

HOW MANY ALDER SPECIES (*ALNUS* SP.) EXIST? A STATISTIC BASED ON HERBARIUM VOUCHERS

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Abstract

In the speciality literature, the number of *Alnus* species varies between 30 and 35. However, by analysing the species present in different herbarium (*Al. Beldie Herbarium from Romania, WU Herbarium from Wien and Harvard University Herbaria from U.S.A.*), this number increases to 42. The most numerous Alder species present in these herbariums are *Alnus incana* and *Alnus viridis* (spread out on a vast natural range, namely Eurasia and North America), followed by *Alnus serrulata* (which can be found in North America). As such, the *Alnus* Genus is well represented in Asia (especially in China and Japan), as well as in North America or Europe. The analysis of vouchers present in different herbariums has significant contributions regarding the number of species from a certain genus, their spreading, as well as their particular characteristics. However, in order to obtain satisfactory results, a large number of herbariums is required, followed by an appropriate geographic distribution. In this regard, the BUCF Romanian herbarium is a good case study.

Key words: *Alnus*, herbarium, species, alder, voucher.

INTRODUCTION

Alnus, or **Alder** under its common name, is a flowering plant of the *Betulacea* Family that is composed of approximately 35 tree and shrub species (Arno and Hammerly, 2007; Tedersoo et al., 2009). The species is well distributed, being present in north temperate areas, the Andes and reaching even Central America (Govaerts and Faden, 2013; Chen and Li, 2004; Enescu et al., 2016; Russo, 1990).

The genus is sectioned in three main subgenres (<https://en.wikipedia.org/wiki/Alder>; Leopold et al., 2012):

***Alnus* Subgenus:** contains approximately 15-25 species, mainly trees with stalked buds. The catkins appear during autumn and remain closed until spring. The pollination starts during late winters up to early springs.

***Clethropsis* Subgenus:** comprised of three species represented by shrubs or trees, also with stalked buds. The catkins also appear during autumn.

***Alnobetula* Subgenus:** represented by one to four species, by shrubs with non-stalked buds. The catkins appear in this case after the leaves, namely during late springs.

The *Alnus* species can be recognized by their simple, deciduous and dented leaves. The flowers are both male and female, growing on different catkins but within the same plant. They are grouped in catkins resembling a cone. The fruits have the same cone resemblance, are also small and woody. Their seeds can amount or exceed the value of one million (Russo, 1990). On a global scale, the *Alnus* species amounts to approximately 30 species (<http://www.arsgrin.gov/cgi-bin/npgs/html/taxon.pl?2448>; Mitchell et al., 1997). Regarding its usage, the plant has been used as medicines in varied cultures around the globe (from China to India). As such, the plant is recognized for its medicinal properties, especially in treating hepatitis, viruses, HIV-1 or even cancer. The bark is used for mouth and throat inflammations, while the vinegar obtained from this bark is used against lice or scabies (Sati, 2011). The genus classification has encountered some difficulties, as certain specialists considered the species belonging to *Betula* (Linnaeus, 1753), while other considering it separately (Spach, 1841 and Murai, 1963). Subsequent molecular and morphological analysis (Bousquet et al.,

1992; Savard et al., 1993) have confirmed that *Alnus* should be differentiated from *Betula* (Crane, 1981; Furlow, 1990). Murai (1963) also divided the genus in two genera: *Alnaster* and *Gymnothyrsus*. However, a year later (Murai, 1964) he decided to give up this division as the differences between them were inconsistent. Furlow (1979) took this division and renamed its genera from *Alnaster* to *Alnobetula* and from *Gymnothyrsus* to *Alnus*, with the addition of *Clethropsis* (Spach.) Murai represented by *A. nitida* (Spach.) Endl. and *A. nepalensis* D. Don. (Asian species) and *A. maritima* Muhl. (from North America).

The specialty literature mentions a number of *Alnus* hybrids, namely: *Alnus* × *elliptica* Req. (*A. cordata* × *A. glutinosa*); *Alnus* × *fallacina* Callier (*A. incana* subsp. *rugosa* × *A. serrulata*); *Alnus* × *hanedae* Suyinata (*A. firma* × *A. sieboldiana*); *Alnus* × *hosooi* Mizush. (*A. maximowiczii* × *A. pendula*); *Alnus* × *mayrii* Callier (*A. hirsuta* × *A. japonica*); *Alnus* × *peculiaris* Hiyama (*A. firma* × *A. pendula*); *Alnus* × *pubescens* Tausch. (*A. glutinosa* × *A. incana*); *Alnus* × *suginoi* Sugim.; *Alnus* × *spaehtii* Callier (*A. japonica* × *A. subcordata*).

Al. Beldie Herbarium (BUCF) contains numerous plants (approximately 40.000 vouchers) belonging to different species, among which we mention: 19 *Scorzonera* species (Dincă and Cântar 2017), 7 *Lycopodium* species (Vechiu et al., 2018), 15 *Ornitogalum* species (Enescu and Dincă, 2017), 69 *Potentilla* species (Crișan et al., 2017), 15 *Veronica* species (Dincă L., et al., 2017), 29 *Allysum* species (Cântar et al., 2018), 19 *Androsace* species (Dincă M., et al., 2017), 41 *Polygonum* species (Vechiu et al., 2018), 16 *Abies* species (Enescu et al., 2018), 80 *Trifolium* species (Cântar and Dincă, 2018) and 17 *Amaranthus* species (Dincă et al., 2018).

WU Herbarium was created in 1879 by Anton Kerner von Marilaun (1831–1898, the Director of Wien's Botanical Museum. It already contained 80.000 specimens by 1889. Today, the herbarium is estimated to contain approximately 1.400.000 specimens, covering all worldwide plant groups (<https://herbarium.univie.ac.at/index.htm>).

The Harvard University Herbaria is considered the largest university herbarium collection in the world and the third largest herbarium from the United States. Composed of six collections

and approximately five million algae, fungi and vascular plant specimens, the HUH is considered a representative of biodiversity sciences starting with the 1800s (<https://huh.harvard.edu/>).

MATERIALS AND METHODS

The first step realized in order to establish the total number of *Alnus* species was represented by a thorough analysis of specialty articles, web pages and other relevant documents.

All the vouchers belonging to the *Alnus* Genus from the WU Herbarium and the Harvard University Herbaria were then inventoried. For the Al. Beldie Herbarium (BUCF), a data base was realized for this genus, focusing on the following data: Herbarium/Botanic Collection/Institution (taken from the herbarium' voucher label); Species name; Harvesting date; Harvesting place; the person who has collected the plant, as well as the voucher's conservation grade, coded with numbers from 1 to 4 (1 = well preserved plant, 2 = plant with parts detached from the plate, but still present, 3 = plant detached from the plate, with missing parts and 4 = plant detached and fragmented, with over 50% of its parts missing).

The *Alnus* species were grouped based on the source that mentions them or the herbarium from where they were identified. In certain cases, their common name and areal was also added. The spreading of this genus was obtained from the specialty literature as well as from the analysis of the vouchers belonging to the two above-mentioned collections. The areal graphics (figures 4 and 5) showcase the areas where these species predominate, with only one area chosen for species that appear in more regions.

The WCSP data base (<https://wcsp.science.kew.org>) was used in order to verify the species' scientific names, as it is regarded as the best resource updated with the latest information regarding their synonyms and internationally accepted scientific names.

RESULTS AND DISSCUTION

The following number of alder species were inventoried: 589 from WU Herbarium, 1680 from the Harvard University Herbarium and 137 from the Al. Beldie Herbarium (figures 1-2).

Table 1. *Alnus* species present in different data bases and herbariums

No species	Species name [synonym]	Popular name	Areal	Wikipedia	Al. Beldie Herbarium (vouchers number)	WU Herbarium (vouchers number)	Harvard University Herbaria (vouchers number)
1	<i>Alnus acuminata</i> Kunth	Andean alder, aliso	Mexico, Central and South America	yes		13	12
2	<i>Alnus alisoviana</i> Mandl (syn. <i>Alnus incana</i> (L.) Moench subsp. <i>incana</i>)		(Russia)			7	
3	<i>Alnus alnobetula</i> (Ehrh.) K. Koch		(USA)	yes		51	3
4	<i>Alnus arguta</i> (Schltdl.) Spach (syn. <i>Alnus acuminata</i> subsp. <i>arguta</i> (Schltdl) Furlow)	Mexican alder	(Mexico)			1	3
5	<i>Alnus barbata</i> C. A. Mey. (syn. <i>Alnus glutinosa</i> subsp. <i>barbata</i> (C. A. Mey.) Yalt.)		(Georgia)			1	
6	<i>Alnus cordata</i> (Loisel.) Duby	Italian alder	Italy, Corsica	yes		15	
7	<i>Alnus corylifolia</i> A. Kern. ex Strobl (syn. <i>Alnus alnobetula</i> subsp. <i>alnobetula</i>)		(Austria)			2	
8	<i>Alnus cremastogyne</i> Burkill		(China)	yes		1	2
9	<i>Alnus crispa</i> (Aiton) Pursh (syn. <i>Alnus viridis</i> (Chaix) DC. ssp. <i>crispa</i> (Aiton) Turrill)	Mountain alder	(Canada, USA)			9	4
10	<i>Alnus densiflora</i> C. H. Müller (syn. <i>Alnus incana</i> subsp. <i>tenuifolia</i> (Nutt.) Breitung)		(USA)				1
11	<i>Alnus djavanshirii</i> H.Zare		Iran	yes			
12	<i>Alnus dolichocarpa</i> H.Zare, Amini & Assadi		Iran	yes			
13	<i>Alnus fauriei</i> H.Lév. & Vaniot		Honshu Island in Japan	yes			
14	<i>Alnus ferdinandi-coburgi</i> C. K. Schneid		southern China	yes		6	1
15	<i>Alnus firma</i> Siebold & Zucc.		Kyūshū Island in Japan	yes		1	1
16	<i>Alnus firmifolia</i> Fernald (syn. <i>Alnus jorullensis</i> subsp. <i>lorullensis</i>)		(Mexico)				1
17	<i>Alnus formosana</i> (Burkill) Makino	Formosan alder	Taiwan	yes			2
18	<i>Alnus fruticosa</i> Rupr. (syn. <i>Alnus alnobetula</i> subsp. <i>fruticosa</i> (Rupr.) Raus)		(Russia, Austria)			6	
19	<i>Alnus glabrata</i> Fernald (syn. <i>Alnus acuminata</i> subsp. <i>glabrata</i> (Fernald) Furlow)		(Mexico)				3
20	<i>Alnus glutinosa</i> (L.) Gaertn.	Black alder	Europe, Central Asia	yes	56	159	36
21	<i>Alnus glutipes</i> (Jarm. ex Czerpek) Vorosch.		Yakutiya region of Siberia	yes			
22	<i>Alnus hakkodensis</i> Hayashi		Honshu Island in Japan	yes			
23	<i>Alnus henryi</i> C.K.Schneid		Taiwan	yes			
24	† <i>Alnus heterodonta</i> (Newberry) Meyer & Manchester 1987		Oligocene fossil Oregon	yes			
25	<i>Alnus hirsuta</i> (Spach) Rupr.	Manchurian alder	Japan, Korea, Manchuria, Siberia, Russian Far East	yes		4	5
26	<i>Alnus incana</i> (L.) Moench	Gray alder	Eurasia, North America	yes	33	125	627
27	<i>Alnus jackii</i> Hu (syn. <i>Alnus trabeculosa</i> Hand)		(China)				1
28	<i>Alnus japonica</i> (Thunb.) Steud	Japanese alder	Japan, Korea, Taiwan, eastern China, Russian Far East	yes	1	7	1
29	<i>Alnus jorullensis</i> Kunth	Mexican alder	Mexico, Guatemala, Honduras	yes			3
30	<i>Alnus kolaensis</i> N. I. Orlova (syn. <i>Alnus incana</i> subsp. <i>kolaensis</i> (Orlova) Å. Löve & D. Löve)		(Russia)			2	
31	<i>Alnus lanata</i> Duthie ex Bean		Sichuan Province in China	yes			6
32	<i>Alnus mairei</i> H.Lév.		Yunnan Province in China	yes			1
33	<i>Alnus mandshurica</i> (Callier) Hand.-Mazz.		Russian Far East, north-eastern China, Korea	yes			
34	<i>Alnus maritima</i> (Marshall) Muhl. Ex Nutt.	Seaside alder	United States (Georgia, Delaware, Maryland, Oklahoma)	yes		3	3

35	<i>Alnus matsumurae</i> Callier		Honshū Island in Japan	yes			
36	<i>Alnus maximowiczii</i> Callier		Japan, Korea, Russian Far East	yes		1	
37	<i>Alnus mitchelliana</i> M. A. Curtis ex A. Gray (syn. <i>Alnus alnobetula</i> subsp. <i>Crispa</i> (Aiton) Raus)					1	
38	<i>Alnus mollis</i> Fernald (syn. <i>Alnus alnobetula</i> subsp. <i>Crispa</i> (Aiton) Raus)		(USA)				1
39	<i>Alnus morisiana</i> Bertol. (syn. <i>Alnus glutinosa</i> (L.) Gaertn. subsp. <i>glutinosa</i>)		(Italy)			1	
40	<i>Alnus nepalensis</i> D. Don	Nepalese alder	Tibet, Yunnan, Nepal, Bhutan, Myanmar, Thailand	yes	1	11	12
41	<i>Alnus nitida</i> (Spach) Endl.	Himalayan alder	Western Himalaya, Pakistan, India, Nepal	yes			
42	<i>Alnus oblongata</i> (Aiton) Willd. (Syn. <i>Alnus serrulata</i> (Aiton) Willd.)					3	
43	<i>Alnus oblongifolia</i> Torr.	Arizona alder	Arizona, New Mexico, Sonora, Chihuahua	yes			12
44	<i>Alnus orientalis</i> Decne.	Oriental alder	Southern Turkey, northwest Syria, Cyprus, Lebanon, Palestine, Iran	yes		6	
45	<i>Alnus oregana</i> Nuttall (syn. <i>Alnus rubra</i> Bong)		(California, USA)				6
46	<i>Alnus ovalifolia</i> Bartlett (syn. <i>Alnus acuminata</i> subsp. <i>Arguta</i> (Schltdl.) Furlow)		(Guatemala)				1
47	<i>Alnus paniculata</i> Nakai		Korea	yes			
48	<i>Alnus pendula</i> Matsum.		Japan, Korea	yes			
49	<i>Alnus pringlei</i> Fernald syn. <i>Alnus acuminata</i> subsp. <i>arguta</i> (Schltdl.) Furlow		(Mexico)				1
50	<i>Alnus rhombifolia</i> Nutt.	White alder	California, Nevada, Oregon, Washington, Idaho, Montana	yes	2		90
51	<i>Alnus rubra</i> Bong.	Red alder	Alaska, Yukon, British Columbia, California, Oregon, Washington, Idaho, Montana.	yes		1	20
52	<i>Alnus rugosa</i> (Du Roi) Spreng.	Speckled alder	North-eastern North America	yes	2		18
53	<i>Alnus serrulata</i> (Aiton) Willd.	Hazel alder, tag alder or smooth alder	Eastern North America	yes		6	403
54	<i>Alnus serrulatoides</i> Callier		Japan	yes			
55	<i>Alnus sibirica</i> Fischer ex Turczaninow		Siberia				1
56	<i>Alnus sieboldiana</i> Matsum.		Japan, Ryukyu Islands	yes			
57	<i>Alnus sinuata</i> (Regel) Rydberg syn. <i>Alnus alnobetula</i> subsp. <i>sinuata</i> (Regel) Raus		(USA)				8
58	<i>Alnus sitchensis</i> (Regel) Sargent syn. <i>Alnus alnobetula</i> subsp. <i>sinuata</i> (Regel) Raus	Sitka alder	(USA)				3
59	<i>Alnus spuria</i> Callier forma <i>viridior</i> Callier syn. <i>Alnus</i> × <i>pubescens</i> Tausch		(Germany)		1	1	
60	<i>Alnus suaveolens</i> Reg. Syn. <i>Alnus alnobetula</i> subsp. <i>suaveolens</i> (Req.) Lambinon & Kerguélen		(France)		1	1	
61	<i>Alnus subcordata</i> C. A. Mey.	Caucasian alder	Caucasus, Iran	yes		2	
62	<i>Alnus tenuifolia</i> Nutt.	Thinleaf or mountain alder	North-western North America	yes		1	26
63	<i>Alnus trabeculosa</i> Hand.- Mazz.		China, Japan	yes		8	2
64	<i>Alnus vermicularis</i> Nakai		Korea	yes			
65	<i>Alnus viridis</i> (Chaix) DC.		Temperate and subarctic Europe, Asia, North America	yes	31	60	330

The parenthesis from the areal section was added to include only the species found in herbarium, as their geographic natural range can be larger. The WU Herbarium contains some “species” (namely 10) that are also mentioned by Wikipedia. However, all these species are represented only by a low number of vouchers (1-3). This herbarium also contains 29 *Alnus pubescens* Tausch (hybrid) vouchers, all collected from Germany. Most of the *Alnus* species present in the herbarium originate from Austria or Germany, with only a few samples from Spain, France, Russia and Georgia. The Harvard Herbarium also contains 12 “species” not mentioned by Wikipedia or present in the WU Herbarium. Most of them (4) were identified by Fernald and are represented by few exemplars (between 1 and 8), being present in this herbarium with only one voucher. The majority of *Alnus* species present in the Harvard Herbarium originate from the USA and Mexico, followed by China, Guatemala or Siberia

At a more in-depth analysis, it was proven that the additional “species” that were not included by Wikipedia, were synonyms with other species and especially with existing sub-species (table 1, column 2).

The Al. Beldie Herbarium contains 9 *Alnus* species, this being a smaller herbarium than the other two international ones mentioned above.



Figure 1. *Alnus glutinosa* in BUCF Herbarium

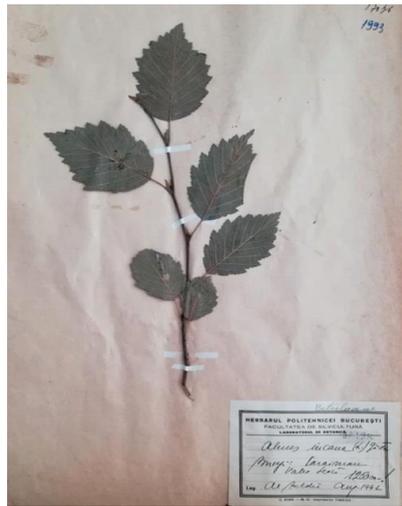


Figure 2. *Alnus incana* in BUCF Herbarium

Most of the exemplars from the BUCF Herbarium were collected from Romania (102 exemplars), with 8 from other locations (Munich, Finland, California etc). On the other hand, 14 alder species are mentioned by Wikipedia but not present in any herbarium used for this analysis.

The most widespread alder species amongst the three studied herbariums were in *Alnus incana* (36 % of the total), followed by *Alnus viridis* (20 %) and *Alnus serrulata* (19 %) (figure 3).

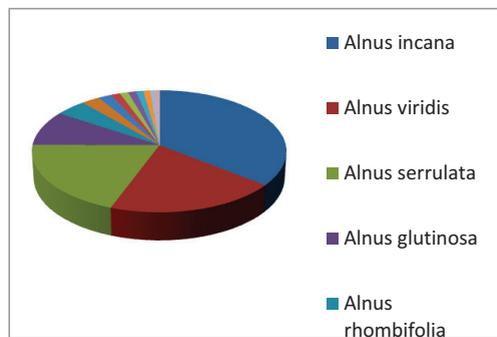


Figure 3. Alder species present in the herbariums

The alder species present in the above-mentioned herbariums are spread out in Asia, North America and Europe (figure 4). At a country level, the top is represented by USA (but we have to mention that one Herbarium belongs to this country), Japan, China and Russia (figure 5).

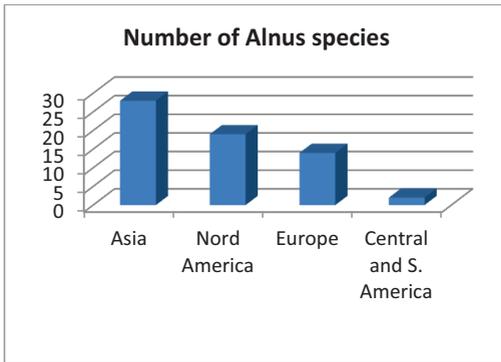


Figure 4. Spread of analysed *Alnus* species on continents

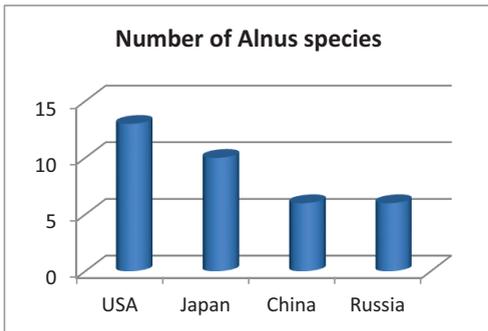


Figure 5. Spread of analysed *Alnus* species on countries

CONCLUSIONS

From the analysis of Wikipedia, World Checklist of Selected Plant Families, WU Herbarium, Harvard University Herbarium and Al. Beldie herbarium, an approximate number of 42 *Alnus* species can be considered, more than the one identified by the specialty literature (30-35 species). However, we have also identified a number of 22 “species” mentioned in certain herbarium that appear as synonyms for species or sub-species from modern data bases. Regardless of these numbers, the maintenance of a certain number of species for this genus is highly problematic. However, through this study, we have managed to demonstrate that the analysis of reference herbariums can lead to important contributions regarding the number of existent plant. In order to achieve this, the number of herbariums must be relevant (a fact that is hard to obtain as few herbariums are digitized or available online). Furthermore, these herbariums must be well distributed on the continents (as only the European ones would provide wrong data

regarding their total number or geographic distribution). From this point of view, the presence of a Romanian herbarium (BUCF) with considerable exemplars represents an opportunity.

The percentage of herbarium species as geographic distribution corresponds with the natural range of the alder species. As such, most herbarium exemplars are represented by *Alnus incana* and *Alnus viridis*, species spread out on a vast natural range, from Eurasia to North America. They are followed by *Alnus serrulata*, a species representative for North America. As such, *Alnus* Genus is well represented in Asia (especially in China and Japan), as well as in North America and Europe.

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