Investigating feedbacks between behavioural strategies and landscape charactersistics: An Introduction

Pratik Gupte and Christoph Netz

8th May, 2020

1 Introduction

This wiki/document is a primer on how to approach this project. The online wiki: **https://github.com/pratikunterwegs/klepto_spatial/wiki** has the same information as the pdf.

2 Contact

2.1 Who

There are two supervisors, Pratik and Christoph, but this project was born of Pratik's old and failing mind. Contact Pratik for immediate issues with R, Python, git/Github, and/or Peregrine, but get in touch with either/both of us for conceptual issues.

2.2 How

You can contact us by email for now, until we set up a Slack or similar. If you have a preference let us know.

Name	Email
Pratik	p.r.gupte@rug.nl
Christoph	c.f.g.netz@rug.nl

NB: We also have `@student.rug.nl` addresses in the system which we don't use. If you email these addresses, we're never going to know.

2.3 When and why

In general, feel free to contact us when you think it's necessary. We'll get a system set up for contact hours etc. in discussion with you. Below, you can see when we're busy with other meetings.

NB: These are difficult times, and we get that. Feel free to contact us if you have an external issue that may impact your participation in the course. You needn't give details, but let us know.

Name	Usually unavailable
Pratik	Mondays 11:00 – 12:00
—	Wednesdays 10:30 – 12:00

Name	Usually unavailable
—	Fridays 10:00 – 12:00
—	All days 18:00 – 20:00
Christoph	Wednesdays 10:30 – 12:00

3 Project Description

Just in case you'd forgotten what you signed up for.

The availability of resources determines the movement and behaviour of individuals on resource landscapes. Simultaneously, individuals deplete resources and thus change the resource landscape they inhabit. The feedback between individuals and resources can have important eco-evolutionary implications, as individuals adapt their behavioural strategies to the resource landscape. This change can itself modify the resource landscape such that it favours a very different behavioural strategy.

Such eco-evolutionary dynamics are difficult to investigate, particularly if there are qualitatively different types of behaviour among individuals. In the Kleptomove simulation model, we have considered two such behaviours: searching for food, or stealing food from other individuals who have already found a food item ('kleptoparasitism'). The model implements the evolution of the two strategies and the implications for the resource landscape. Though kleptoparasitism always evolves and establishes itself as a common strategy, visual inspection of the simulation results suggests that this only occurs at specifc locations in the resource landscape.

This project will study the correlation between each strategy and the spatial characteristics of the resource landscape, and examine the consequences of the evolution of kleptoparasitism on the resource landscape. The student will use Kleptomove output to identify global 'tipping points' in the behavioural strategy, quantify local indicators of spatial association in the landscape at distinct time-points before, during, and following the establishment of kleptoparasitism in the population, and quantify the global change in LISA classes.

4 Worflow

Work should ideally follow this sequence over the next few weeks. Get in touch to discuss changes and so on.

1. Get organised
    - Set up communication channels
2. Reading literature: Consult the *Literature* page from the sidebar.
    - Install Zotero
    - Access the online library
    - Go through the papers
3. Learning tools
    - R, RStudio, and RProjects
    - Python and PyCharm
    - git and Github
4. Getting data
    - Access data from iRODS
5. Outline methods for your project
    - Identify which tools you need
    - Intensive learning session if needed

6. Mid-project presentation (8th June)
    - Convert section (5) into a presentation
7. Final presentation and poster (22nd June)
    - Prepare poster sections text and figures
    - Prepare presentation

5 Literature

It's important to know what you're dealing with, and reading previous findings is a good place to begin. Take a week to read the literature.

A literature collection is being assembled in a Zotero group library: **https://www.zotero.org/groups/2499059/course-2020-comm-ecol**. You'll need to register on Zotero and request access. Contact us if this gets confusing.

Zotero **link: https://www.zotero.org/** is a reference management program for the storage and citation of academic papers. Download Zotero, the connector for your browser, and optionally the plugin for your word processor. Create an account and sync the group library for access to the references and pdfs.

How to approach the literature list

1. Begin by reading papers that give a broad overview of the fields of spatial ecology (Levin 1992), animal movement (Nathan et al. 2008) and the links between movement and large-scale processes such as community assembly (Jeltsch et al. 2013; Schlägel et al. 2020).

   Consider a specific example from a simulation study of how individual movement behaviour can lead to large scale patterns in the spread of rabies (Jeltsch et al. 1997).

2. Move on to reading about the evolution of individual behavioural strategies (Wolf and Weissing 2010; Wolf and McNamara 2012), and the consequences of variation in strategies for ecology and evolution (Wolf and Weissing 2012).

   Read about the North American bluebird system in Duckworth and Badyaev (2007) as an illustration of these concepts.

3. The data you'll analyse comes from *Kleptomove*, a spatially explicit individual based simulation model (IBM); read what IBMs are and why they were developed (Huston, DeAngelis, and Post 1988; DeAngelis and Mooij 2005).

   Return to this document to read more about *Kleptomove* in the section below.

   Continue to explore how IBMs are used to study processes at both the landscape scale (such as spatial patterning; Grimm et al. 2005) and the individual level (such as animal movement; DeAngelis and Diaz 2019).

4. In *Kleptomove* the strategy of stealing food from other individuals, or kleptoparasitism, abruptly takes over the population until a large proportion of individuals attempt to steal from others.

   Such abrupt shifts in a system are called *critical transitions* (Scheffer et al. 2001), and the state of a system at which these shifts occur is called a *tipping point*(van Nes et al. 2016).

   Critical transitions occur in many different systems: from landscapes (Hirota et al. 2011) to animal groups (Tunstrøm et al. 2013). Read these papers about critical transitions to understand more.

5. Critical transitions are often referred to as 'catastrophic', and there is wide ranging interest in detecting them before they happen. The spatial characteristics of landscapes can hold clues to impending critical transitions.

   Read Guttal and Jayaprakash (2009) and Dakos et al. (2010) to see how spatial correlation (how similar are two points on the landscape) can indicate a critical transition.

6. You'll be doing spatial autocorrelation analysis at two scales: global, i.e., referring to the full extent of the Kleptomove landscape, and local, i.e., relating to smaller areas within the landscape.

   Read about global spatial autocorrelation (Sokal and Oden 1978a, 1978b), and then local spatial autocorrelation (Sokal, Oden, and Thomson 1998a, 1998b). Read (Anselin 1995) to look at a specific measure of local spatial autocorrelation called *Moran I local*.

5.1 Literature list

[**1**] Anselin, Luc. 1995. "Local Indicators of Spatial Association—LISA." *Geographical Analysis* 27 (2): 93–115. https://doi.org/10.1111/j.1538-4632.1995.tb00338.x.

[**2**] Dakos, Vasilis, Egbert H. van Nes, Raúl Donangelo, Hugo Fort, and Marten Scheffer. 2010. "Spatial Correlation as Leading Indicator of Catastrophic Shifts." *Theoretical Ecology* 3 (3): 163–74. https://doi.org/10.1007/s12080-009-0060-6.

[**3**] DeAngelis, Donald L., and Stephanie G. Diaz. 2019. "Decision-Making in Agent-Based Modeling: A Current Review and Future Prospectus." *Frontiers in Ecology and Evolution* 6. https://doi.org/10.3389/fevo.2018.00237.

[**4**] DeAngelis, Donald L., and Wolf M. Mooij. 2005. "Individual-Based Modeling of Ecological and Evolutionary Processes." *Annual Review of Ecology, Evolution, and Systematics* 36 (1): 147–68. https://doi.org/10.1146/annurev.ecolsys.36.102003.152644.

[**5**] Duckworth, Renée A, and Alexander V Badyaev. 2007. "Coupling of Dispersal and Aggression Facilitates the Rapid Range Expansion of a Passerine Bird." *Proceedings of the National Academy of Sciences of the United States of America* 104 (38): 15017–22. https://doi.org/10.1073/pnas.0706174104.

[**6**] Grimm, Volker, Eloy Revilla, Uta Berger, Florian Jeltsch, Wolf M. Mooij, Steven F. Railsback, Hans-Hermann Thulke, Jacob Weiner, Thorsten Wiegand, and Donald L. DeAngelis. 2005. "Pattern-Oriented Modeling of Agent-Based Complex Systems: Lessons from Ecology." *Science* 310 (5750): 987–91. https://doi.org/10.1126/SCIENCE.1116681.

[**7**] Guttal, Vishwesha, and C. Jayaprakash. 2009. "Spatial Variance and Spatial Skewness: Leading Indicators of Regime Shifts in Spatial Ecological Systems." *Theoretical Ecology* 2 (1): 3–12. https://doi.org/10.1007/s12080-008-0033-1.

[**8**] Hirota, Marina, Milena Holmgren, Egbert H. Van Nes, and Marten Scheffer. 2011. "Global Resilience of Tropical Forest and Savanna to Critical Transitions." *Science* 334 (6053): 232–35. https://doi.org/10.1126/science.1210657.

[**9**] Huston, Michael, Donald DeAngelis, and Wilfred Post. 1988. "New Computer Models Unify Ecological TheoryComputer Simulations Show That Many Ecological Patterns Can Be Explained by Interactions Among Individual Organisms." *BioScience* 38 (10): 682–91. https://doi.org/10.2307/1310870.

[**10**] Jeltsch, Florian, Dries Bonte, Guy Pe'er, Björn Reineking, Peter Leimgruber, Niko Balkenhol, Boris Schröder, et al. 2013. "Integrating Movement Ecology with Biodiversity Research - Exploring

New Avenues to Address Spatiotemporal Biodiversity Dynamics." *Movement Ecology* 1 (1): 6–6. https://doi.org/10.1186/2051-3933-1-6.

[**11**] Jeltsch, Florian, Müller M. S., Grimm V., Wissel C., and Brandl R. 1997. "Pattern Formation Triggered by Rare Events: Lessons from the Spread of Rabies." *Proceedings of the Royal Society of London. Series B: Biological Sciences* 264 (1381): 495–503. https://doi.org/10.1098/rspb.1997.0071.

[**12**] Levin, Simon A. 1992. "The Problem of Pattern and Scale in Ecology: The Robert H. MacArthur Award Lecture." *Ecology* 73 (6): 1943–67. https://doi.org/10.2307/1941447.

[**13**] Nathan, Ran, Wayne M. Getz, Eloy Revilla, Marcel Holyoak, Ronen Kadmon, David Saltz, and Peter E. Smouse. 2008. "A Movement Ecology Paradigm for Unifying Organismal Movement Research." *Proceedings of the National Academy of Sciences* 105 (49): 19052–9. https://doi.org/10.1073/pnas.0800375105.

[**14**] Nes, Egbert H. van, Babak M. S. Arani, Arie Staal, Bregje van der Bolt, Bernardo M. Flores, Sebastian Bathiany, and Marten Scheffer. 2016. "What Do You Mean, 'Tipping Point'?" *Trends in Ecology & Evolution* 31 (12): 902–4. https://doi.org/10.1016/j.tree.2016.09.011.

[**15**] Scheffer, Marten, Steve Carpenter, Jonathan A. Foley, Carl Folke, and Brian Walker. 2001. "Catastrophic Shifts in Ecosystems." *Nature* 413 (6856, 6856): 591–96. https://doi.org/10.1038/35098000.

[**16**] Schlägel, Ulrike E., Volker Grimm, Niels Blaum, Pierluigi Colangeli, Melanie Dammhahn, Jana A. Eccard, Sebastian L. Hausmann, et al. 2020. "Movement-Mediated Community Assembly and Coexistence." *Biological Reviews*. https://doi.org/10.1111/brv.12600.

[**17**] Sokal, Robert R., and Neal L. Oden. 1978a. "Spatial Autocorrelation in Biology: 1. Methodology." *Biological Journal of the Linnean Society* 10 (2): 199–228. https://doi.org/10.1111/j.1095-8312.1978.tb00013.x.

[**18**] ———. 1978b. "Spatial Autocorrelation in Biology: 2. Some Biological Implications and Four Applications of Evolutionary and Ecological Interest." *Biological Journal of the Linnean Society* 10 (2): 229–49. https://doi.org/10.1111/j.1095-8312.1978.tb00014.x.

[**19**] Sokal, Robert R., Neal L. Oden, and Barbara A. Thomson. 1998a. "Local Spatial Autocorrelation in a Biological Model." *Geographical Analysis* 30 (4): 331–54. https://doi.org/10.1111/j.1538-4632.1998.tb00406.x.

[**20**] ———. 1998b. "Local Spatial Autocorrelation in Biological Variables." *Biological Journal of the Linnean Society* 65 (1): 41–62. https://doi.org/10.1111/j.1095-8312.1998.tb00350.x.

[**21**] Tunstrøm, Kolbjørn, Yael Katz, Christos C Ioannou, Cristián Huepe, Matthew J Lutz, and Iain D Couzin. 2013. "Collective States, Multistability and Transitional Behavior in Schooling Fish." *PLoS Comput Biol* 9 (2): e1002915–e1002915.

[**22**] Wolf, Max, and John M. McNamara. 2012. "On the Evolution of Personalities via Frequency-Dependent Selection." *The American Naturalist* 179 (6): 679–92. https://doi.org/10.1086/665656.

[**23**] Wolf, Max, and Franz J. Weissing. 2010. "An Explanatory Framework for Adaptive Personality Differences." *Philosophical Transactions of the Royal Society B: Biological Sciences* 365 (1560): 3959–68. https://doi.org/10.1098/rstb.2010.0215.

[**24**] ———. 2012. "Animal Personalities: Consequences for Ecology and Evolution." *Trends in Ecology & Evolution* 27 (8): 452–61. https://doi.org/10.1016/j.tree.2012.05.001.