

1 **Large-scale reforestation and afforestation policy in Spain: a historical review of its**  
2 **underlying ecological, socioeconomic and political dynamics**

3

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16 **Abstract**

17 Spain had not more than six million hectares of woodlands in the mid-19<sup>th</sup> century.  
18 Nowadays woodlands cover more than sixteen million hectares. During the last one hundred  
19 and fifty years, much effort was devoted to improving forest cover and, as a result, five  
20 million hectares were artificially regenerated, which represents ten percent of the whole  
21 country area. All this work required large nursery infrastructures, thousands of workers and  
22 high public investments. The outcome of these reforestation and afforestation efforts is  
23 nowadays obvious throughout the Spanish landscapes, and sometimes has given rise to  
24 controversy between supporters and opponents. Nevertheless, the process that led to the vast  
25 reforestation of Spain has not been yet studied in depth from a historical perspective. This  
26 study aims at reconstructing that historical process, by describing it through several features  
27 that help to understand the historical development of the artificial forest regeneration policy  
28 in Spain, together with its social, political and economic context. The study period  
29 comprises since 1879 to present, with special focus on the recent history, that is, since the  
30 mid-20<sup>th</sup> century. The lessons learnt from this analysis may contribute to improving the  
31 design of large-scale reforestation policies as well as their potential impacts in other parts of  
32 the world and, in the end, shed light on the debate about the possible solutions to  
33 deforestation and forest degradation.

34

35 **Keywords:** afforestation, plantation, forest restoration, land-use policy, rural development

## 36 **1. Introduction**

37 In the mid-19<sup>th</sup> century, Spanish woodlands covered approximately six millions hectares  
38 (i.e., 12.5% of the national territory) (Armenteras, 1903). The causes of deforestation in  
39 Spain were similar to those of most developing countries at the time (Allen and Barnes,  
40 1985; Kaplan et al., 2009): forest clearing in order to meet the demands of the growing  
41 population, extensive grazing, timber supply for the shipbuilding industry, mining or  
42 metallurgical activities, as well as successive wars and fires. Bauer (1980) mentioned two  
43 additional causes of deforestation specific to Spain: the seizures and the inappropriate  
44 distribution of the forest ownership.

45 Indeed, from 1766 to 1924, successive seizures that affected 19.9 million hectares (Rueda,  
46 1997) provoked an increase in the deforestation and forest degradation rates. Such seizure  
47 processes consisted in the nationalization by the State of properties owned by certain  
48 institutions (i.e., Church and religious orders, nobility and municipalities) in order to sell  
49 them to private owners. Its primary purpose was tax collection, although it also aimed at  
50 promoting changes in the ownership structure of agricultural land (i.e., land reform).

51 The impact of such process on the drastic reduction of the national forest area varies  
52 according to different authors, ranging from four to seven million hectares, that is, from  
53 sixteen to twenty eight percent of the total forest area of Spain at that time (Aranda, 1999;  
54 GEHR, 1994). According to López Estudillo (1992), ploughing, ground division, as well as  
55 sales and seizures affecting the Monarchy and municipalities, were important at the end of  
56 the 18<sup>th</sup> century and during the first half of the 19<sup>th</sup> century. In consequence, the existing  
57 public rural land experienced a sharp decrease after the beginning of the seizure process in  
58 1855. A significant loss of forest cover was also due to forest fires and illegal logging in  
59 public forests which, in combination with the strong ploughing pressure, entailed a

60 reduction in forest area from 29 million hectares in 1860 to 24.5 million hectares in 1926  
61 (Sanz, 1986).

62 As a consequence of the degradation of the vegetation cover, successive floods occurred in  
63 different parts of Spain, as for instance the cases of Júcar River (1864), where the estimated  
64 losses were seventeen million pesetas (60 million constant €<sub>2006</sub>); Jiloca River in Daroca  
65 (1854, 1865 and 1877); Francolí River in Tarragona (1874), Murcia (1877, 1879 and 1884);  
66 Almería (1879) and Lérida (1907) (Cuesta, 1919; Villanueva, 1924). On the other hand,  
67 wood production in Spain was not enough to meet the demands of the national industry.

68 Deforestation was regarded as a major public concern at the time. In view of the gravity of  
69 forest deforestation and degradation, it was necessary to urgently undertake large-scale  
70 reforestations in order to mitigate the great impact of erosion and flooding processes on  
71 people livelihoods, as well as to meet the demand of the national market in terms of wood  
72 supply. According to Armenteras (1903), 10 to 16 million hectares of forest were required to  
73 improve this situation. The national reforestation plans of 1933 and 1938 estimated that 5 to  
74 6 million hectares should be reforested in 100 years in order to achieve the objectives in  
75 terms of forest regeneration and timber production (Ximénez de Embún i Oseñalde and  
76 Ceballos, 1939). The national reforestation plan of 1938 constituted the main framework for  
77 the reforestations conducted between 1940 and 1984. Timber production-oriented and  
78 conservation-oriented reforestations represented, respectively, 36% and 64% of the overall  
79 reforestations. The reforestations for timber production aimed at responding to an increasing  
80 wood demand of 5 million cubic meters per year. Despite constituting the main planning  
81 framework, in reality the implementation of reforestations hardly followed the 1938 plan  
82 since the availability of funds was highly variable depending on the overall economic  
83 situation of a given year, and the availability of land for reforestation purposes (Casado,  
84 1950; FAO Secretariado, 1958).

85 At the time, such a large-scale reforestation effort was rather unique in the world (Traugott,  
86 1964), which was internationally acknowledged by appointing Spain as the host country of  
87 the 6<sup>th</sup> World Forestry Congress held in Madrid in 1966. Although almost 150 years of  
88 large-scale reforestation has contributed to some of the most relevant changes in the Spanish  
89 landscapes during the modern times, so far, its underlying ecological, socioeconomic and  
90 political dynamics have not been the object of a comprehensive analysis.

91 The aim of this study is to shed light on the large-scale reforestation and afforestation  
92 process undertaken in Spain from the end of the 19<sup>th</sup> century to present by filling the gaps in  
93 knowledge concerning the following features: i) the reasons behind the need for  
94 reforestation in Spain; ii) the evolution reforestation and afforestation since the mid-19<sup>th</sup>  
95 century; iii) the legislation and administrative units set to carry out this activity; iv) the  
96 investment in reforestation/afforestation projects at the national level; v) the tree species  
97 used; vi) the necessary technical infrastructures and technology utilized; and vii) the impact  
98 of large-scale reforestation and afforestation on the structure of the forest ownership. In this  
99 study we use the term “reforestation” to refer to the artificial reestablishment of forest cover  
100 in a deforested land which was previously a forest, and the term “afforestation” to refer to  
101 the artificial establishment of forest cover in an area where the preceding vegetation or land  
102 use was not forest (Helms, 1998).

103

## 104 **2. Materials and methods**

105 In order to properly understand the reforestation pace in different periods, it is necessary to  
106 take into account the political context, the evolution of governmental administrative  
107 structures as well as the changes in the legislation along the entire historical period  
108 considered in this study (Arts and Buizer, 2009; Ayana et al., 2013). Previous research has  
109 divided the historical development of large-scale reforestations in Spain into different

110 episodes (Gómez de Mendoza and Mata, 2002; Navarro-Garnica, 1977). In this study we  
111 have divided this historical process into the following three stages: i) since the origin of  
112 forestry knowledge in Spain until the end of the Spanish Civil War (1877 – 1939), when the  
113 first reforestations were conducted; ii) the period corresponding to Franco’s dictatorship  
114 until the new democratic administrative organization (1940 – 1984), when large-scale  
115 reforestation was conducted by the public administration; iii) the current democratic period  
116 (1984 to present), when reforestation conducted by the public administration was reduced  
117 after the decentralization of forestry competences to the Autonomous Communities, and  
118 when private afforestation of agricultural land partly boosted as a consequence of the EU  
119 policies.

120 Thirteen variables were analysed: i) annual reforested area by the private property and by  
121 the Government between 1879 and 2006; ii) replanted area by the Government due to  
122 seedling failure between 1946 and 2006; iii) total reforested area by tree species from 1940  
123 to 2006; iv) the area to be reforested and afforested according to alternative policy  
124 instruments; v) production of coniferous and broadleaf plants between 1940 and 2006; vi)  
125 production of coniferous and broadleaf seedlings between 1940 and 2006; vii) annual seed  
126 consumption from 1943 to 1987; viii) budget of administration units between 1896 and  
127 1984; ix) investment in field implementation of reforestation projects between 1896 and  
128 1984; x) sowing and planting costs per hectare; xi) plant production in the year ‘n’ in  
129 relation to the reforested area in the year ‘n+1’ in order to estimate the maximum planting  
130 density or plant consumption per reforested hectare; xii) investment in reforestation works in  
131 relation to the total governmental budget; and xiii) number of daily wages, calculated from  
132 the investment in reforestation works and the average agricultural salary of a temporary  
133 labourer. The data concerning the salaries were gathered from the historical series compiled  
134 by Carreras et al. (2005). When replanting after massive seedling failure was made the next

135 year after reforestation, the replanting costs were estimated to be 65-75% of the reforestation  
136 ones. When replanting was delayed for more than one year, then the costs were assumed to  
137 be the same as the reforestation ones (Giménez, 1950). In addition, the following official  
138 publications were consulted in order to compile the datasets of the first eleven variables  
139 analysed: i) sowing and plantation statistics, from 1877 up to the end of the forest year  
140 1894-95; ii) projects and reports of the Reforestation Commissions and Forest Divisions  
141 from 1889 to 1938; iii) yearbooks of national public forests production statistics from 1922  
142 to 1934; iv) State Forest Heritage (*Patrimonio Forestal del Estado*, PFE) reports from 1940  
143 to 1954; v) yearbooks of the Spanish Forest Statistics from 1949 to 1965; vi) reports of the  
144 Spanish Head Office of Forestry, Hunting and Fluvial Fishing (*Dirección General de*  
145 *Montes, Caza y Pesca Fluvial*, DGMCyPF) from 1955 to 1971; vii) reports of the State  
146 Institute for Nature Conservation (*Instituto Nacional para la Conservación de la*  
147 *Naturaleza*, ICONA) from 1972 to 1987; viii) yearbooks of the Ministry of Agriculture,  
148 Fishing and Food from 1983 to 2004; ix) yearbooks of the Ministry of Environment of 2004  
149 and 2005; x) historical database of the Official State Gazzette (BOE), for analyzing the  
150 approved budgets and regulations. The total area reforested between 1896 and 1922 has  
151 been indirectly estimated in this study based on bibliographic references (Barrachina, 1926).  
152 The evolution of reforestation costs was analysed on the basis of bibliographic references  
153 and reforestation projects.

154 There are no official records concerning the investments related to reforestation activities  
155 before the year 1940. Thus, the only available information before that year comes from  
156 published papers. From 1940, the annual reports of the official institutions in charge of the  
157 reforestation activity, namely the PFE (1940-1954), DGMCyPF (1955-1971) and ICONA  
158 (1972-1984), provide information about the invested budget. Thus, the set of time series data  
159 between the years 1940 and 1984 was obtained from the State's annual budgets. The

160 updating of costs and budgets was based on data of the National Statistics Institute. All the  
161 budgets were updated to 2006 in million euros. The data concerning the period before 1940  
162 were updated until that year based on the historical series of Retail Price Index (RPI)  
163 elaborated by Reher & Ballesteros (Maluquer de Motes, 2005). Two updates were computed  
164 from 1940 to 1954. The first one considered 1983 as the reference year using the Retail  
165 Price Index (RPI) of that time, which is calculated in a different way than the current one.  
166 For the second updating, the time series from 1940 to 1984, from 1992 to 2002 and 2005-06  
167 were updated to 2006 in order to make them comparable.

168 The consistency of the historical series of each variable analysed was uneven. This is mainly  
169 due to the successive changes in the criteria used in the official statistics and records along  
170 time. As a result of such successive modifications, some variables were not collected  
171 continuously or their meanings were unclear. To avoid misleading conclusions from such  
172 heterogeneity in the original data, only those sets of time series that were homogeneous and  
173 comparable between them were further considered in the analyses within this study.

174 Similarly, the data concerning the species used in reforestation and afforestation from 1940  
175 to 2006 has some limitations: i) from 1940 to 1970 only some species were recorded every  
176 five years, namely *Pinus sylvestris*, *P. nigra*, *P. pinaster*, *P. pinea*, *P. halepensis*, *P. radiata*,  
177 *P. uncinata*, *P. canariensis*, “other coniferous species”, *Populus* sp., *Eucalyptus* sp., and  
178 “other broadleaf species”, ii) there were some information gaps for some years (1973, 1989-  
179 1992, 1994), and iii) some records were based on estimations but not on real measurements.  
180 Due to these limitations, in this study the classification of the reforested area from 1940 to  
181 2006 by tree species was estimated just for seventy percent of the total reforested area in  
182 Spain.

183

184 **3. Results**

185 3.1. Reforested area

186 The available data for the first period (1877-1940) only cover two sub-periods: i) 8,528 ha  
187 from 1877 to 1895 (Jordana, 1896), and ii) 119,455 ha from 1921 to 1937. The total area  
188 reforested between 1896 and 1922 has been indirectly estimated in this study based on  
189 bibliographic references (Barrachina, 1926) and on reforestation projects. Accordingly, the  
190 area reforested during the first forty years of the 20<sup>th</sup> century could have reached  
191 approximately 220,000 hectares.

192 Between 1940 and 1984 the reforestation rate increased sharply. The total reforested area  
193 during this period amounted to 3,678,522 hectares, and the average annual reforested area  
194 was 80,000 hectares per year. The maximum reforestation rate was achieved in 1957, when  
195 143,968 hectares were planted. Afterwards, the reforestation activity experienced a sharp  
196 reduction between 1988 and 1991, and it was re-enhanced during the 1990s. The reforested  
197 and afforested area from 1984 to 2006 can be estimated at 1,957,973 hectares, which results  
198 in an average rate of more than 63,000 hectares per year. Within this particular period, most  
199 afforestation was carried out from 1993 to 1999.

200 The leading role in the promotion of large-scale reforestation in Spain was assumed by the  
201 public administration and, for that reason, most reforestation projects were mainly  
202 implemented on public lands and had a restoration objective. The State reforested eighty two  
203 percent of the whole reforested area (i.e., 4,265,699 hectares), whereas private owners  
204 contributed to the remaining eighteen percent (i.e., 936,373 hectares). In total, more than  
205 five million hectares have been reforested since 1877, which represents approximately ten  
206 percent of the whole country area and eighteen percent of the national forest area (Fig. 1).

207 < Figure 1 >

208

### 209 3.2. Replanting after massive seedling mortality

210 A considerable proportion of the reforested area had to be replanted afterwards due to high  
211 seedling mortality. The replanting of tree seedlings was done only when the amount of  
212 surviving plants was low enough to endanger the proper development of forest stands.  
213 Although the replanting of trees after massive seedling failure practically started at the same  
214 time as the reforestation activity, the official forest records did not register such information  
215 until 1946, when large-scale replacement of dead seedlings started as a result of the severe  
216 droughts of 1942 and 1954. Thus, the accumulated replanted area since 1946 to present can  
217 be estimated at 865,375 hectares, which represents approximately 17% of the total  
218 reforested area. The proportion of replanted area showed an overall decreasing trend along  
219 the historical period, although between 1946 and the beginning of the 1950s it sharply  
220 increased and it showed also a more erratic behaviour during the last years of the historical  
221 period the behaviour was more erratic (Fig. 2).

222 < Figure 2 >

223

### 224 3.3 Land availability for reforestation purposes

225 There are almost no data on the impact of the large-scale reforestation policy on the  
226 structure of the forest ownership before 1940. In large-scale projects for watershed and  
227 forest restoration, the State often expropriated the land after declaring the public utility or  
228 interest of such projects. However, due to the reduced reforestation activity during that  
229 period the overall impact on the structure of the ownership was rather low.

230 From 1940, the State applied three alternative instruments in order to develop the national  
231 reforestation policy: i) land acquisition, ii) the establishment of consortia, and iii) land  
232 expropriation. The data available for the period from 1940 to 1984 reflect the impact of

233 applying the two first policy instruments (i.e., acquisition and consortia), which were the  
234 most used tools (Fig. 3). The consortia consisted in the establishing agreements or contracts  
235 between the State and landowners (i.e., either private owners or public ones such as  
236 municipalities). According with these consortia, the State should carry out the reforestation  
237 with no cost for the landowner in exchange for a given percentage of the future income  
238 generated by the new forest. The State was responsible for the management of the area until  
239 the recovery of the total public investment. On the other hand, landowners would benefit  
240 from getting reforested areas with no economic cost as well as from the potential share of  
241 the future income generated from timber sales. Such consortia were not very successful  
242 among private landowners inasmuch as only 18% of the land area under consortium was  
243 privately owned, whereas 82% of the area under consortium was publicly owned (Fig. 3).

244 The implementation of the aforesaid alternative policy instruments for increasing the  
245 availability of land for reforestation purposes made it possible for the State to have, every  
246 year from 1940 to 1984, a surplus of land to be devoted to this activity. Land acquisition  
247 followed an increasing linear trend until the 1960s, when it further increased because the  
248 land offer of marginal lands was very high. With the passage of time, the consortia with  
249 public and private landowners became the most important instrument (Fig. 3).

250 < Figure 3 >

251

#### 252 3.4. Investment in reforestation projects

253 A historical series of fifty-four estimates of annual reforestation costs from 1890 to 2010  
254 was constructed (Fig. 4). The costs per hectare at the end of the 19<sup>th</sup> century ranged from  
255 100-200 pesetas (395-790 constant €<sub>2006</sub>), and increased up to 400 pesetas (1.081 constant  
256 €<sub>2006</sub>) in the mid-1930s. The reforestation and afforestation costs may vary much according  
257 to the degree of difficulty of a given Project, which explains the considerable variability

258 observed in Figure 4. In 1940, right after the Spanish Civil War, the average reforestation  
259 cost increased up to 2,000 pesetas per hectare (4,000 constant €<sub>2006</sub>). In 1968, the  
260 reforestation cost per species was 8,000 pesetas (928 constant €<sub>2006</sub>) per hectare for  
261 conifers, 10,000 pesetas per hectare (1,159 constant €<sub>2006</sub>) for eucalypts and 16,000 pesetas  
262 (1,854 constant €<sub>2006</sub>) per hectare for poplars. The replanting cost after seedling failure was  
263 3,500 pesetas (405 constant €<sub>2006</sub>) per hectare. Nowadays, the reforestation costs are  
264 approximately 2.500 € ha<sup>-1</sup>. Between 1940 and 1954, eighty per cent of the total investment  
265 in reforestation projects was devoted to workforce (Patrimonio Forestal del Estado, 1954)  
266 because the mechanization level was very low. As a result, the reforestation policy had a  
267 great socioeconomic impact through the generation of millions of daily wages (Fig. 5).

268 < Figures 4 and 5 >

269 Reforestation budgets at this stage expanded significantly. Whereas until 1900 the annual  
270 budget was 20,000 pesetas (73,600 constant €<sub>2006</sub>), during the first decade of the twentieth  
271 century the budget increased to 600,000 pesetas (212,500 constant €<sub>2006</sub>). The evolution of  
272 the annual investment in reforestation projects in the following decades was also very  
273 significant, exceeding two million pesetas (7.4 million constant €<sub>2006</sub>) in the early 1910s and  
274 three million pesetas (8.2 million constant €<sub>2006</sub>) in the 1920s (Fig. 6).

275 From 1940, the annual reforestation budgets experienced a sharp increase, i.e., from  
276 6 million pesetas (12 million constant €<sub>2006</sub>) in 1940 to 377 million pesetas (126 million  
277 constant €<sub>2006</sub>) in 1953. During those fourteen years, most part of the budget was devoted  
278 directly to reforestation works, which accounted for ninety five percent of the total budget.  
279 The remaining five percent was assigned to indirect costs and materials. The public  
280 expenditure in reforestation between 1940 and 2006 was 56,004 million pesetas (6,304  
281 million constant €<sub>2006</sub>), which represented 26 percent of the public spending in forest

282 policies (Fig. 7). The importance of reforestation budgets during these years was remarkable  
283 and was as high as 1.67 per cent of the State budget in 1957 (Fig. 7).

284 < Figures 6 and 7 >

### 285 3.5. Species used in reforestation and afforestation

286 The most utilized species in reforestation were indigenous pines, especially Maritime pine  
287 (*Pinus pinaster*) which was used in the reforestation of 870,535 hectares (Fig. 8). The use of  
288 hardwood species, especially from the genus *Quercus*, was generalized from 1993 within the  
289 framework of the EU's afforestation programme of agricultural land. Holm oak (*Quercus*  
290 *ilex*) was the most commonly used species in the 1990s covering more  
291 than 185.000 hectares of monospecific and mixed afforestations. On the other hand, the total  
292 area afforested with shrub species within the above-mentioned EU afforestation programme  
293 amounted to 4,000 hectares. Regarding forest restoration, the use of shrubs and herbaceous  
294 species, such as the European marram grass (*Ammophila arenaria*) for dune fixation, was  
295 also enhanced. Some other shrub species used were: dwarf fan palm (*Chamaerops humilis*),  
296 common hawthorn (*Crataegus monogyna*), prickly juniper (*Juniperus oxycedrus*),  
297 Phoenician juniper (*Juniperus phoenicea*), mastic (*Pistacea lentiscus*), rosemary  
298 (*Rosmarinus officinalis*), Spanish broom (*Spartium junceum*), salt cedar (*Tamarix spp.*)  
299 and arar (*Tetraclinis articulata*). The accumulated reforested area with exotic species is  
300 greater than 900,000 hectares. Nowadays, eucalypts cover approximately 500,000 hectares  
301 (Toval, 1999), namely the species *Eucalyptus globulus*, *E. camaldulensis* and *E. nitens*  
302 (Ruiz et al., 2008). The second most used species in plantation forestry has been *Pinus*  
303 *radiata*, which nowadays covers almost 300,000 hectares in Spain. The third most utilized  
304 exotic tree species is a Euro-American hybrid poplar (*Populus x euramericana*). Nowadays,  
305 poplar plantations in Spain cover approximately 135,000 hectares.

306 < Figure 8 >

### 307 3.6. Forest nurseries and seed collection service

308 Since 1940, the increasing reforestation activity boosted the creation of tree nurseries  
309 and the collection of tree seeds for seedling production (Fig. 9). Nurseries were public  
310 and produced all seedlings that both the public administration and private owners needed.  
311 The number of nurseries increased from forty in 1940 to nearly eight hundred in the mid-  
312 1950s, and some Spanish provinces had more than forty nurseries each. Most of them were  
313 temporary nurseries established close to the areas to be reforested, as recommended by  
314 the law. In the capital of each province, a central nursery mainly produced seedlings  
315 for private owners. Nurseries were not mechanized, and their distribution throughout the  
316 national territory had the advantage of avoiding transportation costs and providing better  
317 acclimatization of seedlings due to their proximity to the target reforestation areas.

318 Plant production reached a peak in 1956 with 1,100 million seedlings, ninety eight percent  
319 of which were conifers, the most commonly used trees in reforestation. The decrease of  
320 the reforestation activity over time entailed a significant reduction in the amount of nurseries  
321 and plant production. Nowadays, nurseries are permanent, moderately mechanized,  
322 mainly owned by private enterprises, and produce plant in growing pots.

323 < Figure 9 >

324 The relationship between the amount of seedlings produced and the area reforested showed  
325 a singular evolution along time. During the 1940s and 1950s, in average, 10,000 to  
326 12,000 plants per hectare were produced every year to be used in reforestation the following  
327 year. Such a high quantity was partly due to the high planting density used in standard  
328 reforestations, ranging from 2,000 to 3,000 plants per hectare, and to the common practice  
329 of putting three plants in each hole in order to try to minimize the expensive replanting  
330 operations in case of massive seedling failure. In areas with high populations of rabbits, the  
331 planting density was even higher in order to minimize the damages by herbivory.

332 Nowadays, the standard planting density is approximately between 1,000 and 2,000 plants  
333 per hectare and only one seedling is allocated in each hole.

334 During the first years the seed collection service focused on providing enough seeds to  
335 supply the entire national reforestation activity, which was estimated  
336 at 606,000 kilograms per year. In 1955, seed production reached a historical record  
337 of 985,000 kilograms (Fig. 10). Nowadays, due to the scant reforestation activity and to the  
338 improved germination, storage and cultivation techniques, seed consumption is not as high  
339 as in the past. Hence, seed production has currently fallen sharply to levels below  
340 50,000 kilograms per year. The number of seeds required to produce one thousand seedlings  
341 decreased by sixty two percent from 1941 to 1984.

342 < Figure 10>

343

#### 344 **4. Discussion**

345 4.1. Evolution of the reforested area and associated investments

346 *4.1.1. 1877 – 1939: the first reforestations*

347 The reforestation activity during the last quarter of the nineteenth century was practically  
348 negligible due to the delay in the approval of laws, the lack of administrative units and  
349 technicians, and the limited financial resources. At the time, reforestation was mainly  
350 oriented towards soil protection and forest restoration in target watersheds.

351 The Forest Act and the law for the improvement, promotion and reforestation of public  
352 forests were published, respectively, in 1863 and 1877. The 1877's law was similar to the  
353 German, French and Swiss legislations (Artigas, 1878), but its application in Spain was  
354 limited. The first regulation clearly oriented toward forest restoration came into force eleven  
355 years later; the Royal Decree of 1888 about reforestation in headwaters of rivers. As a result,  
356 several attempts to develop reforestation plans were made, e.g., the Reforestation General

357 Reports based on the law of 1877, and several Watershed Assessment Reports based on the  
358 rule of 1888. The development of the modern Spanish forest administration also began  
359 during this period. The first territorial administrative units, so-called forest districts, were  
360 created in 1856 and extended throughout the country in 1865 (Gómez de Mendoza and  
361 Manuel, 1999; Pemán, 2009). Special administrative divisions so-called Reforestation  
362 Committees were established to develop the forest regeneration promoted by the rules of  
363 1888, but their capacity to undertake their commitments was very limited due to the scarcity  
364 of funding (Castell, 1888) and, in consequence, the area reforested during these years was  
365 very small (Fig. 1).

366 During the first forty years of the 20<sup>th</sup> century, most efforts were devoted to developing  
367 reforestation regulations and laws (Pemán, 2013), although some authors described their  
368 provisions as dead letters (Cuesta, 1919; Ximénez de Embún i Oseñalde, 1933), and to  
369 create new administrative units as the Forest Hydrological Service. This unit was created in  
370 1901 in order to give continuity to the task initially undertaken by the above-mentioned  
371 Reforestation Committees with the aim of protecting headwaters of river basins and fixing  
372 coastal sand dunes (Gómez de Mendoza and Ortega, 1989). The creation of this service  
373 represented an increase of protective reforestations during the first forty years of the century  
374 (Fig. 1) although the political instability and reduced budgets prevented further progress of  
375 reforestation activities (Castell, 1888; Pemán and Vadell, 2009). Although reforestation  
376 budgets were scarce during this stage, they increased from 1901 in order to fund the works  
377 of the recently created Forest Hydrological Service. Although this aimed at enhancing  
378 reforestation, the ambitious reforestation goals were not fully achieved.

379 At the same time, several attempts to integrate reforestation into national-level forest  
380 planning were made, as for instance the proposals of national reforestation plans made in  
381 1911, 1926, 1933 and 1938. Only the *Plan General para la Repoblación Forestal de España*

382 (General Reforestation Plan of Spain), wrote in 1938 by Joaquin Ximénez de Embún and  
383 Luis Ceballos was partially used in the next period.

384

#### 385 *4.1.2. 1940 – 1984: the large-scale reforestation of Spain by the public administration*

386 The end of the Spanish civil war in 1939 inaugurated Franco’s dictatorship, which lasted  
387 thirty-six years (1939-1975) and was a period of great expansion of the reforestation activity  
388 (Fig. 1). The consideration of reforestation as an important national matter by the political  
389 regime also arose, at least in the beginning, from its potential to boost the economy of rural  
390 areas and to face the high unemployment rate (Ortuño, 1975). From 1940 to 1952, the so-  
391 called “autarkic period” (Navarro-Garnica, 1977), the reforestation activity was determined  
392 by the socioeconomic characteristics arising from the international isolation of Spain and its  
393 economic self-sufficiency. Since there was neither any mechanization for executing  
394 reforestation works nor for transporting workers and seedlings to the target reforestation  
395 areas, the reforestation activity was based on the utilization of a large amount of labour.  
396 During the “incipient mechanization period” (1953-1966), the budgets devoted to  
397 reforestation increased and the highest reforestation rates were achieved reaching a  
398 maximum in 1957, when 143,958 hectares were reforested (Fig. 7). During the  
399 “mechanization period” (1967-1984) manual work was mechanized and the use of crawler  
400 for soil preparation became widespread.

401 The key instrument to develop the reforestation policy at this stage was the public agency  
402 called *Patrimonio Forestal del Estado* (State Forest Heritage), created in 1935 but not  
403 completely active until 1940. The reforestation activity was basically conducted by the  
404 forestry administration (Fig.1), as it also happened during the previous historical phase, due  
405 to the widespread opinion that the public administration should mainly focus on forest  
406 restoration (Elorrieta, 1934). The State attempted to promote private reforestations with

407 successive laws, some of them very innovative at the time as the Law of 1952. However, the  
408 low economic profitability of timber harvesting discouraged private investments. The area  
409 reforested by private owners represented nine percent of the total reforested area. On the  
410 other hand, the main problem of public reforestations was the lack of enough public land to  
411 be devoted to reforestation purposes. In consequence, land availability became the main  
412 bottle neck for the implementation of large-scale reforestations (Pemán et al., 2009). In  
413 many cases, the available lands were poor sites with high evidence of soil degradation that  
414 should not have been reforested with trees (Gómez de Mendoza and Mata, 1992; Ortuño,  
415 1990), which resulted in high seedling mortality rates (Fig. 2). In view of the need for  
416 restoring the forest cover and reducing rural unemployment throughout the country,  
417 reforestation policies gave priority to quantity over quality. In consequence, although the  
418 reforested area during these decades was finally higher than expected, the final result was  
419 not always in accordance with the original objectives (Gómez de Mendoza and Mata, 1992;  
420 Ortuño, 1990). Reforestations were developed without a proper land-use planning, which  
421 often resulted in conflicting interests with alternative land uses. Reforestation costs were  
422 very low compared to other countries (FAO Secretariado, 1958), which allowed the  
423 reforestation of large areas with the available budget (Fig. 4).

424 In a context of poverty, until the 60s, the State increased yearly the budgets devoted to  
425 reforestation with a clear a social objective in order to reduce the unemployment rates of the  
426 rural areas (Fig. 5). Despite the high amount of daily wages generated, the employment was  
427 temporary and precarious (García Salmerón, 1990). The period of economic self-sufficiency  
428 ended in 1953 with the signing of the economic agreements with the United States of  
429 America. In 1956, 27% of the budget was provided by this aid. Since the cost of daily wages  
430 had tripled over that period, mechanization was enhanced inasmuch as it was regarded as the  
431 solution for reducing costs and maintaining the reforestation activity with similar intensity

432 and pace as in the past. The evolution of the budgets devoted to large-scale reforestation  
433 since the 60s was linked to the successive Social and Economic Development Plans (Fig. 7).  
434 The first two plans (1964-1967 and 1968-1971) assigned significant budgets to  
435 reforestation, especially aiming at timber production. The reforestation policy carried out  
436 from 1940 found social resistance in some places, especially in rural areas and villages with  
437 communal land or where the land was mainly used as pastureland (Fernández-Muñoz,  
438 2002). On the other hand, the impact of large-scale reforestations on rural depopulation of  
439 mountain villages is still under discussion. The purchase of rural land by the State  
440 represented a good opportunity for some people as they moved to the cities in better  
441 economic conditions. On the contrary, in rural areas with no reforestation plan many people  
442 had to leave their villages anyway, and with no economic reward, due to the  
443 impoverishment of the mountain areas (Fernández-Muñoz, 2002; Satué, 2003). Since the  
444 1970s, the criticisms about the way reforestations were carried out were intensified by  
445 Spanish non-governmental environmental organizations, born after the Spanish universities  
446 introduced the studies of Ecology (García Novo, 2009). The criticisms mainly focused on: i)  
447 the almost exclusive use of pines species, ii) the utilization of non-native species like  
448 eucalypts, Monterrey pines or poplar hybrids, iii) the promotion of monospecific stands, iv)  
449 the use of bench terraces with high visual and soil impact as main site preparation technique,  
450 v) the low multifunctionality of reforestations with regard to other uses such as grazing.  
451 Indeed, reforestations constituted the main focus of the criticisms of environmental  
452 organizations in Spain during those years (Castroviejo, 1978).

453

#### 454 *4.1.3. 1984 to present: Current democratic period*

455 Spain became a democratic State again in 1978, adopting a constitution that  
456 decentralized the State into seventeen autonomous communities and two autonomous cities.

457 Forest policy was among the competences transferred by the State to each autonomous  
458 region, a process that was completed in 1984. The reforestation activity underwent a decline  
459 until the 1990s partly due to: i) the economic stagnation caused by the 1973 oil crisis, ii) the  
460 decentralization of the competences on forest management from the central government to  
461 the Autonomous Communities and, iii) the strong social opposition led by non-  
462 governmental environmental organizations (Castroviejo et al., 1985).

463 The entrance of Spain into the European Economic Community in 1986 represented a  
464 crucial political and economic transformation, and some of the environmental protection and  
465 forestry measures proposed within the Common Agricultural Policy (CAP), approved in  
466 1992, had an enormous impact on the Spanish afforestation dynamics. The approval of the  
467 programme for the afforestation of agricultural lands in 1993, with a 500 million euro  
468 budget for Spain, represented a shift in both the reforestation and afforestation rate and the  
469 techniques utilized. The afforested land during the period 1993-99 reached 460,000 hectares,  
470 with annual afforestation rates similar to the reforestations conducted during the 1950s.  
471 According to Picard (2001), afforestation during this period was mainly characterized by the  
472 following features: i) the target land types for afforestation purposes, namely marginal lands,  
473 arable land (22%), grasslands and grazed fallow land (50%), and open afforested area  
474 (28%); ii) afforestation was conducted by private landowners who were the beneficiaries of  
475 the economic support provided by the CAP (i.e., almost 22,300 beneficiaries with an  
476 average area of 16 hectares per holding); and iii) the innovation in the afforestation  
477 techniques which ranged from modernization of nurseries to new afforestation techniques  
478 and products in order to improve the success in the establishment and survival of seedlings  
479 with a lower impact on the soils and landscapes. Furthermore, in the afforestation for  
480 protection purposes, mixed stands were again preferred as compared to monospecific  
481 plantations, i.e., *Quercus* species were the most utilized in the Mediterranean area. Between

482 2000 and 2006, the afforestation pace reduced its intensity, which resulted in 208,000  
483 hectares afforested during those years (Fig. 1). The impact of this afforestation programme  
484 was uneven throughout Spain. On one hand, it allowed the afforestation of private  
485 abandoned lands under high risk of erosion, which otherwise would have been further  
486 degraded. On the other hand, the resulting stands often represented rather small and isolated  
487 patches within agricultural landscapes with no connection with larger forest areas.  
488 Furthermore, in some cases, afforestation was conducted using excessively low planting  
489 densities or unsuitable slow-growing tree species, whereas in some other cases shrub species  
490 were used in areas suitable for tree species. This contributed to the creation of highly  
491 fragmented forest landscapes (Tribunal de Cuentas, 2005). This is mainly because the CAP,  
492 to a certain extent, used the afforestation programme as an instrument to prevent marginal  
493 agricultural lands to be further cultivated. Thus, many afforested areas did not respond to  
494 forest management interests and objectives, and they have often just contributed to the  
495 fragmentation of the agricultural landscapes by inserting small forest patches lacking  
496 connectivity with the already existing large forest areas. Since the subsidies received by the  
497 beneficiaries under the CAP afforestation programme were in exchange for maintaining the  
498 afforested land for a 20-year period, the future of many of those afforestations remains  
499 uncertain.

500

#### 501 4.2. Species used in reforestation

502 The use of different tree species depended on the purpose of each reforestation project. At  
503 the beginning of the reforestation activities conifers were the most utilized ones based on the  
504 idea that they performed better than broadleaves and that pines were more suitable for  
505 Mediterranean mountain areas, whereas the use of broadleaf species should be restricted to  
506 low-mountain areas, streams and wetlands (Madariaga, 1909). Indeed, the massive use of

507 pine trees arose from the assumption of the ecological facilitation concept (Ximénez de  
508 Embún and Oseñalde and Ceballos, 1939) which suggested the large-scale use of pines, due  
509 to their adaptability to a wide range of environmental conditions, in order to facilitate the  
510 subsequent establishment of hardwood species (Gil and Prada, 1993). However, although  
511 pines were the principal species in reforestation, the resulting forest stands tended to be  
512 mixed. In contrast, in the north of the Iberian Peninsula, hardwood species such as  
513 oaks, lindens, maples, ashes, and even chestnuts and walnuts, were frequently used in forest  
514 restoration (Acebal, 1888). On the other hand, non-native fast-growing species were mainly  
515 used in reforestations oriented toward wood production. Private owners were the first to use  
516 non-native species, whereas the forest administration was more reticent based on the belief  
517 that native trees were more adapted to the Spanish environmental conditions. Although  
518 there is evidence of reforestation with exotic species such as Norway spruce (*Picea abies*) in  
519 the navy forests during the early 19<sup>th</sup> century (Michel, 2004), the veritable introduction  
520 of exotic species began during the second half of the 19<sup>th</sup> century, at the same time as in  
521 other parts of Europe (Ventalló, 1879). The species of greatest interest were eucalypts and  
522 Monterey pine (Adán de Yarza, 1913).

523 The protective reforestations made after 1940 continued to use pine as a target species but  
524 with the difference that the forest stands were monospecific. The use of hardwood species  
525 was negligible (Fig. 8). The massive use of these species was justified by the nature of  
526 pioneer species in forest dynamics and their economic interest compared to native  
527 hardwoods (Ceballos, 1960). Simultaneously, the use of fast-growing species, particularly  
528 eucalypts, Monterey pine and poplar was promoted. Eucalypts were the most used due to  
529 their relevance to cellulose industries, which were declared of national interest. Monterey  
530 pine was the second most commonly used fast-growing species due to its interest for timber  
531 and pulp production. Poplars were also very common, and some regulations such as

532 the law of 1941 on riverbanks, the law of 1952 and the law of 1977 on Promotion of Forest  
533 Production and the Second Social and Economic Development Plan aimed at promoting  
534 their use. The purpose was to use poplars on the riverbanks or in new irrigated land to  
535 produce wood pulp and wood for packaging. Among the native species the most important  
536 one was *Pinus pinaster*, which was used for production purposes in northern Spain, whereas  
537 in the Mediterranean area was used as a pioneer species for forest restoration.

538 The impact of exotic plantations, and specially eucalypt plantations, on soil degradation, as  
539 well as on ecological, hydrological and socioeconomic dynamics have been the subject of  
540 continuous discussions (Ruiz et al., 2008). At the end of the 1950s, the area covered by  
541 eucalypts in Spain represented half of the eucalypt plantations in whole Europe (FAO  
542 Secretariado, 1958). The widespread use of pines in forest restoration and exotic species  
543 also generated strong criticisms from ecologists, mainly during the 1970s and 1980s  
544 (Castroviejo et al., 1985; Groome, 1990; Parra, 1990). Since then, such forest restoration  
545 concepts have been widely studied from the ecological point of view and have been the  
546 object of intense discussion (González-Moreno et al., 2011; Maestre et al., 2003; Pausas et  
547 al., 2004). As a result, from the 1990s the afforestation projects recovered the use of several  
548 species, mainly of the genus *Quercus* in the Mediterranean area, in order to promote mixed  
549 forests. Paradoxically, this conceptual approach is not far from the way reforestation had  
550 been designed in Spain before the 1940s.

551

#### 552 4.3. Land availability for reforestation purposes

553 Land availability for the development of the national reforestation policy at large scale  
554 represented a strong potential limitation due to the structure of the forest ownership. In  
555 1940, the forest area in Spain was approximately 24.293.000 hectares. Only 1% of the forest  
556 area was owned by the State (DGMCyPF, 1941), whereas 78% was privately owned and the

557 remaining 21% belonged to municipalities. Thus, the forests area owned by the State was 10  
558 to 30 times lower as compared to most Central European countries (Fernández-Alonso,  
559 1933).

560 Among the different policy instruments to increase land availability for reforestation, land  
561 acquisition mostly focused on non-wooded lands, although some areas were also acquired  
562 for conservation purposes. As a result, the forest area owned by the State shifted from  
563 242,930 to 1,106,248 hectares. On the other hand, consortia were the most preferred tool by  
564 the State inasmuch as it did not entail any expenses for land acquisition. Moreover, forests  
565 under consortia actually became a sort of co-ownership in which the planted trees and  
566 timber production belonged to the State (Montero de Burgos, 1994).

567 The policy to increase land availability for reforestation caused a considerable change in the  
568 structure of the forest ownership. In turn, this had a significant impact on the rural society  
569 inasmuch as the traditional uses were limited on those areas. This resulted in strong social  
570 resistance in some places, especially in rural areas and villages with communal land or  
571 where the land was mainly used as pastureland (Fernández-Muñoz, 2002). Furthermore,  
572 land acquisition by the State, which sometimes affected whole municipalities, resulted in  
573 massive migration of people from mountain areas. The impact of large-scale reforestations  
574 on rural depopulation of mountain villages is still under discussion. Indeed, the purchase of  
575 rural land by the State represented a good opportunity for some people as they moved to the  
576 cities in better economic conditions. On the contrary, in impoverished rural areas with no  
577 reforestation plan many people had to migrate anyway with no economic reward  
578 (Fernández-Muñoz, 2002; Satué, 2003).

579 Most consortia are still in force nowadays, excepting those areas where consortia were  
580 established to promote reforestation with fast-growing tree species. The State is still

581 responsible for the forest management in the areas under consortium, but some regions  
582 within Spain are currently planning alternative ways to return those areas to their owners.

583

#### 584 4.4. Forest nurseries and seed collection service

585 In the late 19<sup>th</sup> century the recommendation of planting instead of sowing for reforestation  
586 establishment gained strength (Laguna, 1864), although there  
587 were conflicting opinions between experts (Acebal, 1888). Planting took long to be a  
588 generalized practice due to several reasons: i) higher costs than sowing, ii) the need for  
589 tree nurseries to produce seedlings and, iii) the absence of trained personnel to properly  
590 manage seedling production processes. The first laws regulating the installation of tree  
591 nurseries were approved in 1877 and 1888. Those rules stipulated that tree nurseries should  
592 be established in forest districts where reforestations were planned to be implemented  
593 by planting methods. The area of a tree nursery should never exceed ten hectares. This  
594 approach intended to avoid large nursery areas and to reduce plant transportation costs  
595 (Anónimo, 1877).

596 From 1940, the importance of reforestation activities resulted in the creation of numerous  
597 forest nurseries and the Special Forest Seed Service in 1953, which became the  
598 responsible for the supply of seeds for reforestation. Although the need for tree seedlings  
599 was initially very high due to the high planting densities used, forest nurseries were able to  
600 produce all seedlings needed for reforestation throughout the country in a short time after  
601 their establishment (Fig. 9). Afterwards, the reduction of planting density and the  
602 eradication of the practice of planting several plants per hole, led to a significant decline in  
603 the demand for forest plants. The available data concerning the evolution of the seedling  
604 production methods (i.e., from bare root to containerized seedling production) are very  
605 scarce. Already at the time of the first reforestations, the use of containerized seedling

606 production was recommended for reforesting areas characterized by unfavourable growing  
607 conditions. During the 1950s and the beginning of the 1960s, the most utilized seedling  
608 containers were cane tubes, wooden pots, clay pots and cardboard containers (Monzón,  
609 1962; Pita, 1962). These containers presented several shortcomings related to the excessive  
610 weight of clay pots, the low durability of cardboard containers, root deformation problems,  
611 and whether they were removed or not when planting. At the end of the 1960s, polyethylene  
612 bags started to be utilized as seedling containers in reforestations, mainly in southern Spain,  
613 due to the influence of the French and Italian reforestation techniques (Parra, 1968; Peñuelas  
614 and Ocaña, 1996). The main problems of using plastic bags were also related to root  
615 deformation (Peñuelas and Ocaña, 1996). However, until the 1980s the bare-root seedling  
616 production method represented more than 80% of the seedlings produced (Navarro-Garnica,  
617 1980). From 1984, public nurseries progressively disappeared as a consequence of the  
618 decrease in the reforestation activity and, nowadays, the private nurseries are the major  
619 producers of forest tree seedlings.

620 The creation of the Special Forest Seed Service entailed the onset of high standards to  
621 improve seed quality by certifying all seeds collected according to genetic and  
622 ecological criteria, and through the creation of seed orchards (DGMCyPF, 1957). This  
623 allowed for supplying the demand from forest nurseries in terms of forest seeds, even  
624 though the demand decreased progressively along time due to the improved techniques and  
625 efficiency in seedling production (Fig. 10).

626

## 627 **5. Conclusions**

628 The history of large-scale reforestation and afforestation in Spain reflects the multi-sectorial  
629 complexity that involves the development of land-use policies. Reforestation and  
630 afforestation policies were not just part of a broader national forest policy, but also

631 important tools for agricultural and social policies. The reforestations carried out from 1877  
632 until today responded to different national concerns regarding both socioeconomic and  
633 ecological issues. The reforestation activity also varied over time according to the changing  
634 political context of the country. Accordingly, the large-scale reforestation of Spain can be  
635 divided in three historical periods.

636 From 1877 to 1939, the ideological basis of the need for reforestation in order to face large-  
637 scale deforestation and forest degradation was settled. The first protective reforestations  
638 were made during that period, aiming at forest restoration by creating mixed forests, some of  
639 which are nowadays protected natural areas. However, the political instability of the time  
640 and the reduced financial resources limited the reforestation activity during that historical  
641 period. The period 1940-1984 is characterized by the boost of large-scale reforestation in  
642 Spain. The availability of public land was the key factor that explains the distribution of the  
643 reforested area at the national scale. The budget allocated to reforestation increased  
644 significantly since 1940 in order to provide a large amount of daily wages. The widespread  
645 use of pine species resulted in the creation of monospecific stands, in contrast to the mixed  
646 stands promoted during the previous historical period. Reforestations clearly oriented  
647 toward timber production with fast-growing exotic species were also promoted at the time.  
648 The high annual reforestation rate during this stage required the creation of public  
649 infrastructures throughout the country to organize the supply of a large amount of seeds and  
650 seedlings. At the end of this period reforestation started to face strong criticisms. The  
651 decentralization of forest policy coupled with the economic stagnation and strong social  
652 criticisms resulted in a decrease of the reforestation activity at the end of the eighties. The  
653 EU-funded afforestation programme of agricultural lands carried out after 1993 resulted in  
654 the reactivation of the reforestation and afforestation policy in Spain. The ambitious budgets  
655 devoted to this programme contributed to the technological renovation concerning seedling

656 production techniques in nurseries, and the utilization of new materials to improve seedling  
657 establishment after planting (e.g., tree tubes, hydrogels, and mulch systems). However, the  
658 performance of the resulting stands and reforested areas has been uneven throughout the  
659 country, and further research should be devoted in order to conduct a comprehensive  
660 evaluation of the afforestation programme of agricultural lands in Spain.

661 Woodlands currently cover 65% of the Spanish forest area. The socioeconomic, political and  
662 ecological dynamics that resulted in the current national landscape cannot be fully  
663 understood without taking into account the large-scale reforestation policy conducted since  
664 the end of the 19<sup>th</sup> century to present. The lessons learnt from the analysis of the Spanish  
665 experience can contribute to improving the design of large-scale reforestation policies as  
666 well as their potential impacts in other parts of the world and, in the end, shed light on the  
667 debate about the possible solutions to deforestation and degradation in impoverished areas.

668 Nowadays, the stands originated from the historical large-scale reforestation process  
669 represent a challenge in terms of forest management and planning. The management of the  
670 widespread monospecific stands is the object of much debate inasmuch as many are affected  
671 by decaying processes (Navarro-Cerrillo et al., 2007; Sancho-Benages, 2006), and are  
672 highly vulnerable to wild fires (Sancho et al., 2015). The aim is to increase the resilience of  
673 those reforestations and afforestations in order to reduce their vulnerability to biotic and  
674 abiotic hazards (Andrés and Ojeda, 2002; Chapin III et al., 2009). Notwithstanding, some  
675 challenges are shared with native forests inasmuch as some problems arise from the  
676 abandonment and lack of management regardless off the origin of the forest stands.  
677 Probably, the most specific challenge affecting the widespread monospecific and coetaneous  
678 stands is the need for diversifying the stands not only by increasing species richness  
679 (Carreras, 2006; Prévosto et al., 2011), but also in terms of stand age in order to facilitate a  
680 gradual and properly planned regeneration process. On the other hand, reforestation and

681 afforestation with fast-growing species also contributed to the sharp increase of timber  
682 production in Spain. Thus, timber production in Spain achieved in 12 million m<sup>3</sup> in 1984,  
683 and reached 17 million m<sup>3</sup> in 2010, whereas in 1940 timber production was not higher than  
684 1.5 million m<sup>3</sup>. For some species (i.e., eucalypts), reforestations contributed to multiply  
685 timber production by 25 as compared to 1940. Nowadays, many of those productive stands  
686 remain in sites with good growing conditions, whereas the fast-growing species growing in  
687 poorer sites or in areas with strong social opposition are gradually replaced by native forest  
688 species. This is the case for instance of Monterrey pines being substituted by *Pinus*  
689 *canariensis* in the Canary Islands, or the replacement of eucalypts and hybrid poplars by,  
690 respectively, native oaks and riverside forests in other parts of Spain.

691

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887 **Figure captions**

888 **Fig. 1** Evolution of the area reforested and afforested in Spain by the public administration  
889 and by private owners since 1877 to 2006.

890 **Fig. 2** Evolution of the replanted area after massive seedling mortality since 1946 to present,  
891 and of the ratio between replanted area in a given year and reforested or afforested area in  
892 the previous year.

893 **Fig. 3** Evolution of the accumulated area available for reforestation and afforestation under  
894 alternative policy instruments settled by the State, and of the area reforested by the  
895 *Patrimonio Forestal del Estado* (PFE) and *Instituto Nacional para la Conservación de la*  
896 *Naturaleza* (ICONA) (i.e., not including private landowners and other administration units).

897 **Fig. 4** Evolution of reforestation and afforestation costs (constant €<sub>2006</sub>) per hectare from  
898 1890 to present.

899 **Fig. 5** Evolution of the estimated investment (current pesetas) and number of daily wages  
900 associated to the reforestation activity between 1940 and 1954.

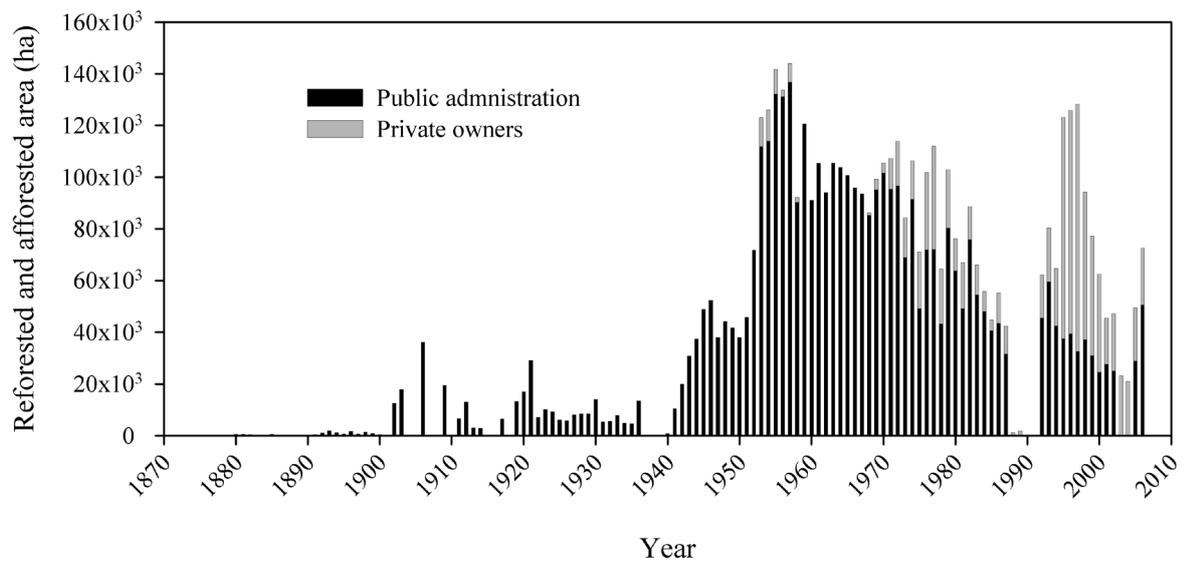
901 **Fig. 6** Evolution of the annual budget (constant €<sub>2006</sub>) for reforestation works between 1889  
902 and 1933. The annual budget values between 1889 and 1900 were 20,000 pesetas.

903 **Fig. 7** Evolution of the annual budget (constant €<sub>2006</sub>) for forestry works and its contribution  
904 to the total national budget as defined by the ratio (in percentage) between the annual  
905 reforestation budget and the corresponding State's budget between 1940 and 1984.

906 **Fig. 8** Accumulated reforested and afforested area in Spain from 1940 to 2002 by tree  
907 species. The sum of the reforested area of all species represents seventy percent of the total  
908 area reforested in Spain during that period.

909 **Fig. 9** Evolution of the production of conifer and hardwood seedlings, and of the ratio  
910 between the seedlings produced in one year and the area reforested and afforested in the  
911 following year.

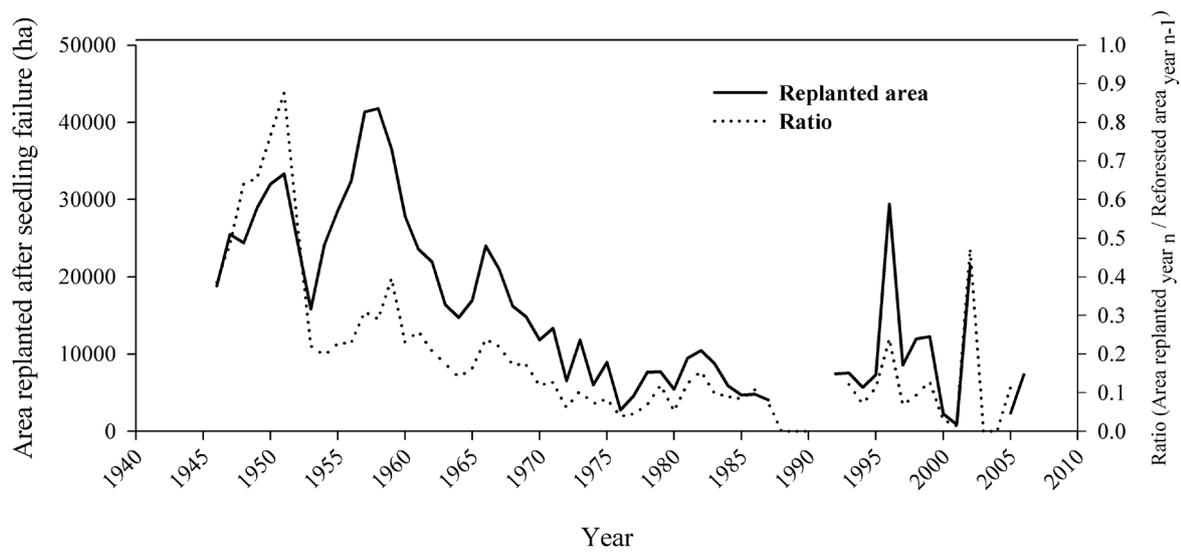
912 **Fig. 10** Evolution of seed collection and consumption and of the ratio between annual seed  
913 consumption and seedling production.



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915 Figure 1

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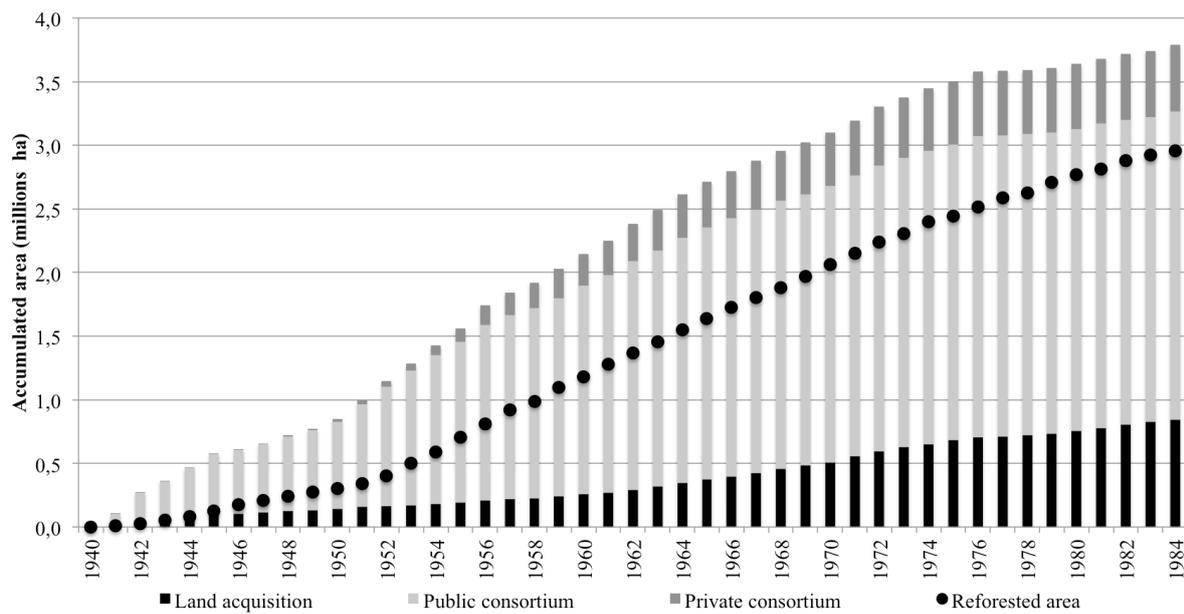


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918 Figure 2

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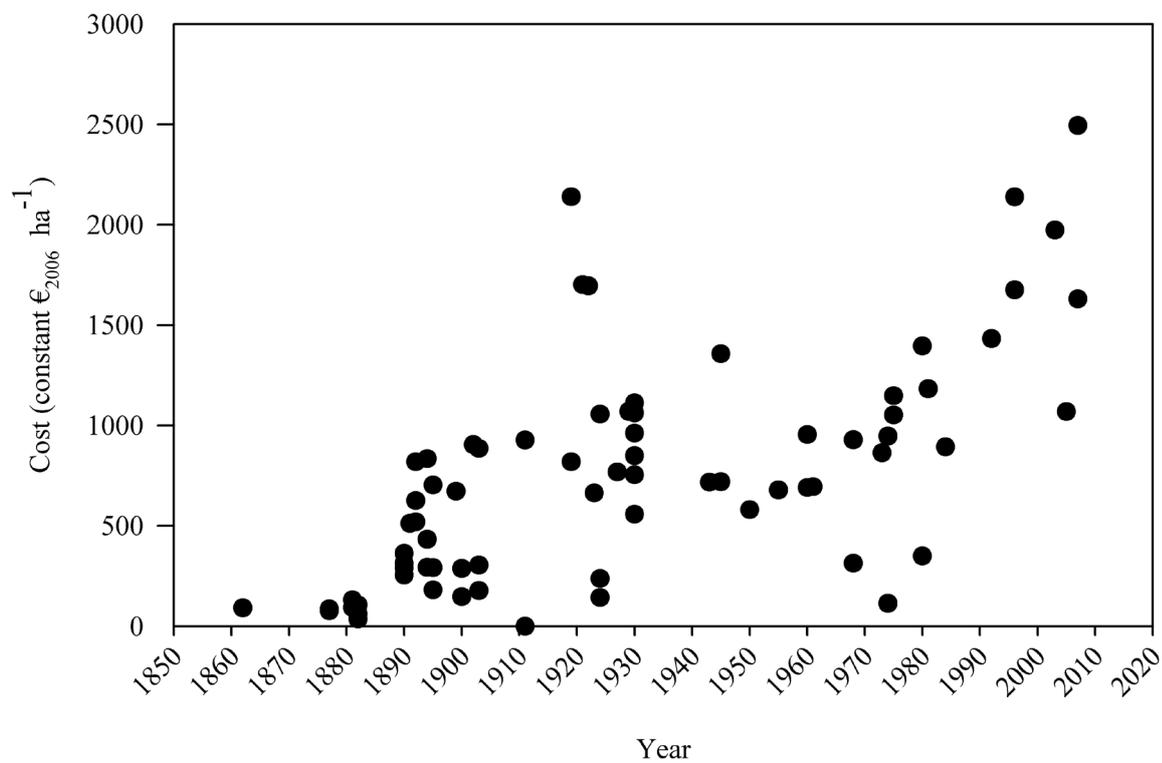
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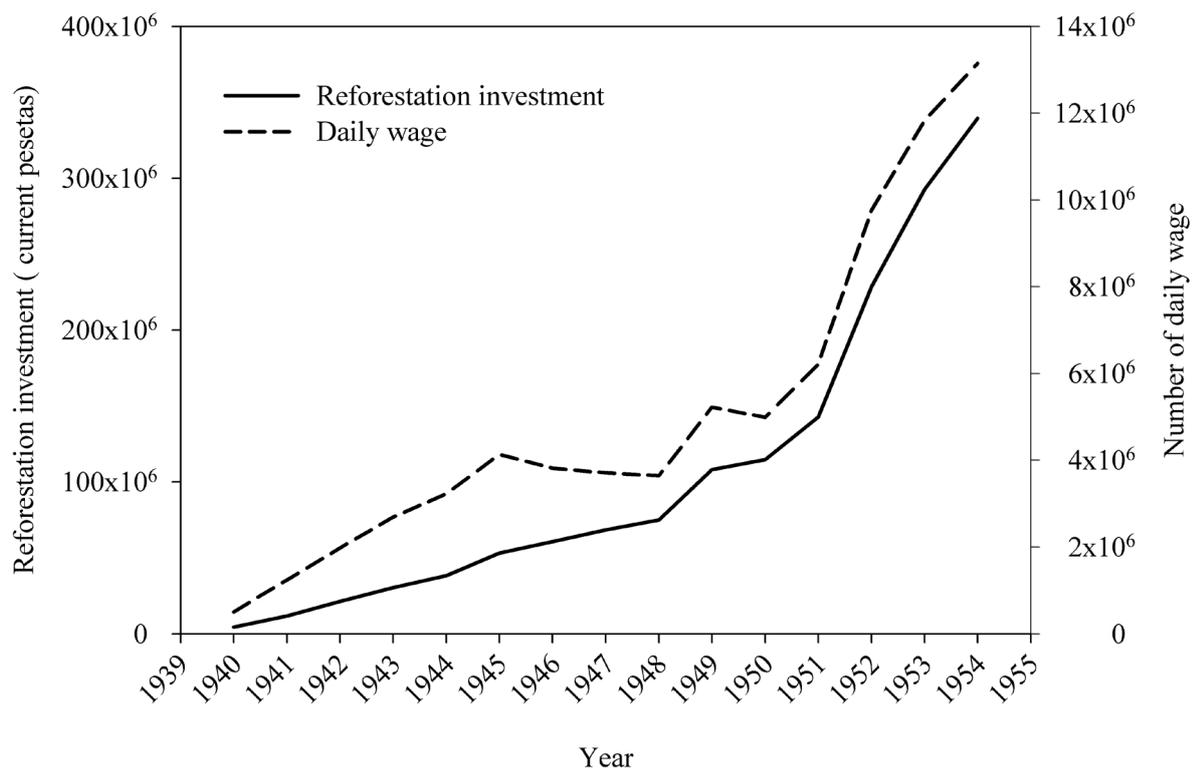
922 Figure 3

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925 Figure 4

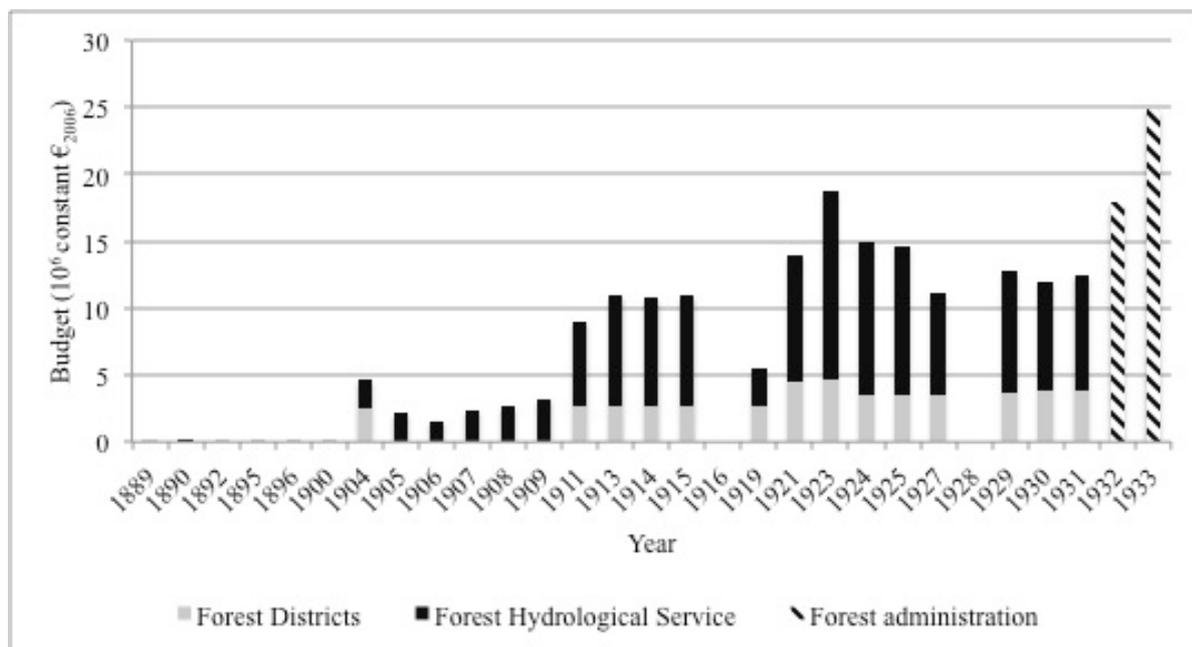


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927 Figure 5

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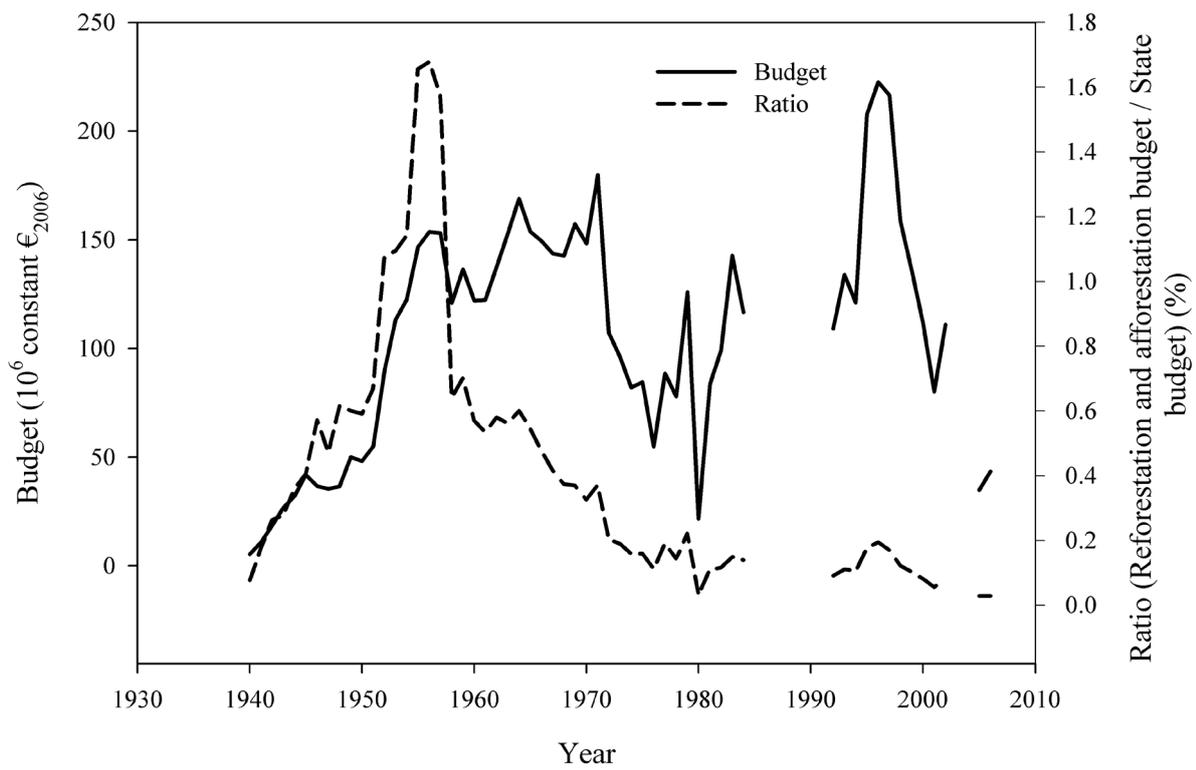
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931 Figure 6

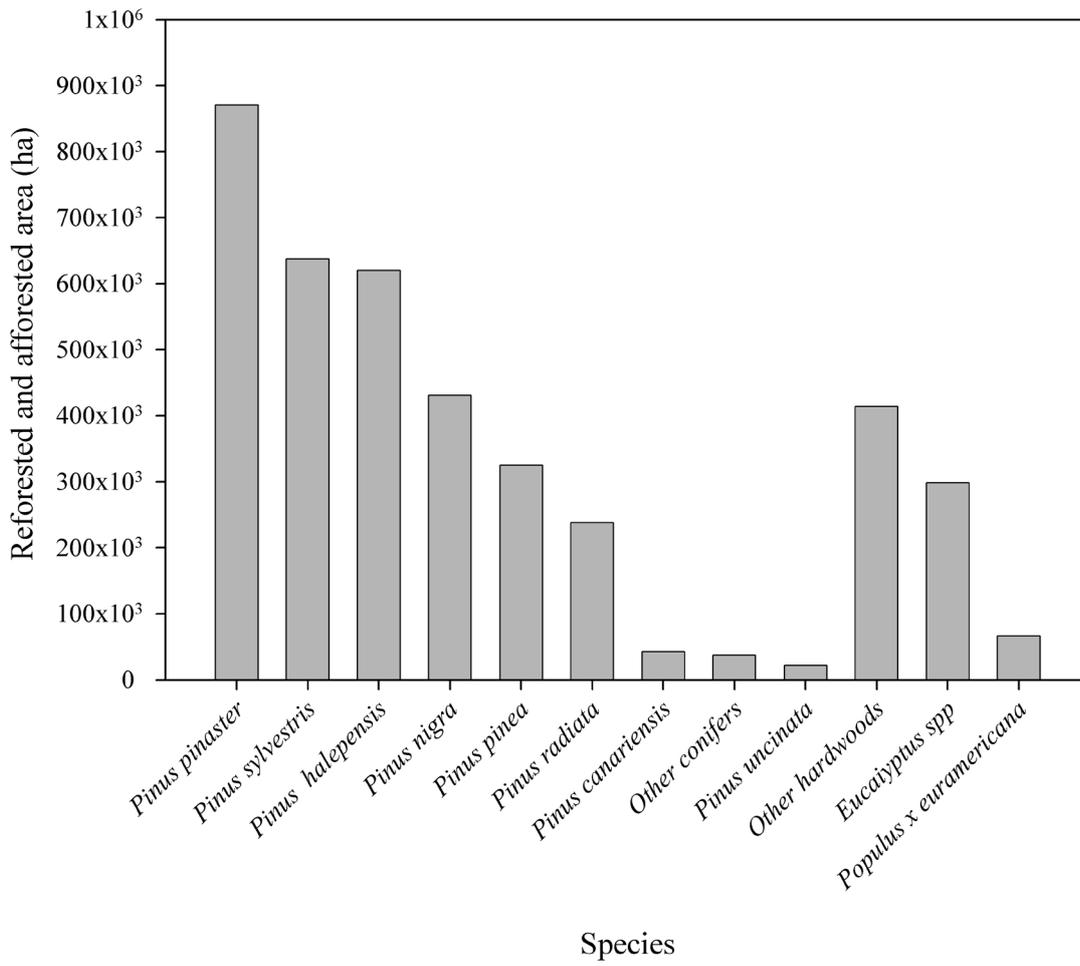
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934 Figure 7

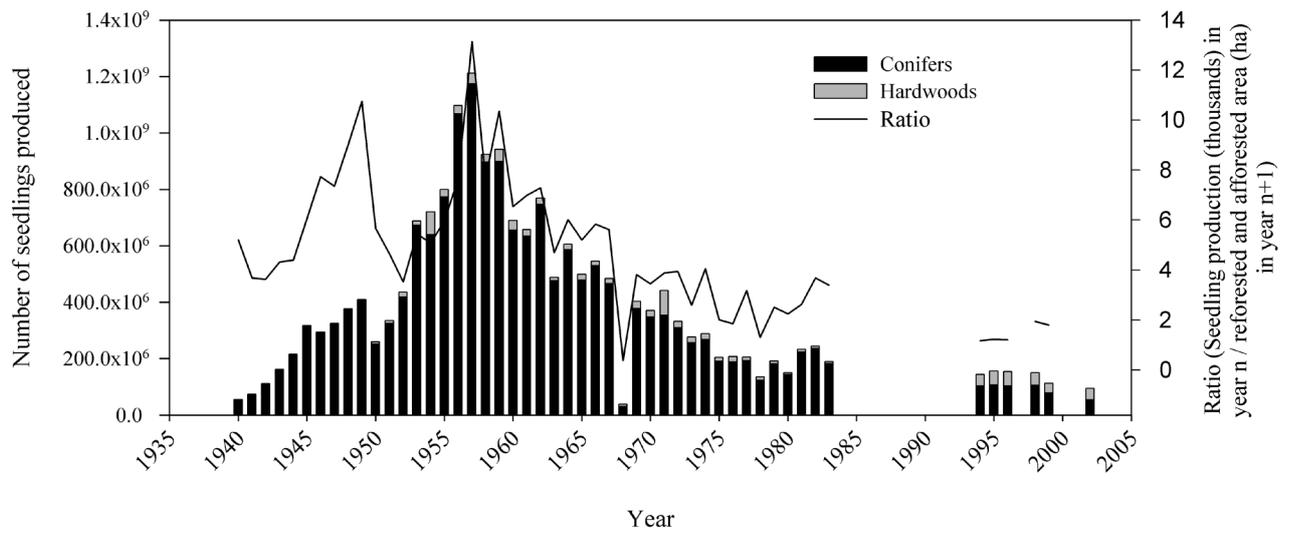
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937 Figure 8

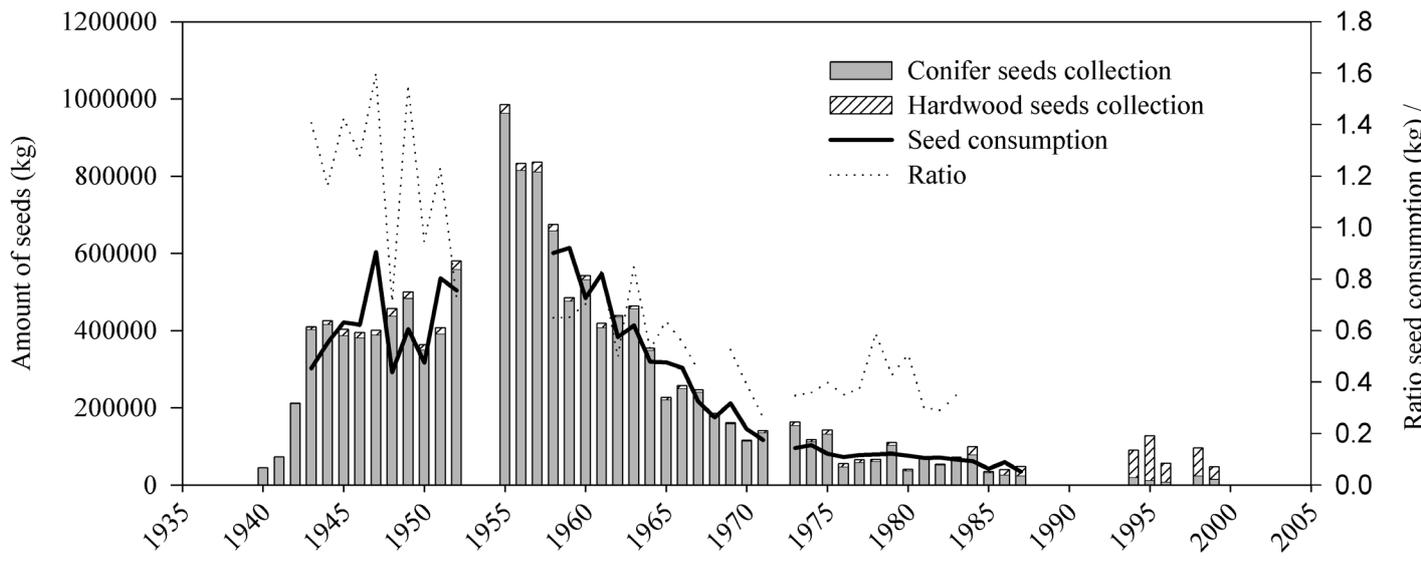
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940 Figure 9

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943 Figure 10