I received data from 24 students.

Note that the implementation of the activity was somewhat different than the one presented in this TIEE paper. The main difference was that student-groups were required to select and aggregate point-count data directly from the Point Count Database, rather than being provided a worksheet with a menu of pre-selected points, as is the case in the present implementation.

1. *I learned ecological concepts by doing this exercise*: median response = 4, range: 3-5.
2. *I improved my research skills by doing this exercise*: median response = 4, range: 2-5.
3. *I improved my skills at locating and acquiring data from the internet*: median response = 4, range: 2-5.
4. *I improved my skills at communicating my research by doing this exercise*: median response = 4, range: 3-5.
5. *This exercise was complicated and difficult to understand*: median response = 4, range: 2-5.
6. *This exercise required a lot of time and effort to complete*: median response = 4, range: 3-5.
7. *This exercise was fun*: median response = 3, range: 1-5.

These results indicate that students generally perceived the exercise as an effective learning tool, but found it to be complicated, difficult, a lot of work and not fun.

Along with the Likert-scale questions on student attitudes about the activity, I also included two narrative-response questions (*Overall, what is your evaluation of this exercise as a tool to learn ecology? What would you change, if anything,*

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about this exercise to make it a better tool to learn ecology?). Themes to the responses included that students needed more time (I only had provided one week for the assignment, whereas at least two weeks would be more reasonable), that the exercise was interesting but difficult and time consuming, and that students learned a lot about geographic patterns of land cover and land use. Students found the exercise difficult at first, but became easier once they learned how to manipulate the data. Students expressed frustration at finding appropriate point count data in the *Bird Point Count Database*. Members of at least one group expressed frustration caused by their own lack of coordination and planning, which obligated them to redo the exercise after making avoidable fundamental errors.

Based on this formative evaluation, my observation of the students' performance, and their comments to me, I streamlined the exercise to make it easier to select point count locations (i.e. the worksheet of preselected points). The exercise presented in this publication is the streamlined version that is intended to reduce many of the frustrations my students had during the first run-through.

Comments on Translating the Activity to Other Institutional Scales or Locations:

In principle, this activity is transferable to any institution, since the data is accessible anywhere there is access to the internet. Moreover, the region of focus is flexible (because the data are continental in scope), thus instructors can tailor the exercise to regions that are most familiar and of most inherent interest to their students.

For institutions with larger classes, oral presentations may not be practical. With large classes, it may be necessary to have teams simply fill in the worksheet, or better, have teams group up with other teams to explain and discuss what each team did and what each learned.

STUDENT COLLECTED DATA FROM THIS EXPERIMENT

I have included three examples of final student-group presentations. Note that these students-groups were tasked to delineate their own criteria for point selection in this implementation of the *Drivers of Avian Local Species Richness* exercise, rather than having a set of points provided by the instructor.

Example Presentation 1
Example Presentation 2
Example Presentation 3

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