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Extended Abstract

REsource INFrastructure for monitoring and adapting European Atlantic FORests under Changing climatE (REINFFORCE): Establishing a network of arboretums and demonstration sites to assess damages caused by biotic and abiotic factors

Cristina Prieto-Recio*, Felipe Bravo and Julio J. Diez

Sustainable Forest Management Research Institute, University of Valladolid- INIA, Avda. Madrid 44, 34004, Palencia, Spain.

*Corresponding author. E-mail: cristina.prieto@pvs.uva.es.

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The reality of global warming is recognized worldwide, and most of the climatic models in the optimistic scenarios of IPCC forecast a 4°C temperature rise over the next 50 years. Nevertheless, the regional consequences are still fuzzy, especially in the case of ocean areas because there are many unknown factors like the climatic, economic and environmental conditions at regional level. However, some specific threats are appearing such as, disturbances in the life cycle of tree species, the introduction of new pathogens, or the mis-adaptation of tree species to new climatic conditions. So the potential climate change impacts on tree diseases could affect many aspects like population and community structure, micro-evolutionary processes and plants dynamics (Chakraborty et al., 2000). European Union Project (INTERREG IVB) REINFFORCE offers the opportunity to install a network of arboretums and demonstration sites unique in the world, located between latitudes 37° and 58° for monitoring the adaptation of European Atlantic forests to climate change through the study of the tree growth, its phenology and the forest health (Figure 1). The participants belong to eleven institutions from United Kingdom, France, Spain and Portugal. This is a key issue for sustainability of Atlantic forest resources, as the trees that are now being planted, will be harvested in 50 years facing new climatic conditions.

The goals of the REINFFORCE project were: i) to establish protocols for the installation of infrastructures and data collection; ii) to perform the technical and administrative evaluation of the work; iii) to create a network of 37 arboretums to anticipate the effects of climate change; iv) to implement a network of 32 demonstration sites to compare usual silviculture with other adaptative measures; and v) to develop databases to share online.

To achieve these objectives, The University of Valladolid is responsible to create, manage and explore; two arboretums and two demonstration sites located in Cantabria and three arboretums and two demonstration sites located in Castilla y León (Figure 2). Thirty one tree species with 3 to 9 provenances of each species are going to be tested in these arboretums (Table 1). One block of 12 seedlings per provenance will be planted in homogeneous plots. Each arboretum will be divided into conifers (species of the genus *Pinus* and other conifers) and broadleaves (*Quercus* species and other hardwoods). In each section, the seedlings will be distributed randomly in framework 3 m × 3 m, according to the parameters of growth and tolerance.

One important point of the study is the susceptibility to biotic and abiotic hazards. This issue depends on individual tree attributes which in turn depends on stand composition, site preparation and silvicultural treatments (Jactel et al., 2009). Hence, these arboretums will be planted following a homogeneous site preparation and concrete distribution of the species. Also, the common protocols will be developed to measure growth parameters, to study plant phenology, and to assess biotic and abiotic damages at different levels. Particularly, the health common protocol will be developed at tree level and at leaf or shoot level (Table 2).

On the other hand, the demonstration sites are mixed plantations based on Nelder Wheels (Nelder, 1962) following the type "a" scheme (Figure 3) designed to evaluate the influence of the density on the mortality, the size, the pathogenic damages and the biomass allocation of each plant. The data analysis will be performed using logistic regression and spatial analysis. In each demonstration site two tree species or clones associated with the different diseases will be tested (Table 3) varying the degree of composition of both species and using systematic designs in concentric circles with different grid of plant positions.

Nowadays, these infrastructures and protocols are in process of creation and development. In the near future these arboretums and demonstration sites will offer a large data collection for monitor and adapt the European Atlantic forests to climate change.

Key words: Climate change, arboretums, demonstration sites, pathogens, silviculture.

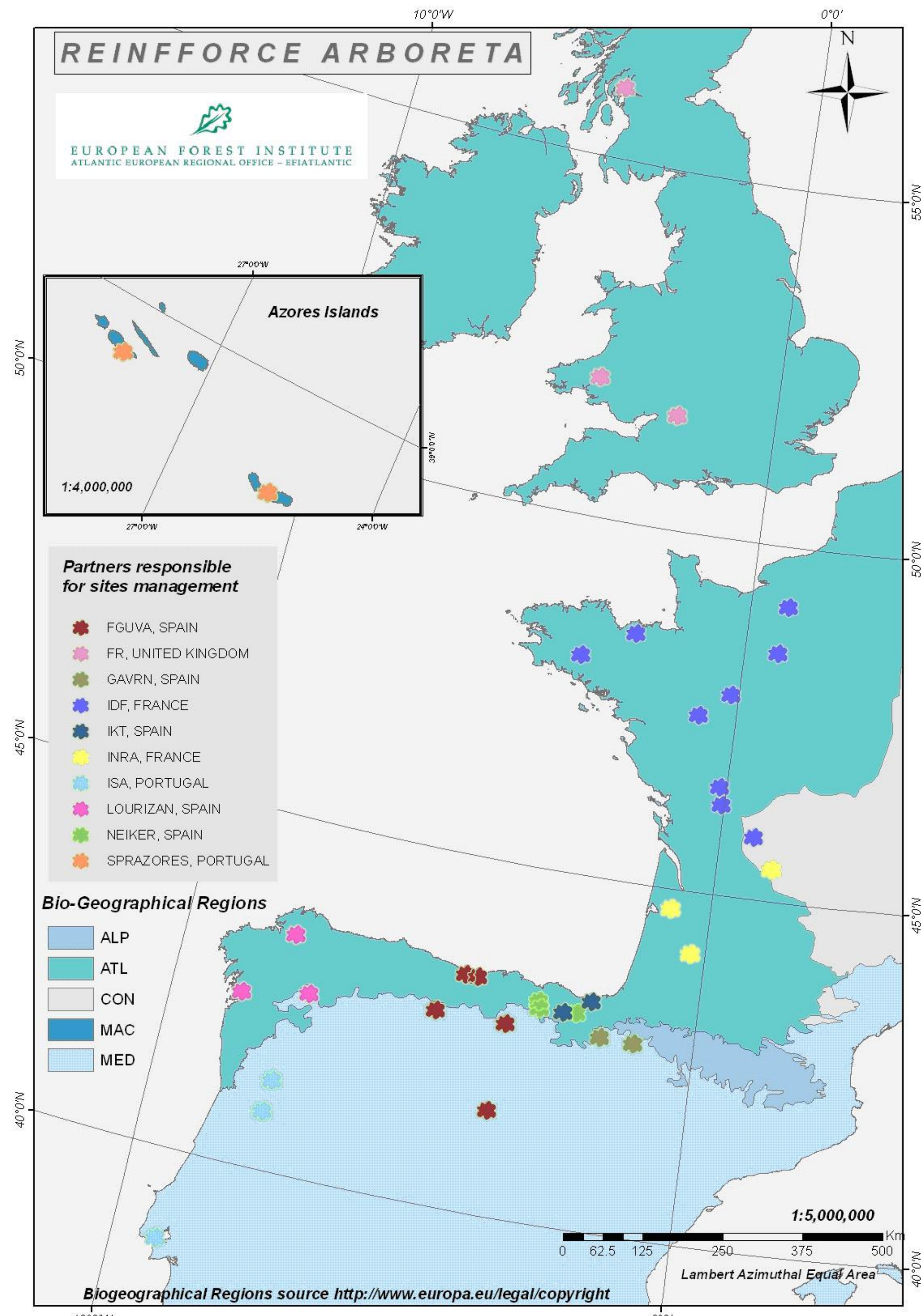

Figure 1. Distribution Map of the Arboretums (Biogeographical Regions of Europe).

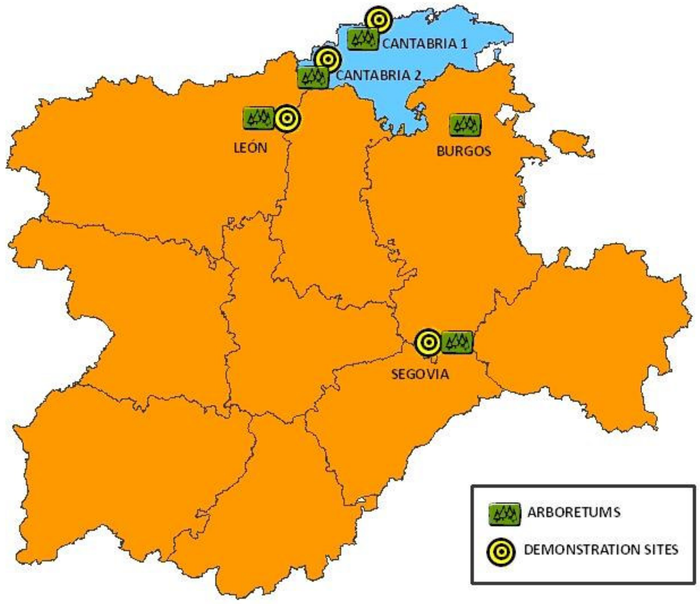

Figure 2. Distribution Map of the Arboretums and Demonstration Sites in Cantabria and Castilla y León.

Table 1. List of common species of the Arboretums.

S/N	Specie of Arboretums
1	*Acer pseudoplatanus*
2	*Betula pendula*
3	*Calocedrus decurrens*
4	*Castanea sativa*
5	*Cedrus atlantica*
6	*Cedrus libani*
7	*Ceratonia siliqua*
8	*Cunninghamia lanceolata*
9	*Cupressus sempervirens*
10	*Eucalyptus sp.*
11	*Fagus orientalis*
12	*Larix decidua*
13	*Liquidambar styraciflua*
14	*Pinus brutia*
15	*Pinus elliottii*
16	*Pinus nigra*
17	*Pinus peuce*
18	*Pinus pinaster*
19	*Pinus pinea*
20	*Pinus ponderosa*
21	*Pinus sylvestris*
22	*Pinus taeda*
23	*Pseudotsuga menziesii*
24	*Quercus rotundifolia*
25	*Quercus petraea*
26	*Quercus robur*
27	*Quercus rubra and Quercus phellos*
28	*Quercus suber*
29	*Robinia pseudoacacia*
30	*Sequoia sempervirens*
31	*Thuja plicata*

Table 2. Forest health protocol.

Biotic and abiotic damage assessment		
Tree level	Tree branch mortality	Record tree mortality and send dead trees to lab for diagnosis
	Crown conditions	Defoliation 0 (no) / 1-10% (low) / 11-50% (moderate) / > 50% (high)
		Discoloration (yellow, red, brown) 0 / 1-10% / 11-50% / > 50%, 100%
Leaf / shoot level	Damage types	Forest hervivore (Chewers / Gall makers / Leaf-miners / Skeletonisers / Leaf-rollers and tiers / Sap feeders / Shoot deformation / Stem / bark borers / Mammal grazer)
		Forest disese (Rust / Mildew / Leaf Necrosis / Red Bands / Canker / Stem - shoot Necrosis)
		Abiotic (Drought / Frost / Wind)

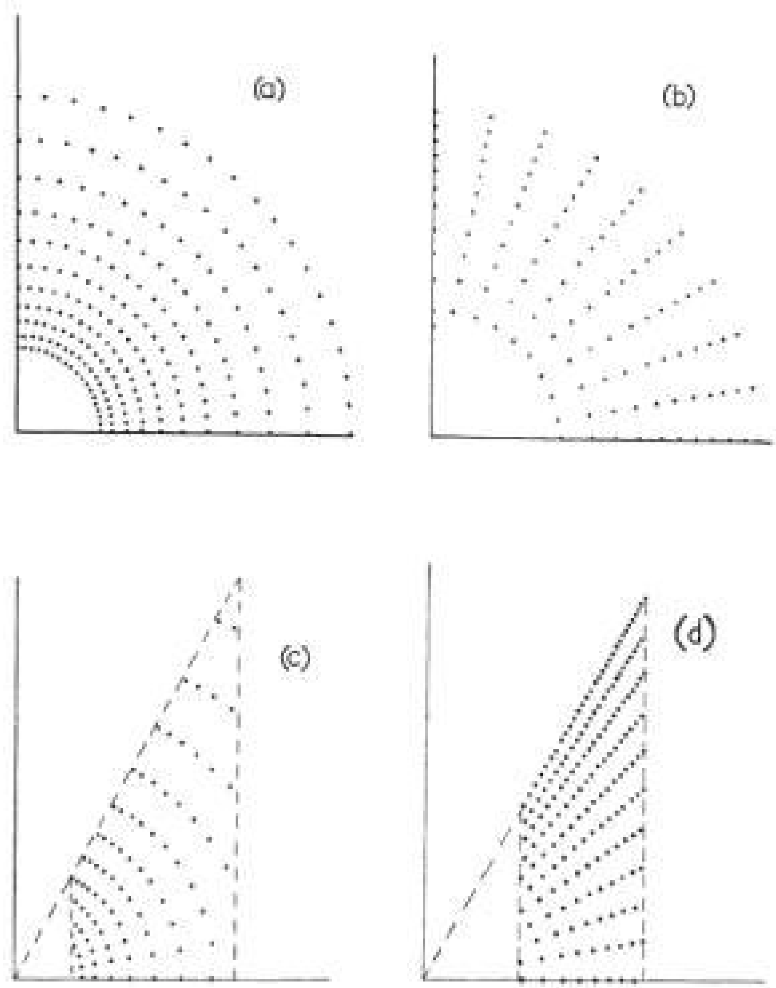

Figure 3. The Nelder Systematic Designs (Nelder, 1962).

Table 3. List of species of the demonstration sites.

Site	Specie 1	Specie 2	Disease
CANTABRIA 1	*Eucalyptus nitens I*	*E. nitens II (Resistant code to Mycosphaerella* sp.*)*	Area affected by *Mycosphaerella* sp.
CANTABRIA 2	*Pinus radiata*	*Pinus sylvestris*	Area affected by *Fusarium circinatum*
LEÓN	*Pinus sylvestris*	*Quercus pyrenaica*	Study of possible pathogens asociated
SEGOVIA	*Pinus pinaster*	*Quercus ilex*	Area affected by *Pinus pinaster* decline

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