Academic Institutions in the United States and Canada Ranked According to Research Productivity in the Field of Conservation Biology

Introduction

Conservation biology is a young, but quickly maturing, scientific discipline currently under much scrutiny (Meine et al. 2006). Recent studies highlight what conservation biologists publish (Fazey et al. 2005*a*), who publishes in the field (Fazey et al. 2005*b*; Harrison 2006), and where and in what systems conservation research occurs (Lawler et al. 2006). At the same time conservation biology has been criticized for its inability to rapidly disseminate (Kareiva et al. 2002) and communicate (Fazey et al. 2004) research results and for how poorly its research has tracked conservation priorities over time (Lawler et al. 2006). Furthermore, and possibly because the field is still young, graduate programs in conservation biology have not been ranked "by a disciplinary organization such as the Society for Conservation Biology, a governmental panel such as the National Research Council, or even a private effort such as that of the magazine *U.S. News and World Report*" (Inouye & Brewer 2003). One reason for this lack is the interdisciplinary nature of conservation biology research and training (Jacobson 1990), which typically results in researchers being scattered across several units, instead of centrally located within a single "department" of conservation biology. Consequently, quantitative rankings must be developed for institutions as a whole.

Quantitative indices based on numbers of publications and their citations continue to serve as the universal yardstick by which institutional research productivity is judged. Such indices include the highly publicized rankings of doctoral programs by the National Research Council (Goldberger et al. 1995) and the recently released Faculty Scholarly Productivity Index by Academic Analytics (2007). Well-established disciplines, such as economics, use standard methods to rank institutions according to journal-specific tallies of faculty publications within a set time period (e.g., Laband 1985; Dusansky & Vernon 1998) and citation counts of published research (e.g., Davis & Papanek 1984). To date, quantitative rankings based on these criteria do not exist for conservation biology (Inouye & Brewer 2003).

Ranking institutions by conservation biology research productivity serves a variety of purposes. First, administrators find measures of productivity important in managing and promoting their institutions. A ranking system provides a means of evaluating an institution's research performance, tracking its magnitude and rate of change over time, and comparing it against peer institutions. Second, the increasing number of students attracted to conservation biology (Orr 1999) would find a ranking system useful when seeking an education and future employment. Third, the rankings would be of great utility to conservation groups, land trusts, nongovernmental organizations, federal agencies, employers of conservation biologists, and others in need of conservation research expertise. We argue that a ranking of institutions according to the strength of their conservation biology research is an important contribution to maturation of the field.

We constructed the first comprehensive ranking of U.S. and Canadian academic institutions based on their relative contribution to the field of conservation biology. We quantitatively ranked the scholarly productivity of 315 universities and colleges from 2000 to 2005 according to their researchers' publication rate in leading conservation journals, citation rate of those publications, and scholarly productivity as measured by the Hirsch (2005) *h* index. We also explored how trends in research productivity have changed in the top-ranked institutions over the past 15 years. Our results provide a clear picture of the quantity and quality of conservation biology research performed at institutions across the United States and Canada and the

Paper submitted February 15, 2007; revised manuscript accepted May 7, 2007.

Conservation Biology Volume 21, No. 5, 1139–1144

DOI: 10.1111/j.1523-1739.2007.00762.x

extent to which the field has grown in recent years.

Methods

Few institutions have accredited conservation biology programs, and researchers engaged in conservation biology are often dispersed throughout multiple departments. Therefore, we developed a comprehensive list of universities and colleges (collectively called institutions) in Canada and the United States with personnel (faculty, staff, graduate and undergraduate students) where research encompasses topics that are publishable in peer-reviewed conservation biology journals. To create this list, we searched Peterson's Guide to Graduate Schools (2006) for the terms *botany*, *conservation biology*, *ecology*, *environmental sciences*, *evolutionary biology*, *fish, game and wildlife management*, *forestry*, *marine biology*, *marine sciences*, and *zoology*. To minimize mistaken omission of institutions, we also added institutions that Romero and Jones (2003) and Wikipedia (2006) identified as offering "biology/ecology/conservation" programs.

We used the Institution for Scientific Information's Web of Science (Thomson Scientific 2006) to compile a list of peer-reviewed papers published by researchers at each of the 315 institutions in six leading conservation journals between 2000 and 2005. These journals included (2005 impact factor in parentheses): *Biodiversity and Conservation* (1.4), *Biological Conservation* (2.6), *Conservation Biology* (4.1), *Ecological Applications* (3.8), *Environmental Conservation* (1.5), and the *Journal of Applied Ecology* (4.6). All papers published were considered in our analysis. This resulted in a collection of conservation biology–oriented publications in which at least one coauthor was affiliated with the institution when the paper was written. We selected the citation period to span the past 6 years so as to focus on present-day scholarly productivity of conservation programs. Next, we calculated three metrics of research performance for each institution: (1) the total number of publications; (2) the total number of times those publications were cited; and (3) Hirsch's *h* index.

Hirsch's (2005) *h* index is a proposed bibliometric measure of productivity, based on a scientist's publication activity and citation impact, that has a number of distinctive advantages over classic measures such as the total number of articles, total number of citations, or number of citations per article (Chapron & Husté 2006). We used it to judge the scholarly productivity of a group of individuals in a single institution (Kelly & Jennions 2006). The *h* index was calculated by ordering the list of all publications from an institution by the number of times they were cited. We then noted the highest-ranked publication for which the number of citations was equal to or greater than its rank. For example, if an institution's 10th most cited article was cited 10 or more times but its 11th most cited article was cited 10 or fewer times, the institution would have an *h* index of 10. Although the *h* index is not the definitive metric for ranking the scientific quality of researchers or journals (Kelly & Jennions 2006), it does provide a powerful indicator for ranking groups of researchers that accounts for both the productivity and impact of high-quality scientific papers (Hirsch 2006; Lehmann et al. 2006).

We ranked all institutions first by their *h* index, with ties broken by the number of publications produced by each institution's researchers and if necessary by the number of citations resulting from those publications. Next we examined the distribution of scholarly productivity across institutions and at the level of states and provinces.

We calculated the *h* index based on articles published between *x* and 2006 (where *x* equaled 1990 to 2006 by increments of 1 year) to assess changes in research productivity over time for the top 10 institutions. For example, for the year 1993 we calculated the *h* index over the 13-year period 1993–2006. The incrementally increasing time period reflects the fact that an institution's scientific quality is based on its cumulative publication record over time. Given that the *h* index of an institution depends on the amount of time since the pool of articles was published we calculated the *m* value (sensu Hirsch 2005) for each institution by dividing *h* by the number of years prior to 2006 (see Kelly & Jennions [2006] for a discussion of the robustness of *m*). By selecting only those articles published prior to 2003, we eliminated the inflated *m* indices of recent years (2004 and 2005) resulting from the over-influence of young scientific age of publications (J. Olden, unpublished results).

Results

Institutions employing academic personnel with the potential to perform publishable conservation biology research were geographically distributed throughout the United States ($n = 271$) and Canada ($n = 44$) (Fig. 1). The number of institutions per state or province ranged from >10 to <2.

The 40 highest-ranked institutions according to the *h* index were located primarily in the western regions of both countries (14/40) (Table 1). Researchers from the top 10 institutions all published more than 50 papers that, combined, garnered over 500 citations, and resulted in *h* indices >15. A list of all 315 institutions with their number of publications, citations, and *h* index is available on-line (http://www.conbio.org/Resources/Programs/).

The distribution of scholarly productivity across institutions was highly right skewed. In the six journals we surveyed, an average of 8.5

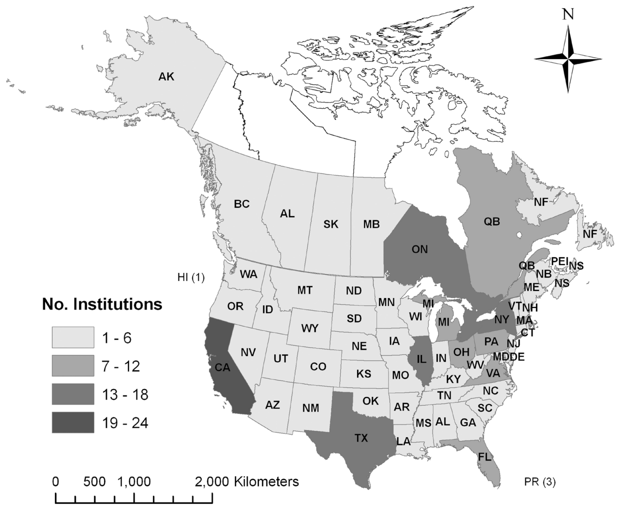

Figure 1. Geographic distribution of the 315 U.S. and Canadian institutions ranked in our study summarized by number found in each state (United States), province, or territory (Canada) (HI, Hawaii; PR, Puerto Rico). The gray scale indicates number of institutions located in each geographical unit from ≤6 (light gray) to ≥19 (dark gray). Institutions are universities and colleges with personnel (faculty, staff, graduate and undergraduate students) whose research encompasses topics that are publishable in peer-reviewed conservation biology journals.

papers were published per institution between 2000 and 2005 (range = 0–123, median = 2). Researchers at the majority of institutions (238 of 315, or 76%) published 10 or fewer papers. Personnel at over half of these institutions (122 of 238) did not publish any papers in the surveyed journals. Researchers at each of the remaining 77 institutions published over 10 papers, which were cited, on average, over 327 times. Similar results were seen in the distribution of *h* indices. Mean *h* value across all institutions was 3.4 (range = 0–20, median = 2). Seventy percent of the institutions had *h* values <5, which translates to an *m* value of <1— the value proposed by Hirsch (2005) as characterizing a successful scientist, or in this case a productive institution.

Geographic patterns of current productivity (according to the *h* index) were not randomly distributed across Canada and the United States (Fig. 2). Total productivity was highest in California, followed by Ontario, Florida, Illinois, and Québec. Relative productivity per state or province (total *h* divided by the number of institutions) was highest for Oregon (10.0), Alberta (8.0), and Montana (7.3) (Fig. 2); however, this measure favored states or provinces with lower numbers of highly productive institutions.

Productivity of researchers at the top 10 institutions followed a general trend of increase over the 15 years sampled (Fig. 3). The ranking of the top 10 institutions was consistent throughout the 1990s, but this ranking changed between 2000 and 2003. Oregon State University was consistently ranked highest for all of the 1990s, but was surpassed by University of California, Santa Barbara, and University of California, Davis, in 2001 and 2002.

Discussion

The number of U.S. and Canadian institutions offering instruction in conservation biology has expanded from 75 in 2003 (Inouye & Brewer 2003) to over 300 in early 2007 (this study; Society for Conservation Biology 2007). The number of papers submitted and published in leading conservation journals has also risen sharply in recent years (Meffe 2006). By taking publication rates into account, we provide a clear ranking of one aspect of the productivity of conservation biology researchers in the United States and Canada. Although many institutions in other countries provide education, training, and research opportunities in conservation biology, we limited our study to the United States and Canada because databases for these institutions were readily available to us and because our target set of journals was geared primarily toward English-speaking researchers.

Although the strength of conservation biology research at an institution may be expected to reflect the size and productivity of institutions in general, this is not the case. We found no correlation between the Faculty Scholarly Productivity Index of Academic Analytics (2007) and the *h* index as calculated in this study for which data were available ($R = 0.07$, $p = 0.68$, $n = 42$). Nevertheless, many of the highly ranked schools, such as Oregon State University and Colorado State University, have a rich history of applied ecological research stemming from their designation as federal land grant universities. These schools in particular have close ties to federal and state natural resource–based agencies, as evidenced by their interactions with researchers at several U.S. Geological Survey, U.S. Department of Agriculture Forest Service, and U.S. Environmental Protection Agency laboratories. The close proximity of federal laboratories in these three university

Table 1. Top-40 academic institutions ranked according to their conservation research productivity (Hirsch's *h* index and total number of publications and citations) in the field of conservation biology.

	Publications		*Citations*		h *index*	
Institution	*total*	*rank*	*total*	*rank*	*value*	*rank*
Oregon State University	95	2	1089	1	20	1
University of California, Santa Barbara	62	8	943	4	20	2
University of California, Davis	123	1	1031	2	19	3
University of California, Santa Cruz	53	12	749	9	18	4
University of Wisconsin, Madison	70	5	995	3	17	5
University of California, Berkeley	70	6	651	11	17	6
University of Washington, Seattle	79	3	763	7	16	7
Colorado State University	72	4	719	10	16	8
Duke University	60	9	788	6	16	9
Stanford University	56	11	550	13	16	10
University of Montana, Missoula	59	10	546	15	15	11
University of Minnesota, Twin Cities	45	14	496	18	15	12
University of Georgia, Athens	42	15	485	19	15	13
University of Florida, Gainesville	63	7	527	16	14	14
Cornell University	53	13	549	14	14	15
University of Colorado, Boulder	32	21	519	17	14	16
University of Missouri, Columbia	30	25	421	21	14	17
University of Michigan	35	17	460	20	13	18
University of Alberta	34	18	311	29	12	19
Ohio State University	32	22	376	22	12	20
Arizona State University	40	16	266	33	11	21
McGill University	32	23	220	41	11	22
University of Tennessee	21	36	753	8	11	23
University of Nevada, Reno	21	37	300	30	11	24
University of New Hampshire	20	40	239	37	11	25
University of Idaho	24	29	277	31	10	26
Harvard University	23	32	795	5	10	27
North Carolina State University	19	42	255	35	10	28
University of Calgary	19	43	220	42	10	29
Michigan Technological University	18	46	370	23	10	30
University of California, San Diego	17	49	249	36	10	31
Université Laval	17	52	152	58	10	32
University of Arizona	33	19	269	32	9	33
University of British Columbia	33	20	264	34	9	34
Michigan State University	31	24	184	52	9	35
Pennsylvania State University	26	26	230	38	9	36
Northern Arizona University	26	27	200	46	9	37
University of California, Riverside	25	28	219	43	9	38
University of California, Los Angeles	24	30	224	40	9	39
Iowa State University	23	33	334	24	9	40

towns likely plays a significant role in the productivity of their conservation biology programs and may do so for other institutions as well.

Our ranking of institutions is based solely on publication in the scientific literature as measured by the *h* index. This index is just one of several single-number criteria that may be used to rank scientists, peer-reviewed journals, and institutions (see Hirsch [2005] for a review of the advantages and disadvantages of these measures). None of these measures are perfect (Kelly & Jennions 2006), but the *h* index was best suited for our purposes because it is a transparent and easily calculated measure. Furthermore, the *h* index performs with greater accuracy than the more commonly used measure of publication frequency (Lehmann et al. 2006).

Publication record is only one measure of the productivity of a conservation biology program and can by no means fully reflect the quality of education in conservation biology. There are several other measures that could be used to judge the quality of conservation biology programs such as student graduation rate, employment of graduates, the quality and variety of courses offered, the number of awarded patents and grants, collaborations with applied conservation groups, published books, and conference presentations. Although publication rate is a useful proxy of these activities (Laband & Zhang 2006), it is not the only one. Institutions with dedicated teaching faculty can also provide competitive educational opportunities.

As the field of conservation biology continues to expand in response

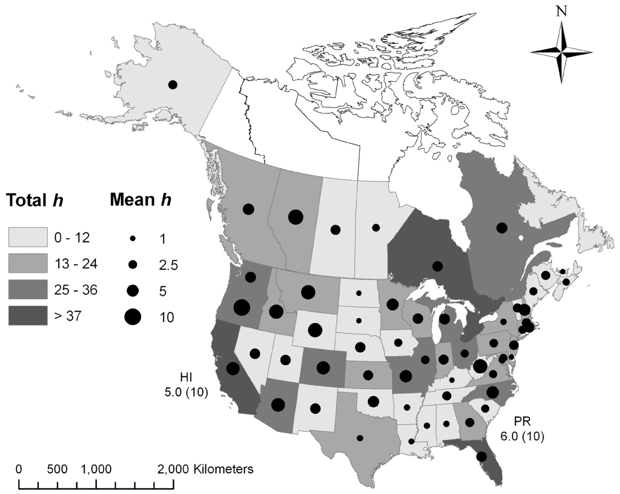

Figure 2. Scholarly productivity (h index, shaded) and relative productivity in the conservation sciences (mean h, symbol size) in the United States and Canada (HI, Hawaii; PR, Puerto Rico).

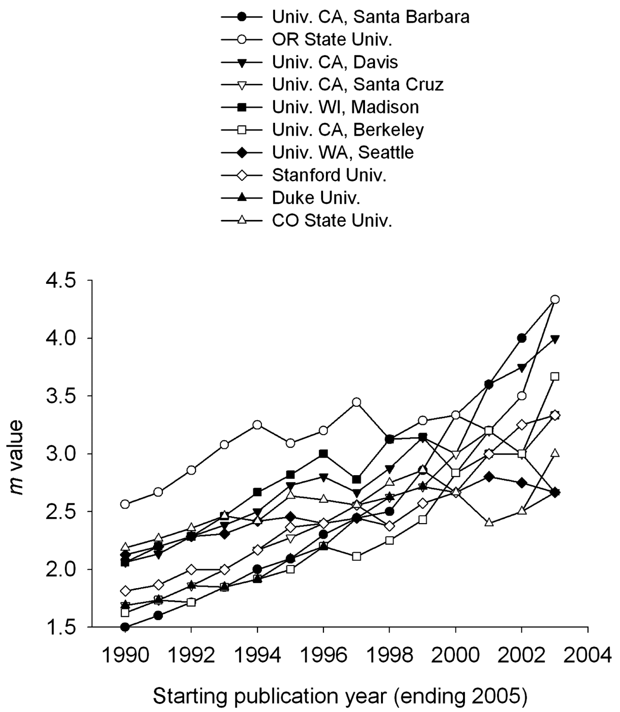

Figure 3. Scholarly productivity according to the m value (a modification of the h index that indicates the rate at which an institution's h index increases) over time for the 10 top institutions (CA, California; OR, Oregon; WI, Wisconsin; WA, Washington; CO, Colorado). The years 2004 and 2005 are omitted because their m indices are inflated due to the overinfluence of young scientific age of recently published papers.

to new and more pressing ecological questions, the number of conservation biology researchers at academic institutions will grow and the ranking presented here will change. Nonetheless, our snapshot of productivity provides employers, administrators, practitioners, and researchers with a new tool to help them evaluate sources of research quality and productivity, as well as one with which students may navigate the route to a career in conservation biology.

Acknowledgments

We thank the Nature Conservancy, the Society for Conservation Biology, and the Cedar Tree Foundation for bringing us together and supporting this work. This is publication number DHS2007–01 of the David H. Smith Conservation Fellowship program.

Jacqualine B. Grant,* Julian D. Olden,† Joshua J. Lawler,‡ Cara R. Nelson,§ and Brian R. Silliman**

*School of Forest Resources and Environmental Science, Michigan Technological University,

Houghton, Michigan 49931-1295, U.S.A., email jbgrant@mtu.edu
†School of Aquatic and Fishery Sciences, Box 355020, University of Washington, Seattle, Washington 98195-5020, U.S.A.
‡College of Forest Resources, Box 352100, University of Washington, Seattle, Washington 98195-2100, U.S.A.
§College of Forestry and Conservation, University of Montana, Missoula, Montana 59812-1224, U.S.A.
**Department of Zoology, Box 118525, University of Florida, Gainesville Florida 32611-8525, U.S.A.

Literature Cited

Academic Analytics. 2007. Faculty scholarly productivity index. Academic Analytics, Chester, Pennsylvania. Available from http://www.AcademicAnalytics.com (accessed January 2007).

Chapron, G., and A. Husté. 2006. Open, fair, and free journal ranking for researchers. BioScience **56:**558–559.

Davis, P., and G. F. Papanek. 1984. Faculty ratings of major economics departments by citations. American Economic Review **74:**225–230.

Dusansky, R., and C. J. Vernon. 1998. Rankings of US economics departments. Journal of Economic Perspectives **12:**157–170.

Fazey, I., J. Salisbury, D. Lindenmayer, J. Maindonald, and R. Douglas. 2004. Can methods applied in medicine be used to summarize and disseminate conservation research? Environmental Conservation **31:**190–198.

Fazey, I., J. Fischer, and D. B. Lindenmayer. 2005*a*. What do conservation biologists publish? Biological Conservation **124:**63–73.

Fazey, I., J. Fischer, and D. Lindenmayer. 2005*b*. Who does all the research in conservation biology? Biodiversity and Conservation **14:**917–934.

Goldberger, M. L., B. A. Maher, and P. E. Flattau, editors. 1995. Research doctorate programs in the United States: continuity and change. The National Academies Press, Washington, D.C.

Harrison, A.-L. 2006. Who's who in *Conservation Biology*—an authorship analysis. Conservation Biology **20:**652–657.

Hirsch, J. E. 2005. An index to quantify an individual's scientific research output. Proceedings of the National Academy of Sciences U.S.A. **102:**16569–16572.

Inouye, D. W., and C. Brewer. 2003. A case study of the Program in Sustainable Development and Conservation Biology at the University of Maryland. Conservation Biology **17:**1204–1208.

Jacobson, S. K. 1990. Graduate education in conservation biology. Conservation Biology **4:**431–440.

Kareiva, P., M. Marvier, S. West, and J. Hornisher. 2002. Slow-moving journals hinder conservation efforts. Nature **420:**15.

Kelly, C. D., and M. D. Jennions. 2006. The *h* index and career assessment by numbers. Trends in Ecology & Evolution **21:**167–170.

Laband, D. N. 1985. An evaluation of 50 ranked economics departments—by quantity and quality of faculty publications and graduate student placement and research success. Southern Economic Journal **52:**216–240.

Laband, D. N., and D. Zhang. 2006. Citations, publications, and perceptions-based rankings of the research impact of North American Forestry Programs. Journal of Forestry **104:**254–261.

Lawler, J. J., et al. 2006. Conservation science: a 20-year report card. Frontiers in Ecology and the Environment **4:**473–480.

Lehmann, S., A. D. Jackson, and B. E. Lautrup. 2006. Measures for measures. Nature **444:**1003–1004.

Meffe, G. K. 2006. The success—and challenges—of *Conservation Biology*. Conservation Biology **20:**931–933.

Meine, C., M. Soulé, and R. F. Noss. 2006. "A mission-driven discipline": the growth of conservation biology. Conservation Biology **20:**631–651.

Orr, D. W. 1999. Education, careers, and callings: the practice of conservation biology. Conservation Biology **13:**1242–1245.

Peterson's. 2006. Peterson's guide to graduate schools. Peterson's, Lawrenceville, New Jersey. Available from http://www.petersons.com (accessed October 2006).

Romero, A., and C. Jones. 2003. Not all are created equal: an analysis of the environmental programs/departments in U.S. academic institutions until May 2003. Macalester Environmental Review: http://www.macalester.edu/environmentalstudies/MacEnvReview/equalarticle2003.htm.

Society for Conservation Biology. 2007. Academic programs in conservation biology. Society for Conservation Biology, Arlington, Virginia. Available from http://www.conbio.org/resources/Programs/ (accessed January 2007).

Thomson Scientific. 2006. Institution for Scientific Information Web of Science. Thomson Scientific, Stamford, Connecticut. Available from http://isiknowledge.com (accessed October 2006).

Wikipedia. 2006. Universities in North America. Wikimedia Foundation, St. Petersburg, Florida. Available from http://en.wikipedia.org/wiki/Universities_in_North_America (accessed October 2006).