CONTRIBUTIONS

Commentary

A Primer on How to Apply to and Get Admitted to Graduate School in Ecology and Evolutionary Biology

In my experience, most students considering graduate school have little knowledge of how to gain admission, how to choose a program, or how to find and select an advisor. Here, I try to remedy these problems with a basic step-by-step guide for the application process and for the prelude to that process. It is my hope that faculty and graduate students who read this and find it valuable will pass it on to interested undergraduates. This guide should get students started down the right track and allow them to ask more refined questions about the whole application process. Overall, this primer applies mostly to graduate programs in ecology, evolution, systematics, and natural resources. In general, students should know right off that applying to graduate school in these disciplines is much different than applying to universities from high school, or applying to medical school, law school, or even graduate programs in other areas of biology.

For the student, it is never too early to start thinking about graduate school. Before applying, however, you should be pretty confident that graduate school is right for you. It can be a long haul (typically 5-6 years for a Ph.D.) and complete commitment is required for success. If you are not sure, or if you are burned out, take a year or two off, gain some experience, travel, or get a job and bank some money, and then carefully consider postgraduate education.

I. Prelude 1: Grades and GREs

Most schools require that you take the Graduate Record Exam (GRE). Although your grade point average (GPA) and the GRE are not always good predictors of success in graduate school, universities will use these metrics to compare and evaluate applicants. Here is some advice:

1. *Try to graduate with at least a 3.0 GPA.* The vast majority of graduate schools have a 3.0 as their cut-off. This is reasonable and suggests that you took your coursework seriously and learned the basics. Still, if you are below this, all is not lost, so do not lose hope (see sections on the GRE and gaining research experience). Note that some programs will emphasize your GPA in the last two years of your degree program, or within your major. If your GPA is higher in these areas, emphasize this in your application. The best or most competitive programs will typically look for GPAs that are substantially higher than a 3.0, while smaller programs, and programs that only offer a Master's degree, may be somewhat less picky.

2. *Try to score well on the GRE.* Most universities or departments will require that you take the general GRE exam, which attempts to evaluate your quantitative, verbal, and analytical abilities. Some will require that you take the biology exam as well. Check with the prospective school or department to be sure.

Your score on the GRE will often be more important than your GPA because there is some belief that GRE compares students on a more equal footing than a GPA. A high score on the GRE can make up for a low GPA (or sometimes vice versa). Note that, like the GPA, most schools will have a cut-off or minimum acceptable score. Some guides to graduate schools or information provided by the university will specify acceptable scores, or the average scores of recently admitted students. Remember, however, that these are usually just targets, and students with lower scores are often admitted, so if you really want to go to Stanford, you might as will give it a try.

3. *Study for the GRE.* When you study for the GRE, you should at the very least purchase one of the many preparation guides available at local bookstores. Practice taking the test under the actual conditions of the exam until you feel comfortable with the format of the test, the speed at which you should work to finish each section, and the overall length of the test from start to finish. At most, if you can afford it, consider taking a formal course on preparing for the GRE (e.g., Kaplan) or check to see if your undergraduate institution offers free help and instruction on preparing

for the GRE. Studying and practicing for the GRE has been shown to significantly increase your score! Note that some universities and other funding agencies award multiyear fellowships and scholarships based on your performance on the GRE, so even a modest improvement in your score at the high end may help you qualify for one of these awards.

4. *Hang in there.* Overall, if your grades and GREs are both relatively low, but your ultimate goal is a Ph.D., do not despair. Consider trying to find a quality Master's program where your chance for admission might be higher. In a Master's program, you can conduct interesting research and demonstrate directly that you have the skills required to pursue a Ph.D. A quality Master's thesis, along with enthusiastic letters of recommendation, can more than make up for relatively low GRE scores and a mediocre GPA.

II. Prelude 2: Gaining experience

1. *Start doing or participating in actual scientific research early.* Know that classes are only one part of your education. You should begin to obtain real hands-on research experience as early as your sophomore year. *Research is the most important thing you can do to prepare yourself for graduate school* because it will teach you not only how to do research, but whether you like research and if so, what areas of research you enjoy the most. Try to obtain research experience by finding a graduate student or faculty member who is doing interesting work, and see if you can:

a) Volunteer.

b) Work as a paid field or laboratory assistant.

c) Conduct independent research (field or laboratory research project).

d) Conduct an independent study (library project that will require reading in the primary (journal) literature).

A note of caution is due here. Do not do any of these things if you are just trying to fill out your resume. You should be genuinely interested in the research project. If you are not, it will end up being a bad experience for you and the researcher. Overall, look around and try to find a lab that is doing research that interests you.

2. *Participate in a scientific meeting.* After gaining experience by one of the above means, try to attend and, if possible, present a paper or poster at a scientific meeting. A paper is usually a short 12-minute oral presentation of your research, while a poster displays your research with text and figures. There are many possible scientific meetings to choose from, beginning with more local meetings that are often sponsored by state-wide scientific academies, to national meetings such as the Ecological Society of America's meeting held annually at different locations around the US. Ask graduate students and professors for advice on which meetings to attend and see if you might be able to go along with them.

Even if you do not have independent research to present, you should still try to attend scientific meetings. Meetings typically last 2–4 days, and consist of a series of short scientific presentations on current research by both students and professors. Meetings will give you a flavor of the type of research that is out there, give you a chance to meet prospective advisors, and probably convince you that you can do interesting research. Most of all, meetings are fun!

3. *Write and try to publish a scientific paper.* This could result from your independent research or an independent library project; it will almost always require the help of a professor or graduate student. Do not think that this is beyond your ability, but it will require dedication and perseverance. Nothing impresses a prospective advisor or graduate school like a publication in a refereed scientific journal! This will no doubt help you get into a top program or is an excellent way to survive low GRE scores or a low GPA.

4. *Get to know your professors.* Recommendations that only include your performance in class will be considerably less influential than recommendations that evaluate your performance both in class and outside of class, conducting independent research, participating in an independent study, or working as a volunteer or paid field assistant. To gain admission to graduate school, you will need three recommendations and sometimes four. These recommendations are extremely important. Your professors are likely to be friends with, or at least acquaintances of, the professors that you are applying to work with. Potential graduate advisors will often trust the recommendation of a close colleague or scientific peer more than a GPA or GRE score.

5. *Participate in departmental events.* These could include departmental picnics or socials, undergraduate biology clubs, and perhaps most importantly, if your department has a weekly seminar series or journal club (an informal meeting of scientists to discuss recent scientific papers), by all means attend it. At first these meetings may seem boring or unintelligible, but with time, as you understand more, they will become more interesting and comprehensible.

6. *Enroll in graduate-level courses or seminars.* Do not think these courses will be over your head; often they are no more difficult than undergraduate courses. They can expose you to the flavor and tone of graduate school and will allow you to interact on a regular basis with graduate students. These courses can give you a window into the graduate school experience.

III. Applying

1. *Should you do a Master's degree first?* Graduate students at research universities typically plunge right into a Ph.D. program. However, don't turn your nose up at completing a Master's degree first. Consider completing a Master's degree if you are unsure whether you want to commit to a lengthy Ph.D. program, or if you are not sure if research is your thing. You will get much-needed experience, and will be able to choose a Ph.D. program with much greater insight.

2. *Application deadlines.* Applications are due usually from mid-December to early February for a program that begins the following September. Only a small number of programs accept graduate students in the middle of the year; thus, it is a once-a-year process!

3. *Choosing an area of research.* Identify the general area of research you would like to pursue. It should be more specific than just ecology or plant ecology. Seek advice from faculty and graduate students. Although it may be difficult, it is important to try to narrow your interests. This is also why it is important to gain exposure to different research areas as an undergraduate so that you can *begin* to narrow your interests.

4. *Selecting a potential advisor.* Identify 6–10 professors who might serve as your potential advisor in graduate school (begin by using the Internet). These should be professors who are conducting research in an area you are interested in, and at universities you are interested in attending. Do not go into this blind! Ask professors, graduate students, and anyone else you trust for advice on appropriate advisors. Your selection of an advisor is *the most important choice* you will make with regard to your graduate degree. It is almost always more important than your choice of a university. Although it may be possible to switch advisors once you enroll, switching advisors can often be awkward and politically difficult, and there may not be another professor who has an opening for a student or one who matches your research interests. Thus, choose your advisor wisely in the first place (for some advice, see *The interview* below).

5. *Selecting an institution.* Select a range of institutions in terms of quality, from major research universities to smaller colleges. You should choose at least one university where you are fairly certain of being admitted. Note: it is sometimes the case that large research universities may be less likely to accept Master's students, or that these applicants are given lower priority than students applying for doctoral programs. This varies by department and discipline, so check to be sure.

6. *Do your homework.* You should read the most recent scientific papers authored by the faculty member you are interested in working with, and find out whatever you can about this person. You will not necessarily be expected to fully comprehend these papers. Still, having a reasonable understanding of the research being conducted in the field or lab will allow you to ask better questions (during an interview, see below), make you seem more astute, and make you a better applicant. *Do not forget to do this!* The strongest applicants will be those who can discuss issues in their field of interest; these candidates will stand above the rest.

7. *The letter of introduction and resume.* Write a personal letter or send an e-mail to each faculty member with whom you are interested in working. This letter should go out well ahead of the application deadline (no later than mid-October to mid-November). In the e-mail, you should say briefly who you are, why you want to work with that person, and your background and experience. Find someone to read and edit this letter, preferably a graduate student or faculty member. In this letter, focus first on your research experience and secondarily on your academic performance. If you have research experience, give the name of the professor(s) with whom you have worked. Ask specifically whether the prospective faculty advisor will be taking on any students in the next academic year. This letter should be limited to one page. Include a resume or Curriculum Vitae (a long resume used in academics) at the end of the e-mail or appended to the letter. Ask advisors, graduate students, or faculty about how to construct a resume or Curriculum Vitae, or contact your placement office.

8. *The follow-up letter.* When you hear back from your initial letters of inquiry, follow whatever recommendations or advice they give you in the letter. If you do not hear anything, follow up your inquiry about 3 weeks later with a short and polite e-mail asking if they received your initial inquiry, and if so, whether they would consider you as a prospective graduate student. Faculty may be out of town for extended periods, so you might consider calling the department secretary, and inquiring about that faculty member's whereabouts.

9. *The interview.* Hopefully some of the professors you contacted will be interested in you. Prior to being accepted, arrange a trip to any and all institutions you can afford to visit. Some universities will have money to fly in excellent prospective candidates for an interview. Wear clothes that are nice but casual. To get into many programs, and for you to evaluate the program, *an interview or informal visit is extremely important.* This visit or interview will:

a) Let you know if you want to work with this person. Major personality differences between a student and an advisor can become a disaster. Ask yourself what you want in an advisor. While at the interview, ask yourself the following questions: Can I get along and work comfortably with this person? How does this person currently interact with their students (regular lab meetings, daily guidance, moderate guidance, total independence)? Have past students done well? Did past students publish their research in good journals? Are students finding jobs on completion of their degree? How are students supported financially (part time teaching, research assistantships, Pizza Hut? see *Financial support* below).

Ask the graduate students what they think of their advisor and of the program in general. Get individual graduate students alone, one on one, so they can tell you what they really think, and so there is less fear that this information will leak out. Ask them if they had to do it all over again, would they? Remember, your selection of an advisor is *the most important choice* you will make with regard to your graduate degree. In general, if the graduate student population is excited and enthusiastic about their advisors and the program, then you have probably found a great place. A note of caution is in order here: many graduate programs will have a small number of disgruntled students who are often vocal and overly negative. Make sure you gauge the graduate population and program as a whole and not the sour comments of a few unhappy students. Nonetheless, a general negative tone from the graduate students is a bad sign.

b) Let the prospective advisor, graduate students, and laboratory personnel evaluate you and decide whether they want you hanging out in their lab. Note that current graduate students will likely have input into the decision on selecting new students. Additionally, you will likely meet with other faculty who will often have a say or vote in graduate admissions. Thus, before your interview, you should read up on the other most relevant faculty and their research interests. Reading some of their recent publications is highly recommended.

c) Allow you to inquire further about the program. You may want to ask such questions as: how many courses are required for the degree? How reasonable are the exams and hurdles associated with the degree? Graduate students are an excellent source for this information, but remember to query as many students as possible. A trip to the local pub may be helpful here.

10. *The application packet.* Fill out the application completely and type it. Make sure you get it in on time. Note that universities charge a fee to apply ($25–100). Most application packets will include an application form that will typically require you to write an essay about your goals or reasons for wanting to pursue a graduate degree. Consider your goals carefully and remember that most faculty are looking for committed, mature students, who will make research their priority. Generally, the more specific you can be in the essay the better. It is important to demonstrate that you have knowledge in the research area you hope to pursue.

11. *Recommendations.* You will need to secure three and sometimes four recommendations. These recommendations should come primarily from faculty, but one may also come from senior graduate students or job supervisors. Choose people who know your abilities both inside and outside the classroom. Ask each person if they are willing to write you a positive letter of recommendation (most will be quite frank). After choosing which programs to apply to, give each reference a brief description of your goals and interests, a copy of your resume, any forms they are required to fill out (typically, there is a formal recommendation form), and stamped envelopes addressed to each institution. Give them this information all at once and well before the application deadline (at least 3–4 weeks). Overall, these materials will allow your references to write a detailed and personal letter and get them in on time. Faculty can be notoriously bad about getting recommendations in on time. It is your job to insure that individuals who are writing your recommendations actually send them in. *Double check* this, preferably by contacting the universities you are applying to, not by asking the faculty member. If the letters have not arrived by close to the due date, contact the faculty member with an e-mail, phone call, or personal visit and request that they send the letter ASAP.

12. *Financial support.* Most institutions offer financial support in the form of Teaching Assistantships, Research Assistantships (sometimes provided directly by the professor), and Fellowships. This support often comes with full tuition remission (i.e., school is free) and a modest but usually livable salary in exchange for conducting research or teaching. A fellowship typically includes a salary and tuition remission with relatively few strings attached. The National Science Foundation offers prestigious 3-year fellowships that you can apply for in the year prior to enrolling or in your first year of graduate school (see <http://www.ehr.nsf.gov/EHR/DGE/grf.htm>). Find out whether you are likely to be awarded financial support upon admission. If so, what kind? Support can vary dramatically among institutions in terms of the actual amount of the salary, whether the salary comes with tuition remission, and how long the support will be guaranteed (from no guarantees to 5 years or more). *Find out the facts regarding your support!* Other questions to ask include: Will there be support during the summer and is there funding for graduate student research? Graduate students enrolled in the program are often a good source of information about whether the financial support is reliable and also livable. Support of $15,000 a year goes a long way in Beaumont, but not so far in New York City.

13. *Accepting an offer.* Once you have decided that a program is right for you, call them to accept their offer and send them a written acceptance. Do not accept an early offer as a “back-up” in case your preferred school declines your application; your acceptance means you agree to attend that school. If a deadline is approaching at one school and you still have not heard from other schools, call and see if you can obtain an extension.

14. *Declining an offer.* Once you have crossed a school off your list or have accepted an offer from another school, immediately contact the other schools and let them know you plan to go elsewhere. Write a short e-mail to each faculty member with whom you interviewed, thank them for considering your application, and let them know where you decided to enroll. Do not forget this simple courtesy; it will save you embarrassment when you run into them at scientific meetings. Additionally, there are students on waiting lists who will appreciate your timely decisions regarding these matters.

IV. Some concluding remarks

1. *Thoughts from a successful graduate student.* When I gave this to a number of graduate students to critique, one had this insightful commentary. Tell prospective students that “Graduate school is not for everyone. It is hard work at low pay,

and the few jobs available at the other end offer hard work at low pay. Do not go to graduate school because you like school; graduate school is very different from the undergraduate experience. Sometimes the choice not to go will be the right choice and send you off on an alternative and rewarding path." This is sound advice.

2. *Get advice from others.* Overall, this is just a primer on applying and getting accepted into graduate school. It reflects primarily my opinion and experiences. Seek out additional advice from professors, graduate students, and advisors. Procedures and strategies on admission can vary from one institution or discipline to another.

3. *Thrive in grad school and dodge the train.* Remember, you are trying to go from one who consumes knowledge to one who produces it. Make research your priority. Know that for every Ph.D. student, there *is* light at the end of the tunnel, but for many, that light will be the headlights of an oncoming train. To help yourself avoid the train, the following two articles are highly recommended and have been read by hundreds of graduate students.

Stearns, S.C. 1987. Some modest advice for graduate students. ESA Bulletin **68**:145–150.

Huey, R.B. 1987. Reply to Stearns: some acynical advice for graduate students. ESA Bulletin **68**:150–153.

These two articles offer a pithy and provocative exchange on how to be a successful graduate student. They each offer humorous advice and sage wisdom. *They should be read by all beginning graduate students.* For a lengthy and more formal treatise on surviving and thriving in graduate school, see: *Getting What You Came For: the Smart Student's Guide to Earning a Master's or a Ph.D.* Robert L. Peters, Noonday Press, 1997.

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Research Productivity and Reputational Ratings at United States Ecology, Evolution, and Behavior Programs

> *Reputation is an idle and most false imposition; oft got without merit, and lost without deserving.*
> —Shakespeare

It is well known that the reputation of a research program has a major impact on its ability to attract top-caliber graduate students and faculty, to secure external funding from federal agencies, and to compete for resources within universities (Roush 1995). In 1995, the National Research Council (NRC) published a survey (Goldberger et al. 1995) of reputational ratings for 41 research fields at Ph.D.-granting universities in the United States. Included in this survey was a reputational rating of 127 Ecology, Evolution, and Behavior (EEB) programs across the US. One of the main stated objectives of the NRC survey was to "permit analysts to extend their work on the nature of 'reputational ratings' or the opinions of faculty peers about a program." This analysis will discuss the broader interpretation of the NRC ratings, and specifically, how these ratings relate to research productivity at the 63 top-rated Ecology, Evolution, and Behavior programs in the United States.

In the original NRC ratings, considerable discussion was devoted to the meaning of "reputation" and factors that might bias ratings. Authors of the NRC report were acutely aware that many factors besides the actual quality of a program might influence its NRC reputational rating. An important assumption of the NRC survey is that a program's reputation is related to its scholarly productivity. It was also clear from prior NRC reputational surveys that the size of a program is often correlated with its reputational rating. There are a number of fair and perhaps unfair reasons why this is generally the case (Goldberger et al. 1995). Other factors that might influence or bias a program's NRC rating include the presence of "stars," or "visibility," and the overall reputation of the university. Highly prestigious universities "may cast a 'halo' over [programs] which do not merit as lofty a reputation" (Goldberger et al. 1995).

Toutkoushian et al. (1998) recently published a general analysis of the NRC ratings across most research fields using data published in the NRC assessment. Their study found that NRC reputational ratings are positively correlated with the size (e.g., number of faculty) and per capita productivity (publications per faculty) of programs across all research fields. There is also a strong tendency for programs located at private and at prestigious universities to have substantially higher reputational ratings than expected based on their size and productivity alone. By comparing the ratings for fields examined in both the 1982 (Jones et al. 1982) and 1995 (Goldberger et al. 1995) NRC reputational assessments, Toutkoushian et al. (1998) found that program reputations change quite slowly; the best predictor of a program's 1995 reputational rating was its 1982 rating. (EEB was not one of the fields assessed in the 1982 survey.) The 1995

NRC survey found the assessments of program faculty quality (e.g., reputational rating) and program teaching/training effectiveness were generally very highly correlated (r^2 = 0.90). Toutkoushian et al. (1998) concluded that this was because reviewers had insufficient information to judge the teaching effectiveness of programs, and thus gave very similar assessments for reputation and teaching effectiveness.

In this study, we will examine how an independently derived measure of EEB program scholarly production correlates with reputational ratings. This measure of scholarly productivity was obtained by searching the electronic database BIOSIS for EEB publications in 226 EEB journals during 1988 to 1997 (see Fig. 1). Our analysis was restricted to the top-rated 50% of EEB programs in the United States (i.e., the top 63 programs). This literature search produced a productivity database with > 24,000 EEB journal articles. We also compared NRC reputational ratings to the size of programs, the university's overall reputation, whether the university was private, the average quality of journal articles, the number of program faculty who were members of the National Academy of Sciences, and change in program productivity during the period 1988–1997.

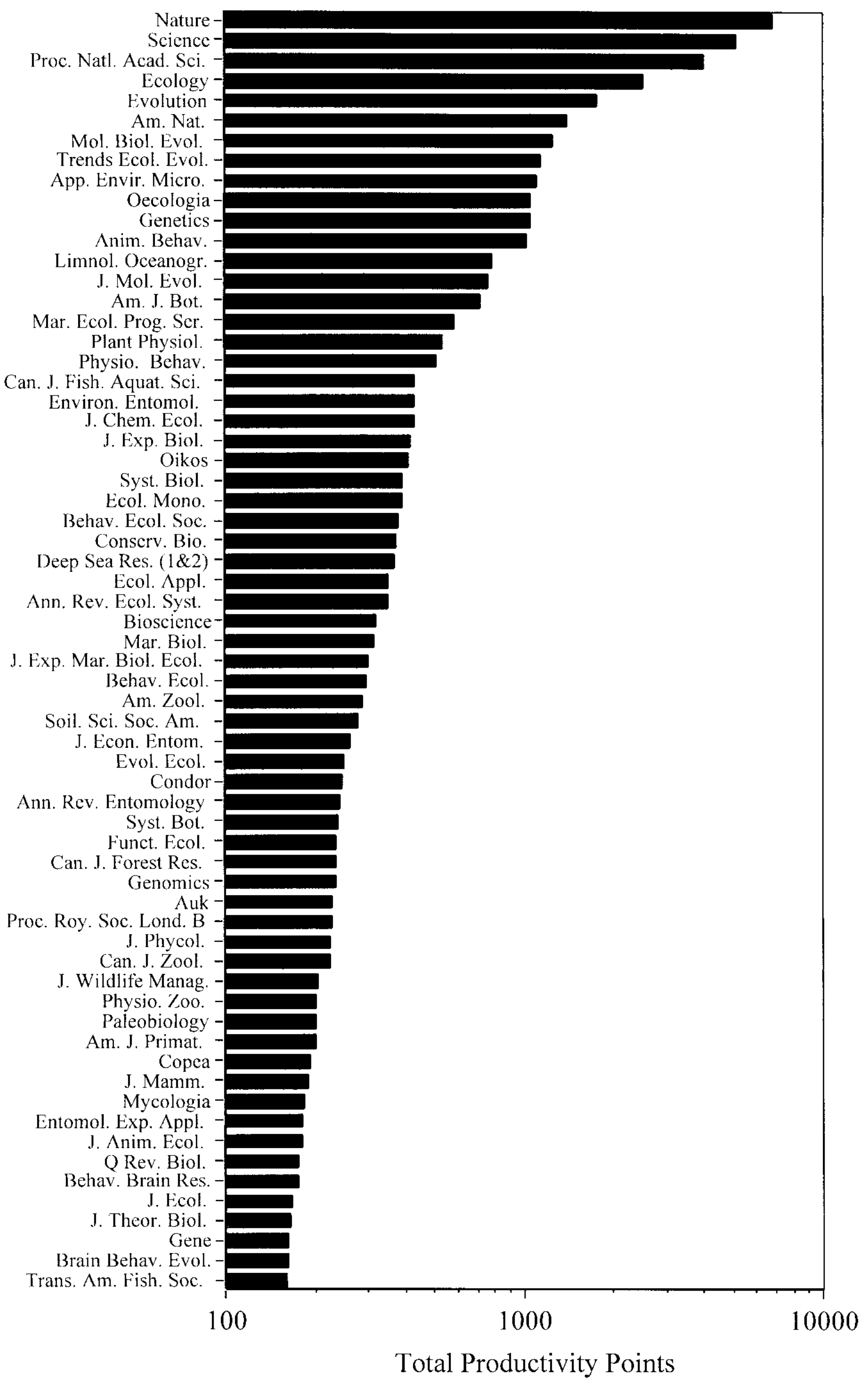

Fig. 1. Contribution of the top 64 journals of the 226 Ecology, Evolution, and Behavior (EEB) journals used in this survey to our measure of program productivity. The journals encompassed 85% of our entire sample of EEB scholarly production at the top-rated EEB programs.

Methods

Compilation of data

A more detailed description of our methods and the journals included in this analysis can be found at: <http://www.ce.washington.edu/NRCEEBsurvey.htm>.

The program reputational ratings used for our analysis were obtained from the NRC report by surveying approximately 100 reviewers per program, with each reviewer asked to rate the programs on a 0–5 scale (0 equal to low and 5 equal to high quality). Measures of uncertainty in NRC ratings for each program were also taken directly from the report. The overall NRC rating for universities included in this analysis was calculated as the median program percentile for all programs rated in the NRC survey at that university.

Our measure of publication productivity was calculated as the total number of publications in EEB for the period 1988–1997, weighted by the impact factor of each journal. We searched the electronic database BIOSIS for 226 EEB journals using a series of "affiliation" searches for each program. The NRC's measure of program productivity was calculated by multiplying the reported number of faculty in the NRC report by the ratio of publications per faculty in the NRC report. The number of program faculty was taken directly from the NRC report. The number of program faculty in the National Academy of Sciences Section 27 (Population Biology, Evolution, and Ecology) was compiled for each institution included in this survey. We calculated per capita productivity by dividing our measure of program productivity by the number of faculty. Change in the program's productivity was assessed by comparing our measure of program productivity for the periods 1988 to 1992, and 1993 to 1997.

The percentage productivity points from papers published in *Nature, Science,* and *The Proceedings of the National Academy of Sciences* was calculated as the portion of total productivity attributable to these journals. The average journal article quality was calculated as our tally of scholarly productivity divided by our tally of journal articles. We also calculated a Shannon's diversity index for the publication productivity data.

We compiled indices of program strengths for 21 subdisciplines (e.g., evolution, animal behavior, marine biology, entomology, ornithology, conservation biology, etc.) of EEB by totaling the number of productivity points within these categories for the various specialty journals. These indices were compiled by totaling the productivity for journal articles representing that subdiscipline and not by compiling actual papers from that subdiscipline. For example, if a paper on birds was published in a conservation biology journal, the program would be credited with productivity points in conservation biology, and not ornithology.

Analyses of data

First, we compared each of the main parameters described above against the NRC reputational ratings. Then, we developed a multivariate regression model to predict program NRC reputational rating. This was done by regressing one form of each of the major predictor variables against the NRC ratings. For scholarly productivity, we used our measure of scholarly output. For faculty size, we used the log-transformed (to normalize the distribution) count of total faculty as reported in the NRC report. For journal article quality, we used the average quality parameter. We also used log-transformed change in productivity, number of program faculty in the National Academy of Sciences, and whether the program was located at a private or a prestigious university. To avoid the most obvious collinearity problems, we did not include different versions of similar variables in our analysis (e.g., productivity, our measure of publications, and the NRC measure of publications).

Results and discussion

Scholarly productivity at U.S. EEB programs

Fig. 2 depicts the total scholarly productivity for 63 top-rated EEB programs in the United States. The five most productive EEB programs are located at UC Davis, Cornell University, UC Berkeley, UC San Diego, and the University of Georgia. This histogram shows that a few programs stand out as being much more productive, but many EEB programs have similar productiv-

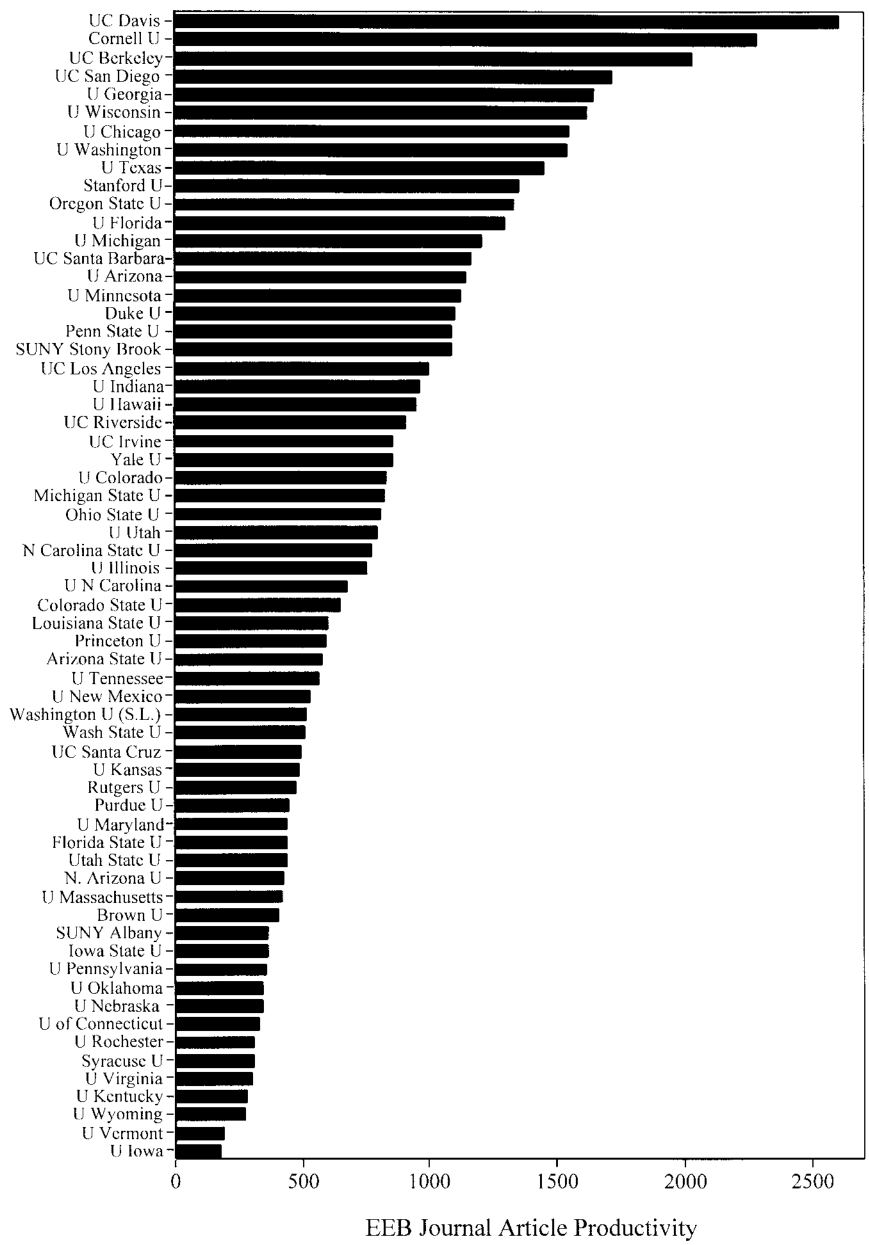

Fig. 2. Journal productivity (number of articles) at the top-rated 63 Ecology, Evolution, and Behavior programs.

ity. Table 1 lists these and other statistics for the top-rated 63 programs.

Correlation matrix of predictor variables

A correlation analysis of predictor variables against NRC reputational ratings shows the single best predictor of a program's reputational rating was our measure of EEB program scholarly productivity, $r^2 = 0.59$; see Table 2. A simple tally of EEB publications (unweighted for impact) had a substantially weaker association with the NRC ratings, $r^2 = 0.41$. The NRC report's tally of EEB publications had a much weaker association with the reputational ratings, $r^2 = 0.18$.

Table 1. Various statistics for the 63 EEB programs examined in this analysis.

University	Publication Productivity	NCR Rating	Overall Rating	Type	Faculty	NAS Members	Article Quality	Change in Prod. (%)	NAS/Our Publications	Top 10 Subdisciplines
UC Davis	2605	4.42	37	Public	197	3	2.13	16	1.73	17
Cornell U	2282	4.44	16	Private	92	1	2.27	15	1.22	12
UC Berkeley	2029	4.29	7	Public	57	1	2.53	-8	0.72	9
UC San Diego	1719	3.82	16	Public	39	0	3.13	-1	0.74	4
U Georgia	1650	3.87	55	Public	84	3	1.94	26	1.14	13
U Wisconsin	1616	4.18	25	Public	90	1	2.03	50	1.40	15
U Chicago	1549	4.51	13	Private	30	0	3.91	-23	0.69	3
U Washington	1540	4.30	28	Public	41	4	1.97	17	0.50	10
U Texas	1453	4.12	24	Public	54	0	2.30	0	0.65	9
Stanford U	1351	4.51	14	Private	10	4	3.49	-8	0.65	4
Oregon State U	1335	3.74	56	Public	127	1	1.81	-2	1.29	9
U Florida	1301	3.57	47	Public	45	0	1.77	-29	0.56	12
U Michigan	1206	4.10	20	Public	52	2	2.00	-28	0.71	8
UC Santa Barbara	1165	3.81	39	Public	28	0	2.53	11	0.75	2
U Arizona	1143	3.80	35	Public	26	1	2.07	43	0.31	7
U Minnesota	1126	3.88	32	Public	66	2	2.19	17	1.17	6
Duke U	1102	4.49	27	Private	62	2	1.89	-8	1.00	6
Penn State U	1091	3.60	40	Public	93	2	2.60	26	2.29	3
SUNY Stony Broo	1090	4.12	40	Public	29	2	2.51	-10	0.71	3
UC Los Angeles	996	3.82	20	Public	41	2	2.59	-20	1.28	4
U Indiana	960	3.49	38	Public	27	0	3.01	-7	0.71	2
U Hawaii	950	2.94	62	Public	64	1	2.32	-25	0.78	2
UC Riverside	910	3.60	51	Public	26	2	1.99	4	0.52	2
UC Irvine	858	3.77	29	Public	21	2	2.96	30	0.88	2
Yale U	857	3.83	16	Private	59	1	3.01	-29	3.48	4
U Colorado	832	3.46	43	Public	38	0	2.20	-19	0.81	2
Michigan State U	825	3.41	48	Public	39	0	2.08	18	1.06	3
Ohio State U	808	3.27	41	Public	105	0	1.96	-35	1.36	4
U Utah	796	3.65	47	Public	16	0	3.12	-17	0.46	0
N Carolina State	772	3.20	43	Public	75	0	1.86	-35	1.44	4
U Illinois	754	3.52	29	Public	74	2	2.25	-33	1.72	1
U N Carolina	674	3.33	34	Public	28	0	2.64	1	0.69	0
Colorado State U	647	2.99	53	Public	17	1	1.41	18	0.35	4
Louisiana State U	598	2.91	65	Public	74	0	1.35	-19	1.36	3
Princeton U	590	4.34	9	Private	11	0	2.84	30	0.31	1
Arizona State U	579	3.41	51	Public	32	0	1.87	12	0.82	2
U Tennessee	563	3.35	68	Public	61	0	2.22	5	1.65	1
U New Mexico	529	3.24	37	Public	30	0	2.33	-12	0.96	0
Washington U (S.	516	3.94	36	Private	24	0	2.55	50	2.20	2
Wash State U	511	3.37	65	Public	84	0	1.92	-10	4.03	0
UC Santa Cruz	494	2.93	45	Public	11	0	2.46	5	0.49	1
U Kansas	487	3.46	60	Public	46	1	1.87	-25	0.93	0
Rutgers U	475	3.60	36	Public	39	0	1.74	9	1.86	2
Purdue U	450	3.10	31	Public	34	0	1.71	-20	0.96	1
U Maryland	443	3.28	44	Public	70	0	1.89	75	3.08	0
Florida State U	443	3.41	58	Public	16	0	1.52	-24	0.37	1
Utah State U	442	3.39	79	Public	70	0	2.29	-26	1.44	1
N. Arizona U	424	3.35	87	Public	22	0	1.98	3	0.91	1
U Massachusetts	420	3.39	46	Public	65	0	1.44	36	1.76	1
Brown U	406	3.30	32	Private	11	0	2.37	81	0.59	0
SUNY Albany	361	3.10	61	Public	8	0	3.61	43	0.50	0
Iowa State U	360	3.00	50	Public	25	0	1.59	55	0.82	1
U Pennsylvania	353	3.90	20	Private	55	1	2.15	-2	3.01	0
U Oklahoma	344	3.11	69	Public	41	0	1.71	-11	1.11	0
U Nebraska	339	2.96	70	Public	17	0	1.57	116	0.56	2
U of Connecticut	330	3.35	60	Public	28	0	1.88	-18	0.68	1
U Rochester	308	2.95	38	Private	12	0	3.22	-47	1.26	0
Syracuse U	308	3.09	55	Private	7	0	3.80	-30	0.94	0
U Virginia	299	3.14	33	Public	42	0	1.91	-4	1.97	0
U Kentucky	282	3.04	63	Public	17	0	1.50	28	1.00	0
U Wyoming	272	3.00	77	Public	39	0	1.09	4	1.33	1
U Vermont	186	3.04	63	Public	27	0	1.51	-10	1.39	0
U Iowa	175	2.94	46	Public	33	0	2.06	-46	3.22	0

Table 2. A correlation matrix of the main parameters measured in this analysis. Reported values are regression coefficients (r^2), boldface indicates that the regression was significant at the P >0.0001 level, italic indicates significance at the 0.05 level, and (-) indicates that the correlation coefficient (r) was negative.

	NRC Ratin r^2	Production r^2	Mean	SD
NRC Rating	-		3.56	0.47
Production	**0.59**	-	830	530
Log Production	**0.59**	**0.89**	2.84	0.27
Overall NRC Rating	**(-)0.47**	**(-)0.28**	42	18
Publications	**0.41**	**0.86**	379	235
Top 10 areas	**0.38**	**0.74**	3.03	4.06
NAS Members	**0.35**	**0.32**	0.66	1.05
NRC Publications	*0.18*	**0.41**	286	232
Production/Faculty	*0.17*	0.08	24	20
Private or Public	*0.14*	0.00	0.17	0.38
Percent Nat., Sci., PNA	*0.12*	0.14	28	12
Publication Quality	*0.11*	0.05	2.23	0.61
NRC Faculty	*0.08*	**0.30**	46	33
Log Faculty	*0.07*	**0.21**	1.56	0.31
Publication Diversity	0.01	0.05	3.53	0.38
Log Prod./Log Faculty	0.01	0.00	1.88	0.39
Change in Productivity	0.01	0.00	3	31

After productivity, the next best predictors of a program's NRC rating were the university's overall NRC ratings, the number of subdisciplines in the top 10, and the number of program faculty in the National Academy of Sciences. Production per faculty, whether the university was private or public, and average quality of publications had statistically significant, but moderately weak, associations with the NRC ratings. Scholarly productivity of EEB programs was correlated with the number of subdisciplines in the top 10, as well as the number of program faculty in the National Academy of Sciences, size of faculty, and the overall NRC ratings of the universities.

A multivariate model

A four-factor regression model explained 77% of the variability in NRC reputational ratings. The most important variable in this model was the publication productivity of the various programs, which accounted for 38.2% of the variability. Whether the university was private accounted for 14.8% of the variability, its overall NRC rating across all programs accounted for 12.3% of the variability, and the number of NAS members on its faculty accounted for 9.8% of the variability in the program NRC ratings.

The coefficients given in Table 3 can be converted to rank equivalencies to place these values in a more intuitive perspective. According to a regression between the rank ordering of programs and their NRC ratings, one rank in the program ordering is worth about 0.0252 points on the NRC 0–5 scale; rating = 4.37 - 0.0252 x rank, r^2 = 0.96. Thus, according to the coefficient for productivity, 500 productivity points would be worth approximately 9.2 ± 1.5 (± 1 SE) ranks. Similarly, being a private university would be worth approximately 11.3 ± 3.6 ranks. Being a moderately highly regarded university (the 25th percentile for this sample, and a median overall NRC percentile of 30) would confer a "halo" effect of approximately 6.5 ± 2.3 ranks compared to being a slightly below-average university (the 75th percentile in this sample and a median overall NRC percentile of 56). The value of having EEB National Academy of Sciences members on a program's faculty was approximately 3.4 ± 1.4 ranks per member.

Size, productivity, and quality

One of the more debated questions in the NRC assessment literature is the meaning of the frequent positive correlations between program size and reputational ratings. This relationship holds for virtually all fields assessed in the ratings (Goldberger et al. 1995). Some researchers argue that it is unfair that the ratings are generally positively correlated with the number of faculty, while others argue that size is a valid component of quality. We side with those who argue that a program with 60 strong faculty is inherently better than a program with 20 strong faculty, even if the production per faculty is similar for both programs. A program with more strong faculty has a greater opportunity for balance, variety, and specialization. However, the more interesting question is, "What do the NRC reviewers of EEB programs think about the general relationship between program size, productivity, and reputation?"

Table 3. Results of the stepwise regression of program NRC rating vs. nine program characteristics. This gave a four-variable model that explained 77% of the variation in NRC ratings.

Variable:	Coefficient	Std. Err.	t-value	P	Partial r^2
Intercept	3.33				
Productivity	0.000463	0.000077	5.99	0.0001	0.382
Private/Public	0.284	0.090	3.17	0.0025	0.148
Overall NRC Ratin	-0.00625	0.00220	-2.85	0.0061	0.123
NAS Members	0.0869	0.0346	2.51	0.0148	0.098

We addressed this question by performing a multivariate regression between these parameters. If reviewers discount programs that obtain high productivity via high numbers of program faculty and not via high faculty productivity per se, then we would find a positive association between productivity and rating and a negative association between size and rating in this multivariate analysis. Our analysis showed reviewers do tend to take a program's size into consideration; however, this tendency was weak. The coefficient for size was negative, but the improvement in variability explained over a single factor regression with program productivity as the sole predictor variable was only 2.4% (from $r^2 = 0.590$ to $r^2 = 0.614$), and the t test for the program size term was only marginally significant ($P = 0.0561$).

We examined the residuals of this two-factor regression to determine whether programs were overrated or underrated relative to their productivity and size. The six most overrated (i.e., high NRC ratings relative to their productivity and size) programs were all located at prestigious private institutions. However, not all private universities were overrated. The less prestigious private institutions were usually not overrated, and Cornell University, which is both private and one of the most prestigious universities included in this survey, was in fact somewhat underrated.

Unexplained variability

Although few researchers studying the NRC assessment would support absolutist interpretations of the NRC ratings, it is common practice for academics who have not studied them to ask questions like "Why didn't our department crack the top 10? We are just as good or even better than several of the programs rated ahead of us." As discussed previously, there are a number of reasons why one program might be more highly rated than another. The average standard error for the NRC ratings of the top 63 programs was ± 0.23 ratings points. Thus, if this survey were conducted twice using similar pools of reviewers, a program's final mean rating would be expected to vary by approximately ± 9 ranks simply due to luck in the draw of reviewers. Coincidentally, the residual unexplained variability in the multivariate regression analysis was also ± 0.23 (± 1 SD), or ± 9 ranks. Based on these results, it should be clear that the NRC rating may simply be too coarse to justify fine-scale interpretations.

Summary

This analysis of the National Research Council's assessment of reputation at Ecology, Evolution, and Behavior programs provides insights that should aid those attempting to decipher the broader meaning of these ratings. Our measure of total program productivity also provides a new parameter by which those interested in EEB programs can judge their "quality."

Reassuringly, the single best predictor of a program's reputational rating was its research productivity in scholarly journals. This result suggests more detailed analyses of program productivity as provided in this analysis may be warranted when assessing the quality of various research programs across the U.S. Although our assessment of total EEB scholarly productivity was quite time consuming, we assume economics of scale would apply if this were attempted on a broader scale, such as during the next round of NRC reputational assessments.

On the negative side, our study provides strong evidence that the reviewers polled in the NRC survey were biased in favor of private or otherwise highly regarded universities, and especially highly regarded private universities. This result is virtually identical to that obtained in an overall analysis of the factors influencing the NRC reputational ratings across all programs. To quote Toutkoushian et al. (1998), these "results seem to say that faculty form their impressions of 'good' and 'bad' programs based on many factors, some of which are related to underlying quality and others of which clearly are not." The bias in favor of prestigious private universities will presumably have a negative impact on the opportunities afforded EEB programs at less prestigious public universities. It may be more difficult for these programs to compete for the best graduate students, postgraduate researchers, and faculty, as well as for research funds in national competitions like solicitations to the National Science Foundation.

The substantial unexplained variability in our analysis and uncertainty in reviewer assessment of program quality suggests that these ratings are not wholly deterministic, and they should not be interpreted too literally. It is quite likely that the rightful position of a specific program in the hierarchy within a field of research may be 10+ ranks higher or lower than one might expect based on the NRC ratings. This result is consistent with those who have argued that the NRC ratings should only be seen as broad indices that distinguish between the truly outstanding, the average, and the marginal research programs (Mac Lane 1996, Stigler 1996).

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Incentives for Prompt Reviewers

I am sympathetic to Mack's (1999) complaint about tardy reviewers—I have been a frequent victim of them myself, and in my darkest moments have also thought that tardy reviewers should be somehow singled out in the list of reviewers. However, all of the editors I discussed this with echoed Baldwin et al.'s (1999) response: stigmatizing tardy reviewers might make it even harder to find willing reviewers. Most editors know which reviewers tend to be tardy, but in many specialized subdisciplines, the choice is often between a tardy reviewer and no reviewer at all.

I propose that instead of punishing tardy reviewers, ESA develop incentives for prompt reviewers. Rewards for reviews are not unprecedented: for example, the Proceedings of the Royal Society sends reviewers a certificate worth some number of free reprints of the next paper they publish in that journal. A reward that would be both appropriate and valuable to the reviewers, and would not cost ESA any money, would be to provide publication priority to the prompt reviewer's next *n* submissions to an ESA journal. In other words, at each stage of the publication process, a prompt reviewer's manuscript would be moved ahead of earlier submissions that were not by prompt reviewers.

As usual, the devil is in the details. How large should *n* be (probably 1, but possibly more)? Should the priority apply only to first-authored manuscripts, or to any manuscript on which the prompt reviewer is an author. (If the latter, then perhaps the prompt reviewer should be given a choice about which manuscript to apply the priority to?) Should the prompt reviewer's manuscript be moved ahead of all other manuscripts, or merely be advanced a certain number of places in the queue? A problem may also arise where a reviewer dashes off a prompt but contentless review solely to receive the incentive—in which case a minimal standard for review quality may become necessary (but I hope that most of us are not that cynical about reviews). If successful in achieving its goals, the incentive faces a new set of problems: when most submitters are prompt reviewers, then papers by nonreviewers (including most students) will languish forever. This might require a modification such that a given paper can be trumped by a prompt reviewer only a certain number of times, with greater protection for student papers.

Nevertheless, I think that these details could be worked out, perhaps through an adaptive management program. The incentive would have an added bonus: the only way to be a prompt reviewer is to be a reviewer, so more individuals will be willing to review ESA manuscripts and contribute to the publication process.

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The Succession of Succession: A Lexical Chronology

The following essay is an expansion of remarks at a Celebratory Symposium, 9–10 April 1999, marking the 100th anniversary of the publication of Henry Chandler Cowles' premier studies of succession on the Indiana dunes of Lake Michigan. The symposium was sponsored by the Field Museum of Chicago, the Indiana Dunes Environmental Learning Center, the Indiana Dunes National Lakeshore, and Chicago Wilderness. It was supported by a major grant through the will of A. Watson Armour.

Recognition of change in nature was long familiar to naturalists, but the term *succession* was coined by H. D. Thoreau to describe the changes in forest trees (Thoreau 1860). Like the word *ecology*, coined in 1866, *succession* lay fallow until they were both resurrected in the late years of the 19th Century (McIntosh 1985). The major concepts of early ecology were community, development, or succession, and stability, or climax, the end of change. Ecologists strove to identify and classify communities in space, and the corollary was to examine change of a community in time, determine what stages it went through, and if, and when, it became stable or climax. Henry Chandler Cowles, one of the first exposi-