Course title: Ecological networks: theory, analysis and applications

University: University of Buenos Aires, Argentina

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Language of instruction: English

Audience: students from outside ISA are allowed in the room

Contact hours: 45

Course's website: http://www.agro.uba.ar/users/mdevoto/ENcourse.htm

General course description

Ever since Darwin contemplated the interdependence of the species in his 'entangled bank', ecologists have been fascinated by the bewildering complexity of ecological interactions between species. In recent years, the study of ecological interactions as complex networks (e.g. food webs, pollination webs, seed-dispersal webs, host-parasitoid webs) has grown to become a vibrant field of research in ecology, and there is mounting evidence that the network approach can prove useful at tackling specific applied problems in biodiversity management.

The study of ecological networks involves the collaboration of researchers from many different disciplines, such as computer science, physics, biology, mathematics, engineering, and sociology. This transdisciplinary approach has revealed some of the fascinating components of the so-called "architecture of biodiversity", which supports biodiversity and functionality of natural communities and has had a central role in the evolution of terrestrial biodiversity.

Objectives

The overall goals of this course are to provide students with a broad conceptual understanding of ecological networks and to present them with a powerful analytical toolkit that will allow them to tackle their own questions, both theoretical and applied, in the future.

The specific objectives are for students to:

- Gain broad understanding of the conceptual description of ecological networks;
- Think creatively about the types of research questions that can be tackled using a network approach;
- Gain a basic understanding of how to use and interpret the results of different analytical techniques using R;
- Develop problemsolving skills in an interdisciplinary team environment;
- Engage in active, project-based learning in preparation for professional life; and
- Refine their written and oral communication skills.

Course organization and contents

The course will consist of the following:

1. Brief lectures on relevant theoretical concepts and applied real-world examples of network analysis.
2. Reading and discussion of selected scientific articles.
3. Computer practicals where students will learn to apply various methods to real-world data to describe networks and solve practical problems. The aim of this is to give students the tools relevant to their own research and interests. Most of the practicals will be run in R, a computing language which is increasingly becoming the tool of choice for researchers from various fields of ecology. Previous experience in R is not a strict requirement as the first practicals will include a short introductory course in R.

Theoretical contents include: ecological and evolutionary aspects of networks, methods for gathering data to build a network, methods for the study of structural properties of a network, mechanisms behind network structure, spatial and temporal dynamics of networks, and network modelling.

Applied contents include the use of ecological networks in the context of biological invasions, grazing management, pest control, conservation of rare species, habitat fragmentation, habitat management, changes in land use, global warming, and restoration of ecosystem services.

Course pre-requisites

Some background in ecology, biology, and/or statistics is recommended.

Required readings

The most relevant readings for the course are listed below. Many are available online or PDFs are available through the course instructor.This list is not exhaustive, though, so a complete list of readings together with a detailed calendar of the course will be available on the course's website a month in advance of the start date.

Bascompte, J. & Jordano, P. (2007) Plant-animal mutualistic networks: The architecture of biodiversity. Annual Review of Ecology, Evolution, and Systematics, 38, 567-593.

Bascompte, J. (2009) Disentangling the Web of Life. Science, 325, 416-419.

Devoto, M., Bailey, S., Craze, P., & Memmott, J. (2012) Understanding and planning ecological restoration of plant–pollinator networks. Ecology Letters, 15, 319-328.

Dormann, C.F., Fründ, J., Blüthgen, N., & Gruber, B. (2009) Indices, graphs and null models: analyzing bipartite ecological networks. The Open Ecology Journal, 2, 7-24.

Ings, T.C., Montoya, J.M., Bascompte, J., Blüthgen, N., Brown, L., Dormann, C.F., Edwards, F., Figueroa, D., Jacob, U., Jones, J.I., Lauridsen, R.B., Ledger, M.E., Lewis, H.M., Olesen, J.M., Veen, F.J.F.v., Warren, P.H., & Woodward, G. (2009) Ecological networks – beyond food webs. Journal of Animal Ecology, 78, 253-269.

McCann, K. (2007) Protecting biostructure. Nature, 446, 29-29.

Memmott, J. (2009) Food webs: a ladder for picking strawberries or a practical tool for practical problems? Philosophical Transactions of the Royal Society B: Biological Sciences, 364, 1693-1699.

Olesen, J.M., Bascompte, J., Dupont, Y.L., Elberling, H., Rasmussen, C., & Jordano, P. (2011) Missing and forbidden links in mutualistic networks. Proceedings of the Royal Society B: Biological Sciences 278: 725-732.

Tylianakis, J.M. (2008) Understanding the Web of Life: The birds, the bees, and sex with aliens. PLoS Biology, 6, e47.

Tylianakis, J.M., Laliberté, E., Nielsen, A., & Bascompte, J. (2010) Conservation of species interaction networks. Biological Conservation, 143, 2270-2279.

Van Veen, F.J.F. (2009) Food webs. Current Biology, 19, R281-R283

Vázquez, D.P., Blüthgen, N., Cagnolo, L., & Chacoff, N.P. (2009) Uniting pattern and process in plant-animal mutualistic networks: a review. Annals of Botany, 103, 1445-1457.

Course calendar

The course will run from Monday to Thursday over three consecutive weeks. Daily sessions (including lectures, discussions and practicals) will be three hours long (with a short break half way through the session).

Day 1: What is a network? Networks in ecology and evolution. Historical context.

Day 2: Types of networks. Graphical and mathematical representations. Introduction to R.

Day 3: How to gather data to build a network. Field sampling and data processing.

Day 4: Network structure I. Network topology and aggregate properties.

Day 5: Network structure II. Species-level analysis.

Day 6: Mechanisms responsible for network structure I. The “forbidden links” hypothesis.

Day 7: Mechanisms responsible for network structure II. The coevolutionary hypothesis.

Day 8: Spatial and temporal dynamics of networks.

Day 9: Network modelling. Use of simulations and null models.

Day 10: The network approach in conservation, monitoring and restoration. Worked examples in R.

Day 11: Work on individual projects.

Day 12: Oral presentations.

A calendar of the course with details of the readings suggested for each class will be available on the course’s website one month in advance of the start date.

Evaluation criteria

Evaluation will be mainly based on a final project which includes a network analysis. Students will be asked to identify a relevant question or hypothesis, apply appropriate analytical tools to real-world data, present their project as a short talk in class, and submit a

written report a few weeks later. The final grade will be calculated as follows: attendance and participation (10%), oral presentation (30%), written report (60%).

Attendance policy

Students are required to attend at least 75% of the classes (9 out of 12). Students with lower levels of attendance risk deregistration from the course.

Special activities

Students are invited to join the course instructor on his weekly visits to an urban nature reserve (http://www.arn.org.ar/Reserva.php) where an ongoing project is studying the network of interactions between frugivorous birds and fleshy-fruited plants. There will be a chance for willing students to help with data recording.