TREE-RING RESEARCH, *Vol. 69(2), 2013, pp. 93–100*
DOI: http://dx.doi.org/10.3959/1536-1098-69.2.93

EDUCATION REPORT
DENDROCHRONOLOGY COURSE IN VALSAÍN FOREST, SEGOVIA, SPAIN

RAMZI TOUCHAN[1]*, DAVID M. MEKO[1], JUAN A. BALLESTEROS-CÁNOVAS[2], RAÚL SÁNCHEZ-SALGUERO[3], J. JULIO CAMARERO[4,6], DALILA KERCHOUCHE[5¶], ELENA MUNTAN[6¶], MADJDA KHABCHECHE[5¶], JUAN A. BLANCO[7¶], CLARA RODRIGUEZ MORATA[2†], VIRGINIA GARÓFANO-GÓMEZ[8†], LUIS A. MARTÍN[9†], RAQUEL ALFARO-SÁNCHEZ[10‡], KENZA GARAH[5‡], ANDREA HEVIA[11‡], JAIME MADRIGAL-GONZÁLEZ[12‡], ÁNGELA SÁNCHEZ-MIRANDA[13‡], TATIANA A. SHESTAKOVA[14‡], and **MARÍA TABAKOVA[15‡]**

[1]Laboratory of Tree-Ring Research, The University of Arizona, 1215 E. Lowell Street, Box 210045 Tucson, AZ, 85721, USA

[2]IGME, Instituto Geológico y Minero de España, C/Rios Rosas, 23, 28003 Madrid, Spain

[3]INIA-CIFOR. Ctra. de la Coruña km. 7.5, 28040 Madrid, Spain

[4]ARAID, Instituto Pirenaico de Ecología, CSIC, Avda. Montañana, 1005. 50192 Zaragoza, Spain

[5]University of Hadj-Lakhdar, Avenue Chahid Boukhlouf, 05000, Batna, Algeria

[6]Universidad de Barcelona, Diagonal Sud, Facultat de Biologia, Pl. 5[a] Diagonal 643, 08028 Barcelona, Spain

[7]Universidad Pública de Navarra, Campus de Arrosadía, s/n, 31006, Pamplona, Navarra, Spain

[8]Institut d'Investigació per a la Gestió Integrada de Zones Costaneres (IGIC), Universitat Politècnica de València, C/ Paranimf, 1, 46730 Grado de Gandia, Valencia, Spain

[9]AREVA. Carretera de Villalba-Madrid, 7 40109 La Pradera de Navalhorno, Segovia, Spain

[10]Escuela Técnica Superior de Ingenieros Agrónomos. Universidad de Castilla-La Mancha, Campus Universitario s/n. 02071 Albacete, Spain

[11]Wood and Forest Technology Research Centre (CETEMAS) Finca Experimental La Mata s/n, 33825 Grado, Asturias, Spain

[12]Depto. de Ecología, Facultad de Ciencias, Universidad de Alcalá. 28871 Alcalá de Henares, Madrid, Spain

[13]Research and Training Institute for Agriculture and Fisheries, Junta de Andalucía, Camino de Purchil s/n, 18004 Granada, Spain

[14]Dept. Crop and Forest Sciences AGROTECNIO Center, University of Lleida, Av. Rovira Roure 191, 25198 Lleida, Spain

[15]Institute of Economic, Management and Environmental Studies, Siberian Federal Institute, 79 Svobodny Prospect. 660041 Krasnoyarsk, Russia

ABSTRACT

This report describes an international summer course, "Tree Rings, Climate, Natural Resources, and Human Interaction", held in Valsaín, Spain, in summer of 2012. The course, with 14 participants from three countries (Spain, Algeria, and Russia), included basic training in dendrochronology skills as well as applied projects in dendroclimatology, dendroecology and dendrogeomorphology.

Keywords: dendroecology, dendroclimatology, dendrogeomorphology, tree rings, Scots pine, *Pinus sylvestris*.

INTRODUCTION

An international summer course, "Tree Rings, Climate, Natural Resources, and Human Interaction", was held from 13 August to 3

*Corresponding author: rtouchan@ltrr.arizona.edu
¶Dendroclimatology Group
†Dendrogeomorphology Group
‡Dendroecology Group

Figure 1. Photo of participants.

September 2012, in Valsaín, Spain. Main goals of the course were to sharpen the dendrochronology skills of the participants, stimulate ideas for future dendrochronological research, and foster collaboration amongst tree-ring researchers around the world. The course, hosted by the National Center for Environmental Education (CENEAM), included 14 participants from Spain, Russia and Algeria (Figure 1). This report describes activities of the course and briefly summarizes exploratory group projects.

Study Area

The study area is located in the Valsaín Forest, on the north-facing slopes of Sierra de Guadarrama, in central Spain (Figure 2). The forest is dominated by Scots pine (*Pinus sylvestris* L.). Secondary tree species include *Quercus pyrenaica* Willd., *Quercus ilex* L. subsp. *ballota* (Desf.) Samp., and *Pinus nigra* Arn. The Valsaín Forest has been sustainably managed since 1888 (CENEAM 2004). Annual rainfall is about 1266 mm, and mean annual temperature is 6.5°C (Spanish National Meteorological Agency, AEMET 2012). The geological substrates are mainly granite and gneiss. Soils are relatively homogeneous, usually acid and predominantly humic cambisol, with leptosol at higher-elevation sites.

Data accessed for use in the course included monthly station climate data (precipitation and mean temperature) for Puerto de Navacerrada (40°47′N, 4°00′W, 1894 m a.s.l.) located at *ca.* 2 km from the study sites, and 0.5° gridded climate CRU TS 3.0 data (Mitchell and Jones 2005). In addition, the course had access to various web-based tools for climatological analysis, and to historical and documentary records of environ-

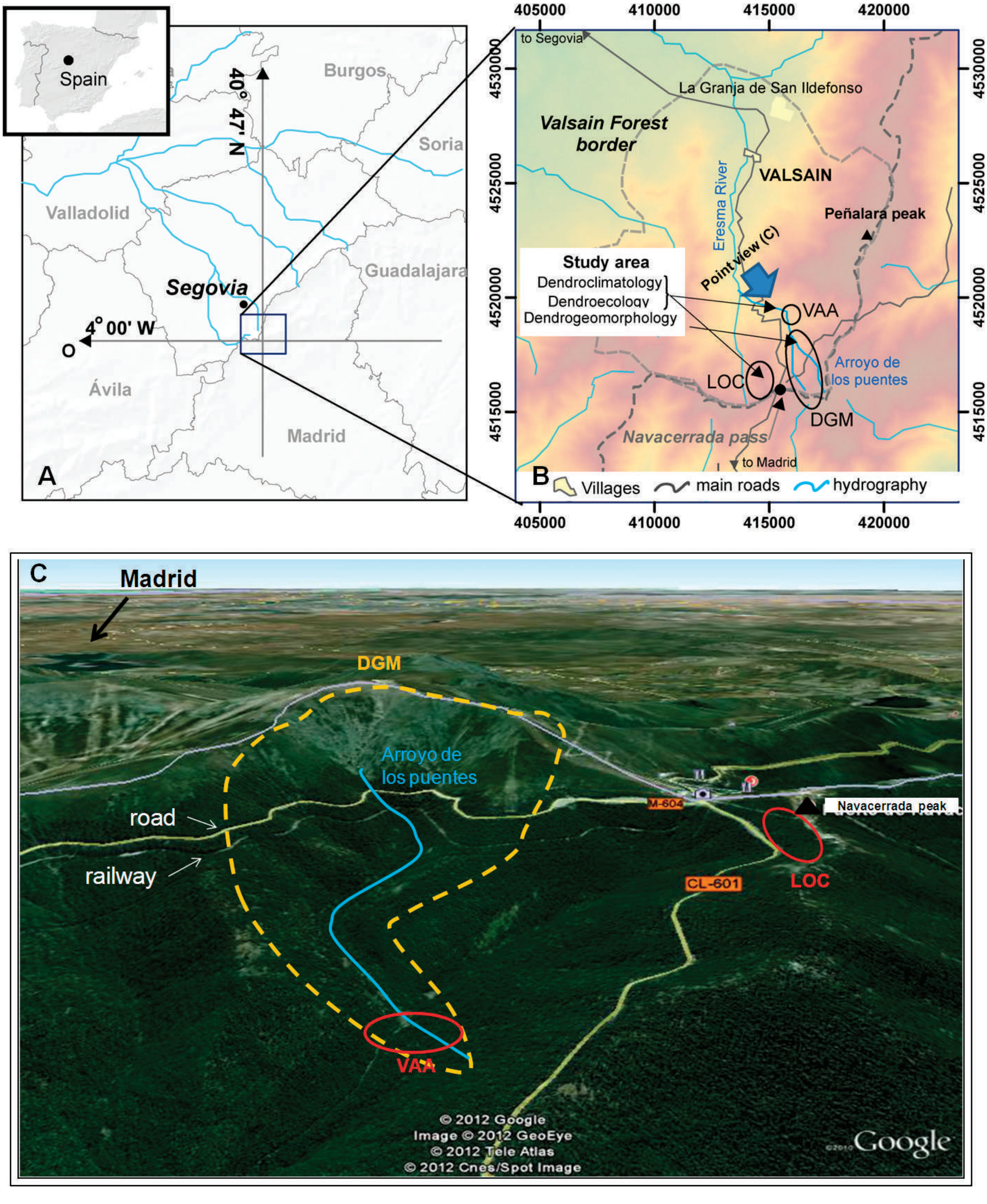

Figure 2. (A) Location of the Valsaín study area in Central Spain (Segovia province), (B) Study area and sites of group projects in Valsaín Forest, (C) 3-D view of sampled sites.

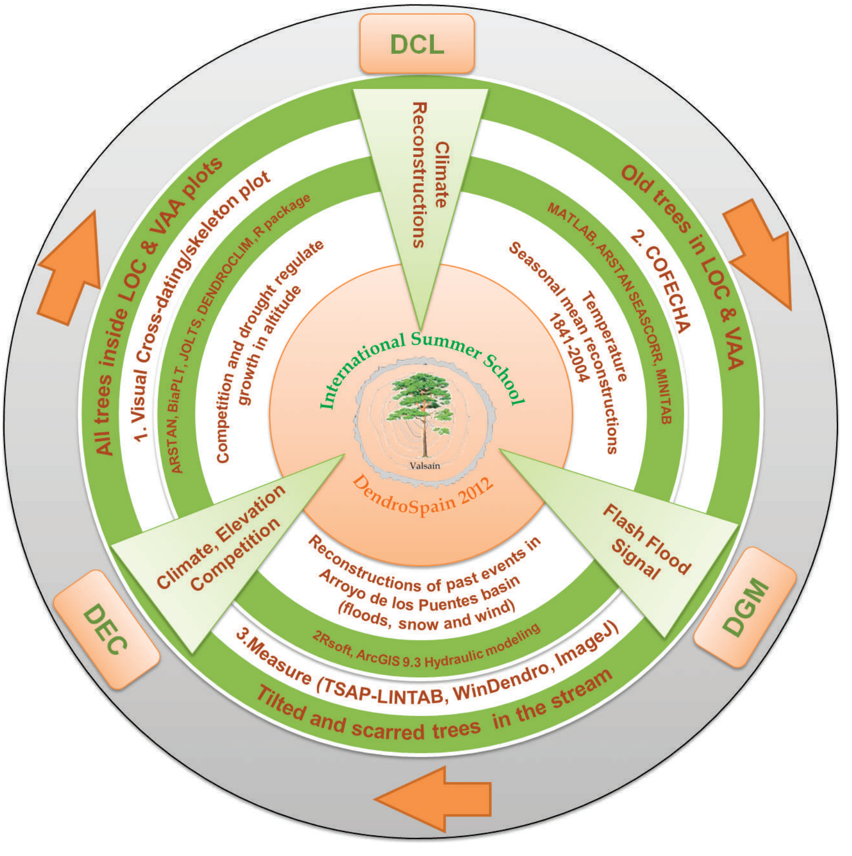

Figure 3. Learning Diagram in Valsaín forest course.

mental change archived in the CENEAM library in Valsaín.

Group projects, described later, focused on three locations in the Valsaín Forest: a high-elevation (1864 m a.s.l.) site, referred to as Los Cogorros (LOC); a lower-elevation (1534 m a.s.l.), referred to as Vaquerizas Altas (VAA); and upper and lower reaches of the flood-influenced area of Arroyo de los Puentes, a tributary of the Eresma River. The flash-flood signal was of particular interest in the course because Arroyo de los Puentes is not gauged and crosses a railway as well as recreational infrastructure (*e.g.* roads and trails).

Course Structure

The course included field trips, laboratory sessions, lectures by the instructors, guest lectures by invited Spanish researchers, short talks by the participants, and class projects. An initial field trip generated discussion of possible project sites and topics. Participants and instructors jointly decided on three disciplines: dendroclimatology (DCL), dendroecology (DEC), and dendrogeomorphology (DGM), and each participant joined the group of greatest interest. On subsequent field trips, participants received training in fundamentals of sampling techniques, equipment maintenance, and site selection geared to specific objectives (Figure 3).

Introductory lectures and laboratory exercises covered the fundamentals of sample preparation, crossdating by skeleton-plots, and tree-ring measurement (Stokes and Smiley 1968). Later lectures and laboratory exercises dealt with computer-assisted quality-control of dating and measurement with COFECHA (Holmes 1983), development of site chronologies with ARSTAN

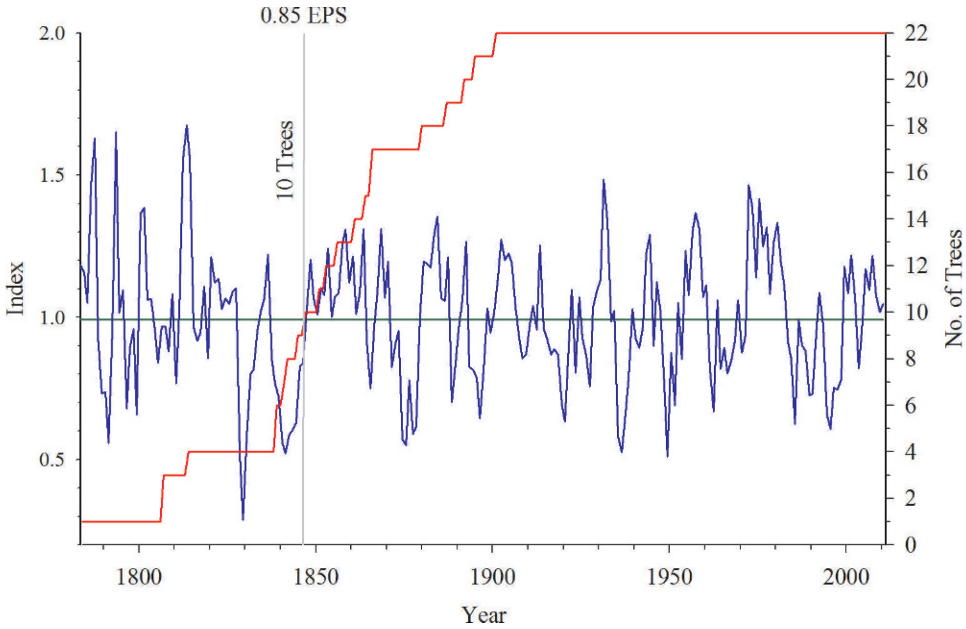

Figure 4. Standard tree-ring chronology and sample depth for Los Cogorros site. Time coverage A.D. 1784–2011. Adequacy of sample replication was judged by the expressed population statistic (EPS), computed from pooled interseries correlations and the time-varying sample size (Wigley *et al.* 1984). We limited our analysis to the period with an EPS of at least 0.85, which was reached in 1847.

(Cook and Holmes 1999, Cook and Krusic 2005), and investigation of seasonal climate signals in tree rings with programs SEASCORR (Meko *et al.* 2011) and Dendroclim2002 (Biondi and Waikul 2004). Other techniques and software were introduced in the context of the group projects (see below). Depending on the group (DCL, DEC, or DGM), participants had access to one or more of the following tree-ring measurement systems: (i) a binocular microscope and moving stage with TSAP-Win Professional 4.63 (Rinntech 2012), (ii) scanning of high-resolution images with the free software ImageJ (http://rsb.info.nih.gov/ij/docs/guide/index.html), and (iii) scanning with application software WinDendro™ (Regent Instruments 2012).

The course ended with a formal presentation of group project findings at CENEAM to an audience that included CENEAM officials and forest managers and researchers (Figure 3). Officials of CENEAM requested that the presentation be translated into Spanish for use by CENEAM in outreach, and suggested that follow-up studies be pursued in the Valsaín Forest.

GROUP PROJECTS

DCL Group

The main goal of the DCL group was to explore the potential of *P. sylvestris* in the Valsaín Forest for dendroclimatic reconstruction (Figure 2 and 3). Core samples were collected from LOC (25 trees) and VAA (16 trees), and were developed into ring-width site chronologies (Figure 4) significantly correlated ($r = 0.48$, $n = 228$, $p \leq 0.001$) with one another over their common period. Analysis of the better-replicated and least problematic of these chronologies (LOC, residual version) with program SEASCORR and the Navacerrada climate data, 1945–2004, revealed that the chronology has a weak and complicated seasonal climate signal, *i.e.* growth is generally negatively correlated with summer temperature in the year prior to the year of tree growth and positively correlated with current summer precipitation. Temperature/tree-ring correlations for the 24 months leading up to September of the growth year vary in sign, but the integrated signal (averaged over months) is generally negative, with the highest correlation for the 12-month grouping found in Jan–Dec of the previous year. Accordingly, annual average maximum temperature (T) was selected as a reconstruction target, and the DCL group proceeded to use Minitab software (http://www.minitab.com/en-US/products/) to generate a T reconstruction for the period 1841–2004 (Figure 4).

Despite the great uncertainty in reconstructed T (regression $R^2 = 0.22$), some reconstructed features were found to be consistent with documentary records of unusually cold or hot years. Composite maps of 500-mb geopotential height anomalies from the National Centers for Environmental Prediction-National Center for Atmospheric Research Reanalysis Project (Kalnay *et al.* 1996) were examined to identify circulation features associated with cold or hot years in the Valsaín Forest. This analysis, keyed to the observed T record, showed that cold years tend to be linked with a strong upper, low-pressure over the Pyrenees, and hot years with large blocking highs over Europe.

DEC Group

The DEC group explored hypotheses about the combined effects of climate, elevation, and competition on the growth response of *P. sylvestris* (Figure 2 and 3). The field strategy consisted of core sampling from two randomly selected square plots (40 m × 40 m), one at LOC and the other at VAA (upper and lower elevations). All trees with diameter at height 1.3 m (dbh) greater than 20 cm in these plots were tagged, measured, mapped, and cored. A total of 76 and 83 trees were sampled at LOC and VAA, respectively. Linear Mixed-effects Models (LMM) were used to explore the dependence of growth, defined as log-transformed basal-area increment (BAI), on climate, elevation, and a distance-dependent competition index (Linares *et al.* 2010). Statistical analyses were carried out using the application software in the R statistical package (http://r-development-core-team.software.informer.com/). The group found that, as expected, BAI decreases with increasing competition, and that a recent climate trend toward warmer and drier conditions has had a negative impact on growth, particularly at the drier, low-elevation site (Figure 2).

DGM Group

The DGM group focused on the flash-flood signal in *P. sylvestris* trees growing on flood deposits and within the stream channel of Arroyo de los Puentes (Figure 2). Twenty "Damaged" trees in the upper reaches of the stream and 28 in the lower reaches, identified in the field by presence of scars, tilting, lost apical leaders or exposed roots in the stream banks, were core-sampled. After preparation and crossdating, the samples were examined for diagnostic features of flash floods (Ballesteros *et al.* 2010). The group found that 36% of the samples had abrupt growth changes related to apical damage (*i.e.* growth decrease) and competition elimination (*i.e.* growth release), 30% of the samples had reaction wood caused by tilting, and 30% had scars associated with local injuries. A few samples (4%) had internal callus tissue associated with earlier stem damage. Comparison of reconstructed event histories, estimated from tree rings, with historical information (Breñosa and Castellarnau 1884; Vías 2001; Díez Herrero *et al.* 2008; AEMET 2012) offered corroboration for some events. Corroborated events in earlier centuries included Eresma River floods of 1767 and 1798. More recently the year 1996, notable for flooding and heavy snowstorms, emerged as the single year with the highest number of synchronous flash-flood, tree-ring features (7), evidence of which was found in both the upper and lower stream reaches.

CONCLUSION

This course follows in the footsteps of existing dendrochronology short courses (*e.g.* Brown and Krusic 1995; Speer *et al.* 2006), but the longer time span (three weeks) provides an opportunity for more in-depth analysis. The course is unique in taking the methods to areas and countries in which the basic data may present challenges and results may be unexpected.

The course demonstrates the great potential of tree-ring data from *P. sylvestris* for studying various aspects of the climate, ecology, and dendrogeomorphology in the Valsaín Forest (Figure 3). Although the climate signal in ring widths of the sampled trees is weak, and for many trees likely distorted by effects of management, stronger climate reconstructions may be possible through the use of other trees in relatively undisturbed settings, and chronology extension may be possible with tree rings from remnant wood. Future dendroclimatology work should also exploit the climate signal in variables other than total ring width, *e.g.* stable isotopes or maximum latewood density. From an ecological point of view, results suggest that the growth of *P. sylvestris* in Valsaín Forest is particularly sensitive to spring-summer water availability, and that the influence of temperature is especially dependent on elevation. Future dendroecological studies should address how the detected growth changes are associated with regional warming in the study area, and should explore in more detail how the growth response is modulated by environmental factors other than those studied in the course project (*e.g.* rising atmospheric CO_2 concentration). Extending analysis to these aspects would allow forecasting the performance of drought-prone tree populations located near their species boundary, as with Scots pine in the Valsaín forest. The dendrogeomorphology findings are extremely positive in identifying settings in the Valsaín Forest with an abundance of flood-damaged trees. Our limited study barely taps the potential for flash-flood reconstruction from this resource, and stresses the need to take more samples in order to isolate the correct geomorphic signal.

ACKNOWLEDGMENTS

This International Summer School was carried out in collaboration with the Laboratory of Tree-Ring Research, University of Arizona, from the United States, and IGME (Instituto Geológico y Minero de España), IPE-CSIC (Instituto Pirenaico de Ecología - Consejo Superior de Investigaciones Científicas), ARAID foundation, INIA-CIFOR (Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria-Centro de Investigación Forestal) and University of Córdoba, from Spain. The organizers sincerely thank the CENEAM (National Center for Environmental Education), Montes de Valsaín and OAPN (Organismo Autónomo de Parques Nacionales) from the Ministerio de Agricultura, Alimentación, y Medio Ambiente in Spain for the support and facilities to organize this course. We thank Drs. Rafael Herrera, Mar Génova and Guillermo Gea-Izquierdo for their contributions in the course. We thank AEET (Asociación Española de Ecología Terrestre) from Spain for generous grants provided to students. We thank the course sponsors: Tree-Ring Society, National Science Foundation-USA (Grant AGS-Paleo Perspectives on Climate Change Program 1103314), Regents Instruments, Beta Analytic, and Cox Analytical Systems.

REFERENCES CITED

AEMET, 2012. Agencia Estatal de Meteorología. Ministerio de Agricultura, Alimentación y Medio Ambiente. Gobierno de España.

Ballesteros, J. A., M. Stoffel, J. M. Bodoque, M. Bollschweiler, O. Hitz, and A. Díez-Herrero, 2010. Changes in wood anatomy in tree rings of *Pinus pinaster* Ait. following wounding by flash floods. *Tree-Ring Research* 66(2):93–103.

Biondi, F., and K. Waikul, 2004. DENDROCLIM2002: A C++ program for statistical calibration of climate signals in tree-ring chronologies. *Computers & Geosciences* 30:303–311.

Breñosa, R., and J. M. Castellarnau, 1884. Guía y descripción del Real Sitio de San Ildefonso. Sucesores de Rivadeneyra, Madrid (Edición facsímil de 1991 en Editorial Ícaro, La Granja).

Brown, P. M., and P. J. Krusic, 1995. The Annual North American Dendroecological Fieldweek: A workweek in applied tree-ring research. In: *Interior West Global Change Workshop* (April 25–27, 1995, Fort Collins, CO), edited by R. W. Tinus, pp. 75–77. USDA Forest Service General Technical Report RM-GTR-262.

CENEAM, 2004. Guía de visita. Los Montes y el valle de Valsaín. Miniesterio de Medio Ambiente, Madrid; 263 pp.

Cook, E. R., and R. L. Holmes, 1999. *Program ARSTAN - chronology development with statistical analysis (user's manual for program ARSTAN)*. Laboratory of Tree-Ring Research, University of Arizona, 18 pp.

Cook, E. R., and P. J. Krusic, 2005. *ARSTAN v. 41d: A Tree-ring Standardization Program Based on Detrending and Autoregressive Time Series Modeling, with Interactive Graphics*. Tree-Ring Laboratory, Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York, U.S.A (http://www.ldeo.columbia.edu/tree-ring-laboratory/resources/software).

Díez Herrero, A., L. Laín Huerta, J. F. Martín-Duque, and F. Vicente Rodado, 2008. A todo riesgo II. Convivir con los desastres geológicos cotidianos. Guión de la excursión científico-didáctica de la Semana de la Ciencia 2008. IGME, UCM e IE Universidad, Madrid-Segovia; 42 pp.

Holmes, R. L., 1983. Computer-assisted quality control in tree-ring dating and measurement. *Tree-Ring Bulletin* 43:68–78.

Kalnay, E., M. R. Kanamitsu, W. Kistler, D. Collins, L. Deaven, M. Gandin, S. Iredell, G. Saha, J. White, Y. Woollen, M. Zhu, W. Chelliah, W. Ebisuzaki, J. Higgins, K. C. Janowiak, C. Mo, J. Ropelewski, A. Wang, R. Leetmaa, R. J. Reynolds, and J. Dennis, 1996. The NCEP/NCAR 40-Year Reanalysis Project. *Bulletin of the American Meteorological Society* 77(3):437–471.

Linares, J. C., J. J. Camarero, and J. A. Carreira, 2010. Competition modulates the adaptation capacity of forests to climatic stress: Insights from recent growth decline and death in relict stands of the Mediterranean fir *Abies pinsapo*. *Journal of Ecology* 98:592–603.

Meko, D. M., R. Touchan, and K. J. Anchukaitis, 2011. Seascorr: a MATLAB program for identifying the seasonal climate signal in an annual tree-ring time series. *Computers & Geosciences* 37:1234–1241.

Mitchell, T., and P. Jones, 2005. An improved method of constructing a database of monthly climate observations and associated high-resolution grids. *International Journal of Climatology* 25:693–712.

Regent Instruments, 2012. *WinDendro. An Image Analysis System for Tree-Rings* Analysis. http://www.regent.qc.ca/products/dendro/DENDRO.html.

Rinntech, 2008. *LINTAB. Precision Ring by Ring*. http://www.rinntech.com/Products/Lintab.htm.

Speer, J. H., P. B. Brown, P. Krusic, and H. Grissino-Mayer, 2006. Professional fieldweeks as an educational experience and a venue for explorative research: Case study of the North American Dendroecological Fieldweek. In: *Experiential learning and exploratory research: The 13th Annual North American Dendroecological Fieldweek (NADEF)*, edited by J. H. Speer. Indiana State University, Department of Geography, Geology, and Anthropology, *Professional Paper Series* No. 23:3–14.

Stokes, M. A., and T. L. Smiley, 1968. *An Introduction to Tree-Ring Dating*. University of Arizona Press, Tucson.

Vías, J., 2001. Memorias del Guadarrama. La Librería, Madrid; 320 pp.

Wigley, T., K. Briffa, and P. Jones, 1984. On the average value of correlated time series, with applications in dendroclimatology and hydrometeorology. *Journal of Climate and Applied Meteorology* 23:201–213.

Received 14 December 2012; accepted 5 May 2013.