

LIMNOLOGY AND OCEANOGRAPHY
BULLETIN

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PUBLISHING LIMNOLOGY, NOW AND THEN

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*This article is dedicated to R. G. Wetzel, 1936 – 2005, who
was scheduled to fill this space but could not. It is our loss not to
know what he would have written here, or in many other places in
the coming years.*

Having begun in 1956 with a paper by Rawson on algal indicators of trophic state, *Limnology and Oceanography* soon will have been publishing limnology for 50 years. This is an occasion for reflection on milestones in the history of *L&O* and for a more data-oriented overview of *L&O* as it reflects, and is reflected by, ASLO and limnology as a whole.

MILESTONES

The fifty-year sequence of *L&O* presents not only a stimulating and significant selection of research in limnology, but also contains some notable items that stand apart for me and probably for many limnologists. Volume 1 is a milestone, not simply because it was first, but because it was immediately successful in presenting the pleasant diversity of brief, well-edited contributions from both oceanography and limnology that has characterized *L&O* throughout its history. The founding editor, David Frey, was well chosen to set a high standard. He could, to quote Robert Ruark, "write like a goat slipping on shingles" and was as exacting as a neurosurgeon in all matters editorial.

For a limnologist, the milestone that was *L&O* volume 1 contained yet another milestone, which was H. T. Odum's paper on the measurement of metabolism in situ by the open-channel method. Like many limnologists interested in production, I have cited this paper many times since my career began. While the method now has been greatly refined through improvement of instrumentation, Odum's equations cover all bases and are as applicable today as they were in 1956. Like some other papers mentioned by David Kirchman (2005), Odum's was more than a new entry in the cookbook of methods in that it arose from his perception of need for a critical kind of information that was unavailable until he showed how it could be obtained.

The next landmark easily visible to me is the special issue on eutrophication that was edited by Gene Likens (1972). The symposium was part of a coming-out process for North American limnologists, who were just then perceiving the public utility of their knowledge (European limnologists came to this realization much earlier). The limnologists most influential in consolidating and packaging information on eutrophication, aside from Gene Likens, included W.T. Edmondson and later David Schindler, who did not contribute to the 1971 symposium because he was just starting his important work at the Experimental Lakes Area in Ontario. Limnologists, along with oceanographers interested in estuaries, reached consensus through the symposium about the powerful effects of phosphorus on aquatic ecosystems, and sent forth through *L&O* a compelling body of evidence to support their case that society must control the anthropogenic distribution of this key nutrient. Bending the journal to the combined purpose of bringing scientific expertise to a sharp focus on an important scientific issue and simultaneously revealing the implications of the issue for society struck me as important business for ASLO. Perhaps the special issue on eutrophication now in preparation will be similarly important.

Aside from its general significance, the 1972 eutrophication volume also contains the most quotable line ever to appear in *L&O* (p. 190). Joe Shapiro, listening to a nonparsimonious argument to the effect that algae cause excess phosphorus, remarked that "it seemed like saying that lung cancer causes cigarettes."

Yet another milestone in the 70's was the special Hutchinson issue of 1971. For me, Hutchinson was, and remains, the Great One. I was fascinated to see through the 1971 issue the breadth of his personal influence, which was achieved not through administration or traditional leadership, but entirely through intellectual influence and personal associations. The graphical tree that accompanies the volume is a classic.

A personal but by no means global milestone was the publication of my first paper in *L&O* (Lewis 1973). The paper

The Limnology and Oceanography Bulletin

The American Society of Limnology and Oceanography is a membership-driven scientific society (501(c)(3)) that promotes the interests of limnology (the study of inland waters), oceanography and related aquatic science disciplines by fostering the exchange of information and furthering investigations through research and education. ASLO also strives to link knowledge in the aquatic sciences to the identification and solution of problems generated by human interactions with the environment.

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The *L&O Bulletin* is published quarterly by the American Society of Limnology and Oceanography, 5400 Bosque Blvd., Suite 680, Waco, TX 76710 USA. Postage paid at Waco, Texas. POSTMASTER: Send address changes to ASLO Business Office, 5400 Bosque Blvd., Suite 680, Waco, TX 76710 USA.

Subscription price to regular members is included in annual dues. Information on institutional subscriptions is available upon request from the ASLO Business Office.

Views expressed in this publication do not necessarily reflect official positions of the American Society of Limnology and Oceanography unless expressly stated.

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was reviewed pointedly but kindly by Dan Livingstone, who dubbed my proudly delivered analyses as “data cookery.” To my relief, he concluded that the paper could be published with some revision, and I felt a great sense of accomplishment in seeing it published by *L&O*.

Along with David Kirchman (2005), I would cite certain methods papers as milestones. For example, while I have never met Dr. Solórzano, I am eternally grateful to her for saving me from extracting ammonia by distillation (Solórzano 1969). Solórzano’s paper is also an excellent indicator of the potential for crossover between oceanography and limnology.

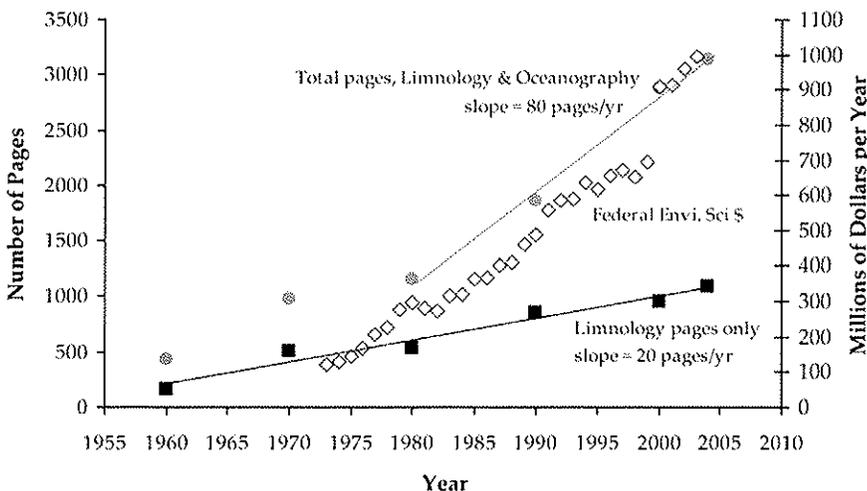
Numerous papers of the 70’s and 80’s changed the way I was thinking about lakes; each of these is a milestone for me. Beyond individual articles, I have valued *L&O*’s ability to present me with a time series of papers on specific, rapidly developing research topics that have been important in building limnology over the last 50 years. Papers on heterotrophic bacteria in water, for example, filled a great void, as did papers that finally described the nature of gelbstoff as well as the achromatic organics that we all knew must be present in water. The recent burst of information on photolysis of dissolved organic matter is a significant addition to this time series of developing information. Some of the most important schools of thought or formulas for research also are well revealed by *L&O*. For example, the numerous papers from McGill University dealing with what I would call “statistical limnology” have always caught my attention.

Two book reviews also go on my list of milestones. One was David Frey’s (Frey 1969) brutal lashing of Hutchinson’s *Treatise*, volume 2, which contained a very large number of errors. Given that I had certain notions of infallibility about Hutchinson, the review required some attitude adjustment on my part. Another memorable review, by Livingstone (1976), was of the first edition of Bob Wetzel’s textbook (Wetzel 1975). Livingstone, in a penetrating analysis that would make any would-be author shiver, found some merits but numerous faults, and declared Wetzel’s delivery “wooden.” Bob, who could stand strong criticism better than anyone I have ever known, groomed the volume through two later editions, bringing it to the point at which Livingstone found it, as reported in the pages of this bulletin (Livingstone 2002), more than acceptable.

GROWTH IN *L&O*, 1960-2004

It will surprise no one that *L&O* has grown by about an order of magnitude since its early days (Figure 1; information shown in Figure 1 and all figures that follow is based on decadal sampling, plus data for 2004). From 1970 to 1980, however, growth was slow. During these formative years, under the editorship of Yvette Edmondson, the journal became

Figure 1. Total number of pages published by *L&O* (without special issues) at decadal intervals from 1960-2000, plus 2004. Number of pages for years 2000 and 2004 is adjusted to the earlier, smaller page size. Growth of U.S. Federal university research support for environmental science is shown for comparison (NSF 2004).



increasingly selective. The ASLO Board, with the urging of the editor (who was not compensated), capped the growth of the journal, thus allowing a rather high rejection rate to develop, and restricted (informally and, some would say, arbitrarily) the breadth of content for *L&O*. Under this policy, *L&O* became a first choice for ambitious authors in certain branches of limnology and a journal that informed limnologists must read, but also a source of disappointment and frustration for many limnologists who found themselves unable to publish in it. Beginning in the 1980s, *L&O* began to grow (Figure 1). Because its rate of growth essentially matched that of environmental science (as indicated by research support), *L&O* could grow while also retaining its selectivity.

Most articles published in *L&O* can be assigned to either limnology or oceanography. Application of such a classification at decadal intervals shows that limnological content of *L&O* has increased at a rate of about 20 pages per year since 1960 (Figure 1). Oceanographic content increased at about the same rate until the end of the 1980s, when the rate increased to about 60 pages per year, which has caused *L&O* to become increasingly oceanographic. The growing differential in annual *L&O* output for the sister disciplines is not a matter of policy, but rather a passive outcome of competition in the review process as handled by the editor, associate editors, and reviewers. Limnologists now appear to have become progressively less successful in competing for space in their most prestigious outlet.

Sensing that ASLO was at best weakly interested in non-lacustrine limnology, and that *L&O* in any event would be publishing only a small percentage of limnological manuscripts, limnologists formed new professional societies and created new journals with limnological content, as did commercial publishers. The present size of the working (cited) literature in limnology can be estimated as an order of magnitude through a two-step process. First, the number of limnological articles in a representative group of journals (*Ecology*, *Journal of Plankton Research*, *Journal of the North American Benthological Society*, *Archiv für Hydrobiologie*, *Freshwater Biology*, *Biogeochemistry*) was tabulated for 2004. The proportion of all items (articles and the occasional book or book chapter, regardless of year) cited by *L&O* authors in 2004 from this representative group, plus *L&O* itself, was calculated (0.24). The number of limnological articles published in 2004 by the representative group of journals, including *L&O*, (539) divided by this proportion is a provisional estimate of the size of the working literature for *L&O* authors in 2004 (2246 items, with no adjustment for duplication of citations). Because *L&O* covers very sparsely a number of major branches of limnology, the working literature for all limnologically-oriented authors

publishing in reviewed journals is several times this amount. Thus, as an order of magnitude, the working literature would appear to be about 10^4 items as of 2004 or, to use the mean article size for the *L&O* and the comparison group, about 10^5 pages. The annual output of working literature, as judged from the frequency distribution of years for citations by *L&O* authors (Figure 2), is approximately 10% of the total, or 10^4 pages. Assuming that most *L&O* articles are cited at least once in the peak year for citations after publication (the 5th year: Figure 2), *L&O* appears to contribute about 10% to the working literature as a whole.

CHANGES IN THE PROFILE OF AN *L&O* ARTICLE: 1960-2004

The general features of *L&O* articles have changed over the decades (Figure 3). *L&O* articles now are slightly longer than they were in 1960. Increase in length is counterintuitive, given the constant pressure on editors to constrain the length of articles in order to be able to publish as many articles as possible. The forces driving up the length of articles appear to include an increase in the length of literature cited and methods sections (Figure 3). These increases might be expected, given that there is more relevant literature to cite

Figure 2. Percent by year of citations given in limnological articles for 2004.

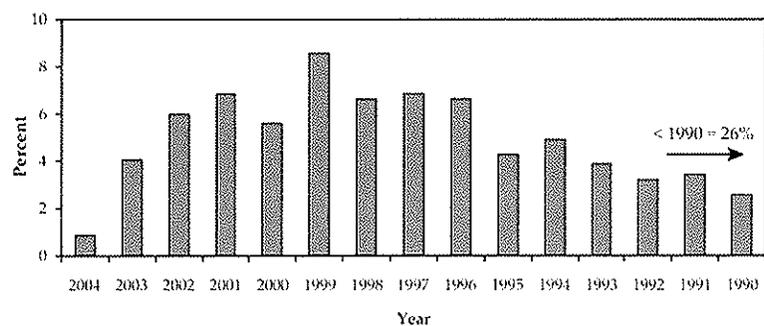
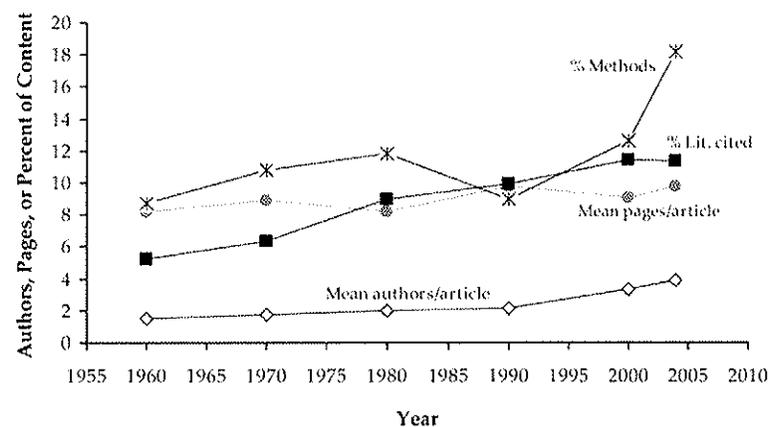


Figure 3. Characteristics of articles published by *L&O* since 1960: mean number of authors per article, mean pages per article (including notes), mean percent of article devoted to methods, and mean percent of article devoted to literature cited. Special issues are excluded.



than there was earlier, and that methods have become more diverse and complicated. The upward trends in literature cited and methods have been offset to some degree by tightening of other parts of articles; introductions now are short and discussions are even shorter.

The median number of authors for papers published in 1960 was 1; the characteristic number of authors for *L&O* articles now is approaching 4 (Figure 3). Funding agencies are increasingly reluctant to provide money to individuals, and reviewers of grant proposals often are interested in encouraging investigators to collaborate. Also, graduate programs are larger today than they were in 1960. These factors likely explain the shift of limnological research from single scientist or single scientist plus a graduate student to multiple scientists and multiple graduate students. Limnological research, including not only what appears in *L&O*, but also in general (Table 1) has become aggregated, and publication reflects this change.

FINANCIAL SUPPORT, NATIONALITY, AND SUBJECTS OF RESEARCH PUBLISHED IN *L&O*

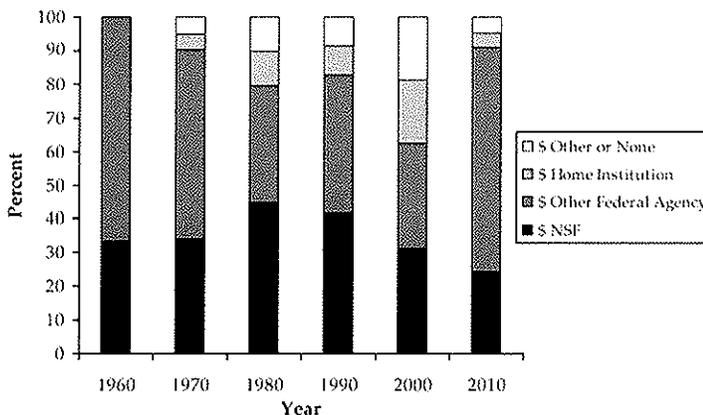
It is not practical to analyze sources of support for research published in *L&O* on an international basis because of the great variety in funding mechanisms, but an analysis of articles with U.S. authors is possible (Figure 4). Within the U.S.,

Table 1. Comparative statistics for articles of limnological content in *L&O* and for a comparison group of 6 other journals (see text for list).

Attribute (2000)	<i>L&O</i>	Comparison Group
Growth 1990-2000, %	11*	25
Number of Authors	3.4	2.9
Percent U.S. Authors	24	29
Percent Lakes	77	50
Percent Plankton	72	38
Percent Benthos	6	21
Percent Biogeochemistry	37	8
Percent Energy Flow	11	10

* The longer-term slope indicates that 20% is more characteristic.

Figure 4. Funding sources acknowledged by U.S. authors of *L&O* articles.

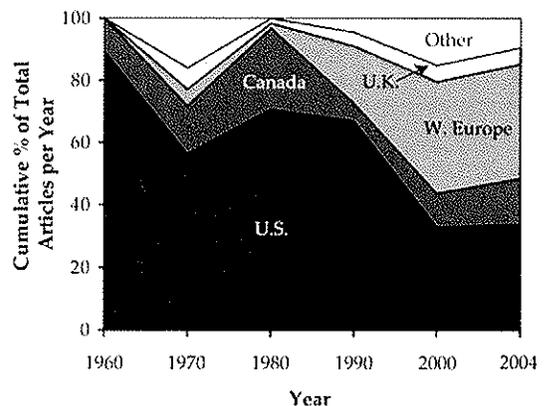


about one-quarter of limnological research published by *L&O* is now supported by the National Science Foundation; NSF support has declined steadily from about 45% in 1980. The relative importance of other agencies, home institutions, and articles with no designated support is too irregular to be interpreted in any detail. The large amount of limnology that is conducted without acknowledged support or with home support seems high, however (mean about 20% since 1980), given that *L&O* is very selective. Evidently, a limnologist who has a good idea will find some way of bringing it to fruition, whether a granting agency likes it or not.

In 1960, *L&O* content in limnology was 90% U.S. and 10% Canadian as judged by senior authors (Figure 5). The UK contribution rose to about 7% as early as 1970, and has hovered mostly around 5% since that time; UK limnologists have published a great deal of influential work, but favor homegrown outlets, a number of which are well distributed. The same was true of non-UK Western European limnologists as recently as 1980, but from 1990 to present continental Western Europe has been a major contributor to *L&O*. In fact, Western Europe and North America have undergone a publishing merger through *L&O*. Other contributions, which are distributed across Latin America, Asia, Africa, Eastern Europe, and Australia, have risen in significance along with the Western European contributions. Thus, *L&O* was strictly a North American journal originally, but it now draws contributions globally, although most notably from North America and Western Europe. Other journals now show a similar mix of nationalities (Table 1).

The limnological side of *L&O* has been directed strongly toward lakes (Figure 6). Astonishing growth in limnological research on streams and rivers after 1970 has not affected relative representation of these ecosystem types in *L&O* articles, except possibly in a limited way over the most recent years (Figure 6). *L&O* consistently has dealt very sparingly with wetlands and pools, although the intensity with which such ecosystems are now studied is far greater

Figure 5. Cumulative proportion of *L&O* articles accounted for by senior authors of specific nationalities.



than it was in 1960. Thus, by convention established in its early years, together with a high rejection rate, *L&O* has maintained very nearly the same allocation of space to ecosystem types within limnology since its inception.

Scoring of articles by organism type shows that 60-80% of the limnological articles in *L&O* that involved organisms (about 60% of articles) have dealt with phytoplankton, zooplankton, and bacteria (mostly bacterioplankton) since 1970 (Figure 7). The wax and wane of trends among lake-oriented limnologists is evident within these three groups. A bloom of interest in phytoplankton peaked near 1980 and was followed by the zooplankton craze of 1975 to 1990, and a weaker but definite emphasis on bacteria between 1980 and 1990. Other organismic categories always have been sparsely covered. Macrophytes, periphyton, and benthic insects show a mean of about 5% each and no obvious trend across the years. Fish have averaged 2-3%, as have mollusks. Other taxa, including viruses and fungi as well as various other invertebrate groups, have appeared at mean frequencies below 1%. Papers that explicitly deal with multiple plankton components (e.g., zooplankton + phytoplankton), entire food webs, or multiple benthic components have shown a frequency of about 10%, which is less than might be expected.

When scored by general subject, *L&O* articles show consistently strong representation of biogeochemical topics; this emphasis had increased to almost 40% as of 2004 (Figure 8). Energy flow and metabolism also have been represented strongly and steadily (at about 20% overall), as has population dynamics (at about 15% overall). Articles dealing with specific adaptations of organisms account for about 10% and show no particular trend. Physical limnology accounts for 10-15% overall, and shows no trend; it is divided almost equally between studies of water movement and studies of heat, irradiance, or optics.

CONCLUSIONS

The last 50 years have produced a transformation of limnology and limnological publishing. In 1960, most publishing and organized professional activity in limnology

was regional; only the International Limnological Society (SIL), with its triennial congresses and published proceedings, operated globally. As of 2004 ASLO, through *L&O* and regular meetings, had established a strong bridge to Western Europe over which unprecedented geographic unification has taken place. The ASLO bridge is narrow, however, and most of the world still uses the old SIL bridge, which is wider and more accommodating but not so statuesque. ASLO and SIL should attempt to make their bridges more actively complementary.

Through *L&O* and its regular meetings, ASLO has built and sustained a fraternal relationship with oceanography, which was a founding goal of ASLO. In pursuing this goal, ASLO and *L&O* came to focus on branches of limnology that most resemble oceanography. Thus, both ASLO and *L&O* probably have contributed to the Balkanization of limnology, particularly in the U.S., where limnology now is less unified than it was in 1960. Whether this matters or not is debatable. Subdivision of a discipline, however, reduces its ability to command financial support and to influence political and societal trends. Limnology has much to offer in these arenas, but its influence is greatly diluted. To a large extent, limnologists must hope that more unified sister sciences such as hydrology or ecology can carry some of the messages that limnologists formulate but cannot deliver effectively. Reassembly of the fragments of limnology would offer many possibilities, but recent family reunions (Council of Aquatic Sciences: 1998-2003) showed that a number of family members were too busy to attend and others could not sustain enthusiasm for togetherness. It would be wrong to give up on this concept, however.

Limnology has been diagnosed previously as anemic (Jumars 1990, Lewis et al. 1995), and the data presented here support the diagnosis. The widening gap between limnology and oceanography in *L&O*, for example, suggests weak competitive ability that could be traceable either to deficiencies in limnologists or deficiencies in resources available to limnology; the latter seems more palatable. Persistence of a significant percentage of unfunded projects,

Figure 6. Percent of *L&O* articles dealing with specific ecosystem types since 1960.

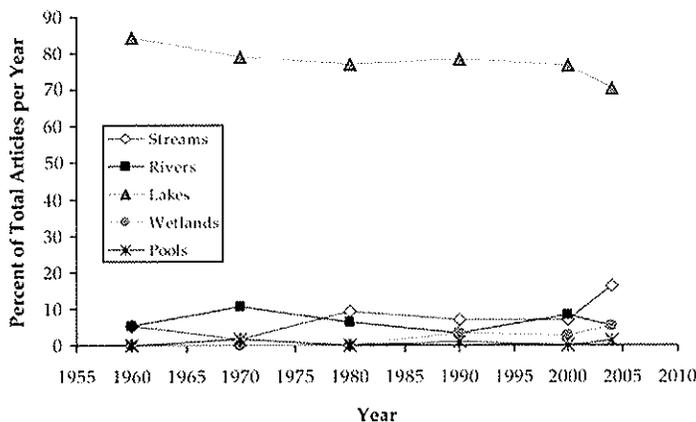
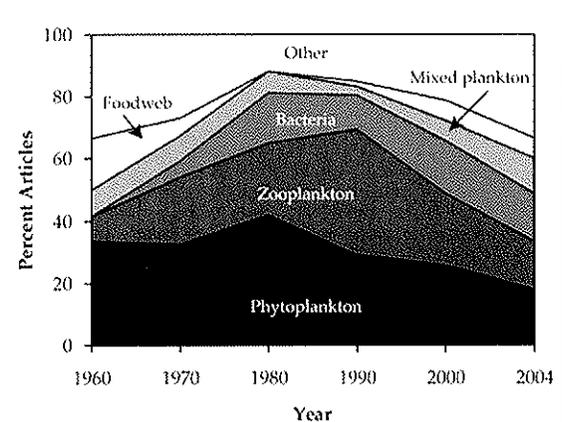


Figure 7. Cumulative percent of *L&O* articles dealing with specific organismic groups since 1960.



even in the rarified pages of *L&O*, and weakening NSF funding also are indicators of inadequate support.

Limnology can remake itself or it can become increasingly obscure. Modern limnology is intellectually and technically vigorous, but remains externally invisible, fragmented, and poorly funded. Business as usual over the next 50 years will likely leave limnology parted out like an old automobile. Science and society need limnology, but limnologists must consciously address this need.

ACKNOWLEDGEMENTS

Melynda May and Rebecca Anthony collected the data presented in this manuscript. Peter Jumars, Everett Fee, Paul Kemp and Greg Cutter provided criticism leading to improvements in the manuscript.

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Figure 8. Cumulative percent of *L&O* articles dealing with specific topics since 1960.

