SHOULD WE BE AFRAID OF NON-NATIVE TREES IN OUR FORESTS?

Stories about Successes and Failures with versatile tree species…

with migration background

Humans are marvellous beings – loving the familiar, the proven and the tested, yet regularly reaching out to discover the unknown. Wherever humans have travelled and settled, they took their companion animals and plants, their skills and customs and introduced them to their new homeland; whenever returning from a voyage, they brought back things they had found useful or pleasant and improved their cultivation back at home.

Over the course of human history many introduced cuttings, tubers and seeds have successfully found new homes, often after surviving hazards such as long journeys across oceans, voyages through deserts, enduring freezing winters and being packed in tight saddlebags. With a mix of inventiveness and sound craftsmanship, humans managed to make use of these exotic resources. Sometimes, these newcomers were even more productive in their new environment than in their area of origin. They could be harvested to feed people, to build houses or ships, to provide clothing, to produce medicines and paper, to improve soils and form landscapes, and simply to add beauty to gardens and parks.

These developments did not occur without setbacks. New diseases in crops or the wrong climate or soil for an agricultural undertaking forced the people to prove their inventiveness. For example, when grape phylloxera, an introduced bug, threatened to destroy the entire wine production of Europe in the second half of the 19th century only the discovery of the resistance of American grapevines and their use as grafting rootstock ensured the survival of European wine production.

Over the centuries, an almost inconceivable number of vegetables, herbs, ornamental plants, fruit trees and forest trees have been shipped across the world and established in new places. Tomatoes, potatoes, poppy, wheat, barley, corn, apricot, walnut, apple, lilac, sweet chestnut, pencil pine/Mediterranean cypress and Nordmann fir are only some of the non-native species which we would not want to miss in our diet, landscape or culture today.

Similarly, the range of introduced deciduous and coniferous forest tree species fulfils a large variety of tasks, offers goods and provides useful forest services. For example, non-native trees can grow

Non-native trees can provide valuable timber; here Black locust (originally from North America), which supplies the most durable wood in Europe.
Source: Valeriu-Norocel Nicolescu

Plantations of non-native trees can be used on many soils which are hard to cultivate, for example on dry, sandy soils or in karst regions, where erosion is a serious problem; here a group of Ailanthus altissima trees close to Dubrovnik, Croatia.
Source: Elisabeth Pötzelsberger

Non-native trees can diversify forests in regions with few native tree species, as typical in north-western Europe; here Sitka spruce and Japanese larch in Scotland.
Source: Elisabeth Pötzelsberger

well in harsh environments where native species may struggle, or they can produce especially large quantities of wood that can be used as a versatile and climate-friendly natural resource.

The topic of non-native forest trees often causes citizens and land managers some discomfort and suspicion. This is partly caused by reports of new problems caused by non-natives, partly caused by blurred definitions and the polemic of popular media. Actually, this debate on whether non-natives are good or bad for our forests and our societies is deep rooted. It is nourished by the disagreement of people from different cultural or economic backgrounds, on what a 'forest' actually is and what shall or can be expected from a forest.

In this booklet we aim to tell some of the success stories about the introduction, cultivation and use of non-native tree species in Europe. However, we also provide accounts of a number of unsuccessful experiments with non-natives, raise awareness of the risks associated with their introduction, show consequences of their uncontrolled spread, and explain our lessons learnt for a responsible handling of non-natives. We will also find out what role non-natives trees may play in the future – what their contributions and threats to maintaining healthy, diverse and productive forests could be.

Concepts and regulation

NON-NATIVE, non-indigenous, introduced, exotic, alien, foreign, allochthonous – all these terms describe more or less the same thing; they describe species that as a result of human activities occur in a place where they have not developed naturally over long periods of time.

NEOPHYTES – the term stems from ancient Greek νέον φυτόν 'neon phyton' and means 'new plant'. From a cultural-scientific point of view, only those plants are considered neophytes, which have entered a new area in the last five hundred years. The year 1492 is typically taken as cut-off as the discovery of America by Christopher Columbus marked the beginning of the large scale two-way exchange of plants and goods between the European and North-American continents.

But even before the year 1492 new species had been brought to Europe, these we call ARCHEOPHYTES. The Romans and Phoenicians traded with their territories of Asia Minor and Africa, and other plants came along the Silk Road from Central and East Asia. Mediterranean cypress, apple, apricot and walnut tree are such archeophytes – Impressive examples that non-native species are not necessarily something 'new'.

NATURALISED PLANTS are introduced plants that produce viable offspring but are not yet spreading. INVASIVE PLANTS or INVASIVE ALIEN SPECIES, that is how non-native plants are called in cases where • indigenous plants hardly can grow anymore in the neighbourhood of a non-native species, where the non-native plant is • so persistent and spreading, or where it • changes the soil or the availability of water, • or in

cases where the local fauna (insects, birds, deer, rodents,…) does not profit from a non-native plant species because it neither provides a suitable source of food nor proper shelter. The severity or extent to which a non-native plant must influence its environment in order to be considered 'invasive' is widely discussed, as well as the question of how to deal with such harmful species. Importantly, a plant species' ability to spread may change over time, with climate change, and depends on the context, on the landscape composition and the state of the ecosystems. Overall, not every non-native plant becomes naturalised, and only some of the naturalised plants become invasive.

The topic of invasive non-natives has entered politics. The EU has established and is regularly updating a list of non-native invasive species of European concern, based on an EU Regulation adopted in 2014 – Regulation (EU) No 1143/2014. The invasive species listed (no trees so far in the year 2018) cannot be imported, traded, planted or allowed to spread. Similarly, more and more national laws and initiatives are dealing with the issue of invasiveness and the protection of biodiversity. The national approaches of different European countries vary from total prohibition of the introduction and use of non-native trees in forests to no restrictions being in place. Besides forest acts and nature conservation acts, various soft approaches like certification or guidelines have a significant influence on forestry. For example, non-native species may be excluded from sensitive or rare ecosystems, buffer zones may be installed around water bodies or protected forests, mixtures with native tree species may be prescribed, or the share of non-natives may be limited to a few percent of the forest area.

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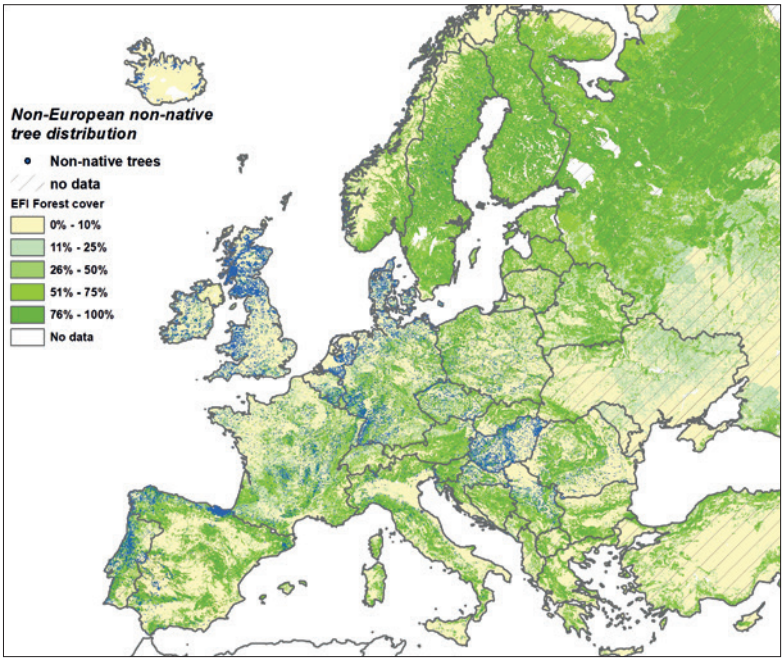
>> ***Example***
Non-native tree species of the genus Eucalyptus grow on approximately 1.5 million hectares on the Iberian Peninsula where they are planted extensively. Eucalyptus globulus or Tasmanian blue gum is now the most important tree species in Portugal (covering 25 % of the forest area). Eucalypts are native to Australia. They are not only suited to the Iberian climate in which they grow fast, about twice as fast as any native tree species, they also provide the main raw material for the paper industry, which is responsible for over 4 % of the Portuguese domestic product and for 1.2 % of all jobs, especially in the countryside. On the other hand, eucalypts are suspected to spread fast, consume large amounts of water and nutrients, provide poorer habitats for insects and other animals and increase the risk of forest fires. Opponents and supporters of Eucalyptus cultivation alike provide evidence that several of these accusations are justified – or not.

The story of eucalypts exemplifies conflicts of interest that decision-makers – foresters, agronomists, biologists, hydrologists, technologists, social scientists and of course politicians – have to deal with. It shows the dilemma of 'Nature versus Culture', but also discrepancies in beliefs, values and interests within our human societies. On the one hand, non-native trees can impact the ecosystem, and a limited number of species may be spreading; on the other hand non-native trees can contribute considerably to the income of people especially in rural areas and produce valuable raw materials whose growth also helps in protecting the climate. ***How would you decide?*** *And can you find an answer to the question –* ***How intensively, and for which purposes are humans allowed to cultivate and change the land?***

The current distribution of non-native tree species

More than 150 non-native tree species originating from outside Europe can be found in European forests. A much larger number can be found growing in parks and arboreta. Despite the high number of species, their share of the overall forest area is small since only about 8.5 million hectares = 4% of the European forest area are covered by non-native trees.

However, there are large regional differences in their importance. For example the share of non-natives ranges from less than 1% in the Baltic states and in some south-eastern European countries to over 60% in Ireland and Scotland. The type of species grown also differs among countries, reflecting the varying suitability of the individual species for



Map of Europe; Blue shows the locations where non-native trees occur in forests, either pure or in mixed stands with native tree species or with other non-native tree species (based on national forest inventories). The different shades of green show the forest coverage. Source: COST Action NNEXT results based on data of Mauri et al. 2017 and ENFIN 2016, and EFI Forest map of Europe.

different environments. Depending on where a tree grows naturally, e.g. in coastal areas of Canada or along rivers in Australia; whether winters are long and cold or mild almost without frost, whether soils are acidic or calcareous, clayey or sandy,… and much more; all these factors will influence where in Europe a tree can find a new home.
The most widespread non-native tree species is black locust, originating from southern Appalachians in eastern North America. Black locust and six other species or species groups make up 90% of the area of non-natives in European forests (the following table shows the numbers for these most widespread non-natives). Most of the other 150 non-native tree species are only found in small areas in a few countries.
Growing non-native tree species is not a recent phenomenon. Fruit trees were introduced to Europe over a thousand years ago or more. Other species such as sweet chestnut were spread over large areas, coming from small refugia in Southern Europe where they survived the ice-age. The first important non-native tree species used in forestry, Eastern white pine, was imported in the middle of the 16th century from eastern North America. The majority of the widely distributed non-native tree species were introduced to Europe two to three centuries later, when travelling around the globe became easier and plant hunting explorations became more frequent. Today, the number of new tree species introductions into Europe is low. Yet, certain non-native tree species tested and grown in one region may not yet have been considered for planting in other countries, and their range in Europe might still expand. Interestingly, the reproductive material (i.e. seeds) of the more important non-native tree species is mainly collected in existing stands or seed orchards in Europe, and is no longer imported from the area of origin, for example North America.

Image of forest diversity. Kilmun Arboretum, western Scotland. Trial site for more than 280 tree species of which over 180 tree species survived. Crown copyright – Forest Research

Some of the most widespread or most abundant non-native tree species in Europe, their continent of origin, year of introduction to Europe and country of first introduction, total area in Europe in pure or mixed stands and the number of European countries where the species is present (numbers are probably slightly underestimated because not for every European country distribution data are available).
Source: COST Action NNEXT results

Common name	Scientific name	Origin	Total area (x 1000 ha)	No. of countries	Year of introduction
Black locust	Robinia pseudoacacia	Eastern North America	2,438	29	1601 (FR)
Eucalyptus / gum tree	Eucalyptus sp. (mainly E. globulus and E. camaldulensis)	Australia	1,538	6	1774 (UK) (E. obliqua), ca. 1850 (ES) (E. globulus)
Sitka spruce	Picea sitchensis	Western North America	1,160	13	1831 (UK)
Douglas fir	Pseudotsuga menziesii	Western North America	831	32	1827 (UK)
Lodgepole pine	Pinus contorta var. latifolia	Western North America	736	11	1845 (IT)
Poplars incl. hybrids	Populus sp.	Northern hemisphere	620	13	1750 (FR) (P. x canadensis)
Larch incl. hybrids	Larix sp.(mainly L. kaempferi and L. x marschlinsii)	Northern hemisphere	404	7	1861 (UK) (L. kaempferi)
Northern red oak	Quercus rubra	Eastern North America	345	24	1691 (FR)
Monterey pine	Pinus radiata	Western North America	257	3	1787 (FR)
Eastern white pine	Pinus strobus	Eastern North America	70	19	1553 (FR)
Atlas cedar	Cedrus atlantica	Northern Africa	23	5	1839 (FR)
Noble fir	Abies procera	Western North America	13	4	1831 (UK)
Japanese red-cedar	Cryptomeria japonica	Japan	11	3	1842 (UK)
Grand fir	Abies grandis	Western North America	10	11	1830 (UK)
Black walnut	Juglans nigra	Eastern North America	8	14	1629 (UK)
Tree of heaven	Ailanthus altissima	China	7	18	1740 (FR)
Box elder	Acer negundo	Central and eastern North America	5	16	1688 (UK)
others	others		58		
total	**total**		**~ 8,500**		

Success stories

The following success stories show one side of the coin, the bright side. Later on we will look to the other, dark side, and will tell equally important stories about failures, so please keep reading.

Let us first share some general thoughts about forests, to better understand the role that non-native trees can play in our success stories. Everyone agrees that forests are very valuable, and typically emotions about forests are deep. This is not only because of a forest's natural beauty and the power and mystery that people experience when wandering through forests, but also because forests are extremely useful, for people and every plant and animal living in and around a forest. Forests fulfil certain functions better than any other vegetation type or human construction could do.

Forests • protect the soil against erosion and nutrients from being washed out or blown away, • store water and carbon, • attenuate floods, • balance the temperature, • protect downhill areas from avalanches and rockfalls, • are a habitat for many species, • produce timber and bio-chemical substances for various purposes, and • are an environment where people love to spend their time pursuing all sorts of activities.

The success stories around non-native trees are diverse. The success stories are associated not only with specific non-native tree species, but also with specific regions because of the wide variation in the European landscape, history, culture, economy. Woods and plantations of non-native tree species can, if planned and used in the right way, fulfil many of the above named forest functions as much as native species, and sometimes even better. Non-native tree species may show, or combine in one species, useful or unique features as none of the native species do.

What are these characteristics that make non-native tree species good?

Non-native tree species should • tolerate the local climate and weather extremes, • cope well with the local soil conditions, • not be vulnerable to pests, • have advantageous timber (including stem form), fibre or bio-chemical properties, • grow fast(er) than the natives, and • have no major negative impact on the forest or surrounding ecosystems (biodiversity, soil, water). From a practical perspective, • high quality seeds (with high genetic diversity and germination rate) should be available, • growing the species in the nursery and planting them in the forest should be reliable, and • mixtures with native tree species should be possible.

At the end of the 19th century forest cover in Scotland was below 5%, and in Ireland it was even as low as 1%. In both cases the forest area today exceeds 12%; these forests are highly productive and an important source of income for the rural economy. Source: Elisabeth Pötzelsberger

AFFORESTATION

Thousands of years of human presence resulted in severe deforestation of many regions across Europe, mostly because of the conversion of forest land to agricultural land and the enormous demand for wood to build ships and settlements, to heat homes and salt pans, produce charcoal for the melting of ore, for fuelling engines and railroad locomotives and much more. For example, the British Isles were vastly deforested over the centuries, and the forest cover had dropped from over 80% in prehistory to below 5% (in Ireland 1%) at the end of the 19th century. Early trials by British and Irish foresters identified the North-American Sitka spruce as a species which grew well on many sites and could alleviate the severe shortage of timber. Today, the forest cover in these islands exceeds 12%, the tree species diversity is increasing and forestry has become a source of reliable income. Similar stories of successful afforestation with non-native species could be told for the Benelux countries, Denmark, Iceland and other countries.

TREE SPECIES DIVERSITY

Increasing diversity may come as a surprising argument, since the number of tree species in Europe, being a few hundred species, is not really small. Nevertheless, tree species diversity is lower in northern Europe, where the variety of conifer = softwood species is especially low. On the British Isles, for example, only three native conifers occur – Scots pine, juniper and yew; valuable Norway spruce and European larch are missing, as they are in Denmark and the Benelux countries. Nonetheless, people have a high need of softwood as it is generally

light but elastic and workable, and is suitable as construction material, for boards and strong paper. These end-uses may not always be fulfilled by hardwood species; as conifers typically grow faster than valuable hardwood species they supply people with higher quantities of cheap but versatile wood.

TIMBER PRODUCTION

Wood is a natural, climate friendly resource for which demand is increasing. Overall, evidence suggests that non-native tree species grow 20% better than equivalent native species in Europe, and sometimes considerably more. Douglas-fir in central Europe, for example, may have up to 40% higher productivity than Norway spruce especially at lower elevations. Interestingly, Norway spruce is a European species naturally occurring in cool areas that was widely planted in warmer, low elevation areas because of its good growth and useful timber and now can be found in forests far beyond its natural distribution range. In effect, it can be considered non-native in large parts of its current distribution. Eucalyptus on the Iberian Peninsula has up to double the productivity of native tree species and is the main resource in the pulp and paper forest chain in Portugal. If Europe cannot meet its demand for wood, the alternative will be an increase in timber imports. For imported timber, however, European standards of sustainable, nature friendly forest management cannot be guaranteed.

...UNDER DIFFICULT GROWING CONDITIONS

Hungary, for example, manages to grow black locust under annual precipitation of as low as 500 mm. Black locust that has been bred for improved stem form for several decades, now covers more than 20% of the forest area in Hungary and its extremely durable, valuable wood is also exported. In western parts of Norway, Sitka spruce was successfully planted (before the use of non-natives was basically completely stopped in recent years due to concerns about invasiveness) because it grows three to four times faster than native birch or Scots pine and even grows well along the coast where it withstands salt spray and heavy winds. This is not surprising, since the species grows naturally along the coasts of western North America.

NON WOOD FOREST PRODUCTS AND SERVICES

Other reasons than timber production dominated the early quest for new tree species. It was the search for food, but also mere curiosity and the pleasure about a beautiful and exotic look that made non-natives attractive. Several non-native tree species produce edible fruits, such as nuts of the misleadingly named European walnut, which actually originates from Asia, of black walnut from North America and sweet chestnut stemming from small refugia in Asia and Southern Europe. Black locust is extremely important for the production of a brand of honey known as 'Acacia honey'. Black locust, in addition to being a great nectar source for bees, is also exceptionally beautiful when blooming with large white, fragrant clusters of flowers in spring. And one of our most typical Christmas trees – Nordmann fir – comes from the Caucasus.

Soil amelioration (improvement) can be another important service of non-native trees. A number of non-native tree species have proven to grow well on difficult soils like highly degraded, sandy soils or in karst areas. Over centuries, people in Europe did not treat their environment well, exploited and cut the natural forests

Sitka spruce harvested in Ireland; Sitka spruce is the main tree species in Ireland (over 50% of the forest area), and as a versatile softwood tree species it is the backbone of the Irish forest industry. Source: Elisabeth Pötzelsberger

and did not take care whether forest or other vegetation would grow again. Often erosion occurred, and soils and nutrients were washed or blown away, as it happened in large parts of the Mediterranean and Atlantic coastal areas. In Denmark for example large areas had turned into sandy heathlands, as forest cover had dropped to less than 5% two centuries ago. It was largely with the use of non-native tree species (some of them being native in other parts of Europe but not in Denmark) that these degraded soils could be revegetated and allow forest cover to be restored. In southern Europe, tree species used for similar purposes include black locust, acacia (e.g. *Acacia longifolia*), and tree of heaven. The former two are nitrogen fixing and therefore fertilise the soil with this important nutrient. Mainly in parts of north-western Europe, black cherry was planted as an understory species, because its leaves decompose easily and enrich the soil with humus and mineral nutrients for plant growth. Despite these non-natives fulfilling the tasks they were originally given, the satisfaction with the results is mixed today. Black locust, acacia and tree of heaven grow and spread so successfully and change their environment so extensively that today, they are often considered a threat to the ecosystem. This point will be discussed in the next chapter dedicated to failures.

Stories about failures

ECONOMIC SETBACKS – 'LEARNIG BY DOING'

Not every endeavour with non-natives was successful. Setbacks mostly occurred after investing in a promising species which did not meet expectations. The decision to plan a new species could not be based on research results and experience as is the case today. Instead people mostly had to rely on vague descriptions of the trees' growth behaviour and preferences, and of the climate of the part of the world where the tree originated. Simple trial and error was a common approach both in practice and in early research plantations.

Interestingly, it is not only a question of selecting the right species for the right site, but also of identifying the most suitable population, the right origin, scientifically and technically called 'provenance'. Within a species, individuals and populations display variable characteristics,- showing variable behaviour or growth abilities. Some provenances may be more tolerant to frost, or to fungi, others may be able to withstand drought better, and some may have finer branches, straighter stems, or grow considerably faster.

Douglas fir is an example where the selection of the right provenance strongly influences the tree's growth and survival in a specific environment. Douglas fir naturally occurs in very varied environments, to which it has adapted over long periods of time. The reason is its large natural distribution range in North America that stretches over roughly 4.5 thousand kilometres from North to South and 2.5 thousand kilometres from East to West, and crosses several mountain ranges.

In the early years of non-native tree species planting these within-species differences were not fully recognised. The result could be confusion and disappointment, when a tree that was supposed

to perform well failed on a site or had to be cut out after a couple of years because of poor health. The disappointment could be even bigger, if a species had grown well for some time was then hit by a natural disaster to which it turned out to be susceptible.

» A sudden wind storm could blow down the trees. Similar to native tree species (because also natives can get blown over), people had to learn two things to reduce the risk of windthrow, 1) not to plant a species that has a naturally shallow root system in areas where high wind speeds egularly occur, and 2) to find the right soil conditions where the species is encouraged to develop a deep root system. For example Douglas fir planted on water logged soils only develops a shallow root system and therefore is very likely to not survive strong winds on such soils.

» Pests could start to attack a tree species. Although every tree species is affected by insects and fungi even in its native range, non-native tree species in Europe may not be adapted to European pests and therefore be especially susceptible. Interestingly, the opposite phenomenon can be observed as well. Some non-native tree species may find no or very few enemies upon their arrival in Europe. For this reason non-natives in Europe may grow better than in their native range, where natural enemies have evolved together with these trees and regularly attack them. This phenomenon is described as the 'enemy release hypothesis'.

Generally, with global change, which includes climate change, increasing trade and the arrival of new pests, for non-natives the same is true as is for native species – what works today may not work anymore in the future.

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>> The most well-known example of a non-native tree species that used to be very popular but then had to be abandoned is that of Eastern white pine (also known as Weymouth pine). Introduced in the 16th century, it became the most widely planted non-native tree species in forestry because of its good timber quality and fast growth. Eastern white pine is closely related to other five-needled pine species – Swiss stone pine *(Pinus cembra)* from the high mountain areas in the Alps, Balkan pine *(Pinus peuce)* from South Eastern Europe and Siberian pine *(Pinus sibirica)* from Russia. A European fungus *(Cronartium ribicola)* naturally occurs on these species but it does not damage them much because, through evolution, they developed a natural resistance. The problem started, when this fungus came into contact with Eastern white pine for the first time, probably close to Russia in the mid-19th century. The fungus then spread to all the European plantations of Eastern White pine and killed almost all of the trees.

Disinfection measure at the entrance of an arboretum to prevent the spread of a new, highly infectious fungus killing larch trees. Source: Elisabeth Pötzelsberger

ECOLOGICAL RISKS

When introduced into a new area, a species can pose an ecological risk to an ecosystem and local biodiversity. This has always to be taken into account and always seriously. A risk is, generally speaking, the probability of occurrence of a negative impact.

Potential negative ecological impacts of non-native species are • changes in the functioning of an ecosystem, • changes in the soil nutrients, the water balance or the light conditions, • an increase in the fire risk, • the spread into neighbouring habitats, • outcompeting native species, • if the species is a less valuable food source or habitat for insects, birds, mammals and all other living organisms, • co-introduces pathogens, or • crosses with related native species and thus contaminates their genome.

Fortunately, where non-native trees used in forestry are concerned, some of these risks can be adequately managed because for many non-native tree species and circumstances the following applies:
1) It takes several years to decades before trees first regenerate, therefore the spread is rather slow;
2) Trees are visible all year round what simplifies detection and control;
3) In managed forests, foresters, due to their knowledge and the responsibility that comes with the job, are able to control the spread of most non-native tree species. Managing the tree species composition through cutting and removing undesired trees is a standard silvicultural practice.
4) Risk assessment protocols help predicting which non-native tree species may become problematic.
5) As a consequence of points 1–3, spread into protected areas from plantations can effectively be avoided, if a buffer zone of a few hundred metres is installed, regularly controlled and kept free of non-natives trees.

Exceptions do exist where non-native tree species can become especially problematic, persistent and invasive, either because of species traits or because of the circumstances. Certain non-native tree species have the ability to • regenerate vegetatively, sprout from root suckers or stumps, • start to flower when still very young, • produce large amounts of viable seeds that germinate easily, • have seeds that are spread by animals, float on the water or fly in the wind over large

distances, • have seeds that survive for many years in the ground (seed bank), or • modify soil conditions with chemical substances from the litter, roots or symbiotic rhizobia. Moreover, non-native trees have more chances to cause damage if • an area is abandoned and human control stops, • buffer zones prescribed by law are not respected, • or forest management skills are low (especially small private forest owners).

The typical examples of tree species that have many of these traits are black locust *(Robinia pseudoacacia)*, tree of heaven *(Ailanthus altissima*), box elder *(Acer negundo)*, red ash *(Fraxinus pennsylvanica)*, black cherry *(Prunus serotina)* and the many wattles *(Acacia species)*. Especially problematic are black locust and acacia/wattle, because they belong to the legume family and therefore enrich the soil with nitrogen. Nitrogen enrichment can have a long-term effect on the ecosystem. Even if the trees are removed, the former plant composition that was adapted to the low-nitrogen soil conditions may not be able to come back for decades because the nitrogen remains in the soil.

Non-native trees planted for non-forestry purposes, e.g. in gardens and parks, along the streets and railways, or abandoned plantations may also be especially problematic. Since these trees are not monitored by a forester, they may spread into adjacent natural habitats freely, without anyone feeling responsible.

Black locust stems that have sprouted from a single root system. Source: Robert Brus

NEGATIVE SOCIAL PERCEPTION

An interest in novelty was one of the drivers for the quest for exotic species. But at the same time people were sometimes concerned about the unknown, potential harm to the environment, or an unknown look or smell. As a matter of fact, not only the introduction of non-native tree species in forestry can stir concern, but any indications of forest management may cause discomfort. Forests, in the view of some people, should be wild and mysterious, and should not be touched unlike intensively managed agricultural land. It is unknown, however, if there is awareness of the manifold consequences that stopping forestry would have.

Today, most people in Europe do not earn their living directly from agriculture and forestry and they spend only a few holidays or weekends in the countryside. Consequently, the feeling of dependency on the natural resources of our environment is reduced. Food comes from the supermarket shelf, and timber from large warehouses, in unrestricted quantities. At the same time, fear about potential ecological risks of non-native tree species and of forestry in general is increasing. There is even the tendency in nature conservation to place all non-native trees under a total ban. Interestingly, the discussion about banning non-native trees mainly focuses on forests. In cities, on the other hand, we enjoy the diversity of trees in the streets and in parks. In fact, in cities we largely depend on a range of non-native tree species. These trees can tolerate the harsh conditions in the city, the heat, the poor soils, the salt used against ice, and other toxic chemicals that are washed into the soil or that pollute the air. These trees make the city a much more habitable place; they cool the roads, clean the air, are a cornerstone for animal life in the city, and make humans simply feel good. Some non-natives became iconic decorative elements of the landscape. Palm trees in Southern France or Spain are perceived attractive by locals and tourists alike; and who would want to imagine Tuscany without the tall and slender cypresses? Despite being called Italian or Mediterranean cypress, this tree originally comes from the eastern and southern Mediterranean and in fact is non-native to Italy. The last example shows very well, that often the question is not, whether a species is native or non-native, but if people have had time to familiarise themselves with the

Mediterranean cypress in Italy; despite being an iconic landscape element this tree species is non-native to Italy.
Source: Elisabeth Pötzelsberger

species, and include them in their culture. Another example is black locust – the most controversial non-native tree species in Europe, and the most widespread one. While condemned by many and considered a real pest, it is perceived as a native species for example in some south-eastern European countries, where people are grateful for the high quality timber, the stabilisation of dry slopes and the 'acacia'-honey. While in these countries strong restrictions on the planting of non-native tree species have been put in place in recent years, these restrictions would not apply to black locust and some other established non-natives.

Humans typically not only are wary of the unknown, humans also don't appreciate change – no matter if the change concerns the planting of an unfamiliar tree or the removal of a familiar tree (even if the tree by definition is non-native, as our examples have shown). However, the search for solutions during an ecological or socio-economic crisis has always pushed us to be creative and to adapt to new conditions. Likewise, we will have to accept some changes if we want to combat climate change or compensate for the loss of native tree species. Only if people are informed about both the risks and opportunities, can they take informed decisions, and hopefully feel comfortable with the results. Even if the use of non-native species is feasible on scientific/ecological grounds, their use may be considered to be 'wrong' because of social concerns.

Opportunities

Just as in recent centuries, in the future non-native tree species are expected to offer many benefits, and they will provide new opportunities. Non-native tree species can help to make forests more resilient to climate change. Climate change is occurring rapidly, and the distribution of native tree species cannot adjust to the speed of change in growing conditions. In extreme cases, only a few or no native species with desirable timber properties and a high productivity may be left in a couple of decades. It is difficult to know now what will be the most suitable species in 50 or 150 years. Consequently, it would be wise to take out an insurance policy – and invest in diversity. Next to assisted migration for native species (where people translocate native species from the south to the north or from lower elevations to higher zones), certain non-native tree species can better tolerate hotter and drier growing conditions. They therefore can help to preserve forests, their functions and structure, and avoid savanna-like conditions developing in southern and central Europe.
Another big challenge is the vulnerability of native tree species to new pests. Trade and climate change will continue to bring new pests to Europe or enable pests to spread more easily. While non-native tree species are not immune to such threats, they nevertheless can help filling the empty niches left by retreating native species. Besides trying to adapt our forests to the challenges of the future, natural developments will always have their place. Protected old-growth forests and national parks, for example, will also in the future be allowed to develop completely on their own.

In extreme cases, environmental stress and pests can bring native tree species at the brink of extinction. This happened to European elms, which began to die in the early 20th century after being attacked by a fungus (Dutch elm disease). Currently, European ash is affected by a fungus that leads to ash dieback, and its next lethal enemy, the emerald ash borer is migrating towards Europe. Common oak and other European oaks are repeatedly suffering from the so called 'Oak decline', where oaks show severe health problems and sometimes are dying because of a complex interplay >>

>> of environmental stress and pest-attacks. European elms, ash and oaks were common tree species for example in floodplain forests. In floodplain forests, North American black walnut has the potential to help fill the gaps that these disappearing European tree species leave. Norway spruce, an extremely important native timber tree species, is another example of a tree species that is challenged by aggravated droughts and attacks by insect pests. The problems are especially severe in lower elevations, where Norway spruce has been planted and would not occur naturally. It is therefore wise to start to replace these Norway spruce forests. Besides some native oaks, Douglas fir is among the most promising species for areas where spruce is already dying. Douglas fir may even be more productive and as softwood species provides a quality timber that is in high demand.

In forests where new tree species will be introduced, we can increase the variety of timber, fibres and bio-chemicals. Some non-native tree species have valuable timber properties that none of the native species have. With non-native tree species we can therefore broaden the potential use of wood for different purposes, as for example in bio-refineries. Highly productive non-native tree species can also help in meeting the demand for locally produced wood to reduce dependency on outside markets, avoid non-sustainable timber production abroad and create jobs within Europe. Breeding is a promising way of further increasing the productivity of these species (increase in production of roughly 20–30 % is possible). Therefore, current research is focusing less on new species but rather on improving the growth of already established non-native species.

CONCLUSIONS

Non-native tree species…

- are not only a phenomenon that has occurred in the last decades,
- have been promoted for centuries to enhance forest production cultivate poor and degraded soils,
- may disturb ecosystems in various ways and spread unintentionally if the tree species are not adequately selected or managed,
- in rare cases may pose a threat to humans, if the tree species increases the risk of forest fires and buffer zones around settlements are not respected
- challenge the 'close to nature' paradigm, but…
- if sensitively managed (e.g grown in mixture with native species) they are accepted by the European federation of professional foresters who advocate and promote close to nature forest management principles,
- allow foresters to choose from a larger variety of tree species, to find the species that grow best on a certain site,
- can replace native tree species threatened by (i) climate change, (II) insects and pathogens, (III) other adverse conditions (e.g. air pollution, soil pollution),
- have to provide a range of forest ecosystem services to allow people to build up a relationship with these new species and give foresters the 'social licence to operate',
- must be used responsibly, after assessment of the risks and knowing how to keep them away from sensitive and rare habitats;

Know what you are doing,
balance the pros and cons,
and take informed decisions.

NNEXT Sources:

COST Action FP1403 NNEXT results; All publications, scientific articles, reports and references are available on the project homepage (http://nnext.boku.ac.at/)
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Short descriptions of some of the most widespread and important non-native tree species in Europe

BLACK LOCUST

- stabilisation of slopes and improving sandy soils
- flowers support honey production
- extremely durable timber
- most important species in Hungary
- perceived as native in south-eastern Europe

Source: Heinrich Spiecker (above), Norocel Nicolescu (below)

TASMANIAN BLUE GUM

- Eucalyptus globulus is the most widespread Eucalyptus species in Europe
- used for pulp and paper
- grown on short rotations ~ 10 years
- very fast growth
- breeding increases growth by 25–50%
- not grazed
- increased fire risk if litter (fuel) accumulates

Source: Hélia Marchante

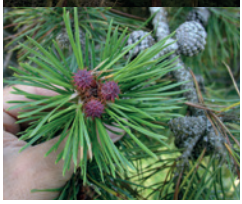
SITKA SPRUCE

- general purpose whitewood (pulp to construction purposes)
- very pointed needles
- most important species in Ireland and western and northern Britain
- tolerates salt spray and exposure along the coast

DOUGLAS FIR

- two or three varieties with distinctly different appearance, growth, and environmental tolerance
- valuable construction wood
- core wood durable
- ornamental tree (Christmas)
- among the tallest trees in the world (>100m)
- largest tree in Germany (66m/100y)

Source: Heinrich Spiecker (above, left),
Elisabeth Pötzelsberger (right)



LODGEPOLE PINE

- four varieties of Pinus contorta, of which lodgepole pine (var. latifolia) is the most widespread and economically important one
- pioneer
- boreal species
- faster growth than native Scots pine
- valuable construction wood
- dominant species in Yellowstone national park
- cones release seeds after fire

Source: Thierry Lamant

POPULUS X CANADENSIS

- hybrid between two closely related poplars from European and North American
- biomass for energy production
- veneer logs for boxes and other light weight packaging
- planted as clones

JAPANESE LARCH

- small natural range on Honshu island
- fast growth even on poor soils
- serious fungus infection in recent years in the British Isles
- valuable construction wood

Source: Thierry Lamant

NORTHERN RED OAK

- fast growth
- versatile timber
- wood quality slightly less compared to important native oaks
- superior performance of adapted European populations

Source: Norocel Nicolescu

MONTEREY PINE

- fastest growing pine species in Europe
- tiny natural distribution area
- most important timber species in New Zealand and Chile

Source: Elisabeth Pötzelsberger (left), Thierry Lamant (right)

EASTERN WHITE PINE

- historically first important non-native species in European forestry
- seriously affected by a fungus since the early 20th century
- currently hardly planted

Source: Robert Brus

ATLAS CEDAR

- ornamental tree
- frames and furniture
- fragrant oil
- used already in ancient times
- forestry plantations in France

Source: Robert Brus (above), Thierry Lamant (below)

NOBLE FIR

- one of the largest silver firs
- light, high quality timber
- decorative Christmas tree and foliage

Source: Robert Brus

JAPANESE RED-CEDAR
- fast growth
- very light and soft
- easy to work with
- durable
- frames and boxes
- most important species on the Azores

Source: Elisabeth Pötzelsberger

GRAND FIR
- one of the largest firs
- fast growth
- alternating needle length
- susceptible to Armillaria sp. fungus
- infected trees die before maturity

Source: Thierry Lamant

BLACK WALNUT
- replacement for European ash in floodplain forests
- light demanding
- pruning necessary for valuable timber production

Source: Norocel Nicolescu (left), Robert Brus (right)

TREE OF HEAVEN
- ornamental tree
- afforestation of poor, sandy and karstic soils
- ash-like timber quality
- vigorous resprouting • not a good habitat and food source

Source: Martin Meyerspeer

BOX ELDER
- ornamental tree
- spreading in floodplain forests

Source: Thierry Lamant

ACACIA/WATTLE
- ornatmental tree
- frost sensitve
- nitrogen fixing
- spreading

Source: Pilar Castro

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