

Expansion of *Himantoglossum robertianum* (Orchidaceae) in Madrid: a case study on environmental variables and geographical distribution

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Received: 6 November 2017 / Accepted: 20 February 2018 / Published online: 29 June 2018

Abstract. The increase of the localities of *Himantoglossum robertianum* in the Community of Madrid region in the last years is studied. We have visited the new discovered populations and characterized their habitats, finding little agreement with the basophilic preferences attributed to the orchid. A model of potential distribution of the taxon has been elaborated showing the southern river basins of the region as the areas of greatest suitability. The lack of data prevents from concluding that the increase of the registered area corresponds with a climatic or land-use change in Madrid region, but the work developed has allowed to properly characterize the distribution and the state of conservation of the species.

Keywords: Threatened flora; SDM; Orchidaceae; Madrid.

Variables ambientales y expansión de *Himantoglossum robertianum* (Orchidaceae) en la Comunidad de Madrid

Resumen. Se estudia la evolución de las localidades de *Himantoglossum robertianum* en la Comunidad de Madrid en los últimos años. Se han visitado las nuevas poblaciones descubiertas y caracterizado los hábitats en que se desarrolla, que no concuerdan con las preferencias basófilas atribuidas a la orquídea. Se ha elaborado un modelo de distribución potencial del taxón que muestra las cuencas meridionales de los ríos madrileños como las áreas de mayor idoneidad. La falta de datos impide concluir que la amplia distribución observada y su expansión coincidan con un cambio del clima o de los usos del territorio madrileño, pero el trabajo desarrollado ha permitido caracterizar con propiedad la distribución y el estado de conservación de la especie.

Palabras clave: Flora amenazada; SDM; Orchidaceae; Madrid.

Introduction

Orchids have been highlighted as indicators of fragile and diverse ecosystems in the Community of Madrid, which has led to propose the entire Orchidaceae family to be included in the legal catalogue of protection for regional flora (Blanco, 1999). This proposal was the base for the study of the 40-orchid species from Madrid region at the initiative of the body of forest rangers to determine the IUCN categories of risk and the most adequate conservation measures for each taxon (Anon., 2014, CAFCM). This study was aimed at the revision and updating of the catalogue of protected species of the Community of Madrid, very obsolete after 25 years of validity (Anon., 1992, BOCM); Moreno Saiz & al., 2011).

Himantoglossum robertianum (Loisel.) P. Delforge, the giant orchid, is a species distributed throughout the Mediterranean basin, from the Balkans to Iberia and the

Maghreb. Its traditional treatment included the species under the name of *Barlia robertiana* (Loisel.) Greuter (Aedo, 2005), but recent taxonomic studies supported by molecular and morphological data led to its combination within the genus *Himantoglossum* Spreng (Bateman & al., 2003, 2017). In the Iberian Peninsula, it has a peripheral distribution, present in almost all the coastal provinces and only in some inland localities, with preference for the areas of basic substrates (Delforge, 2002; Aedo, 2005). In the Community of Madrid the presence of the plant was unknown for revisions of its flora (Cutanda, 1861; Abajo & al., 1982; Morales Valverde, 2003) until it was detected some years ago (Galán Cela & al., 2003). Since then it has been mentioned in more localities scattered mainly in the south of the region (López Jiménez, 2007; García Román & López Colón, 2011; Grijalbo Cervantes, 2016).

The only study on its conservation status had considered the giant orchid as an endangered species

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in the Community of Madrid (IUCN category EN D), with few locations involving reduced number of plants (Anon., 2014, CAFCM). However, its number of citations has been increasing in recent years, often through amateur publications on social networks or new discoveries by forest rangers. These findings had the advantage of the plant height and attractiveness, with stems up to 100 cm, together to an early flowering in Madrid region (February to April), which made the plant easily recognizable.

With this background, a review of the *H. robertianum* status in the Community of Madrid was addressed with several objectives: i) to update its distribution and occupation area in Madrid region; ii) analyze the ecological requirements of the plant through field work in their populations; iii) develop habitat suitability models in order to determine the environmental variables most related to their distribution. These objectives would serve to raise the hypothesis of whether *H. robertianum* is an expanding species in the center of the Iberian Peninsula as a result of the new findings, and if a pilot study like this could be extended to other orchids and threatened plant taxa in the Community of Madrid.

Material and Methods

Data collection

Distributional data referred to *Himantoglossum robertianum* in Madrid region was compiled taking advantage of published articles, technical reports and personal communications. No herbarium sheet referring to Madrid region and correctly

identified could be incorporated after the review of the main Spanish herbaria. The search in public electronic databases of common use (e.g. Global Biodiversity Information Facility, GBIF; Information System about Plants in Spain, Anthos) did not reveal new references to those already known. Based on this preliminary database, the largest possible number of known locations was visited during the spring of 2017, in order to make a contemporary sampling of the populations. In this fieldwork, the localities were georeferenced, the plants were counted as flowering or vegetative individuals, and the plant communities was inventoried.

Species distribution modeling

A dataset composed by the sampled populations spanned to 56 presences at 1 km² grid resolution was used. We relied on an accurate sampling of species presences so we relied on reliable true absence data, using six times more absences than presences in the model to weigh the same. These sets of presence and absence points were used to calibrate the models.

The bioclimatic variables were obtained from CHELSA dataset, which provides high resolution monthly mean temperature and precipitation patterns for the time period 1979-2013 (Karger & al., 2017). For its part, soil characteristics were obtained from the Harmonized World Soil Database (FAO). The six most meaningful species distribution models (SDMs) were selected from the 19 bioclimatic and 20 edaphic variables available. The selection was conducted through hierarchical partitioning approach with the hier.part package (Walsh & Mac Nally, 2003) in R software.

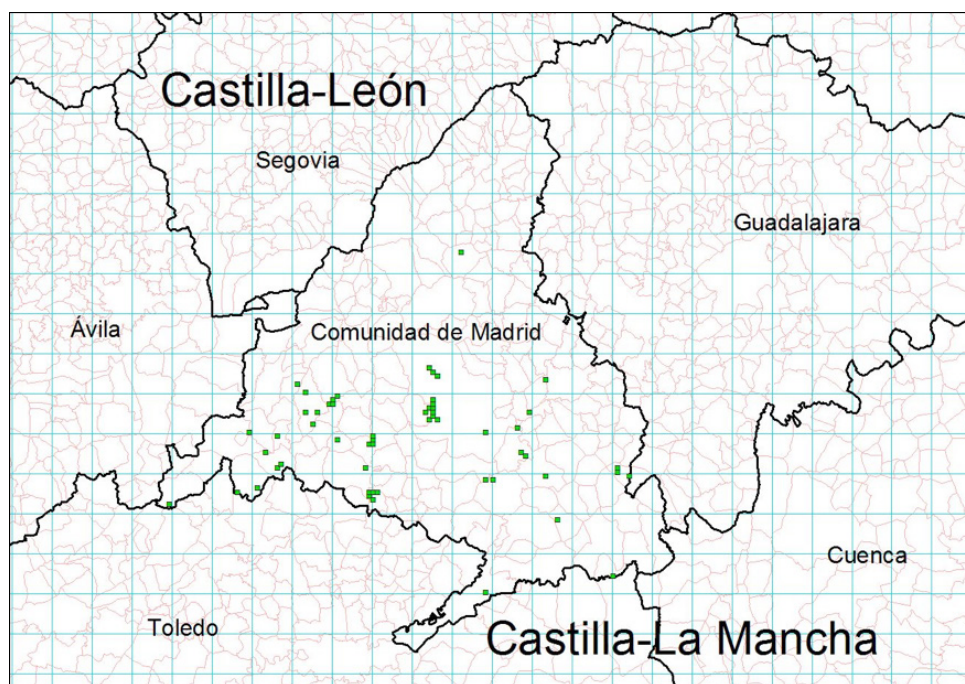


Figure 1. Distribution range of *Himantoglossum robertianum* in Madrid. Every green square represents a UTM cell of 1 km side (datum ETRS89).

Niche model analysis was conducted with Biomod2 package (Thuiller & al., 2009) implemented in R software (R Development Core Team, 2014). The chosen models were generalized additive model (GAM), stepwise generalized linear models (GLM), boosted regression trees (GBM), artificial neural network (ANN), multiple adaptive regression splines (MARS) and random forests (RF). Each algorithm was executed 5 times so that 90% of the randomly selected presence/absence data were used to calibrate the model and 10% to evaluate the quality of the prediction of habitat suitability using the TSS and ROC indices. Thus, 5x5x6=150 models of potential distribution were generated. To construct the unified model of potential distribution of the species, the individual models were filtered excluding all those with a quality lower than 0.8 in any of the two indices considered and were weighted according to the TSS index. The suitability threshold to consider each pixel as part of the potential distribution of the species was established as that value that maximizes the TSS value. The ensemble modeling technique implemented in Biomod2 as a weighted average of all models was utilized to build a single prediction.

Results and Discussion

Range of *H. robertianum* in Madrid region

From the 62 orchid populations included in the database, 51 have been visited and 48 of them found during the fieldwork. So, it has been possible to confirm the increase in the number of localities, as well as the extension of known occupation of the giant orchid in the Madrid region (Figure 1). From a single population discovered in 2003, it has gone to 53 cells occupied in 2017, spread over the southern half of the territory studied. The complete relation of coordinates and localities appear in Annex 1.

The censuses carried out raise up to 300 mature individuals the whole population, to which 507 vegetative rosettes would have to be added. As no previous demographical sampling had been performed, it cannot be determined to what extent the census has followed similar increase during this period. Nevertheless, this census together with the calculation of the Area Of Occupancy and the Extent Of Presence, has allowed to establish a new regional IUCN risk category for *H. robertianum* downgrading it to Vulnerable (Martínez Labarga & al., 2017).

Habitat characteristics

All populations of *H. robertianum* in the Community of Madrid are found at altitudes between 470 to 940 m asl, and are usually presented in E and S orientations. Notably, a preference for *arcosas* is observed in half of their inventories, followed by clays, marls and limestones. Thus, the predominantly basophilic nature of the distribution of this orchid throughout the Mediterranean and the Iberian Peninsula would not be

confirmed in Madrid region (Delforge, 2002). However, the pH of these sands (arkoses) has not been measured *in situ* during our work, which makes it impossible to know the true level of acidity or neutrality of such soils.

The orchids mainly developed in clearings of forest formations (60% of inventories), followed by grasslands and nitrophilous pastures (29%), and shrublands (11%). The main woodlands were holm oaks forests (*Quercus ilex* subsp. *ballota* (Desf.) Samp.) with as much as 41%, followed by semi-natural pine forests of different species (*Pinus pinea* L. and *P. halepensis* Mill.). Plant inventories were heterogeneous in line with the variety of formations detected with presence of the giant orchid.

134 from 150 conducted models scored over 0.8 for both TSS and ROC indices. The 6 selected variables were: annual precipitation (0.828), precipitation of the coldest quarter (0.525), total amount of base exchange on the top of the soil (0.467), precipitation of the coldest quarter (0.377), temperature range (0.152), and temperature of the coldest quarter (0.075). No topographic variables were considered. Threshold suitability was 475 over 1000.

According to the model, the most suitable areas for *H. robertianum* in the Community of Madrid extend through the middle and lower basins of the Alberche, Guadarrama and Manzanares rivers, in the S and SW of the region (Figure 1). The consensus model shows in these basins, and even along the easternmost Henares and Tajuña valleys (Figure 2), large areas not known or occupied in spite of being highly suitable for the orchid. Even though these models can over-predict the potential niche of the species (Guisan & al., 2017), such valleys would be areas where planning prospections in future campaigns in search of new populations.

There are not enough climate data to analyze if there has been a significant change in potential areas modeled before the first appointment in the Community of Madrid of *H. robertianum* was discovered, to this modeled nowadays. This prevents empirically determining whether the appearance of the species in Madrid and the expansion of its known area is related to climate changes or variations in other variables that have occurred in recent decades. In any case, the quasi-exponential growth of discoveries in recent years, given the ease of recognizing the species, must be explained more by a range expansion of the orchid than by the net increase of floristic knowledge of the territory, being Madrid a region with numerous studies during the last century. Variations in rainfall and temperature contrasts, operating synergistically with changes in land use, could be favoring the expansion of this Mediterranean plant to widen its area of occupation into Iberian inland.

A study like the one addressed here, combining data mining, field work and species distribution modeling, has resulted very useful in determining the conservation status of a threatened plant in a given region. In a territory like Madrid region, where it is urgent to renew the catalogue of threatened flora based on updated studies (Moreno Saiz & al., 2011) a pilot study of these characteristics can be a quick and resolute tool to complete a task like this with means and terms in accordance with the importance of the project needed.

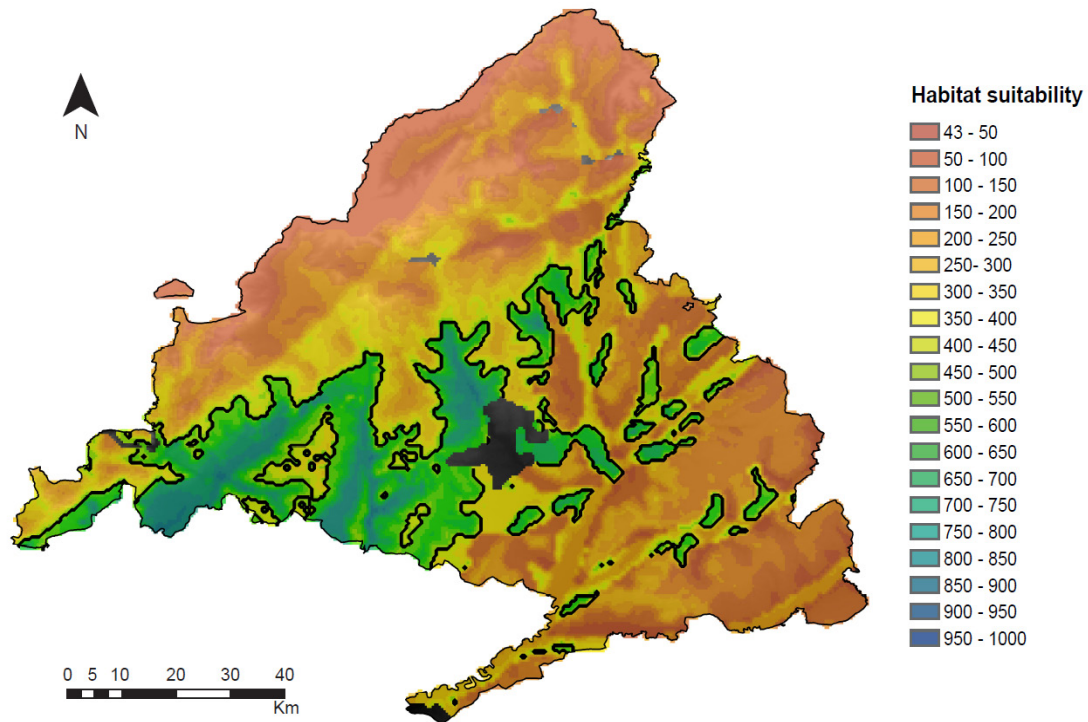


Figure 2. Suitability map of *Himantoglossum robertianum* in Madrid according to the consensus model.

Acknowledgements

The Forest Rangers of the Community of Madrid, the Department of Parks and Gardens of the Madrid City

Council (Casa de Campo), the Citizen Science Platform Biodiversidad Virtual, the asociación ARBA Bajo Jarama and our colleagues who generously shared their field knowledge on the giant orchid are kindly grateful.

References

- Abajo, A., Carmona, E., Escribano, R., Ortega, C., Rodríguez, A., Ruiz Del Castillo, J. & Ruiz de la Torre, J. 1982. Aproximación al catálogo de plantas vasculares de la provincia de Madrid. Cons. Agric. Gan. Com. Madrid. 221 pp.
- Aedo, C. 2005. Barlia Parl. In: Castroviejo, S. (Coord.). Flora Ibérica XXI. Smilacaceae-Orchidaceae. Pp. 151-153. R. Jard. Bot. CSIC, Madrid.
- Anonymous. 1992. Decreto 18/1992, de 26 de marzo, por el que se aprueba el Catálogo Regional de Especies Amenazadas de Fauna y Flora Silvestres y se crea la categoría de árboles singulares. BOCM, Boletín Oficial de la Comunidad de Madrid, Madrid.
- Anonymous. 2014. Proyecto Orquídeas. Informe sobre especies de flora amenazada de la Comunidad de Madrid y propuestas para su conservación: familia Orchidaceae. Informe inédito. CAFCM, Cuerpo de Agentes Forestales de la Comunidad de Madrid. Comunidad de Madrid, Madrid. 120 pp.
- Bateman, R.M., Hollingsworth, P.M., Preston, J., Luo, Y.-B., Pridgeon, A.M. & Chase, M.W. 2003. Molecular phylogenetics and evolution of Orchidinae and selected Habenariinae (Orchidaceae). Bot. J. Linn. Soc. 142:1-40.
- Bateman, R.M., Molnár, R.V. & Sramkó, G. 2017. In situ morphometric survey elucidates the evolutionary systematics of the Eurasian *Himantoglossum* clade (Orchidaceae: Orchidinae). PeerJ 5: e2893.
- Blanco, E. (Coord.). 1999. Revisión del Catálogo Regional de Especies Amenazadas de la Flora Silvestre de la Comunidad de Madrid. Plan Forestal de la Comunidad de Madrid. Pp. 751-779. Informe inédito.
- Cutanda, V. 1861. Flora compendiada de Madrid y su provincia. Imprenta Nacional, Madrid. 759 pp.
- Delforge, P. 2002. Guía de las Orquídeas de España y Europa, Norte de África y Próximo Oriente. Lynx Edition, Barcelona. 592 pp.
- Galán Cela, P., Gamarra Gamarra, R. & Sordo Ansorena, R. 2003. Novedades corológicas y taxonómicas sobre orquídeas ibéricas. Lazaroa 24: 13-17.
- García Román, L. & López Colón, J.I. 2011. Encontrado en Madrid un ejemplar de orquídea gigante. Quercus 307: 47-48.

- Grijalbo Cervantes, J. 2016. Flora de Madrid. Ed. J. Grijalbo Cervantes, Madrid. 384 pp.
- Guisan, A., Thuiller, W. & Zimmermann, N.E. 2017. Habitat Suitability and Distribution Models: With Applications in R (Ecology, Diversity and Conservation). Cambridge Univ. Press, Cambridge.
- Karger, D.N., Conrad, O., Böhner, J., Kawohl, T., Kreft, H., Soria-Auza, R.W., Zimmermann, N.E., Linder, H.P. & Kessler, M. 2017. Climatologies at high resolution for the earth's land surface areas. *Sci. Data* 4: 170122.
- López Jiménez, N. 2007. Las plantas vasculares de la Comunidad de Madrid. Catálogo florístico, claves dicotómicas y estudio detallado de la familia Compositae Giseke. Mem. Doc. (ined.). Univ. Complutense, Madrid. 409 pp.
- Martínez Labarga, J.M., Araújo Díaz, J., Ramos Gutiérrez, I., Giraldo Barragán, C. & Moreno Sáiz, J.C. 2017. Evolución de la población de *Himantoglossum robertianum* (Loisel.) P. Delforge (Orchidaceae) en la Comunidad de Madrid. *Conserv. Veg.* 21: 7-11.
- Morales Valverde, R. 2003. Catálogo de plantas vasculares de la Comunidad de Madrid. *Bot. Complutensis* 27: 31-70.
- Moreno Saiz, J.C., de la Cruz, M., Domínguez, F., Iriondo, J.M., Martínez Labarga, J.M., Martínez García, F., Mazimpaka, V., Moreno, G., Sánchez-Mata, D. & Vargas, P. 2011. Es hora de enderezar el rumbo en la conservación de la flora madrileña. *Quercus* 304: 40-46.
- R Development Core Team. 2014. R: A Language and Environment for Statistical Computing. Vienna, Austria: the R Foundation for Statistical Computing. ISBN: 3-900051-07-0. 2011. Available: <http://www.Rproject.org/>.
- Thuiller, W., Lafourcade, B., Engler, R. & Araújo, M.B. 2009. BIOMOD—A platform for ensemble forecasting of species distributions. *Ecography* 32: 369-373.
- Walsh, C. & Mac Nally, R. 2003. The hier.part Package: Hierarchical Partitioning. (Part of: Documentation for R: A language and environment for statistical computing.) R Foundation for Statistical Computing, Vienna, Austria.

Websites

Harmonized World Soil Database (version 1.2). FAO, Rome and IIASA, Laxenburg. <http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/>

Appendix 1. Relation of localities of *Himantoglossum robertianum* in Madrid province. The numbers in brackets indicate the census of flowering individuals (f) and vegetative rosettes (v) recorded in each locality. Only an herbarium voucher is cited due to the scarcity of the plant.

Himantoglossum robertianum (Loisel.) P. Delforge, *Naturalistes Belges* 80: 401 1999.
(= *Barlia robertiana* (Loisel.) Greuter, *Boissiera* 13: 192 (1967)).

Madrid: Cenicientos, road to Pelahustán, holm oak woods, granites, 30TUK 65, 865 m asl, 2007, *J. Grijalbo*, 1f; *ibidem*, *J. Juárez* (for. ag.), 2010, 2f; therophytic pastures, 890 m asl, *J. Araújo* (for. ag.), 28.03.2017, 1f. Villa del Prado, near to Toledo provincial limit, holm oaks (*Q. rotundifolia*) woodlands with gum rockrose (*Cistus ladanifer*), arkoses, 30TUK 85, 510 m asl, *J. Araújo* (for. ag.), 11.04.2017, 1v. Navas del Rey, Camino del Infante, *Pinus pinea* stands with rockrose-rosemary formations, gneisses, 30TUK 87, 650 m asl, [*L.J. Bernáldez*, *J. Juárez*, *B. García* (for. ag.)], 2011; *ibidem*, *I. Ramos*, [*J. Araújo*, *L.J. Bernáldez* (for. ag.)], *J.C. Moreno*, 14.03.2017, 14f+39v. Villa del Prado, dehesa de Alamar, open holm oaks (*Q. rotundifolia*) woodlands, arkoses, 30TUK 95, 470 m asl, *L. Rubio* (BV), 2008, 30f. Aldea del Fresno, La Dehesilla, near M-510 road, slope in holm oak (*Q. rotundifolia*) woodlands, arkoses, 30TUK 96, 475 m asl, *J. Juárez* (for. ag.), 2011, 1f; *ibidem*, [*J. Juárez*, *B. García* (for. ag.)], 5.04.2017, 6f+2v. Suertes Viejas, open holm oaks (*Q. rotundifolia*) with grasslands, arkoses, 540 m asl, [*B. García*, *J. Juárez* (for. ag.)], 03.2011, 1f, *ibidem*, *J. Juárez* (for. ag.), 5.04.2017, 10f+10v. Chapinería, Huerta de los Álamos, near M-510 road, holm oaks (*Q. rotundifolia*) woodlands, granites, 650 m asl, *A. Malanda*, III-2017; *ibidem*, *I. Ramos*, [*J. Araújo*, *L.J. Bernáldez*

(for. ag.)], *J.C. Moreno*, 14.03.2017, 8f+16v. San Martín de Valdeiglesias, Picadas, slopes on Alberche river, holm oaks (*Q. rotundifolia*) woodlands with silicicolous shrublands, quartzites, 480 m asl, *J. Juárez* (for. ag.), 5.04.2015; *ibidem*, *J. Juárez* (for. ag.), 5.04.2017, 6f+4 v. Navalagamella, La Constancia, holm oaks (*Q. rotundifolia*) woodlands with silicicolous shrublands, granites-arkoses, 30TVK 07, 690 m asl, [*A. López*, *A. Quirós* (for. ag.)], 8.03.2005, 2f+1v; *ibidem*, *M. Higuera*s (for. ag.), *F. Suárez Boada*, 15.02.2008, 28f; *ibidem*, [*M. Higuera*s, *J. Araújo* (for. ag.)], 27.03.2010, 7f+23v; *ibidem*, *I. Ramos*, *J. Araújo* (for. ag.), *J.C. Moreno*, 14.03.2017, 6f+19v. Colada de las Vegas, holm oaks (*Q. rotundifolia*) woodlands with *Juniperus* and *Retama*, gneiss-arkoses, 585 m asl, *C. de Miranda* (for. ag.), 2016, 2v; *ibidem*, *I. Ramos*, *J. Araújo* (for. ag.), *J.C. Moreno*, 14.03.2017, 2v. Quijorna, slopes to El Colmenar gorge, holm oaks (*Q. rotundifolia*) woodlands with grasslands, calcarenite, 605 m asl, *A. López* (for. ag.), 11.04.2013; *ibidem*, *A. López* (for. ag.), 27.02.2017, 3f; *ibidem*, *I. Ramos*, *J. Araújo* (for. ag.), *J.C. Moreno*, 14.03.2017, 4f. Villanueva de Perales, Dehesa municipal, open holm oaks (*Q. rotundifolia*) woodlands with grasslands, sandy soils, 525 m asl, *J. Moreno*, *J. Araújo* (for. ag.), 28.03.2017, 1f. Fresnedillas de la Oliva, open area

inside town, ruderal grasslands, granits, 30TVK 08, 940 m asl, *R. Laorga* (BV), 5.03.2017, 3f. Navalagamella, roadside in Fresnedillas road, holm oaks (*Q. rotundifolia*) woodlands, granits-arkoses, 830 m asl, *M. Higuera*, *J. Araújo* (for. ag.), 16.03.2016, 1f; *ibidem*, *M. Higuera*, *J. Araújo* (for. ag.), 16.03.2017, 1f; *ibidem*, *J. Muddeman* (BV), 16.03.2017, 1f. 30TVK 15, Guadarrama river valley, close to Batres hills, grasslands in open shrublands, Sandy soils, 550 m asl, *J.M. Martínez Labarga*, *J. Grijalbo*, *A. Revilla*, *D. Meliá*, *P. Fraile & al.*, 6.04.2013, 7f. Batres, Batres hills, holm oaks (*Q. rotundifolia*) woodlands with silicicolous shrublands, arkoses, 600 m asl, *E. Chicharro* (for. ag.), V-2010, 1f; *ibidem*, to Cárcava del Arenal, woodlands with silicicolous shrublands, 615 m asl, *E. Chicharro* (for. ag.), V-2010, 2f+9v; *ibidem*, 620 m, *I. Ramos*, [*J. Araújo*, *L. Sotoca*, *C. Giraldo* (for. ag.)], *J.C. Moreno*, 13.03.2017, 23f+6v; Batres hills, holm oak woodland, arkoses, 30TVK 25, 620 m asl, *J. de la Rosa Maldonado* 4.09.2002, MAF 162303; Batres hills, lowlands Barranco del Pastor, holm oaks (*Q. rotundifolia*) woodlands with grasslands, arkoses, 560 m asl, *J.M. Martínez Labarga*, *J. Grijalbo*, *A. Revilla*, *D. Meliá*, *P. Fraile & al.*, 6.04.2013, 2f; *ibidem*, 580 m, *J.M. Martínez Labarga*, *J. Grijalbo*, *A. Revilla*, *D. Meliá*, *P. Fraile, al.*, 6.04.2013, 1f; Batres hills, south Cotorredondo estate, holm oaks (*Q. rotundifolia*) woodlands with some Montpellier maples, arkoses, 575 m asl, *J.M. Martínez Labarga*, *J. Grijalbo*, *A. Revilla*, *D. Meliá*, *P. Fraile & al.*, 6.04.2013, 5f; *ibidem*, open area, ruderal grasslands, arkoses, 650 m asl, [*L. Sotoca*, *L. de Castro* (for. ag.)], 14.03.2017, 1f. Navalcarnero, talud sobre la A5, en herbazal nitrófilo, arcosas, 30TVK 16, 610 m asl, *J. Muddeman* (BV), 31.03.2017, 55f; *ibidem*, [*L. Sotoca*, *L. de Castro*, *Á. Oporto* (for. ag.)], 1.04.2017, 53f. Sevilla la Nueva, Las Portaleras, roadsides in unpaved road, ruderal grassland, arkoses, 660 m asl, [*C. Giraldo*, *E. Chicharro* (for. ag.)], 21.03.2009, 1f; *ibidem*, *I. Ramos*, [*J. Araújo*, *L. Sotoca*, *C. Giraldo* (for. ag.)], *J.C. Moreno*, 13.03.2017, 3f+1v. Villaviciosa de Odón, Dehesa de Monreal, close to Vega stream, holm oaks (*Q. rotundifolia*)-*Pinus pinea* woodlands with Retama and grasslands, arkoses, 575 m asl, [*C. Giraldo*, *J.M. Antón* (for. ag.)], 03.2010, 1f. Quijorna, El Pellejo, Retama formations with grasslands, calcarenites, 30TVK 17, 625 m asl, *A. López* (for. ag.), 27.02.2017, 1f; *ibidem*, *I. Ramos*, *J.C. Moreno*, 15.03.2017, 1f. Valdemorillo, El Vetago, Retama formations with grasslands, sandstones, limestones, gneisses, 640 m asl, [*C. Giraldo*, *L. de Castro* (for. ag.)], 9-V-2012, 2f; *ibidem*, *I. Ramos*, *J. Araújo* (for. ag.), *J.C. Moreno*, 14.03.2017, 3f+1v. Cerro del Castillejo, holm oak woodland with Retama, sandstones, limestones, gneisses, 660 m asl, *Sole Pacheco*, 20-V-2017, 2f. Villaviciosa de Odón, Dehesa de Monreal, holm oaks (*Q. rotundifolia*)-*Pinus pinea* woodlands with gum rockrose and grasslands, arkoses, 30TVK 26, 610 m asl, [*C. Giraldo*, *J.M. Antón* (for. ag.)], 28.03.2013, 1f; *ibidem*, *I. Ramos*, [*J. Araújo*, *L. Sotoca*, *C. Giraldo* (for. ag.)], *J.C. Moreno*, 13.03.2017, 4f+36v. Sotillo de Villaviciosa, to Residencia, restored

Pinus pinea stand with holm oak, arkoses, 620 m asl, *C. Giraldo* (for. ag.), III-2010, 1f+1v; *ibidem*, *I. Ramos*, [*J. Araújo*, *L. Sotoca*, *C. Giraldo* (for. ag.)], *J.C. Moreno*, 13.03.2017, 3f+38v; Sotillo de Villaviciosa, hills close to Residencia, restored *Pinus pinea* stand with holm oak, arkoses, 605 m asl, *C. Giraldo* (for. ag.), 03.2010; *ibidem*, *I. Ramos*, [*J. Araújo*, *L. Sotoca*, *C. Giraldo* (for. ag.)], *J.C. Moreno*, 13.03.2017, 3f. Madrid-Moncloa, Casa de Campo, El Espinillo, restored *Pinus pinea*-holm oak stand, arkoses, 30TVK 37, 660 m asl, [*E. Rodríguez García & al.* (Dpto. Parques y Jardines Ayto. Madrid)], undated, 1f; *ibidem*, [*E. Rodríguez García*, *M. Avilés* (Dpto. Parques y Jardines Ayto. Madrid)], 7.04.2017, 1f; Casa de Campo, Puerta de Rodajos to Portillo de los Pinos, restored *Pinus pinea* stand with holm oak, arkoses, 670 m asl, *P.A. Lázaro* (BV), 07.05.2017, 1f; Casa de Campo, camino de Somosaguas, open holm oak woodland with grasslands, arkoses, 640 m asl, [*F. Rodríguez Pachón*, *E. Rodríguez García & al.* (Dpto. Parques y Jardines Ayto. Madrid)], 2014, 1f; *ibidem*, [*M.J. Muñoz*, *B. Sacristán* (Dpto. Parques y Jardines Ayto. Madrid)], *J.M. Martínez Labarga*, 19.03.2014, 1f; Casa de Campo, slopes of Antequina stream, open holm oak woodland with grasslands, arkoses, 635 m asl, [*E. Rodríguez García & al.* (Dpto. Parques y Jardines Ayto. Madrid)], 2017; *ibidem*, [*E. Rodríguez García*, *M. Avilés* (Dpto. Parques y Jardines Ayto. Madrid)], *J. Araújo* (for. ag.), *J.M. Martínez Labarga*, *J.C. Moreno*, 7.04.2017, 2f; Casa de Campo, Pinar Grande to Cuatro Caminos, open holm oak woodlands with grasslands, arkoses, 655 m asl, [*F. Rodríguez Pachón*, *E. Rodríguez García & al.* (Dpto. Parques y Jardines Ayto. Madrid)], 2014; *ibidem*, [*E. Rodríguez García*, *M. Avilés* (Dpto. Parques y Jardines Ayto. Madrid)], *J. Araújo* (for. ag.), *J.M. Martínez Labarga*, *J.C. Moreno*, 7.04.2017, 1f; Casa de Campo, La Capataza, restored *Pinus pinea* stand, arkoses, 660 m asl, [*M. Avilés* (Dpto. Parques y Jardines Ayto. Madrid)], 2012, 1f; *ibidem*, [*F. Rodríguez Pachón*, *E. Rodríguez García & al.* (Dpto. Parques y Jardines Ayto. Madrid)], 2014, 1f; *ibidem*, [*M. Avilés*, *B. Sacristán* (Dpto. Parques y Jardines Ayto. Madrid)], *J.M. Martínez Labarga*, 21.04.2015, 1f; *ibidem*, [*E. Rodríguez García*, *M. Avilés* (Dpto. Parques y Jardines Ayto. Madrid)], *J. Araújo* (for. ag.), *J.M. Martínez Labarga*, *J.C. Moreno*, 7.04.2017, 1f; Casa de Campo, Cerro Garabitas, restored *Pinus pinea* stand, arkoses, 640 m asl, [*F. Rodríguez Pachón*, *E. Rodríguez García & al.* (Dpto. Parques y Jardines Ayto. Madrid)], 2014; *ibidem*, [*M. Avilés*, *B. Sacristán* (Dpto. Parques y Jardines Ayto. Madrid)], *J.M. Martínez Labarga*, 21.04.2015, 2f+1v; *ibidem*, [*E. Rodríguez García*, *M. Avilés* (Dpto. Parques y Jardines Ayto. Madrid)], *J. Araújo* (for. ag.), *J.M. Martínez Labarga*, *J.C. Moreno*, 7.04.2017, 7f+15v; Club de Campo de la Villa de Madrid, slopes, ruderal grasslands, arkoses, 645 m asl, *L. Pascual*, 3.03.2017, 1f; Batán, underground slope, ruderal grasslands, arkoses, 630 masl, *J.M. Cid*, 2017; *ibidem*, *I. Ramos*, *J.C. Moreno*, *J. Araújo* (for. ag.), *J. Grijalbo*, 22.03.2017, 2f. Madrid-Fuencarral El Pardo, Monte del Pardo, slopes on the Palace, restored *Pinus pinea* stands,

arkoses, 30TVK 38, 630 m asl, *P. Galán*, 24.03.2017, 2f; Monte del Pardo, close to la Quinta stream, open holm oak woodland, arkoses, 640 m asl, *J. Prados* (BV), 13.04.2017, 4f; Monte del Pardo to La Quinta, open holm oak woodland with rockroses, arkoses, 705 m asl, *C. Ruiz*, 2016, 1v; *ibidem*, *C. Ruiz*, 23.02.2017, 1f; Monte del Pardo Cuartel de Valpalomero, open holm oak woodland with rockroses, arkoses, 710 m asl, *C. Ruiz*, 23.02.2017, 9f+50v; Monte del Pardo, Cuartel de Valpalomero to Desaguadero Alto, open holm oak woodland with rockroses, arkoses, 685 m asl, *C. Ruiz*, 23.02.2017, 1f. Aranjuez, Monte del Parnaso, matorral gipsófilo en claros de pinar de pino carrasco, gypsum soils, 30TVK 43, 565 m asl, *R. Laorga* (BV), 12.04.2015, 1f. Getafe, La Torreçilla, restored *Pinus halepensis*, loamy limestones, 30TVK 45, 650 m asl, [*S. Rodríguez, J.L. Pizarro* (for. ag.)], 26.04.2017, 7f+42v. Madrid-Vicálvaro, Almodóvar hill, grasslands, ruderal grasslands, loamy soils, 30TVK 47, 705 m asl, *L. Penelas*, undated, 2f; *ibidem*, *J. Prados* (BV), 30.03.2015, 2f; *ibidem*, *F. Molina* (BV) 1.04.2015, 2f; *ibidem*, *R. Baudet* (for. ag.), *J.M. Martínez Labarga*, 20.03.2016, 2f; *ibidem*, *I. Ramos, J.C. Moreno, J. Araújo* (for. ag.), *J. Grijalbo*, 22.03.2017, 4f. San Martín de la Vega, La Marañososa, fire restored *Pinus halepensis* grasslands, limestone, 30TVK 55, 645 m asl, *M. Núñez*, 12.04.2015; *ibidem*, *D. Meliá*, IV-2017, 2f. Rivas-Vaciamadrid, Campillo de San Isidro, halo-nitrofilous shrubland patches, 30TVK 56, 645 m asl, *R. de Pablo*, 22.04.2009, 1f; *ibidem*, *I. Ramos, J.C. Moreno, J. Araújo* (for. ag.), *R. de Pablo, E. Luengo, J.M. Martínez Labarga*, 30.03.2017, 2f; cliffs northern Campillo Little lake, halo-nitrofilous shrublands, high gypsum level, 550 m asl, *L. Herrero* (BV), 23.03.2014, 1f. Rivas-Vaciamadrid, close to 3M company, ruderal grassland aside restored *Pinus halepensis* stand, high gypsum level, 30TVK 57, 570 m asl, *E. Hernández* (BV), 24.03.2015, 1f; *ibidem*, *E. Hernández* (BV),

27.03.2017, 2f. San Fernando de Henares, El Caserío del Henares farm, close to Aldovea castle, open *Pinus pinea* stand, river sands, 560 m asl, *J.I. López Colón, L. García*, 13.04.2011, 1f. Valdelaguna, slopes to Morata stream, grassland-shrublands, gypsiferous loam, 30TVK 64, 700 m asl, *C. Palomo* (for. ag.), IV-2015, 1f; *ibidem*, *I. Ramos, J.C. Moreno, J. Araújo* (for. ag.), *J. Grijalbo*, 22.03.2017, 1f. Arganda del Rey, Carrascal de Arganda, to Cerro del Molino, slopes restored *Pinus halepensis* stand, loamy limestone, 30TVK 65, 720 m asl, *R. Herranz* (BV), 27.03.2015, 1f. Torrejón de Ardoz, close to USA Air force, ruderal grassland with *Ailanthus*, loamy, 30TVK 68, 615 m asl, *F. Molina*, IV-2016, 22f+21v; *ibidem*, *F. Molina*, III-2017, 5f+12v. Villamanrique de Tajo, gorge close to Alboer, halo-nitrofilous shrublands, high gypsum level, 30TVK 83, 555 m asl, *C. Palomo* (for. ag.), IV-2016, 1f; *ibidem*, *I. Ramos, J.C. Moreno*, [*C. Palomo, B. Paños, J. Araújo* (for. ag.)], *J.M. Martínez Labarga*, 30.03.2017, 1f. Orusco, unpaved road Las Merinas, *Q. coccifera* shrublands with restored *Pinus halepensis* stands, calizas, 30TVK 85, 795 m asl, *J.M. Martínez Labarga*, 29-VIII-2009, 1f; *ibidem*, *J.M. Martínez Labarga*, 29.04.2010, 2f; *ibidem*, *I. Ramos, J.C. Moreno*, [*J. Araújo, A. Pastor* (for. ag.)], *J.M. Martínez Labarga*, 30.03.2017, 17f+60v. Orusco, Orusco hill, restored *Pinus halepensis* stands, rosemary communities, *Q. coccifera* comm., limestones, red clays, 30TVK 86, 795 m asl, II-2012, 1f+2v; *ibidem*, *J.M. Martínez Labarga*, 27.04.2013, 10f; *ibidem*, *J.M. Martínez Labarga*, 19.04.2015, 36f; *ibidem*, *I. Ramos, J.C. Moreno*, [*J. Araújo, A. Pastor* (for. ag.)], *J.M. Martínez Labarga*, 30.03.2017, 67f+153v. Guadalix de la Sierra, close to Espinar chapel, calcicolous shrublands, limestones, 30TVL 41, 850 m asl, *L.H. Díaz Alonso*, 2016, 1f; *ibidem*, *A. Ortega* (for. ag.), 2016, 1f; *ibidem*, *J. Grijalbo*, 2016, 1f; *ibidem*, *I. Ramos, J.C. Moreno*, 23.03.2017, 1f.