THE NAU COLLECTING EXPEDITIONS TO KOREA AND JAPAN IN 1976. PLANT INTRODUCTION, DISTRIBUTION AND SURVIVAL

Jerry W. Leverenz

Arboretet
Hørsholm Kongevej 11
DK-2970 Hørsholm, Denmark

Nordisk arboretsudvalgs indsamlingsekspeditioner til Korea og Japan i 1976. Planteintroduktion, distribution og overlevelse

Key words: species, provenances, history, data registration, regeneration, distribution, survival, latitude, altitude, flowering, commercial use.

Opposite page: Young cones of *Abies vietchii* var. *sikkokiana* collected from Ishizuchi, Shikoku, Japan. NAU collection nr. B234.

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CHAPTER 1. INTRODUCTION TO PLANT COLLECTING EXPEDITIONS

At the end of August in 1976, two groups from the Nordic Arboretum Committee (NAU) travelled together to Tokyo, Japan. One group travelled further on to Korea while the other stayed in Japan. Both were to undertake a woody-plant collecting expedition in the respective countries. These two expeditions were part of a series of expeditions made by the NAU committee over a number of years. This manuscript reviews the affects that these expeditions have had on the Arboretum in

Hørsholm and the arboretums clientele. For a more complete understanding it is good to review plant collecting expeditions in general before proceeding to more specific information.

Cheep, diverse and abundant food and wood products are the basis of our modern thriving economies. Thomas Jefferson, drafter of the American Constitution and American president wrote in 1790: "The greatest service which can be rendered to any country is to add a useful plant to its culture." Even today, wild plant genes are regularly added to exiting agricultural cultivars in order to keep a step ahead of the evolution of new diseases and to increase specific attributes of the crops like drought and cold tolerance as well as starch, sugar, oil, and protein content. Modern forestry also involves improving the value of the tree crops by increasing stem straightness, wood quality and productivity through the selection of better genotypes and the introduction of new provenances. In the near future, energy crops including woody plants will likely be used more and more to replace fossil fuels. These energy crops will probably largely relay on selected plants collected both locally and from far distance lands. New varieties and species are also regularly added to our ornamental gardens. These new ornamental plants are often directly collected in the wild or have incorporate genes from wild collected plants. The introduction and development of new ornamental plant material that is disease free, easy and cheap to regenerate, and cheap to manage, is still very important. These horticultural plants play a significant role in the mental and even physical health of the ever expanding numbers of city dwellers, as it induces people to go outside, partake in one or another form of exercise. The benefits of such plants should not be underestimated.

When considering collecting expeditions it is worth considering if today's new introductions of garden plants are as important as those made in previous eras. Meyer (2000) argued that the accelerating loss of natural habitat, combined with the threats of climate change and global warming to many species, indicate that wild-collected, scientifically-documented plants in botanic collections are becoming even more important. Such collections not only preserve genotypes that may be lost in their native habitat, it may also allow the receiving country to provide new material for the urban and suburban environment before they disappear. He also argued that urban environments are becoming more stressed, by factors including a rapid rate of change in cities and the expansion of new plant diseases. In many aspects how-

ever, cities are becoming less polluted allowing the trial or re-trial of plants that were once thought to be too sensitive to air pollution to be grown in western cities.

These days it is less common that totally new species are introduced into cultivation in Scandinavia. Most commonly new genetic material of previously introduced species is being added. But totally new plant species are still being introduced. In the case of the Arboretum in Hørsholm, which contains one of the largest collections of woody plants in Scandinavia, 15 to 20 % of the new accessions of plant material introduced over the last 20 years have been totally new species. The rest, 80 to 85 % have been reintroductions of previously tried species, however, most of these were new, untried provenances. In absolute numbers, up to 1998 about 100 new species from various sources were accessed every year. In more recent years budget cuts have reduced the number to about 15 new species per year. Most of these new species have not survived as a result of mal-adaptation to the local climate, diseases and animals.

Concerns arise with the introduction of new plant material. There is the possibility of introducing weedy species or provenances that results economic losses instead of economic gains. Still the net economic effect of new plant material is by far on the positive side. Think of the typical Danish suburban garden, without the introduced species, or cultivars of *Buxus, Cornus, Cotoneaster, Chamaecyparis, Rhododendron, Magnolia, Abies, Pinus, Rosa, Spiraea* and of many other genera.

There are different opinions about the usefulness of plant collecting expeditions. One can ask if they are worth the money when it is possible to read about the ecology of the plants, and when it is possible to receive seed through the international seed exchange program. In the international seed exchange system each participating institute issues an "*index seminum*". This international seed exchange program has been in operation since the nineteenth century and has been vital for the building of botanical collections around the world. Receiving seed through the international exchange system among botanic collections, if local collectors do the collecting, may be seen as being cheaper and of a lower environmental impact than sending collectors to distant countries. If all gardens within this system only collected locally and then distributed the seed to others there might be major sav-

ings. For example one could imagine a system where local botany students collected seeds for the local botanic garden's contribution to the international seed exchange program as part of their training.

Nevertheless there are clear advantages of sending people to make expeditions in far off lands. Their interaction with the local botanists would probably improve the general knowledge of both partners. Collectors sent abroad may be more likely to return with provenances or climate races that are well adapted to the local climate. Tor Nitzelius (1983) wrote in his book "Träd i När og Fjärran": "Because we in Scandinavia do not have the climatic conditions of the English, we are to a much larger degree required to pay much more attention to all the problems related to the concept of winter hardiness" (translated from Swedish). From this it would be expected that experienced collectors from Scandinavia will probably choose to collect seed from plants at higher elevations or higher latitudes than those collected by for example by the staff at Kew Botanic Gardens near London, England. While we have often gladly received very well documented plant material from Kew as well as other gardens, it is often questionable if the materials represent the best possible climate races for the Scandinavian conditions.

Making one's own collection expeditions gives fewer middlemen in the chain of information about the plants. Every time plant material changes hands there is a risk that the seeds or plants can end up with the wrong identification number or other information. It only takes one person in a chain to remove what they consider to be superfluous information or to mix up samples for information to be lost.

Because one can collect more precisely where one wants, a third advantage over seed lots from other gardens is that one can collect to test specific hypotheses. A disadvantage is that the year one plans to collect in may be a poor seed year and it is often too expensive to arrange a second trip a year or two later. For local collectors re-collecting is often a much smaller problem.

One can also ask if an expedition where one collects many different species, is as worthwhile as an expedition that concentrates on one or a few species but many provenances, or unusually good individuals. Flinck (1980) in a review of hybridization of magnolias, thought that the 1976 NAU expedition to Japan followed a reprehensible tradition, because they did not first identify the best flowering magnolias before collecting seed, but collected without having seen the plants in flower.

In contrast random samples may be considered much more valid for scientific studies than selected, often atypical, specimens.

Concentrating on a few species is more likely to be done in the case of trying to find new cultivars, whereas collecting from many species is more likely when one is trying to build up an Arboretum or botanical collection or park. Thus, the goals of botanic gardens and arboreta with regards to plant collecting, is distinct from that of commercial nurseries (Tredici 2000), or horticultural research centres. For botanic gardens and arboreta, taxonomic and ecological research is often as important as the living plants themselves. They may furthermore aim to display typical examples, rather than exceptional examples. Whatever one's specific goals, be it for scientific study and teaching, or for the development of economic useful cultivars, in general collecting trips with a clear focus and purpose are often considered to be much more successful (Tredici 2000) and easier to evaluate than general inventory trips. Unfortunately funding for research projects is often based on grants given for 3 years of study. Woody plants less than 3 years old are not usable in many studies. To support research one may need to collect for future researchers as well as one's own current research interests (which might change dramatically with scientific advances). Since it is impossible to know if one is collecting the correct plant material for future studies, collecting an extensive range of plant species might be the only alternative.

While plant collecting expeditions have brought back many useful plants for our parks and gardens and city streets, they have not been without problems. Normally the expeditions themselves are well planned. The participants typically work extremely hard, often under difficult conditions in order to collect the material and document them well. However, thought is often not given to what happens to the plant material when it is received back home. Often there is not enough space in the nursery or enough staff to properly tend the plants and keep records straight. Lighty (2000) noted these problems arise often from a lack of realistic planning for post-expedition policies and protocols. He wrote that often there is a certain naiveté on the part of the planners in believing that getting plants into the country alive was the most important part of the program. By analysing the results from the NAU expedition it is hoped to find out if such typical problems also occurred with the NAU collecting expeditions.

Many times collecting expeditions are not followed up (Lighty

2000) resulting in information being lost about the success, or failure of particular provenances, particular taxa, or individual genotypes. Information is also threatened when those who were involved in the expedition die or retire before they get a chance to publish an evaluation or sort the relevant papers and data. However, some years should pass before a proper evaluation of a long lived woody plant species can be made. Tredici (2000) considered that a minimum time for testing woody plant material for garden use to be 10 years. Geneticists studying forest trees have a general rule, that trees should be tested about 25% of one harvest interval before one can judge the usefulness of a given provenance. Combining these two rules suggests that ornamental plants survive about 40 years on average in our parks and gardens. What is the desired average lifespan (harvest interval) for a garden or street tree or a woody plant in a botanical collection? For arboreta the life span could well be many times the average rotation age in commercial forestry. Old, well-documented specimens are highly valued. However, an average home garden may change hands every 20 years and often new owners remove most plants while incorporating their own ideas into the garden. Survival 30 years after an expedition (as in the case of this review) should give time to make a reasonably accurate assessment of the introduced plant material. Nevertheless indications of strong climate change in the next 100 years may change ideas about which plant material is suitable at a given place.

In evaluating the success of a plant collecting expedition it is helpful to know what the goals were. Lighty (2000) described three possible goals of collecting expeditions. These were:

1. To provide education and experience for the staff.
2. To add plants to the educational, display, and research collections of the institutes.
3. To expand the palette of plants for some of all of the institutions' clientele including nurserymen, plant societies, specialty gardeners, and plant breeders or other researchers.

In June 1972 the Nordic Arboretum Committee was constituted with delegates from Arboreta and Botanic Gardens in the Nordic Countries. Following discussions high priority was given to the collection of plant material from documented, known provenances for the Nordic

Arboreta from underrepresented areas. These areas of interest included Japan and Korea. The main purpose of the collecting expeditions was to supply the Nordic Arboreta and other research institutes with plant material (mainly seed) of well-defined origin (Søndergaard *et al.* 1977). It was also stated that for particular species, collections should be made in order to provide material for provenance tests, something that was less common at that time with ornamental plants (Widriechner *et al.* 1992, 1998, Søndergaard *et al.* 1977).

Of the three possible goals given by Lighty (2000) it is clear that goal 2 was the most important for the NAU group. However, goal 3 was also of considerable importance to at least some participants and much material was distributed in this regards, as will be presented later. Goal 1 has not been mentioned but may have played a role for those at universities by helping to support teaching and research obligations.

Find Günther Christensen (1989) wrote about the NAU expedition to Japan in 1989 in Lustgården: "The large amount of material now waits a general evaluation." The idea of evaluating the material and expeditions re-arose in a meeting of the Nordic Arboretum Committee in 2003. Consequently, people in Sweden, Denmark, Norway and Finland are in the process of analysing their material from these collecting expeditions (Salvesen 2004, and unpublished presentations at the NAU 2006 annual meeting in Umeå). It is hoped that the present work will help provide a good general evaluation although it is not possible to tackle all aspects. In general it is hoped that these analyses would enable the reader to judge as objectively as possible the value of such expeditions and where improvements can be made for future expeditions.

CHAPTER 2. A QUANTITATIVE HISTORY OF INTRODUCED PLANTS FROM JAPAN TO THE ARBORETUM

To understand the effect of the NAU collecting expedition to Japan on the Hørsholm Arboretum's collection of plants it is necessary to know something of the history of plant material from Japan.

Seeds, cuttings or plants from Japan have been brought into Denmark since at least the end of the 1800's. Johannes Rafn's "Skovfrøkontoret" was especially important in such introductions. Unfortunately, it is not possible to know the origin within Japan of this seed because it could for example have been bought from another dealer in Italy, or a Japanese dealer living in China (Jensen 1994). The Forest Botanic Garden in Charlottenlund has a number of examples of Japanese trees from about 1890 including *Thuja standishii, Abies homolepis* and *Larix kaempferi* of unknown provenance.

Since 1935, one year before its official opening, the Hørsholm Arboretum has received 1514 accessions[1] from Japan. Of these, 890 accessions (59%) came from sources other than the 1976 NAU expedition to Japan. Already one can see the large effect of the NAU expedition because it supplied over 40% of all the Japanese material ever tested in the Arboretum over the past 70 years. Furthermore, the origin of this NAU material was better documented than for much of the other material.A significant part of the Japanese material tested in the Arboretum has come from other Scandinavian expeditions to Japan. These expeditions were associated with two other botanic gardens. One is the Gothenburg Botanic Garden, which has sent expeditions on several occasions. The second is The Helsinki botanic Garden, which sent an expedition in 1994. These Scandinavian collections along with the NAU expeditions in 1976 provide information that will be used to test the hypothesis that Nordic collectors will collect material that will be better adapted to the Nordic climates, than non-Nordic collectors.

The arboretum also received small numbers of seed lots from various seed dealers and botanic gardens over the years that are directly or indirectly of Japanese origin since they are species that only occur naturally in Japan. These accessions however have not been counted in the 1514 Japanese accessions quoted above. The sources of this material were for example, Herman A. Hesse Nursery, Ostfriesland, Germany; Johannes Rafn, Denmark; and Aksel Olsen, Kolding. Because of the inability to trace directly back to a particular area in Japan this material will not be discussed further.

[1]*An accession is defined here as a seed lot, or set of cuttings or scions for grafting, or a set of plants. Each accession has an associated number. These accession numbers were originally written down in hardbound books ("protocols") along with some information on the origins of the plant material. These days the*

accession numbers and coupled information are written directly into computer programs like Microsoft Access following internationally agreed formats. Currently our accession numbers are written with the year of accession followed by a decimal marker and then by four digits indicating which seed lot for a given year. For example 1935.0292 was the 292nd seed lot received in 1935. Every plant produced from a seed lot is also given its own unique suffix number when it is planted out in our collection, so that each individual plant in the collection is identifiable (for example 1935.0292 3 is plant 3 in accession 1935.0292).

The first seed lots (accessions) from Japan were provided by the University Botanic Garden in Sapporo Japan in 1935 (Table 1). Undoubtedly these seed-lots were all from northern Japan, but our records only give provenance: "Sapporo". Some of the taxa sent to us only occur naturally on the Kuril or Sakhalin islands. Whether the seed were spontaneous material collected in the wild, or from plants growing in the University Botanic Garden in Sapporo is unknown because such information was not written down for early accessions. Unfortunately, botanic-garden material often turns out to be hybrid seed as closely related plants are often grown within pollination distances in such collections and many of these early seed lots may have been hybrids and not the pure species as written in our records. Of the 50 seed-lots, or accessions received, only 5 plants from 4 accession numbers have survived to the year 2006. Two of these plants were *Corylus sieboldiana* (accessions 1935.0307 and 1935.0330), one was *Tilia japonica* (1935.0333) and two were *Ostrya japonica* (1935.0320). Four surviving accession numbers out of 50 gives a survival rate of 8% (Table 1). This older material, while lacking documentation on the exact provenance has proven its ability to survive in the ever changing Danish climate and in spite of threats from fungal and insect attacks and for this reason are valued plant material. Interestingly the *Ostrya japonica* specimens are still the only living representatives of this species in the Hørsholm collection.

Figure 1. *Corylus sieboldiana* in flower (Arboretum accession no. 1935.0330).

It was another 15 years before a substantial number of accessions from Japan were again received. In the 1950s we received 26 accessions from the Arnold Arboretum, Harvard University, in the form of cuttings collected directly from plants in their collection that had been collected (most likely as seed) in Japan, and seedlings in their nursery that were of Japanese origin and superfluous to their needs. These accessions were sent to the Arboretum in Hørsholm by H. Irgens-Møller. The plants from Japan, came from central and northern Honshu, from Hokkaido as well as from unknown provenances. Of the 26 accessions, 12 plants representing 4 accession numbers have survived to 2006, giving a survivability of 15%. One species, *Betula dahurica* (1950.0780 & 1950.0781), is represented by two accessions. These are striking trees because of their remarkable bark, and most specimens have a dramatic, crooked form that gives these trees a special character that could well be used in landscaping. The remarkable bark on this species makes it interesting for parks and gardens especially during the winter. The other surviving species are *Fagus crenata* (1950.0295) of unknown provenance and *Sorbus rufoferruginea* (1950.0302) from Hokkaido.

Figure 2: *Betula dahurica* sent to the Arboretum by H. Irgens-Møller

Also in the 1950's and in the early 1960's we received 152 accessions from an expedition to Japan led by Bertil Lindquist from the Gothenburg Botanic Garden. He was assisted by Tor G. Nitzelius and a number of Japanese collaborators, whose names are unfortunately not in our records. Experience with this material and other Japanese material was described (in Swedish) in an article in Lustgården (Nitzelius 1968). Because of his experience, it was natural that Tor Nitzelius also later led the 1976 NAU expedition. He has written a delightful and informative book of his experiences in Swedish (Nitzelius 1983). From the 1952 expedition 84 plants have survived representing 40 accession numbers resulting in survivability in Hørsholm of 40/152 or 26%. An additional 7 accessions are registered as having survived in the Forest Botanic Garden in Charlottenlund. Collections were made in both Hokkaido and on the Island of Honshu. For Hokkaido the survivability was 14 of 50 accessions, or 26 %. The survivability for provenances that could be located to Honshu was 28 %. The survivability of accessions from Hokkaido at the Hørsholm Arboretum is not significantly higher than that from Honshu (which includes many central Honshu provenances). This supports the observations of Nitzelius (1983) made when the plants were much younger, that good material for southern Scandinavia can be found all over the islands of Japan, though elevation probably plays an important role.

Figure 3: *Acer sieboldianum* (1953.0033) collected by Bertil Lindqvist near Kegon falls, Honshu, Japan

In the late 1950's and early 1960's the Arboretum received 23 accessions via Mr. Georg Schlätzer. Mr. Schlätzer is known for running the "Desert Arboretum" on the Jutland Peninsula in Denmark. This arboretum was established on a brown-coal quarry site south of Søby, and east of Arnborg on Jutland (Schlätzer 1970). He obtained this plant material from Japanese collectors. Sixteen of the 23 accessions came from the northern island of Hokkaido. Of these, only three plants representing 2 species, *Acer mono* and *Picea jezoensis*, have survived giving a survivability of 9 % (Table 1).

In 1962 we received seed from collections made by the botanist Erik Hultén via the Gothenburg Botanic Garden. Dr. Hultén is internationally known for his botanical exploration and floras of the northern pacific region, including the Kamschatka Peninsula and Alaska. We received only 7 accessions, but of these 6 have survived giving an astonishing survival of more than 80 %. Perhaps this seed had been tested before being sent to us and perhaps each seed lots was large as this affects survivability of a given accession (see analysis later in this chapter). Interesting, one of these survivors a *Betula ermanii* subsp. *apoien-*

sis was described by Kenneth Lorentzon (1992) as a new, useful small birch cultivar for the garden and it is now in commercial use (via grafting) and offered by at least one Danish nursery (Freys planteskole). It is also offered for sale in Great Britain (RHS Plant Finder 2004-2005). This taxon only grows on two ridges on Mt Apoi on Hokkaido with serpentine bedrock and is considered to be threatened in the wild.

Figure 4: Bark of *Betula ermanii* var. *apoiensis* (1962.0265) collected by Erik Hultén of Sweden.

One of the larger sets of plant material was send by a Dr. Saburo Murai, of the Tohoku Forest Tree Improvement Station, in Morioka, Japan. In three years 1962, 1964 and 1968 he sent in total 70 seed lots. Of these 9 were from Hokkaido and one from the southerly island of Shikoku. The rest were from the main island of Honshu, mostly from the three northernmost Prefects on Honshu, namely Aomori, Iwate and Akita. Of all these only 7 accessions have survived giving a survival rate of 10%. All, but one of these survivors came from Iwate Prefect; the remaining survivor was from Hokkaido in support of an idea that the north east Iwate Prefect of Japan is an interesting collecting area.

Figure 5: *Alnus hirsuta* var. *sibirica* (1962.0468) from Hokkaido bud break in May 2006. Source : Dr. S. Murai.

Another Nordic collector was the forester Sten Karlberg from Sweden. He contributed plant material to the Hørsholm Arboretum, again via the Gothenburg Botanic Garden in 1966. In all 11 accession numbers were received from the northern prefects of Akita and Iwate as well as

from Nagano Prefect in central Honshu. Of the 11 accessions, 5 have survived giving a rather high survival rate of 45%. Three of the surviving successions are from the Nagano Prefect and 2 are from the Akita Prefect. The only accession from the Iwate Prefect has not survived. Only three species were sent to us, perhaps an indication that this collector was concentrating on a few species. The two surviving species are *Abies veithchii* and *Cryptomeria japonica.*

Figure 6: Perhaps the three best examples of *Cryptomeria japonica* (1966.0007 & 1966.0008) in the Arboretum were collected by Sten Karlberg in 1966 in Uttozawa National Forest, Akita Prefect, Honshu. Cuttings have been harvested from these three to produce plants for the production of decorative foliage.

The Kobe municipality Arboretum also sent us material in 1966. Only 2 of 11 (18%) accessions have survived. Most recently, in 1994 we received a large number of accessions from the Helsinki Botanic Garden. All of these accessions were collected in Hokkaido. No doubt because of the colder winters in Finland. Of 41 accessions, 10 have survived in our collection, or in the Arboretum nursery giving a survivability of 24 %.

Other sources have sent us smaller amounts of material. However, only the sources with larger numbers of accessions are also included in Table 1 because less variable calculations of survival could be made on these. The table also includes sources not described in detail above.

source	mean year received	survival %	number of accessions
Non-Nordic collectors			
University Botanic Garden in Sapporo Japan	1935	8	50
Arnold Arboretum	1952	15	26
Japan via Jydsk Skov Frø	1954	6	17
Georg Schlätzer (japanese sources)	1958	10	23
Osaki, Japan	1962	13	15
Kyoto University Forest Experiment Station,			
Kyoto Japan	1962	17	24
Tohoka Forest Tree Improvement station,			
Takisawa, Morioka, Japan	1963	0	15
Dr. Saburo Murai, Tohoku Forest Tree			
Improvement Station, Morioka, Japan	1964	10	70
Dr. Kenjiro Morita, Hokkaido	1964	20	10
Government Forest Experiment Station,			
Meguro, Tokyo	1965	30	20
Kobe municipality Arboretum	1966	9	11
Tokyo University Botanic Garden	1980	29	41
American Rhodo society	1995	38	24
Kyoto Univ botanic gardens	1998	26	34
Mean		16.5	
weighted mean		16.6	
Nordic Collectors			
Bertil Lindquist, Gothenburg	1953	26	152
E. Hultén, Gothenburg	1962	86	7
Sten Karlberg, Gothenburg	1966	45	11
NAU expedition	1977	37	605
Hjortsjø, Poul collector	1982	33	9
Helsinki Botanic Garden	1994	24	41
Mean		41.8	
weighted mean		34.8	

Table 1. Survival percents of major sources of Japanese plant material at the Hørsholm Arboretum. Weighted-mean survival was calculated from the mean for each source and the number of accessions from that source divided by the total number of accessions from the respective Non-Nordic or Nordic collectors.

The survival rates from the different sources shown in Table 1 indicates that survival of taxa collected by Nordic collectors was twice as high (35%) as that for non-Nordic collectors (17%). A simple one-sided t-test of the hypothesis that Nordic collectors give material with higher survival was statistically significant at the 2% probability level. It seems a reasonable hypothesis that Nordic collectors mainly collected

in areas known to match the Nordic climate and this resulted in higher survival in Denmark.

As for preferential collecting regions within Japan, there was no strong evidence of a trend for which regions are better than others (Table 2) again supporting the observation by Nitzelius (1983, p111) with this larger set of data. There is a tendency for a higher survivability in the central and southern areas of Japan, but it is strongly insignificant in statistical tests. Nevertheless, some have argued that the more unstable winter temperatures in these areas are similar to the Danish winters. Plants from such unstable winter-climates tend not to break bud too early in the spring. Nor are they likely to re-set the "bud-break clock" by late frosts resulting in no or very late bud break. However, in Japan, local microclimates vary greatly within an area as a result of variation in elevation, variation from the north to south slopes. Combined with varying soil types these local differences perhaps play a more important role in determining the survivability of provenances in Denmark. The data suggests that in very mountainous areas like Japan, local climate differences can be critical for provenance selection.

Prefect or region	**survival %**	**sample size**
Hokkaido Prefect	24	241
Aomori Prefect	19	64
Iwate Prefect	14	81
Akita Prefect	16	19
Nikko region	50	34
Nagano Prefect	22	32
Fuji (Shizouka-Yamanashi border)	73	15
Nara Prefect	43	5
Shikoku Island	50	6
Kyushu Island	25	8

Table 2. Survival of accessions in the Hørsholm Arboretum and their area or origin. The areas or Prefects are arranged in the Table from north to South Japan. Plants from mountains on the border of two prefects were simply placed in one or the other prefect in most cases.

There could be several other reasons for variation in survivability of different accessions. One is simply that the amount or number of seed in each accession varied. If one accession only had a few seed while

another had thousands of seed one would expect the latter to have a much higher chance of leaving a survivor. Above a certain amount however, the effect would be smaller and in very large accessions perhaps not all seeds were sown. When the amount of seed received is in excess of that needed to produce a number of plants we would not expect to see an effect of seed lot size.

Unfortunately information on the size of seed lots received was rarely entered into our records. The weight of seed received was recorded for only four seed sources of Japanese material. All four of these sources were from non-Nordic collectors and they were mostly from commercial seed dealers. The average seed lot sizes from these four sources from Japan varied in weight from 13 to 101 g. Because of the variety of species from each source of seed we can assume that differences in seed weight by and large reflect differences in the average number of seed, not in average seed size. For these four sources, a strong correlation between survival and the mean weight of a seed lot occurred (Figure 7). These data suggest a curved response, in agreement with the "law of diminishing returns". But with only 4 data points it is impossible to reliably access the exact shape of the true response.
The results shown in Figure 7 support the idea that larger seed lots could be the explanation for better results with Nordic collectors. However, Jon Hansen (Skov og Landskab, Hørsholm, unpublished data 2006) showed that survival % calculated from the number of accessions with at least one survivor from a given provenance gives very similar survival % as when calculated from the number of individuals surviving within each accession. The latter method of calculation would not be biased by the size of the seed lots. Thus, the higher survival of the material collected by Nordic collectors is unlikely the result of larger seed lots. One can conclude that both the origin of the collectors and the size of the seed lots play an important role in the survival at the Arboretum.

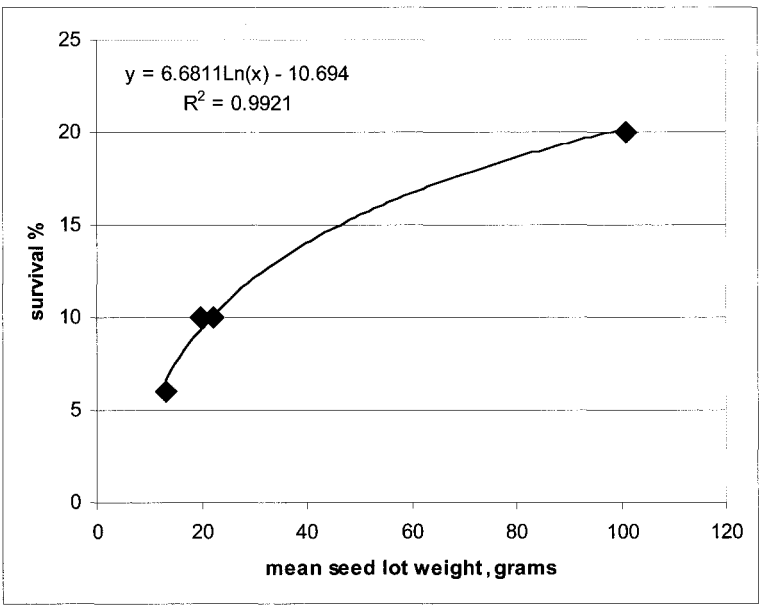

Figure 7. Mean survival of seed lots from different sources plotted against mean weight of seed in the seed lots.

If seed lot size or the number of scions or cuttings received were recorded, such data would clearly help to understanding the suitability of different sources of plant material. A disadvantage with the international seed exchange program (among botanic gardens and arboreta) it that one often only receives rather small lots of seed (usually less than 50 seeds and often for big seeds only one to three). Such small seed lots do not allow one to accurately test a given seed source (provenance, or climate race). The question remains however about the optimal size of a seed lot if the purpose is to test the general suitability for the local climate. For this more information on the size of seed lots needs to be recorded.

It is interesting that the material collected by Helsinki had a rather low survivability (Table 1). This material all came from Hokkaido and the collectors probably collected for the more stable and colder winters found in Finland. It is obvious that there is considerable variation in the growing conditions in the different Nordic countries. Denmark is one of the warmest sites of any of the Nordic Arboreta although the winters are slightly colder that for the Norwegian National Arboretum

at Milde on the West coast of Norway. Furthermore, seeds collected from cold climates are often empty, or immature even by the end of the most growing seasons. Unfortunately germination rate was not recorded for the Helsinki collected material.

In summary a high percentage of all Japanese material introduced in Hørsholm was from the NAU expedition in 1976. However, there is a long history of experience with Japanese material in the Arboretum in Hørsholm when the expedition was planned and executed in 1976. This should have added to the successfulness of the trip and perhaps increase the chances of the plants surviving in Denmark. The large amount of material made it possible to check if the origin of the collectors had an effect on survivability. Indeed two factors were found to play an important role. One was the size of seed lots and the second was the positive effect of using collectors from Scandinavia. The effect of latitude seemed to have little effect on survivability, which may be related to the large topographical variation within Japan.

CHAPTER 3. THE NAU 1976 JAPAN EXPEDITION

Figure 8. *Weigela japonica* (Hørsholm nr. 1977.0639, collection nr. NAU Japan S223) from Mt. Hikosan on Kyushu Island, was one of the new species introduced at the Arboretum by the 1976 expedition to Japan.

3A. INTRODUCTION

The Nordic Arboretum Committee expedition to Japan took place between 27 August and 31 October 1976. It is described in a report written by the Nordic participants (Nitzelius *et al.* 1978). This booklet has been a main source of information about the expedition in combination with notes in the Hørsholm Arboretum archives. After a short introduction there is a schedule for the expedition, followed by descriptions of the collection localities. This is followed by a short description of the handling of the material. At the end of the report a list all the collection numbers is given which include a collector initial. The collection number is followed by the species name, the collection site (including elevation) and an initial for the collection area, which refers back to the collection site descriptions. This report or booklet may be difficult to obtain for many readers so the main part of the introduction is reproduced immediately below:

"The journey to Japan was carried out by the following persons: Tor G. Nitzelius (leader), The Botanic Garden, Gothenburg, Rune Bengtsson from the Agricultural College of Alnarp Sweden, Find Günther Christensen of the Hoersholm Arboretum, Denmark and Magne Sandvik from the Norwegian Arboretum, Milde. Mr. Nitzelius also visited the small Korean island of Ullung-do. R. Bengtson, F. Christensen and M. Sandvik stayed in Japan from August 28 to October 31 and T. Nitzelius from August 28 to September 22 after which time he visited Korea (Ullung-do) for 8 days.

The journey was made possible by grants from the Nordic Cultural Foundation (Nordisk Kulturfond) and the Danish National Bank (Nationalbankens Jubilæumsfond). Furthermore, T. Nitzelius travel expenses were paid by grants from the Wilhelm and Martina Lundgren Foundation (Wilhelm and Martina Lundgrens vetenskabsfond), Gothenburg. We herewith wish to thank these foundations for their valuable support. We express our sincere thanks to the Norwegian shipping company Wilhelmsens etc. who kindly supported our enterprise by free transportation of working outfit Scandinavia – Japan and plant material Japan – Gothenburg.

Much support was given by the administration of the Forestry Agency, Tokyo, who generously put their regional officers and rangers at our disposal, helping us with planning and realization of collecting tours and, last but not least, providing us with pleasant lodgings at a very modest price. We especially want to express our thanks to Mr. Susumu Sakamoto, chief of the international Cooperation Branch for having made a perfect itinerary before our arrival in Japan, organizing our journeys and excursions, and acting as liaison officer during our whole stay.

We are also grateful to professor Satura Kurata and Dr. Toshio Hamaya, Institute of Forest Botany, Faculty of Agriculture, University of Tokyo, for their information on plant distribution and protected areas. They also gave us the opportunity of cool-storing our plant material in the localities of the Forest Institute until the dispatch to Scandinavia at the end of October.

Thanks to Dr. Hamaya's kind assistance we were enabled to employ two competent botanical guides and interpreters Mr. Yuji Ide and Mr. Masahide Kashio.

Professor Nobukiyo Takahashi, former head of the Forest Research Institute Tokyo University Forest, Yamabe, organized and most effi-

ciently supported us in our seed collecting operations on this Island. He also acted as adviser in our contacts with the officials and administrative officers which we had the pleasure to meet. To him and also to the above mentioned officials and administrative officers we want to express our sincere thanks.

During his stay in Korea and on Ullung-do, the undersigned, Tor Nitzelius, had the invaluable help from Mr. Kim Sang Hun of the FAO Seoul, who accompanied him as experienced liason officer and interpreter. We want to express our sincere thanks to him as well as to Mr. Park Chong Hyu, Governor of Ullung-do and Mr. Sim Hung Soo, deputy director, Forest Research Institute, Seoul, who enabled Mr. Nitzelius to visit Ullung-do and who also facilitated his seed collecting operation there. Many thanks also to Mr Han Jin Ho, Ullung-do who in his capacity of nature conservationist and amateur botanist, benevolently and with great interest helped Mr. Nitzelius to find important plant habitats of special interest."

In an unpublished manuscript located at the Hørsholm Arboretum F. Günther Christensen wrote further about the help received from the Japanese hosts (translated into English):

"Upon arrival at Tokyo our group was received by Mr. Sakamoto from the Forestry Agency and Dr. Hamaya from the Forest-botany section of Tokyo University whereupon they presented a very well prepared travel plan with exact information about train and air connections and overnight stops. For the most part we were quartered in the Forestry Agencies own, excellent facilities. Dr. Hamaya provided us with two young English speaking students who, in an excellent way, took care of the absolute necessary job as interpreter and travel leader during the two months long trip, which started after two days preparation in Tokyo.

Everywhere we came were we received of local foresters who helped us in the best possible way and often made available trained seed pickers. On one occasion we were helped by not less than 10 enthusiastic Japanese helpers. All of this helpfulness from the Japanese foresters' side was absolutely, the basis for the good results from the trip. Nearly all the areas we should visit were nature parks where collection was only possible with the approval of the authorities."

The above quotes show that the success of the expedition was to no small degree due to the help of the Japanese hosts. One guesses that they deserve considerable thanks.

The NAU expedition in 1976 did not reach all parts of Japan. In particular, it is striking that northern provenances of Honshu were not included in the itinerary (Nitzelius *et al.* 1978), although material was often received from this area prior to this expedition. The choice of collection areas is explained by the goal to collect seed from Hokkaido in order to get material for arboreta in parts of Scandinavia with more continental climates, and from middle and southern Japan for the Arboreta with more oceanic climates. As will be seen in the next section however, survival at Hørsholm was rather similar for plants from the different main parts of Japan.

From the booklet "Nordic Arboretum co-operation 1972-1977, report on the first five years' results." one can see that the budget for the expedition to Japan was 58.000 NOK (52.954 DKK). In addition there may have be a cost of 2000 DKK for the printing of the booklet on the expedition. Given that 972 seed lots were collected, the average cost per seed lot was 54 DKK.

The costs per accession might be seen to be many times higher that that of receiving seed essentially free of charge, via the international seed exchange system among botanic gardens and arboreta. The international seed exchange system, is based on each participating institute offering seed from their own collecting expeditions. Thus, the cost of this and the other Nordic expeditions can be seen to be in part the price that NAU institutes paid to be members of this international system. The NAU did publish its own seed list making available seed from the expedition to botanic collections around the world. This list of 230 accessions was sent out from the Department of Dendrology at the Agricultural College of Sweden in Alnarp. Because of time constraints, no attempt has been made in this study to locate surviving plants from this expedition in botanic collections around the world. Such an international study would probably yield valuable information (Dosmann and Tredici 2003).

In addition, international researchers utilize cost-free, the arboretums unique collection every year. They often come with valuable ideas and for example help us to find errors and to correct plant names in accordance with modern taxonomic research. To summarize, the international distribution of the plant material collected in

this expedition and the benefits received by the international botanical community over the many years makes it impossible to develop a fully quantitative balance sheet for its costs and benefits. The survival of the material in the Arboretum and its ability to produce reproductive organs certainly contributes to the value of the material to the Arboretums local and international clientele. Such data is presented in the next chapter.

The Arboretum in Hørsholm also distributed live plants and cuttings from its nursery and collection to various nurseries, private property owners and public institutions so that the material could be tried in as wide range of Danish environment as possible. The results from this local distribution and the affects on the Arboretums own collection, are presented in the next section below.

Figure 9: *Styrax obassia* (1977.00491, NAU B327) collected on the slopes of volcano Mt Daisen in Japan during the 1976 NAU expedition to Japan.

3B. RESULTS FROM THE JAPAN EXPEDITION

1. SURVIVAL IN THE ARBORETUM

Of the 972 seed lots collected on the Japan expedition, the Arboretum in Hørsholm received 605 or 62% (Table 3). Most living plants and cuttings that were collected on the expedition arrived in 1976 and these were given Arboretum accessions numbers dated 1976. The seed lots were received in November 1976 at the Botanic Garden in Gothenburg in Sweden and distributed among the participants. Those received in Hørsholm were registered with 1977 accession numbers. Even at the early stage when the distribution of the material among the participants occurred, the Arboretum in Hørsholm could be seen to have "lost" 38% of the material collected. This "loss" probably resulted from a small amount of material for certain collection numbers, the limited amount of space and gardeners at the different institutes and a diversity of interest among the members of the NAU for a particular taxon or provenance. Some of the seed lots that were distributed to others were later sent as living plants to the Arboretum in Hørsholm. These plants are included as part of the 605 accessions received.

Japan 1976 summary			
category	**number**	**%**	**notes**
no. collection numbers	972		
no. accessions Hørsholm	605	62.2	% of collection numbers
no. accessions propagated	385	63.6	% of Hørsholm accessions
no. accessions planted out	309	80.3	% of propagated
no. live > 6-plant accessions planted	38	12.3	% of planted out
no. live accessions 2006	222	71.8	% of planted out
no. live single-plant accessions 2006	80	36.0	% of live accessions 2006
no. live accessions flowering in 2004, 2005 or 2006	188	84.7	% of live accessions 2006
no. accessions exported to others	213	55.3	% of propagated
no. accessions in commerce	4	1.0	% of propagated

Table 3. Overall summary of the 1976 NAU Japanese expedition material, its propagation and survival at the Arboretum in Hørsholm.

Of the 605 lots received, 385 were estimated to be successfully propagated (either germinated or rooted or transplanted successfully). This represents a success rate of 64 % for propagation or a 36% failure rate. A 36 % loss of material at this stage may be rather a common amount

for material collected in the wild. A similar loss was experienced for the Korean expedition (Chapter 5). Dosmann & Tredici (2003) reported that 23 % of the plant material received from the 1980 Sino-American botanical expedition was of questionable viability (empty or rotten seed as well as dead plants, bulbs and cuttings). Undoubtedly, many seeds were empty or dead from the NAU expedition as well.

The seeds received in the winter of 1976-1977 were probably sown the following spring after diverse pre-treatments such as cold stratification. For this reason a lists of plants living in August 1977 and September 1978 (the latter probably presented at a NAU annual meeting that year) were used for the initial estimation of the number of successfully propagated plants. Any accession on either of these lists was deemed to have been successfully propagated. Because some species take more than one season to germinate, this list underestimated the number of successfully propagated accessions. Therefore in addition to the list of plants from 1977 and 1978, all accession numbers not on this list, but later recorded as being planted out (see below) were added to estimate the total number successfully propagated. The plant-out list increased the estimate of successfully propagated accessions by 6 %. It is possible that some accessions germinated successfully and were pricked out into the nursery beds after 1978, but did not live long enough to be planted out. Any such accessions would not have been counted and thus 64% is likely a slight underestimate of the number of successfully propagated. The propagation success was probably around 65%. The lists would not have included seed lots that died immediately after germination, and such material is considered here to be not successfully propagated.

Of the estimated 385 successfully propagated plants, 309 or 80% survived long enough in the nursery to be planted out into the Hørsholm collection (Table 3). Thus 20 % of the successfully propagated were lost in the nursery, where growing conditions would have been more ideal than out in the main collection areas. The accessions that died in the nursery probably were taxa that were least well adapted to the local nursery environment. In our nursery, a neutral or higher soil pH, damage by roe deer, insects, fungi or nematodes and frost heaving as well as exposure to winds and for some plant too much sun, can be seen to cause problems. Some accessions were probably also lost at this stage

by accident. Such accidents would include physical damage (during weeding for example), or loss of plant labels.

At a NAU meeting in 2006, it was reported that the Norwegian National Arboretum at Milde did not have sufficient nursery space for all the new plant material that had arrived from Japan and many collection numbers were lost because of overcrowding. From the records, it appears that this was not as much of a problem at Hørsholm. But this author's personal experience is that overcrowding in the nursery can still be a problem even when fewer accessions are handled.

The statistic on the number of plants planted out is based on the Arboretum's "plantud sedler". When plants were transferred out of the nursery a record is made of the number of plants, the accession number and the destination on a printed form called the "plantud seddel" (planted-out form). The destination could be the Arboretum in Hørsholm (which would contribute to the above statistic) or another institute, for example the Botanic Garden in Århus. These forms were sequentially numbered and most were also dated. Because they were numbered it was possible to check if information was perhaps lost because a number in the sequence is missing. It may be that some forms were disposed of because of mistakes in filling them out, but there is no evidence of this.

There were indeed missing numbers in this series of plant-out forms. Several days were used to sort through old papers in the Arboretum and this effort resulted is the recovery of many of the missing forms, but not all. Thus the information we have in the plant-out forms was incomplete. To correct for the missing data, any accession from the expedition that was registered as having been alive in the collection at one time or another was assumed to have been planted out (and not registered under an incorrect accession number) even if not recorded on any of the existing planted-out forms. All of these live accessions were added to the plant-out list to make the above statistics. This increased the estimated number of accessions planted out by 6 or about 2%.

It is interesting that only about 28% of the accessions planted out in the collection were lost by 2006 (Table 3). A much higher death rate in the collection was expected than in the nursery after planting because of the longer time period (25 years in the collection versus about 5 years in the nursery). Furthermore transplanting problems,

strong weed competition and damage by roe deer and occasionally mice should have added to the death rate in the collection. Even the gardeners occasionally kill plants, especially during the annual weed cutting where many plants are not visible above the weeds. Inaccurate recording of the planting position of accessions by the dendrology staff may also contribute to a loss of some accessions. In conclusion, the high survival after planting perhaps indicates that already in the nursery a considerable amount of selection for fit individuals had occurred.

Survival of an accession in the collection should have depended upon the number of plants that were planted out within each accession or collection number. The number of plants planted out also is important for the determination if the different accessions have been adequately tested at Hørsholm. For example, if only one plant was planted out and it did not survive, it would be hard to tell if this was because of a random event or if the particular accession or provenance is not well adapted to the Danish environment. In the following analysis I assume that a sufficiently good test of the material was made for accessions numbers where 7 or more plants were planted out. Based on this assumption only 38 (12 %) of the planted accession numbers were sufficiently tested in the Arboretum (Table 3). The majority (88%) of accessions were represented by fewer individuals. For 79 accessions (25%) only one individual was planted out.

The neighbouring "Forskningscentret" (research centre, now called SCION DTU) site in Hørsholm was also used to test this new material. If for a given accession number one adds together the plants planted out at the Arboretum and at this neighbouring site, one calculates that 18 % of all accessions planted out were represented by 7 or more plants. This still indicates that only a small part of the accessions were planted out in sufficient numbers in the Hørsholm area. The small number of individuals planted out per accession can be seen as a possible weak point in the exploitation of the expedition. However, 183 accessions or 47 % of the successfully propagated accessions had less than 7 individuals and thus it would have been impossible to test more individuals. The small number of individuals planted out for the many accessions when there were sufficient plants may have been due to lack of space in the Arboretum and the staff to take care of them. This is in spite of the fact that a whole new section 10 hectare of the arbo-

retum was opened in 1986 and many plants from this expedition were planted out there.

A surprisingly large number of accessions (213 or 55% of those that germinated) were sent to other parks and gardens as well. For 134 accessions more plants were given away than planted out in the Arboretum. There has been a policy to distribute the material as widely as possible within Denmark in order to develop a better understanding of the adaptability of the material (Søren Ødum and Poul Søndergaard personal communications). This is in agreement with the importance that both Lighty (2000) and Dosmann & Tredici (2003) placed on distributing plant material for testing.

Interestingly, when less than 7 plants from an accession were planted out in Hørsholm, there was a strong positive correlation between the mean number given away and the number planted (Given away = 2.45 times the number planted out; (R2 = 0.95, Figure 10). That many more plants were consistently given away than kept in Hørsholm, shows a deliberate policy to distribute two-thirds of the plants when the accessions were small. If one wanted to increase the likelihood of survival (Dossmann & Tredici 2003), or if the goal was to see how the accessions were adaptable to the conditions all over Denmark, as opposed to just in Hørsholm, this would have been a logical step.

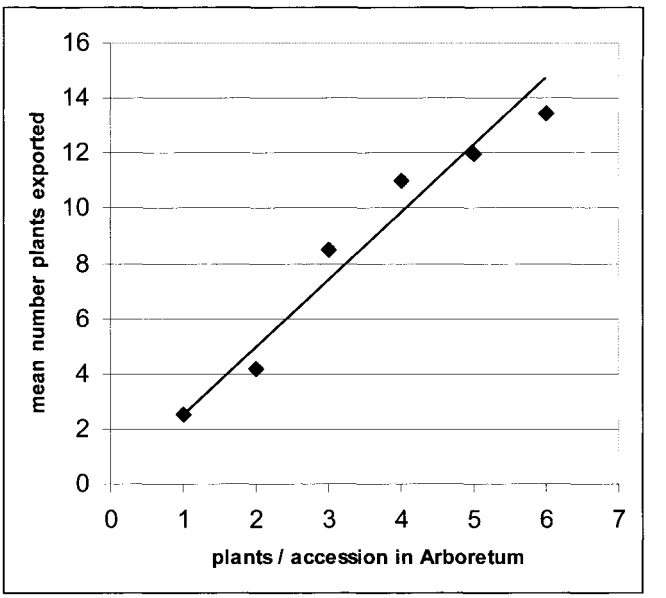

Figure 10. The average number of plants exported per accession plotted against the number planted out in the Arboretum when the number was less than 7. The regression line in the figure was forced through zero.

A problem with distributing the material is that often the recipients are less inclined to keep records on where the material was planted, or why or when it died, or was removed (Lighty 2000). Many plants are removed for diverse reasons which have little relationship to the suitability of the plant to grow on a particular site. This problem is discussed further below and indeed reflects a weakness in the handling of the collection material. It may be that follow-ups were made when members of the Arboretum staff were in the neighbourhood of some of the receivers of these plants, but I have not found any systematic notes about this.

In 2006, 222 accession numbers from this expedition still had living representatives at Hørsholm (Table 3). This represents 72 % of the accessions planted out. Of these, 80 accessions (36 %) were represented by only one single individual and thus might be considered threatened with extinction in the Arboretum. It is recommended that an effort be made to save at least the most interesting of these accessions through vegetative propagation.

Of the 38 accessions where more than 7 plants were planted out, surprisingly only 62 % survived to 2006. This is less than survival in general where the average number of plants per accession was less than 7. Thus, there is no evidence that increasing the number of individuals planted out, increased survival. Perhaps many individuals were planted out for accessions that were thought to have a low chance for survival.

Going back to earlier data (Chapter 2, Table 1) since it inception, the Hørsholm Arboretum has received 1514 accessions from Japan. Forty-one percent of these came from the NAU expedition to Japan (Table 1). But because of higher survival, the plants from the 1976 expedition represent 66 %, or two-thirds of all surviving taxa from Japan in 2006. These NAU expedition accessions included 28 taxa that are not represented by any other living examples.

At the time of the expedition in 1976 the Arboretum had already received at least 450 accessions from Japan (Table 1, Chapter 2). Most of the accessions from the 1976 expedition to Japan were reintroductions of species, subspecies and varieties that had already been tried. However, the NAU expedition did introduce 67 entirely new taxa that had never been tried before the year of the expedition. Of all the new taxa, 17 have survived up to 2006 (Table 4). Of these survivors the following are not listed in the Lange's (1994) book on the introduction of cultivated plants to Denmark: *Abelia serrata, Fraxinus lanuginose, Ilex geniculata, Ilex sugeroki, Meliosma tenuis, Rhus ambigua, Sorbus matsumurana, Tilia maximowiczii, Weigela decora.* These accessions may be the first successful introductions to Denmark.

FAMILY	GENUS	SPECIES	type	name subtaxon	accession no
Caprifoliaceae	*Abelia*	*serrata*			1977.0502
Cephalotaxaceae	*Cephalotaxus*	*harringtonia*	var.	*nana*	1977.0472
Hydrangeaceae	*Deutzia*	*gracilis*			1977.0824
Celastraceae	*Euonymus*	*hamiltonianus*	var.	*sieboldianus*	1977.0656
Oleaceae	*Fraxinus*	*lanuginosa*			1977.0396
Aquifoliaceae	*Ilex*	*geniculata*			1977.0749
Aquifoliaceae	*Ilex*	*sugeroki*	var.	*longepedunculata*	1977.0582
Sabiaceae	*Meliosma*	*tenuis*			1977.0794
Polygonaceae	*Polygonum*	*cuspidatum*			1977.0428
Ericaceae	*Rhododendron*	*quinquefolium*			1977.0867
Anacardiaceae	*Rhus*	*ambigua*			1977.0479
Rosaceae	*Sorbus*	*matsumurana*			1983.0535
Rosaceae	*Spiraea*	*japonica*			1977.0486
Tiliaceae	*Tilia*	*maximowiczii*			1976.0383
Vitaceae	*Vitis*	*flexuosa*			1977.0412
Caprifoliaceae	*Weigela*	*decora*			1977.0701
Caprifoliaceae	*Weigela*	*japonica*			1977.0639

Table 4. Taxa from Japan expedition that were first introductions to Hørsholm in 1977 and that have survived to 2006.

Figure 11. *Ilex geniculata* (1977.0749, NAU Japan C 110) from Shikoku Island, Ehime Prefect, Ichizuchi. This plant and its siblings may be the first successful introduction of the species to Denmark.

Without doubt this single NAU expedition to Japan has had a large, positive affect on the Arboretum collection in Hørsholm. If one considers as well that these plants are of documented origin whereas much of the other Japanese material is not, the value of the expedition is increased even more. For providing material of well documented origin from Japan (its stated goal) this expedition was a tremendous success.

During the NAU meeting in Umeå in 2006, which addressed these collecting expeditions, it became apparent that Hørsholm Arboretum probably has the largest number of living accessions from this expedition. The establishment of a new, 10 hectare area in the Arboretum in 1986 probably was important in preserving this expedition material. The Botanic garden and Arboretum in Gothenburg did not take much material because they already had an extensive collection of Japanese material. The Norwegian National Arboretum in Milde probably experienced a bottleneck at the nursery stage due to overcrowding.

Table 5 shows the percent survival from each major collection locality. These values were calculated as the number of surviving accessions (with at least one plant surviving) divided by the number of accessions actually planted out. Accessions that did not germinate or that died in the nursery are not included. Made in this way, the calculation is comparable with survival percentages presented for the Arboretum in Milde on the west coast of Norway (60°15' N, 5°16' E) (Salvesen 2004). Hørsholm is situated further south and east (55° 52' N, 12° 30' E) and experiences in general colder winters and warmer summers. It is difficult to pick out a pattern of survival within the general data for Hørsholm. This may relate to the complicating factor of elevation of the differences between seed sources on the survivability of the seed (Jon Hansen, Skov og Landskab, unpublished analysis 2006). Averaged over the whole of Japan, survival was essentially identical in Milde and Hørsholm.

Locality	latitude	longitude	elevation meters	survival Milde	survival Hørsholm	survival diference
Hokkaido Daisetsu	142 ° 54'	43° 59'	1300-1600	63.6	75.0	-11.4
Hokkaido Dairoku	142° 54'	43° 21	200-1400	71.4	81.3	-9.8
Hokkaido Horoman	143° 07'	42° 05'	200-400	100	41.2	58.8
Hokkaido Ashibetsu	142° 14'	43° 04'	600-1700	72.7	72.7	0.0
Hokkaido Ishimaidake	143° 10'	42° 02'	100-200	100	100.0	0.0
Honshu Nikko	139° 28'	36° 47'	1400-2200	85.7	88.9	-3.2
Honshu Tateyama	137° 36'	36° 33'	1000-2400	71.2	86.1	-14.9
Honshu Nishidake	138° 21'	35° 59'.	1400-2100	85.7	75.0	10.7
Honshu Mugikusa	138° 20'	36° 43'	2000		75.0	
Honshu Ontake san	137° 31'	35° 53'	1600-2500	87.5	90.0	-2.5
Honshu Akasawa	137° 28'	35° 43'	1000-1200	66.7	78.9	-12.2
Honshu Fuji	138° 46'	35° 20'	1400-2300	57.1	66.7	-9.6
Honshu Atsumi	137°	35°	0-100	100	100.0	0.0
Honshu Odaigahara	136° 07'	34° 10'	1100-1600	66.7	71.0	-4.3
Honshu Daisen	133° 35'	35' 24'	400-1600	57.1	47.8	9.3
Shikoku Tengu	132° 36'	36° 33'	1100-2500		66.7	
Shikoku Ichizuchi	133° 05'	33° 45'	1500-1800		66.7	
Shikoku Kamegamori	133° 10'	33° 43'	1500-1600	61.5	75.0	-13.5
Kyushu Hikosan	130° 56'	33° 28'	700-1200	41.2	62.5	-21.3
MEANS				**74.3**	**74.8**	**-1.5**

Table 5. Mean survival of different accessions from different collection localities in Japan. A given accession is counted as surviving if at least one living example exists in the Hørsholm Arboretum. The difference between survival in Milde in Norway (Salvesen 2004) and Hørsholm is given in the last column. The collection sites are listed in from the Northeast Japan (top) to the southwest Japan (bottom).

The exact taxa surviving in Hørsholm are listed in tables 6, 7 and 8. Comparing these species with those listed by Salvesen (2004) clearly indicates different patterns of survival. Some species survived in Milde, but not in Hørsholm as well as the opposite, although mean survival rates were nearly identical in the two Arboreta. This supports the finding of Dosmann & Tredici (2003) who concluded that the distribution of plant material from an expedition greatly increased the chances that a given accession will survive.

Abies homolepis	*Picea alcoquiana*
Abies mariesii	*Picea glehnii*
Abies sachalinensis	*Picea jezoensis*
Abies veitchii	*Picea koraiensis*
Cephalotaxus harringtonia	*Pinus parviflora*
Cephalotaxus harringtonia var. *nana*	*Pinus pumila*
Chamaecyparis obtusa	*Taxus cuspidata*
Chamaecyparis pisifera	*Taxus cuspidata* form *nana*
Cryptomeria japonica	*Thuja standishii*
Juniperus communis	*Tsuga diversifolia*
Larix kaempferi	

Table 6. Surviving conifers from the NAU Japan expedition in 1976 in the Hørsholm Arboretum (12 taxa).

Acer argutum	*Cornus kousa*
Acer capillipes	*Cornus macrophylla*
Acer caudatum subsp. *ukurunduense*	*Euonymus*
Acer cissifolium	*Fagus crenata*
Acer mono	*Fagus japonica*
Acer palmatum	*Fraxinus lanuginosa*
Acer rufinerve	*Fraxinus mandshurica*
Acer sieboldianum	*Fraxinus spaethiana*
Acer tschonoskii	*Juglans sieboldiana*
Acer ukurunduense	*Magnolia obovata*
Alnus firma	*Phellodendron amurense*
Alnus hirsuta	*Phellodendron japonicum*
Alnus japonica	*Prunus grayana*
Alnus maximowiczii	*Quercus mongolica*
Alnus pendula	*Quercus serrata*
Betula corylifolia	*Sorbus alnifolia*
Betula ermanii	*Sorbus commixta*
Betula platyphylla	*Sorbus matsumurana*
Carpinus japonica	*Stewartia monadelpha*
Carpinus laxiflora	*Styrax japonicus*
Cercidiphyllum japonicum	*Styrax obassia*
Cercidiphyllum japonicum var. *magnificum*	*Tilia maximowiczii*
Cornus controversa	*Ulmus laciniata*

Table 7. Surviving angiosperm trees from the NAU Japan expedition (46 taxa).

Abelia serrata	*Ilex sugeroki* var. *longepedunculata*
Acer carpinifolium	*Leucothoe grayana*
Acer caudatum subsp. *ukurunduense*	*Ligustrum*
Acer japonicum	*Ligustrum tschonoskii*
Acer micranthum	*Magnolia stellata*
Actinidia arguta	*Meliosma tenuis*
Actinidia kolomikta	*Photinia villosa*
Ampelopsis brevipedunculata	*Pieris japonica*
Aralia elata	*Rhododendron albrechtii*
Berberis amurensis var. *japonica*	*Rhododendron brachycarpum*
Berberis thunbergii	*Rhododendron dauricum*
Buxus microphylla	*Rhododendron degronianum* subsp. *heptamerum*
Callicarpa japonica	*Rhododendron quinquefolium*
Callicarpa mollis	*Rhus ambigua*
Celastrus orbiculatus	*Skimmia japonica*
Clematis stans	*Spiraea betulifolia*
Clethra barbinervis	*Spiraea japonica*
Corylopsis glabrescens	*Stachyurus praecox*
Corylus sieboldiana	*Stephanandra incisa*
Deutzia gracilis	*Tripterygium regelii*
Deutzia scabra	*Viburnum dilatatum*
Elaeagnus umbellata	*Viburnum furcatum*
Enkianthus cernuus var. *rubens*	*Viburnum urceolatum*
Euonymus alatus	*Viburnum wrightii*
Euonymus hamiltonianus var. *sieboldianus*	*Vitis coignetiae*
Euonymus macropterus	*Vitis flexuosa*
Euonymus oxyphyllus	*Weigela decora*
Hamamelis japonica	*Weigela hortensis*
Hydrangea	*Weigela japonica*
Ilex geniculata	*Weigela maximowiczii*
Ilex pedunculosa	*Weigela middendorffiana*

Table 8. Surviving angiosperm bushes from the NAU Japan expedition (62 taxa).

Figure 12. *Rhododendron degronianum* subsp. *heptamerum* (1977.0501, NAU Japan B338) flowering in the Arboretum's rhododendron valley.

2. FLOWERING AND FRUITING

Table 4 showed that 188 accessions out of 222 or 85 % of the living accessions produced flowers or fruits in the arboretum at least once in a three year period when flowering and fruiting were recorded (from 2004 to 2006). These accessions are thus shown to be well enough adapted to have reached sexual maturity in the environmental conditions at Hørsholm. The fraction flowering is virtually identical for that for all Japanese material within the collection where 84 % of accessions from all Japanese sources flowered in the three years. The 188 flowering accessions from the Japanese NAU expedition comprised 114 distinct taxa.

The fraction of accessions flowering is probably underestimated, as the recording of flowering and fruiting has largely been made by student helpers who may have missed some less eye catching flowers or fruit. In addition, a few accessions were impossible to locate, although assumed to living, because they were so inter-twined with neighbouring

plants (*Ampelopsis brevipedunculata*) that one cannot determine which plant is flowering. Sometimes this problem in locating a precise accession occurred because of extensive root suckering followed by dieback of the original mother plants. This causes "wandering plants" as in the case of *Aralia elata.*

Lack of flowering in the records is not entirely due to error. Some of the accessions were heavily shaded by other plants in the collection, and this probably caused lack of flower (some *Vitis* species). Others are simply poorly adapted. For example *Quercus* species often do not produce mature shoots in the cool Danish summers resulting in frost damage to immature, unhardened shoots and large numbers of suckering. A few may still not have reached sexual maturity, as is suspected for accessions of *Fagus crenata* and *Fagus japonica.*

Finally some accessions may flower less than once every three years, especially in an environment that is foreign to these taxa. The 15 % (35 accessions) that did not apparently flower is less than the number of accessions (21%) that were recorded as only flowering (or fruiting) once in the three years of the observations. More information about the recording of flowering and fruiting in the Arboretum can be found by checking the working papers (Leverenz *et al.* 2005, Leverenz 2006).

In most cases, the living material that survived for 30 years in the Arboretum in Hørsholm has been well enough adapted to be able to produce flowers or fruit. Unfortunately, systematic testing of the ability of seed to germinate has not been possible at this time and nothing can be written about germination ability. Unlike at Milde (Salvesen 2004) we have not observed natural regeneration of these plants by seed. This is probably because of the strong grass competition in the Arboretum in Hørsholm. The low observation of natural regeneration may also reflect the fact that no one has made a concentrated study of self regeneration by seed to pick up the rare events. Several local nurserymen and avid amateur dendrologists have repeatedly collected seed from plants from the Japan expedition, this indicates that they must have had some success. Unfortunately records of the collection of seed from within the Arboretum's living collection has not been systematically stored. This contrasts the record from the nursery where the data was systematically kept as "plantud sedler" and is much more complete. A systematic registration of seed and cuttings collected in the living collection would be beneficial for further research on adaptation of the collected material from the expeditions.

Table 9 shows the percent of living plants that flowered in each of the main collecting areas in Japan (material from some smaller areas is not included). Although flowering or fruiting appeared to be higher in the plants from central Japan these differences between northern, central and southern Japan were not statistically significant.

					% of alive in 2006 that flower or fruited			
Locality		**latitude**	**longitude**	**elevation**				
				meters	**survival No. living**	**survival No. flowering**	**% flowering**	**mean %**
Hokkaido	Daisetsu	142° 54'	43° 59'	1300-1600	3	1	33.3	
Hokkaido	Dairoku	142° 54'	43° 21	200-1400	13	11	84.6	
Hokkaido	Horoman	143° 07'	42° 05'	200-400	7	7	100.0	
Hokkaido	Ashibetsu	142° 14'	43° 04'	600-1700	8	7	87.5	
Hokkaido	Ishimaidake	143° 10'	42° 02'	100-200	4	3	75.0	**76.1**
Honshu	Nikko	139° 28'	36° 47'	1400-2200	8	7	87.5	
Honshu	Tateyama	137° 36'	36° 33'	1000-2400	31	26	83.9	
Honshu	Nishidake	138° 21'	35° 59'.	1400-2100	15	11	73.3	
Honshu	Mugikusa	138° 20'	36° 43'	2000	3	3	100.0	
Honshu	Ontake san	137° 31'	35° 53'	1600-2500	9	8	88.9	
Honshu	Akasawa	137° 28'	35° 43'	1000-1200	15	13	86.7	
Honshu	Fuji	138° 46'	35° 20'	1400-2300	6	4	66.7	
Honshu	Atsumi	137°	35°	0-100	2	2	100.0	
Honshu	Odaigahara	136° 07'	34° 10'	1100-1600	22	19	86.4	**85.9**
Honshu	Daisen	133° 35'	35' 24'	400-1600	32	27	84.4	
Shikoku	Tengu	132° 36'	36° 33'	1100-2500	4	3	75.0	
Shikoku	Ichizuchi	133° 05'	33° 45'	1500-1800	6	5	83.3	
Shikoku	Kamegamori	133° 10'	33° 43'	1500-1600	6	3	50.0	
Kyushu	Hikosan	130° 56'	33° 28'	700-1200	18	16	88.9	**76.3**
Total								
and %					**212**	**176**	**83.0**	

Table 9. The number of living and the number of flowering accessions and the percent flowering from the major collection areas of the 1976 NAU expedition to Japan. The collecting areas are listed from Northeast to Southwest.

The timing of flowering on average was not significantly correlated with the latitude of the collection sites although a weak trend was evident (Figure 13). Surprisingly, however. a significant negative correlation between mean flowering week and longitude was found (Figure

14). Because latitude was related to longitude (Table 10), this simple regression may incorporate a north-south component. There is substantial variation around the regression line in Figure 14, perhaps indicating the importance of another factor like altitude, which was not taken into account in this regression. However, when analysed, altitude did not have a significant effect.

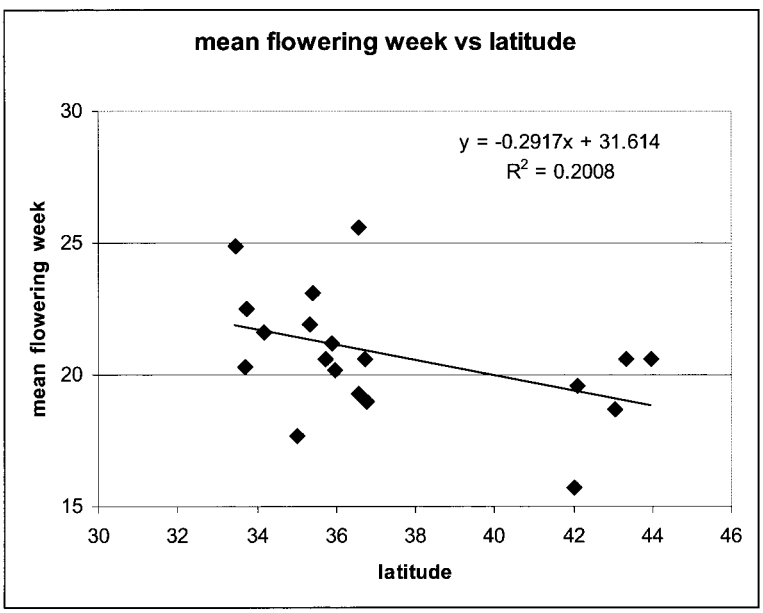

Figure 13. Mean flowering week versus latitude of the collection site in Japan for plants from the 1976 NAU expedition. Each data point represents all mean flowering week for the years 2004 through 2006 for all the accessions at a given site. First the mean of each accession was calculated and then the mean of these means was made to get these data.

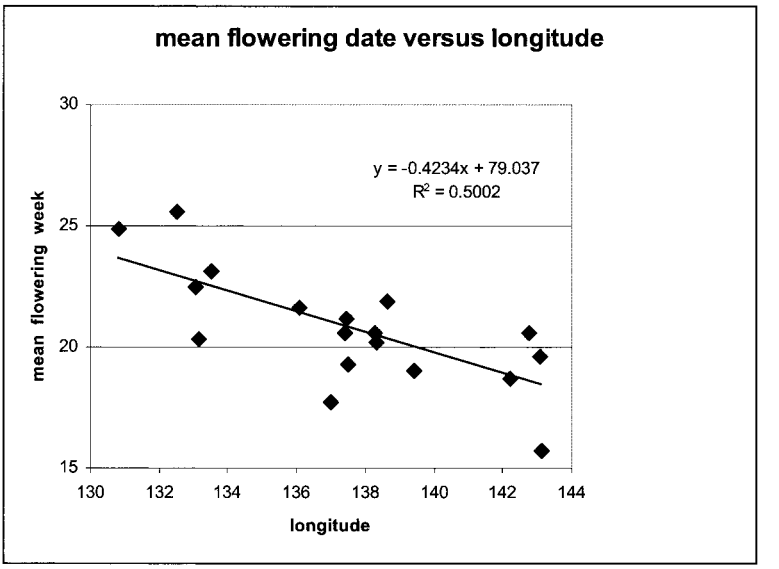

Figure 14. Mean week of flowering of plants from different collection areas in Japan versus longitude.

Figure 15. The decorative bark of *Clethra barbinervis* (1977.0823, NAU Japan C 190) in the Arboretum. This species was distributed in rather large numbers to several different gardens in Denmark and has been reported to still be living at two sites outside the Arboretum.

3. MATERIAL SENT TO PUBLIC AND PRIVATE PARKS IN DENMARK

Up to 1988, 12 years after the expedition the Arboretum in Hørsholm was still receiving and sending plants to the other participants of the expedition. The number of accessions received by Hørsholm was rather small being 13 accessions. Considerably more plants were sent from Hørsholm to other member institutes of NAU. In all 108 accessions (456 plants) were sent to other member institutes of the Nordic Arboretum Committee. This may indicate a well functioning nursery at the Arboretum. Indeed one is impressed with the number of accessions that must have been handled by the nursery in 1977 following several major expeditions including these two.

Many surplus plants from the expedition to Japan were sent to other public and private parks. To judge the number of accessions surviving outside the Arboretum at these other institutes, lists of accessions and plant names and numbers were sent by mail or e-mail to most of the various institutes or major individuals that were on record as receiving such material. For the Botanic Garden in Copenhagen, the database on their internet homepage was used to find living accessions. For the "ForskningsCentret" in Hørsholm, I checked for the plants myself at the site, using old notes kept at the Arboretum and the help of Ole Byrgesen, who had been involved in the transfer and planting out of many of these plants. Individuals receiving just a few plants from the Arboretum (often to celebrate a retirement from the University, or a birthday) were not contacted and not included in this analysis. On average 12 accessions were sent for trial at each of 21 other institutes, but the variation between institutes was large (Table 10).

Destination	no. accession sent	no. plants sent	no. living accessions	no. plants living	% living accessions
Jutland					
Botanisk Have, 8000 Århus C.	27	76	0	0	**0.0**
Dronningelund kommune					
Øster Mølle anlæg	2	9			
Den Geografiske have,					
6000 Kolding	8	scions	?	?	**0.0**
N.J. Petersen, Holstebro	7	cuttings	4	8	**57.1**
Fyn					
Arne Vagn Jakobsen Nursery,					
5620 Glamsbjerg	31	44			
Hofmansgave stiftelsen	2	5			
Zealand					
Blågård Seminarium	2	2			
Borsholm Pinet	3	15	1	4	**33.3**
Copenhagen Commune	4	51	1	12	**25.0**
Den kinesiske ambasade	8	8			
Erhvervsskolen Godhavn 3220					
Tisvildeleje	2	cuttings			
Forskningscentret (SCION-DTU),					
Hørsholm	35	195	4	8	**11.4**
Møllehøjgaard, Jægerpris	12	49			
Gisselfeld Park, 4690 Haslev	2	2			
KVL Garden, Frederiksberg	1	5	1	3	**100.0**
Botanisk Have, København K	41	71	6	7	**14.6**
Sorø Akademihave	4	6	2	?	**50.0**
Vallø	5	6			
Vilvorde Havebrugsskole	42	108			
Other areas					
Færøernes Plantagenævn,					
Faeroe Islands	7	20			
Segen Arboret, Bornholm Island	5	17			
sum or overall mean %	250	689	19	42	**7.6**

Table 10. Number of accessions and plants exported from the Arboretum nursery for trial in different plant collections in Denmark. In some cases scions or cuttings of an unrecorded number were sent.

Of the 21 institutes that received an inquiry, 9 responded (43%). Those responding reported that 19 accessions were still alive. In addition two reported that some plants were probably still alive, but could not be definitely located because of gaps in their records. These unlocated plants have been counted as not surviving in this analysis. On average 32 % of the plant material had survived for those that re-

sponded (Table 10). Four of the 23 surviving accessions were no longer surviving in the Arboretum in Hørsholm in 2006 showing the advantage of distributing plant material. These four accessions represent the following species: *Gaultheria miqueliana* (NAU S159), *Hydrangea* sp. (NAU B321), *Lespedeza bicolour* (NAU C242), and *Veronicastrum sibiricum* (NAU B15).

These data are based only on the incomplete collection of "plantud sedler" and thus underestimates the number of accessions distributed to others. Evidence for this was provided for example by Ulrik Kristensen of Copenhagen Commune, who supplied the Arboretum with a set of maps showing the location of plants that they had received from the Arboretum and how many have survived. The maps showed that they had received 4 accessions from the Japanese expedition. Either someone forgot to fill in the appropriate "plantud seddel" form, or the appropriate data was on one of the missing forms. These accessions were not in our records, but have been added to Table 10, since he also supplied information on how many accessions were still alive.

As mentioned above when plant material was collected directly from the Arboretum's living collection, the data was often written on odd sheets of paper and left in a file or desk somewhere, perhaps waiting to be sorted into a common file. Most of these data is lost. As an example, Niels Jørgen Holm Petersen from western Jutland has collected plant material and tested it in the more oceanic climate there. He was careful to leave records with us on precisely which accession numbers he collected (as cuttings or scions for grafting) but most of these records are lost. His current records showed 11 living accessions from the NAU expedition, in addition to the 5 accessions we had records for. Clearly the information presented in Table 10 represents a minimum estimate of the material that was sent out and underestimates the effect the expedition has had on the garden- and park-flora of Denmark.

The inconsequential recording of information concerning the collecting of plant material from the Arboretums collection is clearly an area where improvements should be made. Fortunately the revolution in electronic computers has made storing of such data less laborious and transfer of the data must easier. At the same time, however, funding for any such tasks is getting more and more difficult.

As can be seen in Table 10, the bulk of the plant material was destined for collections in Zealand and thus did not travel far from Hør-

sholm. Some material however, went as far as the Faeroe Islands and the Island of Bornholm. The data are not sufficient to check if there are any significant differences in survival at different areas within Denmark. However, given that overall survival was identical at Milde in Norway, it would be surprising if survival varied much within Denmark due to variations in climate.

I was pleasantly surprised by the high (32%) survival at responding institutes. However, for all institutes, including both those that responded and those that did not, survival was only 8 %. It may be that those who did not respond had nothing to report (no living plants or they did not know how to identify them. Some institutes, like the Botanic Garden in Copenhagen, and the Århus Botanic Garden, regularly remove trees that grow too large in order to maintain sufficient space for a diverse collection. Trees are also removed to adjust to changing ideas of what plant groups should be concentrated on. Århus Botanic Garden however, pointed out that although no plant material had survived (4 accessions were removed although perfectly healthy) they had served the garden well when alive and were much appreciated. Other institutes also reported that perfectly healthy specimens were removed for one reason or another. I know that at the Research Center in Hørsholm, a significant number of plants were removed when new construction on buildings was made or when re-landscaping undertaken. At the Research Center survival was much higher in areas that were reserved for the sole use by the Arboretum. Even in the Arboretum controlled area however, the creation of an Urban tree Arboretum resulted in the felling and removal some healthy accessions from the NAU expeditions.

Figure 16. The *Sorbus* from Ullung Island (1983.0536, probably NAU Japan N110) and the author at the Arboretum in Hørsholm.

4. COMMERCIALIZATION OF MATERIAL

Although the Arboretum in Hørsholm has been strongly coupled with a forest genetics group, who has been involved in the selection and breeding of forest trees, there has been little concerted effort to de-

velop new ornamental cultivars from the plants in the collection. Nevertheless, 13 species from the expedition to Japan were recommended in Jensen's "Guide to the Arboretum Hoersholm, Denmark" (1992). This was an attempt to promote the better material from the expedition. The species named were: *Acer argutum, Acer micranthum, Acer shirasawanum, Clethra barbinervis, Cornus controversa, Elaeagnus umbellata, Photinia villosa, Rhododendron albrechtii, Sorbus alnifolia, Stachyurus praecox, Styrax obassia, Styrax japonica,* and *Weigela middendorfiana.* The promotion of selected species from the expedition to Japan has also been made through the "Plant of the Month" on the Arboretum Internet page which up to 2007 was written by this author. Nine species are described with examples from the NAU expedition to Japan (www.arboretet.dk).

In Denmark the main effort in systematic testing and development of new woody plant ornamentals has largely been made by a group working at the State Horticulture Research Center at Årslev on the island of Fyn (previously Hornum on the Jutland Peninsula).

They have developed at least one cultivar from the material brought back from the NAU expedition to Japan. This was *Deutzia crenata* 'Dippon' Dafo® Stjernetop. Interestingly enough they received this material as *Symplocos.*

Other cultivars were developed in Sweden as part of the "E plants" (elite plants) system. In one case the cultivar *Sorbus* 'Dodong' (or Ullung-rönn in Swedish) was selected from material collected on the side trip to the Island of Ullung-do in Korea (Bengtsson 1992). There is also a second cultivar from this seed lot called 'Ullung' according to Thomas Lagerström from the Swedish Agricultural University in Ultuna. Both of these plants are superior performers in Sweden, and I have seen the cultivar 'Dodong' performing well as far North as Luleå. Both cultivars are sold in Denmark and at least 'Dodong' has been described as well adapted to Danish conditions.

The Hørsholm Arboretum did not receive seed from the side-trip Tor Nitzelius took to the island of Ullung in Korea as a part of this "expedition to Japan". However we received many plants in 1983 from Rune Bengtson at Alnarp in Sweden. These included 3 *Sorbus* from Ullung Island. One of these is still living and in 2006 was one of the larger *Sorbus* plants in our collection (Fig. 16). This plant is apparently a half-

sister of the cultivars *Sorbus* 'Dodong' and *Sorbus* 'Ullung'. This seed lot came from a single tree that differed from the ordinary S. *commixta* and was collected on Seonginbong at 900 m elevation on 29 September 1976 (Nitzelius 1983).

A seed-propagated cultivar has also been spread by several small commercial nurseries. This is the herbaceous plant *Veronicastrum sibiricum* (Arboretum accession number: 1977.0368, NAU Japan B15). Progeny of this collection number have been sold in for example the Overdam planteskole, and a nursery near Holstebro on the Jutland Peninsula (Niels Jørgen Holm Peterson personal communication 2006). This is an interesting plant because the main aim of the expedition was to collect woody plants and only a handful of herbaceous plants were collected. It is fortunate that one of the participants, Rune Bengtsson, took the effort to do a little collecting on the side and did not merely concentrate on woody plants.

Four definite cultivars out of 354 successfully propagated plants, gives a commercialization success rate of 1 %. Based on the 972 different collection numbers of the expedition the success rate was 0.4%. A success rate for commercialization of 1 % or less is actually rather typical for such collecting expeditions. Lighty (2000) found 0.08 to 1.5 % of the material collected in different expeditions became successful ornamental plants in cultivation. Many factors play a role and most plant material will not be suitable as an ornamental cultivar. Furthermore, even perfectly suitable cultivars often do not obtain (or maintain) popularity in culture.

Figure 17. *Stachyurus praecox* (1977.0768, NAU C131) in flower in the Arboretum.

CHAPTER 4. A QUANTITATIVE HISTORY OF PLANT INTRODUCTIONS FROM KOREA TO THE ARBORETUM

The effects of the NAU expedition to Korea in 1976 is best seen on the background of the general history of woody plant introductions from the Korean Peninsula. The following is a brief history.

A total of 1154 accessions are directly traceable to the Korean Peninsula since the official opening of the Hørsholm Arboretum in 1936. Of these accessions 1090 are traceable to South Korea and 64 accessions to North Korea. The first accession arrived in 1937 and the most recent in 2004. Of the accessions from Korea, 615 or slightly more than half (53%) came from the 1976 NAU expedition to Korea. Thus, solely in terms of the number of accessions, the NAU expedition to Korea had a slightly larger effect on the Arboretum than the expedition to

Japan. Other expeditions from the Nordic countries have been made to Korea and have contributed to the Arboretum's collection in Hørsholm. In preparation for the expedition in 1976 Max Hagmann from the Mustila Arboretum in Finland collected in North Korea in 1974. In 1983 Lennarth Jonsson an avid amateur collector from Sweden contributed material from South Korea. In 1992 a collecting expedition was sent from the Gothenburg Botanic Garden to South Korea which provided material. Most recently, Søren Ødum from the Hørsholm Arboretum collected material in North Korea in 1995.

The earliest material (one accession) directly traceable to Korea came in 1937 from the seed dealer Johannes Rafn, of Denmark. This seed was of unknown provenance and has not survived. The next seed did not arrive until 12 years later, in 1949. It came from Seoul and was a single seed lot of Pinus koraiensis. This material has also not survived. The earliest surviving accessions came a year later in 1950 via Paul Zehngraff, the U.S. Economic Cooperation Administration's Mission to Korea. Mr. Zehngraff sent us 10 accessions from Korea, two of which have survived (*Abies holophylla* and *Quercus mongolica*) giving a survival rate of 20 %. The *Abies holophylla* has been doing well, but now is showing thinning of the crown in the last few years, probably as a result of *Armillaria* infection in the root system. The *Quercus mongolica* survives, but does not do well because of frequent winter damage to its shoots (Figure 18).

Figure 18. *Quercus mongolica* (arboretum accession number 1950.0360) from Kwangnung Experiment Forest in South Korea. This is one of the 3 oldest surviving plants from Korea in the Arboretum. Note the large number of "witches brooms" caused by repeated frost dieback and re-growth. An example of the same species collected in Japan has been much less affected.

In the mid 1950's and early 1960's we received 8 accessions from diverse sources, but none of these have survived. The next material was received in 1974, nearly a quarter of a century after the first significant set of accessions from Korea, and only 2 years before the NAU expedition to Korea. This 1974 material was donated by Max Hagmann of the Mustila Arboretum in Finland, who led the NAU expedition in 1976. Eighteen accessions were donated almost doubling the material directly traceable to the Korean peninsula. Of 18 accessions received only 3 survived giving a 17 % survival rate. The three surviving taxa are all bushes: *Weigela subsessilis, Syringa oblata* var. *dilatata* and *Buxus microphylla.*

It might be noted that the numbers given here do not include 7 accessions (from before 1970) that cannot be traced back directly to Korea, but are Korean endemics and therefore must directly or indirectly have come from Korea. One of these is the interesting *Til-*

ia insularis from Ullung Island (1953.0429). The two surviving plants were received via the Botanical Garden in Copenhagen from Poznan, Botanical Garden in Poland. These two plants were mentioned in a small paper about Ullung Island by Nitzelius (1978), as an example of the potential of finding hardy plants for Scandinavia. These may have helped in the decision to travel to Ullung as a part of the NAU "Japanese expedition". Prior to 1970, the Arboretum had only received 20 accessions directly traceable to Korea, and thus one can say that on the whole, there was little direct evidence available about the potential of taxa from Korea. Notwithstanding the few examples must have given enough information, along with climate data to form an opinion about the potential of plants from this part of the globe.

The next arrival of Korean material came from the 1976 NAU expedition to Korea. Up to this date, the Arboretum had only received 44 accessions from the Korean peninsula. Only 11 plants, representing 6 accessions have survived from the time before the NAU expedition. The NAU expedition itself resulted in 604 accessions of which 238 have survived giving a survivability of 39 %. The survivability was clearly higher than for all earlier accessions.

The 1980's marked a period of much larger numbers of accessions from the Korean peninsula, perhaps in part because of contacts made to botanic gardens and arboreta while carrying out the expedition. In 1981 the Arboretum received 91 accessions from the Kwanak Arboretum of the National University on the southern edge of Seoul, Korea. Of these, 26 or 29 % have survived. In 1982 the Arboretum received an additional 23 accessions from the Kwanak Arboretum. Of this second shipment 9 accessions, or 39 %, have survived.

Figure 19. *Acer triflorum* (1982.0460) received from Kwanak Arboretum shows promise as a garden or park plant, with its fine autumn colours, complimenting brown flaky bark and symmetrical crown form.

In 1983, 12 accessions were received from the amateur dendrologist Mr. Lennarth Jonsson of Sweden. Of these only one (*Gleditsia japonica* var. *koraiensis*) has survived in the Hørsholm Arboretum (survival = 8 %), but another accession, *Magnolia officinalis*, has perhaps survived in the Forest Botanic Garden in Charlottenlund. In 1984 we received seed from the Hongneung Arboretum of the Korean Forest Research Institute. In all 17 accessions were received and of these 4 have survived (24 %).

In 1985 and 1986 Kew Gardens in London sent 16 accessions, but only 1 has survived giving a survivability of 6%. In 1988 we received 17 accessions from Pruhonice Arboretum in Czech Republic, (then Czechoslovakia) with original material from North Korea of these only 3 accessions have survived giving a survivability of 18%. The surviving taxa were *Rhododendron schlippenbachii, Sorbus* sp. and *Syringa velutina.*

The Arboretum has also been receiving material in the 1990's. In 1993 we received 17 accessions from Gothenburg Botanic Garden. Of these

5 have survived, giving a survivability of 29 %. Other sources of accessions arriving in the 1990's are shown in Table 11 below. The most recent accessions, arriving after 2000 are not show in the table as it is too soon to evaluate the material.

Source Non-Nordic Collectiors	year	survival %	Number of accessions
Zengraff, U.S.A.	1950	20	10
Kwanak Arboretum, Seoul National University	1981	29	91
Kwanak Arboretum, Seoul National University	1982	39	23
Hongneung Arboretum, Korean Forest Research Inst.	1983	24	17
Kew Botanic Gardens London	1986	6	16
Pruhonice Arboretum, Czech Republic	1988	18	17
Jeju Botanic Garden, Yeomiji	1993	11	18
Kwangnung (Korean National) Arboretum, Pochon	1995	29	21
Jeju Botanic Garden, Yeomiji	1996	45	11
Suwon Arboretum, Seoul National University	1997	5	20
Suwon Arboretum, Seoul National University	1999	25	28
weighted mean		24.4	
Nordic collectors			
Max Hagmann	1974	17	18
NAU	1977	37	615
Gothenburg	1993	29	17
Søren Ødum	1995	55	18
weighted mean		37.2	

Table 11. Major sources of accessions and their survival from the Korean peninsula.

It might be noted that no trend was found in a plot of survivability against accession date in the Arboretum. This suggests that most losses occur early in the life of new accessions. This agrees with the results form the Japan expedition (chapter 3) where 35 % were lost because they were not successfully propagated, and 20 % of the remaining died in the nursery. Loss of plants is probably also high in the first few years after planting out, but there is no data for this.

There was no statistically significant difference between plant materials collected by Nordic collectors versus materials collected by non-Nordic collectors. However, the trend was in the same direction as for the Japanese material in the Arboretum (Chapter 2). Survival of plant material from Korea averaged 53% higher for material collected

by Nordic collectors (Table 11). This supports the idea that our own expeditions provide material with a higher survival rate compared to material collected by others. This probably reflects better local knowledge of the climate in Scandinavia.

Survival in the Hørsholm arboretum was unrelated to a north-south gradient within the Korean Peninsula based on Province means as shown in Table 12. There were no significant differences in survival between North and South Korean Provinces. Zero survival was found for a couple of South Korean provinces, but the sample sizes were small so the results may just reflect bad luck. Surprisingly, survival rate was quite high from Jeju Island. One would expect however a strong relationship between survival and elevation on this southern island based on data published by Sanda (1982) that is presented in the next chapter. Unfortunately there was not enough elevation information from these various sources to test for gradients in survival against elevation.

country	Province	survival %	Number of accessions
North Korea	Chagang do	57	14
North Korea	Pyongyang city	11	18
North Korea	Kangwon Do	13	15
North Korea	Hwanghae Namdo	40	5
North Korea	weighted mean	26.8	
South Korea	Gangwon Do	27	86
South Korea	Gyeonggi Do	23	122
South Korea	Ullung Island	26	50
South Korea	Chungcheong Bukto	0	7
South Korea	Chungcheong do	19	16
South Korea	Gyeongsang Bukdo	0	6
South Korea	Gyeongsang Namdo	28	29
South Korea	Jeju Island	18	43
South Korea	weighted mean	**23.2**	

Table 12. Survival versus province in plants from the Korean Peninsula. The listing generally follows a north-south pattern with the most southerly provinces last in the list. The data only cover accessions received up to the year 1999. For the years 2000 and beyond, survival was not calculated as the plants have not been tested for a significant amount of time.

In general climate on the Korean peninsula is more continental than that in Denmark with warmer summers at many sites. The problems of winter survival in Denmark may not be due to the minimum temperatures, which are higher in Denmark, but the cool summers and the unstable winter temperature that fluctuate well above and below the freezing point (Nitzelius 1968). Even when plants survive they can be strongly damaged as shown for *Quercus mongolica* in Figure 18.

CHAPTER 5. THE 1976 NAU EXPEDITION TO KOREA

Figure 20. Mature fruit of *Cephalotaxus koreana* (Hørsholm Arboretum nr. 1977.1074, NAU Korea collection nr. 386) growing the in Arboretum in Hørsholm. The last abundant production of fruit occurred in 2002. A number of seedlings were produced from the seed.

5A. INTRODUCTION

The Nordic Arboretum Committee expedition to Korea from 27 August to 30 October 1976 is described in a report written by the Scandinavian participants (Hagman *et al.* 1978). Following a general introduction, the report gives an itinerary for the expedition. This is followed by descriptions of the collection sites and a detailed list of all the collection numbers with information on each species and collecting localities, as well as a Finish seed-registration number for each accession. This latter number is often used by Finnish authors to identify material. The costs of the expedition, maps of Korea showing the collecting sites, suggestions for further activities and contact persons with addresses are given as well.

In addition to the official report, the Hørsholm archives contained a set of papers describing more information about the individual collection numbers. This set of papers, apparently from the Finish participant Max Hagman, with an English introduction, gives the specific elevations for each collection number, the number of "mother" plants collected from, as well as how many herbarium specimens were collected.

As with the NAU expedition to Japan, the official report from the Korean expedition is probably difficult to obtain for many readers, so parts of the introduction are reproduced immediately below:

"Foreword and Acknowledgements

The expedition to the Republic of Korea was arranged by the Finnish Forest Research Institute, Max. Hagman, professor of forest genetics in close cooperation with Lars Feilberg, lecturer at the Hørsholm Arboretum, Denmark, Jan E. Sanda, research assistant at the Agricultural University of Norway and Thomas Lagerström, lecturer at the Agricultural College of Sweden.

The expedition was made possible by grants from the Nordic Cultural Foundation (Nordisk Kulturfond) and the Danish National Bank (Nationalbankens Jubilaefond af 1968). We wish to thank these foundations for their valuable support.

The Norwegian shipping company The Wilhelmsen Lines, Oslo kindly supported the expedition by offering transport of the collected material in special cold stores. Shipowner Tom Wilhelmsen expressed from the very beginning a great interest in the expedition and supported its members personally in many ways.

At the time the first formal contacts were made with the Republic of Korea, most valuable help was given by His Excellency Ambassador K.D. Yoon, Embassy of the Republic of Korea, Helsinki.

The excellent technical planning in Korea was done by the Office of Forestry, Seoul and our most sincere thanks go to Director General Sohn, Soo-Ik who not only personally took great care of the wellbeing of the members of the expedition but also mobilized his staff at the Head Office as well as in the different Forest Regions for the many practical problems that had to be solved.

The Office of Forestry also arranged for the permissions to collect in National Forests, National Parks and other protected areas where the most interesting vegetation was to be found, and provided the expedition with transport facilities in the form of two field-going big jeeps with drivers and also in the form of numerous porters in all the many places where the expedition only could proceed on foot. Only those who have walked the Korean mountains can really appreciate what this means for the success of a botanical expedition.

Of the officers of the Head Office we can only mention here Director Kim, Syung-Yup and Mr. Lee, Kyong-Sang the latter being invaluable in the arrangements of lodging, tickets, mail, local transport, customs etc. etc. thus smoothing our way in to us unfamiliar conditions.

The expedition was very fortunate in being able to set up its headquarters a the Forest Research Institute in Seoul where Director Lee, Sung-Yong kindly provided us with office- and laboratory space and did not mind at all our spreading of herbarium papers to dry all over the front yard lawn of his institute.

Despite his many duties Deputy Director Sim, Hung-Soo took time to follow the expedition on the first and third course thus helping us continuously in many activities and providing us en route with information on Korean forestry and forest research and achievements.

Seeds, silviculture and landscape architecture are at the FRI the responsibility of the Division of Reforestation and it was therefore clear that our presence put great strain on their activities. Nevertheless, the Division Chief Shim Sang-Yung and his staff met our various needs in a most satisfactory way.

Particularly we have to mention Taxonomist Cho, Moo-Yun, Head curator of the Institutes Hong Nung Arboretum who followed us day and night on all our courses thus providing us with a "walking Flora" to be consulted on taxonomic or plant geographical matters whenever needed. His help in checking our collections with his herbarium afterwards can neither be overestimated.

Mr. Cho was during our work assisted in an excellent way by his aide-de-camp, Field assistant Han, Sang-Bae whose great practical experience in seed- and plant collection and handling of the material in the field as well as in the laboratory was of very great help, not to mention his delicious cooking on rainy mountain sides as well as in sunny temple yards.

In matters concerning genetics, provenance research and tree breeding the expedition was fortunate in being able to rely on the Institute of Forest Genetics in Suweon as well as on its branch station in Cheju-do. Director Choi, Jung-Suk and his numerous research officers helped us in many ways and we are very grateful to all of them. Our thanks also to Mr. Hwang, Jae-Woo who followed us on the field trip and Mr. Chung, Min-Sup, who, being a grantee at the Finnish Forest Research Institute, helped us in the preparatory work when the expedition was planned.

Splendid scientific support was also obtained from the faculty members of the College of Agriculture, Seoul National University, Suweon. Professon Hyun, Sin Kyu had helped the expedition already in the preparatory stages by providing references to literature and commenting on the suggested tour programme and in addition he was kindly guiding us when visiting experiments with introduced exotic trees adding to our knowledge from his great experience in forest tree breeding during many years.

Professor Yim, Kyong-Bin who followed us on the third course, broadened our background to the collection work by supplying basic information in his special field, Korean silviculture. He also gave us many valuable data on Korean forestry in general.

Without the excellent help of Dr. Lee, Tchang-Bok, Professor of Dendrology, many a plant would have remained unidentified. His life long experience of the Korean flora, gathered during innumerable field collecting tours all over Korea, formed an unmeasurable source of information from which the expedition gained every day he followed us on the second course. However, it must be admitted that for some of us it caused great difficulty to follow him up and down the gorges and tracks of Mt. Jiri-san, where he proved his reputation as a famous marathon runner. His many publications on Korean plants and their use, so generously given to us, will even in the future for a basic library in our work.

Among the many other persons who help us in Korea, we would here only like to thank Mr. Carl Ferris Miller for his great hospitality and for valuable discussions on Korean dendrology, a field in which he represents great expertise. We would also like to express our gratitude to Mr. W.D. Jones, General Manager of the Everett Steamship Corp. S/A, who helped us with the shipping business when our collections were sent home.

And finally we would like to thank our ground staff at our institutions at home, who has taken care of the plant material and obviously will be very much engaged in it in the years still to come."

As one can read, the Korean counterparts played a critically important role for the success of this expedition. It is nice to remember their contribution whenever one is admiring the many fine Korean plants in the Arboretum from the expedition. As with the Japanese expedition, most of the Korean participants appeared to help without charge to Nordic group.

The text continues:

"Preparatory work in Finland, Denmark and Korea

Korea has, since long ago been of interest to dendrologists. It has a very rich flora despite the fact that its climate is more severe than in Neighbouring Japan.

Since many plants from Japan have been grown successfully in Scandinavian gardens, it could be thought, that plants from Korea would be more hardy and thus suitable for cultivation in the more continental parts of the Nordic countries.

Already E.H. Wilson (1928) pointed out that Korean plants are best suitable for gardens where climatic extremes prevail because they enjoy a fixed climate in their homeland.

In the earlier parts of this century Korean plants were imported into Scandinavia, and were in general growing surprisingly well, withstanding e.g. later such severe winters as 1939-1944.

The material obtained was, however, limited in sources and in many cases the records about origin were missing or incomplete. For a further development it was therefore considered necessary to try to carry out a collecting expedition having especially in mind the variation within species and trying to obtain as many samples as possible from a wide range of localities.

It was also clear that on such an expedition new species which had not been tested before might be collected.

Since Korea reaches from the Manchurian border in the North to the island of Cheu-do in the south a mere transect through Korea would have to cover a very long distance. This was not possible with the resources available and with the time that could be used for an expedition. Also other reasons made plans for an all-covering collection difficult.

Thus the original intentions of having collections through the whole of Korea had to be abandoned and the experiences from Northern Korea were limited to a short visit by one of us (M.H.) in 1974 to Pyongyan, Wonsan and Southern Kumgnag-san.

In 1975 it was decided to concentrate the efforts to Southern Korea where the possibilities looked good. This decision was supported by the fact that a Finnish scientist had collected seeds in the Mur-river region of the USSR in 1974 and that there were promises for a Finnish expedition (which later also took place) to the same area in 1976.

Thus at least a part of the northernmost distribution of many species occurring also in Korea could be covered and the planned expedition could concentrate on the south. ....."

From the above it can be seen that the Korean expedition was an important part of a plan to study the suitability of the flora from Japan, Korea, and the Russian Far East.

From the booklet describing the expedition (Hagman *et al.*1978) one can see that the budget for the expedition to Japan was 58.000 NOK (48.347 DKK) including costs for holding a final meeting to check and distribute the material and the of printing the booklet about the expedition. Given that 774 seed lots were collected the average cost was 62 DKK per seed lot collected. In addition a number of herbarium specimens were also collected.

All material from the expedition arrived in Copenhagen in the beginning of December 1976. The material was then unpacked, checked and distributed to the participating countries between 11 and 14 December (Hagman *et al.*1978). It was noted in Hagman *et al.* (1978) that due to lack of space and working capacity all samples could not be sown in the same place. Therefore the Scandinavian material was divided up according to climatic conditions and to particular interests. Most seeds were sent to Max Hagman at the Forest Research Breeding Station, Maisala, Finland. The people at Maisala, Finland subsequently made a list of available seed in the winter of 1976-77. This seed list was sent to 78 institutions in 12 different countries. Thirty-nine of these institutes from 14 countries returned orders and 3310 lots of material had been distributed by 1978 (Hagman 1978). No doubt more seed lots were distributed afterwards. An updated seed list was circulated in

February 1980, with the weight of seed left for the different seed lots. For most seed lots the remaining seeds if any, weighed less than 10 g. The range in seed weight was between less than 1 g, up to 420 g (for the large seeded *Pinus koraiensis*).

Herbarium specimens were collected for most of the collection numbers. Depending on the number of herbarium specimens per collection number, they were distributed with the following priority: 1- Finland, 2- Sweden, 3- Denmark, and 4- Norway. Any remaining specimens were made available for exchange. The main herbarium collections made from the expedition were given to the Botanical Museum, University of Helsinki and to the Botanical Museum, University of Uppsala where they are available to researchers. Smaller herbaria were given to the Arboretum in Hørsholm and the Agricultural College in Ås, Norway. All herbarium material in Hørsholm has since been distributed to either the Botanic Museum in Copenhagen or the herbarium of the Royal Veterinary and Agricultural University also in Copenhagen and is available to researchers. It was intended that further herbarium specimens be collected from the material grown, in order to provide for studies about variation with the species (Hagman 1978). I am not aware of any such collections being made in Hørsholm, although it has also been an unfulfilled goal at the Arboretum to collect at least one herbarium specimen from every accession in the collection.

Figure 21. *Euonymus sachaliensis* (Hørsholm 1977.0051, NAU Korea 11) from the NAU expedition to Korea. Like many Korean plants it shows rich autumn colours.

5B. RESULTS

1. SURVIVAL

In total the expedition collected 774 lots of seeds or plants. The 763 collection numbers sometimes had suffixes like a,b,c and thus there were more seed lots than collection numbers. These suffixes were usually given to seed from individual trees that were of interest for tree breeding (Hagman 1978). Each of these suffixes was given its own unique accession number at Hørsholm and each is counted as a separate accession within this text. A list of the collections numbers and species along with supporting information is given in Hagman *et al.* (1978). The seed lots that were initially distributed to Hørsholm in December 1976 were given Hørsholm accession numbers between 1977.0001 and 1977.0366. At a later date, the Arboretum in Hørsholm also received seed from the list published by the Finnish participants at the Forest Research Breeding Station, Maisala. These seed lots were assigned accession numbers between 1977.0909 and 1977.1177 and

thus were received in 1977. Five accessions were also received in 1978 and 1980 from other participants who had raised them from seed. Of the 774 lots collected by the expedition, the Arboretum in Hørsholm received 624 or 80% (Table 13). Thus as for the Japan expedition, the Arboretum received a little more than 600 accessions. At this distribution stage, the Arboretum in Hørsholm "lost" nearly 20% of the collected material.

For a few years after the expedition the Arboretum in Hørsholm received and sent plants to the other participants of the expedition. The number of accessions received by Hørsholm was small being only 5 in number. These plants are included as part of the 624 accessions received. More plants were sent from Hørsholm to two other member institutes of NAU (Thomas Lagerström at Uppsala and Tor Nitzelius at Fladalt in Sweden. In all 35 accessions (105 plants) were sent to these two members of the Nordic Arboretum Committee. The exchanges of Korean plant material were smaller than for the Japanese expedition and did not last as long. The last recorded exchange was in 1980. However, it might be noted that a number of selected scions of *Abies koreana* were sent more recently from Hornum in Denmark to The Swedish Agrigultural University at Ultuna (Thomas Lagerström) to build up a seed orchard. Secondary and perhaps tertiary exchanges of material may still occur among the members of the Nordic Arboretum Committee.

Korea 1976 expedition summary category	**number**	**%**	**notes**
No. collection numbers	774		
No. accessions Hørsholm	624	80.6	% of collection numbers
No. accessions propagated	364	58.3	% of Hørsholm accessions
No. accessions planted out	295	81.0	% of propagated
No. > 6 plant accession planted out	39	13.2	% of planted out
No. live accessions 2006	238	80.7	% of planted out
No. live single plant accessions	71	29.8	% of live accessions 2006
No. live accessions flowering &/or fruiting in 2004, 2005 or 2006	207	87.0	% of live accessions 2006
No. accessions exported to others	226	76.6	% of propagated
No. accessions in commerce	18	2.9	% of received accessions

Table 13. Overall summary of the Korea expedition material and its survival at the Arboretum in Hørsholm.

Of the 624 seed lots received, 364 were estimated to be successfully propagated. This represents a success rate of 58 % for propagation or a 42% loss. This is only 5 % larger than the loss for the Japanese expedition and suggests that losses of around 40% because of propagation failures may be typical. At the NAU annual meeting in Umeå in 2006, Mirja Siuruainen reported that a 65 % loss occurred at the Botanic Garden in Oulu Finland, because of unsuccessful propagation. She noted that few seed were received from the 108 different accessions (in some cases only one seed per seed lot) and that this probably contributed to the low success rate there. Hagman *et al.* (1978) noted the difficulties of seeds rotting in the warm and sometimes humid conditions, especially early on in the expedition when the weather was warmest. They also noted that they sometimes had to collect immature seeds because a return to a locality was not possible.

The seeds received in December of 1976 and in 1977 were probably sown as soon as possible after diverse pre-treatments including cold stratification. This allowed a list of plants living in September 1978 (after one or two growth seasons) to be used for the initial estimation of the number of successfully propagated plants. This 1978 list probably underestimated the number of successfully propagated accessions because some accessions may have taken more time to germinate (Hagman *et al.*1978). Therefore, as for the Japanese material, all accession numbers later recorded as being planted out (but not on the 1978 list) were added to estimate the total number successfully propagated. This increased the number propagated by 9% (27 accessions). It is possible that some accessions germinated successfully after 1978 and were pricked out into the nursery beds, but did not live long enough to be planted out. Such accessions would not have been counted and thus 58% is probably an underestimate of the number of successfully propagated. Nevertheless this is the best estimate that can be made and there are no indications that the underestimate should be large. Thus the percentage propagated was probably around 60%.

Of the estimated 364 successfully propagated plants, 295 or 81% survived long enough in the nursery to be planted out into the Hørsholm collection (Table 13). This is virtually identical to that for the Japanese material where 80 % survived this stage. Thus 19 % of the successfully

propagated were lost in the nursery, where growing conditions would have been more ideal than out in the main collection areas.

Of the accessions planted out in the collection, only 19% were lost 25 years after planting out (by 2006). More precisely, a total of 238 accessions or 80.7 % of all accessions planted out were alive in 2006 (Table 13). A relatively low death rate (0.76 %/yr = 19/25) after planting out compared with that in the nursery (3.8 %/yr) again supports the conclusion that already in the nursery a considerable amount of selection for well adapted individuals occurs. The 238 surviving accessions in 2006 was almost identical to that of the Japanese expedition in absolute terms (222 for the later), or in relative terms (37% of all accessions received survived from Japan and 38 % from Korea). It seems that in spite of differences in climate between Japan and Korea (Hagman *et al.* 1978, Salvesen 2004), the expedition was able to bring home material of similar adaptability to the Danish climate.

On average 5.6 plants per accession were planted out from the Korean expedition, whereas only 3.7 plants per accession were planted out for the Japan expedition. However, the median number of plants planted out per accession was identical: 3 for Korea and 3 for Japan. The larger mean value for Korea was the result of a small number of accessions with very large numbers of plants. These accessions represented *Rhododendron* taxa, like *R. brachycarpum* subsp. *fauriei* (59 & 48 plants in 2 accessions), *R. mucronulatum* (62, 42, 34 & 67 plants in 4 accessions), *R. schlippenbachii* (93, 70, 68 & 38 plants in 4 accessions). While strongly increasing the mean, these 10 accessions did not significantly increase mean survival when averaged over all 295 accessions. For Japan the 5 largest accessions had 32, 20, 19, 19 and 18 plants each. From this one can not conclude that the survival of the Korean material was similar to that of Japan merely because it was planted out in greater numbers. This would only have been the case for the 10 Rhododendron accessions.

The neighbouring "Forskningscentret" (now "SCION DTU") site in Hørsholm was also used to test the material from the Korean expedition. If, for a given accession number, one adds together the plants planted out at the Arboretum and at this neighbouring site, then 28.7 % of all accessions planted out from the Korean expedition were represented by 7 or more plants. This almost doubles the number of ac-

cessions with 7 or more individuals that were planted in the Arboretum. Still less than 30 % of all accessions were planted out in sufficient numbers in the Hørsholm area. Although better than for the Japanese expedition, the small number of individuals planted out per accession can also be seen as a weakness in the exploitation of the expedition's material.

In all, 42% of the accessions from Korea produced less than 7 successfully propagated plants. For these it would have been impossible to test more individuals. About 30 % of the accessions had 7 or more individuals propagated, but less than 7 planted out. This perhaps emphasizes the limited space available in the Arboretum, or a policy to distribute the material as widely as possible within Denmark.

A surprisingly large number of accessions (223 or 79% of those that germinated) were sent to other parks and gardens as well. For 160 accessions more plants were given away than planted out in the Arboretum. This is in agreement with the policy to distribute the material as widely as possible within Denmark in order to develop a better understanding of the adaptability of the material. Slightly more accessions from the Korean expedition were given away for trial outside the Arboretum than from the Japanese expedition.

There was no correlation between the number of accessions given away for trial outside the Arboretum and plants planted in the Arboretum even when less than 7 plants from an accession were planted out in Hørsholm (Figure 22). The average number given away averaged between 2.5 and 3.0 irrespective of the number planted out in the Arboretum. However, these averages encompass a significant variation and as many as 10, or a few as 1 plants given away irrespective of the number kept . The Korean results are in contrast to the results from Japan (Chapter 3b) where there was a strong positive correlation between the average number of plants given away per accession and the number kept at the Arboretum. The Korean data indicates that for any given accession, many plants could have been given away for trial elsewhere even when only a few plants were kept for the Arboretum.

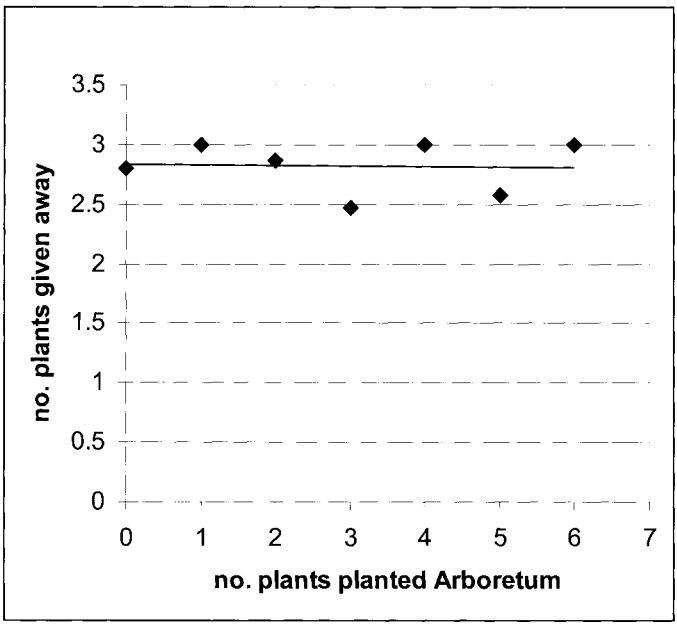

Figure 22. The average number of plants from the NAU expedition to Korea given away per accession versus the number planted out in the Arboretum in Hørsholm. The line represents a fitted linear regression (R2 = 0.002).

Upon closer examination of the data, it was sometimes difficult to understand why particular accessions were given away in large numbers, while few were kept. For example for *Pinus densiflora* with 21 accessions, several accessions were given away in large numbers, but few or no plants were kept for the Arboretum. For *Abies koreana* with 44 accessions, the same pattern occurred. For these species it appears that the large number of accessions for one species could not be fully utilized in the arboretum so some accessions were given away. However, for *Stewartia koreana* the data was different. This interesting species had only 3 accession numbers and rather few plants germinated. Nevertheless, 11 plants (all from one accession) were given away for trial elsewhere and no plants kept for the Arboretum. One can only speculate as to why this would have been so. It might be that the very large amount of material being processed in the nursery at the time made it impossible to keep track of ever accession that had been planted out. This would have resulted in mistakes, and for some accessions more plants were given away than intended.

Thirty percent of the surviving accessions in 2006 (71 accessions) were represented by only one individual and thus might be considered threatened with extinction within the Arboretum. This is especially true considering the current low support for the arboretum and thus few chances for any remaining staff to propagate this material using cuttings or scions. Perhaps the NAU committee should try to obtain funds to save the surviving, but "threatened" accessions from the expeditions by distributing scions of the material among the different member gardens and arboreta.

Of the 39 accessions, where more than 7 plants were planted out, 85.4% survived to 2006. This is only 5 % larger than survival in general where the median number of plants per accession was 3. Thus as for Japan, there is no evidence that increasing the number of individuals planted out, significantly increased survival. This is surprising, but again one might conclude that many individuals were planted out for accessions that were thought to have a low chance for survival. Alternatively, perhaps more care was given to accessions that were represented by one or a few examples during planting of the material.

Because of high survival, the plants from the 1976 expedition represented 73 % of all living Korean accessions in the Arboretum in 2006. That nearly three-fourths of all living material in the collection has come from this one expedition emphasizes its importance. Thus, like the Japanese expedition, the Korea expedition fulfilled its goal of providing the Nordic Arboreta with plant material of known origin.

The Korean expedition introduced in all 235 different taxa (species, subspecies and varieties). The main effect of the Korean expedition was to introduce new provenances of previously tried taxa. However, 69 of these taxa (29%) had never been tried before the expedition took place. Normally only about 15% of all accessions in any given year are totally new taxa, so the expedition was rather rich in new taxa. Of the 69 newly tried taxa, 19 have survived up to 2006 (Table 14). These represent the most mature examples of these species within the collection.

taxon	Hørsholm accession no.	NAU collection number
Acer tschonoskii var. rubripes	1977.0118	176
Aristolochia manshuriensis	1977.0158	264
Carpinus coreana	1977.1037	312
Cephalotaxus koreana	1977.0309	608
Fraxinus rhynchophylla	1977.1021	267
Lonicera chrysantha f. crassipes	1977.1023	273
Maackia fauriei	1977.1121	506
Malus asiatica	1977.0291	567
Malus asiatica var. wrightii	1977.1077	393
Prunus padus var. glauca	1977.0951	107
Rhamnus schneideri	1977.0281	536
Rhododendron weyrichii	1977.1128	539
Smilax sieboldii	1977.0306	603
Spiraea blumei var. latifolia	1977.0985	175
Spiraea fritschiana	1977.0994	208
Spiraea miyabei	1977.1060	362
Spiraea pubescens	1977.0937	61
Symplocos prunifolia	1977.1074	386
Tilia koreana	1977.1019	265

Table 14. Taxa from Korea expedition that were first introductions to Hørsholm in 1977 and that have survived to 2006.

Figure 23. Flowers of *Maackia fauriei* (Hørsholm 1977.0281, NAU Korea 536) from Mt. Halla on Jeju Island. This accession was the first successful introduction of the species to the Arboretum.

Table 15 shows the percent survival from each of the major collecting areas. These values were calculated as the number of surviving accessions (with at least one plant surviving) divided by the number of accessions actually planted out. Accessions that died before being planted out are not included. The data is calculated in an identical way to that calculated by Salvesen (2004) for the Arboretum at Milde near Bergen in Norway (60° N, 5° E). Hørsholm is situated further south and east (56° N, 12° E) and experiences in general colder winters and warmer summers than Milde. The survival in Hørsholm was unrelated to latitude in Korea (Table 15). This is probably related to the complicating factor of elevation, which can interact with latitude to affect the survivability of the seed (Sanda 1982). Overall, survival of plants from the expedition in Milde was only 47% of that in Hørsholm. This difference, contrasts strongly with the results from Japan where survival was essentially identical at the two arboreta. The differences may be due to the warmer summers at Hørsholm matching more closely the warm summers in Korea.

Mirja Siuruainen reported at the 2006 Umeå meeting that of 38 successfully propagated accessions in Oulu, 20 had survived giving a 53% survival rate. For comparison the survival of propagated accessions in Hørsholm was 65%. Considering the extreme differences in climate between Oulu at about 65° N latitude and Hørsholm at 56° N latitude, these numbers are not all that different. The curators at Oulu were probably rather selective in which seed lots they ordered from the expedition.

Locality	latitude	longitude	elevation	survival Milde	survival Hørsholm	survival difference
Seorak-san	128° 30'	38° 09'	200-1700	63.6	85.4	-21.8
Kyebang-san	128° 42'	37° 44	900-1030	48.6	95.6	-47.0
Seoul	127° 03'	37° 35'	50	33.3	50.0	-16.7
Chuulipo	126° 09'	36° 49'	0-100	0	44.4	-44.4
Sogri-san	127° 50'	36° 33'	400-800	50	80.0	-30.0
Palgon-san	127° 46'	35° 59'	100-1050	25	90.0	-65.0
Doekyu-san	127° 46'	35° 55'	500-1550	37.5	97.4	-59.9
Jiri-san	128° 04'	35° 18'	500-1900	20.8	81.3	-60.5
Halla-san	126° 30'	33° 22'	800-1900	53.2	87.7	-34.5
MEAN				**36.9**	**79.1**	**-42.2**

Table 15. Mean survival of accessions from the NAU expedition to Korea in 1976 from different collection areas in Korea. A given accession is counted as surviving if at least one living example exists in the respective Arboreta. The difference between survival in Milde (Norway) and Hørsholm is given in the last column. The collection sites are listed in order from the most northerly collecting sites (top) to the most southerly (bottom).

A study of hardiness was made by Sanda (1982) in 1980 and 1981 at Ås (where temperatures dropped to as low as -24.3°C in 1980 and -19°C in 1981) and Nøtterøy in Norway. It is very valuable with regards to explaining why we could not detect an effect of latitude on survival. Figure 24 below is derived from Table 13 in Sanda's 1982 paper. The figure shows data from three elevation zones. More elevations could have been added, but this would not have changed the conclusions, and made it more difficult to see the results. The High elevation data in Figure 24 was for plant material collected from between 1500 and 1749 m elevation, middle elevation was for material from between 750 and 999 m elevation and low was from between 0 and 250 m elevation. It is clear that latitude had a large effect on winter-damage scores for material from low and middle elevations. The data also indicate that if one wants to collect at low elevations and wishes to have some success with regards to survival in areas near Oslo one has to collect north of latitude 35° in Korea. In contrast, at high elevation, latitude had little if any effect. Thus, there was a strong interaction between elevation and latitude on winter damage and survival. Similar results were presented by Salvesen (2004) where the effect of elevation on survival was quite strong for Mt Halla on Jeju Island, but null or even negative for Mt Soerak in Northern South Korea.

Such an interaction could make it difficult to detect effects of latitude as presented in Table 15 above (or Table 5 in chapter 3) where for southern sites most accessions were collected at higher elevations. One must also remember that other factors might affect survival in Hørsholm and Milde independently of winter hardiness and could also perhaps make it difficult to detect an effect of latitude. These factors include weed competition, and predation by deer, rodents or insects.

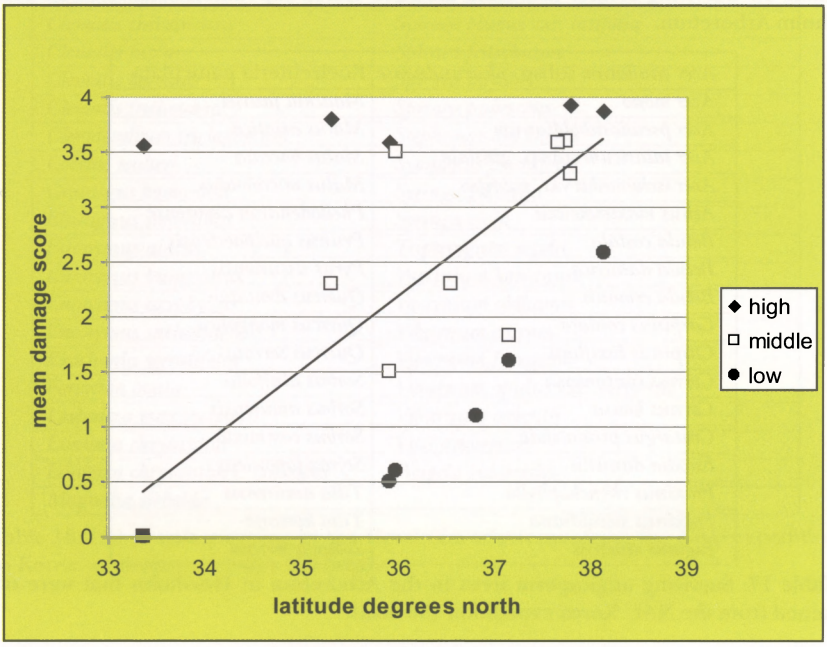

Figure 24. Summary of winter damage in Norway of material from the NAU 1976 expedition to Korea. The data is from table 13 in Sanda (1982). A damage score of zero was used to indicate dead plants while a score of 4 indicates no visible damage. Three elevation zones, high (1500-1749 m), middle elevation (750-999 m) and low (0-250 m). The regression line is fitted to the data from the middle elevation zone (score = 0.675*latitude- 22.12, R2 = 0.65).

The taxa surviving in Hørsholm in 2006 are listed in Tables 16, 17 and 18. Comparing these taxa with those listed by Salvesen (2004) shows 15 species survived in Milde, but not in Hørsholm although on average survival was higher in Hørsholm. The difference of survival at the two sites further supports the finding that the distribution of plant

material from an expedition significantly increased the chances that a given accession will survive (Dosmann & Tredici 2003).

taxon	**taxon**
Abies holophylla	*Pinus densiflora*
Abies koreana	*Pinus koraiensis*
Abies nephrolepis	*Pinus thunbergii*
Cephalotaxus koreana	*Platycladus orientalis*
Juniperus chinensis var. *sargentii*	*Taxus cuspidata*
Picea jezoensis	*Thuja koraiensis*

Table 16. Surviving conifer taxa from the NAU Korea expedition in 1976 in the Hørsholm Arboretum.

Acer caudatum subsp. *ukurunduense*	Koelreuteria paniculata
Acer mono	*Maackia fauriei*
Acer pseudosieboldianum	*Malus asiatica*
Acer tataricum subsp. *ginnala*	*Malus baccata*
Acer tschonoskii var. *rubripes*	*Malus micromalus*
Alnus maximowiczii	*Phellodendron amurense*
Betula costata	*Prunus quelpaertensis*
Betula dahurica	*Pyrus ussuriensis*
Betula ermanii	*Quercus dentata*
Carpinus cordata	*Quercus mongolica*
Carpinus laxiflora	*Quercus serrata*
Cornus controversa	*Sorbus alnifolia*
Cornus kousa	*Sorbus amurensis*
Crataegus pinnatifida	*Sorbus commixta*
Euodia daniellii	*Styrax japonicus*
Fraxinus rhynchophylla	*Tilia amurensis*
Fraxinus sieboldiana	*Tilia koreana*
Juglans sinensis	*Zelkova serrata*

Table 17. Surviving angiosperm trees in the Arboretum in Hørsholm that were obtained from the NAU Korea expedition (36 taxa).

Actinidia arguta	*Philadelphus schrenkii*
Actinidia kolomikta	*Rhamnus schneideri*
Ampelopsis brevipedunculata	*Rhododendron brachycarpum*
Aralia elata	*Rhododendron brachycarpum* subsp. *fauriei*
Aristolochia manshuriensis	*Rhododendron mucronulatum*
Berberis koreana	*Rhododendron schlippenbachii*
Betula chinensis	*Rhododendron weyrichii*
Callicarpa japonica	*Rhododendron yedoense* var. *poukhanense*
Carpinus coreana	*Rosa maximowicziana*
Celastrus orbiculatus	*Schizandra chinensis*
Celastrus stephanotiifolius	*Securinega suffruticosa*
Clematis apiifolia	*Smilax sieboldii*
Clematis chiisanensis	*Spiraea blumei* var. *latifolia*
Clematis fusca	*Spiraea fritschiana*
Clematis koreana	*Spiraea miyabei*
Clematis trichotoma	*Spiraea pubescens*
Clerodendrum trichotomum	*Stephanandra incisa*
Cornus walteri	*Symplocos prunifolia*
Crataegus komarovii	*Syringa velutina*
Elaeagnus umbellata	*Syringa wolfi*
Euonymus alatus	*Tripterygium regelii*
Euonymus bungeanus	*Vaccinium koreanum*
Euonymus oxyphyllus	*Vaccinium oldhamii*
Euonymus sachalinensis	*Viburnum erosum*
Exochorda serratifolia	*Viburnum furcatum*
Forsythia ovata	*Viburnum opulus* var. *sargentii*
Lespedeza maximowiczii	*Viburnum wrightii*
Lonicera chrysantha	*Vitis amurensis*
Lonicera chrysantha f. *crassipes*	*Weigela subsessilis*
Magnolia sieboldii	

Table 18. List of taxa surviving in the Hørsholm arboretum from the NAU expedition to Korea: angiosperm bushes (59 taxa).

Figure 25. *Koelreuteria paniculata* (1977.1145, NAU Korea 605) flowering in early August in the Hørsholm Arboretum. The use of these two plants has been discussed in relation to the development of urban trees for Denmark. Normally this species is only used as an urban street tree in warmer climates.

2. FLOWERING AND FRUITING

As shown in Table 13 above, 207 accessions out of 238 or 87 % of the living accessions produced flowers or fruits in the arboretum at least once in a period when flowering and fruiting were recorded (from 2004 to 2006). Almost all accessions were thus well enough adapted to have reached sexual maturity in the environmental conditions at Hørsholm. The 207 accessions that flowered or fruited comprised 99 distinct taxa.

The fraction of accessions recorded is probably slightly underestimated, as the recording of flowering and fruiting has largely been made by student helpers who may have missed some less eye catching flowers or fruit. Heavy shading, delayed maturity may be a cause of a lack of reproductive effort in some cases. Furthermore, some accessions may flower less than once every three years. The 13 % (23 accessions) that did not apparently flower was approximately equal to the number

of accessions (10%) that were recorded as only flowering (or fruiting) once in the three years of the observations. From the data one suspects that flowering in plants from Korea would be over 90 % of all surviving material if it was given the right micro-sites in the Arboretum. More information about the recording of flowering and fruiting in the Arboretum can be found by checking the working papers (Leverenz *et al.* 2005, Leverenz 2006). Systematic testing of the ability of seed to germinate has not been possible.

Table 19 shows the percent of living accessions that flowered sorted by the main collecting areas in Korea (some material from smaller areas is not included in this table). There was no significant trend between flowering and fruiting, and longitude of the site of origin as was found for Japan.

Locality	latitude	longitude	elevation	survival Hørsholm	flowering Hørsholm	% flowering
Seorak-san	128° 30'	38° 09'	200-1700	35	27	77.1
Kyebang-san	128° 42'	37° 44	900-1030	22	17	77.3
Seoul	127° 03'	37° 35'	50	2	1	50.0
Chuulipo	126° 09'	36° 49'	0-100	4	4	100.0
Sogri-san	127° 50'	36° 33'	400-800	12	10	83.3
Palgon-san	127° 46'	35° 59'	100-1050	10	5	50.0
Doekyu-san	127° 46'	35° 55'	500-1550	38	37	97.4
Jiri-san	128° 04'	35° 18'	500-1900	17	11	64.7
Halla-san	126° 30'	33° 22'	800-1900	57	57	100.0

Table 19. The number of living and the number of flowering accessions and the percent flowering from the major collection areas of the 1976 NAU expedition to Korea. The collecting areas are listed from North to South. This table does not include all accessions so the overall % flowering averages are slightly less than that for all accessions.

As for the results from the Japan Expedition, the timing of flowering on average was not significantly correlated with the latitude of the collection site (Figure 26). In fact the linear regression gave a correlation coefficient (R2) of 0.005 showed that in general flowering week was quite independent of latitude. As for winter damage one might expect it to be difficult to detect an effect of latitude on such data, where interactions between latitude and altitude probably occur. When analysed, altitude also did not have a significant effect.

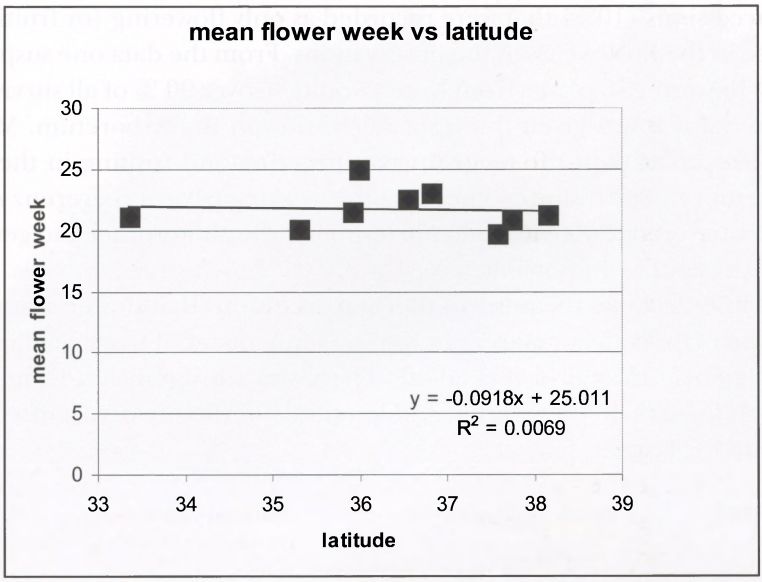

Figure 26. Mean flowering week versus latitude of the collection site in Korea for plants from the 1976 NAU expedition. Each data point represents all mean flowering week for the years 2004 through 2006 for all the accessions at a given site. First the mean of each accession was calculated and then the mean of these means was made to get these data.

Figure 27. *Abies koreana*, (1977.0361, NAU Korea 508c) one of the many collection numbers of this species. This species has been used in several research projects and it has been distributed for testing in rather large numbers of gardens across Denmark. Sixteen accessions were sent to the State Agricultural research station in Hornum where a trial plot was set up.

3. MATERIAL SENT TO PUBLIC AND PRIVATE PARKS IN DENMARK

Many surplus plants from the expedition to Korea were sent to other public and private parks. To judge the number of accessions surviving outside the Arboretum at these other institutes, lists of accessions and plant names and numbers were sent by mail or e-mail to the various institutes or major individuals that were on record as receiving such material. Individuals receiving just a few plants from the Arboretum (often to celebrate a retirement from the University, or a birthday) were not contacted and not included in this analysis. For the Botanic Garden in Copenhagen, the database on their internet homepage was used to find living accessions. For the "Forskningscentret" in Hørsholm, the plants were field checked by the author as described for the Japan expedition in Chapter 3. On average 14 accessions were sent for trial at each of 24 other institutes, but the variation between institutes was large (Table 20).

Destination	No. accession sent	No. plants sent	No. living accessions	No. plants living	% living accessions
Jutland					
Arboretum Paludosum,					
Silkeborg skovdistrict	6	24	0		**0.0**
Botanisk Have, 8000 Århus C.	16	72	0		**0.0**
Dronningelund kommune					
Øster Mølle anlæg	4	16			
Den Geografiske have, 6000 Kolding	2	cuttings	0		**0.0**
Eshøj Plantage, Thy	2	9	2	6	**100.0**
Hornum, Institute of Landscape plants	38	>90			
N.J. Petersen, Holstebro	5	cuttings	3	10	**60.0**
Fyn					
Arne Vagn Jakobsen Nursery,					
5620 Glamsbjerg	26	44			
Zealand					
Blågård Seminarium	3	5			
Borsholm Pinet	5	36	4	27	**80.0**
Copenhagen Commune	5	66	2	?	**40.0**
Den Kinesiske ambasade	8	10			
Erhvervsskolen Godhavn 3220					
Tisvildeleje	1	cuttings			
Forskningscentret (SCION-DTU),					
Hørsholm	102	420	9	24	**8.8**
Møllehojgaard, Jægerpris	7	29			
Gisselfeld Park, 4690 Haslev	3	7			
Hørsholm Kirkegård, Hørsholm	25	100	0		**0.0**
Botanisk have, København K	34	54	9	19	**26.5**
Sorø Akademihave	5	17	0	0	**0.0**
Vallø	9	15			
Vilvorde Havebrugsskole	16	49			
Other areas					
Færøernes Plantagenævn,					
Faeroe Islands	7	17			
Segen Arboret, Bornholm Island	7	24			
Aaholms gods, Nysted,					
Lolland Island	11	26			
sum of overall mean %	347	1040	29		**8.4**

Table 20. Number of accessions and plants exported from the Arboretum nursery for trial in different plant collections in Denmark.

Of the 24 institutes that received an inquiry, 10 responded (42%). Those responding reported that 29 accessions were still alive. Other plants were possibly still alive, but could not be definitely located because of gaps in their records. Such unlocated plants have been count-

ed as not surviving in this analysis. On average 29 % of the plant material had survived for those that responded (Table 20), slightly less than the 34% that survived from the Japanese expedition (Table 10). Only two of the 29 surviving accessions were no longer surviving in the Arboretum in Hørsholm in 2006, showing that the advantage of distributing plant material was not as large as that for the Japanese material. These two accessions represent the following species: *Abies koreana* (NAUk 478a), and *Abies holophylla* (NAUk 154a).

These data are based only on the incomplete collection of "plantud sedler" and thus underestimates the number of accessions distributed to others. Evidence for this was provided for example by Ulrik Kristensen of Copenhagen Commune. He sent the Arboretum a set of maps showing the location of plants that they had received from the Arboretum and how many have survived. These accessions were not in our records, but have been added to Table 20. Also Eshøj Plantation (Thisted Commune) reported that they received more material than on our records, as did Niels Jørgen Holm Petersen.

As mentioned previously, when plant material was collected directly from the Arboretum collection, the data was often written on odd sheets of paper and left in a file or desk somewhere, perhaps waiting to be sorted into a common file. Most of these data is lost. Clearly the information presented in Table 10 represents a minimum estimate of the material that was sent out and underestimates the effect the expedition has had on the garden- and park-flora of Denmark.

As can be seen in Table 20, the bulk of the plant material was destined for collections in Zealand and did not travel far from Hørsholm. The data are not sufficient to check if there are any significant differences in survival at different areas within Denmark. Given that overall survival was half as much at the Milde Arboretum in Norway, it is possible that survival might vary significantly across Denmark.

I was pleasantly surprised by the high (29 %) survival at responding institutes. However, for all institutes, including both those that responded and those that did not, survival was only 8 %. It may be that those who did not respond had nothing to report (no living plants or they did not know how to identify them). Some institutes, like the Botanic gardens in Copenhagen and Århus, regularly remove plant material that grows too large.

A small case study: On 10 April 2006 a visit was made to the Hørsholm Kirkegård (cemetery), which had received 100 *Abies koreana* plants (4 each of 25 different accession numbers) in 1983. I was lucky to meet Asger Christensen, Kirkegård (Cemetery) assistant who planted the trees back in April 1983. He said he remembered it well because it just poured rain the whole day. The trees were planted in a row along the fence to the Arboretum. The Kirkegård chief, Vagn Andersen also reported that in about 1992 every second tree was lifted in a thinning operation. One of these was given to the priests' house-garden on Folehavevej. On checking, this tree no longer existed in 2006. The rest of the lifted-trees were given to Vestre kirkegård where some may still exist. One would be surprised if it was possible to identify them by accession number. In April 2006 only 10 of the original 100 trees were still left at the Hørsholm Kirkegård because many were removed for space or because they were unhealthy. The registration of the trees positions was not sufficient to enable a determination of which accession numbers survived and thus they are not reported as alive in Table 20. The trees are described briefly in Henrik Clausens (1997) article in the Dansk Dendrologisk Forenings Årsskrift. The remaining trees appear to be thriving, but probably most of the poorer trees have been removed prior to 2006. This might be a typical case and indicate the secondary transfer of plant material so the distribution of the expedition material is larger than presented in Table 20.

Figure 28. Magnolia sieboldii (1977.0205, NAU Korea 373) flowering in the Arboretum. This healthy, free flowering individual has on several occasions provided scions to at least two Danish nurseries and perhaps deserves a cultivar name.

4. COMMERCIALIZATION OF MATERIAL

While the Arboretum in Hørsholm has been strongly coupled with a forest genetics group, who has been involved in the selection and breeding of forest trees, there has been little effort to develop new ornamental cultivars from the plants in the collection. Nevertheless 13 species from the expedition to Korea were recommended in Jensen's "Guide to the Arboretum Hoersholm, Denmark" (1992). This was an attempt to promote the better ornamental material from the expedition. The species named were: *Acer tschonoskii* var. *rubripes, Aralia elata, Berberis koreana, Betula davurica, Carpinus coreana, Koelreuteria paniculata, Lonicera chrysantha* var. *crassies, Maackia fauriei, Malus asiatica, Philadelphus schrenkii, Rhododendron mucronulatum, Rhododendron schlippenbachii,* and *Tripterygium regelii.* In contrast to Hørsholm, a member of the expedition from Sweden, Prof. Thomas Lagerström of the Swedish Agricultural University near Uppsala along with Elisabeth Öberg and Bo Nilsson working at the Horticulture centre in Örebyn research sta-

tion near Piteå in Sweden, have taken advantage of the potential of the expedition by testing and promoting ornamental material.

In Denmark the main effort in systematic testing and development of new woody plant ornamentals has largely been made by a group working at Hornum on Jutland and later at the Horticultural Research Center at Årslev on the island of Fyn. Thirty-eight accessions representing more than 90 plants were distributed to the Hornum research station in Denmark where new cultivars have been developed (as 'DAFO' plants). For many accessions they received an indeterminate number of plants because they received flats of seedlings. It is unknown what happened to this material however, I have not found any 'DAFO' plants from the Korean expedition. At Hornum a test plot of *Abies koreana*, was created from 16 accessions from the expedition. Thomas Lagerström has collected 20 selected clones from this test plot near Hornum to build a seed plantation in Sweden. He expects the first seed production in about two years.

Thomas Lagerström has been the main person taking advantage of the expedition to develop new plant material for horticultural use. In addition to the *Abies koreana* seed orchard, he has made a small seed orchard of *Malus baccata* from the expedition that is isolated from other *Malus* species. The plant material from the expedition has provided free flowering, hardy material for more northern parts of Scandinavia. Also from the expedition is *Aristolochia mandschuriensis*. This fast growing climber with large leaves has become so popular in Sweden that it is difficult to produce enough for the market. Also introduced was *Aruncus aethusifolius*, a very valuable perennial which is now one of the most used herbaceous plants in parks and gardens in Sweden. The expedition has also introduced *Rhododendron yedoense* var. *poukanense* a compact growing form from Mt. Halla. This provenance makes pot plants in 2 years. According to Thomas Lagerström this material may already be on the market in Denmark. Three "E plants" have been developed from the expedition's material and are distributed in Sweden and Norway and probably elsewhere. These are:

Weigela florida 'Korea' E: A very rich blooming, mid-sized bush with a broad compact form. The flowers sit in groups of 3-5 and are deep red.

Clematis chiisanensis 'Love Child' E (atragene-group). A plant producing flowers with yellow petals and with small violet spots. It has a pleasant scent and flowers from June to August. It was collected and developed by Prof. Tomas Lagerström.

Syringa wolfii 'San' E is an attractive plant with light-pink coloured flowers. The name San comes from the Korean for mountain and the plant material was originally collected above the tree-line on Sulak-San (Seorak-San).

In addition *Clematis ianthina* var. *kuriopoensis* has made an impact on *Clematis* enthusiasts (web page http://www.clematis.hull.ac.uk/index.html). It is unclear if this material is commercially available or only spread through via contacts among amateur growers.

From the above one can clearly see that more advantage was taken of the Korean material than of the Japanese material. Most of the work has been done in Sweden and this may reflect the more continental climates in Sweden and Korea than in for example Norway and Denmark. The 8 successes out of 774 collection numbers results in a commercialization success rate of about 1 %. This number probably misses a few other accessions in circulation (for example see Figure 28) and thus the affect of the Korean expedition was higher than that for the Japanese expedition.

Figure 29. *Rhododendron schlippenbachii* (1977.1043, NAU Korea 331). This species is the Korean national flower.

CHAPTER 6. GENERAL SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.

The results from the two Nordic Arboretum Committee collecting expeditions to Japan and Korea in 1976 showed that they were successful in meeting the stated goal. However, several things could have been improved, especially with regards to handling the material afterwards and recording systematically information about the material. Because of these several recommendations are made below for future expeditions.

The history of plant introduction for both Japan and then Korea was presented. At the time of the expeditions many more accessions from Japan were tried at Hørsholm than from Korea. Plant material from Nordic collectors (including these two expeditions) on average provided material that was more likely to survive in Denmark than plant material from non-Nordic collectors. Furthermore accessions with larger amounts of seed were shown to have higher probability of survival. It was concluded that it is important to record the size of

seed lots for each accession received. This information will allow a better assessment of the suitability, or lack of suitability of a given provenance. In addition the number of successfully germinated seeds could be recorded for each accession. The recording of such information has been in place at the Arboretum for several years, but was not recorded for the expedition material in 1977.

The stated goal of the expeditions was to supply the Nordic countries with living specimens of well documented (preferably wild) origin. For the case of the Arboretum in Hørsholm, both of these expeditions were a large success. The Japanese expedition constitutes 66 % of all living accessions from Japan in the Arboretum in Hørsholm while the Korea expedition constitutes 75 % of all living accessions from Korea. For nearly all of these accessions detailed descriptions of the collection sites are provided in the reports printed in 1978 (Hagman *et al.* 1978 and Nitzelius *et al.* 1978).

It was suggested that improvements might be made if at least 7 living examples of each accession were planted out in the living collection because of the difficulty of judging the suitability of a given provenance with only a few numbers of plants. Even 7 plants could be judged as a limited number for the rigorous testing of the adaptability of an accession. At the Arboretum however, space and personnel limitations strongly limit how many plants can be set out. These days it may be difficult to find space and resources to plant out even 7 plants for each accession received.

Survival of accessions (seed lots or sets of scions or seedlings) was dependent on several factors and "losses" occurred (for the Hørsholm arboretum) as not every seed lot collected was allotted to the Arboretum in Hørsholm. At this stage there was a 48% loss of the Japanese material and a 20 % loss of the Korean material. Losses also occurred at the propagation stage (46 % for Japan and 42 % for Korea). Unfortunately, we do not have an account of how much seed was received in each accession and no way of knowing if the failed seed lots were largely a result of only a few seed per lot or very low viability. This is a fault that could readily be corrected, and it is suggested that in the future the weight or number of seeds in seed lot be recorded. Losses also occurred in the nursery (20 % for Japan and 19 % for Korea) where apparently selection for the best genotypes of the Southern Scandinavian climate occurs. However, it is unknown how much of this is due to sloppy nursery practice or simply that the nursery was overwhelmed

by the large volume of material it had to process in the years following the expedition. Perhaps the nursery practices could have been more optimal, but it is impossible to make any judgement at this date.

Losses occurred after planting out into the collection (28 % for Japan and 19 % for Korea). In the end, survival at the Arboretum in Hørsholm was surprisingly similar in the material from Japan and Korea (37 % net survival for both Japan, and Korea). This was not the case for the Arboretum at Milde in western Norway where survival was much lower for the Korean material. As for other expeditions the pallet of plants surviving at the sites in Norway and Denmark was not identical. In order to ensure the survival of as many accessions as possible, it is important to spread the material for trial at a number of places.

A high percentage of the living accessions (85 % for Japan and 87 % for Korea) have been shown to be sexually mature in that they have been observed to produce flowers or fruit within the last three years. Statistically significant correlations between survival and latitude did not occur, using simple regression analyses. Probably altitude at the collecting sites played a significant role, especially for the more southerly sites (Sanda 1982) and variation in altitude was responsible. For the material from Japan, survival was almost identical in Milde, near Bergen in West Norway and in Hørsholm in Denmark. However, for the material from Korea the survival in Milde was about half of the survival in Hørsholm. It was suggested that the warmer summers in Hørsholm more closely match the original climate for the Korean material.

Plants, scions, and cuttings were also given away for testing at other public and private gardens and research institutes. Fifty-five percent of all propagated accessions from Japan were given away, while 77 percent were given away for the material from Korea. For many individual accessions more plants were given away than kept. In a few cases all the material from an accession was given away and none kept for the Arboretum. This especially happened when there were many accessions of a given species, but this was not always the case.

The records of plant material given away from the nursery are rather complete because a standard system of recording such plant transfers was established. In contrast recording the plant material collected as scions, cuttings or seed directly from the Arboretum's collection

was not standardized. The information was kept on diverse sheets of papers almost all of which were eventually lost. The recording of the transfer of such plant material has subsequently been improved, and is incorporated into the Arboretums database.

The development of commercial or amateur-spread material from the expeditions was small but typical for such collecting expeditions. The number was larger for the Korean expedition than for the Japanese expedition. The more continental and colder winter climate in Korea may have played a role, as many of the cultivars were developed in Sweden where the winter climate especially can be much colder than in Denmark. Furthermore before the expedition, many fewer plants had been introduced from Korea than from Japan. Development work is still going on at the Swedish Agricultural University. Perhaps if the development of horticulture cultivars was a priority at the Arboretum in Hørsholm more success would have occurred. However few wild plants are suitable for commercial use so one might expect only at most a few percentage of any expedition's material would be suitable for commercialization.

DANSK RESUMÉ.

Resultaterne fra de to nordiske Arboretsudvalgs indsamlingsekspeditioner til Japan og Korea i 1976 viste, at de fuldt ud opnåede det ønskede mål. Adskillige ting kunne dog være gjort bedre, specielt hvad angår den efterfølgende systematiske registrering og praktiske behandling af materialet. Derfor gives der herunder anbefalinger med henblik på kommende ekspeditioner.

Historien om planteintroduktioner for både Japan og Korea præsenteres. På det tidspunkt, hvor ekspeditionen fandt sted, havde Arboretet afprøvet mange flere accessioner fra Japan end Korea. Plantemateriale fra nordiske indsamlere (inklusive disse to ekspeditioner) resulterede gennemsnitligt i materiale, der havde større mulighed for at overleve i Danmark sammenlignet med materiale fra ikke-nordiske indsamlere. Ydermere viste det sig, at indsamlinger, der indeholdt større mængder frø, havde større mulighed for at overleve. Det er derfor vigtigt at registrere frømængden for hver modtaget accession. Denne information øger muligheden for at fastslå om en given proveniens er egnet eller ikke egnet. Desuden kunne antallet af frø, der spirede godt, registreres for hver accession. Optegnelserne af disse informatio-

ner er blevet bevaret i Arboretet i adskillige år men var ikke optegnet for ekspeditionsmaterialet fra 1977.

Ekspeditionernes fastsatte mål var at skaffe levende individer af vel dokumenteret (overvejende vild) oprindelse til de nordiske lande. Hvad Arboretet i Hørsholm angår, var begge disse ekspeditioner store succeser. Materiale fra den japanske ekspedition udgør 66 % af Arboretets levende accessioner fra Japan, mens materialet fra Korea udgør 75% af de levende accessioner fra Korea. For næsten alle disse accessioner kan man hente detaljerede beskrivelser af indsamlingsområdet i den rapport, der blev trykt i 1978 (Hagman *et al.* 1978 og Nitzelius *et al.* 1978).

Det blev foreslået, at forbedringer kunne være gjort hvis mindst 7 levende eksemplarer af hver accession blev udplantet i de levende samlinger pga. vanskeligheden ved at bedømme egnetheden af en given proveniens med kun et lille antal planter. Selv 7 planter kan antages at være et for begrænset antal til en seriøs test for tilpasningsevnen for en accession. Imidlertid var plads og personale begrænsende for, hvor mange planter der kunne udplantes. I dag ville det blive vanskeligt at finde plads og ressourcer til at udplante 7 planter for hver modtaget accession.

Overlevelsen af accessionerne (frøprøver, skud eller frøplanter) var afhængig af adskillige faktorer og 'tab' fandt sted fordi (hvad angår Arboretet i Hørsholm) hver indsamlet frøprøve ikke blev tildelt Arboretet i Hørsholm. På dette tidspunkt, hvor frøindsamlingerne blev fordelt, var der 48% tab for materialet fra Japan og 20 % tab af materialet fra Korea. Tab fandt også sted på formeringsstadiet (46 % for Japan og 42 % for Korea). Uheldigvis ved vi ikke, hvor meget frø der blev modtaget med hver accession og vi har ikke mulighed for at få at vide om de mislykkede frøprøver først og fremmest skyldtes et resultat af kun få frø pr. frøprøve eller meget lav levedygtighed. Denne fejl kunne let korrigeres, og det foreslås, at man i fremtiden vejer eller tæller frøet i frøprøverne. Tab skete også i planteskolen (20 % for Japan og 19 % for Korea) hvor der tilsyneladende sker en udvælgelse af de bedste genotyper for det sydlige Skandinavien. Det er dog uvist, hvor meget der skyldes sløset planteskolepraksis eller simpelthen at planteskolen var overvældet af den store materialemængde som skulle behandles i årene efter ekspeditionen. Måske skulle planteskolepraksis have været mere optimal, men det er ikke muligt at bedømme det på nuværende tidspunkt.

Tab forekom efter udplantning i samlingerne (28 % for Japan og 19 % for Korea). I Arboretet i Hørsholm viste det sig, at overlevelsen for materiale fra Japan var den samme som for materiale fra Korea (37 % nettooverlevelse for både Japan og Korea). Sådan var det ikke i Arboretet i Milde i Vestnorge, hvor overlevelsen var meget lavere for materialet fra Korea. Ligesom for andre ekspeditioner var paletten af planter, der overlevede i Norge og Danmark ikke identisk. For at sikre overlevelsen af så mange accessioner som muligt, er det vigtigt at sprede materialet til afprøvning på flere steder.

En høj procent af levende accessioner (85 for Japan og 87 % for Korea) har vist sig at være formeringsmodne, idet de er observeret med blomst eller frugt inden for de seneste tre år. Der kunne ikke vha simpel regressionsanalyse vises statistisk signifikante korrelationer mellem overlevelse og breddegrad. Muligvis spillede indsamlingsstedets højde en signifikant rolle, specielt for de mere sydlige lokaliteter (Sanda 1982). For materialet fra Japan var overlevelsen næsten ens i Milde, nær Bergen i Vestnorge, og i Hørsholm i Danmark. Men for materialet fra Korea var overlevelsen i Milde ca. halvt så stor som overlevelsen i Hørsholm. Grunden er muligvis, at de varme somre i Hørsholm stemmer mere overens med klimaet i Korea, hvor materialet kommer fra.

Planter, podekviste og stiklinger blev også givet til andre offentlige og private haver og forskningsinstitutter til afprøvning. 55 % af alle formerede accessioner fra Japan blev givet bort, mens 77 % af materialet fra Korea blev givet bort. For mange accessioner blev der givet flere planter væk, end der blev beholdt. I få tilfælde blev alt materialet fra en accession givet bort og intet blev tilbage til Arboretet. Dette skete især, når der var mange accessioner af en given art, men det var ikke altid tilfældet.

Optegnelsen over det plantemateriale, planteskolen gav bort, er temmelig komplet, fordi der blev etableret et standardoptegnelsessystem til at registrere sådanne planteoverførsler. Derimod var registreringen af, hvorvidt plantematerialet var indsamlet som podekviste, stiklinger eller frø direkte fra Arboretets samling ikke standardiseret. Informationerne var optegnet på diverse papirlapper, hvoraf de fleste er bortkommet. Registreringen af overførsler af sådant plantemateriale er efterfølgende blevet forbedret og inkorporeret i Arboretets database.

Der er kun i begrænset omfang foretaget forædling af materialet, men det er typisk for sådanne indsamlingsekspeditioner. Antallet af

kultivarer var størst fra Koreaekspeditionen. Det mere kontinentale og kolde vinterklima i Korea kan have spillet en rolle, da mange af kultivarerne blev udviklet i Sverige, hvor især vinterklimaet kan være meget koldere end i Danmark. Desuden var der inden ekspeditionen fandt sted blevet introduceret langt færre planter fra Korea end fra Japan. Forædlingsarbejdet fortsætter stadig på det svenske Landbrugsuniversitet. Hvis udvikling af kultivarer havde haft højere prioritet på Arboretet i Hørsholm, ville resultatet have været bedre. Imidlertid er det kun få vilde planter, der er egnede til kommercielt brug, så man kan kun forvente, at højst få procent af enhver ekspeditions materiale vil egne sig til kommercialisering.

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REFERENCES

Bengtsson, R. 1992. Faktablad från Projekt 80 – Nya träd och buskar. Lustgården 71: 39-44.

Clausen, H. 1997. Hørsholm Kirkegård. DDÅ Bind 15, p 9-54.

Dosmann, M. and P. Del Tredici 2003. Plant introduction, distribution, and survival: A case study of the 1980 Sino-American Botanical Expedition. BioScience 53:588-597.

Flinck, K.E. 1980. Magnoliahybrider och – hybridisering. Dansk Dendrologisk Årsskrift 5 (3): 10-41.

Hagman, M, L. Feilberg, T. Lagerström, J.E. Sanda 1978. The Nordic Arboretum Expedition to South Korea 1976. Department of Forest genetics, Forest Research Institute, Helsinki, Finland, 102 pp.

Jensen, N. 1994. Guide til Arboretet i Hørsholm. Dansk Dendrologisk Årsskrift 12: 1-237.

Lange, J. 1994. Kulturplanternes Indførselshistorie i Danmark. (Introduction History of Cultivated Plants in Denmark). Jordbrugsforlaget, Frederiksberg. 458 pp.

Leverenz, J.W., K.H. Nielsen and B. Jacobsen. 2005. Timing and abundance of flowering and fruiting in the Hørsholm Arboretum from September 2003 to October 2004. Forest & Landscape Working Paper 7-2005 Forestry. 30 pp.

Leverenz, J.W. 2006. Timing and abundance of flowering and fruiting of woody plants in the Hørsholm Arboretum – results from the first two years. Forest and Landscape working paper 15-2006 Forestry. 35 pp.

Lighty, R.W. 2000. An assessment of ornamental plant introduction in the nor-for-profit sector. In: Proceedings: Plant Exploration: Protocols for the present, concerns for the future. (J.R. Ault Ed.). Pp 14-22. Chicago Botanic Garden publ., Glencoe, IL, USA.

Lorentzon, Kenneth, 1992. *Betula ermani* Cham. 'Mount Apoi' – a new *Betula*-clone. – Lustgården 72: 20-22.

Meyer, P.W. 2000. Plant Collecting Expeditions: A modern perspective. In: Proceedings: Plant Exploration: Protocols for the present, concerns for the future. (J.R. Ault Ed.). Pp 7-13. Chicago Botanic Garden publ., Glencoe, IL, USA.

Nitzelius, T. 1968. Japanska träd i Göteborgs Botaniska Trädgård och Arboretum. Lustgården 1966-1967: 70-113.

Nitzelius, T. 1978. Gedanken über Winterhärte bei eingeführten Gehölzen anlässich eines Besuches auf Ullung-do, Korea. Rhododendron und Immergrüne Laubegebölze Jahrbuch 1978 (Deutchen Rhododendron Gesellschaft). Pp. 7-19.

Nitzelius, T. 1983. Träd i när och fjärran. Äventyr och fynd på botnaiska färder. LTs Forlag Stockholm. 180 pp.

Nitzelius, T. 1990. The Ullung rowan. Lustgården 70 (1989) supplement pp 1-24.

Nitzelius, T., R. Bengtsson, F.G. Christensen and M. Sandvik 1978. The Nordic Arboretum Expedition to Japan 1976. Botanical Garden, Gothenburg, Sweden, 44 pp.

Sanda, 1982. Korea-planter i Norge. Planteskoledrift og dendrologi 28-29: 13-31.

Salvesen, P.H. 2004. Trær og busker fra Øst-Asia i Arboretet på Milde. Årringen 2004: 4-24.

Schlätzer, G. 1970. Strejftog i Økenarboretet. Dansk Dendrologisk Årsskrift 3: 143-158.

Søndergaard, P., T. Benedikz, R. Bengtsson, M. Hagman, T. Nitzelius, O. Reisæter, B. Søegaard, P.M.A. Tigerstedt, P. Wendelbo, S. Ødum 1977. Nordisk Arboretssmarbeide 1972-1977 rapport om resultater etter de förste fem år. (Nordic Arboetum co-operation 1972-1977, report on the first five years' results). 46 pp.

Tredici, P.D. 2000. Plant exploration: A Historic Overview. In: Proceedings: Plant Exploration: Protocols for the present, concerns for the future. (J.R. Ault Ed.). Pp 1-5. Chicago Botanic Garden publ., Glencoe, IL, USA.

Widriechner, M.P., E. R. Hasselkus, D.E. Herman, J.K. Iles, J.C. Pair, E.T. Paparozzi, R.E. Schutzki, and D.K. Wildung 1992. Performance of landscape plants from Yugoslavia in the North Central United States. J. Environ. Hort. 10:192-198.

Widriechner, M.P., J.B. Hebel, D.E. Herman, J.K. Iles, G.J. Kling, A.P. Ovrom, J.C. Pair, E.T. Paparozzi, S.R. Poppe, N. Rose, R.E. Schutzki, C. Tubesing and D.K. Wildung. 1998. Performance of landscape plants from Northern Japan in the North Central United States. J. Environ. Hort. 16: 27-32.