

Appendix A1

1. General distribution

Currently, the Spanish juniper shows a disjointed distribution pattern from the French and Alps to the Atlas Mountains in Morocco, generally in open formations and occasionally forming forests, pure or more usually mixed with other species such as holm oaks or pines. Residual populations are scattered found in the Italian Alps, Corsica and Algeria. By contrast, the most abundant populations are found in Spain (> 200,000 ha) and in Morocco (> 30,000 ha). The separation of the African and European populations by the Strait of Gibraltar seems to have affected gene flow efficiently and for a long time to recognize the existence of two subspecies, *J. thurifera* L. subsp. *thurifera* in Europe, and *J. thurifera* L. subsp. *africana* (Maire) Romo et Boratynski, in Africa (Teixeira *et al.*, 2014). These authors also discovered that this species is a tetraploid ($2n = 40$) with greater genetic diversity in European populations than in African populations, probably due to bottleneck effects, environmental filters or gene drift caused by the migratory process from Europe to North Africa.

2. Old, non-located individuals cited in Granada

The oldest known record of Spanish juniper in Granada was cited by Simón De Rojas Clemente in 1804 (Gil de Albarracín, 2002) in the Cerro de la Media Luna, near what is now known as Cueva Secreta (Sierra Nevada), on acid substrate and at an altitude of 2000 m, ecology very similar to that of the Spanish juniper in the Moroccan high Atlas. However, this specimen, the only one in the entire Sierra Nevada (according to Clemente's words), has not been found or has not arrived alive to this day. Miguel Colmeiro was the first to mention the Spanish juniper in Guadix (Colmeiro, 1888), so it is possible that even then the existence of the Spanish juniper population from Alamedilla or the juniper from Gorafe was known (both belonging to Guadix at that time), or that it was more widespread for this County. The aforementioned author also registers the Clemente's cite of Spanish juniper in Sierra Nevada previously mentioned.

Finally, it is worth highlighting a record of Spanish juniper in Sierra de La Sagra by the botanist Carles Pau (Pau, 1925), at an altitude of 2000 m, which to date has not been found, but which together with that of Clemente, shows that the Spanish juniper was able in past times to vegetate in the timberline of the Betic mountains as reflected in the map of the potential factorial climatic area of the Spanish juniper in the Iberian peninsula (factorial parallelepiped method) by García & Allué (2005).

3. Soils and climate

The space is dominated by limestone with inclusions of sandstone, radiolarites and volcanic rocks. We find two edaphic units: to the north a unit of lithosols, chromic luvisols and rendsins with calcium cambisols; and to the south another unit of calcareous regosols and calcium xerosols with calcareous regosols. The temperature shows an average of 33.9°C for the maximum of the warmest month and 1.7°C on average for the minimum of the coldest month, presenting a total thermal oscillation of 31.5°C.

4. Kriging

We ran an ordinary kriging using two variables in the SAGA GIS 2.3.2 program. The first is the absence/presence of individuals in space, the values ranges between 0 (absence) and 1 (presence). Thus, we can determine those areas that potentially house individuals. The second is the basal diameter of the trunk, which allows us to identify the areas of origin of the current population. There is a diameter value of 0 mm for null points, while in the population the values range between 0.6 mm and 750 mm.

5. Conservation remarks

A search was carried out in the study area for priority Habitats of EU Community Interest (HIC*) (Bartolomé *et al.*, 2005), using the layer of Habitats of EU Community Interest from REDIAM service (2018). The presence of HIC* is a requirement for the

establishment of forms of protection linked to the Natura 2000 Network. The declaration of the area as a Site of Community Interest (SCI) within RN2000 would allow protect the population effectively. For that, the area needs to host Annex I priority listed habitats to apply for a SCI.

We found habitat 5210 (subtype 32,136 thickets the size of a *J. thurifera* tree; non-priority); and habitat 9560 (Endemic forests of *Juniperus* spp.), from Annex I, although it is not recognized by the Junta de Andalucía in the area. Only habitat 1520 (Iberian gypsum vegetation, Gypsophiletalia) is present and recognized in the study area (REDIAM 2018) (Fig. A6). Recently, this space has been included in the Granada Geopark. Its objective is the protection of geological landscapes, which could allow an indirect protection by avoiding actions on the change of terrain geometry.

The conversion of abandoned land and wastelands into groves (olive, almond) is the most important risk-impact. The clearing the scrub cover removes young individuals and damages the superficial root system of well-developing individuals (Caraveli, 2000, Ferrer *et al.*, 2000; Santos & Tellería, 2006; García-Orenes *et al.*, 2013). The bare steep slopes together with the torrential rains, carries a high risk erosion and loss of soil fertility that can affect the future of this population (Rodrigo-Comino *et al.*, 2018) (Fig. A7). If we combine these risks with alterations derived from climate change, it can lead to deaths mediated by the appearance of the parasitic fungi. These species attack the plants when conditions of environmental stress occur (González *et al.*, 2006; Sánchez, 2006).

Despite the species not being protected, the Andalusian List of Singular Trees and Groves contains a series of isolated Spanish junipers and Spanish juniper groves that are cataloged by their singularity or rarity. In Granada, the Sabinar de los Cánovas and the Sabinar de Prado Puerco are registered, both in Huéscar (Junta de Andalucía, 2003). In the province of Almería the Sabina del Batanero, Sabina del Cortijo del Puerto and Sabina del Mancheño are mentioned, all of them in Vélez Blanco, and the millennial Sabina del Chirivel (Junta de Andalucía, 2010). In Jaén, the Sabina de la Fresnedilla in Villacarrillo, the Sabina de la Nava del Espino in Siles and the Sabina de las Lagunillas in Cazorla (Junta de Andalucía, 2004) are listed as singular.

References

- Colmeiro M, 1888. Enumeración y revisión de las plantas de la península Hispano-Lusitana é Baleares. Tomo IV. Madrid, España.
- García-Orenes F, Roldán A, Mataix-Solera J, Cerdà A, Campoy M, Arcenegui V, Caravaca F, 2012. Soil structural stability and erosion rates influenced by agricultural management practices in a semi-arid Mediterranean agro-ecosystem. *Soil Use Manag* 28(4): 571-579.
- Sánchez G, 2006. Evaluación fitosanitaria del *Juniperus oxycedrus* y otros *Juniperus* en la Península Ibérica: Principales plagas y enfermedades. Actas del III Coloquio Internacional sobre Sabinas y Enebrales (Gen. *Juniperus*): ecología y gestión forestal sostenible. Tomo I, 417-425. Soria, España.
- Junta de Andalucía, 2003. Árboles y arboledas singulares de Andalucía. Granada. Sevilla, España.
- Junta de Andalucía, 2004. Árboles y arboledas singulares de Andalucía. Jaén. Sevilla, España.
- Junta de Andalucía, 2010. Árboles y arboledas singulares de Andalucía. Almería. Sevilla, España.
- González V, Tuset JJ, Hinarejos R. 2006. Hongos asociados al decaimiento de los bosques de enebros (*Juniperus* spp.) en áreas de montaña del mediterráneo español. Actas del III Coloquio Internacional sobre Sabinas y Enebrales (Gen. *Juniperus*): ecología y gestión forestal sostenible. Tomo I, 427-435. Soria, España.
- Rodrigo-Comino J, Martínez-Hernández C, Iserloh T, Cerdà A, 2018. Contrasted impact of land abandonment on soil erosion in Mediterranean agriculture fields. *Pedosphere* 28(4): 617-631.
- Santos T, Tellería JL, 2006. Pérdida y fragmentación del hábitat: efecto sobre la conservación de las especies. *Ecosistemas* 15(2): 3-12.
- Bartolomé C, Álvarez J, Vaquero J, Costa M, Casermeiro MA, Giraldo J, Zamora J, 2005. Los tipos de Hábitat de Interés Comunitario de España. Ministerio de Medio Ambiente, Madrid, España. 287 pp.

Supplementary Appendix to the article “Characterization of the Spanish juniper population of El Peñón de Alamedilla (Granada, Spain): conservation status and protection proposal”, by Juan A. Vílchez, José M. Marruecos, María N. Jiménez and Francisco B. Navarro. Forest Systems Vol. 30 No. 2, August 2021
(<https://doi.org/10.5424/fs/2021302-17897>)

- Ferrer A, Lara JJ, Gámez J, 2000. La política de ordenación del suelo y sus usos en la provincia de Granada. Cuadernos Geográficos 30: 223-262.
- Caraveli H, 2000. A comparative analysis on intensification and extensification in Mediterranean agriculture: dilemmas for LFAs policy. J Rural Stud 16(2): 231-242.
- Pau C, 1925. Contribución a la flora española, plantas de Almería. Memorias del Museo de Ciencias Naturales de Barcelona, serie Botánica vol. 1, nº3. Ayto. y Diputación de Barcelona, España.
- Gil de Albarracín A, 2002. Simón de Rojas Clemente Rubio. Viaje a Andalucía. “Historia Natural del reino de Granada” (1804-1809). Griselda Bonet Girabet, Barcelona, España. 1247 pp.
- García JM, Allué C, 2005. Caracterización y potencialidades fitoclimáticas de la sabina albar (*Juniperus thurifera* L.) en la Península Ibérica. Invest. Agrar.: Sist. Recur. For. 14(1), 98-109.
- Teixeira H, Rodríguez-Echevarría S, Nabais C, 2014. Genetic diversity and differentiation of *Juniperus thurifera* in Spain and Morocco as determined by SSR. Plos One 9(2) e88996. doi:10.1371/journal.pone.0088996.