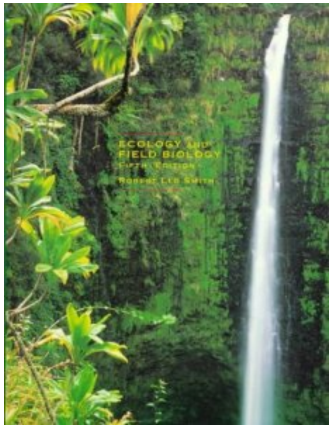
Week 12:

The Future of Ecology

Recent changes in ecology (past two decades):

Research foci:



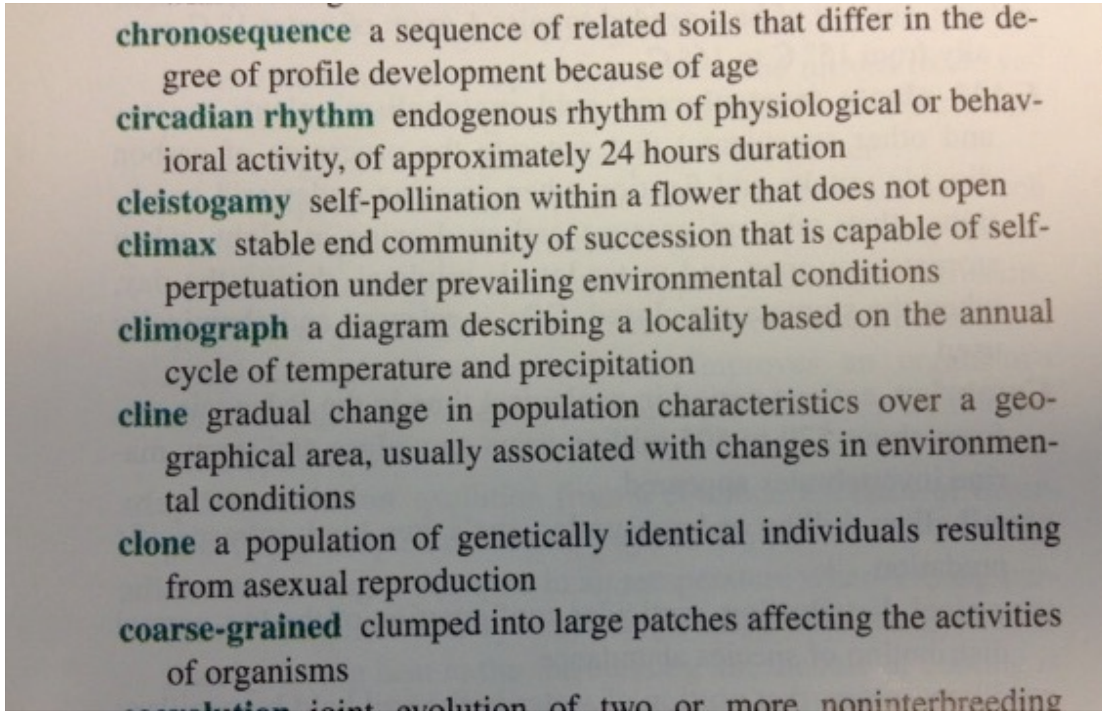
1996 textbook

No mention of:

- neutral theory
- macroecology

Recent changes in ecology (past two decades):

Research foci:



chronosequence a sequence of related soils that differ in the degree of profile development because of age

circadian rhythm endogenous rhythm of physiological or behavioral activity, of approximately 24 hours duration

cleistogamy self-pollination within a flower that does not open

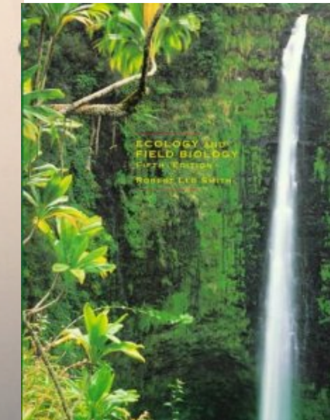
climax stable end community of succession that is capable of self-perpetuation under prevailing environmental conditions

climograph a diagram describing a locality based on the annual cycle of temperature and precipitation

cline gradual change in population characteristics over a geographical area, usually associated with changes in environmental conditions

clone a population of genetically identical individuals resulting from asexual reproduction

coarse-grained clumped into large patches affecting the activities of organisms



1996 textbook

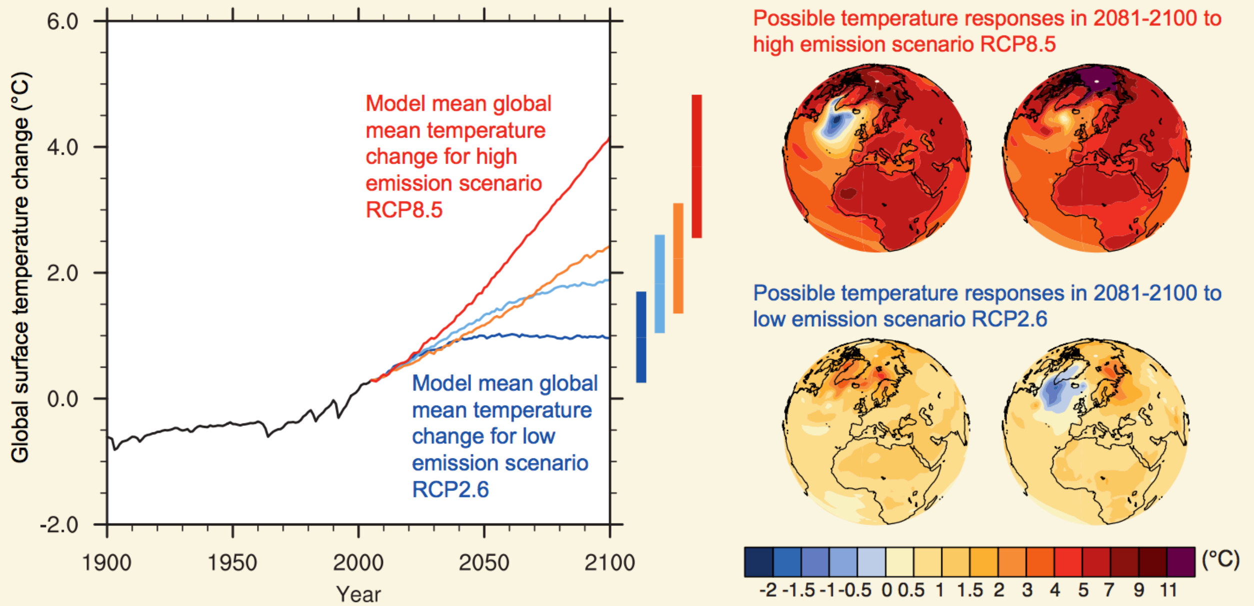
What's missing?

No mention of:

- macroecology
- neutral theory
- climate change (despite a whole chapter on climate!)

Global Climate Change

A game changer in ecology

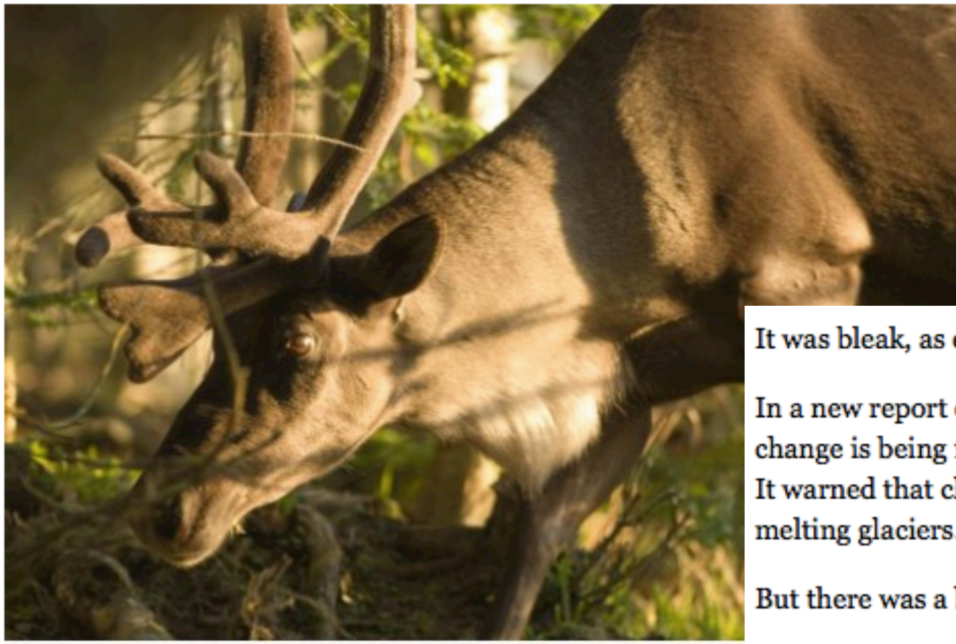


FAQ 12.1, Figure 1 | Global mean temperature change averaged across all Coupled Model Intercomparison Project Phase 5 (CMIP5) models (relative to 1986–2005) for the four Representative Concentration Pathway (RCP) scenarios: RCP2.6 (dark blue), RCP4.5 (light blue), RCP6.0 (orange) and RCP8.5 (red); 32, 42, 25 and 39 models were used respectively for these 4 scenarios. *Likely* ranges for global temperature change by the end of the 21st century are indicated by vertical bars. Note that these ranges apply to the difference between two 20-year means, 2081–2100 relative to 1986–2005, which accounts for the bars being centred at a smaller value than the end point of the annual trajectories. For the highest (RCP8.5) and lowest (RCP2.6) scenario, illustrative maps of surface temperature change at the end of the 21st century (2081–2100 relative to 1986–2005) are shown for two CMIP5 models. These models are chosen to show a rather broad range of response, but this particular set is not representative of any measure of model response uncertainty.

International Panel on Climate Change (IPCC) Report 2013 http://www.thestar.com/news/world/2014/03/30/un_climate_body_backtracks_on_risk_of_species_extinction.html

UN climate body backtracks on risk of species extinction

In new report, scientists say "forecasts of very high extinction rates due entirely to climate change may be overestimated."



TED SIMONET

The woodland caribou faces extinction due to habitat loss. Scientists warn tha "may make habitat loss worse."

It was bleak, as expected.

In a new report on Monday, the UN-sponsored climate panel said the impact of climate change is being felt "on all continents and across the oceans," that no one can escape it. It warned that climate change is already damaging crops, spreading diseases and melting glaciers.

But there was a blip.

Scientists with the Intergovernmental Panel on Climate Change seem to have quietly backpedalled on the risk of species extinction.

In its last assessment report in 2007, the IPCC said humans had shrunk the habitats of many life forms and it predicted that 20 to 30 per cent of all animal and plant species faced a high risk for extinction if average global temperatures rose by 2 to 3 degrees Celsius.

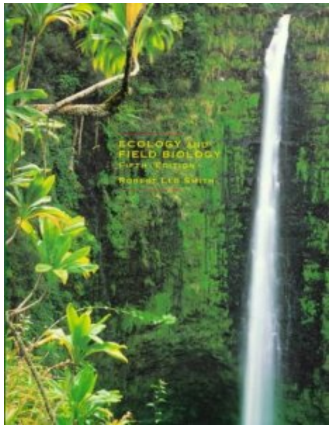
The UN climate body now says it is no longer as certain.

In the new report, scientists say "forecasts of very high extinction rates due entirely to climate change may be overestimated."

Recent changes in ecology (past two decades):

Research tools:

- stable isotopes
- meta-analysis
- remote-sensing data
- genomics

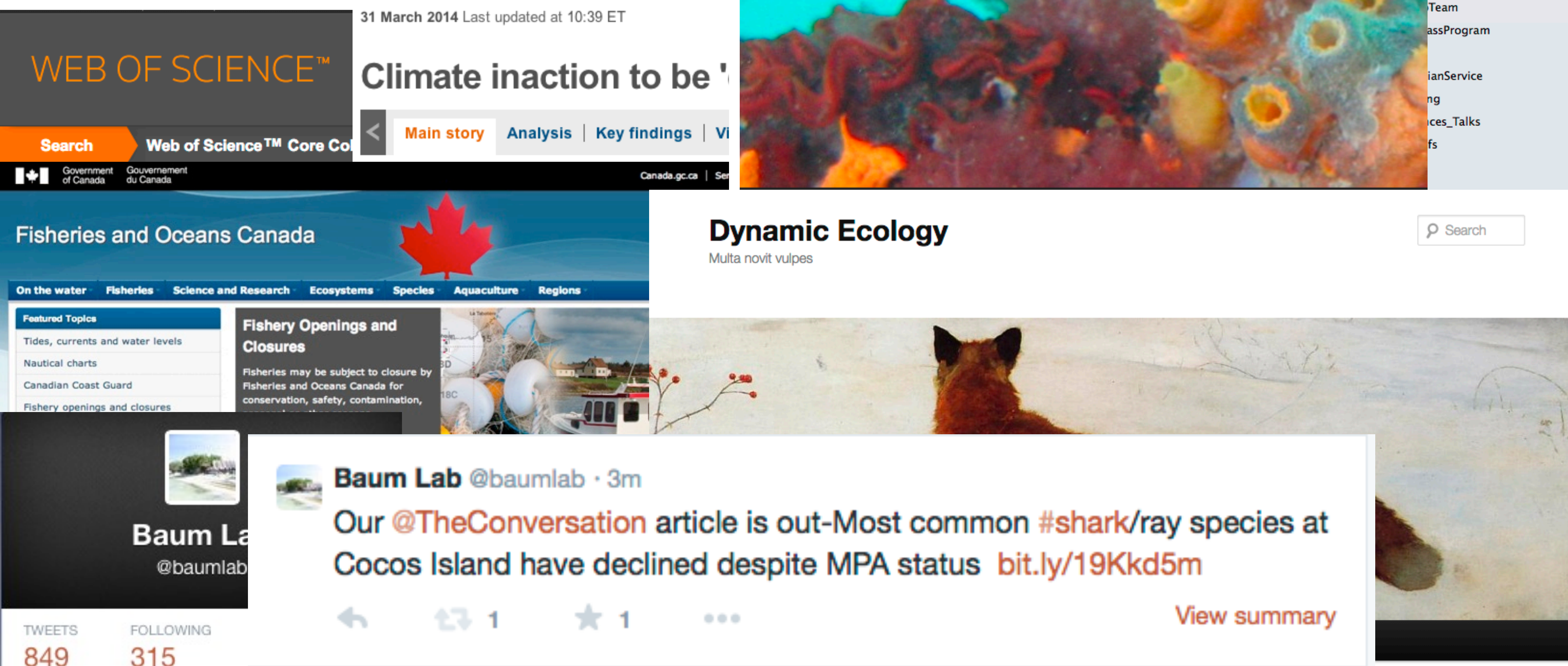


1996 textbook

Recent changes in ecology (past two decades):

Research communication: From letters (!), phone, journals, conferences to….

- phone, journals, conferences AND:
- email
- internet: databases, news, blogs
- websites: academics, agencies, eNGOS
- twitter



April 1 2015, 5.30am EDT

Shark-counting divers off Costa Rica reveal limits of marine reserves

AUTHORS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DISCLOSURE STATEMENT

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Easton White received funding from Fulbright Canada and the National Science Foundation.

The Conversation is funded by Gordon and Betty Moore Foundation, Howard Hughes Medical Institute, Robert Wood Johnson Foundation, Alfred P Sloan Foundation and William and Flora Hewlett Foundation. Our global publishing platform is funded by Commonwealth Bank of Australia.

Despite the high concentration of sharks in Cocos, some species have declined in number – a signal on the effectiveness of marine preserves. Genna Marie Robustelli , Author provided

Marine protected areas – essentially nature preserves in the ocean – are meant to provide a safe harbor for sharks, rays and other ocean species being lost because of intense and often unregulated fishing.

In a **study published in Conservation Biology** last week, we

Recent changes in ecology (past two decades):

In the 21st century, biology is running full tilt into the information age (Spengler 2000); leaders in many fields of the life sciences, including genomics, nanobiology, and medicine, have embraced the new opportunities presented by unprecedented access to digital information. Global-scale environmental issues, from climate change and food security to the spread of disease and the availability of clean water, are creating pressure for ecologists to collectively step forward into this new age. Society is asking ecologists for information that is both specific to particular problems, places, and times, and also predictive, prescriptive, and scalable.

This is a challenge ecologists cannot meet individually.

Hampton et al. 2013 Big data and the future of ecology.

Recent changes in ecology (past two decades):

Synthesis ecology and collaborations

So, my advice to grad students is to try to develop a variety of skills, techniques, and approaches with which you are comfortable. In addition, develop skills that will make you a good collaborator, because the days of a scientist doing innovative, exciting, important work on his/her own are long over. (Brian made this point, too, in his rather lengthy footnote.) The important questions in ecology will not be tackled with a single approach.

Megan Duffy (2013) The Importance of Diverse Approaches in Ecology. Dynamic Ecology (University of Michigan)

Is ecology a success?

Picture it: By 2050 (or by the time you retire in ~ 2060), ecology is regarded as a highly successful and useful scientific discipline?

What has it achieved to earn this status?

What are the key steps ecologists need to take in the next few decades to get there?

RESEARCH COMMUNICATIONS RESEARCH COMMUNICATIONS

The future of ecology: a collision of expectations and desires?

Jeffrey A Lockwood[1*], Derek S Reiners[2], and William A Reiners[3]

A subset of members of the Ecological Society of America was surveyed to describe the current status and infer the future state of ecology. Today's modal ecologist is a 55-year-old male professor who uses field observations and experiments to study communities and ecosystems and finds fulfillment in his research. Younger ecologists rely more heavily on laboratory experiments and modeling but obtain satisfaction in field work. If gender-based retention rates equalize, there may soon be as many women as men in ecology – and their interests differ markedly. Women and men report greater fulfillment from teaching and from data analysis/written communication, respectively. These patterns may explain the poor retention of women in the discipline, given the professional emphasis on publications and grants. Such dissonance between personal satisfaction and the missions of employing institutions must be addressed in order to advance the goals of ecology and enhance the diversity of its practitioners.

Front Ecol Environ 2013; 11(4): 188–193, doi:10.1890/120271 (published online 16 Apr 2013)

A response to Lockwood, Reiners, and Reiners

Lockwood *et al.* (*Front Ecol Environ* 2013; **11[4]**: 188–93) tackle an important state-of-the-field question: how do ecological work and work-related satisfaction track across gender and age categories? However, several aspects of their design and analysis appear to be flawed:

(1) The study design assumes that sources of satisfaction are stable over time and across positions, roles, and circumstances. This assumption is not testable with the available data. Furthermore, predicting that there will be a consistent mismatch between job activities and satisfaction over a scientist's lifetime relies on an inappropriate extrapolation of the available data.

(2) The authors assume (a) that there are only two true "yes" states for job satisfaction per respondent, which is not a meaningful binary outcome and (b) a "non-yes" state automatically equates to a "no" state (eg no job

Lockwood *et al.* may have identified a limited number of gender differences between ecologists but failed to recognize strong patterns of similarity across genders. A re-examination of their data on sources of job satisfaction finds strong congruence in the activities that provide satisfaction for all ecologists. Notably, the top two sources of satisfaction for each gender are field work and data analysis (Table 1).

Lockwood *et al.* highlight studies that point out achievement differences by gender, while apparently overlooking well-documented evidence of biases that create barriers for women in science. For example, recent work

Ecology must evolve

Tackling global problems requires a fresh approach, argues **Georgina Mace**, as the British Ecological Society celebrates its centenary.

Climate change, the threat of pandemics, population growth, food security and the loss of biodiversity and ecosystem services demand a new kind of ecology — one that focuses on how whole communities of organisms, at the scale of landscapes or catchments, interact with people and the physical environment.

The advances in ecology in the past century have hugely improved our understanding of species interactions, such as those between hosts and parasites or between predators and prey, as well as population dynamics, food-web dynamics and how organisms adapt to their local environments. Such gains have come mostly from a combination of theory and modelling, and carefully designed long-term laboratory or field experiments[1] in places as diverse as the Serengeti Wildlife Research Centre in Tanzania and the University of Oxford's Wytham Woods site, UK. Indeed, historically, careers in ecology have tended to revolve around the 'ownership' and analysis of a personal study system or a painstakingly curated data set.

In part because of this history, there are few general theories for how multiple species respond to perturbations, such as disease or shifting weather patterns, at the community level[2,3]. This is a major problem for what is becoming known as global-change science.

The British Ecological Society, founded in 1913 "to promote and foster the study of Ecology in its widest sense", has been key in disseminating knowledge among ecologists over the past few decades, by publishing leading journals and organizing academic meetings, and through its increasing presence in education and policy. As its outgoing president, however, I worry that in today's world, there are more pressing demands. And, as for othe
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Ecology must evolve

Tackling global problems requires a fresh approach,

Ecology must evolve

Tackling global problems requires a fresh approach, argues **Georgina Mace**, as the British Ecological Society celebrates its centenary.

must be tied into global-change science. In fact, a new kind of ecology is needed that is predicated on scaling up efforts, data sharing and collaboration[4–8]. This would link up with related disciplines in the environmental, social and physical sciences, and focus much more on meta-analyses and synthesis. We need to identify general trends, such as the effect of a change in temperature on animal dispersal and the knock-on consequences for ecosystems, and draw general conclusions, for instance on how the practices of local fisherman affect the health of fisheries. A few scaled-up ecological models

I believe that the mass of expertise and breadth of focus from basic science to policy found among members of the BES and other societies, as well as among their contacts and collaborators, could be used to help identify the grand challenges for ecology and environmental-change science, and to design and develop research priorities.

SCIENCE

494 COMMENTS

Billionaires With Big Ideas Are Privatizing American Science

By **WILLIAM J. BROAD** MARCH 15, 2014

VIDEO | 4:26

Schmidt Ocean Institute

Funding the Future

As government financing of basic science research has plunged, private donors have filled the void, raising questions about the future of research for the public good.

Privatizing_Science

CONCEPTS AND QUESTIONS

Big data and the future of ecology

Stephanie E Hampton[1*], Carly A Strasser[2], Joshua J Tewksbury[3], Wendy K Gram[4], Amber E Budden[5], Archer L Batcheller[6], Clifford S Duke[7], and John H Porter[8]

The need for sound ecological science has escalated alongside the rise of the information age and "big data" across all sectors of society. Big data generally refer to massive volumes of data not readily handled by the usual data tools and practices and present unprecedented opportunities for advancing science and informing resource management through data-intensive approaches. The era of big data need not be propelled only by "big science" – the term used to describe large-scale efforts that have had mixed success in the individual-driven culture of ecology. Collectively, ecologists already have big data to bolster the scientific effort – a large volume of distributed, high-value information – but many simply fail to contribute. We encourage ecologists to join the larger scientific community in global initiatives to address major scientific and societal problems by bringing their distributed data to the table and harnessing its collective power. The scientists who contribute such information will be at the forefront of socially relevant science – but will they be ecologists?

Front Ecol Environ 2013; 11(3): 156–162, doi:10.1890/120103 (published online 12 Mar 2013)

Big data and the future of ecology

In a nutshell:

- Ecologists collectively produce large volumes of data through diverse individual projects but lack a culture of data curation and sharing, so that ecological data are missing from the landscape of data-intensive science
- To fully take advantage of scientific opportunities available in the information age, ecologists must treat data as an enduring product of research and not just as a precursor to publications
- Forward-thinking ecologists will organize and archive data for posterity, publicly share
tions that address large-

Simply put, the era of data-intensive science is here. Those who step up to address major environmental challenges will leverage their expertise by leveraging their data. Those who do not run the risk of becoming scientifically irrelevant.

Action items for individual ecologists

Ecologists need to treat data as an enduring product of research, not just a precursor to publication. Individual ecologists therefore must:

(1) Organize, document, and preserve data for posterity. Taking data management seriously now will prepare the individual researcher for the time when the incentives are there to integrate data with larger efforts or simply to share data with colleagues and the public. Free software tools are available to produce standardized, machine-readable metadata (eg Morpho, an open-source, spreadsheet-style desktop application that writes Ecological Metadata Language and helps to enforce best practices with data).

(2) Share data. Data federations, such as DataONE, provide linkages among specialized environmental data holdings; in addition, many ecologists have mechanisms for publishing their data through their university libraries, professional journals (eg ESA's *Ecological Archives*, Dryad-associated journals), or other institutions.

(3) Collaborate with networks of colleagues to bring together heterogeneous datasets to address larger scale questions. Ecologists work at a variety of scales that, when integrated, can help to link process and pattern at broad temporal and spatial scales.

(4) Address data management issues with students and peers. Encourage participation in professional workshops, develop data protocols for laboratories and projects, and feature data management in courses through hands-on activities and group discussions – Borer *et al.* (2009) provided a simple introduction to best practices in data management.

Big data and the future of

Natural History's Place in Science and Society

JOSHUA J. TEWKSBURY, JOHN G. T. ANDERSON, JONATHAN D. BAKKER, TIMOTHY J. BILLO, PETER W. DUNWIDDIE, MARTHA J. GROOM, STEPHANIE E. HAMPTON, STEVEN G. HERMAN, DOUGLAS J. LEVEY, NOELLE J. MACHNICKI, CARLOS MARTÍNEZ DEL RIO, MARY E. POWER, KIRSTEN ROWELL, ANNE K. SALOMON, LIAM STACEY, STEPHEN C. TROMBULAK, AND TERRY A. WHEELER

The fundamental properties of organisms—what they are, how and where they live, and the biotic and abiotic interactions that link them to communities and ecosystems—are the domain of natural history. We provide examples illustrating the vital importance of natural history knowledge to many disciplines, from human health and food security to conservation, management, and recreation. We then present several lines of evidence showing that traditional approaches to and support for natural history in developed economies has declined significantly over the past 40 years. Finally, we argue that a revitalization of the practice of natural history—one that is focused on new frontiers in a rapidly changing world and that incorporates new technologies—would provide significant benefits for both science and society.

Keywords: environmental management, ecological knowledge, human health, food security, sustainability

Box 1. Revitalizing natural history within institutions: Claim the title.

The vitality of natural history will depend on the willingness of professionals in the natural sciences to self-identify as natural historians, to teach natural history, and to articulate the importance of their expertise across a wide range of disciplines, through lectures, conferences, professional societies, and public talks. Those professionals who embrace the revitalization of natural history within and beyond their institutions will lead and define the field for the twenty-first century. This is not an easy path for early-career academics, but it is an essential shift for established academics because they can use their tenure to validate and promote the importance of natural history within and beyond their programs. A big part of this work is the establishment of a strong platform or support structure, which would allow professional naturalists at all levels to claim credit for their work using traditional institutional metrics. Such a platform must include awards, conferences, organizations, and society sections that support and recognize naturalists throughout their career and integrate natural history with other disciplines; sections within high-impact journals devoted to excellent natural history; and increased recognition of data sets, themselves, as legitimate products of research and scholarship.

For example, natural history societies and institutions around the world have been promoting the work of professional naturalists for more than a century, and many of these groups have formed consortia that support a broader community of naturalists and allow greater integration across disciplines (box 5). In the United States, a number of recent initiatives (e.g., the Natural History Initiative, the Natural Histories Project, the Natural History Network, the Natural History Section of the Ecological Society of America) have joined more-established museum- and society-based efforts to explicitly focus attention on the importance of connections between natural history and other disciplines. In addition, journals within established societies have also made changes. The reinstatement of the Natural History Miscellany section within the *American Naturalist* is an excellent example of ways in which high-impact-factor journals can provide legitimacy to the work of naturalists, and journals focused on pedagogy, such as the *Journal of Natural History Education and Experience*, provide a platform for sharing natural history teaching techniques and curricula.

Box 5. Natural history and the digital revolution.

Technology influences how we observe, organize, and share information about the natural world. Here, we highlight programs that use technology to change the way we see the world and programs that organize and standardize the collection and curation of natural history information.

The democratization of natural history information

An increasing number of digital platforms are focused on dramatically expanding participation in the collection, curation, and exchange of natural history information. These platforms represent a fundamental shift away from private records and individual papers and toward a more collaborative approach to observing and understanding our world. Many sites are now dedicated to organizing citizen science projects within and across disciplines, and the number of natural history projects is growing rapidly and includes camera-trap photo identification, online transcription of museum records, and the identification of whale and bat sounds. The growth in citizen science can be seen in platforms such as iNaturalist and iSpot and in taxonomy-focused efforts, such as eBird. These platforms combine a social-media interface with crowd-sourced identification. The iNaturalist platform alone currently hosts over 850 projects.

Going big and getting organized

Big-data efforts to standardize the collection, curation, and dissemination of natural history information are beginning to shift the focus of natural history toward collaborative projects and platforms.

Global Biodiversity Information Facility. The Global Biodiversity Information Facility (GBIF) is a global repository for natural history information, focused on providing open-access data on biodiversity, particularly the vast holdings of specimens and data distributed across natural history museums worldwide. Through a global network of countries and organizations, the GBIF promotes and facilitates the mobilization, access, discovery, and use of information about the occurrence of organisms over time and across the planet.

Encyclopedia of Life. The Encyclopedia of Life is an easy-to-search and freely available compendium of natural history information on thousands of species from around the world. Its content is contributed by members, including the lay public, and reviewed by curators. The total number of pages with content is currently more than 1.3 million.

Map of Life. The Map of Life is a global collection of species-distribution data, currently housing over 365 million records from almost 800,000 species and providing mapping tools and area-specific species lists for anywhere on the globe. The Map of Life is designed to provide a platform and tool set for the development and analysis of species-distribution maps across all taxa.

Vital Signs. Integrating ecosystem service and biodiversity monitoring from an agricultural perspective at local to continental scales, Vital Signs uses standardized, targeted collection of natural history information to build explicit links between biodiversity and human well-being.

USA National Phenology Network. The USA National Phenology Network is a national clearinghouse for data sets focused on the timing of events in nature, from blooming times in plants to migration timing in animals. The platform hosts citizen science projects, curates global data on phenology, and organizes phenological research for a wide range of applications.

FishBase. FishBase is an international online database of the world's fishes. This collaborative effort bridges ecological, genetic, zoological, biogeographical, conservation, and commercial information. It is commonly cited in peer-reviewed literature and used as a management tool.

The Natural Histories *Project*

Listen to conversations on the rebirth of Natural History.

GET INVOLVED »

EXPLORE BY THEME

- Challenges & Opportunities
- Definitions
- Society
- Education
- Science & Research

Josh Tewksbury

An exciting time to be a naturalist

THEMES: Challenges & Opportunities, Society, Technology | WORKSHOP: Synthesis

http://naturalhistoriesproject.org/conversations/an-exciting-time-to-be-a-naturalist

http://evol-eco.blogspot.ca/2013/12/what-can-future-of-ecology-learn-from.html

Thursday, December 5, 2013

What can the future of ecology learn from the past?

Ecology has been under pressure to mature and progress as a discipline several times in its short life, always in response to looming environmental threats and the perception that ecological knowledge could be of great value. This happened notably in the 1960s, when the call for ecology to be better applicable occurred in relation to the publication of Silent Spring and fears about nuclear power and the Manhattan Project. Voices in academia, government, and the public called for ecology to become a "Big Science", and focus on bigger scales (the ecosystem) and questions. And yet, "[Silent Spring] brought ecology as a word and concept to the public...A study committee, prodded by the publication of the book, reported to the ESA that their science was not ready to take on the responsibility being given to it."

Arguably ecology has grown a lot since then: there have been advances in statistical approaches, spatial and temporal considerations, mechanistic understanding of multiple processes, in the number and type of systems and species studied, and the applications being considered. But it is once again facing a call (one that frankly has been ongoing for a number of years) to quickly progress as a science. The Anthropocene has proven an age of extinctions, human-mediated environmental changes, and threats to species and ecosystems from warming, habitat loss and fragmentation, extinctions, and invasions abound. Never has (applied) ecology appeared more relevant as a discipline to the general public and government. This is reflected in the increasing inclusion of buzzwords like "climate change", "restoration", "ecosystem services", "biodiversity hotspot", or "invasion" as keys to successful self-justification. Also similar to the 1960s is the feeling that ecology is not ready or able to meet the demand. Worse, that the time ecology has to respond is more limited than ever.

The Future of Ecology

Ecologists need to become better at:

- embracing different approaches and learning from them
- quantitative skills and data curation, without abandoning natural history expertise
- mobilizing a diverse portfolio of funding sources
- talking to the public, and interfacing with the media and policy makers
- slowing down, remembering the importance of deep thought, meticulous research, and creativity

The Future of Ecology…. You!

How to find a job

List serves: ecology@uvic

JOB POSTING

JOB TITLE: Case study research: large-Marine Protected Areas (Environmental Studies)

DEPARTMENT NAME: Environmental Studies

JOB DESCRIPTION:

The successful applicant will work on carrying out research on case studies that manage large-scale marine systems, focused on large marine protected areas. This short-term research project will contribute a case-study to a meta-analysis that is part of an international research effort to assess environmental governance at large scales. The results from this larger analysis will be used to improve the design and management of large-marine protected areas. This project will primarily include, but is not limited to, peer-reviewed and grey literature searches, developing annotated bibliographies, reading relevant papers, synthesizing key information about social and ecological components of case studies, and entering the information into an online database.

QUALIFICATIONS:

Proficient use of computers, preferably PC-platform, and proficient use of Microsoft Word. Experience doing online and library based research is sought. Experience with or referencing software is an asset, as is familiarity with marine ecosystems, environmental issues, and social-ecological research. Preference will be given to students in Environmental Studies, although applications from students with qualification in other disciplines are also encouraged (the key ingredient is commitment to the project). Good teamwork skills, self-motivation, attention to detail and consistent work habits are essential.

JOB LOCATION ON-CAMPUS:	Turpin building, Room B247
WAGE:	$16.00/hr
HOURS AVAILABLE:	Ideally starting May 1st, for 8 weeks (total hours available: 320), some flexibility with start date is possible.

HOW TO APPLY:

Please e-mail a statement of your interest in the position, your resume, and an unofficial transcript, to Tammy Davies, tedavies@uvic.ca by the 15th April 2015.

The Future of Ecology…. You!

OCEANA Protecting the World's Oceans

Marine Scientist

Location: Canada TBD, based on candidate
Department: Science

Oceana Canada is seeking a Marine Scientist based in Canada. This position offers an exciting opportunity to help set strategy and lead implementation of science efforts for Oceana Canada.

Oceana Canada, an independent charity established to restore Canadian oceans to be as rich, healthy, and abundant as they once were, is proud to be affiliated with the international family of Oceana organizations. Oceana Canada will work with civil society, academics, fishers, and government to return Canada's formerly vibrant oceans to health. We engage in fact-based campaigns designed to preserve the bounty of the sea as a source for wild-caught fish, as well as to preserve the marine ecosystem for our and future generations.

The Marine Scientist is a key member of Oceana Canada's leadership team, playing a substantive role in evaluating science and policy related to Canadian fisheries for our Save the Oceans, Feed the World initiative. The Marine Scientist plays a role in, and may have primary responsibility for, preparing technical reports, developing the scientific foundation for our work on fisheries relevant to Canada, and supporting campaigns. The position requires a combination of equally strong research, critical thinking and communication skills.

Responsibilities include:

- Supports decision-making by preparing credible literature reviews on global fisheries, aquaculture, and marine conservation themes.
- Critiques fisheries policy, implementation and practice at the national and regional level.
- Gathers information through literature searches, data mining, and expert interviews; builds and analyzes large datasets.
- Writes, edits, and presents materials which provide the scientific foundation for Oceana Canada's work. Drafts science-based policy recommendations and prepares reports with meticulous attention to detail.
- Reviews external communications with funders and the public to ensure scientific integrity and the accurate portrayal of complex issues.
- Develops a strong network of scientists and personal expertise in fisheries management.
- Cultivates relationships on behalf of Oceana Canada at external meetings with allies, stakeholders, government representatives, and other organizations.
- Manages a varied and high volume workload and works independently to meet deadlines and accomplish tasks.
- Contributes as a part of a team to support the development of Oceana's initiative to Save the Oceans, Feed the World.
- May supervise consultants and interns.

Building your professional reputation

EDITORIAL

Ten Simple Rules for Lifelong Learning, According to Hamming

Rule 1. Cultivate Lifelong Learning as a “Style of Thinking” That Concentrates on Fundamental Principles Rather Than on Facts

Rule 8. No Matter How Much Advice You Get and How Much Talent You Possess, It Is Still You Who Must Do the Learning and Put in the Time

Rule 10. Make Your Life Count: Struggle for Excellence

Overall, Hamming is “preaching the message that, with apparently only one life to live on this earth, you ought to try to make significant contributions to humanity rather than just get along through life comfortably—that the life of trying to achieve excellence in some area is in itself a worthy goal for your life.. . .[A] life without a struggle. . .is hardly a life worth living.”

The true gain is in the struggle for excellence, and “a life without such a goal is not really living but it is merely existing” [4].

Have fun and maintain your sense of humour

Go forth and be happy!