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Forest and UAV: A Bibliometric Review

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Abstract

Since 2004, increasing attention has been focused on improving UAV applications in forestry.
The technology related to the drones also allowed to prefigure new applications related to forest monitoring in real-time and timely, such as the monitoring of fire fronts during forest fires.
Accurate information about forest composition, structure, volume, growth, and extent is essential for sustainable forest management.
The aim of this paper is to compare the results obtained from Web of Science and Scopus databases in order to have a wide framework of the bibliography to explore between 2004 to date.
The number of found publications in Scopus and Web of Science databases, underline that there is an increasing interesting on the investigated thematic; the comparison between the two databases show that WoS is more complete than Scopus.
In conclusion, the results comparison, for each keywords combination in both databases, show that Web of Science is the best bibliographic database research for the explored thematic.

Keywords: UAV, Forest, Drone, Forestry, Scopus, Web of Science

1. Introduction

The policy for European research, with the Horizon 2020 program, outlines instruments to support research and innovation in food safety and workers' safety [8], [9], [6], [11], [20], the bio-economy and sustainable agriculture, [18], [19], [22], [19], [5] and other issues in agriculture and forestry (climate change, efficient use of natural resources, energy efficient).
In this context of multidisciplinary innovation part of the interest of researchers is oriented to the use of Unmanned Aerial Vehicles (UAV) in forestry management and in precision agriculture.
The latest development of unmanned aerial vehicle has expanded the application possibilities of the high spatial resolution remote sensing forest, with a growing range of applications, even on private property; the technology related to the drones also allowed to prefigure new applications related to forest monitoring in real-time and timely, such as the monitoring of fire fronts during forest fires. On the subject of the woody traceability, the use of systems based on radio-frequency (RFID) allows, through a rapid and efficient identification and mapping, to optimize the programming of the chain of operations, and then to reduce the cost and waste. Accurate information about forest composition, structure, volume, growth, and extent is essential for sustainable forest management and can be extracted directly or indirectly from remotely sensed imagery [25]. From 2004, increasing attention has been focused on improving UAV applications in forestry.
Along with the development of sensor and computation technologies, remote sensing

applications in forestry have evolved from conventional aerial photography-based forest inventories [14] to satellite imagery-based forest resource monitoring [4] [26], [21], from multispectral data-based forest cover mapping [33], [24] to hyperspectral data-based biophysical forest estimations[15], [29], and from passive remote sensing-based forest leaf area index measurements [30] [28] to active remote sensing-based forest structure characterizations [10], [12].Through the integration of multiple data sources, it is possible to improve estimations of forest volume and biomass[13], [11]. One of the most critical barriers to remote sensing applications in forestry is the lack of timely data collection over target areas. For example, when one wants to assess pest outbreaks [32] or wildfire spread [3] in a forested landscape, appropriate satellite imagery might be unavailable and aerial photography from crewed/manned aircrafts might be unaffordable. Stand-level information is critical for sustainable forestry [33] but cannot be extracted from medium- or coarse-resolution remote sensing approaches. Drones as remote sensing platforms have the potential to increase the efficiency of data acquisition, but their applications are still at an experimental stage [2], [31], [23]. In the last decade UAVs have attracted a significant interest, they have been widely used for military applications and extended UAV technology to a wide range of civilian applications.
The aim of this paper is to compare the results obtained from Web of Science and Scopus databases in order to have a wide framework of the bibliography to explore between 2004 to date.

2. Methods

2.1 Web of Science database

The first step is the choice of the:

- ✓ key words to include in the research, in our case we chose:
  - UAV + forest
  - UAV + forestry
  - drone + forest
  - drone + forestry
- ✓ researcher period between 2004 and 2016
- ✓ the keywords in topic and in title in two different time step
- ✓ “Science Technology” domain

2.1 Scopus database

The first step is the choice of the:

- ✓ key words to include in the research, in our case we chose:
  - UAV + forest
  - UAV + forestry
  - drone + forest
  - drone + forestry
- ✓ researcher period between 2004 and 2016

- ✓ type of documents that are automatically selected in database (keywords, title and abstract
- ✓ "Life Science" as Subject Area

3. Results and conclusions

3.1 Web of Science

Table 1 shows the number of publications per year from 2004 to 2016, there is a growing interest in the investigated thematic, according to the different keywords searched. In the last three years, from 2013, the amount of the papers is growing. Searching UAV+Forest combination, WoS shows 138 contributions, in the other and UAV+Forestry combination reveals 32 works, particularly focused between 2011 and 2016. Searching Drone+Forest or Drone+Forestry combinations, WoS show 23 and 11 contributions, respectively.

Table 1. Number of publications per year according to the selected keywords in Web of Science database

PUBLICATION YEAR	UAV FOREST	UAV FORESTRY	DRONE FOREST	DRONE FORESTRY
2004	1		1	
2005	4	1		
2006	9	1	1	
2007	8		1	1
2008	2			
2009	5	2		
2010	5			
2011	12	1		
2012	9	5	2	1
2013	24	8	6	1
2014	26	6	4	2
2015	32	6	5	2
2016	11	2	3	1
Total contributions	**148**	**32**	**23**	**8**

Regarding the type of the documents as show in Table 2, the UAV+Forest combination gives a major number of contributions both for conference papers than for articles. The same decreasing trend of numbers of works for each keywords combinations observed in Table 1, is confirmed for the type of contributions (Table 2). As a matter of fact, the Drone+Forestry combination give the minor number of works for conference papers and articles.

Table 2. Number of publications per type according to the selected keywords in Web of Science database

	CONFERENCE PAPERS	ARTICLES
UAV+FOREST	75	73
UAV+FORESTRY	13	19
DRONE+FOREST	5	18
DRONE+FORESTRY	2	6

3.2 Scopus

Similar results were obtained in Scopus, that underline a peak of publications during 2015 (Table 3). However, there are a sporadic number of contributions until 2013, in fact for UAV+Forest there are not publication until 2011, for UAV+Forestry there is one publication in 2004, 2011 and 2012. From 2004 to 2013 Drone+Forest combination show only 8 works, and just 4 for Drone+Forestry combination.

Table 3. Number of publications per year according to the selected keywords in Scopus database

PUBLICATION YEAR	UAV FOREST	UAV FORESTRY	DRONE FOREST	DRONE FORESTRY
2004		1		
2005				
2006				
2007			2	1
2008			2	2
2009				
2010				
2011		1	1	
2012	2	1	1	
2013	3	8	2	1
2014	5	4	2	1
2015	14	10	6	4
2016	8	4	2	2
Total contributions	**32**	**29**	**18**	**11**

Scopus database distinguish more type of contributions, according to Table 4. The "Article" type is preferred to others by scientific community. In Table 4, this trend is evident, with 29 works for UAV+Forest, 24 for UAV+Forestry, 15 in Drone+Forest searching and 10 in Drone+Forestry combination.

Table 4. Number of publications per type according to the selected keywords in Scopus database

	ARTICLE	CONFERENCE PAPER	ARTICLE IN PRESS	REVIEW	NOTE
UAV+FOREST	29	1	1	1	
UAV+FORESTRY	24	4		1	
DRONE+FOREST	15			2	1
DRONE+FORESTRY	10			1	

In Figure 1 are compared the four keywords combinations of the two databases, both in Scopus than in WoS the majority of the contributions were published during the last four years. Observing the period between 2012 and 2015, UAV+Forest keyword combination reveals that WoS found more publications than Scopus. On the contrary, UAV+Forestry and Drone+Forestry combinations show a lot of works in Scopus, particularly in 2015.
Regarding Drone+Forest, in 2015, the two databases reveal the same numbers of publications.

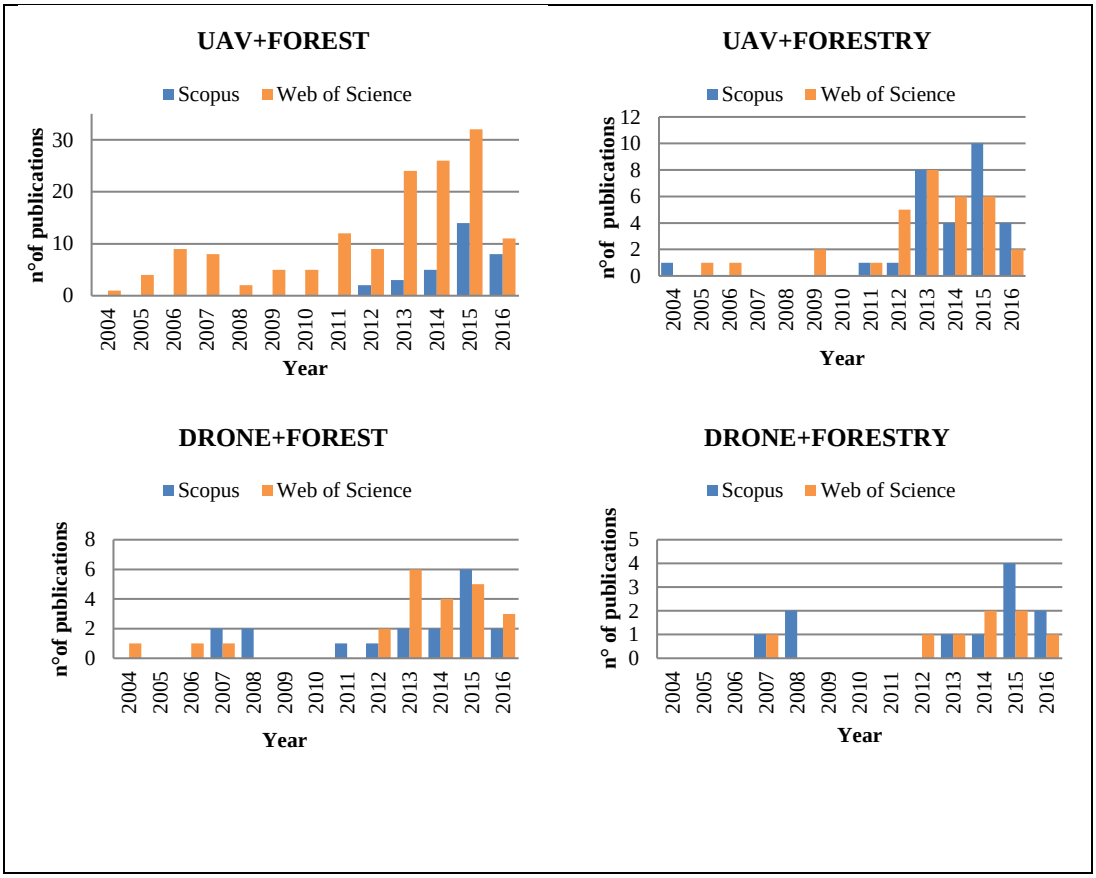

Figure 1. Evolution of the number of publications in the 2004-2016 period, according to the selected keywords in the two databases

Figure 2 display the different types of works, these are subdivided in Article, Conference Paper (CP), Article in Press (AP), Review and Note.
In every keywords combinations the type that reveal the major number of contributions is the Article, excluding the UAV+Forest combination in WoS in which Article and CP appear quite similar.
Is interesting to underline that changing Forest in Forestry in the keywords combination, the two databases reveal different results. In the first case (UAV+Forest and Drone+Forest) WoS reveal more contributions; at the opposite, the combination UAV+Forestry or Drone+Forestry appear more significant in Scopus database.

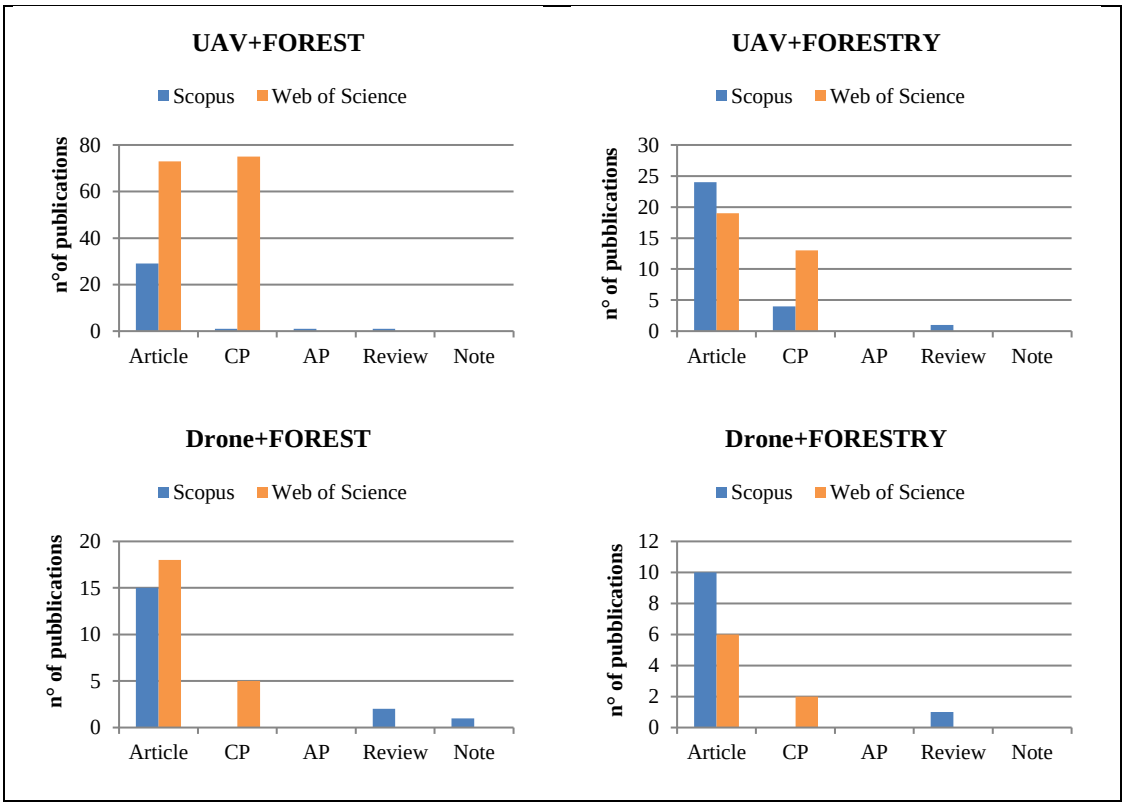

Figure 2. Evolution of the type of publications in the 2004-2016 period, according to the selected keywords in the two databases

Tables 5 and 6 show the numbers of total contributions, located on the diagonal, and the duplicates, located under the diagonal, found in Scopus and WoS database, respectively.
For example in Table 5, in the first column, is possible to see the results about the search UAV+Forest. The total amount of contributions is 32 in Scopus database, the numbers of the works that appear both in UAV+Forest and UAV+Foresty research are 12.

Table 5. Numbers of total contributions (diagonal) and the duplicates found in Scopus database

SCOPUS	UAV FOREST	UAV FORESTRY	DRONE FOREST	DRONE FORESTRY
UAV+FOREST	32			
UAV+FORESTRY	12	29		
DRONE+FOREST	8	6	18	
DRONE+FORESTRY	6	7	9	11

Table 6. Numbers of total contributions (diagonal) and the duplicates found in Web of Science database

WEB OF SCIENCE	UAV FOREST	UAV FORESTRY	DRONE FOREST	DRONE FORESTRY
UAV+FOREST	148			
UAV+FORESTRY	20	32		
DRONE+FOREST	7	3	23	
DRONE+FORESTRY	3	4	5	8

Comparing the two databases, similarly at the previews results, is possible to individuate on the diagonal the duplicates contributions found in WoS and in Scopus (Table 7). For UAV+Forest keywords combination 25 works were found both in WoS than in Scopus, only 5 for UAV+Forestry and Drone+Forestry. Nine publications were individuated searching Drone+Forest combination in the two databases.

Table 7. Numbers of duplicate contributions found in both databases, according to the selected keywords

	WoS UAV FOREST	WoS UAV FORESTRY	WoS DRONE FOREST	WoS DRONE FORESTRY
S - UAV+FOREST	**25**	**9**	**5**	**4**
S -UAV+FORESTRY	**8**	**5**	**5**	**4**
S -DRONE+FOREST	**5**	**2**	**9**	**4**
S -DRONE+FORESTRY	**3**	**2**	**5**	**5**

The number of found publications underline that there is an increasing interesting on the investigated thematic; the comparison between the two databases show that WoS is more complete than Scopus. In fact in WoS we found 148 contributions against 32 in Scopus, for the usual keyword combination UAV+Forest. In conclusion, the results comparison, for each keywords combination in both databases, show that Web of Science is the best bibliographic database research for the explored thematic.

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