Review paper
10.7251/AGRENG1702056I
UDC: 630*232:502.1

THE IMPORTANCE OF WOODY PLANT INTRODUCTION FOR FOREST TREES IMPROVEMENT

Vasilije ISAJEV[1], Milena STANKOVIC[2]*, Sasa ORLOVIC[3], Stefan BOJIC[2], Srdjan STOJNIC[3]

[1]Faculty of Forestry, Belgrade, Serbia
[2]Department for Forestry, Faculty of Agriculture, University of East Sarajevo , Bosnia and Herzegovina
[3]Institute of Lowland Forestry and Environment, Novi Sad, Serbia
*Corresponding author: stankovic.milena08@yahoo.com

ABSTRACT

The history of woody plant introduction is closely linked with that of transportation and the European exploration of the planet (16th–19th centuries). Each colonial power established major botanical gardens and experimental stations in various parts of the world. By the 20th century, the purpose of introductions shifted from food plants to timber and other species yielding non-agricultural products. Finally, during the latter part of the 20th century the importance of ornamental species increased dramatically, especially to the more developed and wealthier regions. Over the past two centuries many species have started to spread in their introduced ranges. Until relatively recently the majority of introduced woody species have been highly beneficial, if not essential, to humanity's development, but now ever-increasing numbers of species are becoming detrimental to the maintenance of the earth's biodiversity and to the well-being of human societies. Throughout the 19th and specially in 20th century the large-scale planting of trees for timber production has been one of the main reasons for the introductions of a large number of species, especially conifers e.g. *Pinus, Picea. Pseudotsuga* and Poplars and Willows species. By using methods of mass and individual selection and by establishing of provenances tests, as well as by half and full sib lines of selected exotics test trees, genetical potential productivity and adaptability of introduced species have been tested in numerous experimental plots in areas where introduced have been done. This paper attempts to unravel the relationships between humans and woody plants by looking at the changes in the introduction of species, the way they are perceived by different human groups and the impact these non native species have on forest trees improvement and other human activities.

Key words: *introduction, forest trees, improvement.*

INTRODUCTION

Woody plants have undoubtedly been transported by humans for millennia and were an essential component of early agricultural societies. Over the past 500 year, the geographic barriers that had maintained an almost static distribution of the world's biota for millions of years have been eroded by human activity, and wild species have consequently moved beyond their natural range, (Richardson et al., 2000). During the discovery and conquest of the world by western European powers, fruit trees and ornamental plants were widely dispersed around the globe (Haysom and Murphy, 2003).

Over the past two centuries many species have started to spread in their introduced ranges. Until relatively recently the majority of introduced woody species have been highly beneficial, if not essential, to humanity's development, but now ever-increasing numbers of species are becoming detrimental to the maintenance of the earth's biodiversity and to the well-being of human societies. This paper attempts to unravel the relationships between humans and woody plants by looking at the importance of introduction of woody plant species for different human activities and especially for forest trees improvement (Isajev and Tucovic, 1986). The location of introduction was identified, in full or in part, for 388 of the 458 forestry tree species known to occur outside their native range (85 percent). Figure 1, shows the number of forestry species that were recorded as introduced, intentionally or by accident, into each of seven geographic regions (Europe, Africa, Australasia, North America, South America, Pacific and Asia). Introductions of forestry species were recorded for all regions.

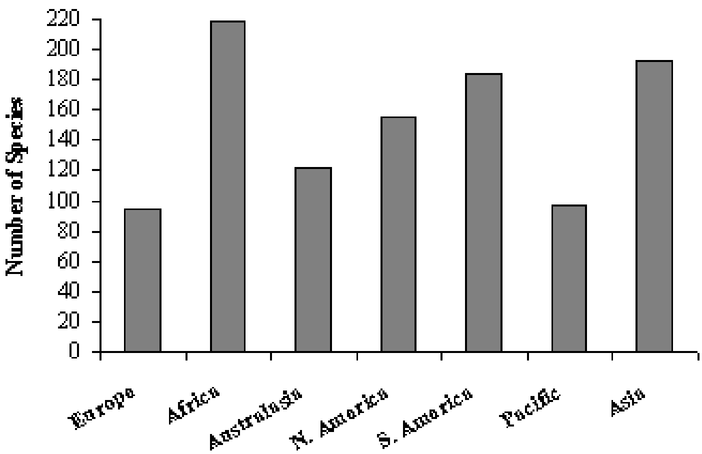

Figure 1. Number of forestry species encountered that having been introduced into each of seven geographic regions, Haysom K.A and Murphy S.T., 2003.

In the majority of cases, there was a lack of information on the mode of introduction (deliberate or accidental) and the country of origin of the introduced material. There were few reports of tree species (from any of the economic use categories) having been introduced accidentally, and several reports expressed uncertainty concerning the nature of the introduction event.

Historical perspective of woody plant introduction

The history of woody plant introduction is closely linked with that of transportation and the European exploration of the planet (16^{th}–19^{th} centuries), Crosby, 1986. The transport of a species from one biogeographical region to another was carried out with a particular purpose. Once introduced to a new region, many of these species have been spread un-intentionally by humans within the new biotic regions.

Each colonial power established major botanical gardens and experimental stations in various parts of the world, first in the home country and on tropical islands, later in coastal areas and finally in more inland locations. By the 20^{th} century, the purpose of introductions shifted from food plants to timber and other species yielding non-agricultural products. Finally, during the latter part of the 20^{th} century the importance of ornamental species increased dramatically, especially to the more developed and wealthier regions.

Ornamentals have been widely introduced in every part of the world. In the past, botanic gardens and individuals were responsible for these introductions. Botanic gardens in all parts of the world have been responsible for the introduction of a large number of species and in every case species have started to spread into the surrounding vegetation. Erosion control has been a common reason for the introduction of plant species in many parts of the world. Species providing a rapid and thorough cover such as *Lonicera japonica* and *Pueraria lobata* have been favoured but these have become major pests (Williams, 1994). *Elaeagnus angustifolia* was commonly planted as a windbreak and *Lonicera japonica* was planted by game managers for wild deer (Blaisdell, 1967). In countries such as Britain shrub species such as *Symphoricarpos albus,* were introduced to provide ground cover for game birds (Gilbert, 1995).

Overview of domestication and conservation approaches of poplar (*Populus* L.) And willows (*Salix* L.)

The natural range of *Populus* and *Salix* spans impressive ecological amplitude, primarily across the North American, European and Asian land masses – from the subtropics to the boreal forests and arctic tundra, riparian to montane ecosystems and the man-made environment of modern agriculture. As a consequence, poplar and willow geneticists – those responsible for conserving and domesticating germplasm of *Populus* and *Salix* – have an especially broad mandate: to study the genetic diversity of natural populations and be familiar with all the modern tools for genetic improvement in order to serve specific societal needs (Kuzovkina and Quigley, 2005; Kuzovkina *et al*., 2008; Kuzovkina and Volk, 2009, Stanton *et al*., 2010).

Populus domestication has a history of nearly 100 years, beginning with Henry's work-1914, at the Royal Botanic Gardens, Kew, in the UK, and the work of Stout and Schreiner (1933) and Stout *et al*. (1927) at the New York Botanical Garden in

the USA. Other early domestication efforts include those of Wettstein-Westersheim 1933 in Germany, Al'benskii and Delitsina 1934 in Russia, Heimburger 1936 in Canada, and Houtzagers 1952 in the Netherlands. *Salix* domestication traces to the hybridization studies of Heribert-Nilsson in Sweden, Heribert-Nilsson, 1918, along with Nilsson and Hakansson's cytological work in the 1930s, Nilsson, 1931; Hakansson, 1933, 1938. In the UK, H.P. Hutchinson began work in willow conservation and breeding in the 1920s at the Long Ashton Research Station that was continued by K.G. Stott for the following 30 years, Newsholme, 1992; Stott, 1992. Most of this work involves 12 species in the genus *Populus* that are noteworthy for their commercial and ecological values. They are the North American species *P. balsamifera*, *P. deltoides*, *P. trichocarpa* and *P. tremuloides* and the Eurasian species *P. alba*, *P. cathayana*, *P. ciliata*, *P. euphratica*, *P. maximowiczii*, *P. nigra*, *P. simonii* and *P. tremula*, Stanton, J.B. et al 2014.
Within the genus *Salix*, 10 species − *S. caprea*, *S. dasyclados*, *S. eriocephala*, *S. koriyanagi*, *S. miyabeana*, *S. purpurea*, *S. udensis*, *S. schwerinii*, *S. triandra* and *S. viminalis* − are being utilized in developing the world's renewable energy industry, while three others − *S. alba*, *S. babylonica* (synonym *S. matsudana*) and *S. nigra* − are favoured for timber products (Stanton et al., 2014).

Experience with some conifer exotics in Europe

Tree species, particularly conifers, have been introduced from all over the northern hemisphere into Europe, and this is an unsurpassed region in which to obtain information on the behavior of exotics. It is notable that, after more two centuries of experience, the majority of foresters in Western Europe are inclined to be pessimistic regarding exotics, because they have not yet found a completely successful introduced tree, even though certain species showed great initial promise. The native European trees grow slowly, so there has been a search for faster growing species. Eastern white pine (*Pinus strobus* L.) grows more rapidly than the native European conifers with which it has been associated. In northern Germany near Eberswalde, the writer has seen 45-year-old Douglas fir (*Pseudotsuga taxifolia* (Lam.) Br.) of the same size as 100-year-old Scots pine. Near Tharandt, 55-year-old Douglas firs were from 14 to 20 inches (36 to 51 cm.) in diameter at breast height, exactly twice the size of Norway spruce (*Picea abies* Karst.) of the same age mixed with them. In southern Germany, near Munich, 45-year-old planted Douglas fir was the same height as 77-year-old naturally reproduced silver fir (*Abies alba* Mill.).

Eastern white pine (*Pinus strobus* L.)

The first exotic to be extensively planted in continental Europe was eastern white pine, introduced in 1705. At first of great promise and hailed with enthusiasm, it finally encountered an unpredictable pathogenic factor - white pine blister rust caused by the rust fungus, *Cronartium ribicola* Fisch., a migrant from Asia - with the result that the tree was all but abandoned throughout Europe. The wide range of soils on which white pine will grow vigorously in Europe is impressive. In Switzerland also he saw superb mature trees which had developed in mixture with beech (*Fagus sylvatica* L.), Scots pine and a little Norway spruce. In southern Germany the tree was seen in its fourth generation, the first two generations having been planted and the second two naturally reproduced.

Douglas fir (*Pseudotsuga taxifolia* (Lam.) Br.)

The first seeds were introduced in Europe by David Douglas in 1827 and then planted at Dropmore Park (Buckinghamshire, UK), where there is a tree which is usually considered the oldest Douglas fir of Europe. Initially planted as ornamental, Douglas fir started to be used as a forest species by the end of the nineteenth century. This fir became a major reforestation species in Western Europe after the Second World War, mainly with the support of national or regional forest grants. In Europe, 80 % of the total Douglas fir area is to be found in three countries: France (half of the European area), Germany and United Kingdom. Outside Europe, Douglas fir has also been introduced in several countries of the southern hemisphere (South Africa, South America, New Zealand and Australia). Following World War I, Douglas fir found high favor and was planted extensively, although enthusiasm diminished somewhat in time because of the low quality of wood produced. Planting of the species has been given up in much of southern Germany, while in Switzerland it is being used in mixture only, not with the idea that the mixed stand as such will check the disease, but merely to have other species to take the place of Douglas fir in the stand should the disease prove as catastrophic as is now feared. The first pathogenic factor to threaten the tree was Phomopsis canker caused by a European fungus, *Phomopsis pseudotsugae* Wilson. This turned out to be not as serious as first feared, being largely connected with frost. Next was Rhabdocline needle cast caused by *Rhabdocline pseudotsugae* Sydow - the causal fungus coming from the native home of the tree, but with its virulence apparently increased by the damper European climate during the growing season. Fortunately, only the intermountain and Rocky mountain or blue forms of the tree were attacked, the coast or green form, the really valuable kind for Europe, being unmolested.

Sitka spruce (*Picea sitchensis* (Bong.) Carr.)

In view of the difficulties besetting Douglas fir, it was natural that Sitka spruce (*Picea sitchensis* (Bong.) Carr.) should increase in favor and by 1935 it was thought that this species might supplant Douglas fir for extensive planting. Plantations of the same species which have failed at 20 to 45 years old with no pathogen responsible have been seen in Germany, Switzerland and Great Britain, and it would seem that failure has clearly resulted from an unsatisfactory site. Sitka spruce is exacting in its site requirements, and too often has been planted on unsuitable soil, where the annual precipitation is too low, where temperatures are too severe or where some other adverse factor occurs. Unfortunately, the bad effects of an unsuitable site frequently do not appear until some years after a stand has been established, growth of the earlier years being vigorous. Sitka spruce on the whole is better adapted to Great Britain, where the climate is nearer that of its native habitat, than to most of continental Europe. Even so, care must be exercised in selecting the areas where it is to be established.

Grand fir (*Abies grandis* Lind.)

Grand fir (*Abies grandis* Lind.) is now being most favorably regarded by many foresters in western Europe because of its rapidity of growth and, up to the present, freedom from disease. It is thought that it may ultimately take the place it was first hoped that Douglas fir would occupy, and next Sitka spruce, neither of which is fulfilling their original promise. Since grand fir occurs over a wide geographical range in its native habitat with marked variations in temperature and precipitation, and since consequently there are climatic races within the species, it would be possible to find a race adapted to drier conditions, but such a race would probably grow so slowly that it would have no advantage over native European conifers. The grand fir which the author saw in Europe was all of the fast-growing coastal form. Severe attacks on conifers by (*Armillaria mellea* (Vahl.) Quel.) following drought are characteristic.

Western red cedar (*Thuja plicata* D. Don.)

Western red cedar (*Thuja plicata* D. Don.) is little seen in continental Europe, probably because in Great Britain the tree had so much difficulty in even getting a start that it was quickly discredited. The cedar leaf blight fungus (*Keithia thujina* Durand), which came with the trees from North America, finding the moist climate of Great Britain so much to its liking has reduced the cedar to a slow-growing tree, at least during its younger stages.

Experience with black locust, *Robinia pseudoacacia* L.

The North American black locust has been widely introduced throughout Europe as a source of high quality timber and for erosion control. Some now regard it as a permanent member of the flora, Gams, 1967. The main uses of *R. pseudoacacia* have been somewhat variable in different parts of Europe and have changed over time. In parts of France and Switzerland the young coppice wood was extensively used in vineyards to support the vines, Monnier, 1992, but in recent decades it has been replaced by metal posts and wire, and now the species is hardly used. Although the tree produces a highly durable timber, it is disliked by German foresters because the wrong strain, a shrubby variety, was introduced to that country. In Hungary the tree has remained a key timber and is the main source of honey (Keresztesi, 1977). Even new uses for the groves of this species have recently been found. The Hungarian Formula 1 Grand Prix brings over 100,000 spectators once a year but also attracts hundreds of prostitutes whose trade, over the past few years, has disturbed the tranquillity of local villages. This has now been restored as the local *R. pseudoacacia* groves have been put to new uses, Thorpe, 2000.

Testing and evaulating of introduced exotic species

Differences among species are ordinarily very large as compared with differences among races within a species or as compared with differences among individual trees within a forest. Thus the introduction of exotic tree species has been the single most important aspect of forest tree improvement for some areas. On the other hand, some regions have such excellent native species or such harsh growing conditions that trees from other lands have proved of little value. There are various intermediate regions in which tree introduction is on of several improvement methods which should be considered.

The procedures and designs used to test exotics are the same as used in the study of individual tree inheritance and racial variation. Exotic testing should be done in two or three stages (Wright, 1993). The first preliminary test should include several scattered plantations on different soil types and with different climates, with few blocks per plantation and small plots. These first tests may well include a few hundred seedlots of several different species or even genera. They may be established over a period of years, with separate plantations for species with different growth rates and growth habits.

The second-stage test should concentrate on those races or species that grew best in the first-stage tests. There should be more replication and perhaps larger plots at each test site, and increased attention can be given to individual tree variation. The second-stage trails may often be considered as semicommercal, designed for the production of wood as well as data. The third-stage trails can consist commercial plantations designed primarily for wood production.

In working with exotic species for the first time, one lacks the background information of site adaptability, pest problems and silviculturals management that is usually available for a native species. This is the reason for suggesting preliminary testing n a variety of site conditions and moderate-scale second-stage testing,

Identification and monitoring of introduced species should be particularly supported in those areas where there is currently little documentation. A number of case studies should be conducted in collaboration with countries that have a high degree of dependence on forestry. Such case studies should cover a range of forestry situations (commercial, developmental and environmental) and include the development and promotion of tools for ecological and economic impact assessments. These could also be incorporated into more general decision support systems that include socio-economic factors as well as biological risk.

CONCLUSIONS

There is a need for further research and monitoring that will provide information on the management processes in planted systems and take account of the scale (i.e. land area) of plantings and of the area occupied by introduced species.

- Introductions should only be considered if clear and well-defined benefits to man or natural communities can be foreseen and demonstrated.
- Introductions should only be considered if no native species are suitable for the purpose for which the introduction is being made.
- Introductions should not be made into pristine natural or semi-natural habitats, reserves of any kind or their buffer zones and, in most cases, oceanic islands.
- The taxonomic identification of the proposed introduction needs to be confirmed.

Only if these first four conditions are met should further assessment be undertaken.

Generally, it may be accepted conclusion, that introduced species can fulfill a gradually increasing role in certain ecological or industrial niches but will probably not replace natives over large areas.

REFERENCES

Al'benskii, A.V. and Delitsina, A.V. (1934): Experiments and investigations. All-Union Institute of Forest Cultivation and Forest Melioration, Moscow, Russia. 2nd Issue, pp. 107–109 (*Plant Breeding Abstracts* 5, 62)

Blaisdell, J.P. (1967): Introduction of wild-land plants into the United States – methods, legal controls, and ecological implications. IUCN Publication NS 9: 13–26.

Crosby, A. W. (1986): Ecological Imperialism: The Biological Expansion of Europe, 900–1900. Cambridge University Press, UK.

FAO. (1996): International standards for phytosanitary measures: guidelines for pest risk analysis. Publication No. 2. Rome, Italy, Secretariat of the International Plant Protection Convention.

Gams, H. (1967): Introduction and spread of 'weed' plants in Europe. IUCN Publication NS 9: 72–75.

Gilbert, O.L. (1995): Biological Flora of the British Isles. Symphoricarpos albus (L.) S.F. Blake (S. rivularis Suksd., S. racemosus Michaux). Journal of Ecology 83: 159–166.

Hakansson, A. (1933): The conjugation of chromosomes in a *Salix* hybrid. *Hereditas* 18, 199–214.

Hakansson, A. (1938): Cytological studies on bastards of *Salix*. *Hereditas* 24, 1–32.

Heimburger, C. (1936): Report on poplar hybridization 1936. *The Forestry Chronicle* 12, 285–290.

Heribert-Nilsson, N. (1918): Experimentelle studien uber variabilitat, Spaltung, Artibildung, und evoluation in der gattung *Salix*. Lunds Universitats Arsskrift N. F.Avd 2.

Houtzagers, G. (1952): Forest genetics and poplar breeding in the Netherlands. II. Poplar breeding in the Netherlands. *Euphytica* 1, 161–174.

Haysom K.A and Murphy S.T. (2003): The status of invasiveness of forest tree species outside their natural habitat: a global review and discussion paper. Forest Resources Development Service Working Paper FBS/3E, Forest Resources Division,FAO,Rome,Italy.

Isajev V., Tucović A. (1986): The importance and the application of introduction in Genetics and tree and shrub improvement. Bulletin of the Faculty of Forestry 67, University of Belgrade - Faculty of Forestry, Belgrade, pp 19-28.

Keresztesi, B. (1977): Robinia pseudoacacia: the basis of commercial honey production in Hungary. Bee World 58: 144–150. Khalanski, M. 1997.

Kuzovkina, Y.A. and Quigley, M.F. (2005): Willows beyond wetlands: uses of *Salix* L. species for environmental projects. *Water, Air, and Soil Pollution* 162, 183–204.

Kuzovkina, Y.A. and Volk, T.A. (2009): The characterization of willow (*Salix* L.) varieties for use in ecological engineering applications: co-ordination of structure, function and autecology. *Ecological Engineering* 35, 1178–1189.

Kuzovkina, Y.A., Weih, M., Romero, M.A., Charles, J., Hurst, S., McIvor, I., (2008): *Salix*: botany and global horticulture. In: Janick, J. (ed.) *Horticultural Reviews*. John Wiley and Sons, Hoboken, New Jersey, pp. 447–489.

Monnier, Y. (1992): L'empreinte des Amériques dans le paysage: de l'insolite au familier. Cahier d'Outre-Mer 45(179–180): 441–460.

Newsholme, C. (1992): *Willows: the Genus Salix*. Timber Press, Portland, Oregon.

Richardson DM, Pysek P, Rejmanek M, Barbour MG, Panetta FD, West CJ. (2000): Naturalization and invasion of alien plants: concepts and definitions. *Diversity and Distributions* **6**: 93–107.

Stanton, B.J., Neale, D.B. and Li, S. (2010): *Populus* breeding: from the classical to the genomic approach. In: Jansson, S., Bhalerao, R.P. and Groover, A.T. (eds) *Genetics and Genomics of Populus*. Springer, New York, pp. 309–348.

Stott, K.G. (1992): Willows in the service of man. *Proceedings of the Royal Society of Edinburgh* 98B, 169–182.

Stout, A.B. and Schreiner, E.J. (1933): Results of a project in hybridizing poplars. *Journal of Heredity* 24, 216–229.

Thorpe, N. (2000): Hungary lays on pit stop for grand prix punters. The Guardian 11 August: p.3.

Wettstein-Westersheim, W. (1933): Die kreuzungsmethode und die beschreibung von F1 – bastarden bei *Populus*. [The method of hybridization and the description of F1 hybrids of poplars.] *Zeitschrift fur Zuchtung* 18, 597–626. (*Plant Breeding Abstracts* 4, 163–164.)

Williams, D.F. (ed.). (1994): Exotic Ants: Biology, Impact, and Control of Introduced Species. Westview Press, Boulder, USA.

Wright J.W. (1993): Introduction to Forest Genetics. Academic Press, INC. San Diego, California. pp.359-399 ISBN 0-12-765250-7.