Graham Sandersfeld
GEOG:3050 Geospatial Programming
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Dr. Caglar Koylu

Deriving a City-Scale Index of Biodiversity Potential for Urban Parks Using Biogeography Patch Matrix Corridor Models

Based on key principles and theories of biogeography and landscape ecology, we can develop a method of classifying urban green spaces based on their land cover, geometry, connectedness, and the urban intensity of areas between parks. This method could allow planners to visualize and compare how biodiversity potential varies within a city (i.e., urban core versus suburban versus fringe areas, or ranking census block groups by biodiversity potential). A city-wide index of biodiversity potential with a standardized choropleth scheme for visualization can also be produced to compare biodiversity potential across study regions.

Urban parks can be extremely diverse and may even function as novel ecosystems with unique biotic and abiotic compositions. Quantifying the habitat provision of urban green spaces requires a perspective that incorporates factors affecting wildlife immigration and extinction. If we apply the theory of island biogeography to urban green space, species diversity should be highest in large parks located near other parks, and lowest in small parks that are isolated from similar "islands." Indeed, studies such as Aronson et al. (2014) and Beninde et al. (2015) have established this effect of park size on species diversity.

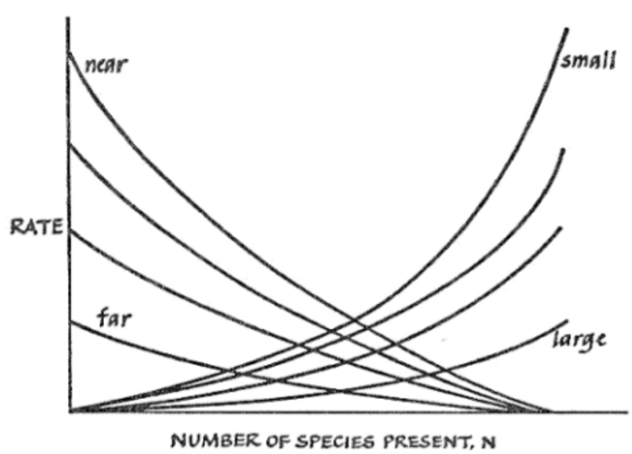

Figure 1. The equilibrium model represents how species diversity changes in response to isolation and island size (Yui and Lei 2001)

In addition to the equilibrium theory of island biogeography, this index will incorporate the patch-corridor-matrix model of landscape ecology. This model defines suitable habitat areas for a given species as “patches,” while corridors or contiguous strips of habitat and the surrounding matrix (unsuitable habitat) determine the species movement potential. Patches vary in quality and this model could take traits of urban parks beyond size and isolation such as land cover, soil type, and elevation.

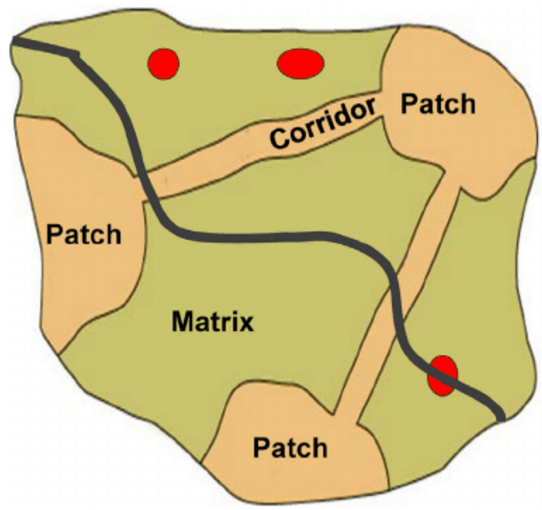

Figure 2. The patch-matrix-corridor model as a representation of landscape structure (Lausch et al. 2015)

Objectives and Questions

The model will be taxa-specific, meaning the user must enter key constraints like search radii and classify what traits differentiate a patch from the matrix for an animal type (for example, roads and the built environment are greater barriers for large mammals than for birds). The goal is to visualize and quantify which urban green spaces for the given study area offer the most biodiversity potential based on landscape factors, which can be used to inform planning decisions about where to invest conservation funds or where new green space locations could be the most useful.

An example question this model can be used to answer and which will be tested directly in the final report:

- Which of two cities offers public green spaces with the most potential for biodiversity based on landscape factors?

This question will be tested on Cedar Rapids, IA, and Des Moines, IA. The null hypothesis:

- Parks in each region offer the same amount of biodiversity potential based on the model.

Data

Land cover types will be taken from the Multi-Resolution Land Characteristics (MRLC) Consortium's National Land Cover Database (NLCD) 2016.[1] The green space data used as input for this model is a shapefile of public lands used for conservation and recreation in Iowa, managed by the Iowa DNR and last updated in 2021.[2] This file contains over 5,000 lands with descriptive fields about owners, managers, and allowed activities with potential implications for planning and following up based on the findings of this model.

Current Layer: public_lands_conservationt

Visible	Read Only	Field Name	Alias	Data Type	Allow NULL	Highlight	Number Format
✓	✓	FID	FID	Object ID			Numeric
✓		Shape	Shape	Geometry			
✓		OBJECTID_1	OBJECTID_1	Long			Numeric
✓		OBJECTID	OBJECTID	Long			Numeric
✓		NAME	NAME	Text			
✓		UNIT	UNIT	Text			
✓		NameUnit	NameUnit	Text			
✓		OWNER	OWNER	Text			
✓		MANAGER	MANAGER	Text			
✓		TYPE	TYPE	Text			
✓		C_R	C_R	Text			
✓		ACCESS	ACCESS	Text			
✓		PUB_HUNT	PUB_HUNT	Text			
✓		ease_hold	ease_hold	Text			
✓		ease_typ	ease_typ	Text			
✓		SOURCE	SOURCE	Text			
✓		DIGSOURC	DIGSOURC	Text			
✓		COUNTY	COUNTY	Text			
✓		ACRES	ACRES	Double			Numeric
✓		GAP_OWNCOD	GAP_OWNCOD	Long			Numeric
✓		GAP_MANCOD	GAP_MANCOD	Long			Numeric
✓		GAP_EASE1	GAP_EASE1	Long			Numeric
✓		GAP_STATUS	GAP_STATUS	Long			Numeric
✓		WLIFE_ID	WLIFE_ID	Long			Numeric

Figure 3. Partial ArcGIS Pro fields view of the Iowa DNR's public lands and conservation areas database.

[1] https://www.mrlc.gov/data/nlcd-2016-land-cover-conus
[2] https://geodata.iowa.gov/datasets/iowadnr::public-lands-used-for-conservation-and-recreation-in-iowa

Proposed Workflow Model

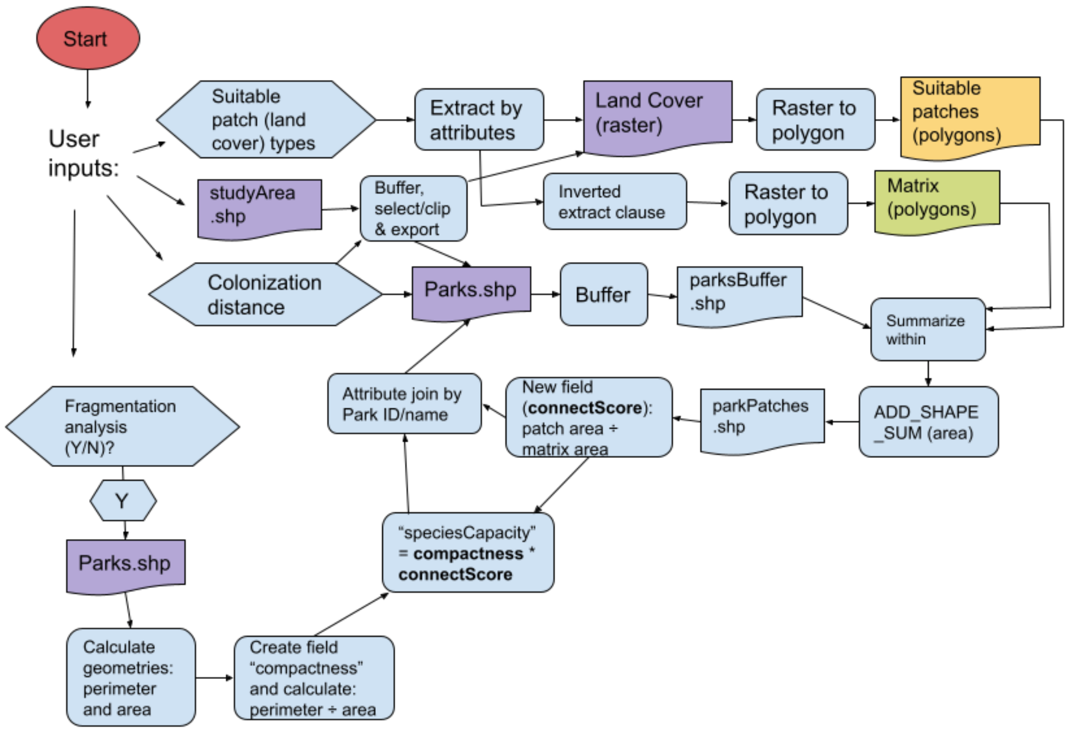

Figure 4. Outline of proposed model to quantify a biodiversity potential index based on landscape factors using a GIS.

Results

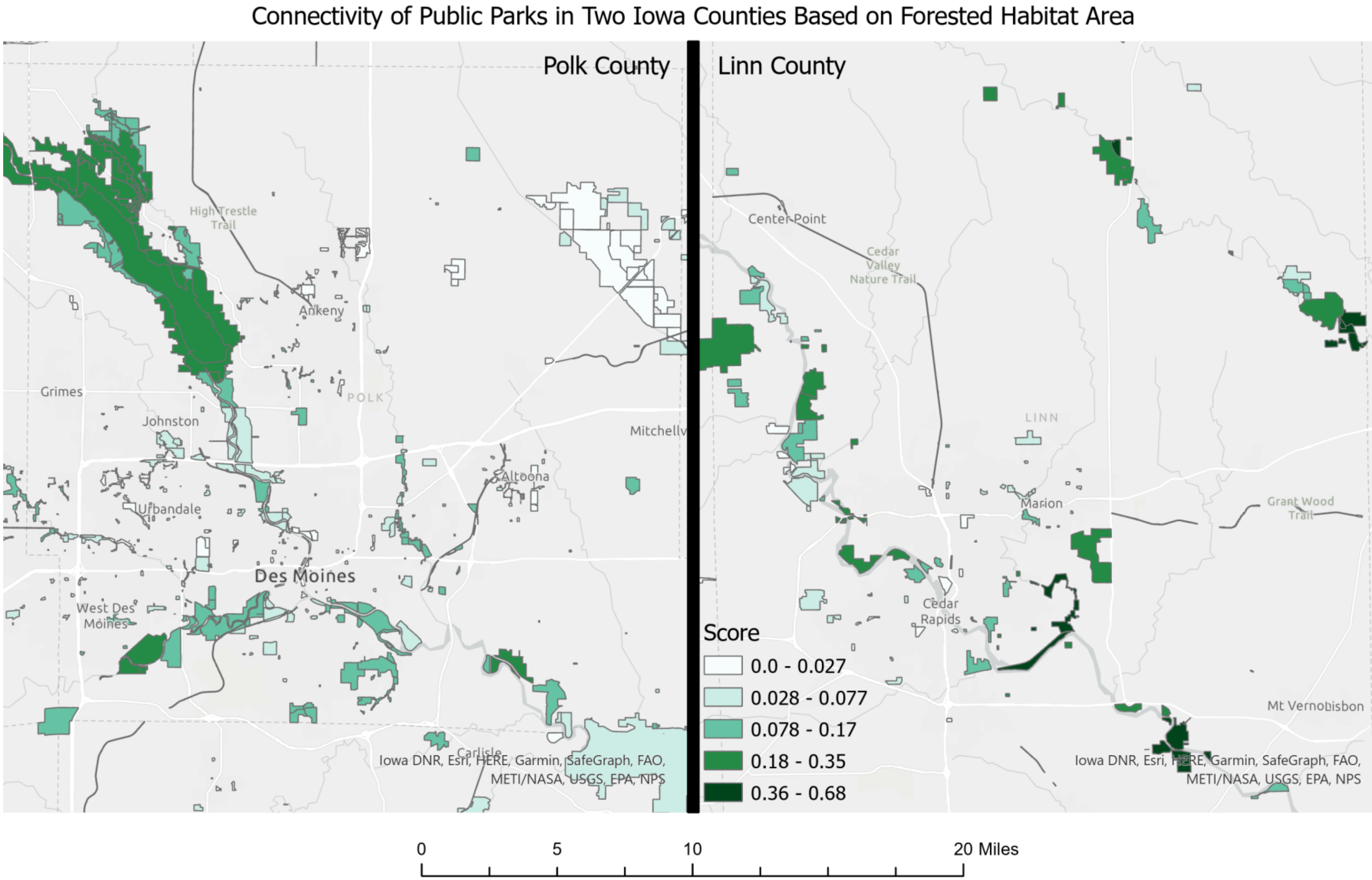

Figure 5. Example products of the biodiversity/connectivity model in ArcGIS Pro 2.8. “Score” indicates the area of deciduous, coniferous, or mixed forest within a 1-mile buffer around each park, divided by the total area of that buffer. Higher is better.

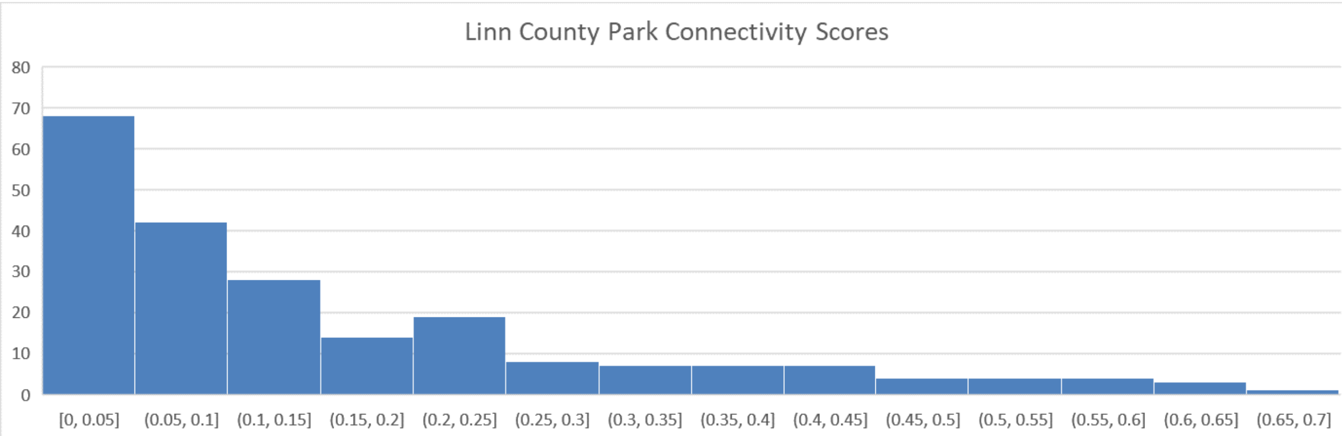

Figure 6. Distribution of “connectScore” of Linn County parks based on forest cover (mean = 0.0679).

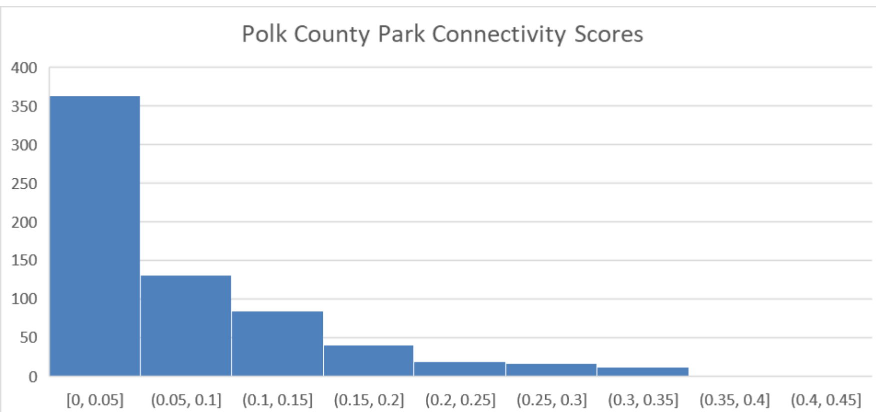

Figure 7. Distribution of “connectScore” of Polk County parks based on forest cover (mean = 0.157).

Discussion and Conclusion

<u>User input section of script with analysis parameters</u>

```
# Choose your study area boundary shapefile:
studyArea = "PolkBoundary"

# Choose your Parks shapefile:
parksFC = "public_lands_conservationt"

# The field in Parks to be used for joining results and exporting final layer of the model (MUST CONTAIN UNIQUE VALUES FOR EACH ROW):
joinfield = "OBJECTID_12”
```

<u>Comments</u>

OBJECTIDs are usually not appropriate to be used as join fields. However, in this example the script is joining a duplicate layer to the original. The OBJECT_12 field thus remains the same and no other fields were usable as unique identifiers for each row.

```
# Choose how far outside of your bounding
study area to search for parks and land
cover:
studyAreaBuffer = "4 Miles"

# Choose the buffer length to use around
parks (species colonization distance):
parksBuffer = "1 Miles"

# Land cover raster:
lcRaster = "nlcd2016_ia"

# Choose suitable land cover types as
habitat with an SQL statement. Select
multiple using OR, AND, NOT, etc.
# Ex: "NLCD_Land = 'Deciduous Forest' OR
NLCD_Land = 'Mixed Forest'"
lcExtractArg = "NLCD_LAND = 'Deciduous
Forest' Or NLCD_LAND = 'Evergreen Forest'
Or NLCD_LAND = 'Mixed Forest'"
### All Land Cover types:
# "Open Water"
# "Developed, Open Space"
# "Developed, Low Intensity"
# "Developed, Medium Intensity"
# "Developed, High Intensity"
# "Barren Land"
# "Deciduous Forest"
# "Evergreen Forest"
# "Mixed Forest"
# "Shrub/Scrub"
# "Herbaceuous"
# "Hay/Pasture"
# "Cultivated Crops"
# "Woody Wetlands"
# "Emergent Herbaceuous Wetlands"
###
```

Note the alternative spelling of "herbaceous" is used in this land cover dataset.

This model provides a simple and quick way of calculating and visualizing the connectivity of parks (or any other shapefile feature class) based on land cover classes. The compactness analysis element of the script from the original workflow was scrapped because the perimeter to area relationship would have given very small parks with few vertices a disproportionate weight in the final "speciesCapacity" score. The model is highly customizable and subject to user knowledge about the study area(s). Thus, inputs in the model should be supported by evidence and scrutinized. In the example comparison between Polk and Linn County, IA, we used arbitrary search distances and the results are not an absolute indicator of forested habitat connectivity. The results are still shown as histograms (Figs. 6-7) to display the differences in their connectScore attribute. A simple two-sided, two-sample t-test suggests that the two means are unequal ($p < 0.001$), supporting a rejection of the null hypothesis that the two counties offer parks with similar habitat connectivity.

The model is essentially an automated proximity analysis designed with habitat connectivity in mind but not necessarily limited to those use cases if the data types align with the example. Depending on the input layers and parameters used, this model could also be used for purposes beyond wildlife and habitat analysis. For example, using an IR or fine-scale temperature raster layer as the “land cover” and houses as “parks,” one could study urban heat vulnerability and combine the results with census data to analyze vulnerability factors.

The full script can be found at github.com/geog3050/gsandersfeld/blob/main/final%20project/finalproject_script.py

References

Aronson MFJ, et al. 2014. A global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers. Proceedings of Royal Society B 281 (art. 20133330).

Beninde J, Veith M, Hochkirch A. 2015. Biodiversity in cities needs space: A meta-analysis of factors determining intra-urban biodiversity variation. Ecology Letters 18: 581–592.

Yui and Lei 2001. Equilibrium Theory of Island Biogeography: A Review. USDA Forest Service Proceedings RMRS-P-21: 163-171.

Lausch, Angela & Blaschke, Thomas & Haase, Dagmar & Herzog, Felix & Syrbe, Ralf-Uwe & Tischendorf, Lutz & Walz, Ulrich. (2015). Understanding and quantifying landscape structure – A review on relevant process characteristics, data models and landscape metrics. Ecological Modelling. 295. 31–41. 10.1016/j.ecolmodel.2014.08.018.