

OXALIS ACETOSSELLA IN FORESTS. A SYSTEMATIC BIBLIOMETRIC STUDY OVER THE LAST 47 YEARS

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Abstract

Oxalis acetosella (wood sorrel) is an herbaceous plant commonly found in beech and spruce forests, indicating fertile areas. By analyzing articles in Web of Science and using VOS viewer, Excel, and Geochart, 91 publications from 1976 to 2023 were reviewed. These articles span 19 research areas, with the highest numbers in Environmental Sciences-Ecology, Plant Sciences, Forestry, and Biodiversity Conservation. Around 2-3 articles have been published annually, with a peak of seven articles in 1998. The studies feature authors from 27 countries, primarily from Sweden, Germany, and the USA, with affiliations mostly at Lund University, Swedish University of Agricultural Sciences, and the University of Tartu. Articles were published in 61 journals, with Forest Ecology and Management, Ecography, and Vegetatio being the most representative. Frequently used key words include “vegetation”, “*Oxalis acetosella*”, “growth”, “dynamics” and “plants”. The evolution of key words shows a shift from “beech forest”, “nitrogen deposition”, and “*Oxalis acetosella*” to terms that reflect the effects of various factors on wood sorrel, such as “impact”, “disturbance”, “dynamics”, and “diversity”.

Key words: topic, articles, wood sorrel, key words, journals.

INTRODUCTION

Oxalis acetosella L. (wood sorrel) is an herbaceous species commonly found in the understory of northern hardwood forests (Tessier et al., 2001). It begins producing seeds earlier in its life cycle compared to many other herbaceous plants (Bierzychudek, 1982). This long-lived herb exhibits extensive rhizomatous growth and is primarily found in relatively undisturbed forest understories, where it can reach very high densities (Shorina, 1985; Grime et al., 1988; Berg, 2002; Murariu et al., 2021). *Oxalis acetosella* thrives in soils with high nutrient levels but relies heavily on the shelter provided by the tree canopy (Spârchez et al., 2017; Crișan et al., 2024). It is a typical forb in mesic and fertile upland forest sites from southern Finland (Kuusipalo, 1987). Its presence is often considered a reliable indicator of forest stand fertility (Kuusipalo, 1985). The plant requires substantial nutrients from the soil

substrate (Dincă et al., 2014) and serves as a dependable predictor of site fertility (Dincă et al., 2020; Crișan et al., 2023). Additionally, it is highly shade-tolerant, surviving under dense canopy shading that many other forest species cannot withstand (Packham & Willis, 1977).

Review articles have been written about different plants from the forest floor (Wright, 2002; Hermy & Verheyen, 2007; Schulze et al., 2016), but there is only one article about *Oxalis acetosella*. This synthesis article refers to changes in the occurrence and abundance of plant species in a Norwegian boreal coniferous forest, 1988-1993, where several plant species with preference for richer sites have been observed. Most notably, an *Oxalis acetosella* decrease during this period.

There are also numerous bibliometric studies in domains such as Environment (Ho, 2007; Chen et al., 2009; Borrett et al., 2018; Ruiz-Real et al., 2018) and Forestry (Polinko & Coupland, 2021; Sullivan, 2022; Fernandes et al., 2022; Van

Winkle et al., 2022; Santillán-Fernández et al., 2023).

MATERIALS AND METHODS

A bibliometric analysis was conducted to examine the global scientific research on indicator plants in mountain forests between 1980 and 2023. This study utilised the Science Citation Index Expanded (SCI-Expanded) from the Web of Science database, identifying 716 publications. Data were obtained from the online SCI-Expanded platform, a multidisciplinary resource managed by the Institute for Scientific Information (ISI) in Philadelphia, PA, USA.

For more than 40 years, ISI - now part of Thomson Reuters - has provided exclusive bibliographic resources, enabling large-scale development of bibliometric indicators. These citation indexes, now integrated into the Web of Science, remain primary sources for bibliometric data.

The database was searched using the term "*Oxalis acetosella* in forests" to compile relevant publications from 1996 onward.

The analysis focused on ten areas: (1) publication types, (2) Web of Science categories, (3) publication years, (4) countries, (5) institutions, (6) languages, (7) journals, (8) publishers, (9) authors, and (10) keywords.

Data processing employed Web of Science Core Collection tools [128], Excel [129], Geochart [130], and VOSviewer version 1.6.20 [51], which facilitates cluster analysis and visualisation. Only research articles and reviews were included in the study.

RESULTS AND DISCUSSIONS

A total of 98 publications were identified and analysed. Of these, 91 are articles (representing 93% of total publications), 5 are proceeding papers (5%) and 2 are review articles (2%), (Figure 1).

The published articles can be divided in 19 research areas, with the most ones being: Environmental Sciences Ecology (46 articles), Plant sciences (35 articles), Forestry (27 articles) and Biodiversity conservation (9 articles) (Figure 2).

The first article on this topic was published in a renowned scientific journal in 1976. In general,

two-three articles were published each year, with the largest number of articles (7 articles) published in 1998 (Figure 3).

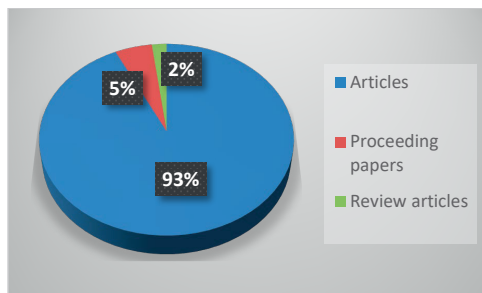


Figure 1. Distribution of the main types of publications used in the bibliometric analysis.

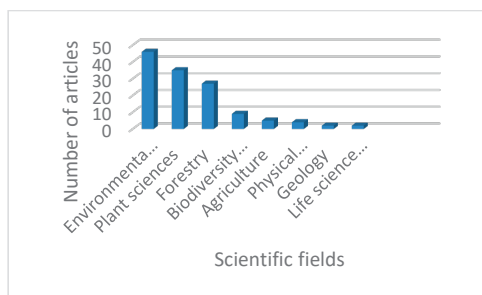


Figure 2. Distribution of the main 10 scientific fields of publications used in the bibliometric analysis.

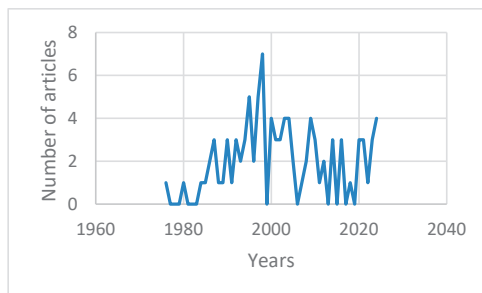


Figure 3. Distribution of articles published per year.

Over 200 authors have published articles on this topic, with the most articles written by Ursula Falkengren-Grerup (9 articles), Jörg Brunet and G. Tyler (each with 8 articles) Hermann Rodenkirchen (7 articles) and Kris Verheyen (6 articles).

The published articles have authors from 27 countries, from three continents, with the following hierarchy based on the largest number of articles: Sweden (23 articles), Germany (18

articles), USA (13 articles), Belgium and Estonia (each with 8 articles), Czech Republic and France (each with 6 articles) (Figure 4).

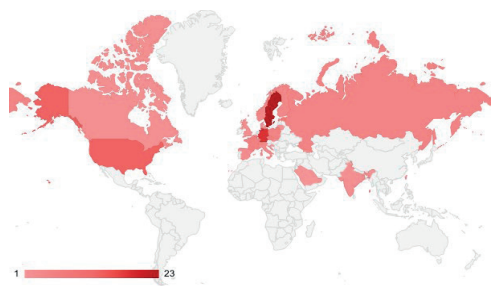


Figure 4. Geography of the use of *Oxalis acetosella* in forests in published articles

The links between the countries with authors that have published about this subject show that there are 3 clusters that contain at least 5 countries. These are: cluster 1 (Belgium, Estonia, France, Germany, Sweden, Taiwan); cluster 2 (Czech Republic, Georgia, India, Italy, Saudi Arabia); cluster 3 (Finland, Norway, Poland, Spain, Switzerland) (Figure 5).



Figure 5. Countries with authors of articles on *Oxalis acetosella* in forests. The node size and thickness of the connecting lines are proportional to the number of documents assigned to each country. The connections represent the collaboration network among countries

The institutions where the authors that have published articles on this subject work include a

top tier represented by institutions from Sweden: (Lund University - with 12 published articles and Swedish University of Agricultural Sciences - with 9 articles) and Estonia (University of Tartu - with 8 articles and Tartu University Institute of Ecology Earth Science - with 8 articles). They are followed by the State University of New York Suny System and University of Munich (each with 7 articles). This aspect is in accordance with the hierarchy of countries from where authors originated, where Sweden occupies the first place, Estonia the fourth place, USA the third place and Germany the second place.

Articles on this topic are published in 61 journals. Based on the number of published articles, the most representative journals are Forest Ecology and Management (11 articles), Journal of the Torrey Botanical Society (4 articles) and Ecography and Vegetation (each with 3 articles). Based on total link strength, the most important journals are Forest Ecology and Management, Ecography and Vegetation (Table 1).

Table 1. The most representative journals where articles about *Oxalis acetosella* in forests have been published.

Crt. No.	Journal	Docu ments	Cita tions	Total link strength
1	Forest Ecology and Management	11	348	20
2	Ecography	3	118	15
3	Vegetatio	3	86	15
4	American Journal of Botany	1	7	14
5	Journal of the Torrey Botanical Society	4	117	12
6	Oecologia	3	311	12
7	Nordic Journal of Botany	2	51	11
8	Acta Oecologica-International Journal	3	43	10
9	Flora	3	40	9
10	Plant and Soil	3	36	7
11	Environmental and Experimental Botany	2	35	5
12	Journal of Ecology	2	126	5
13	Landscape Ecology	2	12	5

We have identified 7 clusters that contain at least 3 journals. The first cluster, containing 6 journals, includes: Biological conservation; Environmental and Experimental Botany;

There are 32 publishers, with the most prominent being Elsevier (26 articles), Wiley (16 articles) and Springer Nature (15 articles). The most frequently used key words are vegetation, *Oxalis-acetosella* (if we consider the two forms in which the term is used: *Oxalis-acetosella* and *Oxalis-acetosella*), growth, dynamics and plants (Table 2). Amongst the key words with a high frequency, we can also note the ones regarding the forest types in which the plant appears (deciduous forest, beech forest, *Picea abies*). As other authors have also noted, wood sorrel is characteristic for beech forests (Kutnar et al., 2002; Godefroid et al., 2005; Ujházy et al., 2007) as well as for spruce forests (Dinca et al., 2022; Kikkeva et al., 2024; Matuszkiewicz et al., 2024).

Crt. No.	Key word	Occurrences	Total link strength
1	vegetation	28	88
2	Growth	13	45
3	Dynamics	13	42

4	deciduous forest	10	40
5	disturbance	9	38
6	Soil	9	35
7	plants	11	33
8	forest	10	32
9	<i>Oxalis acetosella</i>	10	29
10	diversity	7	24
11	vascular plants	7	24
12	communities	7	23
13	<i>Oxalis-acetosella</i>	6	23
14	beech forest	5	21
15	nitrogen	4	20
16	nitrogen deposition	7	20
17	<i>Picea abies</i>	4	20
18	understorey vegetation	3	17

If we analyse the usage of key words over years, we can see that in the beginning (1994-2000), key words such as beech forest, nitrogen deposition and pH were mainly used. Then, during 2000-2004, the main key words were *Oxalis acetosella*, soil, deciduous forest, growth, vegetation; followed by communities,

dynamics, disturbance, nitrogen during 2005-2008, while impact and diversity were mainly used during the last period (2006-2012). From this aspect, we can see that the last two periods have used key words that pertain to the results of different factors on wood sorrel: impact, disturbance, dynamics, diversity.

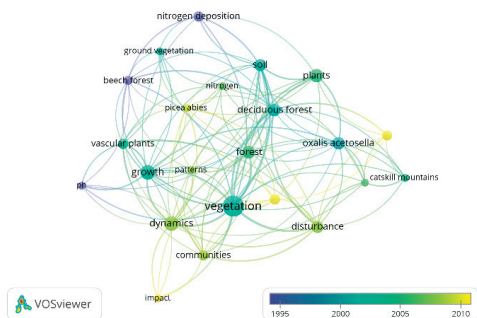


Figure 8. Distribution of key words concerning *Oxalis acetosella* in forests over the years. The node size and thickness of the connecting lines are proportional to the number of documents assigned to each country. The connections represent the collaboration network among key words

CONCLUSIONS

A total of 98 publications were identified and analyzed. Of these, 91 are articles, 5 are proceeding papers and 2 are review articles. The published articles can be included in 19 research areas, with the most representative being Environmental Sciences Ecology, Plant sciences, Forestry and Biodiversity conservation. After the first article was published in 1976, an average of 2-3 articles followed each year. Most articles belong to Ursula Falkengren-Grerup, Jörg Brunet and G. Tyler. The published articles have authors from 27 countries, from three continents, with the first countries being Sweden, Germany and USA. The institutions where these authors belong are especially from Sweden: (Lund University and Swedish University of Agricultural Sciences) and Estonia (University of Tartu), while the most important journals are Forest Ecology and Management, Ecography and Vegetation. The most frequently used key words are vegetation, *Oxalis-acetosella*, growth, dynamics and plants. In total, we have identified 3 clusters for countries and 7 clusters for key words.

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