Alien tree growth comparison in old French arboretums

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Rapport de 2ème année

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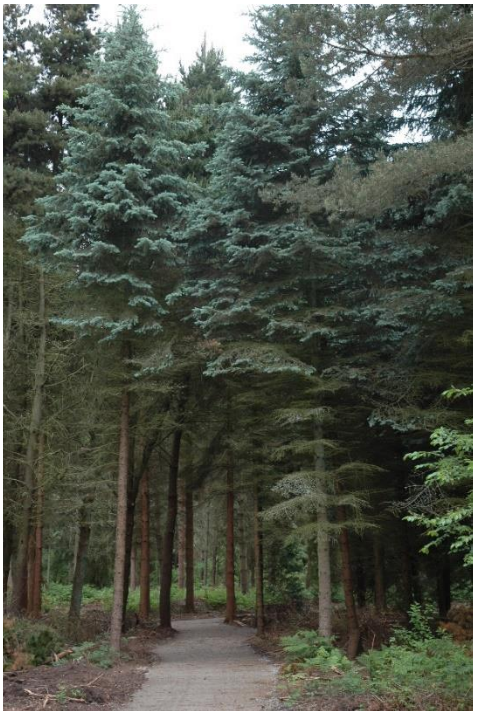

Photographie de l'arboretum de Roumare, Picea engelmanni – Thierry Lamant

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1. Résumé

Le changement climatique n'épargne le secteur forestier, il est maintenant visible et clair que celui-ci aura un impact fort sur l'état sanitaire et la composition des forêts françaises. Les gestionnaires forestiers devant s'assurer que les forêts continuent à assurer leurs différents rôles, il est nécessaire de prévoir les changements à venir et anticiper ceux-ci. Dans ce contexte, plusieurs solutions peuvent-être mises en place, dans ce rapport seule l'adaptation des forêts par un changement de leur composition sera abordée. A cette fin dans un premier temps, nous avons étudié la capacité d'adaptation d'espèces exotiques aux conditions de France métropolitaine dans des arboretums âgés de plus de 40 ans. Après avoir défini des essences de référence dans chacune des régions concernées, nous avons étudié à l'aide de tests statistiques quelles essences possédaient des caractéristiques de survie et de croissance en hauteur au moins aussi bonnes que ces essences de référence. Ce travail nous a fourni une liste de 41 essences exotiques mais a également mis en évidence l'efficience des espèces locales. Dans un second temps, nous avons grâce à de la modélisation recherché les zones climatiques dans lesquelles nos résultats pourraient être utilisés actuellement mais aussi dans le futur. Ce travail a été réalisé par le biais de compatibilité climatique grâce au modèle IKS, prenant en compte différents facteurs pédo-climatiques influençant la croissance des arbres. Ceci a permis d'établir des cartes de compatibilité climatique identiques à celles des sites étudiés en 2019 et à l'horizon 20100. Des propositions d'espèces sont ainsi disponibles avec une application possible de nos résultats dans la moitié Ouest de la France et dans plusieurs pays d'Europe. Ces résultats sont encourageants quant à l'adaptation de nos forêts face aux changements climatiques et fournissent des pistes pour de nouveaux tests à plus grande échelle.

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2. Introduction

Enormous outcomes over almost every sector are bound to happen as climate change is now an unquestionable reality (Intergovernmental Panel on Climate Change et al., 2013, 2014). The decadal or even centennial time scale of forestry requires to react as fast as possible to mitigate these outcomes. The global increasing of the mean temperatures inducing more drought stress resulting from climate change is a mid or long-term threat, especially for the forests which may not have the time to adapt to those changes even though they have a huge genetic diversity (Alfaro et al., 2014). However, an even more concerning problem, which is already discernible is the extreme events which occur with higher frequency and intensity, such as extreme drought which is becoming a big issue in forestry (Allen et al., 2010; Mantgem et al., 2009). These events are already inducing large-scale forest decline and are raising concerns about the suitability of certain species in their habitats (Département de la santé des forêts, 2019). A good example being Norway spruce (*Picea abies* (L.) H.Karst.) widely planted for its good yield in monoculture across Western and Central Europe in poorly adapted site (low altitude stands). For recent years these stands have been massively declining due to the combination of drought stress and the European spruce bark beetle (*Ips typographus L.*) (Kharuk et al., 2016; Stanovský, 2019). These damages are a non-negligible threat to forest sustainability and are raising concerns and the many forest ecosystem services are seriously threatened by these stands. France has a large diversity of forests due to its wide range of climate so it has been less affected by these losses than other European countries such as Germany or Belgium ("La crise du scolyte va s'amplifier," 2019). France is nonetheless still suffering from significant Norway spruce decline in the Eastern part of the country.

Those declines have started to raise concerns because French forest sector is important, France represents the 4th country in Europe for forest cover (Food and Agriculture Organization of the United Nations, 2015) and represents a huge productive asset (The forest time, 2018). French forests represent roughly 30% of the metropolitan territory with about 420,000 direct and indirect jobs which makes as many jobs as in the automobile industry (Observatoire national sur les effets du réchauffement climatique, 2015). In regard to those facts, forest services in France were estimated at 968€/ha/year wood being approximately 1/9 of that total (Aubertin and Vandevelde, 2009).

This great value of French forests and their relative weakness to climate change made the adaptation of French forests to be recognized as a priority for French forest research institutes, the population and French public forest managers (Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt., 2017). In fact, maintaining the forest cover can be an efficient way to mitigate climate change and its effects through various processes (Bonan, 2008) such as carbon uptake, non-renewable resources substitution and long-term carbon sequestration (Intergovernmental Panel on Climate Change, 2019). Current carbon storage of the French forest ecosystem is estimated to be 130 MtCO_2 eq/year and it will probably increase in the next decades due to French forests' relative young age but it will also probably be reduced due to climate change (Roux et al., 2017).

To achieve this goal of forest cover conservation, investigating the whole range of solutions at our disposal is a key to ensure a wide diversity of strategies to cope with the uncertainties created by climate change. It is possible to rely on natural adaptation and forest local diversity to cope with the changes (Parmesan, 2006; Sáenz-Romero et al., 2017) or to rely on renewed sylvicultural practices to help forest to adapt (Kohler et al., 2010). On a more interventional way, it is possible to scope non local intraspecific diversity through provenances trials (Gray et al., 2016; Leites et al., 2012) and to adapt ourselves the forest genetic resources by new provenance planting and assisted migration. At the end of the scope, it is also possible to introduce alien species that are thought to be more adapted to future climate than current species (Messinger et al., 2015; Rédei et al., 2017; Sitzia, 2014), these new species can be related to current species and/or selected for their similar or dissimilar functional traits.

The subject of introducing exotic, also called 'alien' forest species is hugely debated (Ennos et al., 2019; Vítková et al., 2016). European forests having a rather low natural tree species diversity (less than 200 hundred species) because of its past and geography, compared to North-America (1,400 species) (Beech et al., 2017), makes it inclined to try new introduced species. Although, these introductions can have both many advantages and drawbacks. In one way, these introductions can have a positive impact by increasing forest biodiversity in some aspects but can also lower it in others (Quine and Humphrey, 2010). A major threat feared when planting exotic species is the risk of invasion that it may cause, with historic European examples such as the tree of heaven (*Ailanthus altissima (Mill.) Swingle*) (Sladonja et al., 2015), the black locust (*Robinia pseudoacacia* L.) (Vítková et al., 2017) or black cherry (*Prunus serotina* Ehrh.) (Pairon et al., 2010) widely recognized as invasive species in Europe, though a consensual definition of an invasive forest species has not really emerged yet (Richardson and Rejmánek, 2011). These examples enlighten that a careful and thorough risk analysis must be carried before trying to introduce exotic species on a large scale, what has been done for example for the species of the *Hakea* genus in the Esterel forest (Ducatillion et al., 2015).

Taking into account all the benefits that new species introduction can provide, the one that has been the most important for past introduction in recent forestry has been an economic purpose (Nyssen et al., 2016). Indeed, tree species introduction has been widely carried out in the past, mostly aiming at fast-growing and/or high timber quality trees in order to improve forest yield such as douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) (Vor et al., 2016).

Considering that these species are now widely planted in some regions of Europe (Nyssen et al., 2016), it is clear that the introduction of new species has been considered as more beneficial than harmful, though new researches on introducing new alien species are very scarce (DE BOISSESON, 2015; Hoffmann et al., 2018), especially in France where the variety of climate may provide more species to try than in other countries.

In order to find these new species likely to be introduced in France, it is necessary to assess beforehand the suitability of the new species to French climate. A simple assessment of the species natural range may not be sufficient to predict the introduction range. Thus, it is necessary to try these species in the potential introduction range to study its reaction to the new conditions.

New programs are being created with this purpose but their results are still juvenile compared to the life span of trees (Correia et al., 2018). Exotic species may also be hard to find on this new territory because testing new species was not common in France. It may especially be hard to find these introduced species outside botanical gardens or parks, where many conditions make it not suitable for assessment in forestry purpose. The problems are the often lack of history, the non-forest conditions that may bias tree growth and the low number of trees.

Luckily, the French National Institute of Agricultural Research (INRA) tries to address this topic of new species well suited to introduction in French forests. Having installed research trials, that are now known as scientific arboretums almost 50 years ago, it is possible to look further into the topic without most of the above issues. Indeed, these trials allow us to compare various non-exotic species grown in forest-like conditions using local species planted in the trials as witness-species.

So, in this study, we have investigated relatively old arboretums located in France with a huge range of new exotic species distributed in these trials. We will address the following questions:

1. Using the local taxa as witness which species are the most fitted in terms of survival and growth to French forest arboretums?
2. To which conditions in a current climate prospective are those species fitted?
3. To which conditions in various modelled future climate prospective are those species fitted?

3. Material & Methods

Study sites

We have studied 6 sites known as scientific arboretums established by the INRA in the late ‘60s and ‘70s and now managed by the French National Forest Office (ONF). These sites cover 3 different climates, Mediterranean(Treps, Canereit, Plan esterel), oceanic (Roumare) and mountainous (Sainte-Anastasie, Col des 3 soeurs) and were initially established for various purposes; finding new species mostly to replace the maritime pine (*Pinus pinaster* Aiton.) attacked by the maritime pine bast scale (*Matsucoccus feytaudi* Ducasse), finding species more tolerant to atmospheric pollution and finding new species to diversify mountain Norway spruce stands. With the Mediterranean climate having high temperature and low precipitation during summer period; the oceanic climate having both regular precipitation and low temperature variation with no drought stress in summer; the mountainous climate being defined by important local variation due to altitude but receiving a high amount of precipitation and low temperature.

They were planted to test their capacity to survive their new conditions, without any sylvicultural operations in the early stages. Most of the plots were planted with 30 individuals from 1 species and 1 provenance. Depending on the arboretum and the species, either a species was tested in only one plot with one provenance, in multiple plots with each time one different provenance, in multiple plots with only one provenance tested multiple times, and in some cases multiple plots of many provenances are repeated.

Although, on a site, some of the trees were planted during the birthdate of the arboretum, some sites can have varying planting dates depending on the plot. The largest difference being 7 years between the first planted plot and the last one.

An arboretum can be divided into many non-jointed sites, although some are composed only of one site. Within these site distinctions of what we call subdivions have been made, these subdivisions are supposed to be homogenous in term of station. Although it is important to remember that these are not exact repeated blocs so one species is not always repeated on every subdivion of every site.

Detailed characteristics and locations of every arboretum are available in *table 1* and *figure 1* respectively.

Arboretum name	Location	Coordinates (WGS 1984)	Year of birth	Elevation (m)	Soil	Climate	Plan
Canereit (CAN)	Var (83), Forêt domaniale de l'Estérel, SE of France	L: 6.8333, l: 43.4968	1973	260-320	Ryolith	Mediterranean	One site (5 ha), Forming a bowl with slopes facing North, South and South East
Plan Estérel (PLA)	Var (83), Forêt domaniale de l'Estérel, SE of France	L: 6.8223, l: 43.4924	1974	400-420	Ryolith	Mediterranean	One site (3ha), on a flat relief
Treps (TRE)	Var (83), Forêt domaniale des Maures, SE of France	Uplands : L: 6.3658, l: 43.2625 Thalweg : L : 6.3810, l:43.2746	1974	640	Gneiss	Mediterranean	Two sites, one on uplands (1.8ha), one in a thalweg (0.2ha)
Col des 3 Sœurs (COL)	Lozère (48), Forêt domaniale de la Croix-de-Bor, center mountain	L: 3.5652, l: 44.7230	1976	1390-1480	Granitic sand	Mountain	One site (7.5ha), including a mountain pass, a crest, a slope (40% slope at highest) and a bog
Sainte Anastasie (SAI)	Cantal (15), center mountain	L: 2.9776, l: 45.2063	1969	1200	Silt	Mountain	One site (5.3ha), on a flat relief
Roumare (ROU)	Seine-Maritime (76), Forêt domaniale de Roumare and Forêt domaniale Verte, NW of France	Mare Terreuse : L : 0.9793, l : 49.4001 Petit charme : L : 1.0034, l : 49.4186 Verte : L : 1.0576, l : 49.4941	1975	100-140	Silt & flint clay	Oceanic	Three sites (around 5.1ha each), all sites are on a flat relief

Tab 1 : Characteristic of the scientific arboretums managed by the French National Forestry Office

Fig 1 : Location of the scientific arboretums managed by the French National Forestry Office, red dots represent each arboretum, red lines represent French departments

The measured data

These arboretums were all subjected to measurements in the years 2011 and 2012. These measurements consisted in measuring on every plot each living tree's diameter at breast height (Dbh), which has been done only when the diameter at breast height was bigger than 2cm, thus shrubs were not measured. For smaller trees, only the number of trees remaining has been recorded. All those living trees have also been scaled with a sanitary notation ranging from 1 to 3 (healthy, with a few dying branches, life threatened). On top of that for each plot, the 3 trees with the biggest diameter had their total height measured, if less than 3 trees were still alive then all the alive trees were measured.

The data transformation

Firstly, in order to analyse trees survival data, we need to get rid of the problem of varying number of planted trees, that has been done by dividing the number of living trees by the number of initially planted trees, which gives a scale therefore called "Survival Index".

$$Survival\ Index\ (\%) = \frac{number\ of\ living\ trees}{number\ of\ initially\ planted\ trees} \times 100$$

Next, it was necessary to correct the age difference among the trees, both within and without an arboretum, in order to assess their growth accurately. This was achieved by creating 2 indexes, the first index being the "Height Index", consisting of the mean height of the 3 or less measured trees on the plot, divided by the number of vegetation season between the plantation and the measurement. Similarly, the "Diameter Index", is the root mean square of all the Dbh measured on the plot, divided by the number of vegetation season between the plantation and the measurement.

$$Height\ Index\ (m/year) = \frac{mean\ total\ height\ of\ the\ plot\ (m)}{year\ of\ measurement - year\ of\ planting}$$

$$Diameter\ Index\ (cm/year) = \frac{root\ mean\ square\ Dbh\ of\ the\ plot\ (cm)}{year\ of\ measurement - year\ of\ planting}$$

The data analysis per arboretum

Based on these raw indexes, it was possible within each arboretum to compare the surviving capabilities, of the different species and visually assess them based on these criterions. This process has been done differentiating both coniferous and deciduous trees but also differentiating the genus *Eucalyptus* within deciduous trees because of its very high growth rates compared to other deciduous in the Mediterranean arboretums.

Following this visual assessment, for the species having at least two plots within the arboretum, confidence intervals at the range of 95% were calculated for each index. Also, every species index was compared to those of the witness taxa to see if they were statistically below the witness taxa index, still at the range of 95%. This second phase of analysis can have a varying quality of results because of the lack of repetition in some arboretums, meaning significant differences may be hard to see. All the p_v results were then corrected using the package *fdrtool* (Bernd and Korbinian, 2015) within *R* (R Core Team, 2013).

The data analysis across arboretums

In order to approach the indexes at a more regional scale, we have compared the results of the species across arboretums of the same climate, except for the Oceanic climate where only the plot was considered the climate having only one arboretum. To be able to compare the indexes between the arboretums, new indexes per species were modelled using R's *breedR* package because of its ability to produce mixed models.

Both per species survival indexes and height indexes were modelled this way, not the diameter index because of its low relevance being influenced by many uncontrolled factors such as within survival of the plots, surrounding survival of the plots, and spatial distribution of the surviving trees.

After having tested many models for both the survival index and the height index the best models which were defined by the one having the lowest value of AIC are those presented below.

For the survival index, the best model is defined having as fixed effects the taxa, which is the coefficient we are searching for, the arboretum to account for fertility variation between arboretums, the subdivision to account for fertility variations within arboretums, and as random effects the provenance which account for genetic diversity within the species and the plantation date which can account for climatic variations sustained as a seedling. The model thus being:

$$y = X_1\beta_1 + X_2\beta_2 + X_3\beta_3 + Z_1u_1 + Z_2u_2 + \epsilon$$

Where

- y = survival index
- X_1 = unknow fixed effect of the taxa
- X_2 = unknow fixed effect of the arboretum
- X_3 = unknow fixed effect of the subdivision
- β_n = design matrixes relating y to X_1, X_2, X_3 respectively
- Z_1 = unknow random effect of the provenance
- Z_2 = unknow random effect of the planting date
- u_n = design matrixes relating y to Z_1, Z_2 respectively
- ϵ = unknow vector of random errors with mean E(ϵ) = 0

For the height index, after having tested various models, including the same as the survival index, the best model is defined only by fixed effects being the same as the one used for the survival index. This model is detailed below:

$$y = X_1\beta_1 + X_2\beta_2 + X_3\beta_3 + \epsilon$$

Where

- y = height index
- X_1 = unknow fixed effect of the taxa
- X_2 = unknow fixed effect of the arboretum
- X_3 = unknow fixed effect of the subdivision
- β_n = design matrixes relating y to X_1, X_2, X_3 respectively
- ϵ = unknow vector of random errors with mean E(ϵ) = 0

After having these models created, the same procedure has been followed for the per arboretum analysis using the species coefficient indexes that we acquired from the models instead of species mean values, it has the advantage of having these coefficients theoretically free of stationary differences.

Species fitness were then visually assessed using the fitted values of the models, again this process has been done separating coniferous, deciduous and Eucalyptus species when necessary.

Still following the previous method, confidence interval of the species indexes values at the pluri-arboretum scale were then calculated. Again, species were tested as significantly below the witness taxa values for the 2 indexes using t-test corrected using *fdrtool*.

The climate modelling

The prospective of where to advise these species based on climate conditions has been done using IKS model. IKS model is a model of climatic compatibility of species on a 1km grid across Europe based on the data of occurrence of the species in the different national forest inventory. In order to predict climate range, it uses 3 parameters to describe each species compatibility. They are based on the spatialised climate EU-data. These are the degree days sum (GDD), being the sum of days having mean temperature above 5°C, supposed to represent the length of growth period (TMIA), minimal temperature of the coldest month, supposed to represent the tolerance to coldness of the species and soil water balance deficit using Hargreaves evapotranspiration (SDEF), supposed to represent the tolerance to drought of the species. The soil water balance deficit was also calculated using spatial model of the soil maximum water capacity in order not to only consider climate but also pedological factors.

This model was here used with a slightly different function being climate forecast, which takes a single or multiple point on the grid and gives us the point having similar values on the grid. This allows us to check where the arboretums growth conditions can be found other than where they were planted. This feature was here used not only using the single point of the grid representing the arboretum but the whole ecological region defined by the French NFI as having homogenous growth conditions (Vidal et al., 2011). This was done in order to have a larger scale than the point tested, single point analogy being very restrictive.

Another feature used was the future climate analogy, the difference being that the current values of the ecological region are now compared to modelled future grid point values instead of current modelled grid point values. The modelling of the future grid point values has been done using the GIEC model of future predicted climate. The model hereby shown of future climate will be using the RCP 4.5 prevision of carbon emission with average model (on pessimism criteria) in the 2100 horizon.

4. Results

Indexes variation

Regarding the distribution of the different indexes (*figure 2 to 4*), they are very heterogeneous across and within the arboretums. It will be necessary to distinguish these 2 factors for the following analysis. The variations between the arboretums are probably mostly due to environmental factors such as climate, soil, plantation density, sylvicultural practices during young age, arboretum composition, those compositions can be different even within the same climate. The variations within the arboretums may be due to micro-climatic factors, soil variation, topography, incidents (game browsing, localized fire…), arboretum composition, genetic diversity within the species. These many factors may lead to having very heterogeneous indexes even within the same arboretum.

The survival index (*figure 2*) show that for the same arboretum coniferous species tend to have higher survival rate than deciduous species, no matter the arboretum or climate. However, this difference seem to be less pronounced mostly for Roumare, but also for Col des 3 Soeurs and Sainte-Anastasie arboretums (the last having only 1 deciduous species). Furthermore, in general the coniferous species have a higher variation of their survival index. The deciduous species having close to 0 median value, they are more constricted by the nature of the data. Roumare is the only arboretum where the distribution range of the survival index is bigger for the deciduous species than the coniferous species probably due to higher median value which doesn’t constrict the range at the 0 value. Concerning the eucalyptus species, their survival index seems to be higher than both coniferous and deciduous species in the arboretums where they were tested (except for Treps, which seem to have similar survival index between coniferous and eucalyptus). Their distribution range seems to be slightly shorter than coniferous trees which could mean the different species and provenance of the *Eucalyptus* genus react in similar ways in these arboretums. However, this difference could also be a consequence of the smaller number of species in this category than in others.

Concerning differences between arboretums, Mediterranean arboretums tend to have smaller survival rates, although considering the eucalyptus their mean rate is not so much below the others. Within these arboretums, it is hard to tell if the differences are due to climate/soil variation because of the differences in the species tested. For the coniferous trees, the oceanic and mountainous species survival index is displaying similar behaviour with a relatively short range of distribution and median close to 30%. However, Roumare deciduous species has bigger survival rates than Col des 3 Soeurs deciduous species and would tend to show higher survival rates for deciduous species in oceanic conditions than in mountainous conditions.

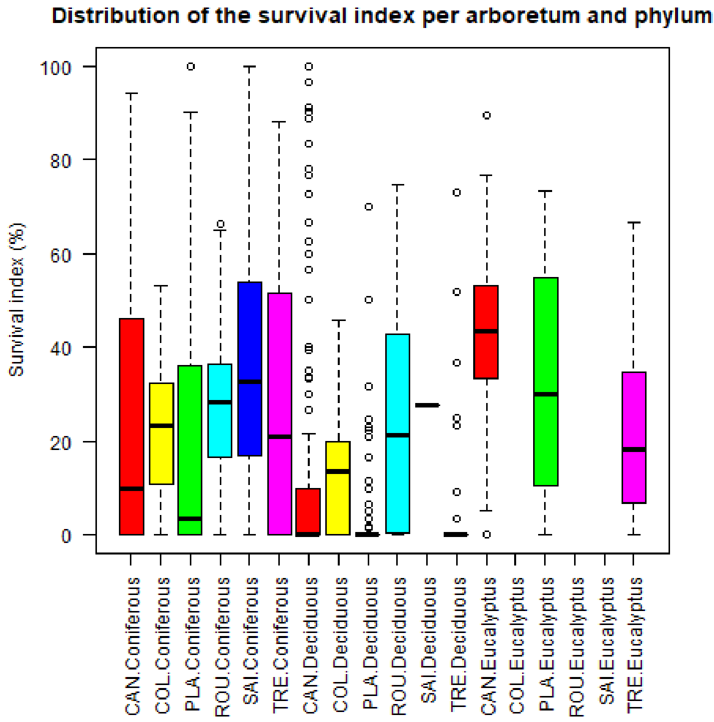

Fig 2 : Boxplot of the range of the species survival index per arboretum and phylum, deciduous species does not include species of the genus Eucalyptus

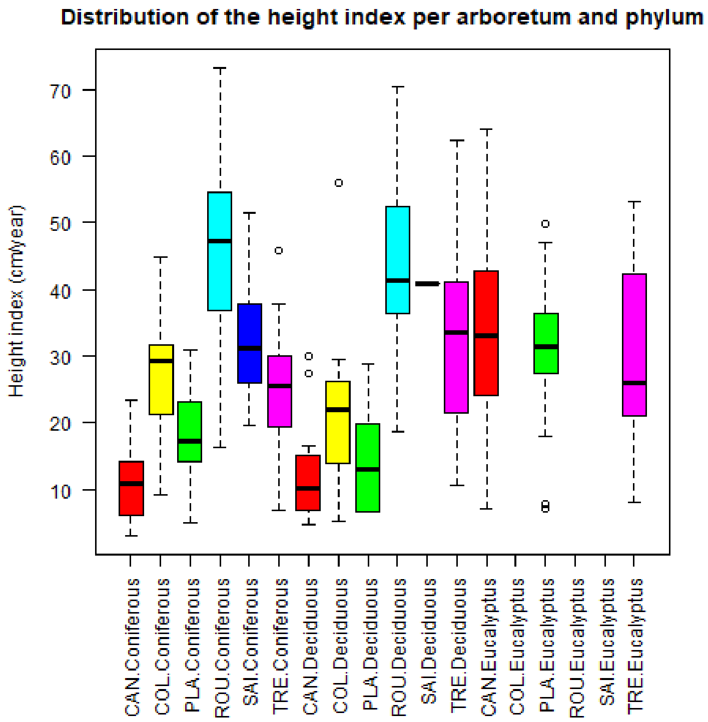

Fig 3 : Boxplot of the range of the species height index per arboretum and phylum deciduous species does not include species of the genus Eucalyptus

For the height index (*figure 3*), it is noticeable that intra-arboretum variation is less important than for the survival index. This is partly due to a selection of the most fitted species, indeed all the species presented here still possess at least one individual so the least fitted species, those with no individual left are not present for this index, contrary to the previous one. Differences between height index between coniferous and deciduous species are very low, except for Treps and Sainte-Anastasie where deciduous species have a higher height index, although the difference is still small. Eucalyptus on the other hand has performed much better in term of height growth than both deciduous and coniferous species in Caneiret and Plan de l'Esterel.

Regarding differences between arboretums, Mediterranean arboretums especially Caneiret and Plan de l'Esterel have lower growth indexes, between the two, Plan de l'Esterel is slightly higher. For the Treps arboretum, it does not appear to act like the two others with higher growth index. Treps arboretum has indeed tested fewer species, which might be the reason for its better results, because it may have tested less proportionally "bad fitted" species than Caneiret and Plan de l'Esterel. These 2 arboretums have tested a much larger range of species and thus more badly fitted species. The mountainous arboretums seem to have lower height index than Roumare arboretum, which has as for the survival index a better height index. Between the 2 mountainous arboretums, Sainte-Anastasie may have slightly higher height index than Col des 3 Soeurs but the difference is not significant.

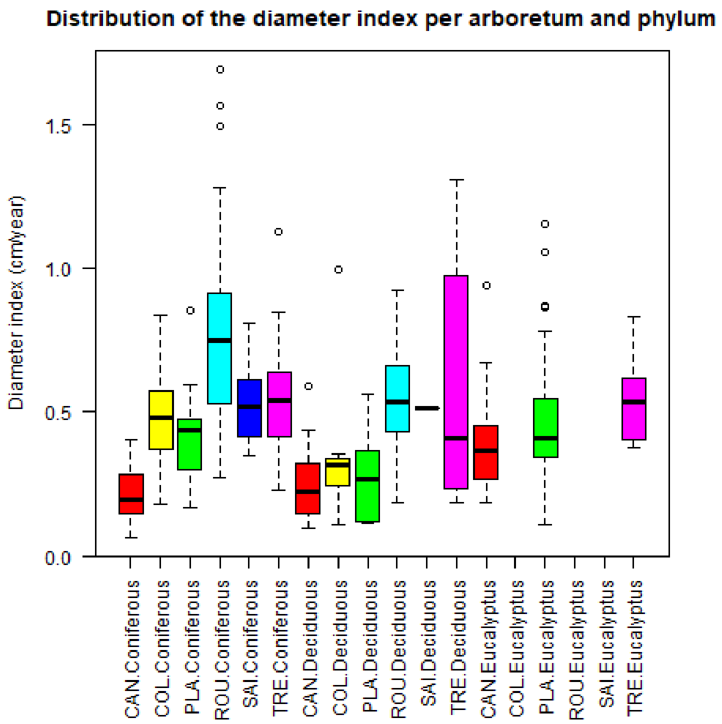

Fig 4 : Boxplot of the range of the species diameter index per arboretum and phylum deciduous species does not include species of the genus Eucalyptus

In the case of the diameter index (*figure 4*) the above all range of distribution is not significantly higher than both the survival index and the height index. Although, this difference is a consequence of a very low number of very fast growing (in term of diameter) species.

As for the height index, differences between coniferous and deciduous species are pretty low, even though coniferous species have slightly higher diameter index. The eucalyptus species also does not display much larger diameter index than the other species. Range of distribution with the arboretums is small, except for the deciduous species in the Treps, which might be partly due to better growth conditions of the deciduous trees in the small thalweg part of the arboretum.

Differences between Mediterranean climate and mountainous climate in regard of this index is not very clear, except for the Treps arboretum with better diameter index than the other 2 of the Mediterranean climate, diameter growth rate might just be slightly higher in the mountainous climate. However, Roumare has bigger diameter indexes than the other climate, although the difference is bigger for coniferous species than deciduous.

In regard of theses graphs, it is clear that differences between arboretums are present. Mediterannean arboretums are the harshest in term of survival and growth, although Treps may have better growing conditions and does not appear to react like the other two. Mountainous arboretums have better growing conditions than Mediterranean ones, though not as good as in Roumare arboretum. This arboretum is the one where both the growth and the survival is for most species better than the rest of the arboretums. These differences may indicate climate restriction because of the rude conditions of Mediterranean and mountainous climate and the much better suited climate conditions of the oceanic climate.

Per arboretum results

Every species was compared to the local species of the arboretum in regard to survival, height and diameter index also taking into account the number of plots considered arboretum per arboretum. That part was done visually via plots (data not shown), as clear rules to define a good or bad fitted species were not possible using that strategy a statistical analysis was required.

That statistical analysis led us to establish a list of the species that were at least as good as (with 95% confidence) the local species for each arboretum and each index. Though, as they are currently no *Eucalyptus* widely spread in the studied part of the Mediterranean region, the local species was chosen to be the same one as other broad-leaved species. It leaves us with in the Roumare arboretum *Fagus sylvatica L.* and *Pinus Sylvestris L.* respectively witness species for the broad-leaved species and the coniferous species. In the Col des 3 Soeurs arboretum *Betula pendula Roth* as witness species for the broadleaved and *Picea abies (L.) H. Karst* as witness for coniferous. In the Sainte-Anastasie arboretum *Abies alba* as witness for all species, as there were not enough broadleaved or *Picea abies (L.) H. Karst* plots. In the Caneiret and Plan de l'Esterel arboretums *Pinus nigra ssp. laricio Maire* was selected as witness for the coniferous, as *Pinus pinaster Aiton* which is more common in the region didn't have enough plots, and *Quercus pubescens Willd.* for the broad-leaved species. Finally, in the Treps arboretum only *Pinus nigra ssp. laricio Maire* was used as once again, no regionally common broad-leaved trees or *Pinus pinaster Aiton* were tested on multiple plots.

All species that had at least 2 plots were tested and classified in per arboretum and filum plots for each index (*Appendix 1 to 3* for respectively, survival index plots, height index plots and diameter index plots). As our goal is to search non-significant differences (as the species is at least as good as) a table available in *Appendix 4* summarise all the non-significant differences for every species tested and each index.

Among all those species, the interesting ones are those with non-significant differences regarding both survival index and the height index, diameter index being more an indicative data in our dataset. The subset created by the species responding to those criterions and their respective values and test values are shown in *Appendix 5*. This list of species contains 79 different species in at least one arboretum, only 74 species if we exclude all the local species. Those species are mostly selected in only 4 arboretums which are Caneiret, Plan de l'Esterel, Sainte-Anastasie and Roumare. Among those in Caneiret and Plan de l'Esterel broadleaved trees represent the vast majority of selected species due to the relative bad fitness of the witness species ie. *Quercus pubescens Willd*. In Sainte-Anastasie significant differences with Abies alba are very hard to assess because of the very low number of repetitions. In Roumare, both broadleaved and coniferous species were selected, accounting for all the species tested and the relatively good growing conditions high number of selected species was to be expected with 22 selected species (without the witness species) for 118 tested species. This is also due to a high number of repetitions allowing to detect significant differences. In the other arboretums, on the one hand, some broadleaved species were selected in the Col des 3 Soeurs arboretum but as broadleaved species were not much tested in this arboretum this selection was to be expected. For the coniferous species of the Col des 3 Soeurs arboretum and the Treps arboretum no species were selected because the witness species have high value for both indexes and no species has as good values as this local species for both the survival and the height index.

Pluri-arboretum results

After having modelled the survival and height index, they were presented in per climate group bi-dimensional plots averaged on the arboretum and subdivision levels to take into account differences in growth conditions within and between arboretums, those plots are not shown as for the same reason as before a more statistical procedure was preferred.

Following the same steps as before but this time using mean values over multiple arboretums and modelized index values, we made a classification for the survival index and the height index of all the species we could test, these classifications are available in *Appendix 6 and 7*, respectively. It is possible to see that values for the Roumare arboretums are different than those previously presented because those fitted values take into account differences between plots and subdivisions conditions and are thus more accurate.

As previously, non-significant differences were displayed into a table (shown in *Appendix 8*) and then selected for both as good as the witness survival and height index, the respective index values of these selected species are shown in *Appendix 9*. This time, only 41 species in total were selected (not taking into account the witness species, except for *Betula pendula Roth* which was selected in Roumare where it's not a witness species). As showed in *figure 5a* most of the species are selected in the Mediterranean arboretums (25 species) followed by the Roumare arboretum (11 species) and with only 3 species selected in the mountainous arboretum. Among those selected species, no matter the arboretum groups a very low amount of coniferous species was selected with only 3 coniferous species selected in the Roumare arboretum. The *Eucalyptus* species are widely dominant in the Mediterranean selection with more than 90% of the species being Eucalyptus. If we compare the global number of selected species (41) and the number of the tested species (330, once again not including local species) that selection is drastic with only 12% of the tested species succeeding this phase.

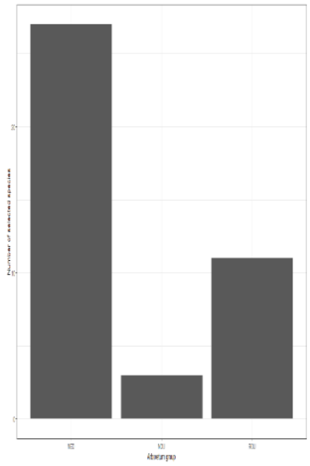

Fig 5a : Repartition of the selected species throughout the arboretum groups

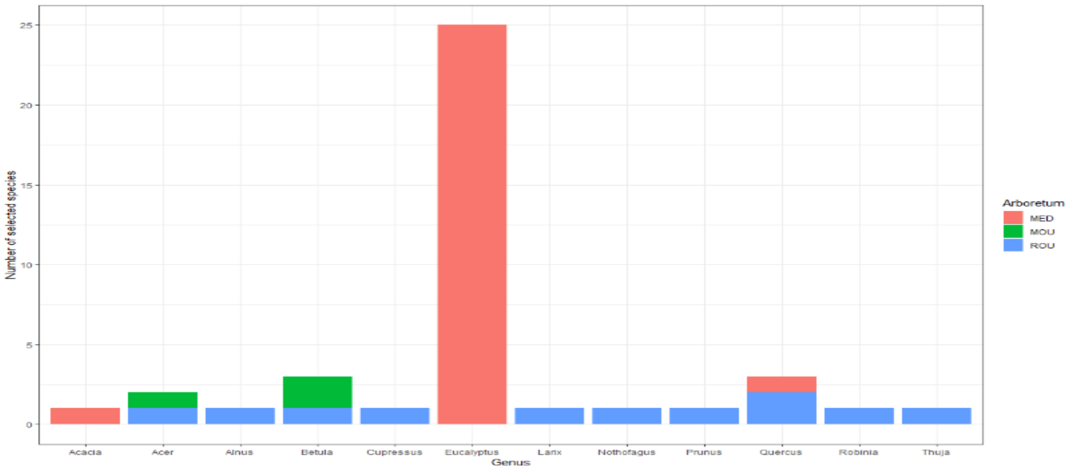

Fig 5b : Repartition of the selected species in genus and arboretum groups

The climate analogies

The list of the species established allow to address the issue of upscaling this scarce data by using climate analogy based on the 3 climate parameters described previously. To have a more global scale to work with, we used the whole ecological region including the arboretums as climate reference, these sylvoecological regions (SER) are described in *table 2* in reference to *Vidal et al., 2011*.

Arboretum name	Location	Coordinates (WGS 1984)	Sylvoecological region code	Sylvoecological region name
Canereit (CAN)	Var (83), Forêt domaniale de l'Estérel, SE of France	L: 6.8333, l: 43.4968	J30	Maures and Esterel
Plan Estérel (PLA)	Var (83), Forêt domaniale de l'Estérel, SE of France	L: 6.8223, l: 43.4924	J30	Maures and Esterel
Treps (TRE)	Var (83), Forêt domaniale des Maures, SE of France	Uplands : L: 6.3658, l: 43.2625 Thalweg : L : 6.3810, l:43.2746	J30	Maures and Esterel
Col des 3 Sœurs (COL)	Lozère (48), Forêt domaniale de la Croix-de-Bor, Center mountain	L: 3.5652, l: 44.7230	G22	Granitic plateau from the middle of the Center mountain
Sainte Anastasie (SAI)	Cantal (15), Center mountain	L: 2.9776, l: 45.2063	G30	Volcanic Center mountain
Roumare (ROU)	Seine-Maritime (76), Forêt domaniale de Roumare and Forêt domaniale Verte, NW of France	Mare Terreuse : L : 0.9793, l : 49.4001 Petit charme : L : 1.0034, l : 49.4186 Verte : L : 1.0576, l : 49.4941	B10	Sides and plateau of the Channel

Tab 2 : Correspondence of the arboretum with the French NFI sylvoecological region system

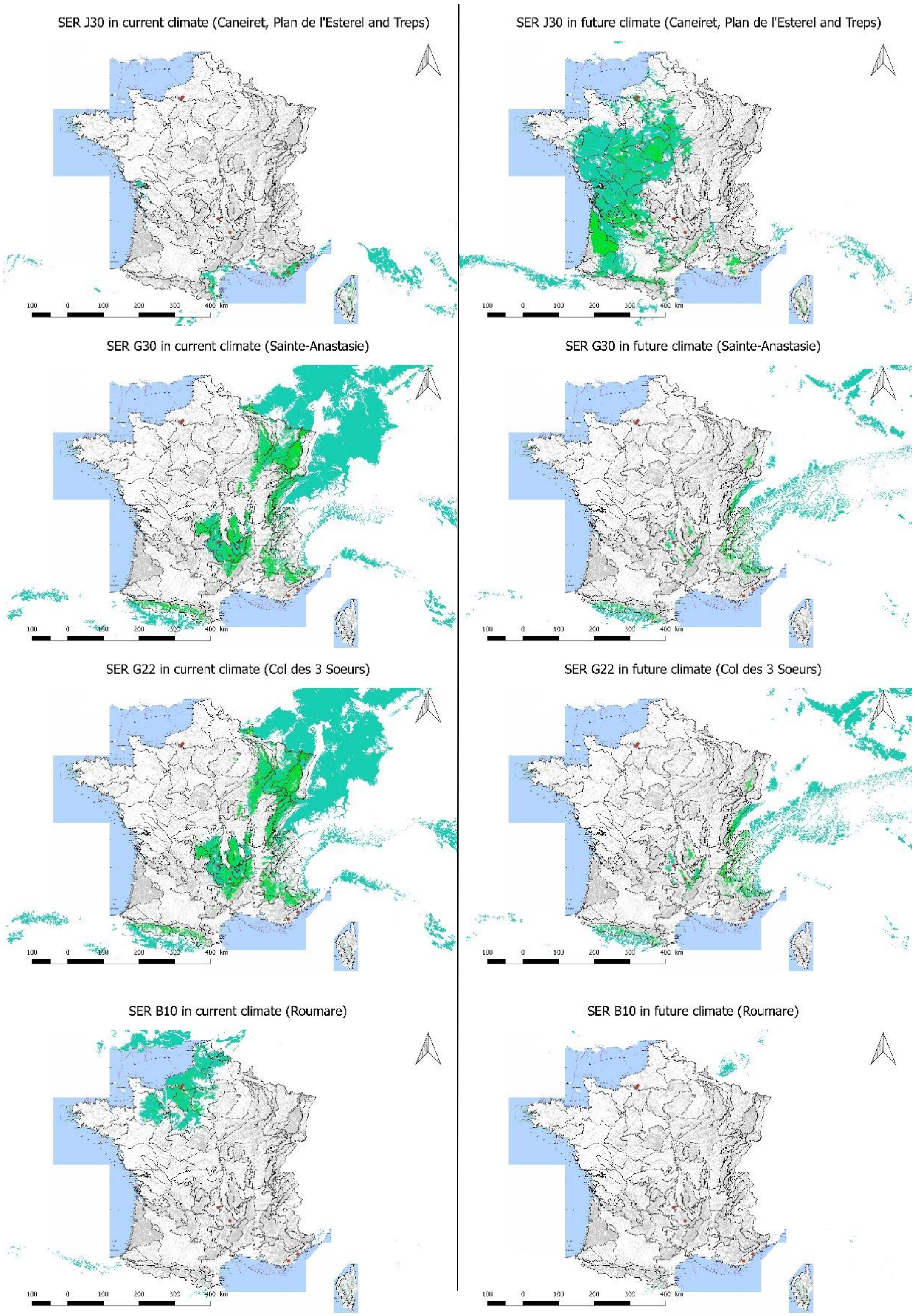

Fig 6 : Climate analogy of various French sylvoecological regions based on the IKS model, future climate is modelized for 2100 with average pessimistic model and 4.5RCP. Red dots represent the localisation of the arboretums, grey dots represent French NFI datapoints with no climate analogy to the SER, green dots represent French NFI datapoints having climate analogy to the SER, blue dots represent points with no French NFI datapoints but with climate analogy to the SER, black lines represent all the sylvoecological regions.

Seeing the mapping of the climate analogies in figure 6, we can say that within current climate conditions, same growing conditions as those we can find in the studied arboretum can be found in vast regions, which is even more true for mountainous arboretums with climate analogy findable in Spain, other French regions, Italy, Switzerland, Luxembourg, Germany and Belgium. The SER including the Roumare arboretum also currently having similar growth conditions as those of Southern-England, Belgium, the Netherlands and some parts of Spain and Italy. Concerning the SER J30 that includes the Mediterranean arboretums, it has same current growth conditions as some parts of the Mediterranean basins' country as Italy and Spain.

Regarding only France, those analogies can make us think that similar growth conditions to some arboretums can be found around the Mediterranean Sea, in the different mountain chains, Eastern France and Northern France. In these regions even though no arboretums of this kind have been installed, those results could have a certain meaning.

On the other hand, in future climate conditions, the analogy to current arboretums SER are scarcer though not totally non-existent. The SER containing the Roumare arboretum does account for future parts of Germany climate, even though the area remains pretty limited, the results from this arboretum are though not the most useful in context of climate change in this range of time and with this climate modelization. Concerning both the mountainous SER, their climate in these future modelled conditions can be fosund in mountainous regions of Western and Central Europe, though they are found in higher altitude that they currently have. In the case of the Maures and Esterel sylvoecological region, it is the most interesting concerning France in the future climate because it is predicted to be the future climate of a vast majority of Western France, and also some parts of Spain and Italy.

We can say that our results are in some way extendable to some parts of French regions, such as the Western part and high mountainous region in order to anticipate future climate in those regions, though it is important to remember that those species may not be well suited for these new regions' climate yet and thus would require some time to assess their suitability under those current climates.

5. Discussion

Study sites

Our results on these arboretums may provide some insight over the fitness of certain species in France however the study sites used here present some downfalls. For instance, we have to take into account their relative low number and limited geographical repartition when trying to upscale the results over France and it prevents us from making any niche model for the species. Concerning those species, it is clear that all the possible tested species were not planted in the different sites at the time of the plantations, we are thus limited to what was planted back then which is not fully representative of what could have been tried. This is the result of the various purposes of the arboretum creations and makes it harder to analyse them on a multi-arboretum scale. For example, species represented in the arboretums mostly come from the Northern hemisphere (North America, Central Europe, Asia) and Australia which leads us to having lots of species in the *Eucalyptus* genus but very few species from the African continent. That certainly induce a bias in the origin of the species finally selected. Those experiments were however selected because of their old age, their high number of species and their repetitions, though this last point differs among the arboretums and can strongly influence statistical results.

Even though, in some cases, the same species can be found in different climates, the Roumare arboretum making the connection, the treatment received prevents us from cross-climate analysis, because young age treatment was the same as for local trees but differs across different regions.

The relative within site diversity could be concerning because our analysis is made with mean site values, that problem has been sorted with the mix-model taking into account plots and subdivisions which were made to have homogenous growth conditions, regarding slope, exposition, soil.

The measured data

These arboretums have been subjected to numerous data measurement, in those, we selected only one dataset because it is the only dataset using the same protocol throughout all the arboretums and thus the only one which is coherent across the study sites. After new measurements, it would be interesting to see the evolution of the results, especially after the recent year severe summer drought which may have an impact on species survival.

The data transformation

The indexes that were used throughout this analysis induce some bias that we need to take into account to mitigate our results. The survival index for instance, is not a survival rate, because the trees measured in 2011-2012 may not be the same ones as those planted, the trees have been numbered at first but it was soon impossible to use because of archiving problems and high mortality rates. Thus, trees that are now measured may not be the exact same ones as those planted, which is notably the case for most *Eucalyptus* that died by frost (event observed but not recorded) and then resprouted as coppice, each new stem counting as an individual. This may introduce an overestimating bias in term of survival and an underestimation bias in terms of growth for those species. As we have no record of the dying date and scale it was not possible to counteract this issue using the data available, though the scale of the problem remains limited and the *Eucalyptus* species still have high growth results even though their age is overestimated.

Concerning this age correction for the growth indexes, it was necessary because of the varying age both within and without the arboretums, it is not flawless though. This was only possible because of a small range of age between the trees, otherwise the changing pattern of growth trend with age would have prevented us from analysing trees planted at different ages.

These growth indexes are moreover uncommon, the height index standing as a proxy of dominant height growth, which is supposedly free from competition effects and thus specific to a certain species in a certain growth conditions, which is the second most important factor in our study. This proxy was the closest index we could compute using the data available and taking into account the low number of trees on the plot. The diameter index is thought to be more dependent of local growth conditions, diameter being strongly affected by competition, though the mean values of the diameter still give us indicative values. This impact of competition, hardly quantifiable in that case, made us choose not to use it for the selection of the species.

We could have chosen other indicators such as basal area, volume or biomass, that were more aggregating that those used were not chosen in our case because of multiple problems. Firstly, the high local disturbance (both within and without each unitary plot) makes it really hard to define an area on which each unitary plot, or trees for the matter, is located. Indeed, variations of competitiveness between species led to have some species to grow only on some parts of the unitary plot, or on the neighbouring unitary plot making the definition of a unitary plot area very complicated.

Plots being too small to install buffer zones to study only the middle of the plots, indicators that are averaged on a surface scale are not usable. Secondly, the high variety of species makes it really hard to find equations well suited to calculate these factors on standing trees.

The data analysis per arboretum

As our goal was to find new species that are at least as fitted as the local taxa, the statistical t-test was the best way to test that. A problem emerging from that though is the choice of the local taxa used which is not always the best suited because it is required to choose a taxa that has been planted in the arboretum, it is notably the case for *Pinus pinaster Aiton* which was not repeated in the Mediterranean arboretums even though it is the most common coniferous in the region. Those choices lead to have different results based on the witness taxa chosen. We always took the most fitted taxa that does currently occur (naturally or not) in managed forests on a large enough scale. This was done to have a hard selection and to be able to relate our results with well-known species. A problem with that method is the lack of Eucalyptus witness species which made us use *Quercus pubescens Willd.* as witness species and led to have most *Eucalyptus* selected. As *Eucalyptus* is not currently widely used in the region no witness *Eucalyptus* species does emerge, though in other European regions such a witness *Eucalyptus* species would have been possible.

Regarding the correction of the pvalues using *fdrtool* as our data does not imply a high number of repetitions, it was thought to be more suited to spot significant differences than more conservative processing such as Bonferroni. Though, the number of tests being rather low, this correction may not be strong enough for our dataset and induce some false-positive.

The data analysis across arboretums

The modelling was used to correct the indexes from the arboretums and the subdivision index in order for them to be only dependent on the species. It is though impossible to correct every effect that took place during the arboretum life span and that may not have been recorded, such as localised fire on a plot, game browsing that can taint our results. Moreover, these experiments not being made with repeated exact same bloc, the subdivision and arboretum effects are highly dependent on some species that are present in different blocs and arboretums, the number of these species being lower than the number of tested species it is possible that some arboretums and subdivisions effects were not entirely assessed through this process. The best model for each index was chosen based on the AIC to try to minimize these factors and make the model as strong as possible.

The climate modelling

Regarding the climate modelling part, as it is a modelling on the European scale at the grid of 1x1km it is expected to have low accuracy on the very local scale, which may have been a problem in our case, especially for the mountainous regions. That issue was avoided by choosing to focus only on the SER scale which drastically reduces the need of local precision and also allows us to have more ranges of results than just single pixel climate analogy. However, upscaling our results from single points to the whole SER level as we did needs to be done with caution because even though SER were made to be homogenous in conditions, some variability within SER still remains and needs to be taken into account. It is even more important to notice that our prediction of potential trying for these species does only take into account climate data (and soil water content) but not soil fertility or humidity level, which are important factor for tree ecology. The range thus proposed must be locally refined to verify these factors before trying the species.

The modelling conditions are the range 2100, average pessimist model and RCP4.5, they were chosen to try to summarize in a single map the climate the trees we plant now are likely to suffer. Indeed, as trees life span is long, having the 2050 which is proposed in the IKS model didn't seem to fit new plantations.

Indexes variation

In regard of the index variation, it is interesting to notice that climate group patterns emerge, it is clear that the best growing conditions can be found in the Roumare arboretum, that is probably due to the regular precipitations and long vegetation period which are favourable to plant growth. The mountainous arboretums still have some good growth and survival but it is still much diminished when compared to Roumare, the mountainous conditions are in one way favourable to plant growth with high precipitation but in the other way the reduced vegetation period because of snow and frost does limit their growing capability, only species strongly resistant to frost and able to grow with short vegetation period resisted. The worst growing and surviving conditions are found in the Caneiret and Plan de l'Esterel arboretums, since those 2 are very similar, it is logical to find them responding the same way, the high drought than can be found in the region does strongly limit both the vegetation period and the survivability of the trees. The species must be very adapted to those kinds of climate and often display resistance to drought strategy that costs them some growth ability. The Treps arboretum displays intermediate reactions between mountainous arboretums and Mediterranean ones because of its relative high altitude, making it a little less prone to high drought than the 2 others.

Per arboretum results

Analysing the per arboretum selected species, it is clear that our choices in witness species strongly influenced the results obtained and that even though the species must not be better than the witness species but only as good as it, if the witness species is well adapted to its environment finding a species that is just as good as it may be difficult. Namely, *Picea abies (L.) H. Karst* is not equalled on the Col des 3 Soeurs arboretum and that would probably also be the case if it was repeated in the Sainte-Anastasie arboretum. Choosing another witness species would be irrelevant as it is the most common species of the region and even the reason to create these arboretums but in the other way it does prevent us to select any species on this arboretum. The same pattern occurs for the Treps arboretum where *Pinus nigra ssp. laricio Maire* does not have any concurrence among the other species tested. In these constrained environments the local taxa are just the best fitted, another way of selecting species may then be applied to those with for example choosing the best 10% of the species, but it also carries the problem of having results that are strongly dependent on the dataset. The Caneiret and Plan de l'Esterel arboretums having selected mostly *Eucalyptus* species in the absence of a proper witness does have the same issue.

On the other side, Roumare being much more favourable more species can be found to be as good as the witness species which shows us that the witness species can be competed with on this arboretum.

Pluri-arboretum results

Concerning the pluri-arboretum results, it is interesting to see that the selected species are more polarized toward deciduous species. Once again, it is mostly a matter of witness species selection, with very good fitted coniferous species as witness species, those species being more wide-ranged than the broad-leaved ones. It is notably the case for the mountainous arboretums where the selected species *Betula pendula Roth.* is not the most suited at such high altitude and thus does not display as good relative performance as the Norway spruce. The same thing happened for the Mediterranean arboretums.

It is also important to notice that the number of selected species is diminished, that is due to reduced standard errors because of corrections for arboretum and subdivision variations, which allows to point more statistical differences. Though these results are obtained on modelled values and are also averaged at the climate scale, which may induce some problems if local differences take place. It is notably the case for the broad-leaved trees in the mountainous arboretums which have been selected only on the Col des 3 Soeurs arboretums and may not be suited for the Sainte-Anastasie conditions.

The climate analogies

The IKS model having been constructed to create climate range compatibility for already widely spread species, the usage made here was not its primary purpose. It is important to consider that, the variables behind this model are supposed to be common to define all tree species range of compatibility and thus should also apply to our non-local species. Since we do not use the climate range compatibility feature, by lack of point to establish its niche, we use the SER as a proxy of its climate range compatibility.

The assessment of current climate analogy, although interesting to see where those species can already be planted without too many risks is not thought to be the most important part in our context of climate change. Indeed, the future climate range is more useful in order to advise forest managers in their plantations or to launch new species trials because it helps us imagine the future conditions the tree we plant is going to live through. Though, it is still important to remember that the tree must also survive the current conditions in order to grow in the future and not blindly plant in the predicted future compatible climate.

6. Conclusion

On a donc vu que l'utilisation des arboretums scientifiques de l'ONF nous a permis d'étudier sous des climats divers l'adaptation climatique de certaines essences exotiques aux conditions de France métropolitaine. Après une comparaison sur des critères de survie et dendrométrique par rapport aux essences références locales, il a été possible d'établir une liste d'essences qui sont statistiquement au moins aussi bonnes que les essences locales sur ces critères. Ce travail nous a permis de mettre en évidence la bonne adaptation des essences locales à leurs conditions de croissance difficile, les essences exotiques ayant du mal à rivaliser avec celles-ci.

Nous avons également pu mettre en évidence grâce au modèle IKS que bien que ce nombre d'arboretums reste limité, les résultats peuvent être généralisés à plus grande échelle. Cela soit dans un contexte de climat actuel où les essences peuvent-être utilisées pour diversifier les peuplements ou dans le cadre d'un climat futur projeté avec notamment les conditions climatiques des arboretums méditerranéens pouvant être attendues et généralisées sur une grande surface à l'échelle française. Il est toutefois nécessaire de prendre en compte les conditions de climat actuel avant d'entreprendre toute intervention et notamment plantation en vue d'adaptation des espèces.

Pour conclure, il est d'une part nécessaire d'améliorer nos connaissances sur la croissance de ces espèces dans d'autres contextes et notamment les contextes prévus comme l'équivalent du climat actuel des arboretums, avec par exemple des plantations d'espèces se trouvant dans les arboretums méditerranéens sur la façade atlantique française. Mais il est d'autre part nécessaire d'apporter des réponses plus rapidement en se concentrant sur les dispositifs déjà mis en place pour améliorer nos connaissances sur l'autécologie de ces espèces. Ce qui est notamment possible par le biais d'autres dispositifs, expérimentations ou simplement plantations atypiques augmentant le nombre de mesures réalisées et permettant d'étendre nos connaissances sur ces espèces par la création d'un gradient de répartition climatique de ces espèces. Ma 3ème année d'apprentissage sera consacrée à ce sujet avec l'étude de l'impact d'évènements climatiques extrêmes sur une partie des essences sélectionnées via une analyse dendroécologique, ce qui permettra de raffiner encore plus la sélection d'espèces en ne sélectionnant que les plus résistantes aux conditions climatiques extrêmes qui risquent de s'accentuer.

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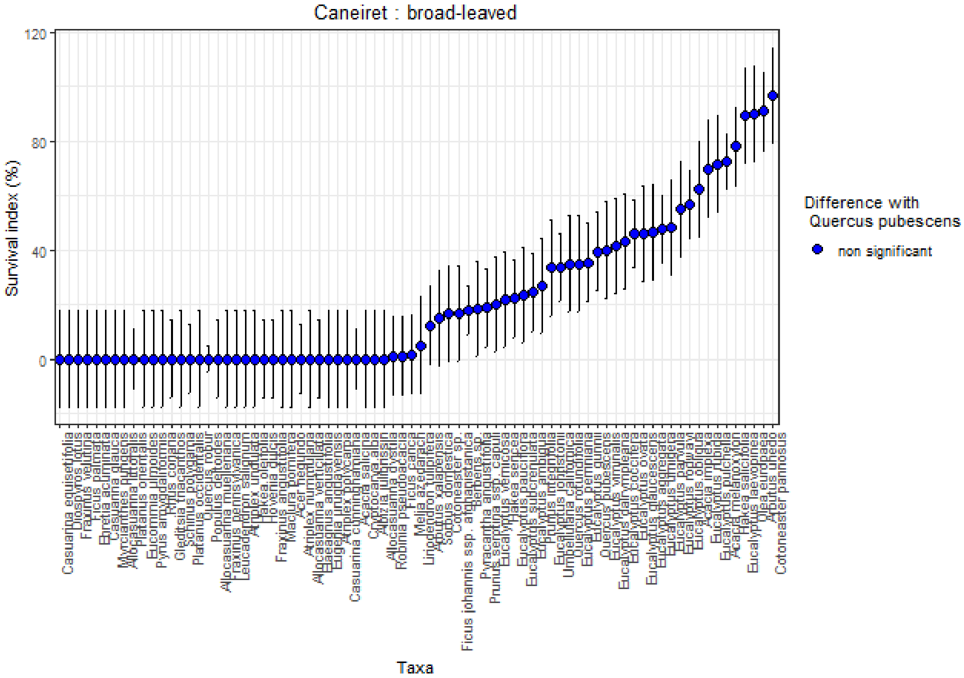
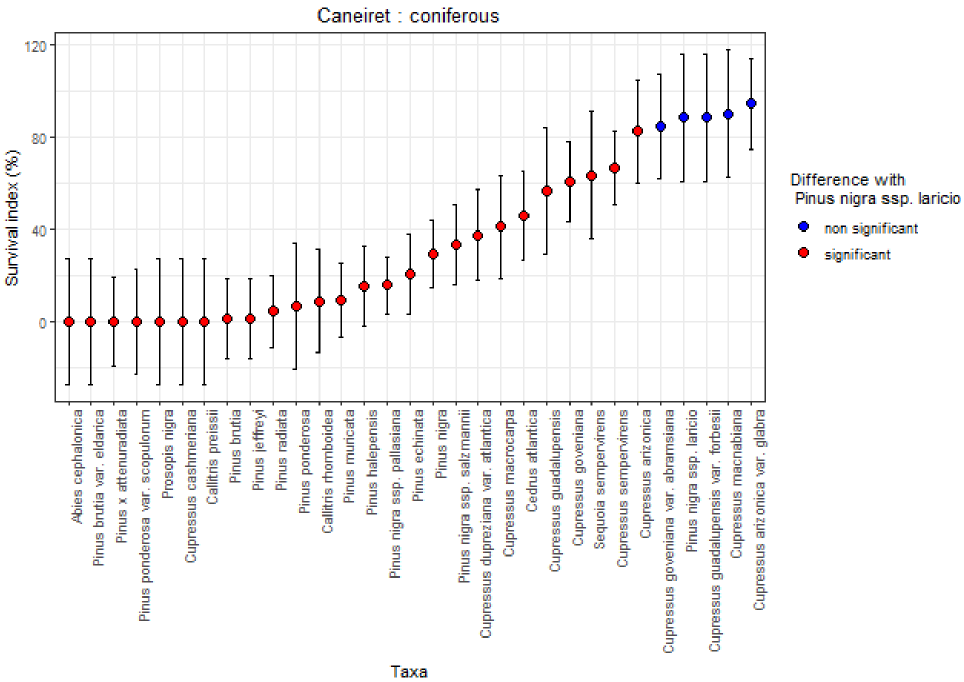
Species in European Forests: Opportunities and Challenges, In Focus - Managing Forest in Europe. European Forest Institute, Joensuu, pp. 148–157.

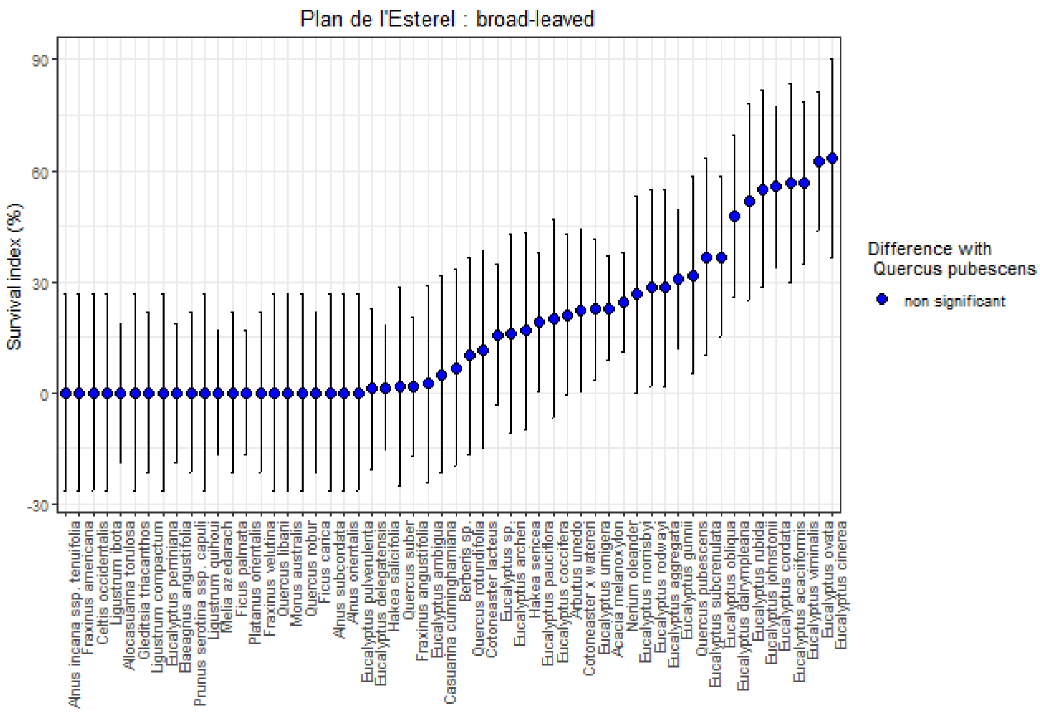
8. Appendix



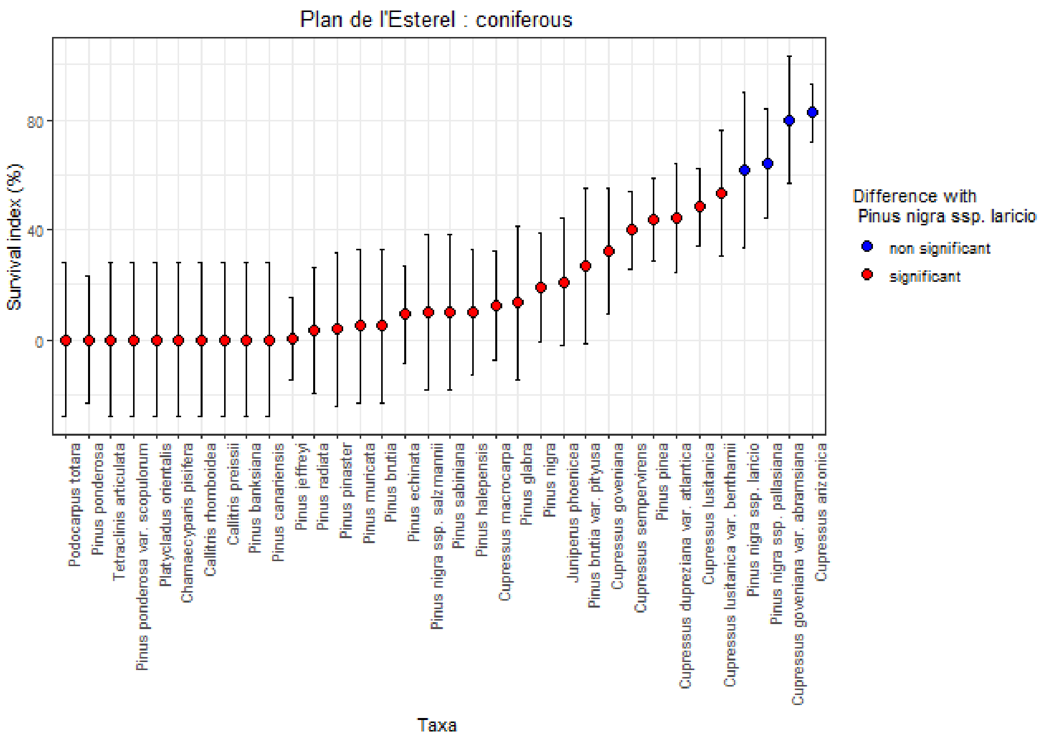
Appendix 1a : Classification of the survival index for the broad-leaved species of the Caneiret arboretum, blue species are non-significantly worse than Quercus pubescens, red species are significantly worse than Quercus pubescens, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



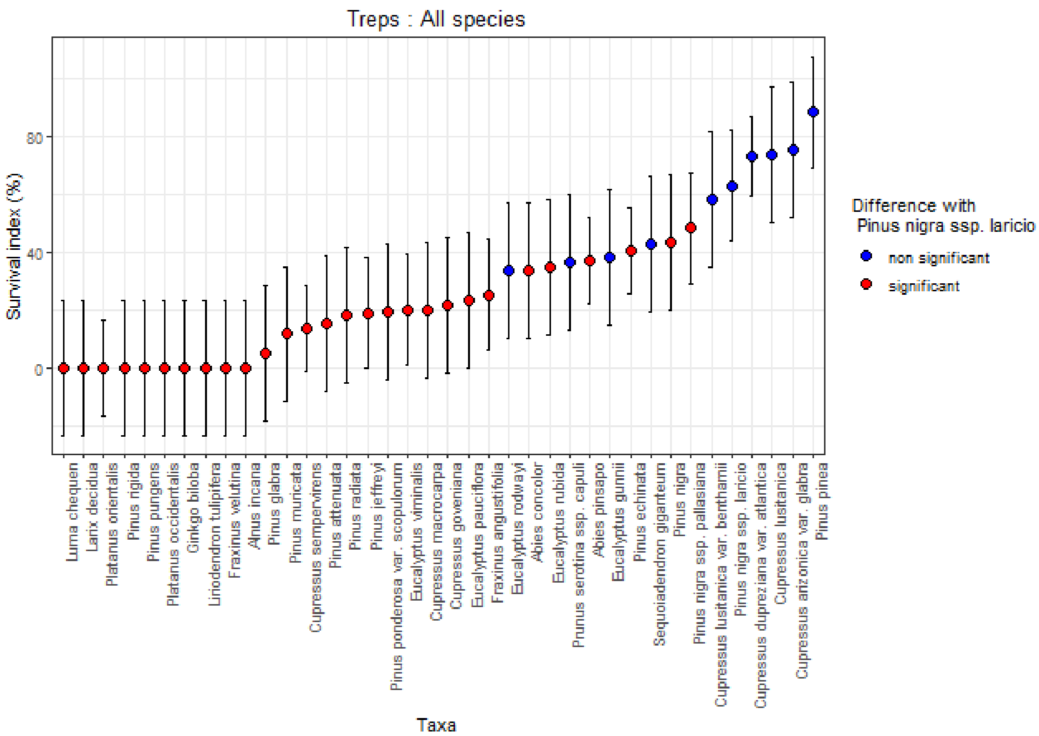
Appendix 1b : Classification of the survival index for the coniferous species of the Caneiret arboretum, blue species are non-significantly worse than Pinus nigra ssp. laricio, red species are significantly worse than Pinus nigra ssp. laricio, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



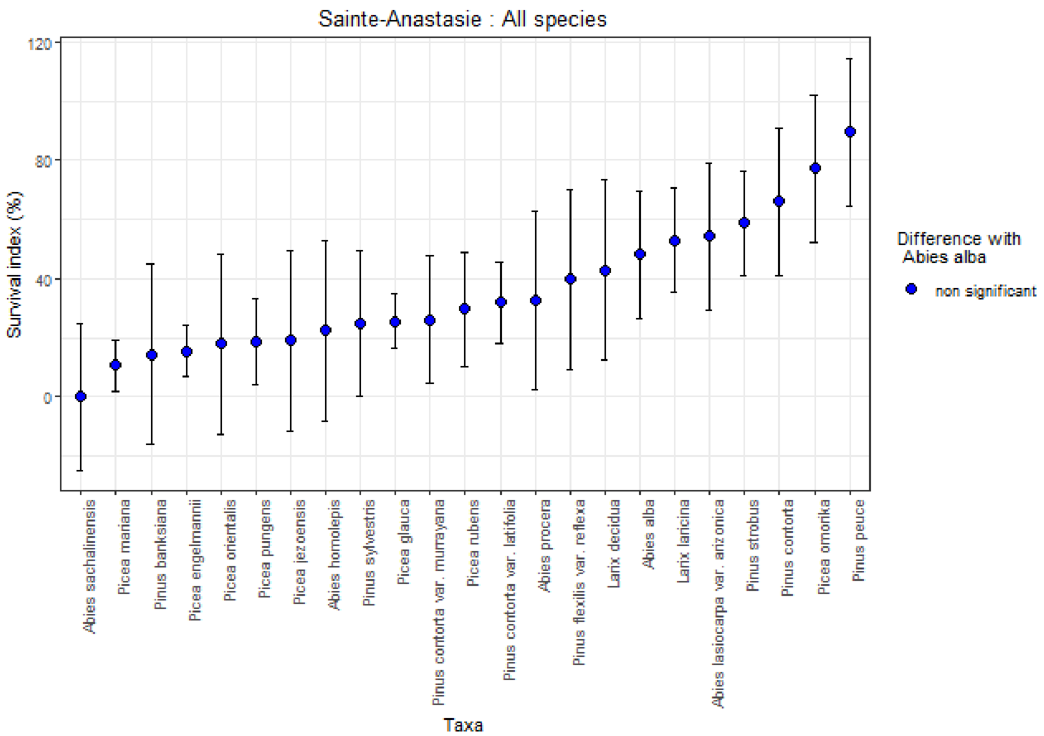
Appendix 1c : Classification of the survival index for the broad-leaved species of the Plan de l'Esterel arboretum, blue species are non-significantly worse than Quercus pubescens, red species are significantly worse than Quercus pubescens, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



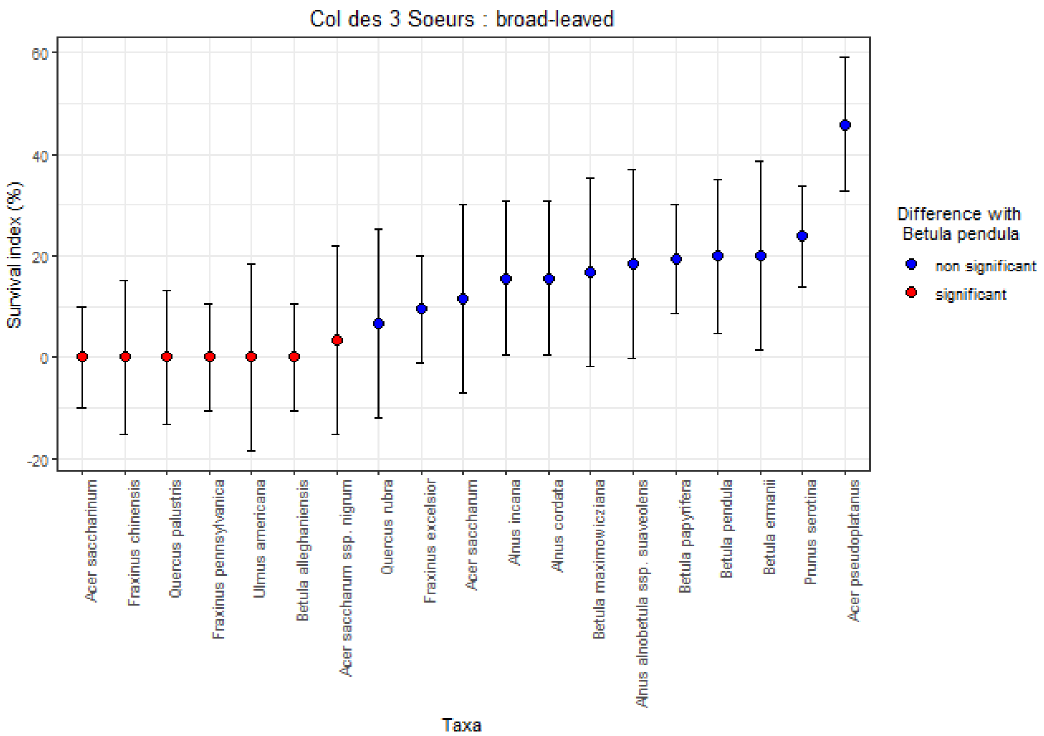
Appendix 1d : Classification of the survival index for the coniferous species of the Plan de l'Esterel arboretum, blue species are non-significantly worse than Pinus nigra ssp. laricio, red species are significantly worse than Pinus nigra ssp. laricio, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



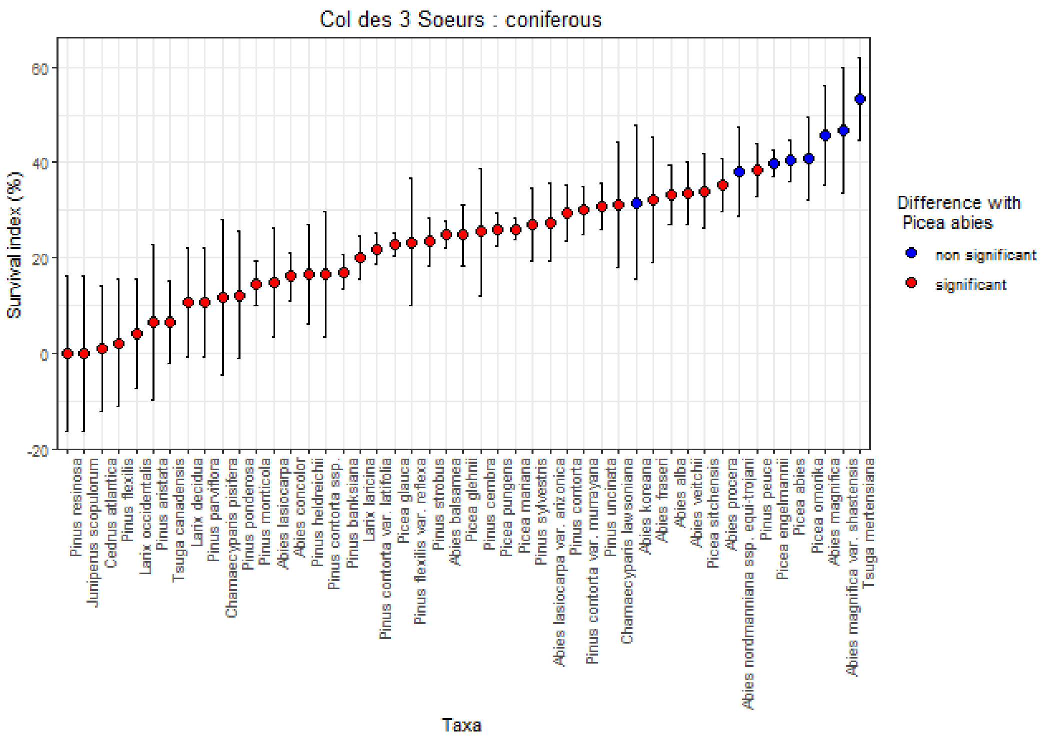
Appendix 1e : Classification of the survival index for the species of the Treps arboretum, blue species are non-significantly worse than Pinus nigra ssp. laricio, red species are significantly worse than Pinus nigra ssp. laricio, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



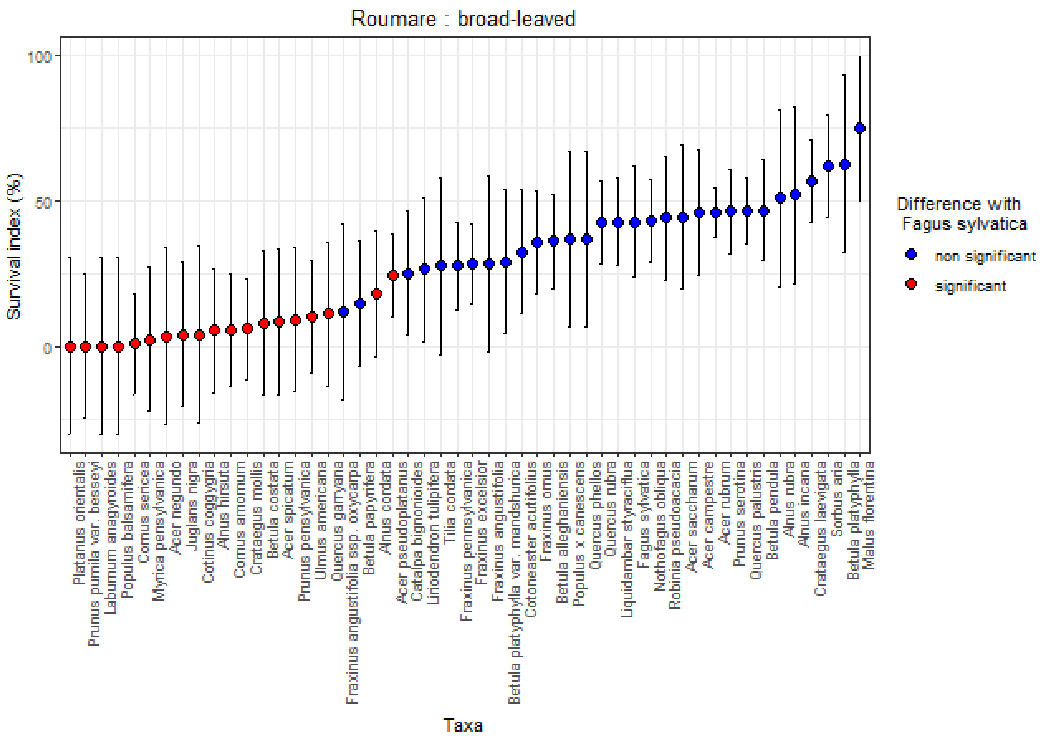
Appendix 1f : Classification of the survival index for the species of the Sainte-Anastasie arboretum, blue species are non-significantly worse than Abies alba, red species are significantly worse than Abies alba, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



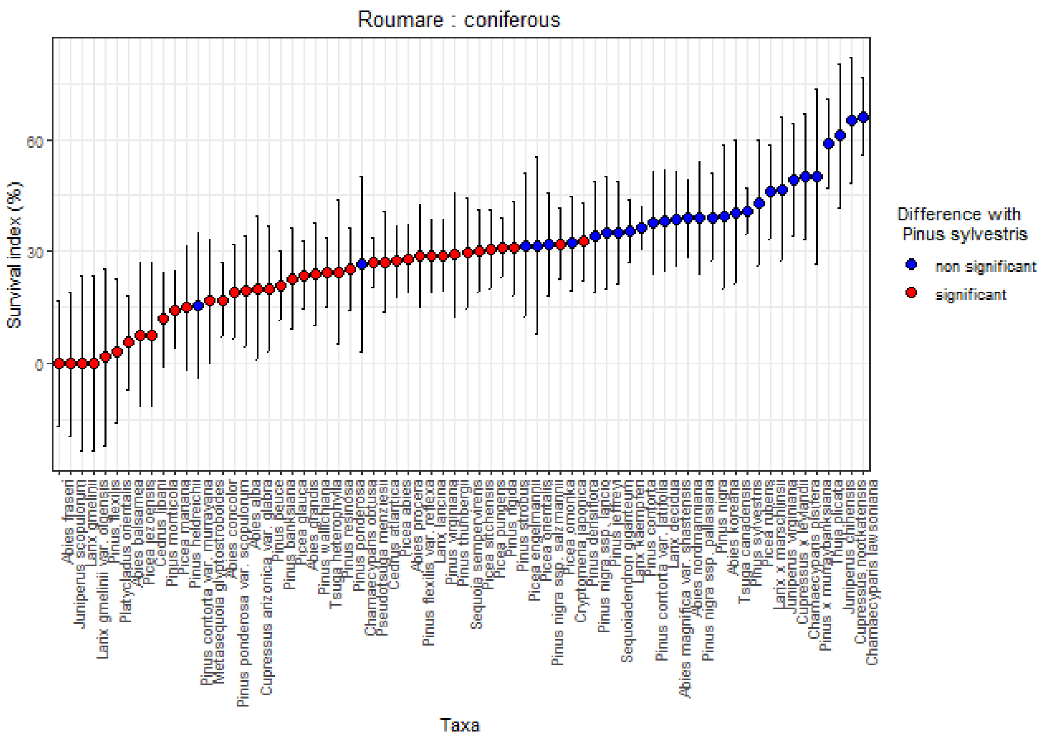
Appendix 1g : Classification of the survival index for the broad-leaved species of the Col des 3 Soeurs arboretum, blue species are non-significantly worse than Betula pendula, red species are significantly worse than Betula pendula, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



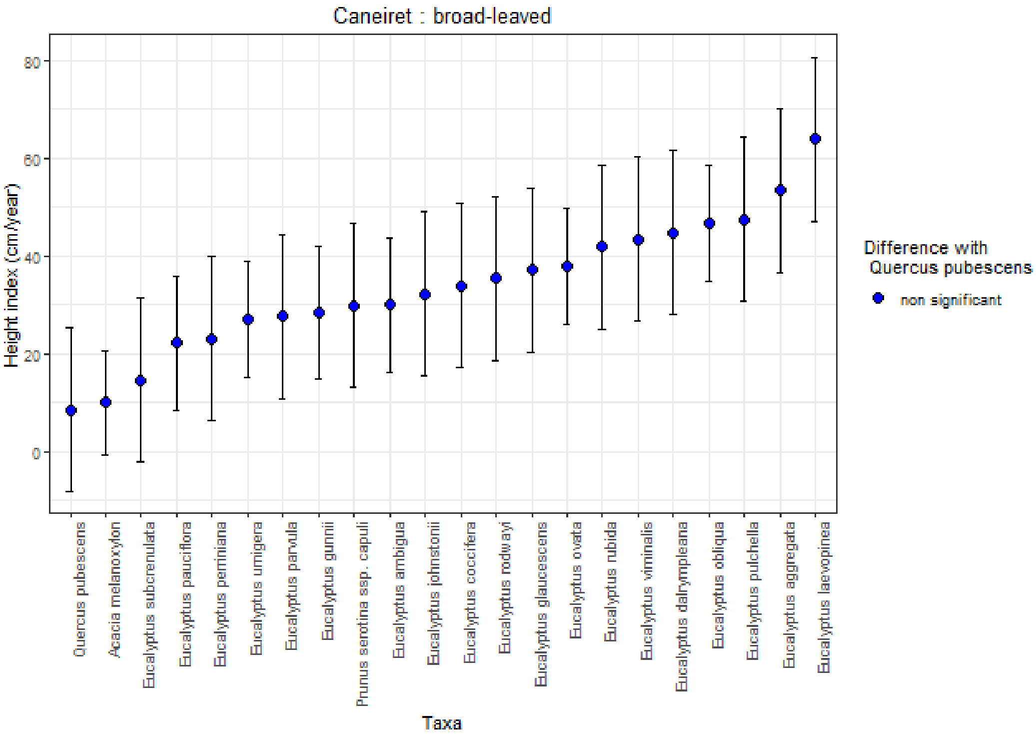
Appendix 1h : Classification of the survival index for the coniferous species of the Col des 3 Soeurs arboretum, blue species are non-significantly worse than Picea abies, red species are significantly worse than Picea abies, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



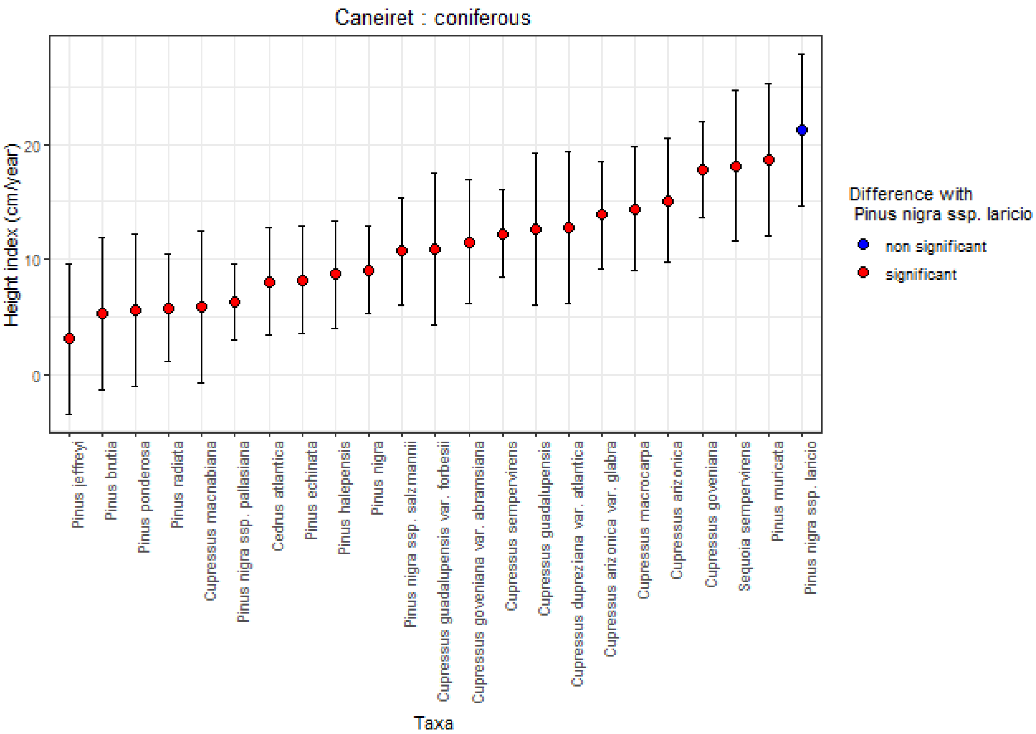
Appendix 1i : Classification of the survival index for the broad-leaved species of the Roumare arboretum, blue species are non-significantly worse than Fagus sylvatica, red species are significantly worse than Fagus sylvatica, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



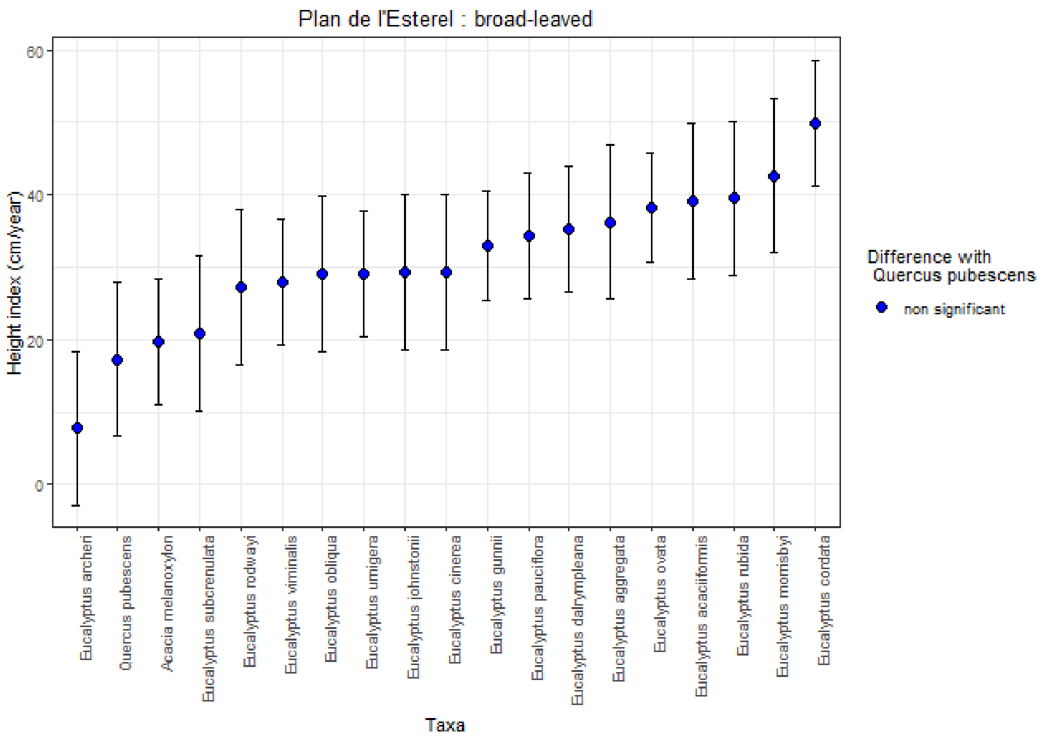
Appendix 1j : Classification of the survival index for the coniferous species of the Roumare arboretum, blue species are non-significantly worse than Pinus sylvestris, red species are significantly worse than Pinus sylvestris, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



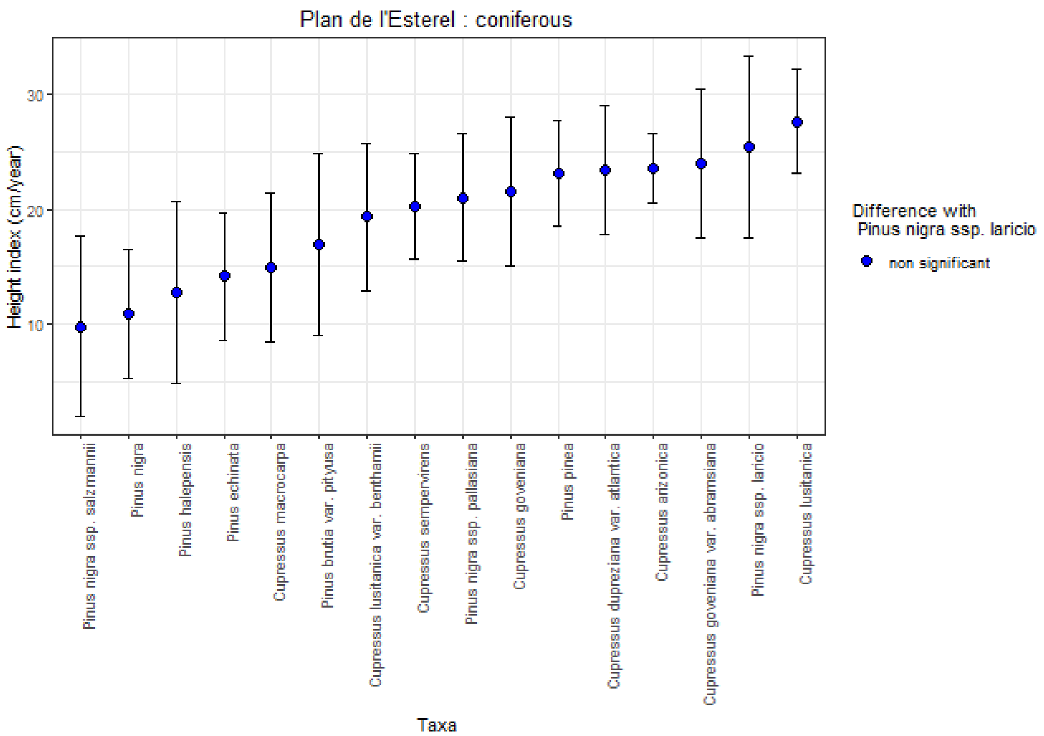
Appendix 2a : Classification of the height index for the broad-leaved species of the Caneiret arboretum, blue species are non-significantly worse than Quercus pubescens, red species are significantly worse than Quercus pubescens, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



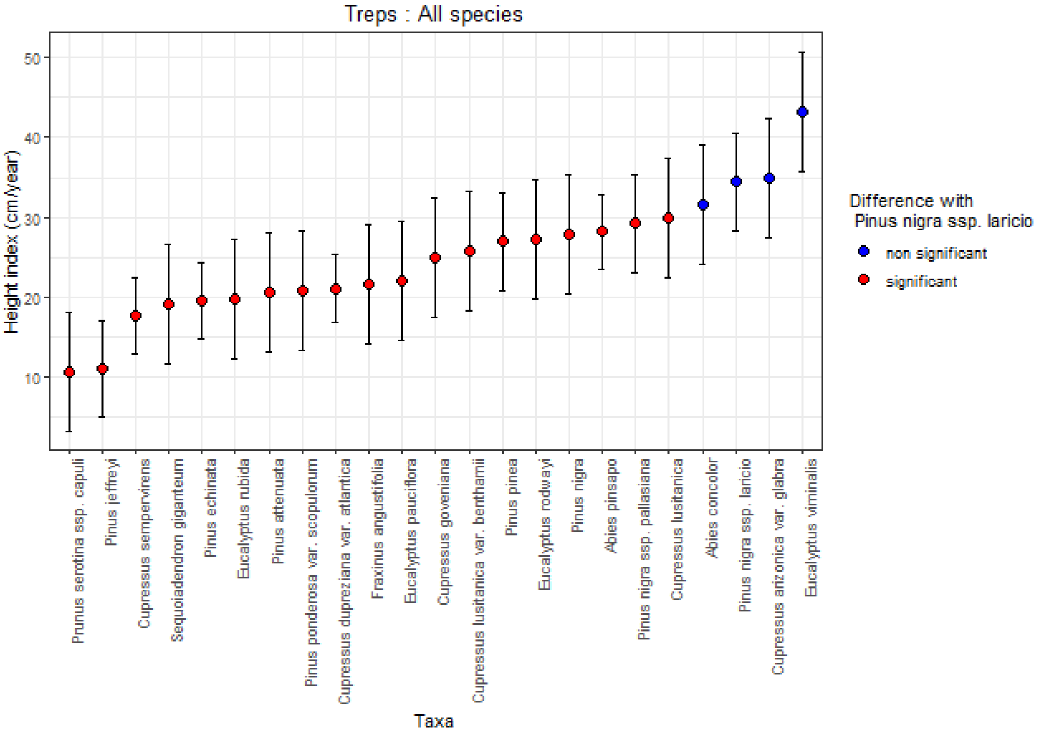
Appendix 2b : Classification of the height index for the coniferous species of the Caneiret arboretum, blue species are non-significantly worse than Pinus nigra ssp. laricio, red species are significantly worse than Pinus nigra ssp. laricio, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



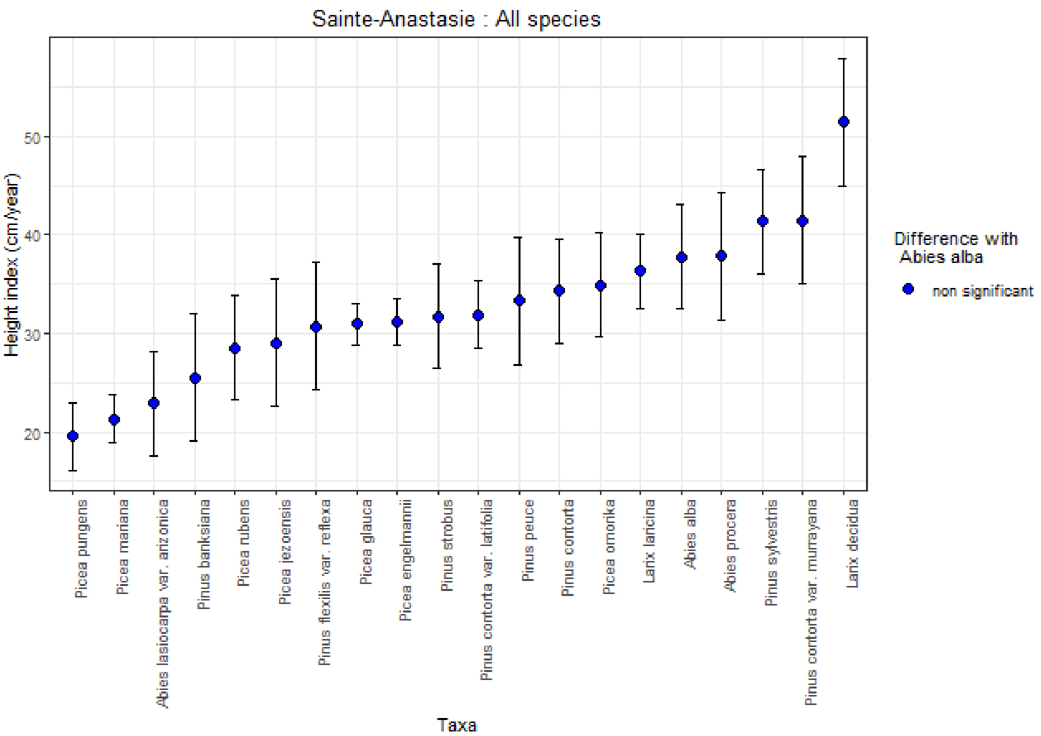
Appendix 2c : Classification of the height index for the broad-leaved species of the Plan de l'Esterel arboretum, blue species are non-significantly worse than Quercus pubescens, red species are significantly worse than Quercus pubescens, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



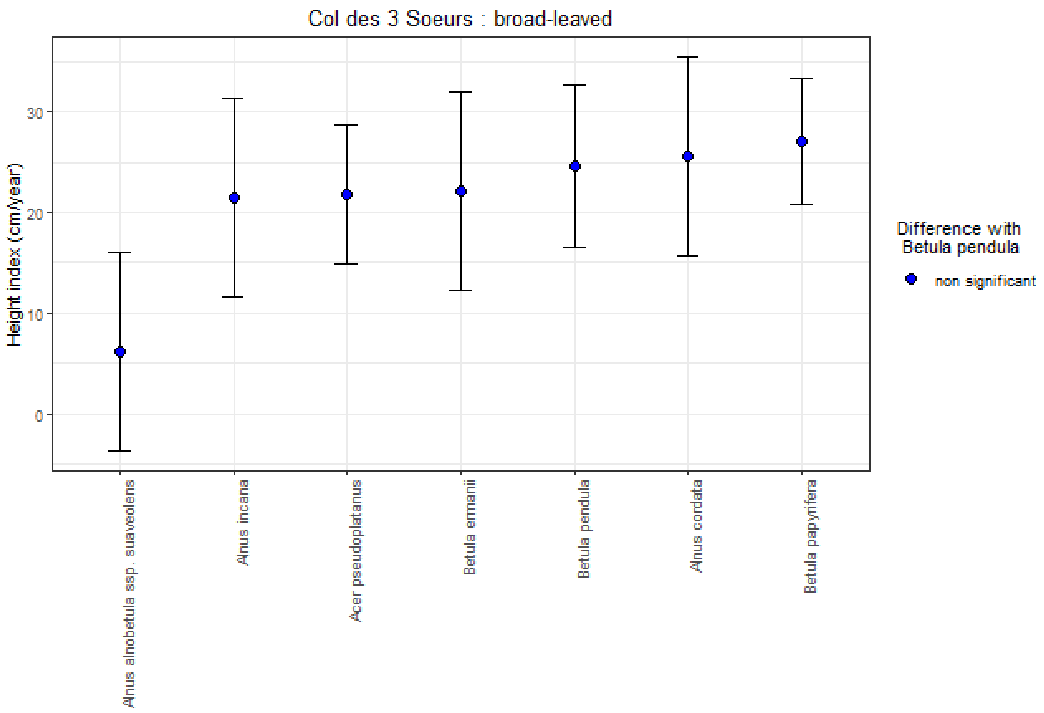
Appendix 2d : Classification of the height index for the coniferous species of the Plan de l'Esterel arboretum, blue species are non-significantly worse than Pinus nigra ssp. laricio, red species are significantly worse than Pinus nigra ssp. laricio, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



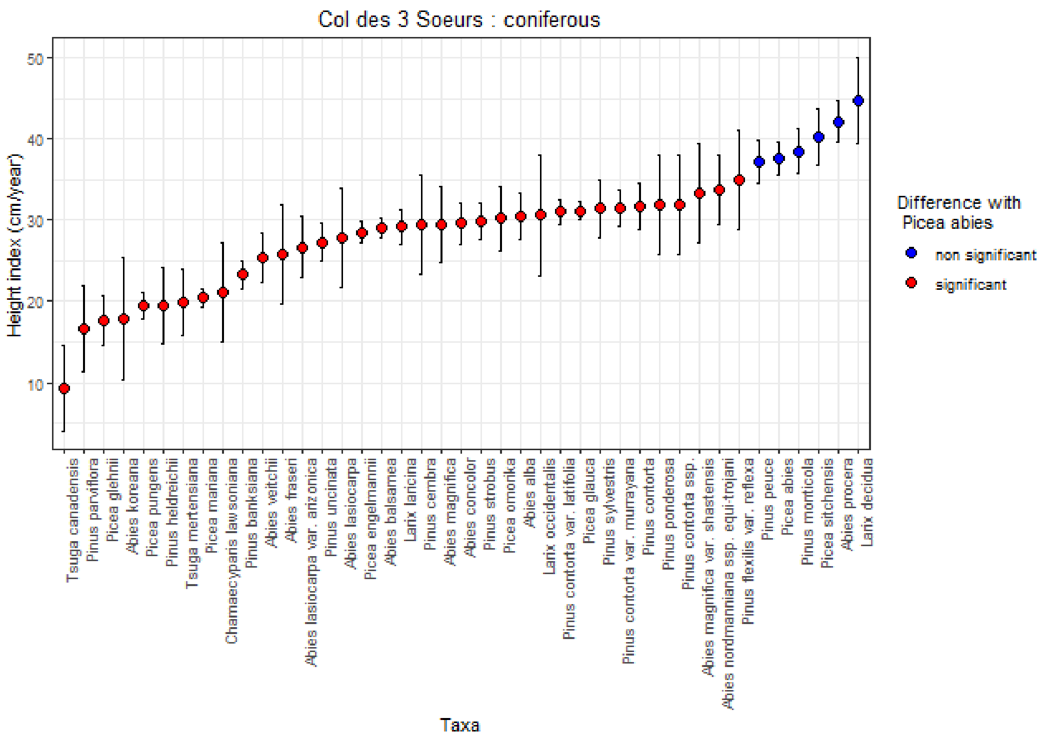
Appendix 2e : Classification of the height index for the species of the Treps arboretum, blue species are non-significantly worse than Pinus nigra ssp. laricio, red species are significantly worse than Pinus nigra ssp. laricio, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



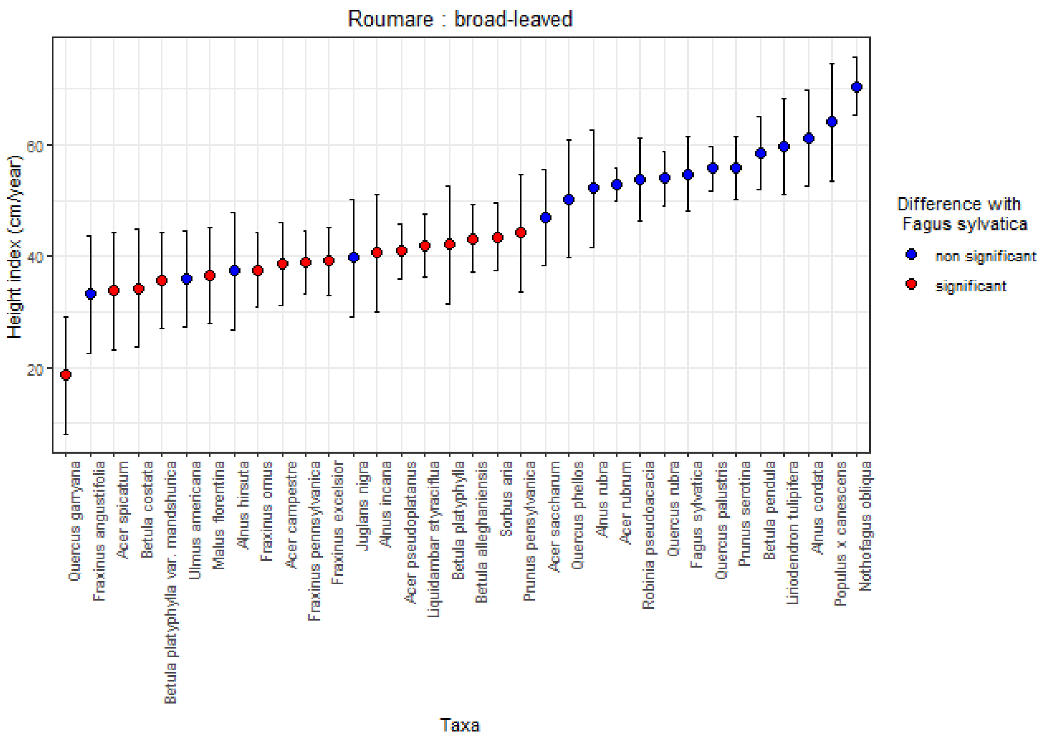
Appendix 2f : Classification of the height index for the species of the Sainte-Anastasie arboretum, blue species are non-significantly worse than Abies alba, red species are significantly worse than Abies alba, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



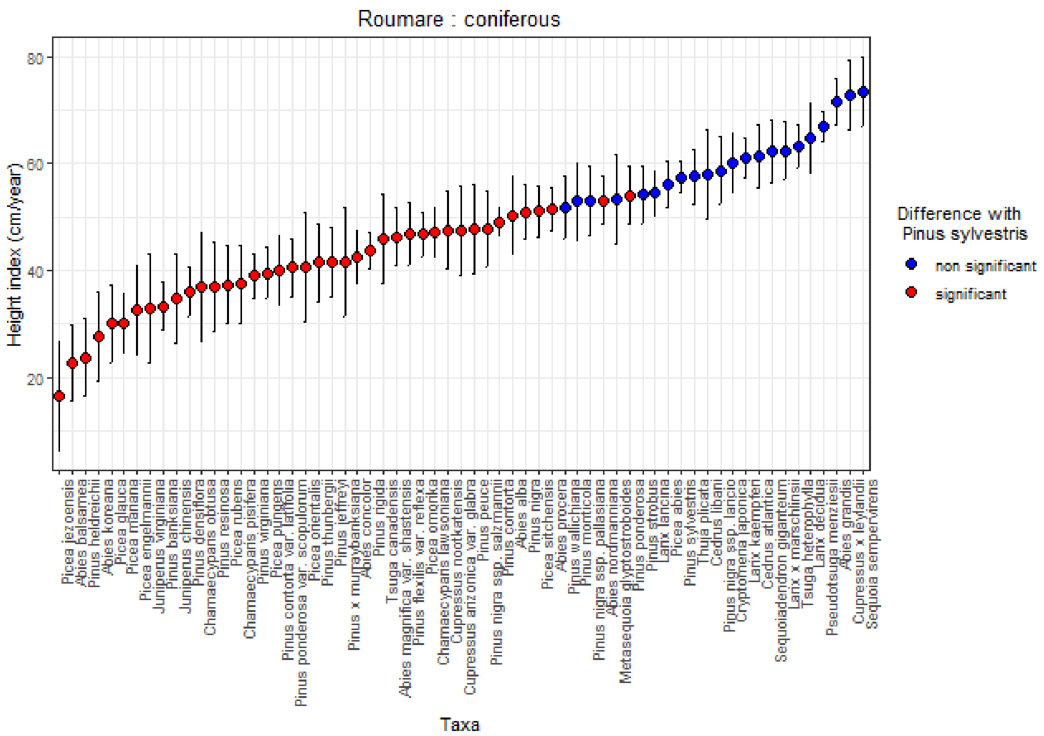
Appendix 2g : Classification of the height index for the broad-leaved species of the Col des 3 Soeurs arboretum, blue species are non-significantly worse than Betula pendula, red species are significantly worse than Betula pendula, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



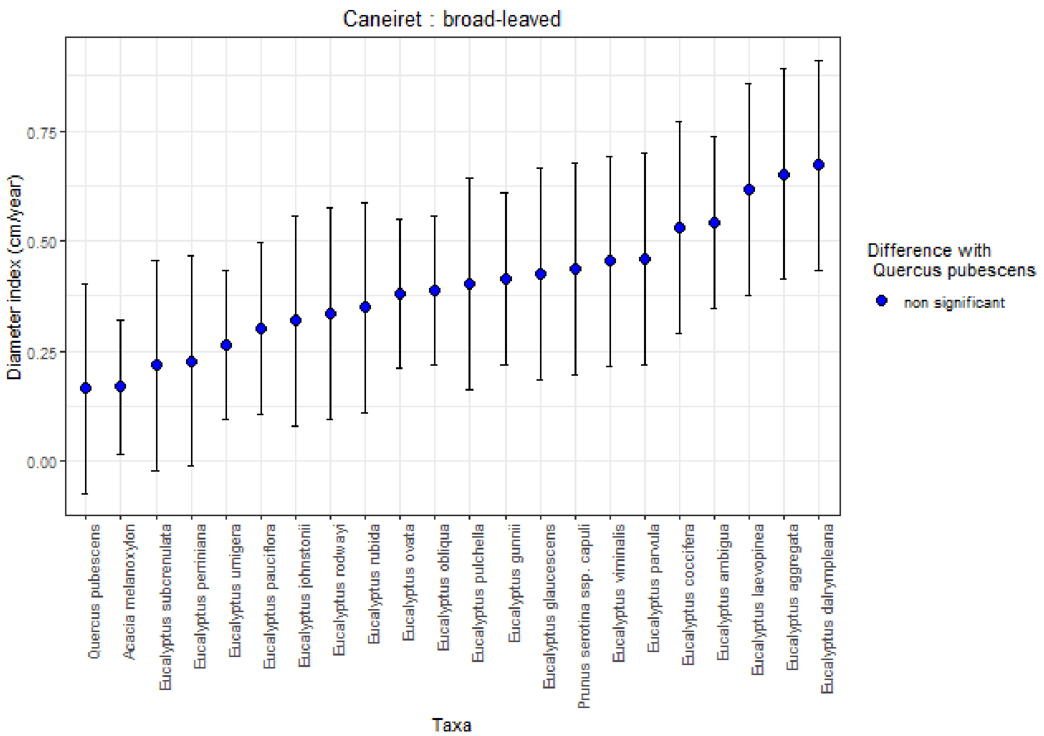
Appendix 2h : Classification of the height index for the coniferous species of the Col des 3 Soeurs arboretum, blue species are non-significantly worse than Picea abies, red species are significantly worse than Picea abies, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



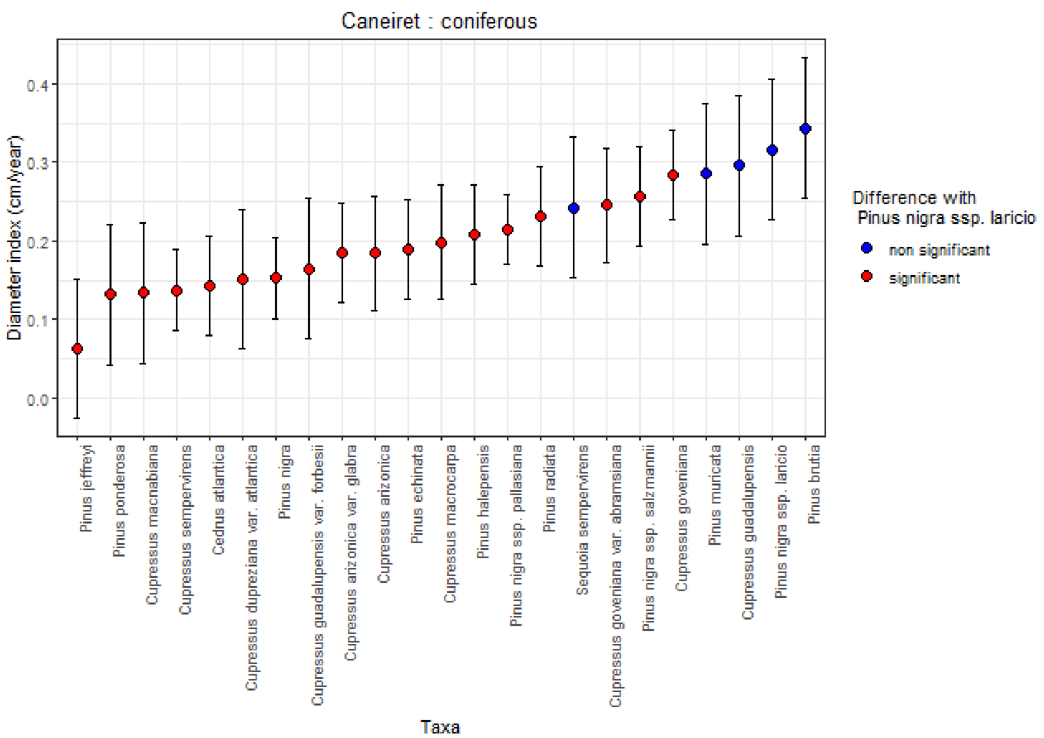
Appendix 2i : Classification of the height index for the broad-leaved species of the Roumare arboretum, blue species are non-significantly worse than Fagus sylvatica, red species are significantly worse than Fagus sylvatica, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



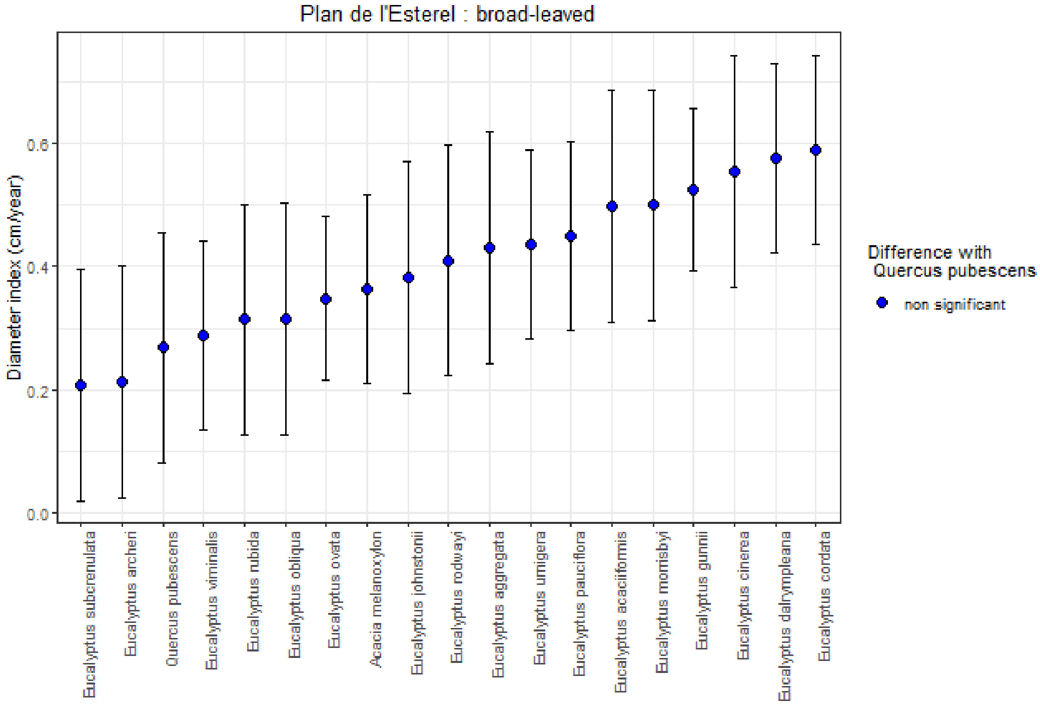
Appendix 2j : Classification of the height index for the coniferous species of the Roumare arboretum, blue species are non-significantly worse than Pinus sylvestris, red species are significantly worse than Pinus sylvestris, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



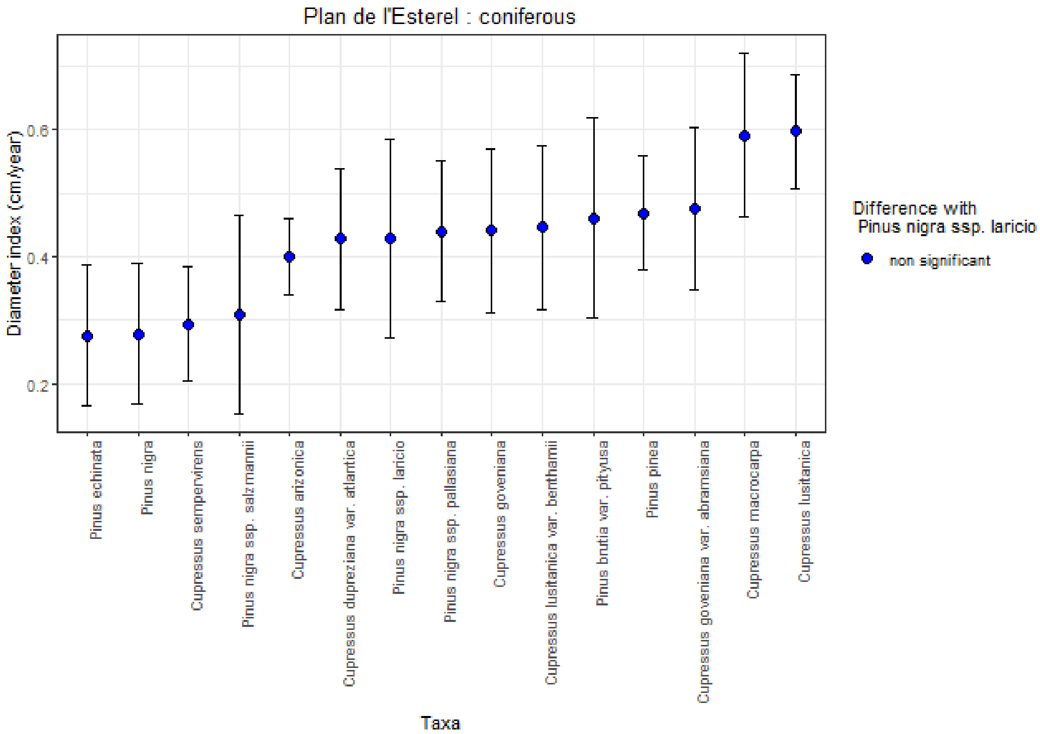
Appendix 3a : Classification of the diameter index for the broad-leaved species of the Caneiret arboretum, blue species are non-significantly worse than Quercus pubescens, red species are significantly worse than Quercus pubescens, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



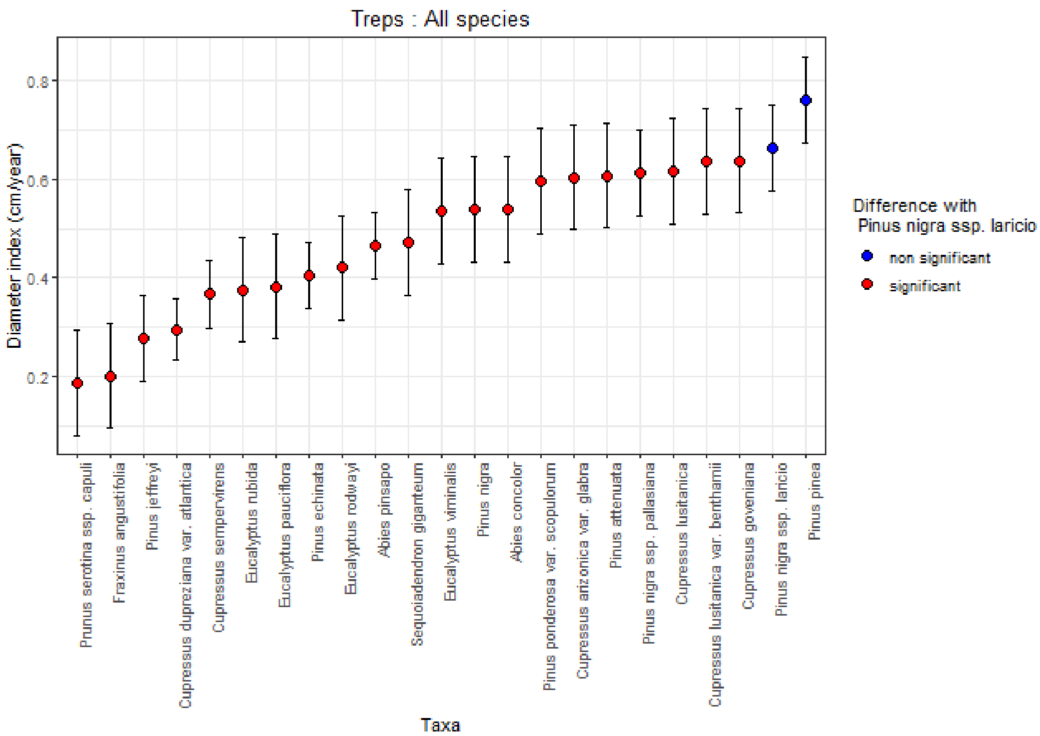
Appendix 3b : Classification of the diameter index for the coniferous species of the Caneiret arboretum, blue species are non-significantly worse than Pinus nigra ssp. laricio, red species are significantly worse than Pinus nigra ssp. laricio, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



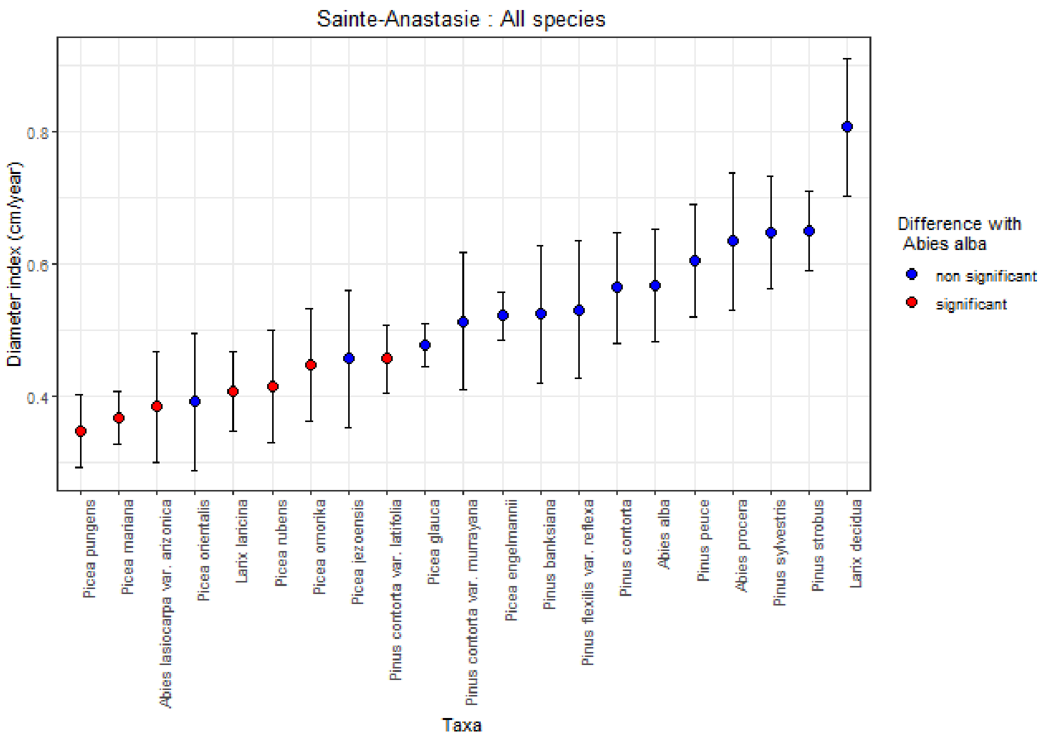
Appendix 3c : Classification of the diameter index for the broad-leaved species of the Plan de l'Esterel arboretum, blue species are non-significantly worse than Quercus pubescens, red species are significantly worse than Quercus pubescens, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



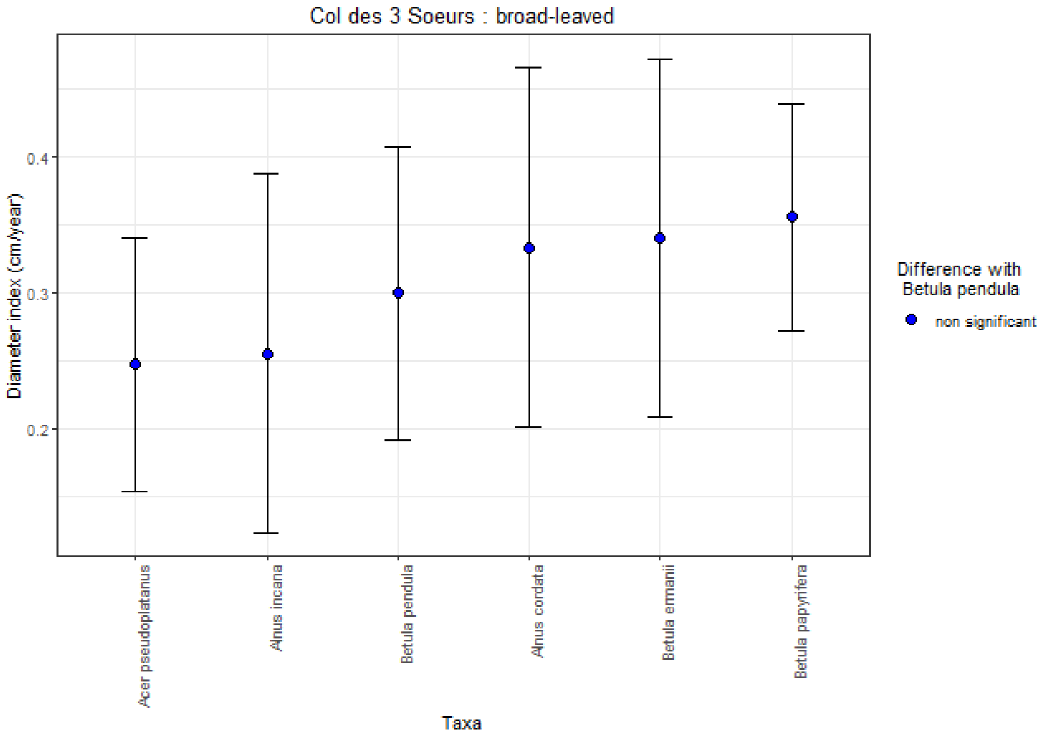
Appendix 3d : Classification of the diameter index for the coniferous species of the Plan de l'Esterel arboretum, blue species are non-significantly worse than Pinus nigra ssp. laricio, red species are significantly worse than Pinus nigra ssp. laricio, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



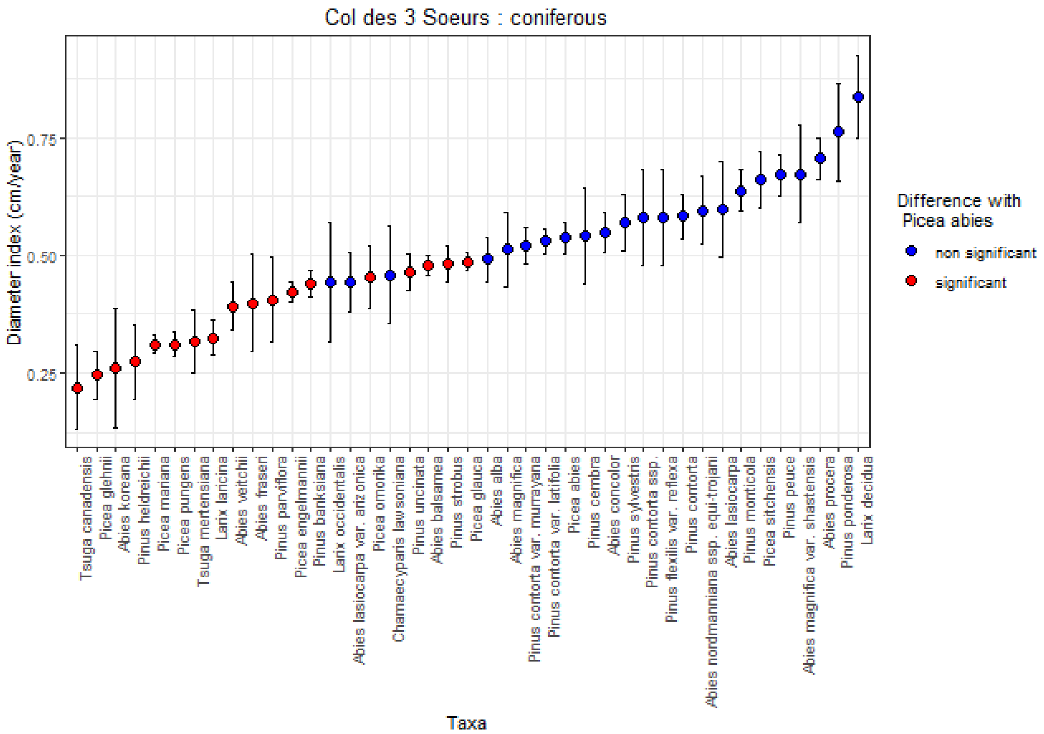
Appendix 3e : Classification of the diameter index for the species of the Treps arboretum, blue species are non-significantly worse than Pinus nigra ssp. laricio, red species are significantly worse than Pinus nigra ssp. laricio, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



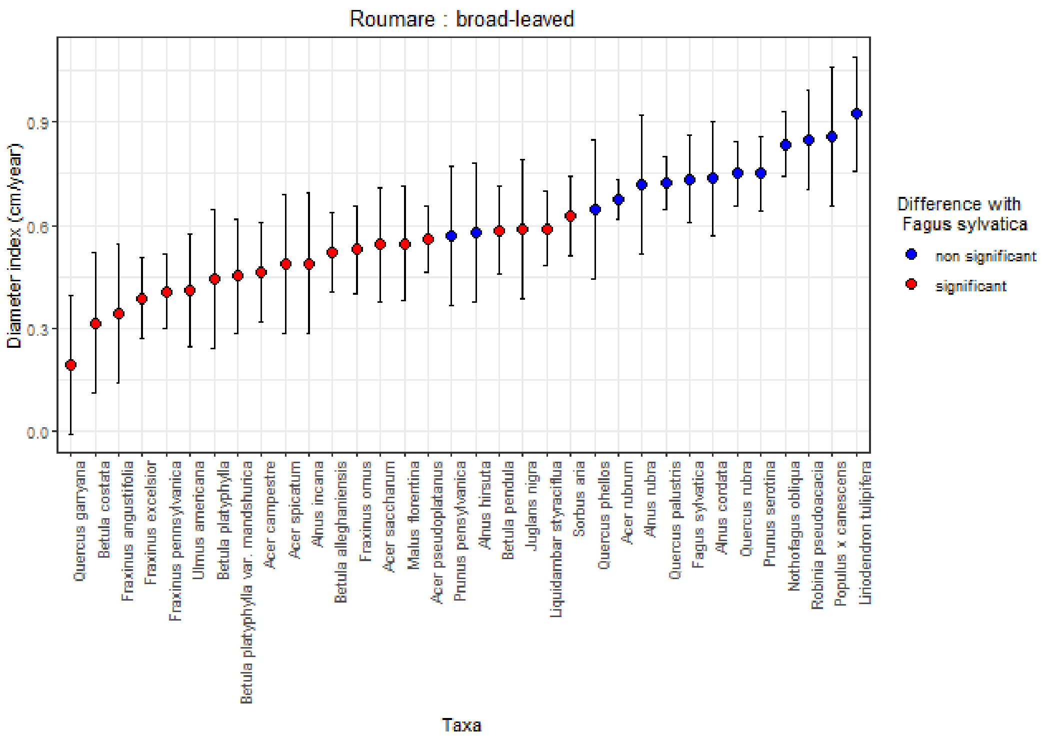
Appendix 3f : Classification of the diameter index for the species of the Sainte-Anastasie arboretum, blue species are non-significantly worse than Abies alba, red species are significantly worse than Abies alba, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



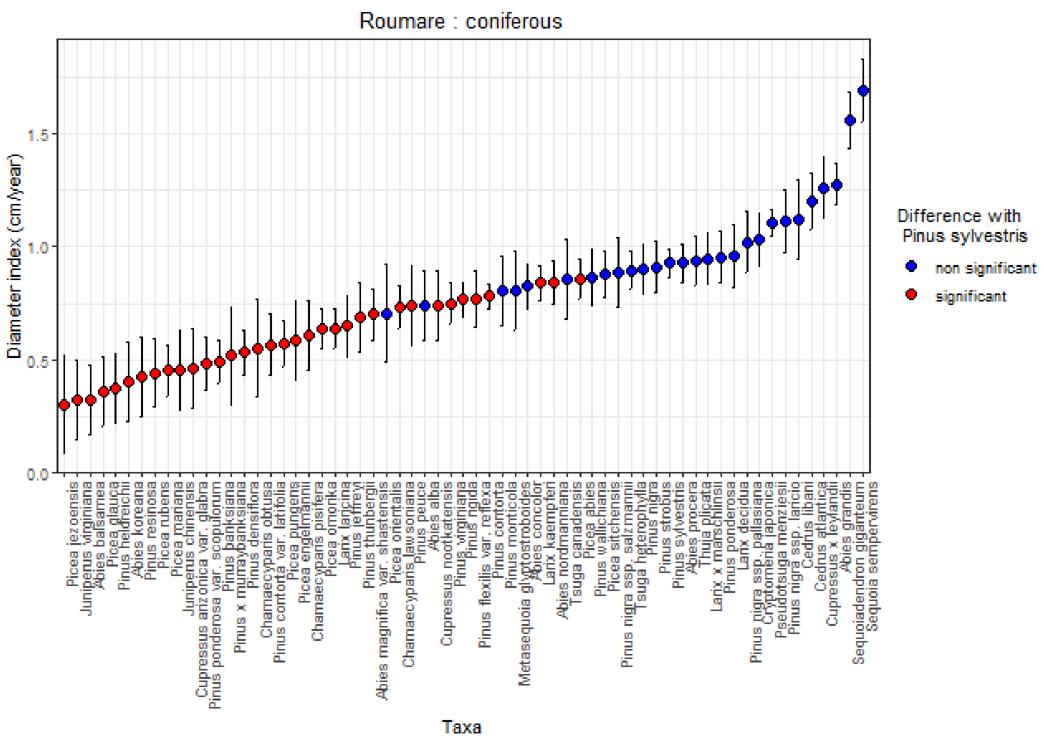
Appendix 3g : Classification of the diameter index for the broad-leaved species of the Col des 3 Soeurs arboretum, blue species are non-significantly worse than Betula pendula, red species are significantly worse than Betula pendula, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



Appendix 3h : Classification of the diameter index for the coniferous species of the Col des 3 Soeurs arboretum, blue species are non-significantly worse than Picea abies, red species are significantly worse than Picea abies, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



Appendix 3i : Classification of the diameter index for the broad-leaved species of the Roumare arboretum, blue species are non-significantly worse than Fagus sylvatica, red species are significantly worse than Fagus sylvatica, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package



Appendix 3j : Classification of the diameter index for the coniferous species of the Roumare arboretum, blue species are non-significantly worse than Pinus sylvestris, red species are significantly worse than Pinus sylvestris, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package

Taxa	Arboretum	Reference species	Survival index	Height index	Diameter index
Abies cephalonica	CAN	*Pinus nigra ssp. laricio*			
Acacia implexa	CAN	*Quercus pubescens*	x		
Acacia melanoxylon	CAN	*Quercus pubescens*	x	x	x
Acacia salicina	CAN	*Quercus pubescens*	x		
Acer negundo	CAN	*Quercus pubescens*	x		
Albizia julibrissin	CAN	*Quercus pubescens*	x		
Allocasuarina dystila	CAN	*Quercus pubescens*	x		
Allocasuarina littoralis	CAN	*Quercus pubescens*	x		
Allocasuarina muelleriana	CAN	*Quercus pubescens*	x		
Allocasuarina verticillata	CAN	*Quercus pubescens*	x		
Arbutus unedo	CAN	*Quercus pubescens*	x		
Arbutus xalapensis	CAN	*Quercus pubescens*	x		
Atriplex nummularia	CAN	*Quercus pubescens*	x		
Atriplex polycarpa	CAN	*Quercus pubescens*	x		
Atriplex undulata	CAN	*Quercus pubescens*	x		
Berberis sp.	CAN	*Quercus pubescens*	x		
Callitris preissii	CAN	*Pinus nigra ssp. laricio*			
Callitris rhomboidea	CAN	*Pinus nigra ssp. laricio*			
Casuarina cunninghamiana	CAN	*Quercus pubescens*	x		
Casuarina equisetifolia	CAN	*Quercus pubescens*	x		
Casuarina glauca	CAN	*Quercus pubescens*	x		
Cedrus atlantica	CAN	*Pinus nigra ssp. laricio*			
Cotoneaster pannosus	CAN	*Quercus pubescens*	x		
Cotoneaster sp.	CAN	*Quercus pubescens*	x		
Cryptocarya alba	CAN	*Quercus pubescens*	x		
Cupressus arizonica	CAN	*Pinus nigra ssp. laricio*			
Cupressus arizonica var. glabra	CAN	*Pinus nigra ssp. laricio*	x		
Cupressus cashmeriana	CAN	*Pinus nigra ssp. laricio*			
Cupressus dupreziana var. atlantica	CAN	*Pinus nigra ssp. laricio*			
Cupressus goveniana	CAN	*Pinus nigra ssp. laricio*			
Cupressus goveniana var. abramsiana	CAN	*Pinus nigra ssp. laricio*	x		
Cupressus guadalupensis	CAN	*Pinus nigra ssp. laricio*			x
Cupressus guadalupensis var. forbesii	CAN	*Pinus nigra ssp. laricio*	x		
Cupressus macnabiana	CAN	*Pinus nigra ssp. laricio*	x		
Cupressus macrocarpa	CAN	*Pinus nigra ssp. laricio*			
Cupressus sempervirens	CAN	*Pinus nigra ssp. laricio*			
Diospyros lotus	CAN	*Quercus pubescens*	x		

Ehretia acuminata	CAN	*Quercus pubescens*	x		
Elaeagnus angustifolia	CAN	*Quercus pubescens*	x		
Eucalyptus aggregata	CAN	*Quercus pubescens*	x	x	x
Eucalyptus ambigua	CAN	*Quercus pubescens*	x	x	x
Eucalyptus coccifera	CAN	*Quercus pubescens*	x	x	x
Eucalyptus dalrympleana	CAN	*Quercus pubescens*	x	x	x
Eucalyptus glaucescens	CAN	*Quercus pubescens*	x	x	x
Eucalyptus gunnii	CAN	*Quercus pubescens*	x	x	x
Eucalyptus johnstonii	CAN	*Quercus pubescens*	x	x	x
Eucalyptus laevopinea	CAN	*Quercus pubescens*	x	x	x
Eucalyptus obliqua	CAN	*Quercus pubescens*	x	x	x
Eucalyptus ovata	CAN	*Quercus pubescens*	x	x	x
Eucalyptus parvula	CAN	*Quercus pubescens*	x	x	x
Eucalyptus pauciflora	CAN	*Quercus pubescens*	x	x	x
Eucalyptus perriniana	CAN	*Quercus pubescens*	x	x	x
Eucalyptus pulchella	CAN	*Quercus pubescens*	x	x	x
Eucalyptus rodwayi	CAN	*Quercus pubescens*	x	x	x
Eucalyptus rubida	CAN	*Quercus pubescens*	x	x	x
Eucalyptus subcrenulata	CAN	*Quercus pubescens*	x	x	x
Eucalyptus urnigera	CAN	*Quercus pubescens*	x	x	x
Eucalyptus vernicosa	CAN	*Quercus pubescens*	x		
Eucalyptus viminalis	CAN	*Quercus pubescens*	x	x	x
Eucommia ulmoides	CAN	*Quercus pubescens*	x		
Eugenia uruguayensis	CAN	*Quercus pubescens*	x		
Ficus carica	CAN	*Quercus pubescens*	x		
Ficus johannis ssp. afghanistanica	CAN	*Quercus pubescens*	x		
Ficus palmata	CAN	*Quercus pubescens*	x		
Fraxinus angustifolia	CAN	*Quercus pubescens*	x		
Fraxinus pennsylvanica	CAN	*Quercus pubescens*	x		
Fraxinus velutina	CAN	*Quercus pubescens*	x		
Gleditsia triacanthos	CAN	*Quercus pubescens*	x		
Hakea oleifolia	CAN	*Quercus pubescens*	x		
Hakea salicifolia	CAN	*Quercus pubescens*	x		
Hakea sericea	CAN	*Quercus pubescens*	x		
Hovenia dulcis	CAN	*Quercus pubescens*	x		
Leucadendron salignum	CAN	*Quercus pubescens*	x		
Liriodendron tulipifera	CAN	*Quercus pubescens*	x		
Maclura pomifera	CAN	*Quercus pubescens*	x		
Melia azedarach	CAN	*Quercus pubescens*	x		
Myrcianthes pungens	CAN	*Quercus pubescens*	x		
Olea europaea	CAN	*Quercus pubescens*	x		
Pinus brutia	CAN	*Pinus nigra ssp. laricio*			x
Pinus brutia var. eldarica	CAN	*Pinus nigra ssp. laricio*			

Pinus echinata	CAN	*Pinus nigra ssp. laricio*			
Pinus halepensis	CAN	*Pinus nigra ssp. laricio*			
Pinus jeffreyi	CAN	*Pinus nigra ssp. laricio*			
Pinus muricata	CAN	*Pinus nigra ssp. laricio*			x
Pinus nigra	CAN	*Pinus nigra ssp. laricio*			
Pinus nigra ssp. laricio	CAN	*Pinus nigra ssp. laricio*	x	x	x
Pinus nigra ssp. pallasiana	CAN	*Pinus nigra ssp. laricio*			
Pinus nigra ssp. salzmannii	CAN	*Pinus nigra ssp. laricio*			
Pinus ponderosa	CAN	*Pinus nigra ssp. laricio*			
Pinus ponderosa var. scopulorum	CAN	*Pinus nigra ssp. laricio*			
Pinus radiata	CAN	*Pinus nigra ssp. laricio*			
Pinus x attenuradiata	CAN	*Pinus nigra ssp. laricio*			
Platanus occidentalis	CAN	*Quercus pubescens*	x		
Platanus orientalis	CAN	*Quercus pubescens*	x		
Populus deltoides	CAN	*Quercus pubescens*	x		
Prosopis nigra	CAN	*Pinus nigra ssp. laricio*			
Prunus integrifolia	CAN	*Quercus pubescens*	x		
Prunus serotina ssp. capuli	CAN	*Quercus pubescens*	x	x	x
Pyracantha angustifolia	CAN	*Quercus pubescens*	x		
Pyrus amygdaliformis	CAN	*Quercus pubescens*	x		
Quercus pubescens	CAN	*Quercus pubescens*	x	x	x
Quercus robur	CAN	*Quercus pubescens*	x		
Quercus rotundifolia	CAN	*Quercus pubescens*	x		
Rhus coriaria	CAN	*Quercus pubescens*	x		
Robinia pseudoacacia	CAN	*Quercus pubescens*	x		
Schinus polygama	CAN	*Quercus pubescens*	x		
Sequoia sempervirens	CAN	*Pinus nigra ssp. laricio*			x
Sorbus domestica	CAN	*Quercus pubescens*	x		
Umbellularia californica	CAN	*Quercus pubescens*	x		
Abies alba	COL	*Picea abies*			x
Abies balsamea	COL	*Picea abies*			
Abies concolor	COL	*Picea abies*			x
Abies fraseri	COL	*Picea abies*			
Abies koreana	COL	*Picea abies*	x		
Abies lasiocarpa	COL	*Picea abies*			x
Abies lasiocarpa var. arizonica	COL	*Picea abies*			x
Abies magnifica	COL	*Picea abies*	x		x
Abies magnifica var. shastensis	COL	*Picea abies*	x		x
Abies nordmanniana ssp. equi-trojani	COL	*Picea abies*	x		x
Abies procera	COL	*Picea abies*		x	x

Abies veitchii	COL	*Picea abies*			
Acer pseudoplatanus	COL	*Betula pendula*	x	x	x
Acer saccharinum	COL	*Betula pendula*			
Acer saccharum	COL	*Betula pendula*	x		
Acer saccharum ssp. nigrum	COL	*Betula pendula*			
Alnus alnobetula ssp. suaveolens	COL	*Betula pendula*	x	x	
Alnus cordata	COL	*Betula pendula*	x	x	x
Alnus incana	COL	*Betula pendula*	x	x	x
Betula alleghaniensis	COL	*Betula pendula*			
Betula ermanii	COL	*Betula pendula*	x	x	x
Betula maximowicziana	COL	*Betula pendula*	x		
Betula papyrifera	COL	*Betula pendula*	x	x	x
Betula pendula	COL	*Betula pendula*	x	x	x
Cedrus atlantica	COL	*Picea abies*			
Chamaecyparis lawsoniana	COL	*Picea abies*			x
Chamaecyparis pisifera	COL	*Picea abies*			
Fraxinus chinensis	COL	*Betula pendula*			
Fraxinus excelsior	COL	*Betula pendula*	x		
Fraxinus pennsylvanica	COL	*Betula pendula*			
Juniperus scopulorum	COL	*Picea abies*			
Larix decidua	COL	*Picea abies*		x	x
Larix laricina	COL	*Picea abies*			
Larix occidentalis	COL	*Picea abies*			x
Picea abies	COL	*Picea abies*	x	x	x
Picea engelmannii	COL	*Picea abies*	x		
Picea glauca	COL	*Picea abies*			
Picea glehnii	COL	*Picea abies*			
Picea mariana	COL	*Picea abies*			
Picea omorika	COL	*Picea abies*	x		
Picea pungens	COL	*Picea abies*			
Picea sitchensis	COL	*Picea abies*		x	x
Pinus aristata	COL	*Picea abies*			
Pinus banksiana	COL	*Picea abies*			
Pinus cembra	COL	*Picea abies*			x
Pinus contorta	COL	*Picea abies*			x
Pinus contorta ssp.	COL	*Picea abies*			x
Pinus contorta var. latifolia	COL	*Picea abies*			x
Pinus contorta var. murrayana	COL	*Picea abies*			x
Pinus flexilis	COL	*Picea abies*			
Pinus flexilis var. reflexa	COL	*Picea abies*			x
Pinus heldreichii	COL	*Picea abies*			

Pinus monticola	COL	*Picea abies*		x	x
Pinus parviflora	COL	*Picea abies*			
Pinus peuce	COL	*Picea abies*		x	x
Pinus ponderosa	COL	*Picea abies*			x
Pinus resinosa	COL	*Picea abies*			
Pinus strobus	COL	*Picea abies*			
Pinus sylvestris	COL	*Picea abies*			x
Pinus uncinata	COL	*Picea abies*			
Prunus serotina	COL	*Betula pendula*	x		
Quercus palustris	COL	*Betula pendula*			
Quercus rubra	COL	*Betula pendula*	x		
Tsuga canadensis	COL	*Picea abies*			
Tsuga mertensiana	COL	*Picea abies*	x		
Ulmus americana	COL	*Betula pendula*			
Acacia melanoxylon	PLA	*Quercus pubescens*	x	x	x
Allocasuarina torulosa	PLA	*Quercus pubescens*	x		
Alnus incana ssp. tenuifolia	PLA	*Quercus pubescens*	x		
Alnus orientalis	PLA	*Quercus pubescens*	x		
Alnus subcordata	PLA	*Quercus pubescens*	x		
Arbutus unedo	PLA	*Quercus pubescens*	x		
Berberis sp.	PLA	*Quercus pubescens*	x		
Callitris preissii	PLA	*Pinus nigra ssp. laricio*			
Callitris rhomboidea	PLA	*Pinus nigra ssp. laricio*			
Casuarina cunninghamiana	PLA	*Quercus pubescens*	x		
Celtis occidentalis	PLA	*Quercus pubescens*	x		
Chamaecyparis pisifera	PLA	*Pinus nigra ssp. laricio*			
Cotoneaster lacteus	PLA	*Quercus pubescens*	x		
Cotoneaster x watereri	PLA	*Quercus pubescens*	x		
Cupressus arizonica	PLA	*Pinus nigra ssp. laricio*	x	x	x
Cupressus dupreziana var. atlantica	PLA	*Pinus nigra ssp. laricio*		x	x
Cupressus goveniana	PLA	*Pinus nigra ssp. laricio*		x	x
Cupressus goveniana var. abramsiana	PLA	*Pinus nigra ssp. laricio*	x	x	x
Cupressus lusitanica	PLA	*Pinus nigra ssp. laricio*		x	x
Cupressus lusitanica var. benthamii	PLA	*Pinus nigra ssp. laricio*		x	x
Cupressus macrocarpa	PLA	*Pinus nigra ssp. laricio*		x	x
Cupressus sempervirens	PLA	*Pinus nigra ssp. laricio*		x	x
Elaeagnus angustifolia	PLA	*Quercus pubescens*	x		
Eucalyptus acaciiformis	PLA	*Quercus pubescens*	x	x	x
Eucalyptus aggregata	PLA	*Quercus pubescens*	x	x	x
Eucalyptus ambigua	PLA	*Quercus pubescens*	x		
Eucalyptus archeri	PLA	*Quercus pubescens*	x	x	x
Eucalyptus cinerea	PLA	*Quercus pubescens*	x	x	x

Eucalyptus coccifera	PLA	*Quercus pubescens*	x		
Eucalyptus cordata	PLA	*Quercus pubescens*	x	x	x
Eucalyptus dalrympleana	PLA	*Quercus pubescens*	x	x	x
Eucalyptus delegatensis	PLA	*Quercus pubescens*	x		
Eucalyptus gunnii	PLA	*Quercus pubescens*	x	x	x
Eucalyptus johnstonii	PLA	*Quercus pubescens*	x	x	x
Eucalyptus morrisbyi	PLA	*Quercus pubescens*	x	x	x
Eucalyptus obliqua	PLA	*Quercus pubescens*	x	x	x
Eucalyptus ovata	PLA	*Quercus pubescens*	x	x	x
Eucalyptus pauciflora	PLA	*Quercus pubescens*	x	x	x
Eucalyptus perriniana	PLA	*Quercus pubescens*	x		
Eucalyptus pulverulenta	PLA	*Quercus pubescens*	x		
Eucalyptus rodwayi	PLA	*Quercus pubescens*	x	x	x
Eucalyptus rubida	PLA	*Quercus pubescens*	x	x	x
Eucalyptus sp.	PLA	*Quercus pubescens*	x		
Eucalyptus subcrenulata	PLA	*Quercus pubescens*	x	x	x
Eucalyptus urnigera	PLA	*Quercus pubescens*	x	x	x
Eucalyptus viminalis	PLA	*Quercus pubescens*	x	x	x
Ficus carica	PLA	*Quercus pubescens*	x		
Ficus palmata	PLA	*Quercus pubescens*	x		
Fraxinus americana	PLA	*Quercus pubescens*	x		
Fraxinus angustifolia	PLA	*Quercus pubescens*	x		
Fraxinus velutina	PLA	*Quercus pubescens*	x		
Gleditsia triacanthos	PLA	*Quercus pubescens*	x		
Hakea salicifolia	PLA	*Quercus pubescens*	x		
Hakea sericea	PLA	*Quercus pubescens*	x		
Juniperus phoenicea	PLA	*Pinus nigra ssp. laricio*			
Ligustrum compactum	PLA	*Quercus pubescens*	x		
Ligustrum ibota	PLA	*Quercus pubescens*	x		
Ligustrum quihoui	PLA	*Quercus pubescens*	x		
Melia azedarach	PLA	*Quercus pubescens*	x		
Morus australis	PLA	*Quercus pubescens*	x		
Nerium oleander	PLA	*Quercus pubescens*	x		
Pinus banksiana	PLA	*Pinus nigra ssp. laricio*			
Pinus brutia	PLA	*Pinus nigra ssp. laricio*			
Pinus brutia var. pityusa	PLA	*Pinus nigra ssp. laricio*		x	x
Pinus canariensis	PLA	*Pinus nigra ssp. laricio*			
Pinus echinata	PLA	*Pinus nigra ssp. laricio*		x	x
Pinus glabra	PLA	*Pinus nigra ssp. laricio*			
Pinus halepensis	PLA	*Pinus nigra ssp. laricio*		x	
Pinus jeffreyi	PLA	*Pinus nigra ssp. laricio*			
Pinus muricata	PLA	*Pinus nigra ssp. laricio*			
Pinus nigra	PLA	*Pinus nigra ssp. laricio*		x	x

Pinus nigra ssp. laricio	PLA	*Pinus nigra ssp. laricio*	x	x	x
Pinus nigra ssp. pallasiana	PLA	*Pinus nigra ssp. laricio*	x	x	x
Pinus nigra ssp. salzmannii	PLA	*Pinus nigra ssp. laricio*		x	x
Pinus pinaster	PLA	*Pinus nigra ssp. laricio*			
Pinus pinea	PLA	*Pinus nigra ssp. laricio*		x	x
Pinus ponderosa	PLA	*Pinus nigra ssp. laricio*			
Pinus ponderosa var. scopulorum	PLA	*Pinus nigra ssp. laricio*			
Pinus radiata	PLA	*Pinus nigra ssp. laricio*			
Pinus sabiniana	PLA	*Pinus nigra ssp. laricio*			
Platanus orientalis	PLA	*Quercus pubescens*	x		
Platycladus orientalis	PLA	*Pinus nigra ssp. laricio*			
Podocarpus totara	PLA	*Pinus nigra ssp. laricio*			
Prunus serotina ssp. capuli	PLA	*Quercus pubescens*	x		
Quercus libani	PLA	*Quercus pubescens*	x		
Quercus pubescens	PLA	*Quercus pubescens*	x	x	x
Quercus robur	PLA	*Quercus pubescens*	x		
Quercus rotundifolia	PLA	*Quercus pubescens*	x		
Quercus suber	PLA	*Quercus pubescens*	x		
Tetraclinis articulata	PLA	*Pinus nigra ssp. laricio*			
Abies alba	ROU	*Pinus sylvestris*			x
Abies balsamea	ROU	*Pinus sylvestris*			
Abies concolor	ROU	*Pinus sylvestris*			x
Abies fraseri	ROU	*Pinus sylvestris*			
Abies grandis	ROU	*Pinus sylvestris*		x	x
Abies koreana	ROU	*Pinus sylvestris*	x		
Abies magnifica var. shastensis	ROU	*Pinus sylvestris*	x		
Abies nordmanniana	ROU	*Pinus sylvestris*	x		
Abies procera	ROU	*Pinus sylvestris*			x
Acer campestre	ROU	*Fagus sylvatica*	x		
Acer negundo	ROU	*Fagus sylvatica*			
Acer pseudoplatanus	ROU	*Fagus sylvatica*			
Acer rubrum	ROU	*Fagus sylvatica*	x	x	x
Acer saccharum	ROU	*Fagus sylvatica*	x	x	
Acer spicatum	ROU	*Fagus sylvatica*			
Alnus cordata	ROU	*Fagus sylvatica*		x	x
Alnus hirsuta	ROU	*Fagus sylvatica*		x	x
Alnus incana	ROU	*Fagus sylvatica*	x		
Alnus rubra	ROU	*Fagus sylvatica*	x	x	x
Betula alleghaniensis	ROU	*Fagus sylvatica*	x		
Betula costata	ROU	*Fagus sylvatica*			
Betula papyrifera	ROU	*Fagus sylvatica*	x		
Betula pendula	ROU	*Fagus sylvatica*	x	x	

Betula platyphylla	ROU	*Fagus sylvatica*	x		
Betula platyphylla var. mandshurica	ROU	*Fagus sylvatica*	x		
Catalpa bignonioides	ROU	*Fagus sylvatica*	x		
Cedrus atlantica	ROU	*Pinus sylvestris*		x	x
Cedrus libani	ROU	*Pinus sylvestris*		x	x
Chamaecyparis lawsoniana	ROU	*Pinus sylvestris*	x		
Chamaecyparis obtusa	ROU	*Pinus sylvestris*	x		
Chamaecyparis pisifera	ROU	*Pinus sylvestris*	x		
Cornus amomum	ROU	*Fagus sylvatica*			
Cornus sericea	ROU	*Fagus sylvatica*			
Cotinus coggygria	ROU	*Fagus sylvatica*			
Cotoneaster acutifolius	ROU	*Fagus sylvatica*	x		
Crataegus laevigata	ROU	*Fagus sylvatica*	x		
Crataegus mollis	ROU	*Fagus sylvatica*			
Cryptomeria japonica	ROU	*Pinus sylvestris*	x	x	x
Cupressus arizonica var. glabra	ROU	*Pinus sylvestris*			
Cupressus nootkatensis	ROU	*Pinus sylvestris*	x		
Cupressus x leylandii	ROU	*Pinus sylvestris*	x	x	x
Fagus sylvatica	ROU	*Fagus sylvatica*	x	x	x
Fraxinus angustifolia	ROU	*Fagus sylvatica*	x	x	
Fraxinus angustifolia ssp. oxycarpa	ROU	*Fagus sylvatica*	x		
Fraxinus excelsior	ROU	*Fagus sylvatica*	x		
Fraxinus ornus	ROU	*Fagus sylvatica*	x		
Fraxinus pennsylvanica	ROU	*Fagus sylvatica*	x		
Juglans nigra	ROU	*Fagus sylvatica*		x	
Juniperus chinensis	ROU	*Pinus sylvestris*	x		
Juniperus scopulorum	ROU	*Pinus sylvestris*			
Juniperus virginiana	ROU	*Pinus sylvestris*	x		
Laburnum anagyroides	ROU	*Fagus sylvatica*			
Larix decidua	ROU	*Pinus sylvestris*	x	x	x
Larix gmelinii	ROU	*Pinus sylvestris*			
Larix gmelinii var. olgensis	ROU	*Pinus sylvestris*			
Larix kaempferi	ROU	*Pinus sylvestris*	x	x	
Larix laricina	ROU	*Pinus sylvestris*		x	
Larix x marschlinsii	ROU	*Pinus sylvestris*	x	x	x
Liquidambar styraciflua	ROU	*Fagus sylvatica*	x		
Liriodendron tulipifera	ROU	*Fagus sylvatica*	x	x	x
Malus florentina	ROU	*Fagus sylvatica*	x		
Metasequoia glyptostroboides	ROU	*Pinus sylvestris*		x	x
Myrica pensylvanica	ROU	*Fagus sylvatica*			
Nothofagus obliqua	ROU	*Fagus sylvatica*	x	x	x

Picea abies	ROU	*Pinus sylvestris*		x	
Picea engelmannii	ROU	*Pinus sylvestris*	x		
Picea glauca	ROU	*Pinus sylvestris*			
Picea jezoensis	ROU	*Pinus sylvestris*			
Picea mariana	ROU	*Pinus sylvestris*			
Picea omorika	ROU	*Pinus sylvestris*			
Picea orientalis	ROU	*Pinus sylvestris*	x		x
Picea pungens	ROU	*Pinus sylvestris*			
Picea rubens	ROU	*Pinus sylvestris*	x		
Picea sitchensis	ROU	*Pinus sylvestris*			x
Pinus banksiana	ROU	*Pinus sylvestris*			
Pinus contorta	ROU	*Pinus sylvestris*	x		
Pinus contorta var. latifolia	ROU	*Pinus sylvestris*	x		
Pinus contorta var. murrayana	ROU	*Pinus sylvestris*	x		
Pinus densiflora	ROU	*Pinus sylvestris*			
Pinus flexilis	ROU	*Pinus sylvestris*			
Pinus flexilis var. reflexa	ROU	*Pinus sylvestris*			
Pinus heldreichii	ROU	*Pinus sylvestris*			
Pinus jeffreyi	ROU	*Pinus sylvestris*	x		
Pinus monticola	ROU	*Pinus sylvestris*		x	x
Pinus nigra	ROU	*Pinus sylvestris*	x		x
Pinus nigra ssp. laricio	ROU	*Pinus sylvestris*	x	x	x
Pinus nigra ssp. pallasiana	ROU	*Pinus sylvestris*	x	x	x
Pinus nigra ssp. salzmannii	ROU	*Pinus sylvestris*	x		x
Pinus peuce	ROU	*Pinus sylvestris*			
Pinus ponderosa	ROU	*Pinus sylvestris*			x
Pinus ponderosa var. scopulorum	ROU	*Pinus sylvestris*			
Pinus resinosa	ROU	*Pinus sylvestris*			
Pinus rigida	ROU	*Pinus sylvestris*			
Pinus strobus	ROU	*Pinus sylvestris*		x	x
Pinus sylvestris	ROU	*Pinus sylvestris*	x	x	x
Pinus thunbergii	ROU	*Pinus sylvestris*			
Pinus virginiana	ROU	*Pinus sylvestris*			
Pinus wallichiana	ROU	*Pinus sylvestris*		x	x
Pinus x murraybanksiana	ROU	*Pinus sylvestris*	x		
Platanus orientalis	ROU	*Fagus sylvatica*			
Platycladus orientalis	ROU	*Pinus sylvestris*			
Populus balsamifera	ROU	*Fagus sylvatica*			
Populus x canescens	ROU	*Fagus sylvatica*	x	x	x
Prunus pensylvanica	ROU	*Fagus sylvatica*			x

Prunus pumila var. besseyi	ROU	*Fagus sylvatica*			
Prunus serotina	ROU	*Fagus sylvatica*	x	x	x
Pseudotsuga menziesii	ROU	*Pinus sylvestris*		x	x
Quercus garryana	ROU	*Fagus sylvatica*			
Quercus palustris	ROU	*Fagus sylvatica*	x	x	x
Quercus phellos	ROU	*Fagus sylvatica*	x	x	x
Quercus rubra	ROU	*Fagus sylvatica*	x	x	x
Robinia pseudoacacia	ROU	*Fagus sylvatica*	x	x	x
Sequoia sempervirens	ROU	*Pinus sylvestris*		x	x
Sequoiadendron giganteum	ROU	*Pinus sylvestris*	x	x	x
Sorbus aria	ROU	*Fagus sylvatica*	x		
Thuja plicata	ROU	*Pinus sylvestris*	x	x	x
Tilia cordata	ROU	*Fagus sylvatica*	x		
Tsuga canadensis	ROU	*Pinus sylvestris*	x		x
Tsuga heterophylla	ROU	*Pinus sylvestris*		x	x
Ulmus americana	ROU	*Fagus sylvatica*		x	
Abies alba	SAI	*Abies alba*	x	x	x
Abies homolepis	SAI	*Abies alba*	x		
Abies lasiocarpa var. arizonica	SAI	*Abies alba*	x	x	
Abies procera	SAI	*Abies alba*	x	x	x
Abies sachalinensis	SAI	*Abies alba*	x		
Larix decidua	SAI	*Abies alba*	x	x	x
Larix laricina	SAI	*Abies alba*	x	x	
Picea engelmannii	SAI	*Abies alba*	x	x	x
Picea glauca	SAI	*Abies alba*	x	x	x
Picea jezoensis	SAI	*Abies alba*	x	x	x
Picea mariana	SAI	*Abies alba*	x	x	
Picea omorika	SAI	*Abies alba*	x	x	
Picea orientalis	SAI	*Abies alba*	x		x
Picea pungens	SAI	*Abies alba*	x	x	
Picea rubens	SAI	*Abies alba*	x	x	
Pinus banksiana	SAI	*Abies alba*	x	x	x
Pinus contorta	SAI	*Abies alba*	x	x	x
Pinus contorta var. latifolia	SAI	*Abies alba*	x	x	
Pinus contorta var. murrayana	SAI	*Abies alba*	x	x	x
Pinus flexilis var. reflexa	SAI	*Abies alba*	x	x	x
Pinus peuce	SAI	*Abies alba*	x	x	x
Pinus strobus	SAI	*Abies alba*	x	x	x
Pinus sylvestris	SAI	*Abies alba*	x	x	x
Abies concolor	TRE	*Pinus nigra ssp. laricio*		x	
Abies pinsapo	TRE	*Pinus nigra ssp. laricio*			

Alnus incana	TRE	*Pinus nigra ssp. laricio*			
Cupressus arizonica var. glabra	TRE	*Pinus nigra ssp. laricio*	x	x	
Cupressus dupreziana var. atlantica	TRE	*Pinus nigra ssp. laricio*	x		
Cupressus goveniana	TRE	*Pinus nigra ssp. laricio*			
Cupressus lusitanica	TRE	*Pinus nigra ssp. laricio*	x		
Cupressus lusitanica var. benthamii	TRE	*Pinus nigra ssp. laricio*	x		
Cupressus macrocarpa	TRE	*Pinus nigra ssp. laricio*			
Cupressus sempervirens	TRE	*Pinus nigra ssp. laricio*			
Eucalyptus gunnii	TRE	*Pinus nigra ssp. laricio*	x		
Eucalyptus pauciflora	TRE	*Pinus nigra ssp. laricio*			
Eucalyptus rodwayi	TRE	*Pinus nigra ssp. laricio*	x		
Eucalyptus rubida	TRE	*Pinus nigra ssp. laricio*			
Eucalyptus viminalis	TRE	*Pinus nigra ssp. laricio*		x	
Fraxinus angustifolia	TRE	*Pinus nigra ssp. laricio*			
Fraxinus velutina	TRE	*Pinus nigra ssp. laricio*			
Ginkgo biloba	TRE	*Pinus nigra ssp. laricio*			
Larix decidua	TRE	*Pinus nigra ssp. laricio*			
Liriodendron tulipifera	TRE	*Pinus nigra ssp. laricio*			
Luma chequen	TRE	*Pinus nigra ssp. laricio*			
Pinus attenuata	TRE	*Pinus nigra ssp. laricio*			
Pinus echinata	TRE	*Pinus nigra ssp. laricio*			
Pinus glabra	TRE	*Pinus nigra ssp. laricio*			
Pinus jeffreyi	TRE	*Pinus nigra ssp. laricio*			
Pinus muricata	TRE	*Pinus nigra ssp. laricio*			
Pinus nigra	TRE	*Pinus nigra ssp. laricio*			
Pinus nigra ssp. laricio	TRE	*Pinus nigra ssp. laricio*	x	x	x
Pinus nigra ssp. pallasiana	TRE	*Pinus nigra ssp. laricio*			
Pinus pinea	TRE	*Pinus nigra ssp. laricio*	x		x
Pinus ponderosa var. scopulorum	TRE	*Pinus nigra ssp. laricio*			
Pinus pungens	TRE	*Pinus nigra ssp. laricio*			
Pinus radiata	TRE	*Pinus nigra ssp. laricio*			
Pinus rigida	TRE	*Pinus nigra ssp. laricio*			
Platanus occidentalis	TRE	*Pinus nigra ssp. laricio*			
Platanus orientalis	TRE	*Pinus nigra ssp. laricio*			
Prunus serotina ssp. capuli	TRE	*Pinus nigra ssp. laricio*	x		
Sequoiadendron giganteum	TRE	*Pinus nigra ssp. laricio*	x		

Appendix 4 : Table of the non-significant differences between every species tested and the reference species for every arboretum, each x represent a non-significant difference, statistical test used is t-test with 95% confidence corrected using fdrtool package

Taxa	Arboretum	Reference species	Index	mean value	Reference species mean value	test value	qvalue
Acacia melanoxylon	CAN	*Quercus pubescens*	height	10.03	8.53	-0.56	1
Acacia melanoxylon	CAN	*Quercus pubescens*	diameter	0.17	0.16	-0.10	1
Acacia melanoxylon	CAN	*Quercus pubescens*	survival	72.76	39.44	-1.49	0.456514
Eucalyptus aggregata	CAN	*Quercus pubescens*	diameter	0.65	0.16	-2.97	1
Eucalyptus aggregata	CAN	*Quercus pubescens*	height	53.30	8.53	-20.27	1
Eucalyptus aggregata	CAN	*Quercus pubescens*	survival	46.66	39.44	-0.32	0.371243
Eucalyptus ambigua	CAN	*Quercus pubescens*	diameter	0.54	0.16	-1.50	1
Eucalyptus ambigua	CAN	*Quercus pubescens*	survival	24.44	39.44	0.59	0.221443
Eucalyptus ambigua	CAN	*Quercus pubescens*	height	30.00	8.53	-2.67	1
Eucalyptus coccifera	CAN	*Quercus pubescens*	diameter	0.53	0.16	-1.99	1
Eucalyptus coccifera	CAN	*Quercus pubescens*	survival	43.33	39.44	-0.18	0.351657
Eucalyptus coccifera	CAN	*Quercus pubescens*	height	33.96	8.53	-2.74	1
Eucalyptus dalrympleana	CAN	*Quercus pubescens*	diameter	0.67	0.16	-2.16	1
Eucalyptus dalrympleana	CAN	*Quercus pubescens*	height	44.83	8.53	-2.87	1
Eucalyptus dalrympleana	CAN	*Quercus pubescens*	survival	41.66	39.44	-0.10	0.339934
Eucalyptus glaucescens	CAN	*Quercus pubescens*	height	37.07	8.53	-1.24	1
Eucalyptus glaucescens	CAN	*Quercus pubescens*	diameter	0.43	0.16	-1.38	1
Eucalyptus glaucescens	CAN	*Quercus pubescens*	survival	45.84	39.44	-0.27	0.364547
Eucalyptus gunnii	CAN	*Quercus pubescens*	diameter	0.41	0.16	-2.07	1
Eucalyptus gunnii	CAN	*Quercus pubescens*	height	28.41	8.53	-2.49	1
Eucalyptus gunnii	CAN	*Quercus pubescens*	survival	35.55	39.44	0.16	0.298227
Eucalyptus johnstonii	CAN	*Quercus pubescens*	height	32.20	8.53	-10.74	1
Eucalyptus johnstonii	CAN	*Quercus pubescens*	survival	33.33	39.44	0.23	0.286951
Eucalyptus johnstonii	CAN	*Quercus pubescens*	diameter	0.32	0.16	-0.81	1
Eucalyptus laevopinea	CAN	*Quercus pubescens*	survival	89.52	39.44	-2.31	0.472371
Eucalyptus laevopinea	CAN	*Quercus pubescens*	height	63.93	8.53	-18.55	1
Eucalyptus laevopinea	CAN	*Quercus pubescens*	diameter	0.62	0.16	-14.36	1
Eucalyptus obliqua	CAN	*Quercus pubescens*	height	46.74	8.53	-13.86	1
Eucalyptus obliqua	CAN	*Quercus pubescens*	survival	56.67	39.44	-0.79	0.418088
Eucalyptus obliqua	CAN	*Quercus pubescens*	diameter	0.39	0.16	-5.96	1
Eucalyptus ovata	CAN	*Quercus pubescens*	height	37.83	8.53	-4.75	1
Eucalyptus ovata	CAN	*Quercus pubescens*	diameter	0.38	0.16	-3.33	1
Eucalyptus ovata	CAN	*Quercus pubescens*	survival	45.83	39.44	-0.28	0.365626
Eucalyptus parvula	CAN	*Quercus pubescens*	survival	48.33	39.44	-0.39	0.379674
Eucalyptus parvula	CAN	*Quercus pubescens*	height	27.60	8.53	-4.26	1
Eucalyptus parvula	CAN	*Quercus pubescens*	diameter	0.46	0.16	-2.00	1
Eucalyptus pauciflora	CAN	*Quercus pubescens*	height	22.22	8.53	-1.15	1
Eucalyptus pauciflora	CAN	*Quercus pubescens*	diameter	0.30	0.16	-1.84	1
Eucalyptus pauciflora	CAN	*Quercus pubescens*	survival	22.22	39.44	0.74	0.199871
Eucalyptus perriniana	CAN	*Quercus pubescens*	survival	35.00	39.44	0.19	0.292905
Eucalyptus perriniana	CAN	*Quercus pubescens*	height	23.11	8.53	-1.61	1

Eucalyptus perriniana	CAN	*Quercus pubescens*	diameter	0.23	0.16	-0.96	1
Eucalyptus pulchella	CAN	*Quercus pubescens*	survival	71.67	39.44	-1.24	0.449306
Eucalyptus pulchella	CAN	*Quercus pubescens*	diameter	0.40	0.16	-2.06	1
Eucalyptus pulchella	CAN	*Quercus pubescens*	height	47.44	8.53	-2.07	1
Eucalyptus rodwayi	CAN	*Quercus pubescens*	diameter	0.33	0.16	-3.72	1
Eucalyptus rodwayi	CAN	*Quercus pubescens*	survival	55.00	39.44	-0.60	0.403744
Eucalyptus rodwayi	CAN	*Quercus pubescens*	height	35.50	8.53	-6.38	1
Eucalyptus rubida	CAN	*Quercus pubescens*	height	41.93	8.53	-3.76	1
Eucalyptus rubida	CAN	*Quercus pubescens*	diameter	0.35	0.16	-2.41	1
Eucalyptus rubida	CAN	*Quercus pubescens*	survival	70.00	39.44	-1.37	0.451835
Eucalyptus subcrenulata	CAN	*Quercus pubescens*	survival	23.34	39.44	0.72	0.205049
Eucalyptus subcrenulata	CAN	*Quercus pubescens*	height	14.59	8.53	-2.73	1
Eucalyptus subcrenulata	CAN	*Quercus pubescens*	diameter	0.22	0.16	-0.72	1
Eucalyptus urnigera	CAN	*Quercus pubescens*	survival	47.50	39.44	-0.34	0.374281
Eucalyptus urnigera	CAN	*Quercus pubescens*	diameter	0.27	0.16	-2.44	1
Eucalyptus urnigera	CAN	*Quercus pubescens*	height	26.98	8.53	-4.87	1
Eucalyptus viminalis	CAN	*Quercus pubescens*	survival	40.00	39.44	-0.03	0.328922
Eucalyptus viminalis	CAN	*Quercus pubescens*	diameter	0.45	0.16	-8.81	1
Eucalyptus viminalis	CAN	*Quercus pubescens*	height	43.47	8.53	-3.26	1
Pinus nigra ssp. laricio	CAN	*Pinus nigra ssp. laricio*	height	21.19			
Pinus nigra ssp. laricio	CAN	*Pinus nigra ssp. laricio*	diameter	0.32			
Pinus nigra ssp. laricio	CAN	*Pinus nigra ssp. laricio*	survival	88.33			
Prunus serotina ssp. capuli	CAN	*Quercus pubescens*	diameter	0.44	0.16	-8.37	1
Prunus serotina ssp. capuli	CAN	*Quercus pubescens*	height	29.90	8.53	-6.16	1
Prunus serotina ssp. capuli	CAN	*Quercus pubescens*	survival	18.89	39.44	0.87	0.181858
Quercus pubescens	CAN	*Quercus pubescens*	survival	39.44			
Quercus pubescens	CAN	*Quercus pubescens*	height	8.53			
Quercus pubescens	CAN	*Quercus pubescens*	diameter	0.16			
Acer pseudoplatanus	COL	*Betula pendula*	diameter	0.25	0.30	1.04	0.382402
Acer pseudoplatanus	COL	*Betula pendula*	survival	45.84	20.00	-2.12	0.233823
Acer pseudoplatanus	COL	*Betula pendula*	height	21.79	24.60	0.58	0.296277
Alnus alnobetula ssp. suaveolens	COL	*Betula pendula*	survival	18.34	20.00	0.19	0.131522
Alnus alnobetula ssp. suaveolens	COL	*Betula pendula*	height	6.14	24.60	4.27	0.070947
Alnus cordata	COL	*Betula pendula*	height	25.52	24.60	-0.21	0.366013
Alnus cordata	COL	*Betula pendula*	survival	15.56	20.00	0.59	0.10879
Alnus cordata	COL	*Betula pendula*	diameter	0.33	0.30	-1.06	0.728239
Alnus incana	COL	*Betula pendula*	diameter	0.26	0.30	2.95	0.187476
Alnus incana	COL	*Betula pendula*	survival	15.55	20.00	0.63	0.10605
Alnus incana	COL	*Betula pendula*	height	21.47	24.60	0.54	0.299924
Betula ermanii	COL	*Betula pendula*	height	22.09	24.60	0.22	0.3219
Betula ermanii	COL	*Betula pendula*	diameter	0.34	0.30	-0.24	0.661809

Betula ermanii	COL	*Betula pendula*	survival	20.00	20.00	0.00	0.139177
Betula papyrifera	COL	*Betula pendula*	height	27.12	24.60	-0.46	0.402104
Betula papyrifera	COL	*Betula pendula*	diameter	0.36	0.30	-1.53	0.755508
Betula papyrifera	COL	*Betula pendula*	survival	19.44	20.00	0.08	0.13529
Betula pendula	COL	*Betula pendula*	diameter	0.30			
Betula pendula	COL	*Betula pendula*	survival	20.00			
Betula pendula	COL	*Betula pendula*	height	24.60			
Picea abies	COL	*Picea abies*	diameter	0.54			
Picea abies	COL	*Picea abies*	survival	40.42			
Picea abies	COL	*Picea abies*	height	37.58			
Acacia melanoxylon	PLA	*Quercus pubescens*	survival	22.86	31.67	0.42	0.182781
Acacia melanoxylon	PLA	*Quercus pubescens*	height	19.79	17.30	-0.84	1
Acacia melanoxylon	PLA	*Quercus pubescens*	diameter	0.36	0.27	-1.14	1
Cupressus arizonica	PLA	*Pinus nigra ssp. laricio*	survival	82.62	61.67	-5.28	0.135466
Cupressus arizonica	PLA	*Pinus nigra ssp. laricio*	diameter	0.40	0.43	0.77	0.677816
Cupressus arizonica	PLA	*Pinus nigra ssp. laricio*	height	23.52	25.39	0.37	0.07983
Cupressus goveniana var. abramsiana	PLA	*Pinus nigra ssp. laricio*	height	24.02	25.39	0.18	0.086624
Cupressus goveniana var. abramsiana	PLA	*Pinus nigra ssp. laricio*	diameter	0.48	0.43	-0.55	0.848207
Cupressus goveniana var. abramsiana	PLA	*Pinus nigra ssp. laricio*	survival	80.00	61.67	-3.42	0.132038
Eucalyptus acaciiformis	PLA	*Quercus pubescens*	survival	56.66	31.67	-1.11	0.328393
Eucalyptus acaciiformis	PLA	*Quercus pubescens*	height	39.12	17.30	-3.54	1
Eucalyptus acaciiformis	PLA	*Quercus pubescens*	diameter	0.50	0.27	-2.80	1
Eucalyptus aggregata	PLA	*Quercus pubescens*	height	36.28	17.30	-2.27	1
Eucalyptus aggregata	PLA	*Quercus pubescens*	survival	28.34	31.67	0.13	0.216085
Eucalyptus aggregata	PLA	*Quercus pubescens*	diameter	0.43	0.27	-2.14	1
Eucalyptus archeri	PLA	*Quercus pubescens*	survival	15.95	31.67	0.80	0.153518
Eucalyptus archeri	PLA	*Quercus pubescens*	height	7.78	17.30	2.92	1
Eucalyptus archeri	PLA	*Quercus pubescens*	diameter	0.21	0.27	1.09	1
Eucalyptus cinerea	PLA	*Quercus pubescens*	diameter	0.56	0.27	-3.89	1
Eucalyptus cinerea	PLA	*Quercus pubescens*	survival	63.34	31.67	-1.14	0.327471
Eucalyptus cinerea	PLA	*Quercus pubescens*	height	29.33	17.30	-1.63	1
Eucalyptus cordata	PLA	*Quercus pubescens*	survival	55.56	31.67	-1.56	0.332817
Eucalyptus cordata	PLA	*Quercus pubescens*	diameter	0.59	0.27	-2.84	1
Eucalyptus cordata	PLA	*Quercus pubescens*	height	49.86	17.30	-9.37	1
Eucalyptus dalrympleana	PLA	*Quercus pubescens*	survival	47.69	31.67	-0.79	0.312306
Eucalyptus dalrympleana	PLA	*Quercus pubescens*	diameter	0.58	0.27	-2.51	1
Eucalyptus dalrympleana	PLA	*Quercus pubescens*	height	35.21	17.30	-3.95	1
Eucalyptus gunnii	PLA	*Quercus pubescens*	diameter	0.53	0.27	-2.40	1
Eucalyptus gunnii	PLA	*Quercus pubescens*	height	32.86	17.30	-4.02	1
Eucalyptus gunnii	PLA	*Quercus pubescens*	survival	30.83	31.67	0.05	0.225792

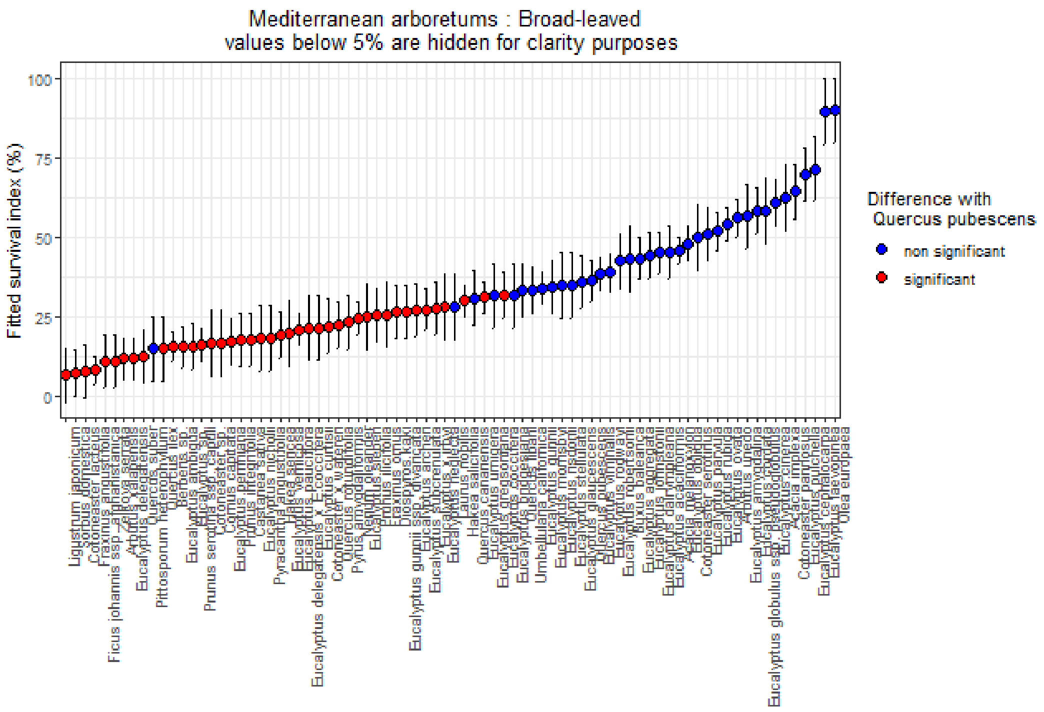
Eucalyptus johnstonii	PLA	*Quercus pubescens*	diameter	0.38	0.27	-1.97	1
Eucalyptus johnstonii	PLA	*Quercus pubescens*	survival	55.00	31.67	-0.67	0.297792
Eucalyptus johnstonii	PLA	*Quercus pubescens*	height	29.31	17.30	-3.58	1
Eucalyptus morrisbyi	PLA	*Quercus pubescens*	survival	26.67	31.67	0.20	0.208057
Eucalyptus morrisbyi	PLA	*Quercus pubescens*	height	42.62	17.30	-6.25	1
Eucalyptus morrisbyi	PLA	*Quercus pubescens*	diameter	0.50	0.27	-2.60	1
Eucalyptus obliqua	PLA	*Quercus pubescens*	survival	36.67	31.67	-0.19	0.256581
Eucalyptus obliqua	PLA	*Quercus pubescens*	diameter	0.32	0.27	-0.61	1
Eucalyptus obliqua	PLA	*Quercus pubescens*	height	29.07	17.30	-0.88	1
Eucalyptus ovata	PLA	*Quercus pubescens*	height	38.13	17.30	-6.69	1
Eucalyptus ovata	PLA	*Quercus pubescens*	survival	62.50	31.67	-2.00	0.342603
Eucalyptus ovata	PLA	*Quercus pubescens*	diameter	0.35	0.27	-1.40	1
Eucalyptus pauciflora	PLA	*Quercus pubescens*	height	34.35	17.30	-2.82	1
Eucalyptus pauciflora	PLA	*Quercus pubescens*	diameter	0.45	0.27	-1.57	1
Eucalyptus pauciflora	PLA	*Quercus pubescens*	survival	19.17	31.67	0.70	0.162276
Eucalyptus rodwayi	PLA	*Quercus pubescens*	diameter	0.41	0.27	-2.88	1
Eucalyptus rodwayi	PLA	*Quercus pubescens*	height	27.22	17.30	-2.10	1
Eucalyptus rodwayi	PLA	*Quercus pubescens*	survival	28.34	31.67	0.14	0.214418
Eucalyptus rubida	PLA	*Quercus pubescens*	survival	51.67	31.67	-0.84	0.313275
Eucalyptus rubida	PLA	*Quercus pubescens*	diameter	0.31	0.27	-1.16	1
Eucalyptus rubida	PLA	*Quercus pubescens*	height	39.54	17.30	-2.80	1
Eucalyptus subcrenulata	PLA	*Quercus pubescens*	diameter	0.21	0.27	0.70	1
Eucalyptus subcrenulata	PLA	*Quercus pubescens*	height	20.88	17.30	-0.46	1
Eucalyptus subcrenulata	PLA	*Quercus pubescens*	survival	36.67	31.67	-0.30	0.266071
Eucalyptus urnigera	PLA	*Quercus pubescens*	height	29.16	17.30	-4.95	1
Eucalyptus urnigera	PLA	*Quercus pubescens*	survival	22.50	31.67	0.52	0.177263
Eucalyptus urnigera	PLA	*Quercus pubescens*	diameter	0.44	0.27	-1.90	1
Eucalyptus viminalis	PLA	*Quercus pubescens*	survival	56.67	31.67	-1.52	0.337473
Eucalyptus viminalis	PLA	*Quercus pubescens*	diameter	0.29	0.27	-0.37	1
Eucalyptus viminalis	PLA	*Quercus pubescens*	height	27.93	17.30	-1.83	1
Pinus nigra ssp. laricio	PLA	*Pinus nigra ssp. laricio*	diameter	0.43			
Pinus nigra ssp. laricio	PLA	*Pinus nigra ssp. laricio*	height	25.39			
Pinus nigra ssp. laricio	PLA	*Pinus nigra ssp. laricio*	survival	61.67			
Pinus nigra ssp. pallasiana	PLA	*Pinus nigra ssp. laricio*	survival	64.17	61.67	-0.22	0.083127
Pinus nigra ssp. pallasiana	PLA	*Pinus nigra ssp. laricio*	height	21.02	25.39	0.82	0.07983
Pinus nigra ssp. pallasiana	PLA	*Pinus nigra ssp. laricio*	diameter	0.44	0.43	-0.33	0.831534
Quercus pubescens	PLA	*Quercus pubescens*	diameter	0.27			
Quercus pubescens	PLA	*Quercus pubescens*	survival	31.67			
Quercus pubescens	PLA	*Quercus pubescens*	height	17.30			
Acer rubrum	ROU	*Fagus sylvatica*	diameter	0.68	0.73	1.46	0.056424
Acer rubrum	ROU	*Fagus sylvatica*	height	52.80	54.71	0.85	0.147517
Acer rubrum	ROU	*Fagus sylvatica*	survival	45.99	42.67	-0.38	0.40067

Acer saccharum	ROU	*Fagus sylvatica*	height	46.85	54.71	2.00	0.05812
Acer saccharum	ROU	*Fagus sylvatica*	survival	44.45	42.67	-0.10	0.357442
Alnus rubra	ROU	*Fagus sylvatica*	height	52.15	54.71	0.22	0.260327
Alnus rubra	ROU	*Fagus sylvatica*	survival	50.72	42.67	-0.37	0.390021
Alnus rubra	ROU	*Fagus sylvatica*	diameter	0.72	0.73	0.04	0.23758
Betula pendula	ROU	*Fagus sylvatica*	survival	46.67	42.67	-0.32	0.391471
Betula pendula	ROU	*Fagus sylvatica*	height	58.48	54.71	-1.20	0.415619
Cryptomeria japonica	ROU	*Pinus sylvestris*	survival	32.23	40.84	1.14	0.058125
Cryptomeria japonica	ROU	*Pinus sylvestris*	height	60.04	57.39	-0.91	0.288176
Cryptomeria japonica	ROU	*Pinus sylvestris*	diameter	1.03	0.93	-1.67	0.414739
Cupressus x leylandii	ROU	*Pinus sylvestris*	height	72.74	57.39	-3.24	0.331551
Cupressus x leylandii	ROU	*Pinus sylvestris*	diameter	1.26	0.93	-4.38	0.430407
Cupressus x leylandii	ROU	*Pinus sylvestris*	survival	49.17	40.84	-1.24	0.262047
Fagus sylvatica	ROU	*Fagus sylvatica*	diameter	0.73			
Fagus sylvatica	ROU	*Fagus sylvatica*	height	54.71			
Fagus sylvatica	ROU	*Fagus sylvatica*	survival	42.67			
Fraxinus angustifolia	ROU	*Fagus sylvatica*	survival	28.34	42.67	1.05	0.184587
Fraxinus angustifolia	ROU	*Fagus sylvatica*	height	33.23	54.71	1.95	0.106468
Larix decidua	ROU	*Pinus sylvestris*	height	64.74	57.39	-2.52	0.328818
Larix decidua	ROU	*Pinus sylvestris*	survival	38.33	40.84	0.27	0.139082
Larix decidua	ROU	*Pinus sylvestris*	diameter	0.96	0.93	-0.37	0.325136
Larix kaempferi	ROU	*Pinus sylvestris*	survival	35.59	40.84	0.71	0.094782
Larix kaempferi	ROU	*Pinus sylvestris*	height	60.98	57.39	-1.86	0.326263
Larix x marschlinsii	ROU	*Pinus sylvestris*	height	62.37	57.39	-0.96	0.290694
Larix x marschlinsii	ROU	*Pinus sylvestris*	survival	45.99	40.84	-0.88	0.244963
Larix x marschlinsii	ROU	*Pinus sylvestris*	diameter	0.95	0.93	-0.21	0.304936
Liriodendron tulipifera	ROU	*Fagus sylvatica*	survival	26.29	42.67	1.55	0.099242
Liriodendron tulipifera	ROU	*Fagus sylvatica*	height	59.52	54.71	-1.55	0.425979
Liriodendron tulipifera	ROU	*Fagus sylvatica*	diameter	0.92	0.73	-2.99	0.384669
Nothofagus obliqua	ROU	*Fagus sylvatica*	diameter	0.84	0.73	-0.81	0.33338
Nothofagus obliqua	ROU	*Fagus sylvatica*	height	70.46	54.71	-2.85	0.448206
Nothofagus obliqua	ROU	*Fagus sylvatica*	survival	43.15	42.67	-0.04	0.348764
Pinus nigra ssp. laricio	ROU	*Pinus sylvestris*	diameter	1.11	0.93	-2.52	0.424946
Pinus nigra ssp. laricio	ROU	*Pinus sylvestris*	height	58.69	57.39	-0.42	0.247166
Pinus nigra ssp. laricio	ROU	*Pinus sylvestris*	survival	34.00	40.84	1.21	0.054276
Pinus nigra ssp. pallasiana	ROU	*Pinus sylvestris*	diameter	1.02	0.93	-1.86	0.418434
Pinus nigra ssp. pallasiana	ROU	*Pinus sylvestris*	survival	38.91	40.84	0.26	0.140063
Pinus nigra ssp. pallasiana	ROU	*Pinus sylvestris*	height	53.01	57.39	1.32	0.057997
Pinus sylvestris	ROU	*Pinus sylvestris*	diameter	0.93			
Pinus sylvestris	ROU	*Pinus sylvestris*	height	57.39			
Pinus sylvestris	ROU	*Pinus sylvestris*	survival	40.84			
Populus x canescens	ROU	*Fagus sylvatica*	survival	36.67	42.67	0.77	0.203436
Populus x canescens	ROU	*Fagus sylvatica*	diameter	0.86	0.73	-0.73	0.310766
Populus x canescens	ROU	*Fagus sylvatica*	height	64.07	54.71	-1.28	0.396039

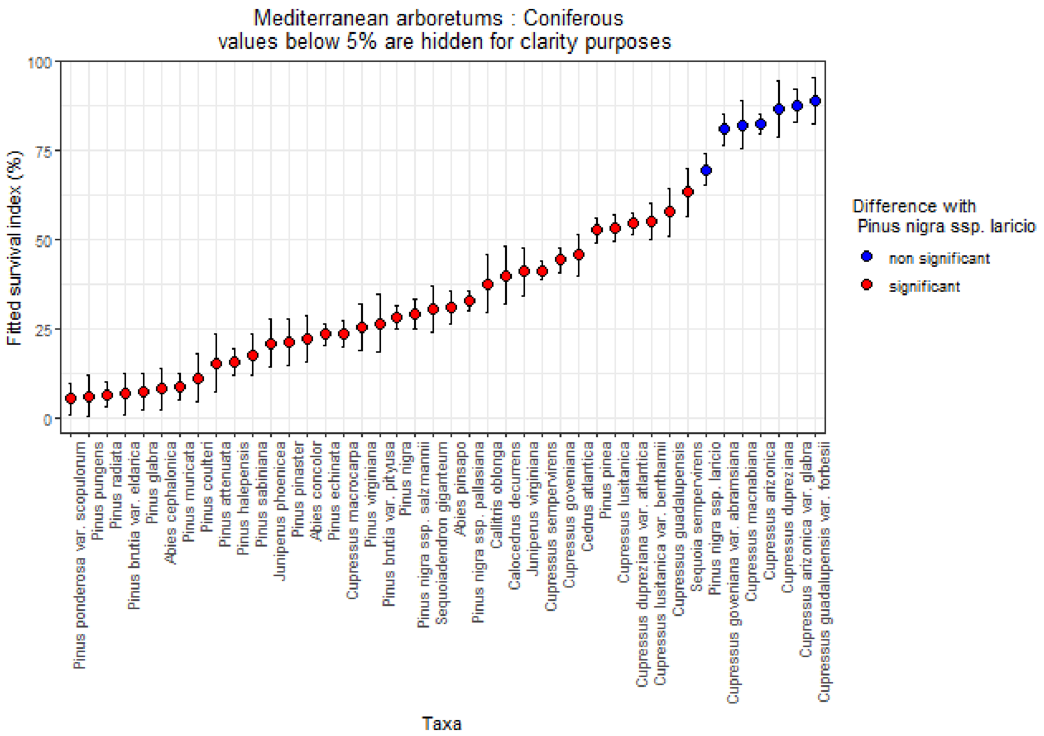
Prunus serotina	ROU	*Fagus sylvatica*	survival	46.20	42.67	-0.27	0.384245
Prunus serotina	ROU	*Fagus sylvatica*	diameter	0.75	0.73	-0.28	0.280203
Prunus serotina	ROU	*Fagus sylvatica*	height	55.84	54.71	-0.49	0.358642
Quercus palustris	ROU	*Fagus sylvatica*	diameter	0.72	0.73	0.18	0.215075
Quercus palustris	ROU	*Fagus sylvatica*	survival	46.38	42.67	-0.41	0.40366
Quercus palustris	ROU	*Fagus sylvatica*	height	55.66	54.71	-0.36	0.343047
Quercus phellos	ROU	*Fagus sylvatica*	survival	36.67	42.67	0.62	0.230701
Quercus phellos	ROU	*Fagus sylvatica*	diameter	0.65	0.73	0.83	0.146603
Quercus phellos	ROU	*Fagus sylvatica*	height	50.20	54.71	0.61	0.208002
Quercus rubra	ROU	*Fagus sylvatica*	diameter	0.75	0.73	-0.25	0.275785
Quercus rubra	ROU	*Fagus sylvatica*	survival	42.33	42.67	0.04	0.335071
Quercus rubra	ROU	*Fagus sylvatica*	height	53.94	54.71	0.29	0.242091
Robinia pseudoacacia	ROU	*Fagus sylvatica*	height	53.74	54.71	0.26	0.248416
Robinia pseudoacacia	ROU	*Fagus sylvatica*	diameter	0.85	0.73	-2.29	0.383274
Robinia pseudoacacia	ROU	*Fagus sylvatica*	survival	43.96	42.67	-0.12	0.361131
Sequoiadendron giganteum	ROU	*Pinus sylvestris*	survival	35.00	40.84	1.12	0.058237
Sequoiadendron giganteum	ROU	*Pinus sylvestris*	diameter	1.56	0.93	-7.96	0.431212
Sequoiadendron giganteum	ROU	*Pinus sylvestris*	height	62.11	57.39	-1.28	0.305823
Thuja plicata	ROU	*Pinus sylvestris*	survival	58.96	40.84	-2.22	0.282615
Thuja plicata	ROU	*Pinus sylvestris*	height	57.52	57.39	-0.11	0.2143
Thuja plicata	ROU	*Pinus sylvestris*	diameter	0.94	0.93	-0.17	0.299523
Abies alba	SAI	*Abies alba*	diameter	0.57			
Abies alba	SAI	*Abies alba*	height	37.73			
Abies alba	SAI	*Abies alba*	survival	48.33			
Abies lasiocarpa var. arizonica	SAI	*Abies alba*	survival	54.45	48.33	-0.30	0.373456
Abies lasiocarpa var. arizonica	SAI	*Abies alba*	height	22.88	37.73	2.58	0.121621
Abies procera	SAI	*Abies alba*	survival	32.69	48.33	0.47	0.257124
Abies procera	SAI	*Abies alba*	diameter	0.63	0.57	-1.81	0.439819
Abies procera	SAI	*Abies alba*	height	37.84	37.73	-0.02	0.230951
Larix decidua	SAI	*Abies alba*	height	51.39	37.73	-1.90	0.353507
Larix decidua	SAI	*Abies alba*	diameter	0.81	0.57	-6.54	0.464583
Larix decidua	SAI	*Abies alba*	survival	42.91	48.33	0.24	0.286324
Larix laricina	SAI	*Abies alba*	height	36.32	37.73	0.24	0.196967
Larix laricina	SAI	*Abies alba*	survival	53.04	48.33	-0.21	0.362335
Picea engelmannii	SAI	*Abies alba*	diameter	0.52	0.57	1.05	0.134209
Picea engelmannii	SAI	*Abies alba*	height	31.23	37.73	1.13	0.140373
Picea engelmannii	SAI	*Abies alba*	survival	15.62	48.33	1.65	0.184584
Picea glauca	SAI	*Abies alba*	height	30.93	37.73	1.23	0.139929
Picea glauca	SAI	*Abies alba*	diameter	0.48	0.57	2.36	0.058558
Picea glauca	SAI	*Abies alba*	survival	25.57	48.33	1.13	0.19665
Picea jezoensis	SAI	*Abies alba*	diameter	0.46	0.57	3.07	0.052204
Picea jezoensis	SAI	*Abies alba*	survival	19.16	48.33	1.43	0.184584
Picea jezoensis	SAI	*Abies alba*	height	29.02	37.73	1.56	0.136746

Picea mariana	SAI	*Abies alba*	survival	10.65	48.33	1.88	0.184584
Picea mariana	SAI	*Abies alba*	height	21.28	37.73	2.96	0.121621
Picea omorika	SAI	*Abies alba*	survival	77.23	48.33	-1.27	0.459374
Picea omorika	SAI	*Abies alba*	height	34.87	37.73	0.52	0.165248
Picea pungens	SAI	*Abies alba*	survival	18.75	48.33	1.45	0.184584
Picea pungens	SAI	*Abies alba*	height	19.53	37.73	3.13	0.121621
Picea rubens	SAI	*Abies alba*	survival	29.83	48.33	0.75	0.206986
Picea rubens	SAI	*Abies alba*	height	28.53	37.73	1.64	0.135826
Pinus banksiana	SAI	*Abies alba*	diameter	0.52	0.57	1.08	0.13863
Pinus banksiana	SAI	*Abies alba*	survival	14.33	48.33	1.60	0.184584
Pinus banksiana	SAI	*Abies alba*	height	25.48	37.73	2.16	0.12913
Pinus contorta	SAI	*Abies alba*	diameter	0.56	0.57	0.07	0.293144
Pinus contorta	SAI	*Abies alba*	height	34.32	37.73	0.60	0.160145
Pinus contorta	SAI	*Abies alba*	survival	66.00	48.33	-0.61	0.411612
Pinus contorta var. latifolia	SAI	*Abies alba*	survival	32.01	48.33	0.74	0.207758
Pinus contorta var. latifolia	SAI	*Abies alba*	height	31.86	37.73	1.02	0.141272
Pinus contorta var. murrayana	SAI	*Abies alba*	height	41.43	37.73	-0.66	0.297417
Pinus contorta var. murrayana	SAI	*Abies alba*	survival	26.00	48.33	0.89	0.202896
Pinus contorta var. murrayana	SAI	*Abies alba*	diameter	0.51	0.57	1.50	0.11278
Pinus flexilis var. reflexa	SAI	*Abies alba*	diameter	0.53	0.57	0.48	0.231965
Pinus flexilis var. reflexa	SAI	*Abies alba*	height	30.69	37.73	0.85	0.146259
Pinus flexilis var. reflexa	SAI	*Abies alba*	survival	39.68	48.33	0.33	0.274199
Pinus peuce	SAI	*Abies alba*	height	33.28	37.73	0.81	0.148266
Pinus peuce	SAI	*Abies alba*	diameter	0.60	0.57	-0.99	0.408746
Pinus peuce	SAI	*Abies alba*	survival	89.52	48.33	-2.09	0.478523
Pinus strobus	SAI	*Abies alba*	survival	58.86	48.33	-0.51	0.399922
Pinus strobus	SAI	*Abies alba*	diameter	0.65	0.57	-2.13	0.449456
Pinus strobus	SAI	*Abies alba*	height	31.73	37.73	1.09	0.141062
Pinus sylvestris	SAI	*Abies alba*	survival	24.84	48.33	1.05	0.198003
Pinus sylvestris	SAI	*Abies alba*	height	41.35	37.73	-0.44	0.281306
Pinus sylvestris	SAI	*Abies alba*	diameter	0.65	0.57	-0.87	0.404082
Cupressus arizonica var. glabra	TRE	*Pinus nigra ssp. laricio*	survival	75.00	62.80	-1.09	0.163339
Cupressus arizonica var. glabra	TRE	*Pinus nigra ssp. laricio*	height	34.82	34.44	-0.07	0.082202
Pinus nigra ssp. laricio	TRE	*Pinus nigra ssp. laricio*	diameter	0.66			
Pinus nigra ssp. laricio	TRE	*Pinus nigra ssp. laricio*	survival	62.80			
Pinus nigra ssp. laricio	TRE	*Pinus nigra ssp. laricio*	height	34.44			

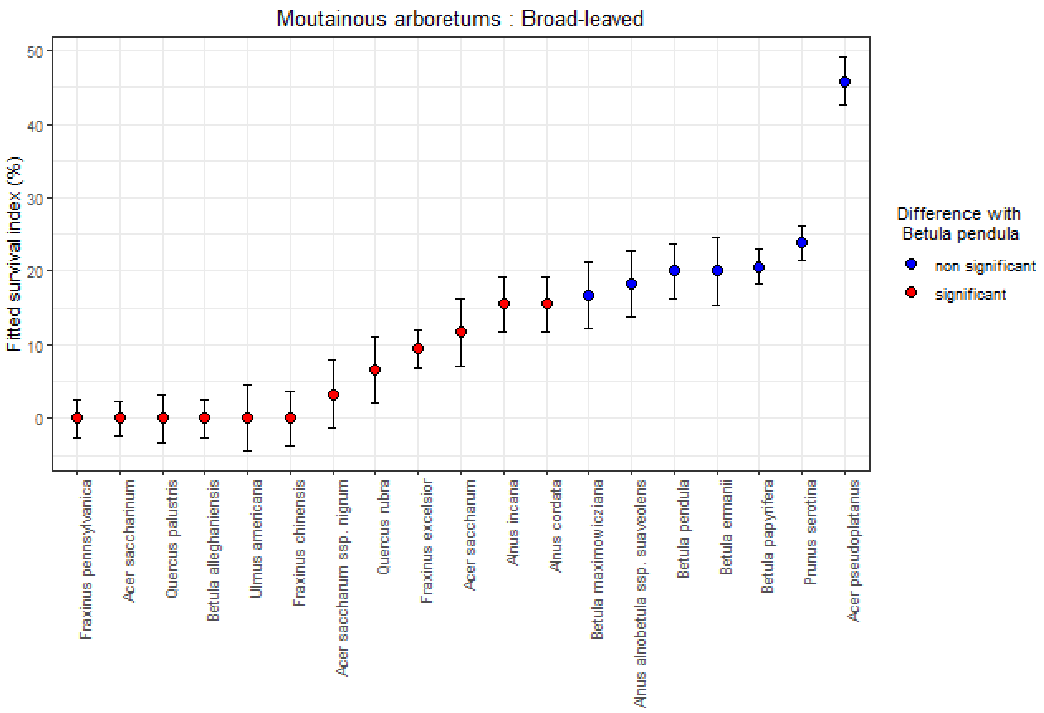
Appendix 5 : Table of the results of the t-test with 95% confidence for every species with at least non-significant differences for survival and height index, qvalue is the corrected pvalue computed using the fdrtool package



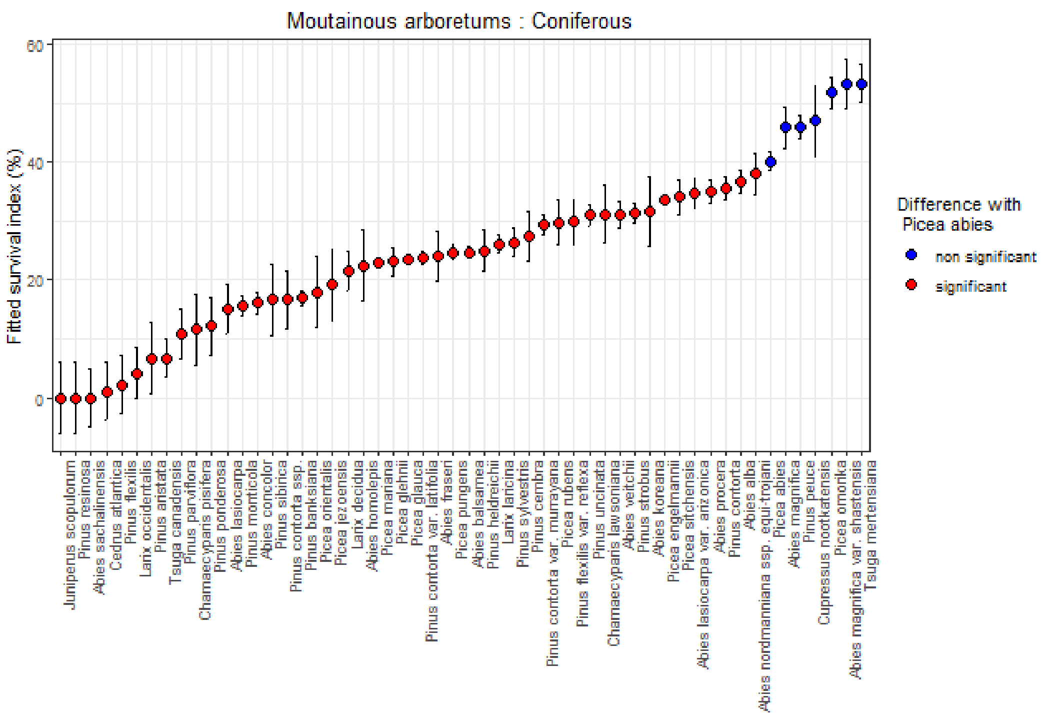
Appendix 6a : Classification of the fitted survival index for the broad-leaved species of the Mediterranean arboretums, blue species are non-significantly worse than Quercus pubescens, red species are significantly worse than Quercus pubescens, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package, fitted values are calculated via mix-models as described previously



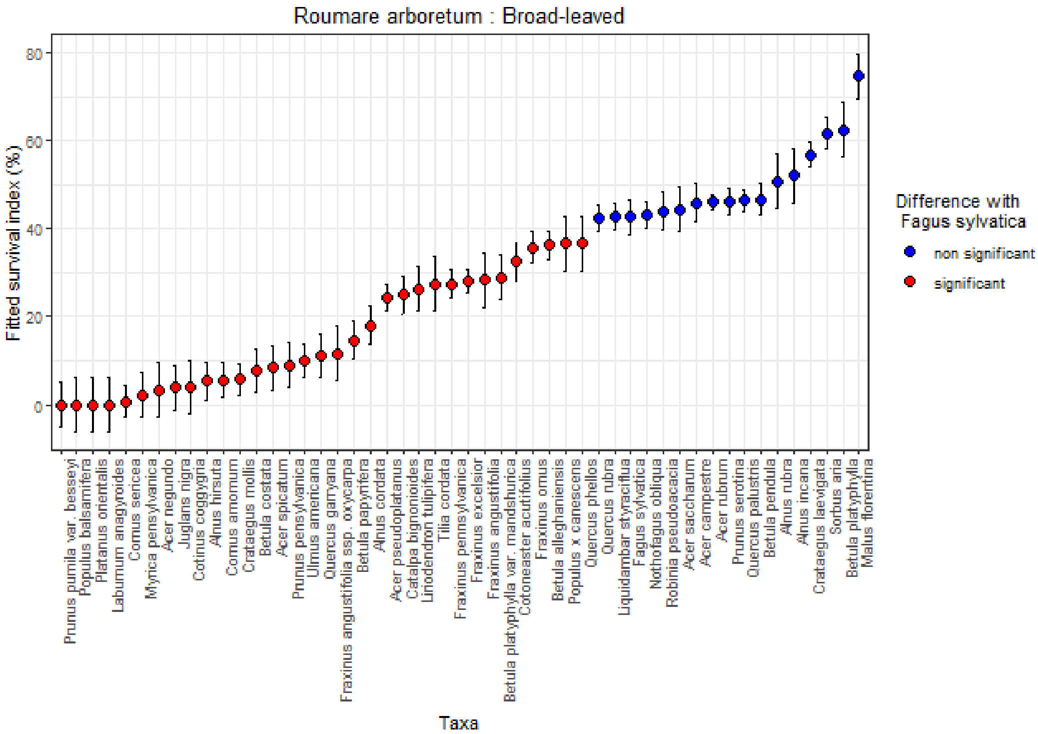
Appendix 6b : Classification of the fitted survival index for the coniferous species of the Mediterranean arboretums, blue species are non-significantly worse than Pinus nigra ssp. laricio, red species are significantly worse than Pinus nigra ssp. laricio, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package, fitted values are calculated via mix-models as described previously



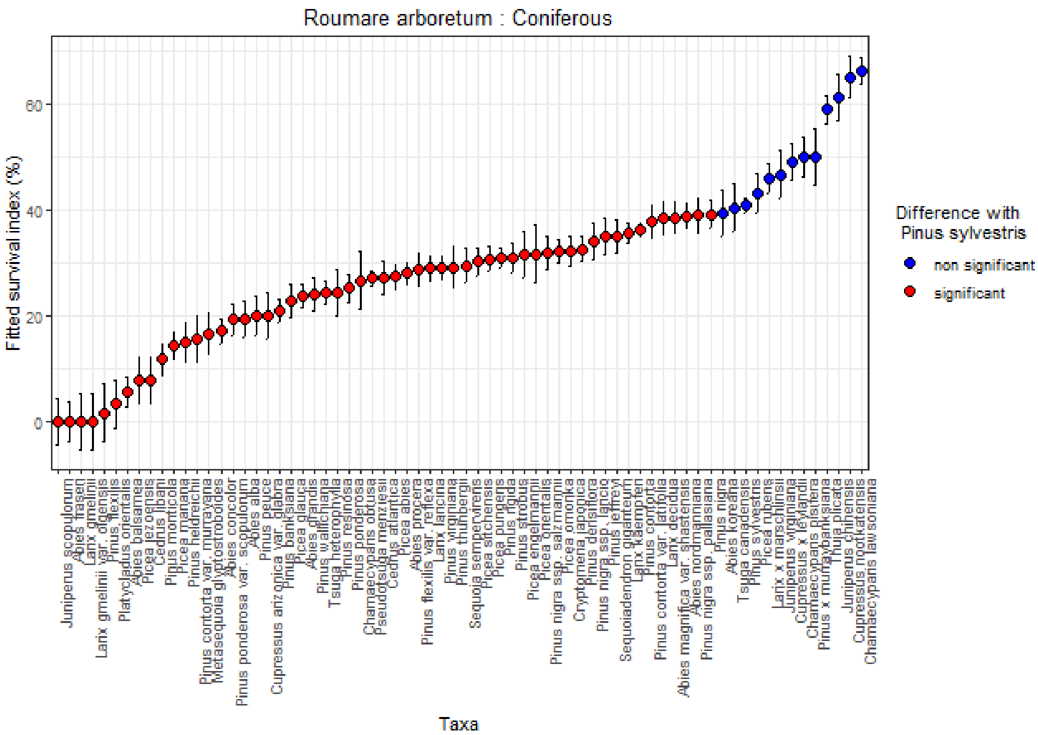
Appendix 6c : Classification of the fitted survival index for the broad-leaved species of the mountainous arboretums, blue species are non-significantly worse than Betula pendula, red species are significantly worse than Betula pendula, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package, fitted values are calculated via mix-models as described previously



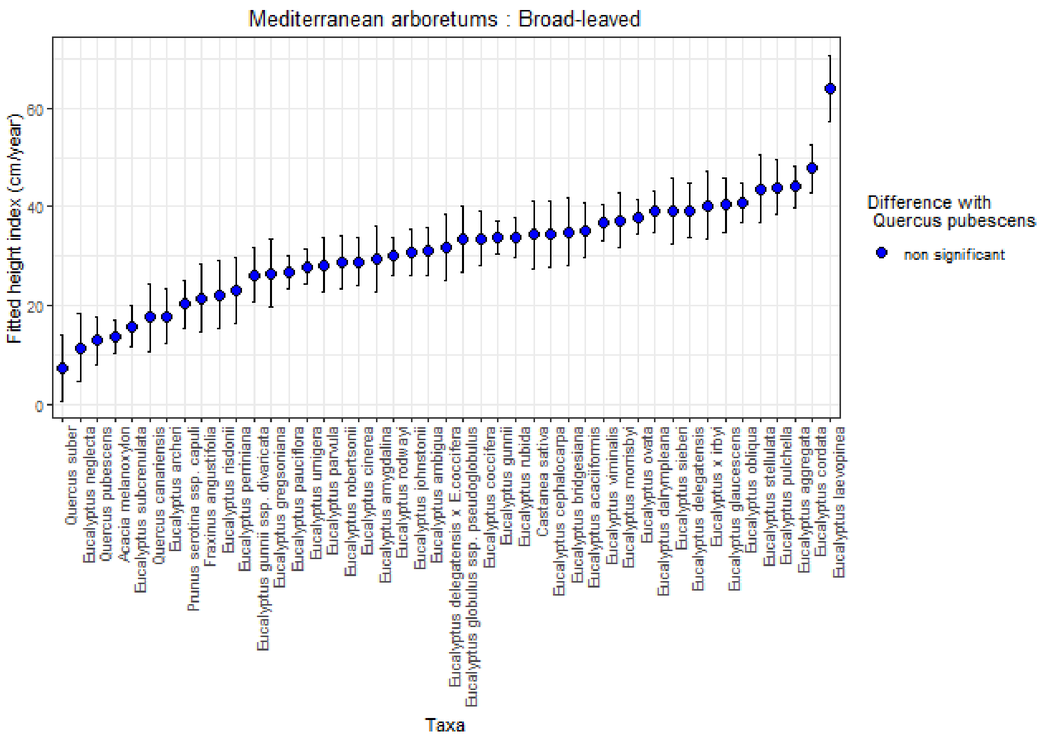
Appendix 6d : Classification of the fitted survival index for the coniferous species of the mountainous arboretums, blue species are non-significantly worse than Picea abies, red species are significantly worse than Picea abies, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package, fitted values are calculated via mix-models as described previously



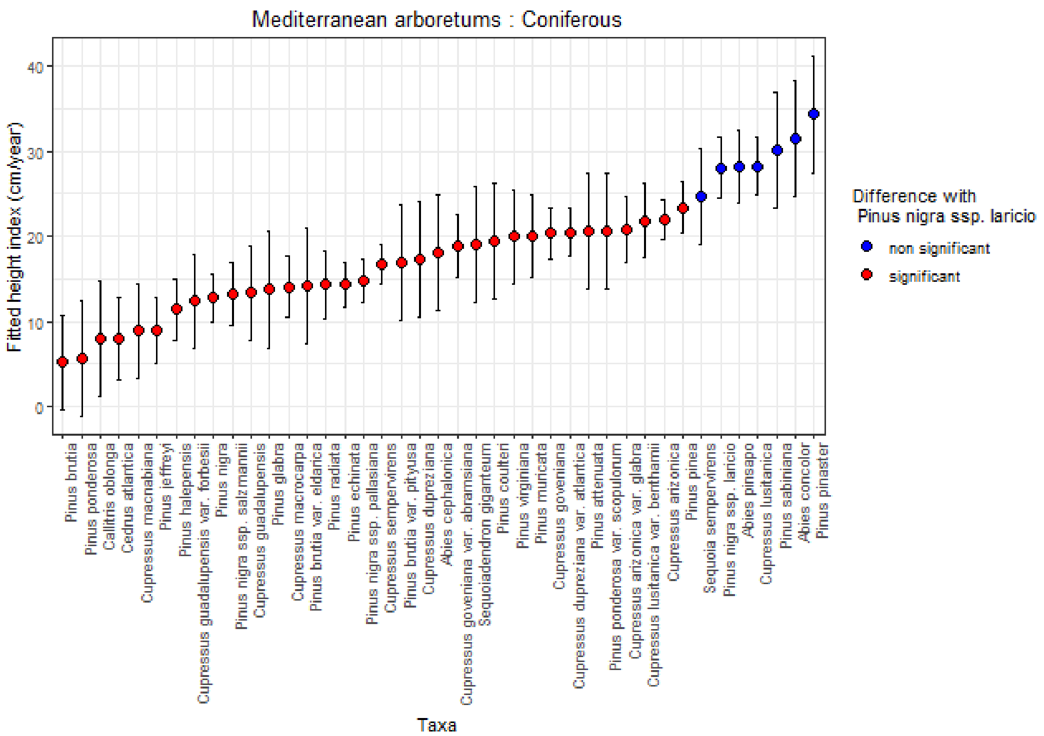
Appendix 6e : Classification of the fitted survival index for the broad-leaved species of the Roumare arboretum, blue species are non-significantly worse than Fagus sylvatica, red species are significantly worse than Fagus sylvatica, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package, fitted values are calculated via mix-models as described previously



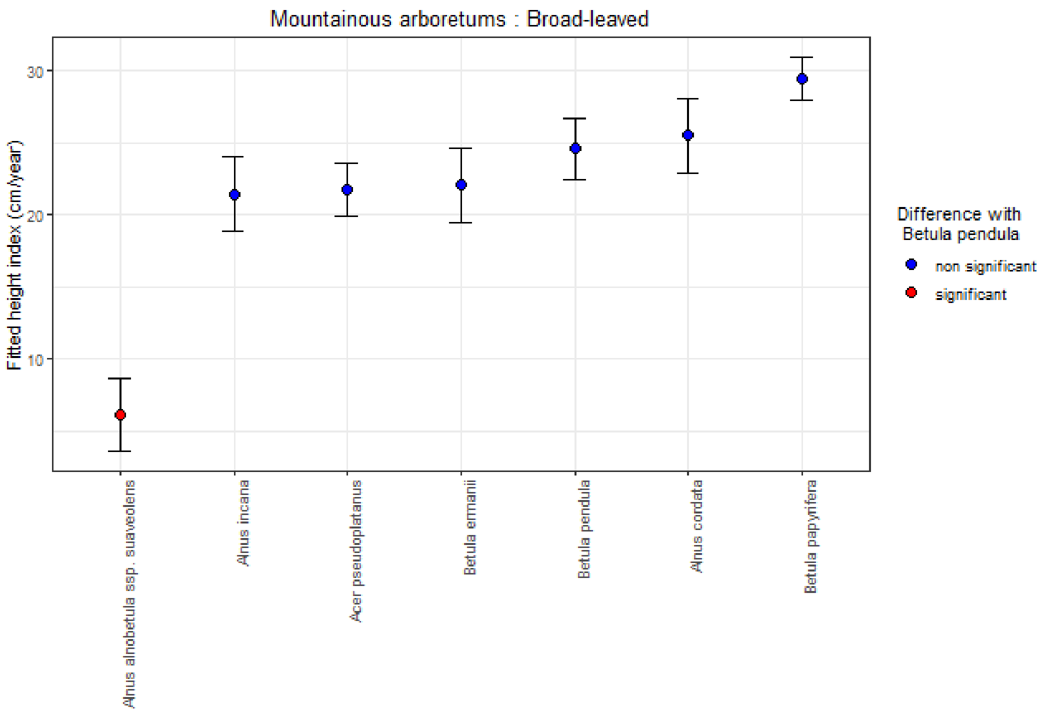
Appendix 6f : Classification of the fitted survival index for the coniferous species of the Roumare arboretum, blue species are non-significantly worse than Pinus sylvestris, red species are significantly worse than Pinus sylvestris, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package, fitted values are calculated via mix-models as described previously



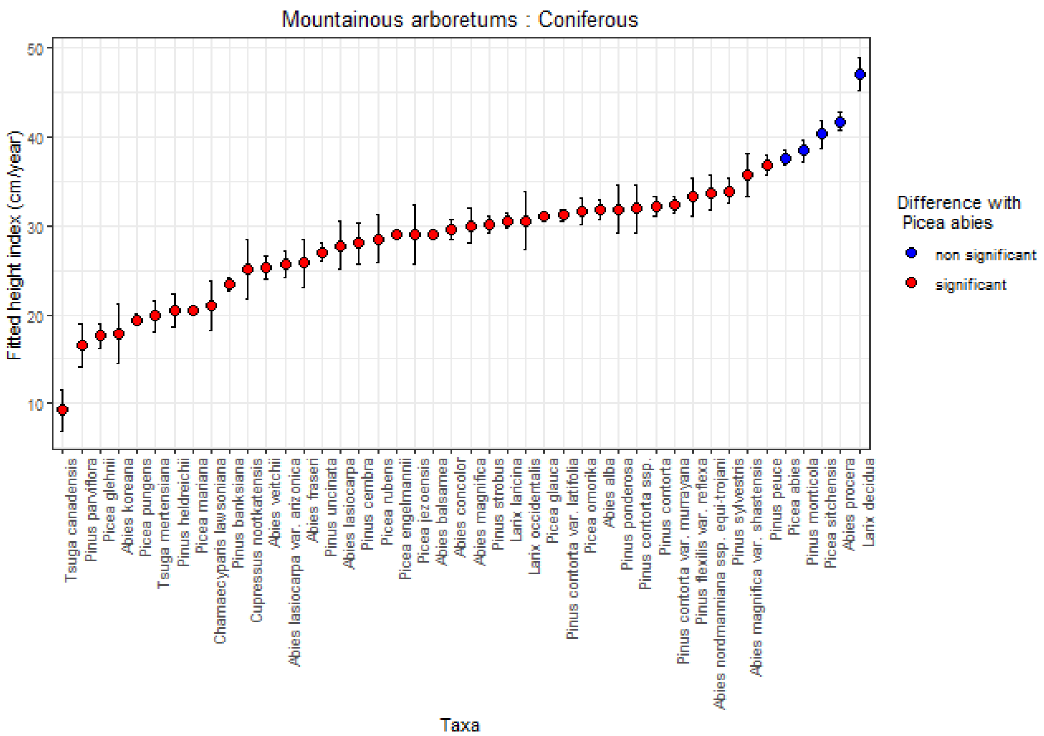
Appendix 7a : Classification of the fitted height index for the broad-leaved species of the Mediterranean arboretums, blue species are non-significantly worse than Quercus pubescens, red species are significantly worse than Quercus pubescens, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package, fitted values are calculated via mix-models as described previously



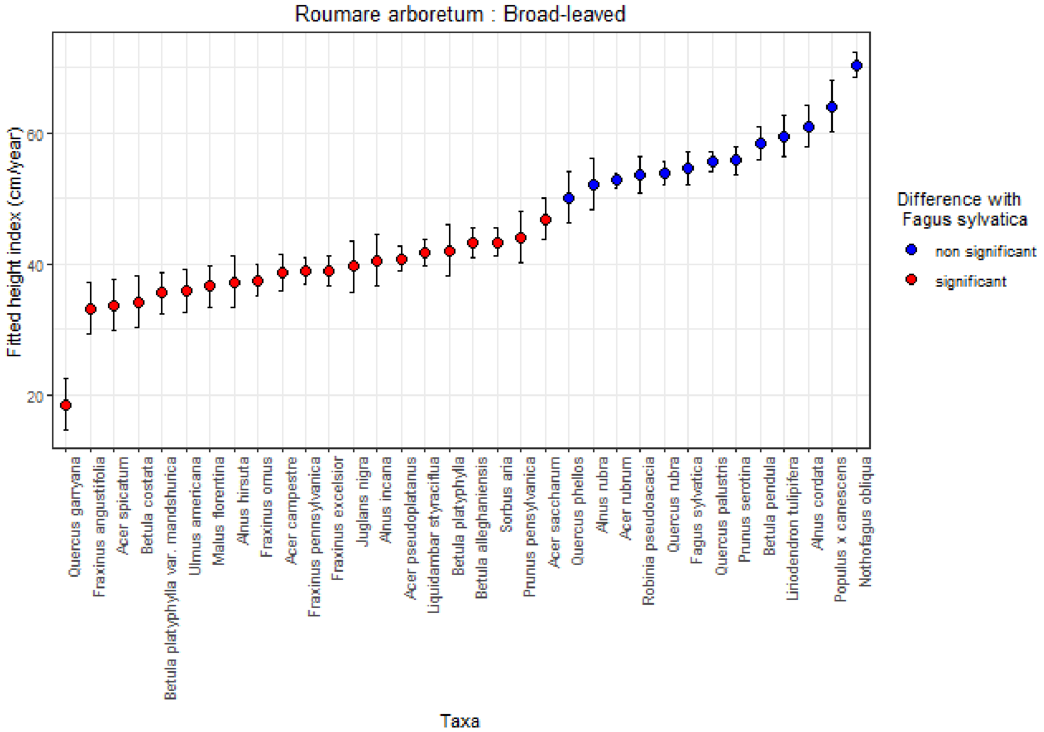
Appendix 7b : Classification of the fitted height index for the coniferous species of the Mediterranean arboretums, blue species are non-significantly worse than Pinus nigra ssp. laricio, red species are significantly worse than Pinus nigra ssp. laricio, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package, fitted values are calculated via mix-models as described previously



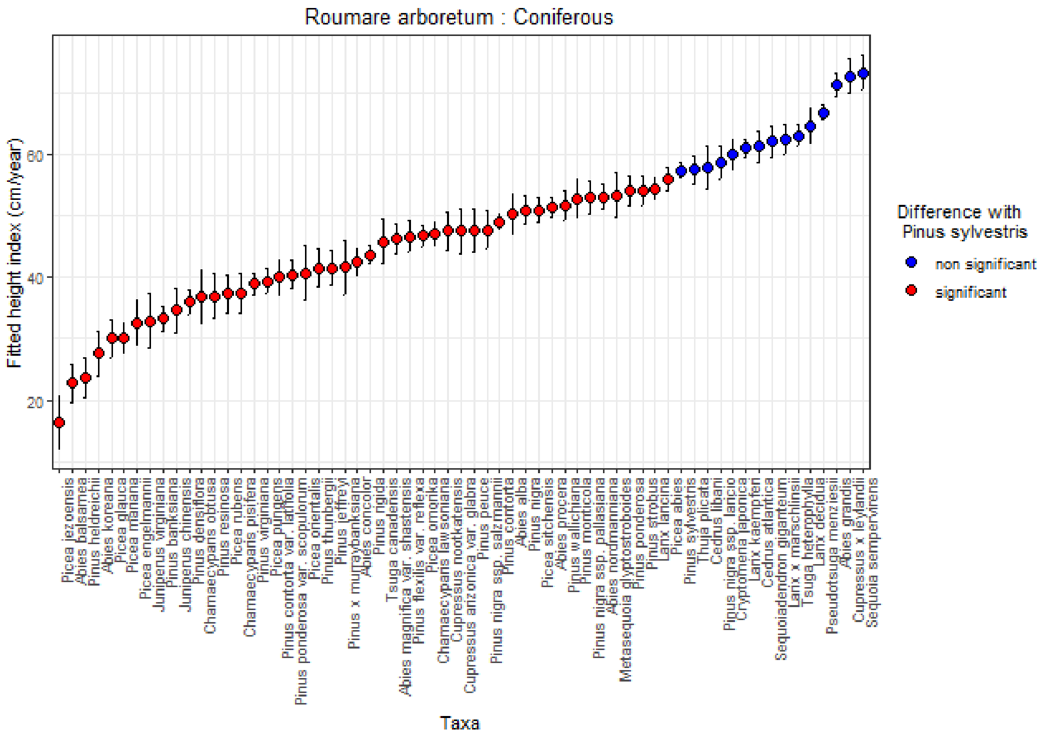
Appendix 7c : Classification of the fitted height index for the broad-leaved species of the mountainous arboretums, blue species are non-significantly worse than Betula pendula, red species are significantly worse than Betula pendula, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package, fitted values are calculated via mix-models as described previously



Appendix 7d : Classification of the fitted height index for the coniferous species of the mountainous arboretums, blue species are non-significantly worse than Picea abies, red species are significantly worse than Picea abies, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package, fitted values are calculated via mix-models as described previously



Appendix 7e : Classification of the fitted height index for the broad-leaved species of the Roumare arboretum, blue species are non-significantly worse than Fagus sylvatica, red species are significantly worse than Fagus sylvatica, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package, fitted values are calculated via mix-models as described previously



Appendix 7f : Classification of the fitted height index for the coniferous species of the Roumare arboretum, blue species are non-significantly worse than Pinus sylvestris, red species are significantly worse than Pinus sylvestris, bar represents confidence interval of the mean at range of 95%, statistical test used is t-test with 95% confidence corrected using fdrtool package, fitted values are calculated via mix-models as described previously

Taxa	**Arboretum**	**Reference species**	**Survival index**	**Height index**
Abies alba	MOU	*Picea abies*		
Abies balsamea	MOU	*Picea abies*		
Abies concolor	MOU	*Picea abies*		
Abies fraseri	MOU	*Picea abies*		
Abies homolepis	MOU	*Picea abies*		
Abies koreana	MOU	*Picea abies*		
Abies lasiocarpa	MOU	*Picea abies*		
Abies lasiocarpa var. arizonica	MOU	*Picea abies*		
Abies magnifica	MOU	*Picea abies*	x	
Abies magnifica var. shastensis	MOU	*Picea abies*	x	
Abies nordmanniana ssp. equi-trojani	MOU	*Picea abies*		
Abies procera	MOU	*Picea abies*		x
Abies sachalinensis	MOU	*Picea abies*		
Abies veitchii	MOU	*Picea abies*		
Acer pseudoplatanus	MOU	*Betula pendula*	x	x
Acer saccharinum	MOU	*Betula pendula*		
Acer saccharum	MOU	*Betula pendula*		
Acer saccharum ssp. nigrum	MOU	*Betula pendula*		
Alnus alnobetula ssp. suaveolens	MOU	*Betula pendula*	x	
Alnus cordata	MOU	*Betula pendula*		x
Alnus incana	MOU	*Betula pendula*		x
Betula alleghaniensis	MOU	*Betula pendula*		
Betula ermanii	MOU	*Betula pendula*	x	x
Betula maximowicziana	MOU	*Betula pendula*	x	
Betula papyrifera	MOU	*Betula pendula*	x	x
Betula pendula	MOU	*Betula pendula*	x	x
Cedrus atlantica	MOU	*Picea abies*		
Chamaecyparis lawsoniana	MOU	*Picea abies*		
Chamaecyparis pisifera	MOU	*Picea abies*		
Cupressus nootkatensis	MOU	*Picea abies*	x	
Fraxinus chinensis	MOU	*Betula pendula*		
Fraxinus excelsior	MOU	*Betula pendula*		
Fraxinus pennsylvanica	MOU	*Betula pendula*		
Juniperus scopulorum	MOU	*Picea abies*		
Larix decidua	MOU	*Picea abies*		x
Larix laricina	MOU	*Picea abies*		
Larix occidentalis	MOU	*Picea abies*		
Picea abies	MOU	*Picea abies*	x	x
Picea engelmannii	MOU	*Picea abies*		
Picea glauca	MOU	*Picea abies*		
Picea glehnii	MOU	*Picea abies*		
Picea jezoensis	MOU	*Picea abies*		
Picea mariana	MOU	*Picea abies*		
Picea omorika	MOU	*Picea abies*	x	
Picea orientalis	MOU	*Picea abies*		
Picea pungens	MOU	*Picea abies*		
Picea rubens	MOU	*Picea abies*		
Picea sitchensis	MOU	*Picea abies*		x
Pinus aristata	MOU	*Picea abies*		
Pinus banksiana	MOU	*Picea abies*		
Pinus cembra	MOU	*Picea abies*		
Pinus contorta	MOU	*Picea abies*		

Pinus contorta ssp.	MOU	*Picea abies*		
Pinus contorta var. latifolia	MOU	*Picea abies*		
Pinus contorta var. murrayana	MOU	*Picea abies*		
Pinus flexilis	MOU	*Picea abies*		
Pinus flexilis var. reflexa	MOU	*Picea abies*		
Pinus heldreichii	MOU	*Picea abies*		
Pinus monticola	MOU	*Picea abies*		x
Pinus parviflora	MOU	*Picea abies*		
Pinus peuce	MOU	*Picea abies*	x	
Pinus ponderosa	MOU	*Picea abies*		
Pinus resinosa	MOU	*Picea abies*		
Pinus sibirica	MOU	*Picea abies*		
Pinus strobus	MOU	*Picea abies*		
Pinus sylvestris	MOU	*Picea abies*		
Pinus uncinata	MOU	*Picea abies*		
Prunus serotina	MOU	*Betula pendula*	x	
Quercus palustris	MOU	*Betula pendula*		
Quercus rubra	MOU	*Betula pendula*		
Tsuga canadensis	MOU	*Picea abies*		
Tsuga mertensiana	MOU	*Picea abies*	x	
Ulmus americana	MOU	*Betula pendula*		
Abies alba	ROU	*Pinus sylvestris*		
Abies balsamea	ROU	*Pinus sylvestris*		
Abies concolor	ROU	*Pinus sylvestris*		
Abies fraseri	ROU	*Pinus sylvestris*		
Abies grandis	ROU	*Pinus sylvestris*		x
Abies koreana	ROU	*Pinus sylvestris*	x	
Abies magnifica var. shastensis	ROU	*Pinus sylvestris*		
Abies nordmanniana	ROU	*Pinus sylvestris*		
Abies procera	ROU	*Pinus sylvestris*		
Acer campestre	ROU	*Fagus sylvatica*	x	
Acer negundo	ROU	*Fagus sylvatica*		
Acer pseudoplatanus	ROU	*Fagus sylvatica*		
Acer rubrum	ROU	*Fagus sylvatica*	x	x
Acer saccharum	ROU	*Fagus sylvatica*	x	
Acer spicatum	ROU	*Fagus sylvatica*		
Alnus cordata	ROU	*Fagus sylvatica*		x
Alnus hirsuta	ROU	*Fagus sylvatica*		
Alnus incana	ROU	*Fagus sylvatica*	x	
Alnus rubra	ROU	*Fagus sylvatica*	x	x
Betula alleghaniensis	ROU	*Fagus sylvatica*		
Betula costata	ROU	*Fagus sylvatica*		
Betula papyrifera	ROU	*Fagus sylvatica*		
Betula pendula	ROU	*Fagus sylvatica*	x	x
Betula platyphylla	ROU	*Fagus sylvatica*	x	
Betula platyphylla var. mandshurica	ROU	*Fagus sylvatica*		
Catalpa bignonioides	ROU	*Fagus sylvatica*		
Cedrus atlantica	ROU	*Pinus sylvestris*		x
Cedrus libani	ROU	*Pinus sylvestris*		x
Chamaecyparis lawsoniana	ROU	*Pinus sylvestris*	x	
Chamaecyparis obtusa	ROU	*Pinus sylvestris*		
Chamaecyparis pisifera	ROU	*Pinus sylvestris*	x	
Cornus amomum	ROU	*Fagus sylvatica*		
Cornus sericea	ROU	*Fagus sylvatica*		
Cotinus coggygria	ROU	*Fagus sylvatica*		

Cotoneaster acutifolius	ROU	*Fagus sylvatica*		
Crataegus laevigata	ROU	*Fagus sylvatica*	x	
Crataegus mollis	ROU	*Fagus sylvatica*		
Cryptomeria japonica	ROU	*Pinus sylvestris*		x
Cupressus arizonica var. glabra	ROU	*Pinus sylvestris*		
Cupressus nootkatensis	ROU	*Pinus sylvestris*	x	
Cupressus x leylandii	ROU	*Pinus sylvestris*	x	x
Fagus sylvatica	ROU	*Fagus sylvatica*	x	x
Fraxinus angustifolia	ROU	*Fagus sylvatica*		
Fraxinus angustifolia ssp. oxycarpa	ROU	*Fagus sylvatica*		
Fraxinus excelsior	ROU	*Fagus sylvatica*		
Fraxinus ornus	ROU	*Fagus sylvatica*		
Fraxinus pennsylvanica	ROU	*Fagus sylvatica*		
Juglans nigra	ROU	*Fagus sylvatica*		
Juniperus chinensis	ROU	*Pinus sylvestris*	x	
Juniperus scopulorum	ROU	*Pinus sylvestris*		
Juniperus virginiana	ROU	*Pinus sylvestris*	x	
Laburnum anagyroides	ROU	*Fagus sylvatica*		
Larix decidua	ROU	*Pinus sylvestris*		x
Larix gmelinii	ROU	*Pinus sylvestris*		
Larix gmelinii var. olgensis	ROU	*Pinus sylvestris*		
Larix kaempferi	ROU	*Pinus sylvestris*		x
Larix laricina	ROU	*Pinus sylvestris*		
Larix x marschlinsii	ROU	*Pinus sylvestris*	x	x
Liquidambar styraciflua	ROU	*Fagus sylvatica*	x	
Liriodendron tulipifera	ROU	*Fagus sylvatica*		x
Malus florentina	ROU	*Fagus sylvatica*	x	
Metasequoia glyptostroboides	ROU	*Pinus sylvestris*		
Myrica pensylvanica	ROU	*Fagus sylvatica*		
Nothofagus obliqua	ROU	*Fagus sylvatica*	x	x
Picea abies	ROU	*Pinus sylvestris*		
Picea engelmannii	ROU	*Pinus sylvestris*		
Picea glauca	ROU	*Pinus sylvestris*		
Picea jezoensis	ROU	*Pinus sylvestris*		
Picea mariana	ROU	*Pinus sylvestris*		
Picea omorika	ROU	*Pinus sylvestris*		
Picea orientalis	ROU	*Pinus sylvestris*		
Picea pungens	ROU	*Pinus sylvestris*		
Picea rubens	ROU	*Pinus sylvestris*	x	
Picea sitchensis	ROU	*Pinus sylvestris*		
Pinus banksiana	ROU	*Pinus sylvestris*		
Pinus contorta	ROU	*Pinus sylvestris*		
Pinus contorta var. latifolia	ROU	*Pinus sylvestris*		
Pinus contorta var. murrayana	ROU	*Pinus sylvestris*		
Pinus densiflora	ROU	*Pinus sylvestris*		
Pinus flexilis	ROU	*Pinus sylvestris*		
Pinus flexilis var. reflexa	ROU	*Pinus sylvestris*		
Pinus heldreichii	ROU	*Pinus sylvestris*		
Pinus jeffreyi	ROU	*Pinus sylvestris*		
Pinus monticola	ROU	*Pinus sylvestris*		
Pinus nigra	ROU	*Pinus sylvestris*		
Pinus nigra ssp. laricio	ROU	*Pinus sylvestris*		x
Pinus nigra ssp. pallasiana	ROU	*Pinus sylvestris*		
Pinus nigra ssp. salzmannii	ROU	*Pinus sylvestris*		
Pinus peuce	ROU	*Pinus sylvestris*		

Pinus ponderosa	ROU	*Pinus sylvestris*		
Pinus ponderosa var. scopulorum	ROU	*Pinus sylvestris*		
Pinus resinosa	ROU	*Pinus sylvestris*		
Pinus rigida	ROU	*Pinus sylvestris*		
Pinus strobus	ROU	*Pinus sylvestris*		
Pinus sylvestris	ROU	*Pinus sylvestris*	x	x
Pinus thunbergii	ROU	*Pinus sylvestris*		
Pinus virginiana	ROU	*Pinus sylvestris*		
Pinus wallichiana	ROU	*Pinus sylvestris*		
Pinus x murraybanksiana	ROU	*Pinus sylvestris*	x	
Platanus orientalis	ROU	*Fagus sylvatica*		
Platycladus orientalis	ROU	*Pinus sylvestris*		
Populus balsamifera	ROU	*Fagus sylvatica*		
Populus x canescens	ROU	*Fagus sylvatica*		x
Prunus pensylvanica	ROU	*Fagus sylvatica*		
Prunus pumila var. besseyi	ROU	*Fagus sylvatica*		
Prunus serotina	ROU	*Fagus sylvatica*	x	x
Pseudotsuga menziesii	ROU	*Pinus sylvestris*		x
Quercus garryana	ROU	*Fagus sylvatica*		
Quercus palustris	ROU	*Fagus sylvatica*	x	x
Quercus phellos	ROU	*Fagus sylvatica*		x
Quercus rubra	ROU	*Fagus sylvatica*	x	x
Robinia pseudoacacia	ROU	*Fagus sylvatica*	x	x
Sequoia sempervirens	ROU	*Pinus sylvestris*		x
Sequoiadendron giganteum	ROU	*Pinus sylvestris*		x
Sorbus aria	ROU	*Fagus sylvatica*	x	
Thuja plicata	ROU	*Pinus sylvestris*	x	x
Tilia cordata	ROU	*Fagus sylvatica*		
Tsuga canadensis	ROU	*Pinus sylvestris*	x	
Tsuga heterophylla	ROU	*Pinus sylvestris*		x
Ulmus americana	ROU	*Fagus sylvatica*		
Abies cephalonica	MED	*Pinus nigra ssp. laricio*		
Abies concolor	MED	*Pinus nigra ssp. laricio*		x
Abies pinsapo	MED	*Pinus nigra ssp. laricio*		x
Acacia implexa	MED	*Quercus pubescens*	x	
Acacia melanoxylon	MED	*Quercus pubescens*	x	x
Acacia salicina	MED	*Quercus pubescens*		
Acca sellowiana	MED	*Quercus pubescens*		
Acer negundo	MED	*Quercus pubescens*		
Acer pseudoplatanus	MED	*Quercus pubescens*		
Aesculus hippocastanum	MED	*Quercus pubescens*		
Ailanthus altissima	MED	*Quercus pubescens*		
Albizia julibrissin	MED	*Quercus pubescens*		
Allocasuarina dystila	MED	*Quercus pubescens*		
Allocasuarina littoralis	MED	*Quercus pubescens*		
Allocasuarina muelleriana	MED	*Quercus pubescens*		
Allocasuarina paludosa	MED	*Quercus pubescens*		
Allocasuarina torulosa	MED	*Quercus pubescens*		
Allocasuarina verticillata	MED	*Quercus pubescens*		
Alnus cordata	MED	*Quercus pubescens*		
Alnus incana	MED	*Quercus pubescens*		
Alnus incana ssp. tenuifolia	MED	*Quercus pubescens*		
Alnus orientalis	MED	*Quercus pubescens*		
Alnus subcordata	MED	*Quercus pubescens*		
Arbutus canariensis	MED	*Quercus pubescens*		

Arbutus unedo	MED	*Quercus pubescens*	x	
Arbutus xalapensis	MED	*Quercus pubescens*		
Atriplex canescens	MED	*Quercus pubescens*		
Atriplex nummularia	MED	*Quercus pubescens*		
Atriplex polycarpa	MED	*Quercus pubescens*		
Atriplex undulata	MED	*Quercus pubescens*		
Berberis sp.	MED	*Quercus pubescens*		
Broussonetia kazinoki	MED	*Quercus pubescens*		
Buxus balearica	MED	*Quercus pubescens*	x	
Callitris oblonga	MED	*Pinus nigra ssp. laricio*		
Callitris preissii	MED	*Pinus nigra ssp. laricio*		
Callitris rhomboidea	MED	*Pinus nigra ssp. laricio*		
Calocedrus decurrens	MED	*Pinus nigra ssp. laricio*		
Castanea sativa	MED	*Quercus pubescens*		x
Casuarina cunninghamiana	MED	*Quercus pubescens*		
Casuarina equisetifolia	MED	*Quercus pubescens*		
Casuarina glauca	MED	*Quercus pubescens*		
Catalpa bignonioides	MED	*Quercus pubescens*		
Ceanothus americanus	MED	*Quercus pubescens*		
Cedrus atlantica	MED	*Pinus nigra ssp. laricio*		
Celtis occidentalis	MED	*Quercus pubescens*		
Cercis siliquastrum	MED	*Quercus pubescens*		
Chamaecyparis pisifera	MED	*Pinus nigra ssp. laricio*		
Cormus trilobata	MED	*Quercus pubescens*		
Cornus capitata	MED	*Quercus pubescens*		
Cotoneaster lacteus	MED	*Quercus pubescens*		
Cotoneaster pannosus	MED	*Quercus pubescens*	x	
Cotoneaster serotinus	MED	*Quercus pubescens*	x	
Cotoneaster sp.	MED	*Quercus pubescens*		
Cotoneaster x watereri	MED	*Quercus pubescens*		
Cryptocarya alba	MED	*Quercus pubescens*		
Cupressus arizonica	MED	*Pinus nigra ssp. laricio*	x	
Cupressus arizonica var. glabra	MED	*Pinus nigra ssp. laricio*	x	
Cupressus cashmeriana	MED	*Pinus nigra ssp. laricio*		
Cupressus dupreziana	MED	*Pinus nigra ssp. laricio*	x	
Cupressus dupreziana var. atlantica	MED	*Pinus nigra ssp. laricio*		
Cupressus goveniana	MED	*Pinus nigra ssp. laricio*		
Cupressus goveniana var. abramsiana	MED	*Pinus nigra ssp. laricio*	x	
Cupressus guadalupensis	MED	*Pinus nigra ssp. laricio*		
Cupressus guadalupensis var. forbesii	MED	*Pinus nigra ssp. laricio*	x	
Cupressus lusitanica	MED	*Pinus nigra ssp. laricio*		x
Cupressus lusitanica var. benthamii	MED	*Pinus nigra ssp. laricio*		
Cupressus macnabiana	MED	*Pinus nigra ssp. laricio*	x	
Cupressus macrocarpa	MED	*Pinus nigra ssp. laricio*		
Cupressus sempervirens	MED	*Pinus nigra ssp. laricio*		
Diospyros kaki	MED	*Quercus pubescens*		
Diospyros lotus	MED	*Quercus pubescens*		
Dodonaea viscosa	MED	*Quercus pubescens*		
Ehretia acuminata	MED	*Quercus pubescens*		
Ehretia macrophylla	MED	*Quercus pubescens*		
Elaeagnus angustifolia	MED	*Quercus pubescens*		
Elaeagnus macrophylla	MED	*Quercus pubescens*		
Eriobotrya japonica	MED	*Quercus pubescens*		
Eucalyptus acaciiformis	MED	*Quercus pubescens*	x	x
Eucalyptus aggregata	MED	*Quercus pubescens*	x	x

Eucalyptus ambigua	MED	*Quercus pubescens*		x
Eucalyptus amygdalina	MED	*Quercus pubescens*	x	x
Eucalyptus archeri	MED	*Quercus pubescens*		x
Eucalyptus bridgesiana	MED	*Quercus pubescens*	x	x
Eucalyptus cephalocarpa	MED	*Quercus pubescens*	x	x
Eucalyptus cinerea	MED	*Quercus pubescens*	x	x
Eucalyptus coccifera	MED	*Quercus pubescens*		x
Eucalyptus cordata	MED	*Quercus pubescens*	x	x
Eucalyptus curtisii	MED	*Quercus pubescens*		
Eucalyptus dalrympleana	MED	*Quercus pubescens*	x	x
Eucalyptus delegatensis	MED	*Quercus pubescens*		x
Eucalyptus delegatensis x E.coccifera	MED	*Quercus pubescens*		x
Eucalyptus glaucescens	MED	*Quercus pubescens*	x	x
Eucalyptus globulus ssp. pseudoglobulus	MED	*Quercus pubescens*	x	x
Eucalyptus gregsoniana	MED	*Quercus pubescens*	x	x
Eucalyptus gunnii	MED	*Quercus pubescens*	x	x
Eucalyptus gunnii ssp. divaricata	MED	*Quercus pubescens*		x
Eucalyptus johnstonii	MED	*Quercus pubescens*	x	x
Eucalyptus laevopinea	MED	*Quercus pubescens*	x	x
Eucalyptus morrisbyi	MED	*Quercus pubescens*	x	x
Eucalyptus neglecta	MED	*Quercus pubescens*		x
Eucalyptus nicholii	MED	*Quercus pubescens*		
Eucalyptus obliqua	MED	*Quercus pubescens*	x	x
Eucalyptus ovata	MED	*Quercus pubescens*	x	x
Eucalyptus parvula	MED	*Quercus pubescens*	x	x
Eucalyptus pauciflora	MED	*Quercus pubescens*		x
Eucalyptus perriniana	MED	*Quercus pubescens*		x
Eucalyptus pulchella	MED	*Quercus pubescens*	x	x
Eucalyptus pulverulenta	MED	*Quercus pubescens*		
Eucalyptus regnans	MED	*Quercus pubescens*		
Eucalyptus risdonii	MED	*Quercus pubescens*	x	x
Eucalyptus robertsonii	MED	*Quercus pubescens*	x	x
Eucalyptus rodwayi	MED	*Quercus pubescens*	x	x
Eucalyptus rubida	MED	*Quercus pubescens*	x	x
Eucalyptus sieberi	MED	*Quercus pubescens*		x
Eucalyptus sp.	MED	*Quercus pubescens*		
Eucalyptus stellulata	MED	*Quercus pubescens*	x	x
Eucalyptus subcrenulata	MED	*Quercus pubescens*		x
Eucalyptus urnigera	MED	*Quercus pubescens*		x
Eucalyptus vernicosa	MED	*Quercus pubescens*		
Eucalyptus viminalis	MED	*Quercus pubescens*	x	x
Eucalyptus x irbyi	MED	*Quercus pubescens*		x
Eucommia ulmoides	MED	*Quercus pubescens*		
Eugenia uruguayensis	MED	*Quercus pubescens*		
Ficus carica	MED	*Quercus pubescens*		
Ficus johannis ssp. afghanistanica	MED	*Quercus pubescens*		
Ficus palmata	MED	*Quercus pubescens*		
Ficus virgata	MED	*Quercus pubescens*		
Fraxinus americana	MED	*Quercus pubescens*		
Fraxinus angustifolia	MED	*Quercus pubescens*		x
Fraxinus ornus	MED	*Quercus pubescens*		
Fraxinus pennsylvanica	MED	*Quercus pubescens*		
Fraxinus uhdei	MED	*Quercus pubescens*		
Fraxinus velutina	MED	*Quercus pubescens*		
Ginkgo biloba	MED	*Pinus nigra ssp. laricio*		

Gleditsia triacanthos	MED	*Quercus pubescens*		
Hakea oleifolia	MED	*Quercus pubescens*		
Hakea salicifolia	MED	*Quercus pubescens*		
Hakea sericea	MED	*Quercus pubescens*		
Hovenia dulcis	MED	*Quercus pubescens*		
Juniperus phoenicea	MED	*Pinus nigra ssp. laricio*		
Juniperus virginiana	MED	*Pinus nigra ssp. laricio*		
Larix decidua	MED	*Pinus nigra ssp. laricio*		
Laurus nobilis	MED	*Quercus pubescens*	x	
Leucadendron salignum	MED	*Quercus pubescens*		
Ligustrum compactum	MED	*Quercus pubescens*		
Ligustrum ibota	MED	*Quercus pubescens*		
Ligustrum japonicum	MED	*Quercus pubescens*		
Ligustrum lucidum	MED	*Quercus pubescens*		
Ligustrum quihoui	MED	*Quercus pubescens*		
Liriodendron tulipifera	MED	*Quercus pubescens*		
Luma chequen	MED	*Quercus pubescens*		
Maclura pomifera	MED	*Quercus pubescens*		
Malus floribunda	MED	*Quercus pubescens*		
Melia azedarach	MED	*Quercus pubescens*		
Morus australis	MED	*Quercus pubescens*		
Myrcianthes pungens	MED	*Quercus pubescens*		
Nerium oleander	MED	*Quercus pubescens*		
Olea europaea	MED	*Quercus pubescens*	x	
Olea europaea ssp. cuspidata	MED	*Quercus pubescens*		
Paulownia tomentosa	MED	*Quercus pubescens*		
Peumus boldus	MED	*Quercus pubescens*		
Phillyrea latifolia	MED	*Quercus pubescens*		
Pinus attenuata	MED	*Pinus nigra ssp. laricio*		
Pinus banksiana	MED	*Pinus nigra ssp. laricio*		
Pinus brutia	MED	*Pinus nigra ssp. laricio*		
Pinus brutia var. eldarica	MED	*Pinus nigra ssp. laricio*		
Pinus brutia var. pityusa	MED	*Pinus nigra ssp. laricio*		
Pinus canariensis	MED	*Pinus nigra ssp. laricio*		
Pinus coulteri	MED	*Pinus nigra ssp. laricio*		
Pinus echinata	MED	*Pinus nigra ssp. laricio*		
Pinus glabra	MED	*Pinus nigra ssp. laricio*		
Pinus halepensis	MED	*Pinus nigra ssp. laricio*		
Pinus heldreichii	MED	*Pinus nigra ssp. laricio*		
Pinus jeffreyi	MED	*Pinus nigra ssp. laricio*		
Pinus lambertiana	MED	*Pinus nigra ssp. laricio*		
Pinus montezumae	MED	*Pinus nigra ssp. laricio*		
Pinus muricata	MED	*Pinus nigra ssp. laricio*		
Pinus nigra	MED	*Pinus nigra ssp. laricio*		
Pinus nigra ssp. laricio	MED	*Pinus nigra ssp. laricio*	x	x
Pinus nigra ssp. pallasiana	MED	*Pinus nigra ssp. laricio*		
Pinus nigra ssp. salzmannii	MED	*Pinus nigra ssp. laricio*		
Pinus pinaster	MED	*Pinus nigra ssp. laricio*		x
Pinus pinea	MED	*Pinus nigra ssp. laricio*		
Pinus ponderosa	MED	*Pinus nigra ssp. laricio*		
Pinus ponderosa var. scopulorum	MED	*Pinus nigra ssp. laricio*		
Pinus pungens	MED	*Pinus nigra ssp. laricio*		
Pinus radiata	MED	*Pinus nigra ssp. laricio*		
Pinus rigida	MED	*Pinus nigra ssp. laricio*		
Pinus roxburghii	MED	*Pinus nigra ssp. laricio*		

Pinus sabiniana	MED	*Pinus nigra ssp. laricio*		x
Pinus virginiana	MED	*Pinus nigra ssp. laricio*		
Pinus x attenuradiata	MED	*Pinus nigra ssp. laricio*		
Pistacia chinensis	MED	*Quercus pubescens*		
Pittosporum heterophyllum	MED	*Quercus pubescens*	x	
Pittosporum tobira	MED	*Quercus pubescens*		
Platanus occidentalis	MED	*Quercus pubescens*		
Platanus orientalis	MED	*Quercus pubescens*		
Platycladus orientalis	MED	*Pinus nigra ssp. laricio*		
Podocarpus totara	MED	*Pinus nigra ssp. laricio*		
Populus deltoides	MED	*Quercus pubescens*		
Prosopis nigra	MED	*Pinus nigra ssp. laricio*		
Prunus dulcis	MED	*Quercus pubescens*		
Prunus ilicifolia	MED	*Quercus pubescens*		
Prunus integrifolia	MED	*Quercus pubescens*		
Prunus pensylvanica	MED	*Quercus pubescens*		
Prunus serotina ssp. capuli	MED	*Quercus pubescens*		x
Pyracantha angustifolia	MED	*Quercus pubescens*		
Pyrus amygdaliformis	MED	*Quercus pubescens*		
Quercus canariensis	MED	*Quercus pubescens*	x	x
Quercus glauca	MED	*Quercus pubescens*		
Quercus ilex	MED	*Quercus pubescens*		
Quercus libani	MED	*Quercus pubescens*	x	
Quercus pubescens	MED	*Quercus pubescens*	x	x
Quercus robur	MED	*Quercus pubescens*		
Quercus rotundifolia	MED	*Quercus pubescens*		
Quercus suber	MED	*Quercus pubescens*		x
Rhus coriaria	MED	*Quercus pubescens*		
Robinia pseudoacacia	MED	*Quercus pubescens*		
Schinus polygama	MED	*Quercus pubescens*		
Sequoia sempervirens	MED	*Pinus nigra ssp. laricio*		x
Sequoiadendron giganteum	MED	*Pinus nigra ssp. laricio*		
Sorbus domestica	MED	*Quercus pubescens*		
Tetraclinis articulata	MED	*Pinus nigra ssp. laricio*		
Umbellularia californica	MED	*Quercus pubescens*	x	
Zelkova serrata	MED	*Quercus pubescens*		

Appendix 8 : Table of the non-significant differences between every species tested and the reference species for every grouped arboretum, each x represent a non-significant difference, statistical test used is t-test with 95% confidence corrected using fdrtool package, test used the fitted values computed by the mix-model previously described

Taxa	Arboretum	Reference species	Index	mean value	Reference species mean value	test value	qvalue
Acer pseudoplatanus	MOU	*Betula pendula*	height	21.79	24.60	1.89	0.056423
Acer pseudoplatanus	MOU	*Betula pendula*	survival	45.83	20.00	-9.99	0.288846
Betula ermanii	MOU	*Betula pendula*	survival	20.00	20.00	0.00	0.168933
Betula ermanii	MOU	*Betula pendula*	height	22.09	24.60	1.13	0.128951
Betula papyrifera	MOU	*Betula pendula*	height	29.42	24.60	-3.48	0.431007
Betula papyrifera	MOU	*Betula pendula*	survival	20.64	20.00	-0.35	0.203133
Betula pendula	MOU	*Betula pendula*	height	24.60			
Betula pendula	MOU	*Betula pendula*	survival	20.00			
Picea abies	MOU	*Picea abies*	survival	40.16			
Picea abies	MOU	*Picea abies*	height	37.61			
Acer rubrum	ROU	*Fagus sylvatica*	survival	45.99	42.67	-1.60	0.35101
Acer rubrum	ROU	*Fagus sylvatica*	height	52.80	54.71	1.16	0.079543
Alnus rubra	ROU	*Fagus sylvatica*	survival	50.72	42.67	-2.41	0.350523
Alnus rubra	ROU	*Fagus sylvatica*	height	52.15	54.71	1.45	0.056449
Betula pendula	ROU	*Fagus sylvatica*	height	58.48	54.71	-2.11	0.352136
Betula pendula	ROU	*Fagus sylvatica*	survival	46.67	42.67	-1.89	0.356964
Cupressus x leylandii	ROU	*Pinus sylvestris*	survival	49.17	40.84	-4.41	0.206995
Cupressus x leylandii	ROU	*Pinus sylvestris*	height	72.74	57.39	-8.95	0.267497
Fagus sylvatica	ROU	*Fagus sylvatica*	height	54.71			
Fagus sylvatica	ROU	*Fagus sylvatica*	survival	42.67			
Larix x marschlinsii	ROU	*Pinus sylvestris*	height	62.37	57.39	-3.14	0.266044
Larix x marschlinsii	ROU	*Pinus sylvestris*	survival	45.99	40.84	-3.17	0.206608
Nothofagus obliqua	ROU	*Fagus sylvatica*	survival	43.15	42.67	-0.18	0.250127
Nothofagus obliqua	ROU	*Fagus sylvatica*	height	70.46	54.71	-8.87	0.361686
Pinus sylvestris	ROU	*Pinus sylvestris*	height	57.39			
Pinus sylvestris	ROU	*Pinus sylvestris*	survival	40.84			
Prunus serotina	ROU	*Fagus sylvatica*	survival	46.20	42.67	-1.56	0.350444
Prunus serotina	ROU	*Fagus sylvatica*	height	55.84	54.71	-0.56	0.284938
Quercus palustris	ROU	*Fagus sylvatica*	height	55.66	54.71	-0.54	0.28246
Quercus palustris	ROU	*Fagus sylvatica*	survival	46.38	42.67	-1.47	0.348881
Quercus rubra	ROU	*Fagus sylvatica*	height	53.94	54.71	0.42	0.162956
Quercus rubra	ROU	*Fagus sylvatica*	survival	42.33	42.67	0.17	0.202516
Robinia pseudoacacia	ROU	*Fagus sylvatica*	height	53.74	54.71	0.46	0.157756
Robinia pseudoacacia	ROU	*Fagus sylvatica*	survival	43.96	42.67	-0.58	0.292855
Thuja plicata	ROU	*Pinus sylvestris*	survival	58.96	40.84	-13.21	0.207299
Thuja plicata	ROU	*Pinus sylvestris*	height	57.52	57.39	-0.12	0.166361
Acacia melanoxylon	MED	*Quercus pubescens*	height	13.69	12.91	-0.40	1
Acacia melanoxylon	MED	*Quercus pubescens*	survival	45.89	36.33	-1.54	0.257617
Eucalyptus acaciiformis	MED	*Quercus pubescens*	survival	45.55	36.33	-1.86	0.259889
Eucalyptus acaciiformis	MED	*Quercus pubescens*	height	35.20	12.91	-7.53	1
Eucalyptus aggregata	MED	*Quercus pubescens*	height	44.09	12.91	-10.99	1
Eucalyptus aggregata	MED	*Quercus pubescens*	survival	43.33	36.33	-1.84	0.260758
Eucalyptus amygdalina	MED	*Quercus pubescens*	height	29.42	12.91	-8.62	1
Eucalyptus amygdalina	MED	*Quercus pubescens*	survival	56.67	36.33	-4.69	0.271192
Eucalyptus bridgesiana	MED	*Quercus pubescens*	height	34.95	12.91	-5.54	1
Eucalyptus bridgesiana	MED	*Quercus pubescens*	survival	31.67	36.33	0.59	0.105808
Eucalyptus cephalocarpa	MED	*Quercus pubescens*	survival	71.67	36.33	-5.79	0.269118
Eucalyptus cephalocarpa	MED	*Quercus pubescens*	height	34.44	12.91	-11.65	1
Eucalyptus cinerea	MED	*Quercus pubescens*	survival	60.83	36.33	-4.78	0.271914
Eucalyptus cinerea	MED	*Quercus pubescens*	height	28.85	12.91	-6.50	1
Eucalyptus cordata	MED	*Quercus pubescens*	height	47.72	12.91	-13.92	1

Eucalyptus cordata	MED	*Quercus pubescens*	survival	58.33	36.33	-4.72	0.271944
Eucalyptus dalrympleana	MED	*Quercus pubescens*	height	39.06	12.91	-12.34	1
Eucalyptus dalrympleana	MED	*Quercus pubescens*	survival	45.28	36.33	-2.19	0.265805
Eucalyptus glaucescens	MED	*Quercus pubescens*	height	40.36	12.91	-6.06	1
Eucalyptus glaucescens	MED	*Quercus pubescens*	survival	36.11	36.33	0.03	0.154282
Eucalyptus globulus ssp. pseudoglobulus	MED	*Quercus pubescens*	survival	58.33	36.33	-4.22	0.26886
Eucalyptus globulus ssp. pseudoglobulus	MED	*Quercus pubescens*	height	33.49	12.91	-3.15	1
Eucalyptus gregsoniana	MED	*Quercus pubescens*	height	26.53	12.91	-3.42	1
Eucalyptus gregsoniana	MED	*Quercus pubescens*	survival	31.67	36.33	0.63	0.102115
Eucalyptus gunnii	MED	*Quercus pubescens*	height	33.72	12.91	-10.71	1
Eucalyptus gunnii	MED	*Quercus pubescens*	survival	34.07	36.33	0.63	0.094003
Eucalyptus johnstonii	MED	*Quercus pubescens*	height	30.75	12.91	-10.32	1
Eucalyptus johnstonii	MED	*Quercus pubescens*	survival	44.17	36.33	-1.88	0.26183
Eucalyptus laevopinea	MED	*Quercus pubescens*	survival	89.52	36.33	-11.56	0.27209
Eucalyptus laevopinea	MED	*Quercus pubescens*	height	63.93	12.91	-9.17	1
Eucalyptus morrisbyi	MED	*Quercus pubescens*	survival	34.45	36.33	0.34	0.122876
Eucalyptus morrisbyi	MED	*Quercus pubescens*	height	37.23	12.91	-8.34	1
Eucalyptus obliqua	MED	*Quercus pubescens*	survival	48.10	36.33	-3.18	0.270225
Eucalyptus obliqua	MED	*Quercus pubescens*	height	40.85	12.91	-8.19	1
Eucalyptus ovata	MED	*Quercus pubescens*	survival	54.17	36.33	-5.02	0.271799
Eucalyptus ovata	MED	*Quercus pubescens*	height	37.98	12.91	-9.43	1
Eucalyptus parvula	MED	*Quercus pubescens*	height	28.21	12.91	-3.53	1
Eucalyptus parvula	MED	*Quercus pubescens*	survival	51.11	36.33	-2.39	0.264081
Eucalyptus pulchella	MED	*Quercus pubescens*	survival	70.00	36.33	-5.50	0.271505
Eucalyptus pulchella	MED	*Quercus pubescens*	height	44.00	12.91	-7.18	1
Eucalyptus risdonii	MED	*Quercus pubescens*	survival	35.00	36.33	0.16	0.143164
Eucalyptus risdonii	MED	*Quercus pubescens*	height	22.19	12.91	-2.29	1
Eucalyptus robertsonii	MED	*Quercus pubescens*	height	28.76	12.91	-3.93	1
Eucalyptus robertsonii	MED	*Quercus pubescens*	survival	42.59	36.33	-1.53	0.25429
Eucalyptus rodwayi	MED	*Quercus pubescens*	height	29.99	12.91	-6.27	1
Eucalyptus rodwayi	MED	*Quercus pubescens*	survival	38.89	36.33	-0.70	0.217598
Eucalyptus rubida	MED	*Quercus pubescens*	survival	52.11	36.33	-4.31	0.271593
Eucalyptus rubida	MED	*Quercus pubescens*	height	33.75	12.91	-7.65	1
Eucalyptus stellulata	MED	*Quercus pubescens*	height	43.65	12.91	-7.72	1
Eucalyptus stellulata	MED	*Quercus pubescens*	survival	35.00	36.33	0.16	0.143474
Eucalyptus viminalis	MED	*Quercus pubescens*	height	36.74	12.91	-9.49	1
Eucalyptus viminalis	MED	*Quercus pubescens*	survival	38.75	36.33	-0.68	0.216239
Pinus nigra ssp. laricio	MED	*Pinus nigra ssp. laricio*	survival	69.77			
Pinus nigra ssp. laricio	MED	*Pinus nigra ssp. laricio*	height	28.07			
Quercus canariensis	MED	*Quercus pubescens*	height	17.57	12.91	-0.41	1
Quercus canariensis	MED	*Quercus pubescens*	survival	31.06	36.33	0.58	0.101591
Quercus pubescens	MED	*Quercus pubescens*	survival	36.33			
Quercus pubescens	MED	*Quercus pubescens*	height	12.91			

Appendix 9 : Table of the results of the t-test with 95% confidence for every species with at least non-significant differences for survival and height index, qvalue is the corrected pvalue computed using the fdrtool package, test used the fitted values computed by the mix-model previously described