Prospectus on Graduate Studies and Advising

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The quality of a graduate education depends in part on the quantity and quality of interactions between students and advisors (and between students and students!). Each student's experience in graduate education is unique, and advising expectations need to be developed through discussions between the student and advisor. This prospectus gives my general view of graduate education, providing a starting point for developing programs that suit each student.

Philosophy:

Graduate education deals with developing knowledge, the ability to use knowledge, and the ability to think with creativity and skepticism. A Masters level education aims to develop a student's ability to participate in science, typically at the level of applying science (to natural resource issues, for example). A doctoral level education aims to produce scientists (professional or avocational). I have high expectations for student accomplishments, and work to help students achieve their goals.

A doctoral program is qualitatively different from a masters program – not just more of the same. Differences include greater rigor for a PhD -- not just in hours expended, but in accomplishments and abilities as a scientist.

Students gain knowledge and understanding from many parts of a university -- by hanging out with fellow students, in classes, in journals, and in research projects.

The advisor serves a double role in graduate programs. As a mentor, the advisor supports, encourages and nurtures each student's development. As a professor, the advisor also judges the accomplishment and potential of each student. Students should expect support from advisors, but this support may sometimes include uncomfortable criticism and challenges. Some students begin graduate work with a vision that turns out not to match the real program – such as the program requiring greater dedication, sharper thinking, broader knowledge, more skills in math or chemistry. The advisor is responsible for helping students develop their visions and accomplishments to meet the demands of the program. On rare occasion, the match just doesn't come, and the student and advisor need to discuss a transition out of the program.

Expectations for MS level students:

A student completing an MS program should:

A. Have personal motivation, curiosity, and enthusiasm for learning science;
B. Have a general, working knowledge of science, including its philosophy, methods, and current state;
C. Have a solid understanding of the state of science within the area of his or her interest;
D. Be able to understand and use basic statistics, sampling procedures, and analytical methods;
E. Be able to communicate clearly and effectively, in written and oral presentations;
F. Begin to read the literature; and

G. Reach these milestones:
    1. Coursework plan developed by end of first semester.
    2. Research plan developed by middle of second semester; file GS-6 form.
    3. Steady progress on research
    4. Submission of at least one paper for publication by the time of graduation, with a second near-ready for submission (alternatively, one large paper would be fine).

<u>Expectations for PhD level students:</u>

A student completing a PhD program should:

A. Have personal motivation, curiosity, and enthusiasm for becoming a scientist;
B. Have a broad knowledge of the philosophy, history, and current state of science;
C. Be competent in major techniques used in ecological research, including statistical, field, and laboratory methods;
D. Be an expert in the state of science within his or her specialty – ideally knowing more about the subject than the advisor knows!;
E. Be able to think clearly, critically, and creatively – beyond the level expected for MS-level students;
F. Routinely read the literature;
G. Be able to communicate clearly and effectively, in written and oral presentations; and
H. Reach these milestones:
    1. Coursework plan developed by end of first semester;
    2. Research plan developed by end of second semester; file GS-6 form;
    3. Steady progress on research; and
    4. Submission of one review paper for publication, and one original research paper before graduation; at least 2 more papers ready to submit near the time of graduation. For diversity, one original-data paper should deal with a topic outside the dissertation field. The number of papers would of course be flexible in cases where large (monograph) papers are produced. NOTE: The people who get good jobs tend to have 50-100% beyond this level of paper production during their PhD programs. Do you want a job?

<u>Expectations for advising:</u>

The graduate advisor should:

A. Take a personal interest in each student's education, including goals, areas of interest, and abilities;
B. Challenge each student to achieve;
C. Provide feedback on progress, critique written and oral presentations; a 2-week (or less) turnaround on review of student paper should be expected.
D. Provide insights on the inner workings of science – funding, personalities, publications, manuscript review and publication, proposal writing;

E. Financial support (to the extent possible), including tuition, stipend, research funds and travel to a variety of ecosystems and scientific meetings.

Workload:

If a student uses graduate school to advance toward career goals, it's important to develop a clear idea of the professional playing field. Good job openings have many well-qualified competitors; a graduate program needs to produce graduates who are well positioned to win the competition. Four points of successful preparation for the job arena are:

A. Number of publications.
B. Presentations at meetings, and other direct ways of developing personal contacts with peers.
C. Quality of publications and presentations. This includes style -- but also pizzazz of the topic (hypothesis, question examined, context of the question, etc.)
D. Breadth and depth of experience, including multiple ecological questions and ecosystems.

In my experience, there are 3 "strategies" used by successful scientists:

A. I work very hard, so I'm successful.
B. I'm clever and efficient, so I'm successful.
C. I spend many hours on my favorite pastime, Science, so I'm successful even though it's not work.

A graduate student needs to understand her own approach to the issues of how to achieve high productivity (with hours of toil, or with efficiency, or with abandon), and structure the graduate program accordingly. If a student is being very productive, I don't care if he takes a week in August to kayak. If a student is struggling, more hours of work are probably needed. The level of fun and enjoyment one finds in the dull, daily work of ecology may be a good indicator of whether a career in this direction is a good idea.

Words of warning: If your graduate program is not fun, and you're not being productive, think about changing career paths.

More words of warning: essentially all professional jobs in ecology require the juggling of multiple tasks daily – large blocks of time to focus on single projects are rare. Successful professionals are often good at juggling; frustrated and over-worked professionals are often poor jugglers. What's your style?

Where do research ideas come from?
(see a great development of this in: Ford, E.D. 2000. Scientific method for Ecological Research. Cambridge Univ. Press, Cambridge.)

General guidelines include:

A. Finding a research site that is begging to be measured for a great idea. Sometimes the availability of an on-going research site provides the fertile ground for a new test of an idea.
B. Discussing the state of knowledge, esp. the limitations, with fellow students and professors. The most fertile ground is often at the juncture of 2 fields. For example, ecosystem ecologists may have one view of productivity, and physiological ecologists another – are there any areas where the two fields bring different expectations to the forest? Such junctures can also include two levels of scale – can something that looks true at one scale be different at another?
C. Find an argument in the literature, and identify the corner of reality where one theory makes a prediction that is opposed by the other – set out to falsify something. If done well, this could form the basis of a review/synthesis article to publish.
D. Think about a more complete context than the one presented in a literature debate or a current research project. "If proposition 1 is true locally, what would be the implications for expectation A over there?" For biogeochemistry, these complete contexts include conservation of matter (you can't have a budget line item here that is inconsistent with another budget item over there…).
E. Think of an idea that we all hold to be self-evident, and ask if the evidence supports our credulity. Do we really understand the underlying processes, or just assume we do? If the expectation is logically sound, how well does the evidence support it?

Good topics have some of these characteristics:

A. The subject is of interest to peers, often with some implications for how populations, species, or ecosystems are sustained or managed.
B. Your approach is different from those used for similar questions in the past – your approach has an element of insightful testing (clarity or perhaps cleverness) that has been lacking. The power of your work might be stronger if it covers a bigger scale (working in 3 or 10 unrelated sites to test an idea), or a spatially explicit scale. Your approach would often benefit from modeling – but the value gained from modeling depends on how you go about it (in advance is better than after the fact), and whether you create the model as a constrained work of art, a tool, or a hypothesis to be falsified.
C. Your approach is risky – the idea is novel and fascinating enough that it may not be true. But what if you disprove your clever idea? I suggest 2 backup strategies: have a good descriptive story to tell (independent of the outcome of the hypothesis test), and have at least one solid side-project that can stand on its own.

One insomniacal night I typed out a list of case studies from my work (and from some of my students), identifying how the ideas developed. If you promise not to laugh, or to think the list is too biographically ego-centric, you can click on Binkley Case Studies.

Suggested Reading:

Masters students should read several of the following books (or ones on similar topics); books with asterisks are especially recommended. Doctoral students should read 2X several.

Biographies are included as a way to gain perspectives on how science *really* operates in social and cultural contexts.

EVERYONE with a career interest in Science should read Bill Bryson's book, *A Short History of Nearly Everything* – this is by far the best rendition of the big picture of Life, the Universe, and Everything. An educated ecologists needs to know where she sits in the universe, and how she got there.

Nature and history of science:

*Faraday, M. 1857. The forces of matter. Prometheus Books, New York.

Boorstin, D.J. 1983. The discoverers. Vintage, New York.

Carey, J. (ed.) 1995. Eyewitness to science. Harvard Univ. Press, Cambridge.

*Ford, E.D. 2000. Scientific method for Ecological Research. Cambridge Univ. Press, Cambridge.

Kuhn, T. 1962. The structure of scientific revolutions. Univ. Chicago Press, Chicago.

Latour, B. 1987. Science in action. Harvard Univ. Press, Cambridge

Mayr, E. 1982. The growth of biological thought. Harvard Univ. Press.

*Sagan, C. 1996. The demon-haunted world: science as a candle in the dark. Ballantine, New York.

Schick, T, Jr., and L. Vaughn. 1995. How to think about weird things. Mayfield, London.

General science knowledge:

*Hazen, R.M., and J. Trefil. 1991. Science matters: achieving scientific literacy. Anchor Books, New York.

von Baeyer, H.C. 1998. Warmth disperses and time passes. Modern Library, New York.

Chaisson, E.J. 2001. Cosmic evolution, the rise of complexity in nature. Harvard Univ. Press, Cambridge MA.

Biography:

Curie: Marie Curie : A Life by Susan Quinn

*Pasteur: Louis Pasteur by Patrice DebrJ

Leopold: Aldo Leopold : His Life and Work by Curt Meine

Darwin: Darwin: The Life of a Tormented Evolutionist by Adrian Desmond, James Moore

Huxley: Huxley: from Devil's Disciple to Evolution's High Priest, by Adrian Desmond.

Carson: Rachel Carson : Witness for Nature by Linda J. Lear

Lovelock: Homage to Gaia, the Life of an Independent Scientist, by James Lovelock

Ecology:

*Leopold, A. 1947. A sand county almanac.

Margulis, L., and D. Sagan. 1986. Microcosmos: four billion years of microbial evolution. Simon & Schuster, New York.

*Pielou, E.C. 199 . After the ice age.

Turner, B.J. et al. 1985. The earth as transformed by human action. Cambridge Univ. Press, Cambridge.

Vernadsky, V.I. 1930/1998. The biosphere. Springer-Verlag, New York.

Smil, V. 2002. The Earth's biosphere. MIT Press.

Forest science:

Johnson, D.W., and S.E. Lindberg (eds.) 1992. Atmospheric deposition and forest nutrient cycling. Springer-Verlag, New York.

Nambiar, E.K.S., and A. Brown (eds.) 1997. Management of soil, nutrients and water in tropical plantation forests. ACIAR, Canberra.

Whitney, G. 1994. From Coastal Wilderness to Fruited Plain. Cambridge Univ. Press, Cambridge.

Foster, D. 1999. Thoreau's Country. Harvard Univ. Press, Cambridge.

Perlin, J. 1991. A forest journey: the role of wood in the development of civilization. Harvard Univ. Press, Cambridge.

English and writing:

Bryson, Bill. 1996 (paperback). The Mother Tongue: English and how it got that way. Avon books.

Williams, Joseph. 2002. Style: Ten Lessons in Clarity and Grace. Longman

Williams, Joseph, and J.M. Salvage. 2002. Style: The Basics of Clarity and Grace. Longman

Perry, Carol R. 1991. The fine art of technical writing. Blue Heron Press.

Some Rules:

Each student benefits from our whole group, and I expect that students will be willing to help other students at particular times of need (such as a quick sampling trip that needs extra hands, or a particular lab analysis need). This also includes helping new students learn the ropes. I occasionally need help on a project that may not be directly funding a student, and I expect students to be willing to pitch in. This approach to helping others doesn't involve great time and effort, but it contributes a great deal to morale and accomplishing our goals.

Each student is responsible for:

- Knowing the safety rules of the lab, including personal safety, chemical safety, and hazardous waste requirements.
- Helping keep the lab clean, equipment in good shape (and accounted for).
- Backing up all computer files regularly, and storing the back-up disk or tape safely (away from the computer in case of theft).

Publication – unless a student's project is self-funded, the student has an obligation to see the work through to the end – which is defined as publication. If a student has not submitted a manuscript within a year of completion, I would like to have the right to take over the obligation. In such a case, the student would remain an author on the work – sometimes first author, sometimes second author. When I have had to write the papers from student projects, about ¾ of the time the student has remained the first author, and ¼ of the time I thought I couldn't justify leaving the student first.

Authorship – I subscribe to the commonly held ideas in scientific societies: authorship denotes major contributions in ideas or writing. Contributions of funding or labor alone are appropriately noted in acknowledgements. If a student develops a project very independently, I do not expect to be a coauthor. In general, I think PhD students should produce at least one substantial paper without the advisor as a coauthor. If I'm providing a good portion of the ideas or writing, then coauthorship may be appropriate. Senior authors (ie, students) should have the final say in deciding authorship; if disagreements arise, decisions should lean in favor of giving more credit to people at a junior career stage than a senior career stage.

Other ideas about graduate education from students and colleagues:

- Participation in national meetings is fundamentally important to developing a career in ecology (for insights, check out Indy Burke's article from the ESA Bulletin)
- Coauthoring papers with other graduate students is a great idea.
- Presentations of research ideas, and research findings, to the lab group is valuable.
- Professor should launch year with an introduction to expectations, the lab, current research, issues.
- Students should take advantage of opportunities to provide guest lectures in undergraduate classes (see Dan).
- Students are expected to presentation research at the Front Range Student Ecology Symposium.
- Students should plan on presenting research at regional or national science meetings (discuss with Dan).
- Ideas on graduate study from other professors (I don't agree with all the points – but good grist for your mill): Schulz and Knapp