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Lessons for Sustaining Ecological Science and Policy through the Internet

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INTRODUCTION

Surfing the Web. That image is not at all bad for an internet journal. The image captures the thrill of unexpected opportunity we have experienced in developing *Conservation Ecology*. And it also captures the stress of crisis and survival. I've had lots of sleepless nights worrying about financial stability. But also wakeful moments savoring the novel inventions and novel papers offered by our community. We have now solved the financial challenge in a sustainable way, and can focus on the creative adventures at hand.

The journal has been published for three years now, sponsored by the Ecological Society of America. Its initial stages of development have been intentionally conservative and deliberate. We have practiced our surfing skills on small waves, building the journal on the solid traditions of science: that is, on peer review, on an international community of scientists, scholars, and practitioners, and on volunteer service for and by that community.

This editorial will review what we have learned. Most importantly, it will describe our grand invention for sustaining a journal on the internet. A way to sustain an avenue of free communication of scientific information and knowledge for authors, subscribers, and readers.

A recent Opinion article in *Nature* argues that the days of ink and paper for scientific journals are numbered (*Nature* 401: 727). Sooner than most expect, lightweight, high-resolution screens and instant page upload through high-speed wireless access will make reading an internet journal as comfortable in hammock or armchair as reading your favorite paper magazine.

Already, electronic journals are more accessible to many scientists than are paper journals. We have had several spontaneous messages from scientists in developing countries saying how much easier it is to access our e-journal than paper journals. Power outages might be frequent, telephone service inconstant, but the web awaits whenever power and service returns. In contrast, surface and air mail is often so poor that receipt of paper

information can be entirely unreliable in many developing nations and often vanishes forever. Moreover, even when paper journals have a web version, they are costly and library budgets are limited in both developed and developing world organizations. Less accessible paper journals discriminate against diversity.

But electronic journals can offer an effective alternative if two problems are solved. The first is a way to nurture a quiet, reliable eddy of quality knowledge in the midst of the turbulent storm of junk on the internet. The second is to make that information and knowledge free and accessible.

We solve the first problem by a double-blind peer review system managed by an international group of over 60 editors covering a wide range of disciplines and experience. Peer review can sometimes concentrate so much on rigor that creative novelty is squeezed out. But with the luxury of free publishing space, we have evolved a tradition among editors of combining rigorous review with mentoring of authors whose work expresses a novelty that would otherwise be rejected. Still, our rejection rate for submitted manuscripts is about 50%.

The key problem for survival has been, prosaically, money. An e-journal is certainly less expensive than a paper journal. There are zero distribution costs. We have designed a web-based peer review and manuscript tracking system that, for the moment, is unique. It makes the review process much faster and cheaper. All clerical steps are automated. The software system frees the editor-in-chief, subject matter editors, and reviewers of much of the routine burden. Papers can be easily published within three months of receipt, if authors and reviewers react promptly. That is notably better than the two-year delay encountered by authors publishing in many paper journals in our field. The software has become that effective because it evolved from the experience of processing over 150 manuscripts that have been submitted. The bugs have been caught, and the interface with people made smooth and friendly. It is so good that we have invited scientific and scholarly societies to join us in a consortium to generalize and utilize the system for publication of nonprofit journals. (Those interested should read more at <http://www.consecol.org/Journal/prp-consortium.htm>.)

Although less expensive to run and operate, there are still costs to support the team of programmer, coordinator, senior editors, and copy editor. Hardware, software, and maintenance of an office are not free. Annual costs for a bare-bones operation with some modest development are about \$60,000. Until now, those activities have been supported exclusively from grants, but that solution is not sustainable. Traditional alternatives include levying of subscription fees or pay-per-paper schemes.

Two years ago we surveyed readers and discovered that there was a willingness from many subscribers to pay. But we concluded that the price of shifting to a subscriber fee was too great. One of *Conservation Ecology's* greatest assets is a diverse audience of subscribers and readers: there are now more than 7200 subscribers from 94 different countries, representing academic, government, and private groups. About 20% are from (or neighboring) the Southern Hemisphere. That diversity is much greater than that of the three other ecological journals sponsored by the Ecological Society of America. Any barrier to subscription, however minor, would reduce that diversity when our goal is to expand it energetically. It would work against the enormous potential opened by the internet. We therefore sought a different solution to maintain a free flow of knowledge, to expand diversity, and to sustain the publication over time. The solution came from a parallel development.

THE RESILIENCE ALLIANCE

At the same time that the journal was being developed, a subset of the editors was involved in an ongoing international program, "Resilience of Ecological, Economic, and Institutional Systems," funded by the MacArthur Foundation. Its purpose was to develop tested theory that integrated ecological, economic, and institutional theories. A year-end report can be found at <http://www.emory.edu/COLLEGE/ENVS/rmet/report.html>. The project involved an international group of leading ecologists, economists, mathematicians, and social scientists. This group has now joined with some others to

form the Resilience Alliance, one of whose purposes is to provide sustained support for the infrastructure of *Conservation Ecology*.

Ten groups from around the world provide membership dues on a continuing basis to publish the journal and seed interesting web experiments. The Resilience Alliance includes the Ecological Society of America and groups at Carleton University (Canada), CSIRO Ecology (Australia), Emory University (Georgia, USA), University of Florida (Florida), the International Institute of Agricultural Policy (Minnesota), the International Institute of Applied Systems Analysis (Austria and Poland), University of Wisconsin (Wisconsin), Stockholm University (Sweden), and the University of Zimbabwe/WWF, Southern Africa (Southern Africa). A few other groups will be added to diversify further into Asia, South America, and Europe.

The Resilience Alliance is an "Institute–without–Walls." Its features are summarized at <http://www.resalliance.org/>. It is effectively acting as a horizontally organized, international university program with research, application, and teaching projects in major regions of the world. The focus is on integrative theories of evolutionary and developmental change, on regional experiments for practicing sustainability, and on use of the web to facilitate the development of an international community. The Alliance will publish *Conservation Ecology*, sustaining it from membership dues paid by member groups annually to the Alliance. As a consequence, journal subscription can be entirely free, and incentives can be added that involve subscribers in collaborative projects. Authors can contribute initiatives that utilize opportunities provided by the web, such as interactive dialogues, downloadable models, colored illustrations, and movies. Hence, the diversity of subscribers, readers, and authors can be maintained and now expanded. It provides a significant new and sustainable opportunity to launch experiments in collaboration and communication.

The Alliance is governed by two Boards. One is a traditional Board of Directors with representatives from each of the Alliance members. It is chaired by Dr. Brian Walker, CSIRO, Ecology, Australia. The Executive Director of the Resilience Alliance is Dr. Phil Taylor, Department of Biology, Acadia University. In order to assure independence of the journal and its objectivity, a Board of Science has been added for the balance provided by bicameral governance. It is chaired by Professor Stephen Carpenter, Center for Limnology, University of Wisconsin. The purpose of the Board of Science is to monitor and maintain the quality and objectivity of the journal, to hire and fire the Editor–in–Chief, and to suggest and help design Special Features and projects for the journal.

Alliance members benefit by combining their expertise in joint efforts of research, application, and training. Their work will be expanded in the regions represented by members and will draw on the Alliance to create global collaboration and shared learning among regions.

One sample project is a web–facilitated short course being developed, entitled "Theories and Practices for Sustainable Futures" (<http://www.consecol.org/Journal/ra/futures.html>). The development of the resource material on the web is supported with grants from the MacArthur Foundation and from the U.S. National Center for Ecological Analysis and Synthesis in Santa Barbara, California. Its implementation in several regions will be supported by a grant to the Alliance recently received from the Rockefeller Foundation. A pilot of the short course will be tested in May 2000 by student nominees of members, and we anticipate formal implementation initially in four places: two in the United States, one in Sweden, and one in Zimbabwe. *Conservation Ecology* plays a role by providing a "mock" publication and manuscript review experience for the results of student projects, and by providing its facilities for student dialogues. These will link the participants in the different regions, and with an international faculty of advisors and reviewers. The journal will also advertise the opportunity for subscribers to nominate students for future courses.

When we combine the speed of the net with the quality assurance of peer review that *Conservation Ecology* offers and with the team–building interactions of an exciting course, the Resilience Alliance has a powerful engine indeed.

From its start, *Conservation Ecology* was an experiment not only to establish an e–journal, but also to see if that format specifically allows us to establish a journal in a special niche not easily served by traditional paper

journals. That niche was to publish fundamental scientific and scholarly research that underpins relevant policy, and to publish developments in policy research that are relevant to sustainability issues. We encouraged novel integrative studies: ones that integrate over scales in time and space, or across disciplines, or between fundamental science and application. We wanted papers written in a way to be accessible and readable by a wide audience from different disciplines, countries, and organizations. A paper journal cannot do that for reasons of economics: high costs of publication and a diverse, but thin market. Can an e-journal? After three years of experience, our evidence is that it can.

AUDIENCE

Even without the marketing resources of a commercial publisher, *Conservation Ecology's* audience has evolved to be an international community of scholars and practitioners representing the natural and social sciences, business, government, and NGOs.

Now that a way has been invented for sustainable development of the journal and its experiments on the web, we are in a good position to expand the number and diversity of subscribers. At the moment, most of the 7200+ subscribers to *Conservation Ecology* are affiliated with academic institutions, but a substantial portion (26%) represents commercial organizations, and 3% of subscribers represent nonprofit organizations. Of the approximately 2600 subscribers in the United States, 17% are affiliated with government organizations. Overall, that number and diversity of subscribers is not too bad, particularly since no effort has been made to advertise the journal and its purpose, other than in the print journals and *ESA Bulletin* published by the Ecological Society of America. So far, the journal has otherwise been discovered by word of mouth or keyboard, and by the increasing number of references to its articles.

That has limited our international reach, an issue that the Resilience Alliance and its expanding regional diversity and regional experiments can help to rectify. Most of our subscribers are North Americans (United States 50%, Canada 12%), with a respectable, but still insufficient number from elsewhere (Western Europe 15%, Latin America 7%, Australasia 7%, Asia 4%, Africa 2%, Eastern Europe 1%, and the Caribbean 0.5%). The Southern Hemisphere is reasonably represented as a portion of our subscribers (16%). *Conservation Ecology* currently has subscribers in 42 developing countries and supports easy and rapid international access to the journal by providing mirror sites in Australia, Sweden, Brazil, and South Africa.

Because access to the journal is free, there are many more regular readers of *Conservation Ecology* who are not registered subscribers. Web Server Statistics indicate that in the first nine months of 1999, the journal has served close to 50,000 distinct hosts, suggesting a much larger audience than is revealed by our subscriber's list alone. Recent analyses indicate that the web site has received an average of 140,000 successful requests for papers per month in 1999. This number rose to 250,000 in September, following the first announcement we have ever made to subscribers about a remarkable paper, in this case, one that links economics and ecology and offers a downloadable computer model for readers to explore (Carpenter et al. 1999. <http://www.consecol.org/vol3/iss2/art4>). That paper is one of the papers in *Conservation Ecology's* Special Feature on Recent Advances in Ecological Theory and Practice. Science magazine's NETWATCH (*Science* 286, 8 Oct. 1999: 195) recommended the paper, highlighting it as a paper in ecological economics, "one of the hottest areas in environmental science." That near-doubling of hits, at the least, suggests an attentive readership.

In order to encourage interested readers to become subscribers, the free subscription to *Conservation Ecology* will now be attached to modest benefits: e-mail notice of the Table of Contents for each new issue, messages that highlight special papers and features, news from the Resilience Alliance Projects, notices of research writing competitions for prizes, and invitations to nominate people for collaborative projects.

AUTHORS

Will authors write about their own research in a way that is accessible to people in other disciplines, in other functions than research? Some certainly can do so, and delight in exercising the skill. For example, the most popular paper published in the journal, as measured by the number of requests to access it (number of "hits"), has been the paper by Ludwig et al. (<http://www.consecol.org/vol1/iss1/art7/>) (Table 1). That paper was written by a mathematician about properties of stability that are essential for any understanding of ecological systems or of the policies appropriate for them. Collaborating coauthors provided illuminating examples from nature. It was explicitly written to communicate clearly and simply to biologists, economists, and social scientists. The clarity of the presentation was novel, and the mathematical treatment revealed novel features not previously recognized. It has become one of the handful of papers published anywhere that communicates between ecology and other disciplines in a way that does justice to the unique attributes of multistable ecological systems.

Table 1. The top 10 most accessed *Conservation Ecology* papers as recorded by the number of requests, corrected for the number of figures and tables.

Authors			
Don Ludwig, Brian Walker, and C. S. Holling	Sustainability, Stability, and Resilience	http://www.consecol.org/Journal/vol1/iss1/art7	83556
Timothy Keitt, Dean L. Urban, and Bruce T. Milne	Detecting Critical Scales in Fragmented Landscapes	http://www.consecol.org/Journal/vol1/iss1/art4	23298
Carl Walters	Challenges in Adaptive Management of Riparian and Coastal Ecosystems	http://www.consecol.org/Journal/vol1/iss2/art1	9909
Lynn van Collier	Automated Techniques for the Qualitative Analysis of Ecological Models: Continuous Models	http://www.consecol.org/Journal/vol1/iss1/art5	9202
Stephen R. Carpenter and Kathryn L. Cottingham	Resilience and Restoration of Lakes	http://www.consecol.org/Journal/vol1/iss1/art2	7301
Ronald L. Trosper	Incentive Systems that Support Sustainability: A First Nations Example	http://www.consecol.org/Journal/vol2/iss2/art11	5008
Fred Johnson and Ken Williams	Protocol and Practice in the Adaptive Management of Waterfowl Harvests	http://www.consecol.org/Journal/vol3/iss1/art8	4400
Garry Peterson, Giulio A. De Leo, Jessica J. Hellmann, Marco A. Janssen, Ann Kinzig, Jay R. Malcolm, Karen L. O'Brien, Shealagh E. Pope, Dale S. Rothman, Elena Shevliakova, and Robert R.T. Tinch	Uncertainty, Climate Change, and Adaptive Management	http://www.consecol.org/Journal/vol1/iss2/art4	4046
Brian Walker and Will Steffen	An Overview of the Implications of Global Change for Natural and Managed Terrestrial Ecosystems	http://www.consecol.org/Journal/vol1/iss2/art2	3865

Will authors see value in publishing in an e-journal that speaks to large issues, that seeks for breadth and depth? There is a mixed answer. So much of the recent forces in science and academia encourage small papers on small subjects for the sake of promotion, or because of the limitations of research time and money. Graduate students are encouraged to get their five published papers or lose out on job opportunities; to pick modest, not bold projects, to swim with the current for reasons of practical career development. Moreover, some authors question the viability and career value of e-journals.

In many and a growing number of organizations and universities, however, e-journals have become an entirely appropriate avenue for publication, led by the extensive use made by physicists, in particular. The format for referencing of such papers has become an accepted standard and is the one adopted by *Conservation Ecology* on the header of each article. There has been a wonderful mix of novel, relevant papers from both young and older scientists. The top 10 most requested papers are shown in Table 1 as examples. Among that list of authors are a freshly graduated Ph.D., two more senior postdoctoral students, early- and mid-career scientists in government organizations, and several more senior scientists in government and university laboratories.

Many of these papers are from the first volume of 1997, as enough time has elapsed for their recognition. We have now been publishing for enough years that, each December, we will announce the most accessed papers from the volume of two years preceding.

REVIEWERS

We wondered if reviewers would have the time and interest to transcend the essential, but narrow, traditions of rigorous critique to be alert to novelty and willing to nurture it. That bias against novelty is reinforced by limitations in the publication space provided by paper journals. The same thing happens when demand and supply of grant money are tight: novelty inevitably suffers. But *Conservation Ecology* has no such limitation.

With the help of editors, a culture of rigor and of mentoring has evolved. The first example concerns what has become the most accessed paper in the journal (Ludwig et al., <http://www.consecol.org/vol1/iss1/art7/>). Initially, reviewers rejected it as nothing new, until its insightful editor saw the didactic value in its remarkable clarity of writing for a multidisciplinary audience, and I saw the complete novelty in two discoveries described in the paper. Oddly, the clarity of the exposition hid those novel discoveries from the experts. It triggered the designation of a new category of paper for *Conservation Ecology*, that of Insight.

Another example was the paper by Lindgren on tick-borne encephalitis and climate change (Lindgren, E. 1998. Climate and Tick-borne Encephalitis. <http://www.consecol.org/Journal/vol2/iss1/art5/>). It was an example of transdisciplinary research in which experts in the separate fields of statistics, epidemiology, medicine, and ecology initially recommended rejection. But the process of mentoring by a wise editor led to a fine contribution that pleased everyone. It was referred to in the World Health Organization (WHO) Recommendation for Policymakers and in the WHO background document "Early Human Health Effects of Climate Change in Europe" at the Third Ministerial Conference on Environment and Health, held in London in June 1999. The contents of the paper have led to the suggestion by WHO to include tick-borne encephalitis as one of four "health indicators" of early signs of climate change in Europe. The article has been cited in a recent review article in the *British Medical Journal* on climate change and human health in Europe (Kovats et al. 1999: 1682–1685).

It is often such interdisciplinary papers and efforts that are most needed, but most vulnerable to narrow critique. Interdisciplinarity is a lot of work. Peer-reviewed, high-quality, widely available publications are an important part of building interdisciplinary science. And yet, as noted by several authors in a recent special feature on interdisciplinarity in *Ecosystems*, quality avenues for publishing are rare. (Turner and Carpenter 1999: 275–307). *Conservation Ecology* fills a crucial niche in the creation of academically credible, peer-reviewed, interdisciplinary dialogue.

The interactive nature of the web, and of *Conservation Ecology*, opens novel opportunity for such dialogues on complex issues. Several of our experiments have shown what does not work and what does. The most successful device, by far, has been the Young Scholars Group, and the Young Scholars' Dialogues that they organize. Given two or three papers that highlight aspects of a large issue, the group of Young Scholars has invented a way to use the Internet and *Conservation Ecology's* software to generate constructive expansions that deepen and generalize a topic. A good example concerned regional ecological, land use, and economic consequences of climate change and adaptive ecosystem management. Three of the papers in that effort, including the summary of the Young Scholars Dialogue, are among the set of 10 most accessed articles (Walters, Peterson et al., and Walker and Steffen; Table 1). The Young Scholars group is international, interdisciplinary, and interactive. They are thoroughly professional, broadly read, and deeply trained. They are the ones who will help to shape science, scholarship, and practice in the 21st century.

CONCLUSION

The inventive opportunity that the internet has opened for science, scholarship, and policy works. It forces attention on the development of diverse sources of quality knowledge for a diverse audience. It taps the open source, volunteer tradition of science publishing and expands its impact. But we conclude that to do so, to sustain an environment for authors and users of knowledge, there must be free access for subscribers. We invented one way—publication and financial support by the Resilience Alliance, an alliance of like-minded groups with diverse strengths and broad regional representation. That is not a universal solution, and it will be interesting for us to learn of alternative inventions that are viable. I encourage readers to use the Response facility associated with this article to share their discoveries.

Now that *Conservation Ecology* has a solid base of experience, a diverse and growing audience, and a foundation for sustained publication with broad impact, I offer an invitation:

To Readers : Many more people read than subscribe to a free, open-access journal. We are adding incentives for subscription and invite readers to freely subscribe <http://www.consecol.org/Journal/subscribe/index.html>.

To Authors : We invite authors to submit novel, integrative papers about people, populations, ecosystems, and landscapes across scales, for a multidisciplinary audience of scientists, scholars, and practitioners. And we urge authors to invent ways to exploit the special opportunities for communication that the web provides (e.g., many illustrations of many kinds, animations of model output, downloadable models and policy games, questionnaires on issues) <http://www.consecol.org/Journal/submit/>

To Subscribers : We invite subscribers to offer proposals to questions@consecol.org for innovative uses of the Web and of *Conservation Ecology* that further its goal of developing considered conversations about complex ecological, economic, and social issues. <http://www.consecol.org/Journal/vol2/iss1/art6/>

And we invite all to use the Response facility associated with each article to share tested experience and knowledge and thereby add value to the topic of the papers.

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RESPONSES TO THIS ARTICLE

Responses to this article are invited. If accepted for publication, your response will be hyperlinked to the article. To submit a comment, follow [this link](#). To read comments already accepted, follow [this link](#).

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