ensuring this does not come at the cost of losing familiarity with one's own particular research specialties.

We find that research specialization influences one measure of academic success (H-index). However, we caution that success is not just about publications and citations. The challenge facing every scientist is to decide what really constitutes "academic success" and subsequently to identify the best ways to achieve it.

Jonathan Belmaker[1*], Natalie Cooper[1], Tien Ming Lee[1,2], and Hamish Wilman[1,2]
[1]Yale University, New Haven, CT [*](jonathan.belmaker@yale.edu); [2]University of California, San Diego, La Jolla, CA;
all authors contributed equally

Hackett EJ. 2005. Essential tensions: identity, control, and risk in research. *Soc Stud Sci* **35**: 787–826.

Hirsch JE. 2005. An index to quantify an individual's scientific research output. *P Natl Acad Sci USA* **102**: 16569–72.

Hirsch JE. 2007. Does the *h* index have predictive power? *P Natl Acad Sci USA* **104**: 19193–98.

Kelly CD and Jennions MD. 2006. The h index and career assessment by numbers. *Trends Ecol Evol* **21**: 167–70.

Leahey E. 2007. Not by productivity alone: how visibility and specialization contribute to academic earnings. *Am Sociol Rev* **72**: 533–61.

Lee S and Bozeman B. 2005. The impact of research collaboration on scientific productivity. *Soc Stud Sci* **35**: 673–702.

doi:10.1890/10.WB.25

Statistical danger zone

In a recent review, Ellison and Dennis (*Front Ecol Environ* 2010; **8[7]**: 362–70) argued that advanced statistical fluency is essential for ecologists and identified paths to increase such fluency. We agree that the next generation of ecologists needs a solid understanding of the statistical theory underlying both standard and cutting-edge applications. All ecologists should be able to postulate clear hypotheses, and then – on their own or with assistance – translate alternative hypotheses into probability models tailored for their specific investigation (Hilborn and Mangel 1997). A well-designed series of integrated courses can bring students far beyond the traditional approach of teaching calculus as prerequisite material to be forgotten, statistics as a "grab bag" of analytical tools, and both subjects as disconnected from ecological theory and practice. Such an integrated approach could further serve a fundamental principle for effective instruction: teaching in context. This would improve motivation and help students retain and apply these concepts more effectively (Millenbah and Millspaugh 2003).

However, Ellison and Dennis greatly overestimate how far down the path of statistical fluency the average ecologist will go with a few semesters of probability theory and calculus, no matter how well integrated. Essentially the authors are suggesting that instead of teaching a teenager to drive a car safely, we can tweak driver education so the average 16-year-old becomes able to pilot a fighter jet. Some ecologists will develop sophisticated understanding of statistical theory and implementation during or after graduate school, but usually this will require advanced coursework, collaborative experience working with a quantitative expert, a great deal of self study, and prodigious effort. This minority of ecologists may develop the capability for extending complex statistical methods to novel situations. But we are skeptical that redesigned coursework as described by Ellison and Dennis will offer most other ecologists a shortcut to statistical self-sufficiency.

In fact, we view "self-sufficiency" as a misguided goal. Most ecologists will never develop the statistical expertise of practicing, master's-level statisticians. Ecologists need to recognize the value of investing in statistical help from the start of a study, become fluent in statistical basics and conversant with statisticians, and invest time and money in accessing such help. Furthermore, ecologists' agencies and institutions should facilitate collaboration and greater access to statistical expertise. Society cannot afford for us to view statistical partnerships as simply nice when convenient.

Ellison and Dennis's commentary places little emphasis on the most critical quantitative skill needed by ecologists: designing data collection (ie experimental design and sampling design) that will support reliable inference regardless of whether the resulting data are analyzed with a *t* test or a stochastic differential-equation model. In our view, too many ecologists think that complex analytical methods can extract meaningful results from any dataset, irrespective of how those data were collected. Yet even in a calculus-free environment, students can learn the critical principles involved in designing solid, robust, and meaningful studies, and can learn that these principles, not complex analyses, determine the validity of studies.

Joshua J Millspaugh[*] and Robert A Gitzen
Department of Fisheries and Wildlife Sciences, University of Missouri, Columbia, MO
[*](MillspaughJ@missouri.edu)

Hilborn R and Mangel M. 1997. The ecological detective: confronting models with data. Princeton, NJ: Princeton University Press.

Millenbah KF and Millspaugh JJ. 2003. Using experiential learning in wildlife courses to improve retention, problem solving, and decision-making. *Wildlife Soc B* **31**: 127–37.

doi:10.1890/10.WB.26

A reply to Millspaugh and Gitzen

Current graduate programs in the ecological sciences neither equip aspiring ecologists with sufficient ability to draw reliable conclusions from data collected with non-standard designs or existing and emerging observation systems, nor do they prepare them to understand thoroughly the disciplines' central theories. In response to this deficiency, the course-based solution we prescribed for graduate students in ecological sciences (*Front Ecol Environ* 2010; **8[7]**: 362–70) includes four semester-length courses, amounting to one year of "real" calculus and one year of senior undergraduate probability and mathematical statistics. We believe that this proposal largely solves the problem, but we remain open to better, more practical alternatives.

Millspaugh and Gitzen (M&G) do not offer a viable solution, however. Their "well-designed series of integrated courses" is neither clearly defined nor specified; the concepts in Hilborn and Mangel's *The Ecological Detective* – probability and probability models, likelihood and maximum likelihood estimation, confidence intervals, bootstrapping, and Bayesian estimation – are standard ingredients of any *undergraduate-level*, calculus-based, two-semester sequence in probability and mathematical statistics. And although *The Ecological Detective* provides a welcome and gentle entry into statistical modeling, it stops far too short. For example, ecologists face a bewildering variety of challenges with dependent data (eg observational data with spatial and temporal autocorrelation, data with non-standard distributions from designed experiments with both mixed random and fixed effects), and would greatly benefit from the more systematic study of jointly distributed random variables as presented in a traditional sequence of calculus-based probability and mathematical statistics.

Our prescription has two further advantages. First, the necessary courses *already exist* at most liberal-arts colleges and research universities. For some graduate students, undergraduate calculus might need refreshing, but this would be less problematic if undergraduate and graduate courses in the ecological sciences *actually used* calculus when it was fitting. Second, students following our prescription will have a strong understanding of statistical concepts essential for their scientific careers and the confidence to use these concepts appropriately. M&G are rightly fond of experiential learning, and such enhancements (especially computational methods) are frequent supplements to contemporary calculus, probability, and mathematical statistics courses. And we of course agree with M&G that knowing how to design a valid and reliable study is a crucial skill. However, standard "service courses" on experimental design are nowhere near as useful as experimental-design courses offered by mathematics/statistics departments and that require calculus as a prerequisite; basic calculus-based statistical knowledge is extremely helpful when designing studies that are expected to generate non-standard data.

Moreover, M&G's fighter pilot analogy is an exaggeration. Our recommendations come nowhere near even what is expected for an average master's-level degree in statistics and mostly involve taking different courses rather than the additional courses implied by M&G. Even so, the amount of statistical self-sufficiency afforded by our proposal is remarkably large for the small investment of time. Statisticians certainly can and should be consulted, not only when data are in hand, but especially when studies are being designed. In our experience, conversations between ecologists and statisticians are greatly enhanced when both speak the same language – mathematics with a healthy dose of calculus. Yet in our view, ecologists who must frequently call in statisticians, and who must find the additional grant funds to get their focused attention, are quite simply ill-prepared for careers in ecological research.

M&G suggest that ecologists need a solid understanding of statistical theory and should be able to frame and test clear hypotheses. To graduate students in the ecological sciences, we ask: how confident are you in your understanding of the theoretical statistical concepts that are important in contemporary ecology, such as the ideal free distribution, neutral biodiversity theory, negative binomial, zero-inflated Poisson, or mark–recapture models, population viability and wildlife survival analysis, diffusion and birth–death processes, Bayesian inference, Markov chain Monte Carlo integration, bootstrapping, maximum likelihood estimate, information–theoretical model selection, or kriging? And further, how secure do you feel about basic introductory statistical concepts such as hypothesis testing, statistical power, the multinomial distribution, the Central Limit Theorem, or the expected value of a random variable?

The prevailing approaches for learning statistics in the ecological sciences condemn our graduate students to a lifetime of misunderstanding, insecurity, and frustration with both basic and advanced statistical concepts. Statistics is not a big secret; its mastery requires only appropriate education and practice.

Brian Dennis[1] **and Aaron Ellison**[2*]
[1]*Department of Fish and Wildlife Resources and Department of Statistics, University of Idaho, Moscow, ID;* [2]*Harvard University, Harvard Forest, Petersham, MA*
[*]*(aellison@fas.harvard.edu)*

doi:10.1890/10.WB.27

Farewell to Laws of Nature

As regular readers may have noticed, we are making a few changes in *Frontiers*. We already have a new back-page columnist, and there are interesting new series planned for next year.

However, it is with regret that we say farewell to our legal columnist, Douglass Rohrman, who has been writing the Laws of Nature column since the journal's very first issue! With clear, understandable language and his own brand of wit, Doug has been our guide, taking us through the legal and political complexities of the Clean Air Act, the Clean Water Act, Superfund sites, CAFE standards, endangered species, and much more.

With many thanks to Doug and very best wishes from all of us on his upcoming retirement.

Sue Silver
Editor-in-Chief, Frontiers in Ecology and the Environment,
Washington, DC