

A Bibliometric Analysis of Worldwide Publications on Scrub

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In the last decades, concern for environmental conservation, especially desertification, has taken on an unprecedented significance. The advance of desertification has provoked the disappearance of tree cover, followed by the proliferation of scrub as an intermediate step in the final disappearance of vegetation cover. Scrub is found throughout the world, particularly in the Mediterranean Region, which includes such disparate regions as Chile, California, South Africa, Southern Europe, North Africa, the Near East and Southwestern Australia. This concern has led to a great number of studies of scrub.

Of all the world's scrublands, perhaps the Mediterranean type has been traditionally the most exploited. The wide range of uses include gastronomy, chemicals, fauna, protection of the soil, and so forth. Since the time of antiquity, scrub has been cut and converted into a low caloric content charcoal (known in Spanish as *cisco* or *picón*) for purely household use. The wood has been used as kindling for traditional baker's ovens, and roasting with labdanum (*Cistus ladanifer*) and brezos (*Erica*) as fuel etc. gives the meat a very particular smoked flavour. Other scrub species are used as kitchen spices (thyme, rosemary, oregano, ...), nuts (pistachios), and berries for fresh consumption or for jams (blackberry, redcurrant, ...).

Chemically, products from scrub have been used as mordants and essences in perfumery, and there are presently investigations of uses as biocides against certain pests and/or weeds whose development they impede via mechanisms of incompatibility or allelopathy. Also the genus *Cytisus* is currently under study for making high quality paper pulp, and scrub in general for electricity generation from its biomass.

The existence of scrub in a given area protects the soil naturally against rain erosion. It reduces the flushing away of surface material and screens the soil from the direct impact of heavy rainfall. For this reason, labdanum has been introduced into the western United States to minimize erosion damage. The litterfall also provides a layer which favours soil creation, recycling nutrients which otherwise would be washed away. In addition to this, there is the protection that scrub affords to fauna, providing nesting cover for small birds (Fringillidae, Paridae, Silviidae, Turdidae, . . .) and micromammals, and refuge against predators for a wide range of small game (rabbit, hare, partridge, . . .).

Traditionally, both trees and shrubs are usually cleared, decreasing the density of individuals (by controlled burning and cutting) and cutting back branches. The result is a population of trees that are well formed, upright, and at a medi-



Worldwide distribution of mediterranean scrub: 1-Mediterranean basin, 2-California, 3-Chile, 4-South Africa, 5-Australia

um density, allowing a greater aeration and penetration of light. Usually the main objective of such management is suitability for livestock production, taking advantage of the fertility of the soil that resulted from the previous tree and shrub presence.

However, the shrubs are usually destroyed and reincorporated too quickly into the soil's mineral bank, with little formation of litter and humus. The soil too is broken by harsh mechanical means, by ploughing or at least harrowing. Moisture is to a great proportion lost. The soils thus become very loose structured, and really a "new" habitat is formed which can be rapidly and intensely colonized by grassland species. The pasture may be left as natural, since many spontaneously growing species have considerable nutritional value, or it may be sown with other species of interest for grazing which have to be resown after some years. The splendour of the early days of the pasture tends to decline after 6–10 years, with steady losses of richness and density. In general, either tractors are again introduced even in the knowledge that the next generation of pasture will be poorer, or more often the land is abandoned to colonization by scrub, thus to repeat the cycle. At the end of this process, there has been the inexorable rapid nutrient loss from the soil, the greater exposure to direct sunlight increases evaporation and temperature extremes, with a resulting loss of moisture and liability to erosion.

These problems are obviated by appropriate management of these systems, focusing on soil fertility and optimizing the yield of usable biomass. Senescence of exploitable

species has to be avoided, with the system being cultivated in a controlled and sustainable manner.

Since the types of scrub that are found in the different zones depend on the territory's physical characteristics, mainly soil and climate, most of the studies are oriented toward analyzing the effects of those factors. Furthermore, there are many papers on the management of large extensions of land after fire (whether natural or from human intervention), since many scrub lands are mainly formed by fires, which eliminate the woody stratum and increase grazing land. In these conditions, scrub advances or disappears through human pressure (provoked fires), according to whether the livestock load increases or decreases, in zones dedicated to grazing. A gradual phasing out of grazing will lead to a continual increase in scrub coverage. Therefore many of the studies on scrub focus on the vegetation fire, on the effects of grazing and on secondary succession. Amongst other topics studied, there also are papers on scrubland diversity, analyzing and comparing the variations from man-made causes such as deforestation, fire, grazing, etc.

To analyze bibliographically the worldwide scientific output on scrub, it was necessary to search several databases. A bibliometric study was carried out with the records obtained to determine the distribution and evolution of world production on scrub. Bibliometric studies are an alternative to the scientific literature reviews, providing information on the size, growth and distribution of scientific literature, and on the structure and dynamics of the groups that produce it. It is well established that the development of Science is di-



The "jara" (*Cistus ladanifer*, rockrose or labdanum), one of the most abundant Mediterranean scrubland species of the SW of the Iberian Peninsula, colonizes the steepest areas of terrain. In these zones, it commonly forms single-species patches of scrub.



Mediterranean scrubland of the SW of the Iberian Peninsula. In the foreground: formations of Cistus ladanifer and Cytisus striatus scrub in flower. In the background: peaks of armorican quartzite, which, due to their inaccessibility, constitute a refuge for scrubland species.

rectly related to, among other factors, output of scientific papers and the flow of information in the direction of becoming general knowledge. In particular, one may determine which countries have the greatest output, how papers are distributed amongst the journals and the other documents, languages of publication, the authors output, nationalities, etc.

Though bibliometric studies have a long history already (Cole and Eales 1917; Hulme 1923; Narin and Moll 1977), this is the first application on analyzing the worldwide literature on scrub.

The study material (bibliographic references to scrub) was obtained from the following data bases: AGRICOLA, AGRIS INTERNATIONAL, BIOSIS PREVIEWS and CAB ABSTRACTS.

AGRICOLA: produced by the National Agriculture Library (NAL) of the United States. The information coverage en-

compasses all types of publication on agriculture and related subjects from the 1970s until the present. The data base is updated monthly.

AGRIS International: produced by the National Agriculture Library (NAL) of the United States. This file forms a part of AgrIndex, a monthly publication of FAO of the United Nations. It collects information on agriculture and plant and animal production in all fields from 1975 until the present time, with monthly updates of the data base.

BIOSIS Previews: produced by BIOSIS, Philadelphia, United States. Contains about 8.3 million bibliographical citations, from 1969 until the present, updated weekly, coming from the principal publications of BIOSIS. It provides an exhaustive world coverage of investigations in biomedical and biological sciences.

CAB ABSTRACTS: Produced by CAB International, Wallingford, Slough, United Kingdom. This is a file of information on agriculture and biology and includes all the records in 26 principal abstract journals published by CAB International.

These databases were searched for the words SCRUB, MATORRAL and CHAPARRAL in the title field and/or in descriptors from 1985–1994. After eliminating repetitions and overlaps between the data bases, we found 1,165 references. More than 80% of the references were journal articles (940), the rest being congress proceedings (129), books (70) and doctoral theses (26).

Table 1 shows the distribution of documents of each type by year. The greatest production occurred in 1989 with 177 documents, though the annual output was fairly uniform over the first seven years (85–91). The progressive decline in the last three years is simply caused by the time many databases take to update new material.

The 940 journal articles were published in 519 journals. Table 2 lists the journals with at least five scrub publications, the number of articles, the 1993 Impact Factor (see below) and the country of publication. These 32 journals contain 30% of the total of articles. It is also noteworthy that 40% of the journals (376) published only 1 article, thus indicating a great degree of dispersion of the publications.

The Journal Citation Reports, published by ISI (Institute for Scientific Information, Philadelphia, USA), provides the

Table 1. Document distribution

Year	Articles	Proceedings	Books	Theses	Total
1985	113	19	7	5	144
1986	103	28	14	5	150
1987	114	21	5	4	144
1988	111	6	8	2	127
1989	132	25	18	2	177
1990	102	10	1	3	116
1991	111	6	2	2	121
1992	79	7	5	2	93
1993	54	7	6	0	67
1994	21	0	0	1	22
U. Y.	0	0	4	0	4
Total	940	129	70	26	1,165

U.Y.: Unknown Year

Table 2. Journals ranked by number of published articles, together with Impact Factor and Nationality.

Journal	No.	I.F.	Country
Journal of Range Management	30	0.609	United States
Lazaroa	21		Spain
New Zealand Journal of Botany	16	0.361	New Zealand
Studia Œcologica	16		Spain
Acta Œcologica	15	0.523	France
Biological Conservation	14	0.746	United Kingdom
Monti e Boschi	12		Italy
Œcologia	10	1.386	Germany
Ecología Mediterránea	9		Spain
Ecology	9	2.561	United States
Forest Ecology and Management	9	0.528	Netherlands
Ecología	8		Spain
Journal of Ecology	8	1.045	United Kingdom
Studia Botanica	8		Spain
Indian Forester	7		India
Japanese Journal of Ecology	7		Japan
Lagascalía	7		Spain
Vegetatio	7	0.412	Netherlands
Australian Journal of Ecology	6	0.806	Australia
Boletín Real Sociedad Española de Historia Natural	6		Spain
American Midland Naturalist.	5	0.5	United States
Anales de Edafología y Agrobiología	5		Spain
Bosque	5		Spain
Dissertation Abstracts International, B	5		United States
Lesnoe Khozyaistvo	5		Russia
Oikos	5	1.566	United States
Pakistan Journal of Forestry	5		Pakistan
Photogrammetric Engineering & Remote Sensing	5	0.504	United States
Reporte Científico de la Facultad de Ciencias, Forestales, Universidad Autónoma de Nuevo León	5		Mexico
Revista Chilena de Historia Natural	5		Chile
South African Journal of Botany	5		South Africa
Weed Technology	5	0.409	United States

list of journals with its respective Impact Factor every year. The ISI Impact Factor is the ratio between the citations obtained by a journal in a year for articles published in the two preceding years, divided by the total of articles published in the journal in those two years. Some 23% of the journals (121) appeared in the Journal Citation Reports of 1993. Respecting the journal's country of publication, 25% corresponded to the United States; other countries such as Spain, United Kingdom, Holland, France, Germany, etc., contributed smaller proportions.

Table 3 lists the author's productivity as a function of the number of papers published. There were 2068 authors, ranked from smaller to greater output. Thus, in column 2, one finds that 1790 authors published a single work, 185 published two, etc., up to two who published 9 papers each. Column 4, the apparent papers, is the product of columns 1 and 2. The average productivity is obtained dividing the number of apparent papers by the number of authors: in this case $2,480/2,068 = 1.20$ papers/author. In light of these results, it seems that the average productivity is very low, since 86.6% of the authors have published only a single work. Moreover, only 0.1% had published 9 papers or more. The reason for this low productivity on scrub may

be because the authors work on this subject only on occasionally within their normal research. Also, the number of publications per author a) does not provide any idea of their quality, b) ignores other communication media in science (meetings, interviews, reports, ...), and c) there exist political and social pressures to publish for the sake of the *curriculum vitae*, with the fragmentation of data into several papers and/or publishing the same work, with slight variations (revisions), in different journals.

Table 3. Author Productivity.

Papers	Authors	Percent	Apparent Papers
1	1790	86.56	1790
2	185	8.95	370
3	53	2.56	159
4	19	0.92	76
5	9	0.44	45
6	0	0.00	0
7	2	0.10	14
8	1	0.05	8
9	2	0.10	18
Anonymous	7	0.34	0
Total	2,068	100	2,480

Table 4. Number of Co-authors.

Co-authors	Papers	Percent
1	432	37.08
2	354	30.39
3	221	18.97
4	86	7.38
5	37	3.18
6	13	1.12
7	4	0.34
8	4	0.34
9	3	0.26
10	1	0.09
11	1	0.09
12	1	0.09
18	1	0.09
Anonymous	7	0.60
Total	1,165	100.0

Eliminating the 7 anonymous papers from Table 4 leaves 1,158 signed papers. There are 432 with a single author, i.e. 37.1% of the total; of the rest, 59.9% have 2 to 5 co-authors, the remainder being papers with more than 5 authors. There is a close relationship between the productivity of authors and the number of co-authors of a work: highly productive author's papers are co-authored by their assistants. This is natural since the rise in the cost of investigation and the need to find projects in high priority areas require the involvement of ever more human resources.

Table 5. Document's publishing language.

Language	Papers	Percent
English	768	65.9
Spanish	164	14.1
French	71	6.1
German	35	3.0
Italian	24	2.1
Russian	16	1.4
Portuguese	13	1.1
Czech	10	0.9
Chinese	9	0.8
Japanese	8	0.7
Afrikaans	4	0.3
Hindi	4	0.3
Polish	4	0.3
Korean	3	0.3
Catalan	2	0.2
Danish	2	0.2
Hebrew	2	0.2
Romanian	2	0.2
Arabic	1	0.1
Azeri	1	0.1
Greek	1	0.1
Kazakh	1	0.1
Swedish	1	0.1
Thai	1	0.1
U. L.	18	1.6
Total	1,165	100

U.L.: Unkown Language

Table 5 lists the languages in which the documents were published. English is predominant followed by Spanish, then French and German.

Conclusions

This is the first bibliometric study of the scientific literature on scrub. This alternative to other review type works provides a general picture of the size of the field and its evolution over the years. In the period 1985–1994, the total output on scrub was at a more or less steady level of 140 documents/year. The apparent decline in the last 3 years is due to the lag in updating of some databases. Most of the documents (80%) are journal articles, which facilitates the diffusion of these studies. The productivity of the authors is low: 86% of them have published only one work. There is a great degree of dispersion of the literature reflected in the many journals in which authors publish. Authors seem to be devoted to this topic as a side issue or for a specific purpose. The most used language was English, followed by Spanish.

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