CULTIVATION OF FOREIGN SPECIES OF TREES

by

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The tree flora of Europe is, compared with the flora of other continents on the northern hemisphere, very poor in genera and species. Data given by Professor H. MAYR [1]) concerning the number of genera and species of trees in the cool and temperate zones in Europe, North America and Asia are, in this respect, illuminating, even if they are not absolutely correct. In these zones there are in Europe only 7 genera and 18 species of coniferous trees, whereas the corresponding figures for the eastern part of North America are 13 and 30, for the western part of North America 22 and 50, and for eastern Asia 26 and 100. Of deciduous trees, there are in Europe 30 genera and 60 species, in the eastern part of North America 100 and 220, in the western part of North America 34 and 70, and in eastern Asia 150 genera and 400 species. Very marked is the scarcity of genera and species in the northern parts of Europe. E. g., Suomi has only 4 genera and the same number of species of coniferous trees and 12 genera and 18 species of deciduous trees, out of which number 2 species of coniferous trees and 3—4 of deciduous trees are of economic value. The tree flora of Scandinavia is almost as poor: only the deciduous trees are represented by a few additional species.

Investigation of the history of vegetation gives evidence that the tree flora of Europe has not always been so poor in genera and species as at present. During the tertiary period, stately forests abounded which in richness of genera and species were quite comparable with the present forests of North America. *Sequoia*, *Taxodium*, *Chamaecyparis*, *Thuya*, *Magnolia*, *Liquidambar*, *Liriodendron* and other coniferous and broadleaf trees which are not in the present time natives of the European flora, but are so in North America, were distributed over large areas, till the catastrophe of the glacial period almost totally destroyed this rich tree flora north of the Pyrenees,

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[1]) HEINRICH MAYR: Waldbau auf naturgesetzlicher Grundlage. Berlin 1909, pp. 49—50.

the Alps and the Carpathians. The traces of this destruction have only partly been restored by the great migration of tree species which took place in the post- glacial period: the destroyed forests were replaced with new ones, but these were far poorer in genera and species than the forests of the tertiary period.

What nature has failed to do in the work of reconstruction, man has tried to supplement, *i. e.*, measures have been taken to enrich the naturally poor tree flora by acquiring new species from other continents. The earliest efforts in this direction were made in Central Europe in the 17th and in Suomi in the 18th century, but systematic experiments with the cultivation of foreign species were begun only as late as towards the end of last century. Even these experiments were, however, mostly rather summary and therefore frequently unsuccessful. More positive results were obtained only after the experiments in the cultivation of foreign trees advanced from the summary stage on a solid scientific basis. The chief merit for this is due to Prof. MAYR who in his works and articles emphasized the plant geographical attitude.

The cultivation of foreign species of trees is, however, not a purely European question. In South Africa and Australia which have a comparatively poor native flora of coniferous trees, experimental cultivation of South European and North American conifers has been taken up. In the mountains of New Zealand, among other trees *Larix europaea* is cultivated. On the slopes of the Himalayas and in Java South American Cinchona trees are cultivated. In Java, extensive plantations of the rubber trees *(Hevea brasiliensis* etc.) have been made, likewise in the Malay Peninsula. In California, experiments are being made with Australian Eucalyptus trees and in the eastern states of the United States and in south-eastern Canada with European species. The cultivation of trees beyond their natural area of distribution, from having been a European, has thus become an international silvicultural question with far-reaching economic consequences.

It seems, therefore, necessary to examine on what general premises the cultivation of trees outside their natural area of distribution is possible. Questions of chief interest are then: the choice of species, the origin of the seed used, the choice of site and the method of formation and tending of a culture.[1])

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[1]) See A. K. CAJANDER: Metsänhoidon perusteet. II. Suomen dendro-

In the choice of species we are bound within limits due to the climate of the area of cultivation. Each species will thrive only in a climate which fulfils its claims of heat and moisture. Each species has its optimum climate in which it flourishes best and the more climatic conditions differ from this optimum, the more difficult it is for the tree to thrive, until this becomes impossible. Experimental cultures made in Europe with species that are natives of different climates in different parts of the world,[1]) show that the degree of success of each species is proportionate to the degree of similarity between the climate of cultivation and the climate of natural distribution. The more the climates in question differ from one another, the poorer have been the results. The same conclusions have been reached from experiments with species of the northern hemisphere, made in the southern hemisphere (Australia, New Zealand, South Africa).[2]) It is, therefore, necessary as MAYR has already emphasized, for experimental cultivation to use in the first instance mainly such species as are natives of a country with a climate similar to that in which experiments are made. The possibilities of cultivating certain species of trees are, however, far greater than could be judged only by the climate of their native country, as has been clearly shown by experiments. So, for instance, *Chamaecyparis Lawsoniana* and especially *Picea omorica* and *Pinus peuce* seem to thrive in Europe in such regions in which the climate differs considerably from the climate of their very limited area of natural distribution, a fact which can probably be explained by other, biologically stronger species having limited their natural area of distribution. Thus, their area of distribution is far smaller than would have been the case, if climatic conditions had been the only active agents. Such comparatively rare exceptions to the general rule, however, show that, even if we have, in the choice of species for experimental purposes,

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logian pääpiirteet. (Principles of Silviculture. II. The main features of Finnish Dendrology). Porvoo 1917.

Id.: Der Anbau ausländischer Holzarten als forstliches und pflanzengeographisches Problem. (Acta Forestalia Fennica 24, 1923.)

[1]) See LAURI ILVESSALO: Ulkomaalaisten puulajien viljelemismahdollisuudet Suomen oloja silmälläpitäen. (On the possibilities of cultivation of foreign species of trees, with special regard to Suomi. (Acta Forestalia Fennica 17, 1920.)

[2]) See ERNEST H. WILSON: Northern trees in Southern Lands. Journ. of the Arnold Arboretum 1923, pp. 61—90.

in the first place to be guided by climatological reasons, we must not in a summary way leave out of our experiments all species which do not come from a country with marked similarities in climate to the country where cultivation takes place. This is all the more necessary, as in many cases available data concerning the climate of the country of origin are incomplete.[1])

O r i g i n. — Clearly as MAYR has expressed the idea that foreign trees must come from climatically similar countries, he took quite a negative attitude to the question of origin in the narrower sense. However, in cases where the area of distribution of a species includes climatically different sections, the results of experimental cultures vary according to the section, where the seed is obtained. The species in question are apparently divided into biological races, a fact which has already been previously observed in the common pine *(Pinus silvestris)* and in the common spruce *(Picea excelsa)*. In Suomi especially A. F. TIGERSTEDT, who has carried out experimental cultivation on his estate Mustila (lat. N. 60° 44′, long. 26° 29′ E.) on a grand scale, has drawn attention to the problem of origin and established its great importance for many species.[2]) So, for instance, young plants of Douglas fir *(Pseudotsuga Douglasii* Carr.) from seed obtained from the West Coast of the United States (Oregon) could not endure the climate of South Suomi, whereas seed from Quesnel gave rise to plants *(Pseudotsuga Douglasii*, var. *caesia* v. Schwerin) which thrive extremely well and were at the age of 13 years 4—5 metres high. The climate of Quesnel is about the same as in Mustila, whereas the climate in the west is far more maritime. In Central Europe, both the main coastal form as well as the variety *caesia* have succeeded, but the former has proved to be a faster grower, because it comes from

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[1]) As guidance in the search of climatically corresponding regions, the divisions of climates of KÖPPEN, KÖPPEN-PASSARGE, DE MARTONNE, and others, may be used. In Suomi, CAJANDER's division which is closely related to that of Köppen, has been accepted. His division has been developed with due consideration to plant geographical and silvicultural views, and to the maritime or continental nature of a climate which is of such importance in the case of cultivating foreign trees. (A. K. CAJANDER: Zur Frage der gegenseitigen Beziehungen zwischen Klima, Boden und Vegetation. Acta Forestalia Fennica 21, 1921). The plant geographical zones put forward by MAYR (Picetum, Fagetum etc.) include too heterogeneous climatic regions to serve as sufficient foundation for comparing climates.

[2]) A. F. TIGERSTEDT: Arboretum Mustila. (Acta Forestalia Fennica 24, 1922.)

a climate which is more like that of Central Europe, especially in its more maritime parts. Young plants of *Pinus Murrayana* Balf. raised from seed which was obtained from Montana, did not grow in Mustila nearly as well as plants from seed which came from the region of Banff (Alberta), the latter growing faster. Round Banff climatic conditions are very similar to those of Central Suomi. *Picea sitkaënsis* Carr. from Alaskan seed has thriven tolerably well, but from Oregonian seed no plants could be got. Therefore, if for experimental planting ordinary seed to be had in the market is used, as is still mostly the case, we are on unsafe ground and cannot from our failures draw the conclusion that a certain species is not suitable for cultivation. Full certainty concerning the adaptability of a foreign tree can be attained, only when seed from regions with a corresponding climate has been used in the experimental planting. Therefore, it is essential that seeds are delivered by reliable persons in the native country of the tree, *e. g.* with local foresters as intermediaries. In cases where there are already in the country itself fairly well thriving and seed making stands of foreign trees, such seed ought to be utilized for planting new stands, as under such circumstances we can be convinced that it is of suitable origin.

The choice of site. — The climate of even highly uniform regions shows local variations, which are due to variations in the formation of the surface. It is, therefore, not only necessary that the climate of a region, where the planting takes place, corresponds on an average to the climate of the country whence the species (the seed) is derived, but the very site of the plantation must show this correspondence. The conditions of the soil must also be taken into account. The importance of the correct choice of the site is shown especially by the experimental plantations of TIGERSTEDT. When Tigerstedt began his experiments in the early part of this century, he had not yet found time to acquire sufficient experience concerning the site which different species claim, and the result was that several species were planted on unsuitable sites and did not thrive well. But these difficulties were gradually overcome by the study of literature, through correspondence and travels abroad, and thus it was possible to place each species under experiment on a site which corresponded in the highest possible degree to the biological claims of the plant. Many species which on the basis of previous experiments had been regarded as unfit for cultivation, were now found to be quite satisfactory. Even new results have been obtained: through the choice

of most favourable sites even such trees have been a success as in their native regions have a somewhat more favourable climate than Mustila. Species that claim a higher mean temperature have been planted on warm southern slopes with rich soil, and species that are used to a warmer winter and a more even climate, on slopes with rich soil, but not on southern slopes, as they always show greater variations in temperature than northern and eastern. Again, when a species comes from regions, where the yearly rainfall is greater than in Mustila, the scarcity of rain has been compensated for by planting them on humid or even moist soil. These methods have often given excellent results.

Information concerning the soil foreign species claim is often very vague or even contradictory in the dendrological literature, and it is, therefore, not an easy task to take into account the claims of a species in this respect. It is true that the conditions of soil are intimately connected with those of the climate, especially of temperature and moisture, so that a climate has its corresponding conditions of soil, or, in other words, that climatic areas have roughly corresponding areas of soil. But, in spite of this, local conditions of soil vary considerably. Investigations prove that the so-called forest types [1]) fairly well reflect the conditions of soil.[2]) If it were known on what forest types foreign species appear in their native country and how they grow in different types of forests, it would be far easier to choose a correct site than at present. When the region of planting has the same types of forests as the country of origin of a species, the forest type can simply be used as a guide; or else the species should be planted on a type of forest which corresponds biologically to those types on

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[1]) A. K. Cajander: Ueber Waldtypen. (Acta Forestalia Fennica 1, 1909.)

A. K. Cajander und Yrjö Ilvessalo: Ueber Waldtypen II. (Acta Forestalia Fennica 20, 1921.)

A. K. Cajander: Was wird mit den Waldtypen bezweckt? (Acta Forestalia Fennica 25, 1923.)

A. K. Cajander: The Theory of Forest types. (Acta Forestalia Fennica 29, 1926.)

[2]) J. Valmari: Beiträge zur chemischen Bodenanalyse. (Acta Forestalia Fennica 20, 1921.)

Yrjö Ilvessalo: Ein Beitrag zur Frage der Korrelation zwischen den Eigenschaften des Bodens und dem Zuwachs des Waldbestandes. (Acta Forestalia Fennica 25, 1923.)

V. T. Aaltonen: Ueber den Aziditätsgrad (Ph) des Waldbodens. (Communic. ex Inst. Quaest. Forest. Finlandiae edit. 9, 1925.)

which it thrives well in its native region. So far, forest types are sufficiently investigated only in a few countries.

The method of formation and tending of culture, as experience shows, exercises considerable influence on the result. Previously, foreign species were planted (or sown) in most cases in Suomi (as well as in Central Europe) mixed with either native species or with one another. The results were, however, anything but satisfactory: in mixed stands of indigenous and foreign species the latter were suppressed almost without exception and often totally destroyed, and when two foreign species were planted mixed, the species that grew quickly in its early age usually gained, while the other suffered. Therefore, the formation of mixed stands soon had to be abandoned and they had to give place to pure stands. The influence of the method of formation and tending on the results of experimental cultures is clearly exemplified by the experiments of TIGERSTEDT. In Mustila, foreign species have generally been planted in fairly large groups or small stands. Species sensitive to frost have been planted in small gaps of the old growth pine forest or, in the case of shade tolerant species, under thinned forest. The method last mentioned has also been applied to such conifers as are sensitive to the warmth of the sun in the early spring. Thus, planted in the cover of the woods, in Mustila even such maritime species have thriven well as would have been destroyed, if planted in the open. As the trees have grown bigger, the covering forest has been thinned in order to ensure them sufficient space, till it has ultimately been cut down altogether. For the young plants of tender species special measures are, of course, necessary, too, in the nurseries *(e. g.* spreading of bast mats above the young plants during frosty nights). It is also suitable to found a nursery under the cover of a thin forest, on a slope declining gently towards north or east. A sufficient number of young plants must be grown, so that the nursery yields enough healthy, vigorous plants and weak ones may be discarded.

Successful cultivation of tree species outside their natural area of distribution involves:

that in their area of distribution a climate similar or nearly similar to that of the region of cultivation is to be found;

that seed is procured from that part or those parts of the area of distribution, where the climate is most similar to the climate of the cultivation;

that a site which satisfies the biological claims of the species is chosen for the cultivation, and

that the method of formation and tending of the culture satisfies the biological claims of the species in a sufficient degree.

In order that foreign species should not only be capable of cultivation, but also *worth* cultivating, they must, if they are not meant to fulfil only ornamental purposes, offer real advantages over the native species. Among such may be mentioned:[1])

(1) The wood of a foreign species differs to such an extent from that of the indigenous species that it is suitable for a purpose or even several purposes better than the indigenous.

(2) Greater production of wood.

(3) Smaller pretensions concerning the site (afforestation of drift sand ground and heath land).

(4) Greater endurance against spring frosts and cold in the winter.

(5) The foreign species yield valuable by-products (as rubber, quinine, tanning material, campho, sugar, ethereal oils, nuts).

As additional advantages the following may be considered:

(6) A foreign species resists damage from cattle or game (e. g. *Picea pungens* and *Picea sitkaënsis)*, insects, fungi etc. *(Pinus Peuce)* better.

(7) A foreign species improves the soil (e. g. *Robinia pseudoacacia)*.

Many of the advantages mentioned above are such that long and systematic planting experiments, often in conjunction with experiments with indigenous trees, are necessary in order to establish them with certainty. The fact that in many countries experiments with several species have yielded economically important results shows that sacrifices for the experiments are justified. In Suomi, two species of larch *(Larix sibirica* and *L. europaea)* have been naturalised, which both yield more produce than the indigenous species and in addition to this are more suitable for such special purposes for which durability against rotting is necessary.[2]) European larch

[1]) See A. K. CAJANDER: Metsänhoidon perusteet. II. Suomen dendrologian pääpiirteet. (Principles of Silviculture. II. The main features of Finnish Dendrology). Porvoo 1917.

[2]) An excellent example of how well the Siberian larch thrives in Suomi and at the same time of the fact to what results cultivation of a foreign species may lead under favourable circumstances, is the famous Raivola larch forest in south-eastern Suomi (See LAURI ILVESSALO: Raivolan lehtikuusimetsä. (The Larch Forest of Raivola. Commun. ex. Inst. Quest. Forest. Finlandiae edit. 5, 1923.)

has also been thoroughly naturalised in the Scottish mountains. In Central Europe, Douglas fir and White Pine *(Pinus strobus)* have proved to be excellent forest trees, likewise Sitka spruce *(Picea sitkaënsis)*. In Hungary, Robinia *(Robinia pseudoacacia)* has attained unexpected economic importance. (The area of Robinia forests there is calculated at about 100,000 hectares). In countries on the Mediterranean and in South Africa, California, etc., Eucalyptus trees have been planted with success. The Monterey pine *(Pinus insignis* Dougl. syn. *P. radiata* Don) has become a favoured forest tree in Australia. We have already mentioned the Chincona plantations in India and Java, and the rubber tree plantations in Java and in the Malay Peninsula. In many other regions of the tropical zone rubber trees have proved to be as productive as in their native country far outside their natural area of distribution. These are only mentioned as examples. Many useful species of trees which have a comparatively limited natural distribution, have thus already become international property, although systematic experiments based on a firm scientific foundation have generally only just been started.

Suomenkielinen selostus.

Ulkomaalaisten puulajien viljelemisen edellytykset.

Kysymys puulajien viljelemismahdollisuuksista niiden luonnollisten levenemisalueiden ulkopuolella on, oltuaan aikaisemmin pääasiassa vain eurooppalainen kysymys, myöhempinä aikoina laajentunut yleismaailmalliseksi kysymykseksi, jolla on varsin huomattava taloudellinen kantavuus. Näyttää näin ollen olevan syytä tarkastaa, millä yleisillä edellytyksillä ulkomaalaisten puulajien menestyksellinen viljeleminen on mahdollinen. Huomio kiintyy tällöin lähinnä puulajin valintaan, viljelykseen käytettävien siementen alkuperään (provenienssiin), kasvupaikan valintaan sekä viljelyksen perustamis- ja hoitotapaan.

Puulajin valinnassa ollaan sidotut viljelysseudun ilmaston asettamiin rajoihin. Sekä Euroopassa että eräissä muissakin maanosissa erilaatuisista ilmastoista kotoisin olevilla vierailla puulajeilla toimitettujen viljelyskokeiden tulokset osoittavat, että jokaisen puulajin menestymisen luonnollisen levenemisalueensa ulkopuolella on sitä parempi mitä enemmän viljelysseudun ilmasto on puulajin luonnollisella levenemisalueella vallitsevan ilmaston kaltainen; mitä jyrkemmin ilmastot eroavat toisistaan, sitä huonompi on puu-

lajin menestyminen. Mutta lisäksi viljelyskokeiden tulokset myös osoittavat, että viljelyskokeet puulajeilla, joiden levenemisalueet käsittävät ilmastollisesti toisistaan poikkeavia osia, johtavat erilaisiin tuloksiin sen mukaan, mistä levenemisalueen osasta kotoisin olevaa siementä kokeisiin käytetään, joten kysymyksessä olevat puulajit ilmeisesti ovat maantieteellisesti jakaantuneet biologisiin rotuihin, samoin kuin esim. mänty ja kuusi. Täysi varmuus vieraan puulajin viljelyskelpoisuudesta saavutetaan siis vasta silloin, kun viljelystulokset perustuvat kokeiluihin ilmastollisesti vastaavilta (tai mahdollisimman vastaavilta) seuduilta polveutuvilla siemenillä.

Ilmastossa on sangen yhtenäisilläkin alueilla paikallisia eroavaisuuksia, jotka johtuvat maan pinnanmuodostussuhteiden vaihtelevaisuudesta. Ei näin ollen riitä, että viljelysseudun ilmasto keskimäärin vastaa viljeltävän puulajin (siementen) kotiseudun ilmastoa, vaan tulee myös juuri viljelyksen paikan ilmaston sitä vastata. Samaten ovat kasvupaikan maaperäsuhteet otettavat huomioon. Tutkimukset ovat osoittaneet, että metsätyypit verraten hyvin kuvastavat maaperän ominaisuuksia. Milloin on tiedossa, millä metsätyypeillä puulaji kotiseudullaan esiintyy, voidaan siis viljelyksen paikan valinnassa metsätyyppejä käyttää ohjeena.

Eri tahoilla ulkomaalaisten puulajien viljelemisestä saavutetut kokemukset osoittavat, että viljelyksen perustamis- ja hoitotapa vaikuttaa varsin huomattavasti viljelystulokseen. Niinpä Suomessa useimmat ulkomaalaiset puulajit menestyvät tyydyttävästi vain puhtaina kulttuureina; sekaisin kotimaisten puulajien tai toistensa kanssa istutettuina ne viihtyvät huonosti. Hallanarkoja puulajeja on saatu menestymään istuttamalla niitä vanhan (mänty-) metsän pienehköihin aukkoihin tai — varjoa sietäviä puulajeja — harvennetun metsän alle; aukealla, suojattomalla paikalla ovat samat puulajit epäonnistuneet.

Puulajien menestyksellinen viljeleminen niiden luonnollisten levenemisalueiden ulkopuolella siis edellyttää,

että niiden levenemisalueella tavataan samanlaista tai lähimain samanlaista ilmastoa kuin viljelysseudulla;

että siemeniä hankitaan siitä tai niistä levenemisalueen osista, joissa ilmasto enimmän on viljelysseudun ilmaston kaltainen;

että viljelykselle valitaan puulajin biologisia vaatimuksia tyydyttävä kasvupaikka; sekä

että myös viljelyksen perustamistavassa ja hoidossa puulajin biologiset vaatimukset riittävästi tyydytetään.

Ollakseen paitsi viljelyskelpoisia myös viljelemisen *arvoisia* tulee vieraiden puulajien, ellei niitä tahdota viljellä pelkästään koristeellisiin tarkoituksiin, tarjota oleellisia etuja kotimaisten puulajien rinnalla. Sellaisia saattavat olla:

1. Ulkomaalainen puulaji eroaa puulaatunsa suhteen kotimaisista puulajeista niin, että sitä voidaan käyttää johonkin tai useampiinkin tarkoituksiin paremmin kuin kotimaisia.
2. Suurempi puuntuottokyky.
3. Vähäisemmät vaatimukset kasvupaikan suhteen. (Lentohietikköjen ja autioiden nummimaiden metsittämiset.)
4. Suurempi kestävyys hallaa tai talven pakkasia vastaan.

5. Ulkomaalaisesta puulajista saadaan arvokkaita »sivutuotteita». (Esim. kautsukkia, kiinakuorta, kamferttia, parkitusaineita, sokeria, eteerisiä öljyjä, pähkinöitä.)

Useat näistä eduista ovat sellaisia, että niiden varma toteaminen edellyttää pitkäaikaisia ja järjestelmällisiä viljelyskokeita ja joskus myös rinnakkaiskokeita kotimaisilla puulajeilla. Eri maissa lukuisien puulajien suhteen saavutetut, myöskin taloudellisesti huomattavat viljelystulokset kuitenkin osoittavat, että tällaisiin viljelyskokeisiin tehdyt uhraukset hyvin ovat puolustettavissa. Niinpä Suomeen on varmuudella saatu kotiutetuiksi kaksi lehtikuusilajia *(Larix sibirica* ja *L. europaea)*, jotka ovat tuottokyvyltään ylivoimaiset kotimaisiin havupuihin verrattuina ja sitäpaitsi soveltuvat paremmin sellaisiin tarkoituksiin, joissa puulta vaaditaan suurta kestävyyttä lahoa vastaan. Keski-Euroopassa on varsinkin douglaskuusi *(Pseudotsuga Douglasii)* osoittautunut erinomaiseksi metsäpuuksi. Unkarissa on valeakaasia *(Robinia pseudoacacia)* saavuttanut aavistamattoman taloudellisen merkityksen. Välimeren maissa, Etelä-Afrikassa, Kaliforniassa y. m. on australialaisia *Eucalyptus*-puita viljelty menestyksellisesti. Australiassa on kalifornialainen Monterey-mänty *(Pinus insignis)* tullut arvossa pidetyksi metsäpuuksi. Jaavan saarella ynnä eräillä muillakin Kaakkois-Aasian seuduilla viljellään jo suuressa mittakaavassa erinomaista eteläamerikkalaista kautsukkipuuta *(Hevea brasiliensis)* ja eteläamerikkalaisia kiinapuita *(Cinchona)*. Nämä vain esimerkkeinä mainittuina. Lukuisat hyödylliset puulajit, joiden luonnollinen leveneminen on ollut verraten rajoitettu, ovat täten, vaikka määrätietoinen, kestävälle tieteelliselle pohjalle nojaava kokeilutoiminta ulkomaalaisten puulajien viljelemisen alalla suurin piirtein on vasta alulla, jo tulleet kansainväliseksi omaisuudeksi.