A COMPARATIVE ANALYSIS OF ECOLOGY LITERATURE DATABASES

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ABSTRACT:
There is a bewildering array of databases currently available for literature searches. Major, traditional indexes to the primary literature of ecology include: Biological Abstracts, Biological and Agricultural Index, CAB Direct, CSA Biological Sciences, Web of Science, Wildlife and Ecology Studies Worldwide, and Zoological Record. New indexes and search engines have recently appeared; notably Google Scholar, Scirus, and Scopus. Multidisciplinary, full text, undergraduate-oriented, databases such as Academic Search Premier from EBSCO, and/or Academic Index ASAP from Gale are widely available and frequently used at academic libraries. All of these electronic databases were compared and ranked using quantitative criteria and search results. Database content was benchmarked against randomly selected bibliographies from articles in well known ecology literature review journals. A list of the top 20, most important, journals for ecology was compiled based on a citation analysis of the bibliographies; this analysis revealed that 84% of the literature cited is journal articles and 11% was books or book chapters. Criteria for evaluating databases included: coverage of the most important ecology journals, freshness of indexing, completeness of indexing, inclusion of citations from the bibliographies examined, and size as indicated by keyword searching of title fields. Somewhat surprisingly, based on these analyses, the best databases overall for finding the primary literature of ecology are: Web of Science, Scopus, Google Scholar, Academic Search Premier, and Scirus. An additional analysis of ecology books and book chapters showed OCLC's WorldCat to clearly have the most content.

INTRODUCTION:

Many academic libraries present a bewildering array of databases available for literature searches. Science librarians and science researchers often have definite opinions about the best databases to search for literature about particular topics. These preferences may be based on initial advice, past experiences, vendor provided information, continuing education (e.g. professional literature, pathfinders, conferences, workshops), what is available locally, and/or first hand testing of various products. Database selection and literature search habits once established are resistant to change and likely to be infrequently re-examined even when the local availability of databases changes. However, as database options change over time, the relative performance of databases may also change as well. What was once considered one of the "best" databases for a particular topic may no longer be so.

The subject area of ecology (the study of organisms and their environments and the evolutionary history of that relationship) was selected for analyzing databases and their relative performance in this study because of the high interest in ecology related literature by university students and faculty (in departments and classes from biology, environmental science, general education, forestry, and wildlife) and the large number of relevant databases available for finding ecology literature. Major, traditional, electronic indexes to the primary literature of ecology include: Biological Abstracts, Biological and Agricultural Index, CAB Direct, CSA Biological Sciences, Web of Science, Wildlife and Ecology Studies Worldwide, and Zoological Record. New indexes and search engines have recently appeared; notably Google Scholar, Scirus, and Scopus. Multidisciplinary, full text, undergraduate-oriented, databases such as Academic Search Premier from EBSCO, and/or Academic Index ASAP from Gale are widely available, and frequently used, at academic libraries. Traditional and new databases for searching books and book chapters on ecology include: Amazon.com Books, Biosis, CAB Direct, Google Books, OCLC's WorldCat, Wildlife & Ecology Studies Worldwide, and Zoological Record. Given this plethora of databases a systematic, quantitative, comparative, analysis appears to be useful for testing assumptions and examining the relative performance of the many different database choices currently available for searching the literature of ecology.

Davis and Schmidt (1995) identify sources for "reviews of the literature" in ecology. Of the seven journals listed in that chapter, two of them (Trends in Ecology & Evolution, Annual Review of Ecology, Evolution and Systematics) were selected for use in this study as benchmarks for establishing criteria used in this ecology database analysis. Those two journals are also identified as having the highest impact factor within the subject category of ecology journals as listed in the 2005 Journal Citation Reports (JCR), Science (published by Thomson). Criteria established for evaluating databases in this study included: coverage of the most important ecology journals, freshness of indexing, completeness of indexing, inclusion of citations from the bibliographies examined, and size as indicated by keyword searching of title fields.

Most previous life science database analyses and comparisons have looked at journal numbers and the overlap in journal indexing between databases and the need to use multiple indexes for comprehensive literature searches (Poyer 1984; Bearman and Kunsberger 1977; Chisman 1989; Chisman and Brekke 1996; Hughes 2001; Parker 2005). Jatkevicius (2000) and Parker (2005) are some of the few studies to use keyword searches to compare and rank databases. Many reviews and comparisons have now been published with various combinations of Google Scholar, Scirus, Scopus and Web of Science (Jasco 2005; Deis and Goodman 2005; Giustini and Barsky 2005; Dess 2006; Bosman et al. 2006; Tompson 2007). Often reviewers express reservations about Google Scholar based on the uncertainty of what is indexed in it, and from what publishers, and the incompleteness of content from some journals; Christianson (2007) states the need for additional studies to look at how well Google Scholar indexes the very latest research.

METHODS:

Ten articles were randomly selected (using a random number sequence generator) from the 2005 journal issues of *Trends in Ecology & Evolution*, and *Annual Review of Ecology, Evolution and Systematics* (Appendix 1). The entire contents of the bibliographies of those ten articles were completely analyzed, by one library student worker, with the type of information source noted, and journal names identified, and number of occurrences counted. The top 20 ecology journals were then identified based on occurring 10 or more times in the bibliographies, and used for subsequent database analyses. These methods are similar to those used by Brown (In Press).

20 Citations were randomly selected (using a random number sequence generator) from the bibliographies of the 10 Articles from the 2005 issues of *Trends in Ecology and Evolution*, and *Annual Review of Ecology, Evolution and Systematics* (Appendix 2) and used for subsequent database analyses.

Twelve databases were identified (Appendix 3) for analysis and comparison with ecology primary literature searches. Each of the following criteria was searched, and results noted (Tables 2 – 6), in each of the databases: 1) Coverage of the top 20 ecology journals (the journal name and issn number were searched in the appropriate field; each journal not included was scored as one point; note: if the most recent articles included were over 2 years old then the journal was listed as not included); 2) Freshness of indexing (as measured by the most recent issue with content for each of the top 20 ecology journals if included by that database; each issue behind was scored as one point and all journals were averaged with results rounded to one tenth; note: if 2 or fewer articles were listed then the issue was not considered to be indexed and the next issue was examined); 3) Completeness of journal table of contents indexing (as measured by searching for the first 10 articles indexed, from the most recent issue available within the database for each of the top 20 ecology journals, if included by that database; each article missing was scored as one point and all journals were averaged with results rounded to one tenth; note: some content, e.g. news, editorials for some journal titles was consistently skipped and not counted as an article); 4) Inclusion of the 20 citations randomly selected from the bibliographies (as measured by presence or absence, with each article not included scored as one point); and 5) Size of ecology content (as measured by keyword searching " ecology or ecological or ecosystem" in the title field for 2005 and for 1995; total results for each of the two years was listed and combined). These methods generally follow Jasco's (2001) recommendations of keyword title searches as a quick way to gauge the scope of a database, and additional testing to determine a database's composition, currency, retrospectivity, and journal base.

Based on the results, the databases were ranked for each of the 5 criteria examined. And based on combining each of the 5 individual criteria rankings an overall ranking of databases was established (Table 7). The individual rankings were combined, instead of using the scores for each category, so that no one criteria (with may have higher amounts and ranges of scores than other criteria) would dominate the overall ranking, and instead all the criteria would contribute equally to the final, overall ranking of the databases.

Keyword searches, in the title field, for each of the terms: ecology, ecological, and ecosystem, restricted to the document type of books or book chapters, and also restricted to the publication year of 2005 and also of 1995 were performed in Amazon.com Books, Biosis, CAB Direct, Google Books, OCLC's WorldCat, Wildlife & Ecology Studies Worldwide, and Zoological Record. Results are listed in Table 8.

RESULTS:

There were 1,010 total citations examined from the bibliographies of the ten articles randomly selected from the 2005 journal issues of *Trends in Ecology & Evolution*, and *Annual Review of Ecology, Evolution and Systematics* (Appendix 1). 84% of the citations were journal articles (835), 11% were books or book chapters (115), and 5% were unknown or other types of information sources (60).

From the 835 journal article citations examined there were 190 individual journal titles identified. Of those 190 journal titles there were 20 journal titles that were listed 10 or more times. Those 20 journal titles were identified, for the purpose of this study, as the most important journals for ecology (Table 1).

Table 1: Top 20 Most Important Journals for Ecology
(based on a citation analysis of 1,010 citations from bibliographies of 10 randomly sampled articles from ecology literature review journals for 2005):

American Journal of Botany (13 citations)
American Naturalist (50 citations)
Annual Review of Ecology, Evolution, and Systematics (18 citations)
Biological Journal of the Linnean Society (13 citations)
Conservation Biology (13 citations)
Ecological Entomology (11 citations)
Ecology (91 citations)
Ecology Letters (15 citations)
Evolution (37 citations)
Functional Ecology (13 citations)
Genetics (10 citations)
Journal of Animal Ecology (21 citations)
Journal of Applied Ecology (11 citations)
Journal of Ecology (12 citations)
Journal of Evolutionary Biology (16 citations)
Nature (44 citations)

Oecologia (60 citations)
Oikos (39 citations)
Science (26 citations)
Trends in Ecology & Evolution (24 citations)

Of the 20 citations randomly selected from the bibliographies of the 10 articles from the 2005 issues of *Trends in Ecology and Evolution*, and *Annual Review of Ecology, Evolution and Systematics* (Appendix 2) and used for subsequent database analyses, 1 of the 20 citations was a book chapter and the rest were journal articles. Subject wise, the citations broke down roughly into half focused primarily on plants and half on animals.

All of the 12 primary literature databases were analyzed and ranked using criteria and procedures described in the Methods section. And the results are listed in Tables 2-7. All of the 7 book literature databases were analyzed using criteria and procedures described in the Methods section and listed in result order in Table 8.

Table 2: Coverage of Top 20 Ecology Journals

Rank (Lowest is Best)	Database	Score: # Top 20 Journals Excluded
1	Academic Search Premier	0
1	Biological Sciences	0
1	Google Scholar	0
1	Scopus	0
1	Web of Science	0
1	Zoological Record	0
7	Biological Abstracts	1
8	CAB Direct	2
9	Wildlife & Ecology Stud WW	3
10	Scirus	8
11	Expanded Academic ASAP	9
12	Biological & Agricultural Index	10

Table 3: Freshness of Indexing (Issues of Top 20 Ecology Journals)

Rank (Lowest is Best)	Database	Score: Average # Issues Behind
1	Academic Search Premier	0.4
2	Biological & Agricultural Index	1.0
2	Scopus	1.0
2	Web of Science	1.0
5	CAB Direct	2.8

6	Biological Abstracts	3.1
7	Google Scholar	4.1
8	Expanded Academic ASAP	4.2
9	Zoological Record	4.8
10	Biological Sciences	5.0
11	Scirus	5.1
12	Wildlife & Ecology Stud WW	5.8

Table 4: Completeness of Table of Contents (Top 20 Ecology Journals)

Rank (Lowest is Best)	Database	Score: Aver. # Articles Excluded (out of the first 10 articles)
1	Scirus	0
1	Web of Science	0
3	Academic Search Premier	0.1
4	Expanded Academic ASAP	0.2
5	Biological Abstracts	0.7
5	Scopus	0.7
7	Biological Sciences	1.9
8	Biological & Agricultural Index	2.1
9	Google Scholar	2.2
10	CAB Direct	4.3
10	Zoological Record	4.3
12	Wildlife & Ecology Stud WW	7.3

Table 5: Inclusion of Citations (Bibliographies from Top 20 Ecology Journals)

Rank (Lowest is Best)	Database	Score: # Citations Excluded (out of 20 citations sampled)
1	Google Scholar	0
1	Scirus	0
1	Web of Science	0
4	Scopus	4
5	Biological Sciences	5
6	Biological Abstracts	8
7	Zoological Record	9
7	CAB Direct	9
9	Academic Search Premier	11
10	Expanded Academic ASAP	12
11	Biological & Agricultural Index	13
12	Wildlife & Ecology Studies WW	15

Table 6: Size (Title Keyword Search of Ecology or Ecological or Ecosystem)

Rank (Lowest is Best)	Database	Score: # for 2005 + 1995 = Total
1	Google Scholar	99,200 + 79,800 = 179,000
2	Scirus	28,117 + 680 = 28,797
3	Scopus	3,783 + 1,753 = 5,536
4	Web of Science	2,598 + 1,771 = 4,369
5	Zoological Record	2,149 + 1,882 = 4,031
6	Biological Abstracts	2,181 + 1,487 = 3,674
7	CAB Direct	1,674 + 1,126 = 2,800
8	Academic Search Premier	2,024 + 494 = 2,518
9	Biological Sciences	1,607 + 142 = 1,749
10	Wildlife & Ecology Studies WW	1,043 + 703 = 1,746
11	Expanded Academic ASAP	748 + 535 = 1,283
12	Biological & Agricultural Index	255 + 196 = 451

Table 7: Overall Ranking of Relative Performance for Ecology Literature Searches

Rank (Lowest is Best)	Database	Score: Individual Rankings Sum
1	Web of Science	9
2	Scopus	15
3	Google Scholar	19
4	Academic Search Premier	22
5	Scirus	25
6	Biological Abstracts	30
7	Biological Sciences	32
7	Zoological Record	32
9	CAB Direct	37
10	Expanded Academic ASAP	44
11	Biological Agricultural Index	45
12	Wildlife & Ecology Studies WW	55

Table 8: Keyword, title search, restricted to books and book chapters document type

Database	Date	Keyword Title	Total Results
OCLC WorldCat	2005	ecology	873
OCLC WorldCat	2005	ecological	595
OCLC WorldCat	2005	ecosystem	317
OCLC WorldCat	1995	ecology	1,348

OCLC WorldCat	1995	ecological	807
OCLC WorldCat	1995	ecosystem	395
Google Books	2005	ecology	610
Google Books	2005	ecological	377
Google Books	2005	ecosystem	160
Google Books	1995	ecology	420
Google Books	1995	ecological	227
Google Books	1995	ecosystem	117
Amazon.com Books	2005	ecology	461
Amazon.com Books	2005	ecological	202
Amazon.com Books	2005	ecosystem	137
Amazon.com Books	1995	ecology	217
Amazon.com Books	1995	ecological	86
Amazon.com Books	1995	ecosystem	65
Biosis	2005	ecology	194
Biosis	2005	ecological	212
Biosis	2005	ecosystem	109
Biosis	1995	ecology	621
Biosis	1995	ecological	400
Biosis	1995	ecosystem	290
CAB Direct	2005	ecology	54
CAB Direct	2005	ecological	53
CAB Direct	2005	ecosystem	44
CAB Direct	1995	ecology	49
CAB Direct	1995	ecological	35
CAB Direct	1995	ecosystem	9
Zoological Record	2005	ecology	42
Zoological Record	2005	ecological	15
Zoological Record	2005	ecosystem	8
Zoological Record	1995	ecology	64
Zoological Record	1995	ecological	17
Zoological Record	1995	ecosystem	5
Wildlife & Ecology Studies WW	2005	ecology	2
Wildlife & Ecology Studies WW	2005	ecological	1
Wildlife & Ecology Studies WW	2005	ecosystem	8
Wildlife & Ecology Studies WW	1995	ecology	23
Wildlife & Ecology Studies WW	1995	ecological	17
Wildlife & Ecology Studies WW	1995	ecosystem	27

DISCUSSION:

Examining one's long held assumptions and beliefs about traditional databases, and comparing their performance using explicit criteria, to newer databases, can be a valuable, labor intensive, and potentially disillusioning exercise. Some databases scored and ranked unexpectedly high and some unexpectedly low in this current analysis of ecology literature. Results are similar to those of Brown (In Press) analyzing freshwater ecology literature with three of the same databases (Google Scholar, Scopus, Web of Science) in the top five; the biggest difference in the two studies was the performance of Academic Search Premier, Scirus and Biological Sciences all of which are rated higher in this current study of ecology literature. The biggest surprises of this study were how well Academic Search Premier and the multidisciplinary, citation indexes (Scopus and Web of Science), and the web search engines (Google Scholar, Scirus) performed, and how poorly many of the traditional, specialized, life science indexes performed. However, given the fact that Scirus did not include indexing for 8 of the top 20 ecology journals (Table 2) and that Academic Search Premier did not contain 11 of the 20 randomly selected ecology citations checked (Table 5), and since both of these databases had a dramatic drop in coverage of older literature (Table 6), neither of those databases can be recommended as a "best database for ecology". That would leave a recommendation for researchers looking for ecology primary literature to use either Scopus or Web of Science, along with Google Scholar; and if one wanted to be very thorough to add a third database search of either Biological Sciences or Biological Abstracts. Additionally for comprehensive coverage of ecology book and book chapter literature researchers should be directed to use OCLC's WorldCat.

The literature of ecology, as determined by citation analysis for this study, is overwhelmingly (84%) journal articles, and to a much smaller extent books and book chapters (11%); these percentage results are very similar to a citation analysis done for veterinary literature (Crawley-Low 2006). When the top 20 ecology journals, as determined by citation analysis for this study, are compared with the results for ecology journals sorted by impact factor (Journal Citation Reports – Science, 2005) both lists share more than half (11) of the top 20 journals. Two of the top 20 journals identified are *Science* and *Nature* which are widely read, premier, multidisciplinary journals (and which are not included in the JCR Science category of ecology). Over half of the top 20 ecology journals, as determined by citation analysis for this study, are published by Blackwell. Bradford's Law appears to be upheld by the results of this study's citation analysis as 20% of the journals (the top 38 out of 190) produced 75% of the cited articles.

The analysis looking at inclusion of the top 20 ecology journals showed six of the databases indexing all of the journals (Academic Search Premier, Biological Sciences, Google Scholar, Scopus, Web of Science, Zoological Record). A few of the databases excluded a surprising number of the top journals (e.g. Biological & Agricultural Index did not index 10, Expanded Academic ASAP did not index 9, and Scirus did not index 8). The performance of the two undergraduate oriented, multidisciplinary databases was strikingly different (i.e. Academic Search Premier versus Expanded Academic ASAP).

The analysis examining freshness of indexing showed a wide range of variation. Academic Search Premier had indexing, on average, of less than one issue behind (0.4!). Both multidisciplinary, citation indexes (Scopus, Web of Science) had indexing, on average, of only one issue behind (1.0). Both search engines had significant indexing lag times with Google Scholar, on average, 4 issues behind and Scirus, on average, 5 issues behind. Others have also noted the lag time of indexing by Google Scholar (Vine 2006).

The analysis measuring the selectiveness of indexing for journal contents also showed a wide range of variation. Academic Search Premier, Expanded Academic ASAP, Scirus, and Web of Science scored extremely high with all journals, on average, being completely indexed. Biological Abstracts and Scopus both scored high with all journals, missing, on average, indexing about 1 out of 10 articles checked. Biological & Agricultural Index, Biological Sciences, and Google Scholar were missing, on average, indexing about 2 out of 10 articles checked. CAB Direct, Wildlife & Ecology Studies, and Zoological Record all proved to be extremely selective for which articles were indexed out of the top 20 ecology journals.

The analysis determining the number of citations included, based on the random sample of 20 citations from the bibliographies of the articles analyzed showed that Google Scholar, Scirus, and Web of Science were very comprehensive (i.e. they had all 20). Less than half the citations were included in Academic Search Premier, Biological & Agricultural Index, Expanded Academic ASAP, and Wildlife & Ecology Studies Worldwide. Most of the traditional, specialized, life science indexes were not very comprehensive. Christianson (2007) raises the concern that while Google Scholar contains lots of citations they are often incomplete and do not lead to accessible articles.

The analysis looking at size of the ecology relevant content of the databases (Table 6 - using a title keyword search of: ecology or ecological or ecosystem) obviously favored the search engines (Google Scholar, Scirus) and the precision of the actual numbers may be open to questions. However, if that entire analysis is removed from the overall ranking of databases (Table 7) the overall results are not significantly changed and the same top 5 databases remain; the only difference is that Google Scholar slips down one ranking, Academic Search Premier moves up one ranking, and CSA Biological Sciences moves up in a tied ranking of 5th place with Scirus. Based on the results of this study, CSA Biological Sciences appears to now be a viable competitor to Biological Abstracts contrary to what Jatkevicius (2000) found when he used 42 keyword searches to compare Biological Sciences with Biosis. Some databases (Academic Search Premier and Scirus) had dramatically lower results for 1995 compared to 2005. A better test than size, or a good additional test, would be one of relevance utilizing ecology researchers (e.g. undergraduate students, graduate students, and faculty) and asking them to rate the usefulness of search results for different topics and uses across all the databases (ideally with a double blind review process). However, convenience of access and ease of interface may ultimately be more important factors for user selection of databases. There are many reasons that library users have turned increasingly to Google and Google Scholar for literature searches and this analysis indicates that content may justify that choice for ecology related searches.

OCLC's Worldcat, is the clear leader, for now, in ecology related book and book chapter content (Table 8). However, the newer databases of Amazon.com Books and Google Books have a significant amount of content and provide the additional functionality of fulltext searching (search inside the book) for many of their books. There is a pattern in the traditional databases (except for CAB Direct) of more book content for 1995 than for 2005; this is not true for the newer databases (Amazon.com Books and Google Books). Wildlife and Ecology Studies Worldwide and Zoological Record had less book content by orders of magnitude than the other databases.

Librarians serving users searching for ecology literature may wish to review the results of this study and adjust their recommendations for database selection and use. Some science librarians have resented the perennial popularity with users of Web of Science and have done their best to show that specialized indexes are better (Parker 2005). However, the results of this study show otherwise and the future of traditional, specialized databases is uncertain (both in their local use and continued availability) given the competition from freely available search engines that now provide significant access to the scholarly literature. Some forecasters predict the demise of traditional, specialized indexes (Dupuis 2007) while others (DeGuire 2006) foresee a continuing and important role for them and stress their consistency and the added value of subject headings, etc. Sadeh (2006) predicts that Google Scholar will not replace library metasearch systems anytime soon. With many academic libraries juggling acquisition dollars to acquire large ejournal packages providing access to journal content, and maintaining large, popular, multidisciplinary indexes (e.g. Web of Science, Scopus) a further prioritization and perhaps weeding of traditional, specialized, indexes seems inevitable.

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Appendix 1: Random Sample of 10 Articles from 2005 issues of *Trends in Ecology and Evolution*, and *Annual Review of Ecology, Evolution and Systematics*.

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Appendix 2: Random Sample of 20 Citations from the bibliographies of 10 Articles from 2005 issues of *Trends in Ecology and Evolution*, and *Annual Review of Ecology, Evolution and Systematics*

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2) Batten, S.D. and Welch, D. W. 2003. Changes in oceanic zooplankton populations in the North-east Pacific associated with the possible climatic regime shift of 1998/ 1999. *Deep Sea Res II* 51: 863-873.

3) Begon, M. et al. 2003. Rodents, cowpox virus and islands: densities, numbers and thresholds. *J. Anim. Ecol.* 72: 343-355.

4) Bradshaw, B. 2004. Plus c’est la meme chose? Questioning crop diversification as a response to agricultural deregulation in Saskatchewan, *Canada. J. Rural Stud*. 20: 35-48.

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Appendix 3: Databases Analyzed & Compared for Ecology Literature Searching

Primary Literature Databases Examined
- Academic Search Premier (Ebsco)
- Biological Abstracts (Biosis)
- Biological & Agricultural Index (Wilson)
- Biological Sciences (Proquest CSA)
- CAB Direct (CABI)
- Expanded Academic ASAP (Thomson Gale)
- Google Scholar (Google)
- Scirus (Elsevier)
- Scopus (Elsevier)
- Web of Science (Thomson)
- Wildlife & Ecology Studies Worldwide (NISC)
- Zoological Record (Biosis)

Books and Book Chapters Databases Examined
- Amazon.com Books
- Biosis
- CAB Direct (CABI)
- Google Books (Google)
- Wildlife & Ecology Studies Worldwide (NISC)
- WorldCat (OCLC)
- Zoological Record (Biosis)