Canonical Ecology Curriculum: a working document for its core content

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1 About

Which elements of ecology should be known to any ecologist reaching MSc (or early PhD) level? Following Dormann & Mello (2023), we suggest to organise the topics by spatio-temporal scale (= level of organisation) from large to small. This repository aims at collecting and communicating ideas and links to resources (books, papers, MOOCs, videos) that help teaching (and learning) about a subject.

We recognise that opinions will differ about what to include as *core* ecological topics. Take your pick and add your ideas! This is not aiming to be prescriptive or homogenising, but fostering a common language and knowledge base.

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2 Introduction

Within ecology, collaborations are key to understanding the beauty and complexity of nature, and for addressing urgent environmental problems. But how often did we experience collaborations thwarted by miscommunication and lack of a common language? We seem to work with loosely defined concepts and inconsistent vocabulary. Overcoming such problems starts with a well-trained new generation of ecologists. For them, a Canonical Ecology Curriculum is needed, focusing on core theories, seminal papers and standard methods used by ecologists.

Based on a conceptual and operational backbone, such a curriculum could be taught in graduate programmes worldwide, augmented by local examples, individual research interests and enthusiasm. It would minimize the ambiguity of what ecologists learn, while enriching our common vocabulary, reinforcing our ability to understand nature and address complex environmental issues.

We call for a global, open collaboration to collectively develop the curriculum, and make it directly usable in real-world teaching. As a starting point, we provide eight central spatiotemporal themes, ranging from molecular to global, with recommendations on target variables, theories, classical studies, methods and teaching resources.

If you are interested in joining our cause, take a look at, and comment on, the current version of our curriculum's backbone (for more background reading see our paper in Basic and Applied Ecology):

- Below the table, please link your teaching material to openly share with colleagues.
- If you miss something in the curriculum, please add this topic at the bottom of the text along with a justification.
- If you think something is not important enough for a core curriculum, please leave a similar note below the table to tell us why.

3 Elements of the Canonical Ecology Curriculum

Only unshaded rows are developed to some extent, the others are very preliminary.
Links point to resource. Purple: advanced topics, MSc-level or higher; teal: fundamental technical skills.

Scale	Target variables (examples)	Theory or Framework	Classics (by keyword)	Methods
Global	Biomass, productivity	species-energy relationship (incl. Bergmann's Rule;)	Biome delineation	database skills; Model 2 regression;
	species occurrence; species richness	(Macroecology); island biogeography; speciation, extinction mechanisms; (animal) migration; mid-domain effect	Island radiation (*Echium*, *Geospiza*); Latitudinal gradient in species richness	(non)linear (mixed-effects) model;
	functional traits	Rapaport's Rule, Foster's Rule		
	stoichiometry	stoichiometry-energy relationship		
	C-balance, O2-production		GlobalCarbonBudget	
Landscape	Patch-level population size	Landscape configuration, meta-community, meta-population; species-area law;	SLOSS; fragmentation; landscape networks	GIS; remote sensing; biotelemetry; mathematical modelling
Ecosystem	C-, N-, P-pools and fluxes; water fluxes; decomposition rates; tree growth; energy density per trophic level types of ecosystems (terrestrial, limnic, marine)	Nutrient cycles; energy fluxes; metabolic scaling theory; BD-EF	Biosphere 2; Duke & Harvard Forest; FLUXNET; Si-deposition from Chad in Amazon	EC-towers; decomposition bags; leaf chemistry; Earth system models; forester diagram-models; ODEs (ordinary differential equations)
Community	Richness, functional/phylogenetic/other diversity; species abundance distributions;	(modern) coexistence theory: equalising (storage, Janzen-Connell, niche differentiation) and stabilising; Temporal community dynamics (succession);	Succession: Michigan dunes, Mount Glacier forefield;	Plot sampling in the field; diversity metrics; multivariate statistics, ordination, distances and clustering; network analysis; Database skills; taxonomic expertise, meta-genomics stochastic coupled ODE simulations;
	co-occurrence patterns, beta-diversity;	Assembly rules, neutral theory;	neutral theory: BCI	
	network structure and stability	food webs; ecological networks; indirect interactions;	top-down/bottom-up: Oksanen/Fretwell/HSS; keystone species: starfish-algae: Paine; otter-kelp forest: Estes; beaver, elephants, ...; frugivorous bird networks along Andean altitude gradient;	
Pairwise dynamics	Abundances of both species;	Continuous Lotka-Volterra competition, predation, and mutualism models; (modern) coexistence theory; parasite-host dynamics (discrete: Nicholson-Bailey, Hassall);	Competition experiment; Janzen-Connell effect; biocontrol (importance of timing); snowshoe-hare-lynx; *Paramecium aurelia* vs *P. caudata*;	Microbial/plant competition experiments in field and lab; designs for feeding trials; population monitoring; ODE/DE simulations; state/phase-space plots; game theory
		Functional and numerical response;	...	
		Tilman's Isocline model;	...	
		Character/niche displacement, fundamental & realised niche;	Hohenheimer ground water experiment;	
		Herbivory & plant defence;	...	
		allometric prey-predator rules;	...	
		disease spread/epidemiology (SIR);	SARS-CoV2 (SIR)	
		multiple resource model;	...	
		apparent competition/apparent facilitation	...	
	fitness;	...	...	
	interaction strength	...	...	
Individual	Activity budget; movement; niche; feeding preferences; ontogenetic changes in behaviour	Individual specialisation; behavioural ecology; evolutionary game theory; allometric growth law; dynamic energy budget (incl. optimal foraging); Liebig's law of minimum	Individual specialisation; evolution of altruistic behaviour; the logic of animal conflict	Biotelemetry; cafeteria trials; captivity experiments; mathematical modelling (ODE, DE; IBM)
Genes	Allele frequencies; heterozygosity	Population genetics (selection, mutation, genetic drift, gene flow); coalescent theory; landscape genetics	*Drosophila* and *Arabidopsis*; bottleneck effect; inbreeding depression; genetic drift	Behavioural observations; fitness manipulation; game theory

References

Dormann, C. F. & Mello, M. A. R. (2023). Why we need a canonical ecology curriculum. *Basic and Applied Ecology*, 71, 98–109.