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Plant Exploration: Protocols for the Present, Concerns for the Future

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Symposium Proceedings

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Edited by:
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Plant Exploration: Protocols for the Present, Concerns for the Future

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Contents

About the Speakers

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Peter Bristol is the Director of Horticulture at The Holden Arboretum. He began his career as an assistant curator at The Morton Arboretum. His seed collecting expeditions have taken him to England, South Korea and China. He is the founder of the North America China Plant Exploration Consortium (NACPEC).

Dr. Peter Del Tredici is the Director of Living Collections at the Arnold Arboretum of Harvard University. Previously at the Arnold Arboretum, he held the positions of plant propagator and editor of *Arnoldia*. In addition, he is Curator of the Larz Anderson Bonsai Collection and a lecturer in the Department of Landscape Architecture at the Harvard University Graduate School of Design.

Dr. Thomas Elias is the Director of the U.S. National Arboretum. His specialties are the systematics of woody plants of temperate regions of the world, biogeography and conservation of rare and endangered plants and habitats. He has made numerous expeditions to Russia and also to China as well as arranged botanical exchange programs with both of those countries.

Dr. Edward (Ned) Garvey is Plant Exchange Officer at the USDA/ARS/National Germplasm Resources Lab in Beltsville, Maryland. His responsibilities include developing and supporting plant collection trips. He has led or participated in plant explorations in the United States, Mexico, China, Albania, India and Israel.

Dan Hinkley is co-owner of Heronswood Nursery in Kingston, Washington, where he grows and evaluates seeds collected on numerous expeditions. During the past decade he has mounted a number of privately funded plant collecting expeditions to China, Japan, Korea, Nepal, Chile, Tasmania and Mexico. The current edition of the Heronswood Nursery catalog lists 2,800 plants.

Rick Lewandowski is the Director of Mt. Cuba Center for the Study of Piedmont Flora after many years at the Morris Arboretum of the University of Pennsylvania, where he was the Director of Horticulture and Curator of the Living Collections. He has led several NACPEC sponsored explorations to China, South Korea and the Kingdom of Bhutan in the Himalayas.

Dr. Richard (Dick) Lighty retired in 1998 as the Director of Mt. Cuba Center for the Study of Piedmont Flora. Previously, for 16 years he was in charge of the Longwood Graduate Program in Public Horticulture Administration at the University of Delaware. He has participated in expeditions to Korea, Japan, Central and South America and Nigeria. He is the recipient of numerous awards for his distinguished work in the field of horticulture.

Paul Meyer is the F. Otto Haas Director of the Morris Arboretum of the University of Pennsylvania. He also teaches Urban Horticulture in the University of Pennsylvania's Landscape Architecture and Regional Planning Department. He is a leader in the field of plant exploration and evaluation, having completed nine trips to China and Korea.

Dr. John Randall is The Nature Conservancy's Invasive Weed Specialist and is based in the Department of Vegetable Crops and Weed Science at the University of California-Davis. He provides information, advice and referrals on pest plant problems to The Nature Conservancy stewards and other land managers across the U.S. He also helps develop management policies and conducts research on weed biology and control.

Craig Regelbrugge is the Director of Regulatory Affairs and Grower Services for the American Nursery and Landscape Association. He represents the nursery industry on the National Plant Board's Quarantine and Nursery Standards Committee. He is also the Nursery/Greenhouse Commodity Chair for the North American Plant Protection Organization's U. S. industry advisory group.

Dr. Sarah Reichard has been an assistant research professor in the College of Forest Resources at the University of Washington since 1997. Her Ph.D. work is focused on the assessment of invasive potential in woody plants introduced into North America. She is a conservation biologist and is involved in programs on both invasive plants and on the growth and propagation of rare plant species.

Charles Tubesing holds the position of Horticulturist at The Holden Arboretum. He has previously worked as plant propagator for the Missouri Botanical Garden and the Botanical Garden of the University of British Columbia. He has participated on two plant collecting expeditions to China organized by NACPEC.

Barry Yinger is the New Products Resources Manager for Hines Nurseries Inc. of Irvine, California, a large wholesale nursery with growing facilities in California, Texas and Oregon. He searches for plants new to Hines in the United States and Asia. Many of these plants are evaluated in Pennsylvania, where he lives and gardens on the farm where he was born. He has been on innumerable collecting trips to Japan and elsewhere throughout Asia.

Foreword

This conference convenes as our society experiences a period of unprecedented globalization. Most of the world has almost instant access to information, technology and consumer goods: we can make a purchase or be in touch with an acquaintance halfway around the world with the click of a button. This globalization is much more than just free trade agreements and e-mail; it has also impacted our environment. A hundred years ago the United States first entered plant exploration, and while the physical fieldwork of such an expedition has changed comparatively little, our society has changed dramatically.

Plant exploration provides the horticulture industry, public gardens, the scientific community, arboreta — and ultimately the public — with more diverse and hardier germplasm that increases the breadth of plants available for research and landscape use. The issues fundamental to plant exploration presented in this symposium included protocols for working with foreign governments and scientists, evaluating plants from expeditions, controlling the importation of invasive plant species, maximizing the scientific value of the plants and ensuring the preservation and transfer of plants to the commercial trade.

As more and more institutions and individuals undertake exploration, it is critical that they be broadly knowledgeable about the legal, scientific and ethical issues of foreign plant collecting. Most critical is the likelihood of increased national and international restrictions on the importation of plants to the United States. In February 1999, the Clinton Administration issued an Executive Order calling for a review and possible revision of the regulations under which plants and animals are brought into the United States. The International Convention on Biological Diversity, while not ratified by the United States, still impacts international plant exploration since the countries our explorers largely visit have signed this treaty. The purpose of this conference was to be a catalyst for increased awareness and continued discussion of the issues relating to plant exploration, to bring together the leaders of public and private organizations who are or would be affected by these regulations and to search for viable solutions.

The remarkable successes of international plant exploration have brought great improvements to the food we eat (e.g., soybeans, wheat and rice) and to the plants we enjoy (Magnolias, Daffodils and Rhododendrons). While most international-based introductions of new plants have been problem-free, there are a number that have caused extensive damage to native habitats. As a result, some argue to ban the importation of new plants.

New pests and diseases on agricultural crops and changing climatic conditions warrant the importation of plants that may prove more resistant and better adapted. Consequently, it is arguable to continue allowing plants to enter the United States. The irreversible loss of natural habitat around the globe also justifies plant importation. Botanic gardens, arboreta, governmental agencies, and even commercial firms can act as

reservoirs that hold valuable germplasm, thereby assisting in and being a partner of a global conservation effort.

One solution might be to allow new plants to continue to enter the United States through regional centers of excellence. Such non-biased groups or organizations could systematically screen new introductions using existing models to evaluate, over a series of years, the reproductive capabilities of newly acquired plant species on a region-by-region basis. Obviously, a system such as this would need political, scientific, and financial support.

We stand at a crossroads of economic pressures, human needs, environmental understanding, and cultural values. The need for a balanced examination of issues revolving around the importation of plants from abroad is imperative. This conference and its proceedings are intended to enrich the continuing debate.

We are pleased to have organized and hosted this important symposium as the first joint effort by the two public plant-collecting collaboratives in the United States. The Midwest Plant Collecting Collaborative (MWPCC) and the North American and China Plant Exploration Consortium (NACPEC), include among their members the botanic gardens and arboreta most actively involved in international plant exploration today.

We are deeply grateful for the support of the Daniel F. and Ada L. Rice Foundation, which has long supported research efforts and symposia relating to the natural world.

Galen Gates, Chicago Botanic Garden
Kevin Conrad, United States National Arboretum

Plant Exploration: A Historic Overview

Peter Del Tredici
Arnold Arboretum of Harvard University, Jamaica Plain, Massachusetts

Introduction

The domestication of food plants, the very foundation of human civilization, is inseparably linked to the process of plant exploration, which is defined as the collection of seeds or plants in one geographical area and their transportation to another (Fairchild, 1939; Heiser, 1990; Evans, 1993). While the methods of plant exploration have changed dramatically over the last several thousand years, the basic economic motivation for plant exploration has remained more or less constant. People are always looking for new and improved sources of food, medicine, wood, fiber, and ornamentation.

Traditionally plant exploration was a time-consuming process that mainly involved the human, animal or wind-powered transportation of seeds. With every improvement in the technology of transportation, from horses, wagons, and ships to trains, cars, and airplanes, the efficiency of the process has steadily improved. Ocean crossings that once took many months are now done in a day or less, and arduous treks across successive ranges of mountains that took weeks to accomplish are now routinely done by car in a matter of days (Wilson, 1913). The introduction of the Wardian case in 1836, in conjunction with improved ship design, was a major breakthrough in plant exploration that allowed the rapid and safe transport of living plants across the oceans.

Plant exploration is about the marriage of the practical and the theoretical—the fusion of pure and applied botanical research. Plant exploration is also about hard work and discipline, both in terms of putting up with the rigors of fieldwork, as well as staying focused in the herbarium while trying to identify plants. And finally, despite of all the careful planning, plant exploration is about luck: being in the right place at precisely the right time; spotting a solitary seedling in a crowded forest understory; or taking the wrong turn to find the right plant. The annals of plant exploration are filled with stories of only one plant surviving the rigors of transport, which then goes on to become a legendary cultivar, propagated a million fold. As romantic as such stories are, they underline the fact that many important horticultural crops have a genetic base limited to a one-time seed collection from just a few individuals.

The Collaborative Nature of Plant Exploration

The great plant explorers of the past were generally funded in a number of different ways: by subscription of wealthy patrons; by private nurseries speculating on the potential profitability of the collections; or by governmental entities interested in large-scale, long-term agricultural development. The nature of the financial support has always exerted a major influence on the nature of the collections. Frank Meyer, who collected for the USDA in China in the early 1900s, focused his energies on agricultural crop germplasm, to the frustration of the Arnold Arboretum's Director, Prof. C. S. Sargent, who felt that Meyer should also be doing botanical collecting as well. The truth of the matter is that David Fairchild, the chief of the USDA Foreign Seed and Plant Introduction Division, was right in limiting his collectors to economic plants. In general, collecting trips with clear focus and purpose are much more successful than general inventory trips (Cunningham, 1984; Sutton, 1970).

The plant exploration process is collaborative by nature, with different individuals and institutions playing different roles. For starters, every good field collector needs to collaborate with a taxonomist working in the herbarium. Very few collectors are good at both field and herbarium work. Robert Fortune had John Lindley, Armand David had Adrien Franchet, and E. H. Wilson had Alfred Rehder (Spongberg, 1990). The problem of determining the proper identification of a plant is one of the more complex aspects of the plant exploration process; unfortunately, it is also one of the least appreciated and understood. Working in the field with plants in fruit, one can usually get an identification down to the genus level, but getting it down to species can be very difficult, particularly within the highly diverse families such as the Rosaceae or Ericaceae.

In general, it is always a good idea to insist that one's host institution provide a botanist who is familiar with the local flora and can provide tentative identifications in the field. These field identifications, together with follow-up work on herbarium specimens, will allow one to make accurate determinations back at home. Without access to the resources of a major botanical institution, one often needs to seek out the advice of an expert who is willing to look at the herbarium specimens. It is of paramount importance to put the correct name on a plant before distributing it. Plants that leave the nursery with the wrong name, with a number, or with "sp." (species) attached to their labels are usually stuck with those appellations for the rest of their entire lives.

The relationship of botanical gardens to the plant exploration process is, and should be, distinct from that of commercial nurseries. In the case of the former, taxonomic and ecological research is as important as the plants themselves. For the latter, the distribution of plants typically has a much higher priority than their taxonomy. Given this complementary division of both labor and interest, it makes sense for botanical gardens and nurseries to cooperate with one another on the introduction of new plants.

Plant exploration clearly means different things to different people, and organizations that engage in it, be they academic or commercial, should be honest with themselves about what their goals are. In a very real sense, this symposium provides all of us with the opportunity to think hard about what we do, and to ask some hard questions:

- What do we do about the future of plant exploration? Given the alarming rate at which natural habitats are being destroyed around the world, modern plant collectors have a minimum obligation to document with herbarium specimens and accurate field notes the composition of the forests in which they work. For all we know, any collecting trip to a given area could be the last.
- Are we respecting the culture of the country in which we are working? That is to say, are we giving the host country the credit it deserves for facilitating the collecting? Or are we making it look like we did all the work—"trophy hunting"— without any assistance from our host?
- Are we compensating the host country adequately? By this not meaning just financially, but also by providing training and support for local scientists and field workers in resource management and habitat preservation.
- Are the plants we are introducing potentially invasive? If nurseries and botanical gardens do not police themselves in this regard, then state and federal agencies should and will do so accordingly.
- Are we inadvertently introducing associated pests or diseases? This is particularly relevant when it comes to digging up plants from the field. There should be absolutely no compromising the USDA regulations on the question of full inspection of imported plants and seeds, as well as subsequent and continued scrupulous inspection of the germplasm by the institutions growing the plants.

On the subject of invasive plants, it is important to keep in mind that many of the worst ones, particularly among herbaceous species, were not intentionally introduced and are not offered for sale by nurseries. As for woody plants, it is important to remember that many of the species now threatening our natural areas were originally planted along highway and railroad right-of-ways with the encouragement and subsidy of various state and federal agencies from the 1930s through the 1970s. Not surprisingly, the massive erosion control planting of a given species often triggers an "invasion" by that plant 10 or 20 years later.

From the biological perspective, exotic plant "invasions" can be viewed as symptoms of human-induced environmental degradation rather than a cause of it. Invasive species, by definition, have broad ecological adaptability that allows them to take advantage of the "chaos" that ensues when existing plant communities are destabilized by some form of anthropogenic disturbance. Defining disturbance quite broadly includes the deleterious effects of all kinds of pollution, including acid rain, ozone, deicing salts, fertilizer runoff, and global warming (Hobbs and Huenneke, 1992). As with so many things in life, the ever-expanding human population is the real culprit; exotic plants are convenient scapegoats.

The Concept of Introduction

Another assumption that plant explorers need to look closely at is the concept of taking credit for specific plant introductions — the question of who introduced what, where, and when. Personally, I find it annoying to read about North American plants in British gardening books because they attach so much importance to the date at which it was first introduced into Britain, as if this is the point at which a plant's "real" history begins. I can only imagine how the Chinese feel about the descriptions of "their" plants in our books and nursery catalogues, particularly when so many of them are named after Western botanists or wealthy patrons of horticulture (Bretschneider, 1981).

When horticulturists engage in infighting over who should get credit for introducing a particular plant, especially a wild plant, it only serves to divert attention from the much more important issue of biological conservation. The well-known case of *Metasequoia glyptostroboides*, the dawn redwood, offers a pertinent example. The Arnold Arboretum has always maintained that it introduced the tree into general cultivation, generally neglecting to mention the fact that the seeds distributed in 1948 were provided by Professor H. H. Hu, the describer of the species. The Arboretum's actual role was to respond positively to Hu's requests first for $250 to fund a collecting trip, then to subsequently distribute the seed free of charge to botanical gardens throughout the world (Arnoldia, 1999).

Arguing about whom should get credit for introducing a particular plant is a holdover of the colonial mentality that American horticulturists have slavishly copied from the British. In today's world, plant explorers need to acknowledge the work done by scientists in their own countries with their native flora. The days of the great white hunter are gone. Indeed, competition to be the first botanical garden or nursery to introduce a "new" plant into cultivation has often led to the premature release of many inadequately tested plants of uncertain horticultural value, particularly among herbaceous perennials and grasses. Holding back on the commercial introduction of a plant until adequately tested is one thing that can be easily done to minimize the chances of introducing an invasive species. In my opinion, the minimum test period for herbaceous plants should be five years and for woody plants, 10 years.

Conclusion

As a result of the technological changes that have occurred during the last century, plant exploration is now easier to pursue than it has ever been before. In the past, the expense and strenuousness of the process limited who could participate in plant exploration expeditions to young men and wealthy institutions. These constraints have now been effectively removed. Anyone can now go plant hunting, and everyone seems to be doing it. Like it or not, plant exploration has been democratized.

Many of us at this symposium grew up with the assumption that plant exploration was an altogether positive activity for botanical gardens and nurseries to engage in. And so it is with a certain measure of surprise that we find ourselves on the defensive, having to justify not only the past actions of our predecessors, but also the importance of continuing to introduce plants in the future. In the trendy language of the 1990s, this change in attitude is a classic paradigm shift. The challenge facing us today is to come up with guidelines for responsible plant exploration that will carry us into the 21st century. The economic motives that have driven the plant exploration process in the past must now be balanced with the conservation issues of the present and future.

In conclusion, a quotation about plant exploration from Augustine Henry is perhaps even more relevant today than when it was written in 1893 (Spongberg, 1990): "Money is not what is wanted, but time, oceans of time. Nothing astonishes people at home so much as the fact, a real fact, that in countries like China, you cannot do everything with money. Patience is more valuable."

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Figure 1. Alfred Rehder, E. H. Wilson, and Professor C. S. Sargent in the Arnold Arboretum. Photograph taken in August 1916. From the archives of the Arnold Arboretum.

Figure 2. Joseph Rock, fifth horseman on the right, with part of his Moslem escort on the shores of Lake Kokonor, Tibet, elevation 10,700 feet. Photograph taken on September 24, 1925. From the archives of the Arnold Arboretum.

Figure 3. A "hostel" at Fang-xian, Hubei Province, China, where E. H. Wilson spent a very uncomfortable night. *Pinus armandii* is in the background, elevation 7,000 feet. Photographed on June 16, 1910, by E. H. Wilson. From the Archives of the Arnold Arboretum.

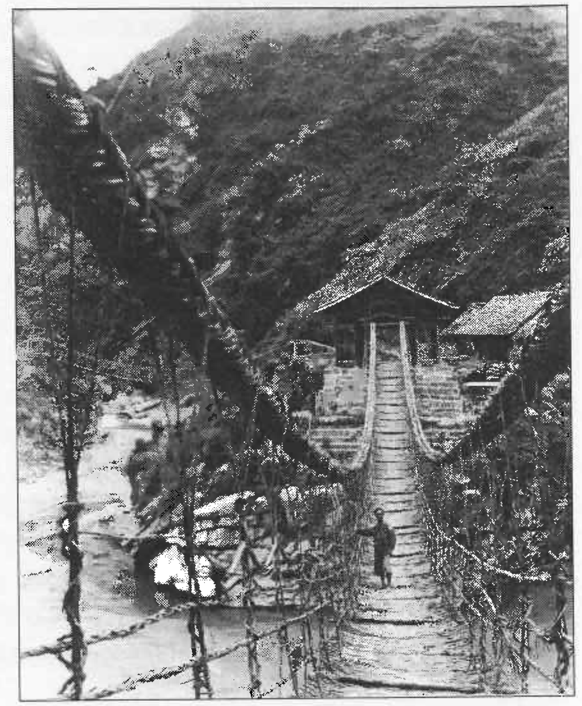

Figure 4. A bamboo suspension bridge, laid on eight cables, each a foot in diameter and suspended from two similar cables on either side; floor is of rough wicker work. Photographed on August 12, 1910, by E. H. Wilson in "Shih-chuan Hsien," Sichuan Province, China, elevation 2,700 feet. From the archives of the Arnold Arboretum.

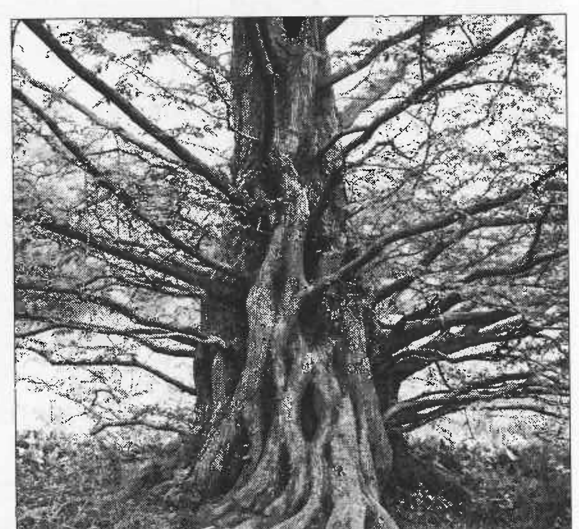

Figure 5. One of the original introductions of *Metasequoia glyptostroboides*, #524-48-AA, growing at the Arnold Arboretum. Photographed on May 15, 1988, by Racz and Debreczy. From the archives of the Arnold Arboretum.

Plant Collecting Expeditions: A Modern Perspective

Paul W. Meyer
Morris Arboretum of the University of Pennsylvania, Philadelphia, Pennsylvania

The greatest service which can be rendered to any country is to add a useful plant to its culture. Thomas Jefferson, 1790

Introduction

Jefferson's words of nearly 200 years ago still ring true today; with the accelerating loss of natural habitat and biodiversity, the preservation of wild-collected, scientifically documented plants in botanic gardens has never been more important. Rapidly emerging issues such as climate change, global warming, increasing urbanization, and the potential of genetic engineering all add to the critical importance of plant exploration. As our urban and suburban environments become more stressed, and as the rate of climatic change increases, the relative importance of non-native plants in our human landscapes will only increase.

But what about issues such as genetic property rights, the preservation of a sense of place, and the introduction of invasive species? It is essential that we balance these concerns with the potential benefits of plant exploration when we consider protocols for plant expeditions of the future.

Plant Exploration Objectives

Plant exploration today and in the future must be driven by clearly defined objectives. Targeted collecting areas should be based on climatological reviews, species distribution, and the condition of the remaining natural habitat. Individual species should be collected for the purpose of broadening the genetic pool for increased vigor, cold-hardiness, heat tolerance, and adaptability to stressful conditions.

The North American China Plant Exploration Consortium (NACPEC), a leader in plant exploration initiatives in China, provides a model for establishing and achieving plant exploration objectives for modern expeditions. The group was founded in 1990 for the purpose of fostering academic interactions and the exchange of genetic material between North American and Chinese botanic gardens. In 1991, Peter Bristol of the Holden Arboretum, Lawrence Lee of the U.S. National Arboretum, and Paul Meyer of the Morris Arboretum visited a number of botanical institutions in China to explore their interest in such exchanges. The result was a series of plant exploration expeditions that occurred throughout the last decade. In all of the explorations, NACPEC has strived to maintain the highest level of professionalism and to ensure that the exchanges are equally beneficial to our Chinese colleagues.

To target a potential collecting area, NACPEC identifies areas where the climate best approximates that of northeastern United States, the location of most of the North American gardens represented in NACPEC. Seasonal rainfall, mean seasonal temperatures, and ultimate summer high and winter low temperatures are carefully reviewed. Priority species are identified, and in some cases, specific parts of their natural range are targeted for maximizing selected traits, such as heat or cold tolerance and/or drought resistance.

When targeting individual species, NACPEC typically uses the following objectives:

Broadening the genetic pool of known species
Perhaps one of the most important objectives of modern-day plant exploration is the introduction of new genetic material of species already widely grown and cultivated in this country. There are a number of potential benefits, including increased vigor, cold-hardiness, and heat tolerance.

Increased vigor
Many common but valuable landscape plants introduced from abroad are showing loss of vigor from successive generations of inbreeding. For example, poor vigor in some lines of kousa dogwood (*Cornus kousa*) has been attributed to this problem. Dr. Elwin Orton of Rutgers University, while doing extensive hybridization work with kousa dogwood and our native common dogwood (*Cornus florida*), noted poor vigor and a high rate of albinism—both signs of inbreeding. "Growers are urged to exercise caution in the selection of their seed source for growing seedlings of this species," reported Dr. Orton, "as the seedling material in commerce today exhibits tremendous variation in plant vigor and quality. I believe that the seed source presently used, in some cases, represents a relatively narrow genetic base as a result of brother-sister matings among seedlings that trace to a single introduction of seeds collected abroad from a limited number of plants" (Orton, 1985). In recent years, a number of new, wild-collected accessions of kousa dogwood have been added to botanic garden collections. These new plants exhibit great vigor and variation in garden characteristics.

Paperbark maple (*Acer griseum*) is another example of a narrow gene pool and consequent lack of vigor in cultivation. Most paperbark maple plants in the U.S. trace back to a narrow collection made by E. H. Wilson for the Arnold Arboretum at the turn of the century. Recent new introductions collected by NACPEC in Hubei, China, however, are showing exceptional vigor—for instance, a Morris Arboretum plant from this wild-collected source grew 34 inches last year, an exceptional rate for this species.

Increased cold-hardiness
Broader genetic representation is also useful in selecting forms that might be more winter-hardy. In 1984, a group of gardens, led by the U.S. National Arboretum, collected plants from several South Korean islands located in the Yellow Sea, just above the 38th parallel. These islands are home to the northernmost population of Japanese camellia (*Camellia japonica*), believed to be the most cold-hardy of this species. Since then, laboratory tests and field studies have supported this belief, and collaborative work in

selecting promising Japanese camellia cultivars continues. The most cold-tolerant individuals could be introduced as clones or used as a source of increased cold-hardiness in breeding programs.

The future of Japanese camellia on these islands is precarious, however. While the local people recognize the beauty of individual specimens and fence them off to protect them from the goats that heavily graze the land, natural reproduction of camellia no longer occurs. It is therefore only a matter of time before this genetically important population disappears.

Increased heat tolerance
Just as collectors can go to the northern and coldest part of a species' natural range to find cold-hardy plants, we also can go to the hotter southern ranges of northern species to find forms that might be more heat-tolerant. For instance, Manchurian fir (*Abies holophylla*), a species that naturally occurs in low elevations in parts of South Korea where summers are very hot, appears to be one of the best heat-tolerant firs for the Philadelphia area. Early evaluations of plants collected as seed in 1981 are very encouraging.

Increased tolerance of stressful urban and suburban conditions
It has been well documented that stressful sites encourage natural selection processes that increase the stress tolerance of the plants in those sites. For that reason, we seek out naturally stressful sites that mimic urban environments, in search of especially stress-tolerant plant populations.

A 1993 NACPEC expedition conducted in Heilongjiang, China, found a population of *Maackia amurensis* growing in dry, rocky soils that periodically flood. In addition, *Maackia* is a legume that supports nitrogen-fixing bacteria. This combination of traits makes it a good candidate for use in urban tree pits, where plants must withstand poor soils, drought, periodic flooding, and anaerobic soil conditions.

During the 1980s, several collections of Goldenrain tree (*Koelreuteria paniculata*) were taken from a population growing on an exposed beach along the Yellow Sea in South Korea. There, the plants were subject to high winds, salt spray, drought, seawater inundation, intense sun, and reflected heat—another stressful natural habitat that mimics urban planting sites. Trees representing this population are now growing well in the Morris Arboretum parking lot, demonstrating their heat- and drought-tolerance.

Introduction of species with insect and disease resistance
A key objective of modern plant exploration is the introduction of plant species with natural resistance to insect and disease problems; the use of these species is vital to integrated pest management programs, which help reduce reliance on toxic pesticides. Resistant species can be used just as they occur in nature or they can be used in controlled hybridization programs. Documented botanic garden collections are essential to any screening or breeding programs—programs focusing on resistance to chestnut blight, Dutch elm disease, hemlock wooly adelgid, anthracnose on dogwood, bronze

birch borer, and black spot resistance in roses all have made use of collections grown from plant explorations.

As wooly adelgid on Canada hemlock (*Tsuga canadensis*) became increasingly problematic throughout the northeastern U.S., it became evident that botanic garden specimens of Chinese hemlock (*Tsuga chinensis*) were quite resistant to this pest. Representative material in this country was limited, however, until recent NACPEC collecting trips to China by Rick Lewandowski and Ned Garvey made material available for breeding and selection of adelgid-resistant lines.

Although we cannot anticipate what future pest problems might arise, it is clear that the wild-collected, scientifically documented genetic resources of botanic gardens will be needed. Furthermore, it is likely that advanced genetic engineering will only increase the important genetic resource and breeding selection of resistant individuals.

Conserving rare species

Plant species are best preserved through habitat preservation, but in many situations, this might not be possible. In such cases, *ex situ* preservation is a viable alternative. Through its exchange program with Nanjing Botanical Garden, the Morris Arboretum is conducting a germplasm collection of the endangered species hardy rubber tree (*Eucommia ulmoides*). This species is very important in traditional Chinese medicine and is being collected in the wild to extinction. Because it is almost impossible to protect wild plants in China, garden collections are an important alternative. Meanwhile, research continues on the curative powers of the hardy rubber tree. As scientists learn more about its uses and functions, the importance of this genetic library could grow.

Other species are naturally rare and are being pushed to the edge of extinction through habitat destruction. When we hiked the forest of Hubei for three weeks in 1994, we spotted two trees of *Emmenopterys henryi,* a beautiful and rare Chinese species with dark green, glossy leaves and white flower clusters the size of a dinner plate (Meyer, 1995). We collected seed, and the plants have been growing successfully in Chinese and North American botanic gardens. These selections now represent a significant genetic reservoir.

Selecting new garden forms

Gardeners are always in search of new variants to add aesthetic richness to the garden. At the Morris Arboretum, we now have wild-collected, documented collections of kousa dogwood from China, South Korea, and Japan. We have noticed a wide variation in flowering time, flower density, and the size and shape of the bracts. Similarly, specimens of *Acer pseudosieboldianum* exhibit diverse autumn color ranging from reds to yellows, all of which are clear and bright. And the flowers of Korean rhododendron (*Rhododendron mucronulatum*) grown from Korean seed range from muddy magenta to clear lavender. Each of these characteristics provides opportunity for cultivar selection. Plant explorations of the past 20 years have broadened the diversity of botanic garden collections, thereby increasing the potential for the selection of superior individuals for clonal introduction and breeding.

Introducing new species

In 1879, after ascending the Yangstze River as far as Inchang, plant explorer Charles Maries reported that all the Chinese plant species of any merit had already been introduced. His word was widely accepted for more than 20 years—in fact, in 1899, when Ernest Wilson was sent to China by Vietch Nursery in England in search of the dove tree (*Davidia involucrata*), he was told, "Stick to the one thing you are after, and do not spend time or money wandering about. Probably almost every worthwhile plant in China has now been introduced" (Wilson, 1929). Fortunately, Wilson did not follow these directions and went on to introduce more than 1,000 new plant species during the next 11 years, literally changing the face of Western gardens (Coates, 1969).

Until the recent round of plant exploration, similar attitudes prevailed. Yet in our limited travel in Taiwan, Korea, and China we have encountered countless variants of known species, and several species that are virtually unknown in Western gardens. A quick review of the modern Chinese flora gives us an inkling of the species variation in China. For example, in Fang Wen-Pei's monograph of maples, he acknowledges 143 species (Fang, 1981). Of these, fewer than 10 are readily found in American nurseries. Although a few more species can be found in botanic garden collections, that still leaves more than 100 species that are not represented in North American botanic gardens.

It is not desirable nor is it practical for all of these species to be grown in botanic gardens, but field surveys are an important step in documenting these species through herbarium specimens and for evaluating their potential contribution to American gardens and to plant sciences in general.

Guidelines for Collectors

Now, more than ever, collectors must act diplomatically and in an environmentally responsible manner. Usually, this requires a long-term program that includes both genetic and academic exchange. Such an exchange agreement involves obtaining official permission from the host nation and acknowledges that collections will be made in keeping with the intent of the International Convention on Biological Diversity.

Additional standards that should always be upheld:

- Conduct field collecting in a professional manner; scientific documentation must include thorough field notes and herbarium voucher preparation.
- Honor any site restrictions imposed by the host and share collections, data, and field knowledge with the host.
- Adhere to conservation ethics and do not, in any way, harm a natural population.
- Before bringing plants back into the country, contact the appropriate officials (APHIS) to discuss regulations and procedures. While it is not uncommon to hear plant smugglers boast of their successes, the smuggling of plants is both illegal and immoral. Thoroughly clean and examine all material to be imported; declare all material for inspection and observe all CITES regulations.

- After the trip, be sure to credit host institutions in presentations and papers, while being respectful of the local culture and conditions. Most important, be responsive to future requests from your hosts.
- Post-trip evaluation of the plant material is a critical part of any plant exploration effort; however, evaluation results will vary from region to region. Camellias that are hardy in Philadelphia might not be hardy in Cleveland. Similarly, what appears to be a well-behaved street tree in Chicago could be a notorious weed in Atlanta. For that reason, local testing is important; any new species should be evaluated over many years for general adaptability, garden merit, disease and insect resistance, and potential for invasiveness.

A Balanced Approach

For thousands of years, introduced plants have made outstanding contributions to the health, culture, environment, and economies of human societies. Today, changing political and environmental conditions are bringing into question the processes of plant exploration, evaluation, and introduction. The wholesale destruction of native habitats makes the garden preservation of plant species all the more urgent, while the increasing awareness of the destructive potential of invasive species raises flags of caution.

It is essential that we continue to cultivate our native floras and to develop a strong sense of place. At the same time, introduced plants are an important part of our cultural history and play a key role in the greening of our constructed environments and post-industrial landscapes. Careful study and a balanced approach are needed to begin to resolve these environmental dilemmas.

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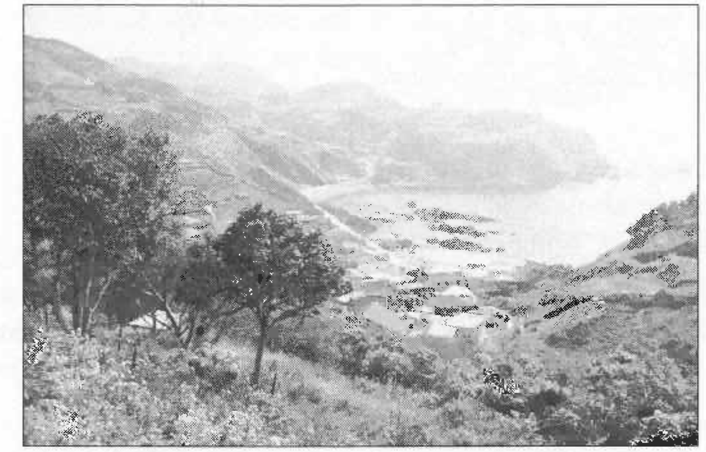

Figure 1. This grove of *Camellia japonica* is part of the northern-most population of this species. Preliminary testing of seedlings grown from seed collected on this site suggests that they are more winter hardy than others already in cultivation.

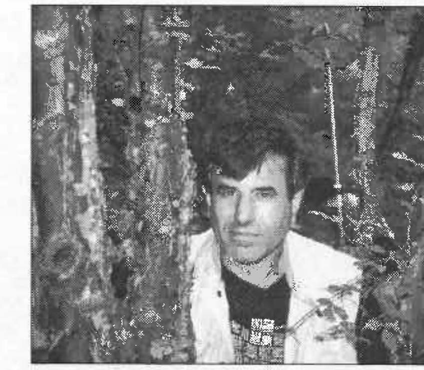

Figure 3. Peter del Tredici (from Arnold Arboretum, U.S.A.) proudly stands with a fine wild specimen of *Acer griseum* growing on Wudang Mountain, Hubei, China. Collections made on this site are the first made by Americans since the turn of the century. Seedlings grown from this collection show remarkable vigor thus far.

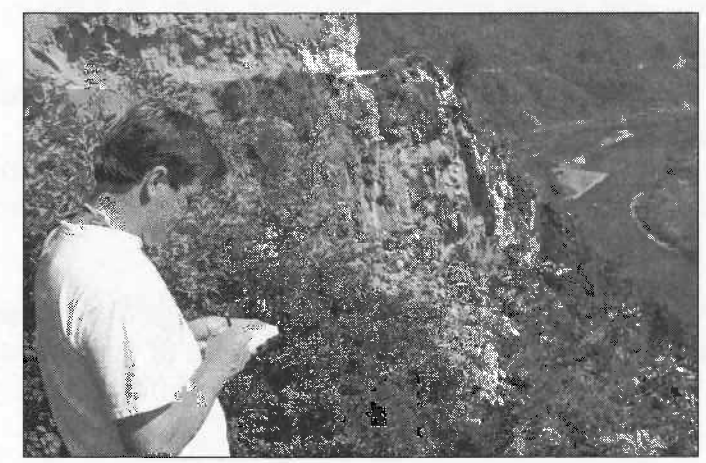

Figure 2. Kris Bachtell (from Morton Arboretum, U.S.A.) records notes on the vegetation growing on cliffs above the Yalu River, which flows along the border between North Korea and China. This area is floristically rich and has exceptionally cold winters.

Photographs: Paul W. Meyer

Figure 4. Scientific documentation is a critical part of the collecting process. Here Paul Meyer (from Morris Arboretum, U.S.A.) and Sheng Ning (from Nanjing Botanical Garden) process herbarium specimens following the 1997 NACPEC trip to Changbai Mountain in northeastern China.

An Assessment of Ornamental Plant Introduction in the Not-For-Profit Sector

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Introduction

In the context of this symposium, my contribution must fall under the heading "concerns for the future"; specifically, concern for those ornamental plant introduction programs mounted by the not-for-profit sector, and principally the public garden field. My concern is basic: Is there a way to objectively assess the success of our programs and, if so, how have we succeeded to date?

Any program of any sort is designed and funded to accomplish something. If it does, we call it a success to some degree; if it does not, it is in some degree a failure. The degree of success or failure, the efficiency of the program, if you will, is measured by the amount of product and the cost in institutional resources.

What, then, is any plant introduction program supposed to do? There are several possibilities:

- It could be designed to provide experience for staff.
- It could be designed to add plants to the educational, display, and research collections of the institution.
- It could be designed to expand the palette of plants for some or all of the institution's clientele, including nurserymen, plant societies, specialty gardeners, and plant breeders or other researchers.

Most of the ornamental plant introduction programs carried out by public gardens in this century have had each of these as partial rationales for their expenditure of institutional resources; and that is good. Multiple use of resources always adds efficiency to a program.

Now I won't address the benefits that accrue to an institution or to an individual from staff participation in such programs, other than to suggest that this should not be the prime reason for planning a trip. I doubt if any institution has justified plant exploration to its board or donors for this reason. Tax-exempt institutions do not exist to serve their staffs.

The second reason, to add to an institution's permanent collections, for example through plant exploration; is certainly a viable one; but I submit that it is seldom used as the primary reason when justifying expenditures of funds.

From a pragmatic standpoint, the usual primary justification, and also the necessary and sufficient rationale, is the introduction of new and better plants and germplasm for our landscapes and for the ornamental horticulture industry.

With this as an assumption, I want to postulate a measure of productivity; call it return on investment, if you wish, but the bottom line is the answer to the question: "Are we doing what we say we are, and are we doing it efficiently and effectively? Are we getting new or better plants to those who can use them to promote the public welfare - the understanding, use, and enjoyment of plants?"

The measurement of productivity in service organizations has always been difficult and controversial. Not only is it a problem to decide what the product is, but those charged with producing it are not always happy with being graded. Nevertheless, teachers, physicians, librarians, and bureaucrats are increasingly being called to account for the use of institutional resources by the public granting their institution its special status. In this connection I'll have to say that I have never known a public garden professional, and here I include myself, to turn down an opportunity to roam the hills of Xanadu in search of the new and strange - crossing mountain torrents on slender, swaying rope bridges, suffering intestinal disorders, eating strange foods, and enduring borderline accommodations. On the other hand, I have seen many situations where reports were late or never made, documentation was sparse and incomplete, evaluation was haphazard and poorly thought out, and distribution of introductions was done in the barest *pro forma* manner.

I assert that the primary product of institutional investment in plant introduction is *the entry of useful new and improved plants into commerce and into the landscape.* To measure the success of our programs then requires tracking the plants or their germplasm from discovery through evaluation and distribution, into nursery catalogues and research programs and, ultimately, out into the landscape. The conduct and documentation of these steps is, I submit, precisely the area where we have fallen short, if not failed.

Past Programs

If I look at programs that have run their course in the 20th century, I have to cite that of the Arnold Arboretum as the one I judge to be most visibly successful. While I was unable to obtain documentation directly from the Arboretum, it is apparent that E. H. Wilson and Charles S. Sargent were able to get many new species into nurseries and gardens. This despite the low cost of the program by present day standards, and despite the fact that the primary goal was to enhance the Arboretum's own collections. The obvious reason for its success lay in the large numbers of correspondents and connections—nurserymen, gardeners and horticulturists, maintained by Sargent and Wilson—and in their generous distribution of surplus plants to enthusiastic and dedicated laymen and professionals. In the Philadelphia area alone the duPonts, the Morrises, the Scotts, and others benefitted from this largesse.

Those plants in private gardens and arboreta that did not immediately get into commerce continued to filter in over time to join those that the nurserymen friends of Wilson had promoted earlier. Yet success is always relative, and a study by Kristine Bast in 1978 (Bast, 1978) found that of 54 randomly selected Wilson introductions said to be in commerce, 44% were found to be presently unavailable through nurseries. This in spite of the fact that plantsmen like Peter Bristol, Fred Galle, Bill Frederick, Gary Koller, Paul

Meyer, Donald Wyman, and Ray Schulenberg had found no aesthetic or horticultural barriers to the success of 81% of that sample of 54 species.

Contrast that program with the one with which I am most familiar, the USDA/Longwood Ornamental Plant Introduction Program, the largest and most costly of its kind. I believe that this program exemplifies many of the aspects that are right and wrong with more recent efforts. As the person in charge of the Experimental Greenhouses at Longwood while much of the material from the 13 trips was being grown and evaluated, and as a participant in the 1966 Korean trip, I have a 40-year perspective providing a basis for objectively assessing the program according to the criterion I have chosen. Of the more than 10,000 taxa collected on these trips, only seven have made it into the nursery catalogues. Another is said to be widely planted in the south. Four of the eight were introduced by Dr. John Creech from his trips between 1956 and 1962; and four were from the 1966 Korean trip by Dr. Edward Corbett and myself. By my calculations this gives a .08% yield for the entire program. Is this success? I can say with some confidence that the successful introduction of these eight plants to the trade was the result of the personal efforts by the explorers themselves and not from institutional policies or procedures.

But one of the goals of this program was to introduce germplasm for ornamental breeders, and to be fair we must factor in eight additional genera (there are no records I can find of the number of species involved) that are known to have contributed to breeding programs, principally at the USDA and Longwood Gardens. Taking these into account, we have a yield of 16 out of 10,000 or 0 .16%.

Bending over backwards to be fair, I know that of the 450 plants we brought back from Korea, seven of the 30 species that exist in my garden are also found to be, through my efforts, in at least one other garden. If we assume that all the other trips under this program resulted in a similar number of plants in a few anonymous landscapes around the country, we would project a success rate of 1.5%, or 150 plants extant out of the 10,000 introduced. Without quibbling about fractions of a percent, it is clear that almost all of the plants introduced over 15 years by 17 competent horticulturists at considerable expense no longer exist in cultivation in America.

Discussion

Now what can we learn from this? First, given the planning that went into these trips (and I know this to have been exemplary, at least for the physical and political arrangements made by the staff of the New Crops Research Branch of the USDA); given that planning and the generally competent and professional nature of those conducting the trips, it is unlikely they would bring back thousands of plants with little or no potential for American horticulture. I might accept 70 to 80% failure due to poor discrimination, but not 98.5%. I cannot fault the program at the collecting level.

It was the policy of the New Crops Research Branch to publish a popular report, including an inventory, of each trip upon completion. This was done for the early trips, I believe the first four, but as the frequency of trips and rate of introduction overwhelmed

the systems, leaders were neither inclined nor pressed to get reports in. However, all Longwood/USDA introductions, so far as I know, were documented in the published inventories of the New Crops Branch, which served all of its introduction programs.

While a few collections failed to arrive alive, and a few others were destroyed because of quarantine problems, most arrived in good condition. Seed was sown, cuttings rooted and plants established at the Glendale Research Station, and in general this part of the program was well-conducted despite the enormous numbers flowing in. The station was responsible, by the original agreement, for distribution and evaluation, but evaluation was to be required of those receiving plants. Seedlings and other propagules were distributed in small size. Dr. William Ackerman, who was in charge of the station throughout the life of the program, estimated in 1976 (Tschanz, 1977) that "60-70% of all material collected was distributed at some level." Lists of plants available were sent to regional USDA Plant Introduction Stations, nurseries, professional cooperators at universities, and, of course, Longwood Gardens. Longwood had first call on any introductions available in limited numbers. Regional stations received plants they requested, and this was a function of the personal or professional interest of staff at each station. Where such interest existed, small numbers of plants were evaluated through observation and personal judgement in an acceptable way, but not according to any official protocol. The interested staff drew noteworthy plants to the attention of regional nurserymen and other plantsmen. Notable among those who took their responsibility seriously were Des Dolan at Geneva and Augie Kehr at Ames. At any rate, only a small number of the total introductions received evaluation at these stations. Evaluations were often, but not always, noted in the reports to the regional cooperative research advisory boards, made up of plant breeders from each of the state experiment stations in the region.

University recipients were variable in their treatment of introductions received for evaluation. For example, Lyle Littlefield at the University of Maine faithfully evaluated those plants he received and, on his own initiative, published his evaluations.

Evaluation cards were sent by the Glendale station to some of those who had received plants. Some were returned, but so far as I am aware, no summary reports of these were ever made or published. There were no penalties for neglecting to respond.

The result is that, other than the few cases in which interested individuals took their responsibility seriously, there was essentially no meaningful evaluation of any of the 6,000 to 7,000 introductions that survived to distribution. Probably not more than 1,000 taxa were evaluated by those people. The agency responsible for oversight of evaluation was unable to assure that it was done.

For its part, Longwood Gardens had no formal obligation to evaluate plants coming to it as a result of the program, except for its own purposes. Neither did they have any obligation to propagate or distribute plants they received. Eventually they developed a distribution program which initially comprised only 12 public gardens (Tschanz, 1977), but in the final years of the program, this grew to include over 70 institutions. By policy they did not, until 1970, distribute to private individuals or nurseries for fear they would be accused of favoritism.

Evaluation at Longwood was accomplished at Longwood's Experimental Greenhouses, where all plants were received, and at its nursery, where plants judged to be hardy were sent to be grown to maturity. A committee of five to seven staff members participated in all evaluation meetings. There was no formal protocol, nor were there any objective criteria developed for evaluation; so the standard procedure that evolved was for each member to make a personal judgement as to the taxon's usefulness and then vote. There was some attempt to work for a consensus, but because of the employment relationships of those involved, the opinions of senior staff tended to dominate the decision. Remarks such as "It looks like a weed to me," "We don't have room for it" and "It doesn't fit into our displays" were frequently heard. Decisions to deaccession a plant were often based on such remarks, but were recorded as "Deleted-N.H.V."; that is, deleted by reason of no horticultural value. To be fair, these plants were always offered to the USDA before they were destroyed, but few were requested.

But perhaps the most revealing failure of the program's procedures was the simple disappearance of accessioned introductions at Longwood. At one point a colleague came to me with a stack of more than 500 cards with plant introduction numbers, representing plants that simply could not be located; they were not reported dead and they had not been deaccessioned; they were supposed to be in the nursery but were just not there! Above the 500 or so in the "disappeared" category were an equal number that had been recorded as dead, supposedly because they lacked hardiness in Zone 6. A brief check at the time found that a majority of these were known to be, or were expected to be, hardy to at least Zone 5. Sloppy cultural practices were never recorded as the reason for a plant's demise.

The Longwood/USDA Cooperative Ornamental Plant Introduction Program was begun with the stated mission to introduce plants "Which will have potential value to the future of ornamental horticulture." What happened? Pre-trip planning was excellent. The Washington staff of the New Crops Research Branch were experienced and skilled, and had connections through other branches of government to solve the problems of foreign travel and the field support of the explorers. Funding was more than adequate; the board of Longwood Foundation, Inc. appreciated the need for and the promise of such efforts. The actual conduct of the trips was, in most cases, exceptionally good. Dedicated, competent and enthusiastic plantsmen in the field did all they could to maximize the effectiveness of each trip, often enduring discomfort and long hours to see things were done properly. Plants, in most cases, got back to Glendale quickly. In the case of the Korean trip, plants were seldom out of the ground for more than four or five days, and never more than 10.

The failure (and I use that word advisedly) of the program as a whole stemmed from two principle causes: the lack of realistic planning for post-trip policies and protocols and the too-rapid rate of entry of new plants into the system. In regard to the first, there was a certain naïveté on the part of the planners in believing that getting plants into the country

alive was the most important part of the program. They failed to see that the more demanding task would be to evaluate the plants objectively over time and assure that each type of plant would get into the hands of those who would value it and work to get it into commerce. They also failed to realize that those who would value the plant might be members of plant societies, private gardeners of good reputation, small specialty nurseries and other enthusiasts outside the public garden and university experiment station establishment. Two things we know about most plant enthusiasts: they will accept and do their best to grow new and better plants, and they will take pride in distributing them to their fellow plant aficionados. This basic characteristic has been used by E.H. Wilson, J.C. Raulston and others to assure the continuance of plants they have introduced.

The planners also failed to realize the need for comprehensive, objective evaluation across the regions of the country where the plant could be expected to be useful and valued. Connections with cooperatives should have been established and the standards for their involvement clearly stated and enforced. All this takes resources, financial and human; and it takes time and attention to detail to record and disseminate information to those who will ultimately benefit from the plant's introduction. But without such discipline, can there be success?

The second basic flaw, the too-rapid rate of entry of plants into the system, resulted in overloading facilities and staffs that would otherwise have been sufficient. At the U.S.D.A., seeds were put into storage because greenhouses were filled, and, at least in the case of Korean collections, some never got out. For the same reason, many taxa were distributed as very small seedlings and, since they were often species with which the recipients were unfamiliar, post-distribution mortality was greater than expected. Even at Longwood, where only a portion of the collections were grown, the fine facilities were not adequate to properly handle the material from one trip before that from the next began to flow in. When I arrived in 1960, there were still plants from John Creech's 1956 trip to southern Japan; many more of Fred Meyer's 2,800 plants from Western Europe; and Llewelyn William's 1,100 plants from Southern Brazil and Argentina. Most of the 400 taxa from Walter Hodge and George Spaulding's 1959 trip to Australia were in the greenhouses, and we had already begun paring down the number of plants from that trip from six to four, then from four to two for each accession. Is two plants a sufficient population on which to evaluate a species' performance? Even as we struggled to do small justice to this mass of material, Fred Meyer was bringing in 1,200 more from Northern Europe, and John Creech was preparing for another trip to Japan in 1961, and still another to Nepal with Francis de Vos in 1962. A four-year-old program was already in deep stress, but no one in a position of authority advocated putting the brakes on. We were having too much fun and getting too much good press. The program was, *ipso facto*, so visionary that results would be assured whether or not we exhibited diligence and discipline.

Of course, we have come a long way since 1970! To find out, I asked eight public gardens involved in foreign ornamental plant introduction programs since 1970 to complete a brief survey aimed at determining the success rate of their programs according to the criterion I have put forward. I would like to thank those institutions and individuals who responded, but I will not, for obvious reasons, directly identify any institution with the data I have summarized, nor with the conclusions I will draw.

I asked each institution to supply me with, for each trip, the number of taxa successfully returned, the number of taxa distributed, the number of taxa known to be alive now, the number of taxa known to have been commercially available, and the number known to have been or which are now being used in research, display, and education. Unfortunately, I did not discriminate between evaluation and other forms of research such as breeding. It turned out that the survey was more tedious to answer than I had supposed, because most of the respondents do not routinely track the progress of introduced plants in a way compatible with the survey. But several did keep track of them in an exemplary manner while they remained within the institution.

A first conclusion from the returns is that programs still fall into two categories: the "entrepreneurial" programs, best exemplified by that of the North Carolina State University Arboretum (The Raulston Arboretum) and by the historical programs of the Arnold Arboretum, and what I will call the "institutional" programs, exemplified by the NACPEC cooperators. The first is characterized by individuals who travel extensively and inexpensively to wherever good plants for their purposes might be found, and who enthusiastically and inexpensively promote those plants widely to a loosely targeted audience. Traditionally these individuals receive little support in any way from their institutions and make judgements based on their own experiences and knowledge of plants. Published documentation is often in narrative form. Plants are quickly propagated and promoted through newsletters, distribution lists, lectures and field days. Evaluation is largely left for others to do through time and experience. Accurate numbers for plants introduced by these programs are not available, but from my familiarity with them, I estimate that at least 4,000 taxa have come into the country in this way over the last 20 years. It is even harder to determine how many of those not already in commerce were introduced into the trade by the efforts of these programs; but those closest to them have indicated that 6 new plants are successfully established in nursery catalogues as a result of their programs. This gives a success rate of .15%, almost identical with that of the USDA/Longwood program, but at a fraction of the cost.

The second type of program I will call "institutionalized." These programs involve a number of individuals working cooperatively on tasks that apply institutional resources to achieve success. All of the institutions answering the survey, and filling this description, were involved in at least one collaborative effort in plant introduction, and several have their own programs as well. Two respondents have been supporting trips for 10 years or more. To make the data somewhat more compatible with that I have already referred to, I looked separately at the degree to which trips completed ten or more years ago and trips completed more recently satisfied my measure of success. Of the five trips completed 10 or more years ago, 564 plants were reported as returned, and 221 of these are known to be alive. 147 taxa were distributed, and so far as I could ascertain, this was by one of the cooperating institutions. None are in commerce, and none were reported as being in

research other than evaluation. Success rate as measured by presence in commercial catalogues is zero.

Of the 871 plants introduced through the eight more recent trips conducted by three collaborating institutions, 456 are still alive, and 66 have been distributed. Such distribution is difficult to assess in summary reporting because the reports were, in some cases, nonstandard and overlapping in their coverage. Again, none are in commerce, and those reported in research are probably under evaluation for their use as germplasm, not actively being used in breeding programs.

It may be an artifact of my being out of the loop in recent years, but I have not seen a published report of the results of any NACPEC trips, nor any of those conducted by each institution alone. What taxa were collected? Why were they collected? How and when will they be evaluated and distributed, and by and to whom? Without such reports, targeted to most likely users, how do good plants, or the germplasm they represent, find a significant place in American horticulture?

If I appear to be critical, then I fulfilled my function at this symposium. The history of discussions about our plant introduction programs is filled with bonhomie and self-congratulatory statements obscuring very limited success. We have given ourselves a false sense of productivity.

Conclusions

In summary then, what are the major lessons we can learn from the past? The basic premise underlying my conclusions is that those tax-exempt institutions mounting programs to bring new plants into American horticulture have a responsibility to assure the documentation, evaluation, promotion, and dissemination of useful taxa arising from those programs. Simply put, we should be doing what we say we are doing.

Where have we failed in the past? We have failed to fully institutionalize the process from concept to conclusion. We have generally done well in planning for the trip and in conducting the trip. We have generally failed in evaluating the plants, in promoting those that would be useful to some groups in some areas of the country, and in getting the plants to those who would further distribute them and advocate their wider use. We can depend on the competence and enthusiasm of individuals to accomplish the exciting tasks, but must rely on policies and protocols to assure that the tedious and mundane work is completed.

Why have we failed? We have failed because we did not base the rate of introduction, a function of the frequency of trips and the taxa introduced, on our institutional ability to properly evaluate them and promote, publish, and distribute those plants. We have failed because we didn't state clearly and unequivocally the full dimensions of staff responsibility to see that work begun was finished, and finished according to rational standards of performance and success.

It is a paean to the vision and productivity of competent and enthusiastic individuals that one person working with meager financial and support resources can match the success rate of large institutions in the introduction of plants. It is an indictment of our institutions that with all their resources, they cannot do better. When those institutions are using public monies or operating under favored tax status, the failures assume a moral significance.

Our success should not be measured by numbers of plants collected or numbers of plants returned alive, but by the numbers of plants coming out of our programs that have made a positive difference in American horticulture.

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Screening and Monitoring for Invasive Ability

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Introduction

Invasive non-native plants are one of the most profound environmental problems we are facing today. Non-native invasive plants may be intrusive from an aesthetic point of view, and they may spoil our vision of how a landscape "should" look. Increasingly, however, we are becoming more aware of the environmental problems caused by non-natives as they compete for resources, alter ecosystem properties and function, and increase fire frequency and disturbance (Parker and Reichard, 1998). A recent study implicated non-native species as the second leading cause of endangerment to imperiled species in the United States (Wilcove *et al*, 1998).

Non-native plants enter the United States through many pathways. Many species, especially herbaceous plants, are introduced accidentally through contamination of imported seed or other commodities. However, it is very likely that the majority of species invading natural areas were introduced intentionally, mostly for horticulture. For example, of the invasive woody species in North America, 85% were introduced for landscape purposes (Reichard, 1997).

Nor should we expect that all invasive species have already been introduced. It has been estimated that if 10% of the 260,000 vascular plants in the world are good colonizers, then there are 26,000 potential weed species in the world (Rapoport, 1991). Only about 4,000 have been distributed around the world to date; the remainder are still natives in only the areas in which they are considered weeds. That leaves about 22,000, or 85% of the potential weed species out there, yet to be introduced. Even it this estimate is off by 75%, we could still be facing many more weed species than we currently have!

With some concern and vigilance on the part of horticulture professionals, we may be able to prevent some invasions in the future. The efforts needed must take two directions: we must screen new species being introduced for their invasive potential, and we must stop the distribution and spread of non-native invaders that are already present.

Screening Species for Invasive Potential

Traits that separate invaders from non-invaders

I have been researching what taxonomic, geographic, and biological traits can be used to distinguish the harmless from the harmful introduced species. I have looked at a number of traits for 235 woody invaders and 114 woody non-invaders that have been available in the United States since prior to 1930, to ensure the species had opportunities to invade. I have found that a high proportion of the species that are invasive in the United States share certain traits. These include the findings that 54% of the woody species that invade the U.S. also invade other parts of the world, that 44% spread by vegetative means such as rhizomes and root suckers, that they have shorter juvenile periods (time from flowering to fruiting), and that 51% do not require pretreatment of seeds before germination. These traits may be directly affecting invasive ability of the species, or they may be linked to other traits that are harder to identify and so merely serve as indicators of those traits. My findings also indicated that very few invaders are introduced from other parts of North America (3%) or are interspecific hybrids (1%).

Non-invasive plants, on the other hand, rarely invade elsewhere (15%), spread by vegetative means (23%), or have a juvenile period on average 3 years longer than invaders, and only 30% do not require pretreatment to induce germination (and 44% require cold-chilling). 25% of the non-invaders are from other parts of North America and 11% are interspecific hybrids.

Taxonomic relationships also provided some clues as to invasive success. Of the 76 serious pest species that I studied, 48, or 63% are in six families: Rosaceae, Leguminosae, Myrtaceae, Salicaceae, Oleaceae, and Caprifoliaceae. If a species is in a family or genus with known invasive ability, it may not necessarily mean that it will become invasive, but if, as shown on the decision tree (below), a species itself invades another part of the world and also had relatives invasive here in the U.S., there is a high probability of invasive success. Species that are descended from a common ancestor often share traits that are the same, including invasiveness.

Combining the traits to evaluate invasive ability

The differences above in traits between woody invaders and non-invaders are not sufficient enough alone to evaluate invasive ability: any given invader will lack some of the traits associated with invasive species (and it is likely that non-invaders will have also share some of the traits). Therefore, there need to be ways of combining and prioritizing the traits.

I have used two types of statistical analyses to find combinations of traits: discriminant analysis and classification and regression trees. These analyses are detailed in Reichard and Hamilton (1997). All of the analyses, including the trait comparisons, were then combined to develop an easy-to-use decision tree (Figure 1). The tree has three outcomes: accept (low probability of invasiveness), reject (high probability of invasiveness), and evaluate/monitor further. The latter category means there are indications of invasive potential and the species should be observed beyond the decision tree evaluation.

In a test of the chart with 204 woody invaders, 85% were rejected, 13% required further evaluation and monitoring, and two percent (three species) were accepted (no known pest species were accepted, however). Many of those rejected were on the basis of being invasive elsewhere, but even when that branch of the tree was deleted, 93% were still rejected or held for monitoring. Among the 87 non-invaders tested 46% would be accepted, 36% would need further monitoring, and 18% would be rejected. Thus, the tree is highly effective in evaluating invasive ability, but less effective in allowing unrestricted access to non-invasive species. The outcome of the chart encourages the use

of North American species, non-vegetatively reproducing species, hybrids, and slow-growing species from previously non-invasive taxonomic groups.

The information needed to utilize the decision tree for a given taxon may be obtained in a variety of ways. In general, the branches higher on the tree are easy to fill in with a trip to a well-equipped library. Information on where a species invades as well as whether its relatives invade North America can be determined using floras and plant manuals, horticultural books such as *Hortus Third*, typing the species name into Web search engines, and by searching abstract services available at university libraries on CD-ROM (e.g., AGRICOLA and BIOSIS). Those with access to the World Wide Web may also use a site developed in Australia that lists over 9,000 known invasive species (http://www.agric.wa.gov.au/progserv/plants/weeds/weeds/weedlist.htm). Information about species origin, hybridization, vegetative reproduction, and seed-germination requirements are often found in horticultural texts and journals. Even species that seem obscure have often been studied by government agencies for economic development; these studies can be discovered in the CD-ROM searches. Establishing the length of the juvenile period is the most difficult trait to determine, but it may be inferred from early vegetative growth rates; fast-growing species generally have shorter juvenile periods.

Monitoring To Prevent Spread

The predictive methods discussed above are for woody species only. Models for herbaceous species are still under development. Until these models are available, it is critical to evaluate untested herbaceous species for invasiveness. In the absence of predictive models, observation over a period of time is an excellent starting point (and recommended even when using the decision tree). A little common sense will go a long way. If you plant a species and find, as it flowers and fruits, that seedlings are coming up aggressively (not the occasional garden volunteer) then it and all the seedlings should be removed. This is especially true if the seedlings are coming up in areas that are not irrigated. The decision to remove the plant can be a difficult choice because of your economic investment and, perhaps, enjoyment of the species, but the possible environmental consequences are just too great. This is all the more true if you have done the literature searches suggested above and have uncovered information that the species is invasive elsewhere.

Many species do not begin to invade right after introduction. This is called the "lag phase," and there are many possible explanations for it. There are even arguments among biologists as to whether it exists. It does appear, however, that some species may not begin to invade immediately. For these species, predictive efforts may serve as a warning of invasive potential. For other species it may be best to hold them in the garden for at least two reproductive seasons, so that seeds have had some opportunity to be dispersed and germinate. Be sensitive to events such as unusual weather years, e.g. El Niño climatic seasons, that may skew your observations. A longer period of observation is even better and allows you with more likelihood to assure your customers that the plants you sell are likely free of invasive traits.

If you are planning to sell a species that is aggressively seeding in, or one whose seeding habits are unfamiliar to you, be aware that you may be responsible for the permanent alteration of ecosystems, the possible endangerment of native species, and the use of private and taxpayer money for subsequent control measures. Even the great plant explorer David Fairchild introduced several species that became invasive in Florida. These species today are cursed as "Fairchild's Follies." "Follies" seems like a polite term.

Why is it so critical to identify and stop invaders at the earliest stage of introduction and before distribution has taken place? Models and experience have shown that when a species is in one place, even with a large infestation, control and perhaps eradication are possible (Moody and Mack, 1988). Figure 2 illustrates this. The large population on the left is within one area, and because it is large, seeds disperse back into the existing population and do not increase the distribution of the species as quickly. With one large population control methods may be effective. Many scattered small populations, on the other hand, may be difficult to locate and, because they are small, are dispersing seeds mostly out into non-invaded territory.

Customer Preferences

There are numerous reasons not to introduce and sell invasive species from an ecological point of view. There are also reasons from a business point of view. Since the mid-1980's scientists have become increasingly aware of the problems of invasive species, and the issue is gaining in visibility. Figure 3 shows the number of non-scientific articles published since 1971. The graph reflects the number of articles listed in the Lexis-Nexis database as containing the words "invasive species, invasive plants, exotic species, exotic plants, alien species, or alien plants." As of March 1999, the number of articles for the 1998-1999 period is already equal to the 1995-1996 interval. As the public becomes aware of an environmental issue, it demands action. Pesticides, air and water pollution, and recycling of waste materials are all issues that have garnered the attention of the public, resulting in substantial changes in policy and business.

As a nursery owner, here are questions to ask yourself. What do consumers want? Do they care if they are buying invasive plants? Would they prefer to know if a species is likely to be invasive? To learn what nursery consumers thought and what preferences existed, I conducted a survey. I asked the participants of six e-mail lists relating to horticulture (Table 1) a series of questions to determine their level of familiarity with the issue of non-native invasive plants in natural areas, what their consumer preferences were, and a series of demographic questions. The only stated criteria for participation was that they had purchased plants from a nursery within the last year. Presumably every-one on such lists has; otherwise, there would be little reason to participate in a horticulture interest list.

There were a total of 157 respondents, with 137 of them from 32 of the 50 United States. There were also 15 from Canada, three from New Zealand, and one each from Norway and Ireland. Most respondents (81%) were women. Seventy-five percent identified themselves as avid amateur gardeners, while 15% said they were casual gardeners. Ten

percent were horticulture professionals. Only 3% were under the age of 30, while 36% were between 31-45, 47% were between 46-60, and 14% were older than 61. A key consideration for nursery owners is what their largest-spending customers think about the issue. Six percent of the respondents said that they spent less than $100 a year on plants, 26% spent $101-$200, 24% spent $201-$400, and 43% spent more than $400 per year.

Familiarity with the issue of non-native invasive plants influenced the responses. For instance, of the 50 individuals that said they were not at all to somewhat familiar with the issue, 66% said that it was very important to them to buy plants that will not become invasive. Of those that said they were quite a bit to very much familiar with the issue, 92% said that it was very important to them. With the increase in popular articles about invasive plants seen in Figure 3, we can likely expect more people to become familiar with and more concerned about buying invasive plants. Nursery owners in turn will need to become more responsible to those with such concerns.

Although opinion did not vary considerably based on annual expenditures on plants, it is useful to see that those that spent the greatest amounts at nurseries are also among the most concerned. A few of the questions broken down by expenditure are:

Is it important to you to buy plants that will not become invasive? Of those who responded that they spent more than $401 annually, 87% said that it was quite a bit to very important to them; 75% of those that spent $201 to $400, 85% of those that spent $101-200, and 90% of those that spent $100 or less also responded that it was quite a bit to very important.

If your nursery did not sell a species listed as invasive, would you seek it out from another nursery? Eighty-eight percent of the biggest spenders said that they would not at all to infrequently seek out a species if they were told it was invasive and their nursery did not carry it, while 92% of those who spent $201-$400, 100% of those who spent $101-$200, and 80% of those who spent less than $100 also replied that way.

How likely are you to buy a plant that has been previously labeled as a known invasive species? Across all categories, respondents did not want to buy a species if it is labeled as invasive. Of those who spent the most, 88% would not buy it if it were labeled, compared to 89% of the $201-$400, 93% of the $101-$200, and 90% of the less than $100 groups.

Would you prefer to shop at nurseries that advertise "We sell only approved non-weedy plants?" The consensus on this issue was less clear than on the others. Of those who spend more than $401, 64% would strongly prefer to shop at such a nursery, 63% of those in the $201-$400 group, 61% of the $101-$200 group, and 60% of those who spend less than $100.

Would you prefer to shop at nurseries that have been certified by an independent group as being "forest friendly" or having a similar designation indicating that they do not sell identified invaders? A few respondents took issue with the term "forest friendly," apparently believing it was referring to other nurseries as "forest unfriendly." The term is from a program that has been used in New Zealand. Despite that, slightly more respondents preferred this method of informing customers to the latter. Of those that spent more than $401, 67% preferred to shop at such nurseries, compared to 72% of the $201-$400 group, 63% of the $100-$200 group, and 70% of the less than $100 respondents.

The answers to the above questions clearly demonstrate that nursery consumers do not want to buy invasive plants, and if they are informed that a species is invasive, they will not seek it out from other nurseries. The greatest preference seems to be for labeling species as invasive so that consumers can make their own choices about purchasing, although a substantial number also favor having an independent group investigating and certifying nurseries as "safe" for purchasing non-invasive plants. A follow-up question indicated that most people would want to be informed as to the nursery's status by a certificate displayed at the nursery, though there was strong support for newspaper ads, Web pages, and phone book yellow page ads.

Conclusions and Recommendations

Given the concerns expressed by informed nursery customers and the nearly exponential increase in articles written on invasive species, nursery owners would do well to take actions to prevent the introduction and spread of invasive plants. Those who bring in species from other countries should use a method such as the decision tree for woody plants to establish invasive potential. Those species that demonstrate a clear risk should either be destroyed or should be held in the garden for an extended period before sale to ensure that new invasive species are not introduced. Plants that are questionable should also be held and not sold. Species that are already invasive in a local area can be labeled so consumers can make their own choices about purchasing them. Mail-order nurseries, as well as botanical gardens that participate in seed exchanges, can mark known invaders with the message that that species has been invasive in some areas in which it has been grown. And be aware that no one can prevent an invasive species from escaping from his or her garden if it is truly invasive. Even the most vigilant person, removing all seed every year, may find herself on vacation or in the hospital when the seed fruits, or she may move and the next occupant may not be as knowledgeable or careful. *Do not* advise people that they can control an invader from escaping, because you will be wrong and the consequences can be serious.

Nurseries and especially botanical gardens can play an important role in educating the public about invasive plants in general as well as about particular species. Talk to customers as well as your own staff and suppliers about plant selection. Create displays about invaders, suggesting "safe" alternatives, and supply interpretative material. Look at discouraging sales of invasive species not as a loss of sales but as a way to promote the sales of other species to replace existing invaders and to reassure your customers that you (and they) are working to protect the environment.

The issue of invasive non-native plants sold through the nursery industry and promoted and introduced by both nurseries and botanical gardens is not going to go away. It is becoming more visible every day. It is likely that regulations regarding the importation and transportation of plants are going to become more complex in the future. Attempts now to implement the common sense measure advocated here may make the future a bit easier.

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Table 1. E-mail list servers to which the consumer preferences survey was posted.

List address	Focus of list
Coho-l@listserv.vt.edu	Commercial horticulture
Woodyplants@mallorn.edy	Woody plants
Pacngardn@u.washington.edu	Gardening in the Pacific Northwest
Gardens@lsv.eky.edu	Gardening
Ogl@lsv.eky.edu	Organic gardening

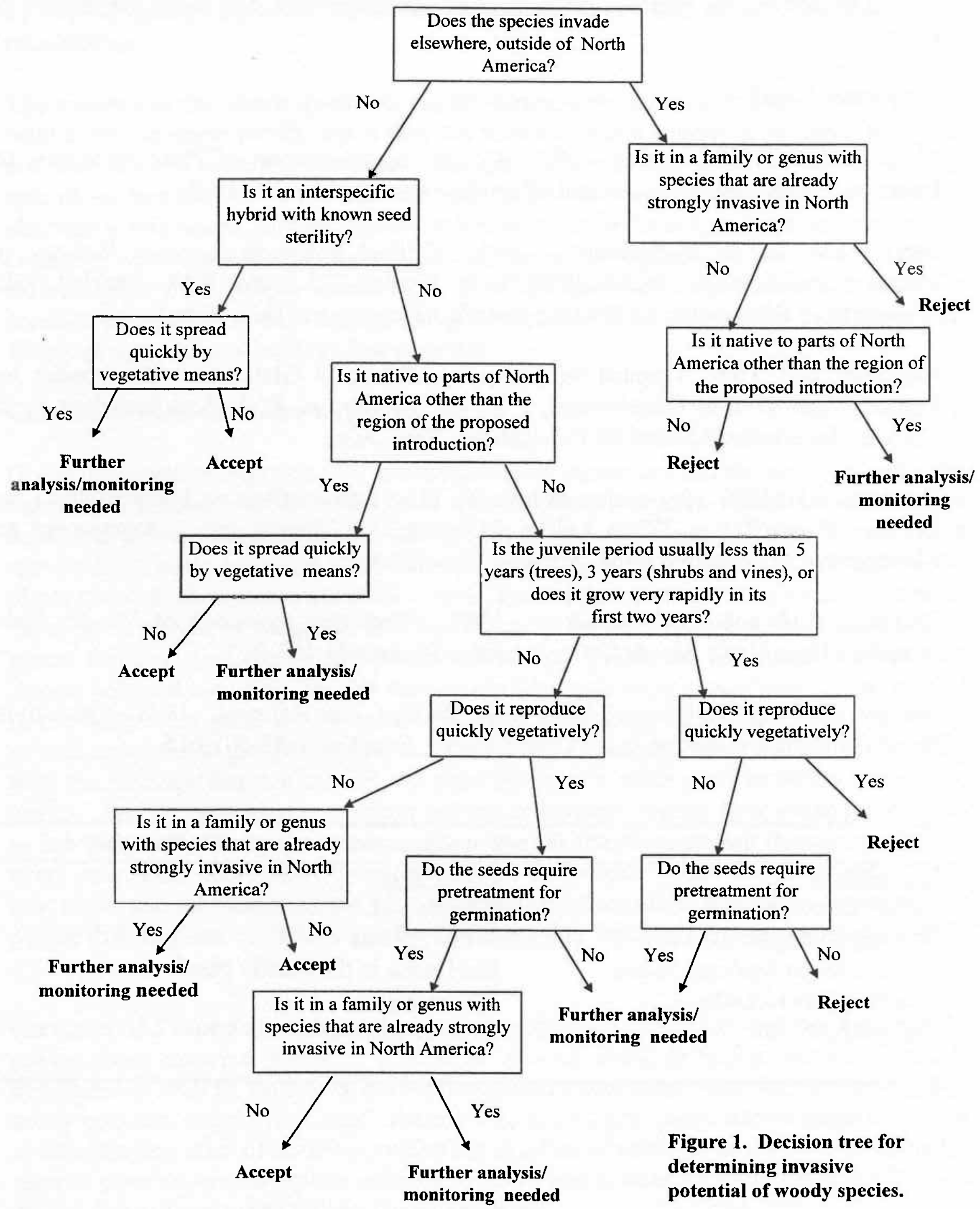

Figure 1. Decision tree for determining invasive potential of woody species.

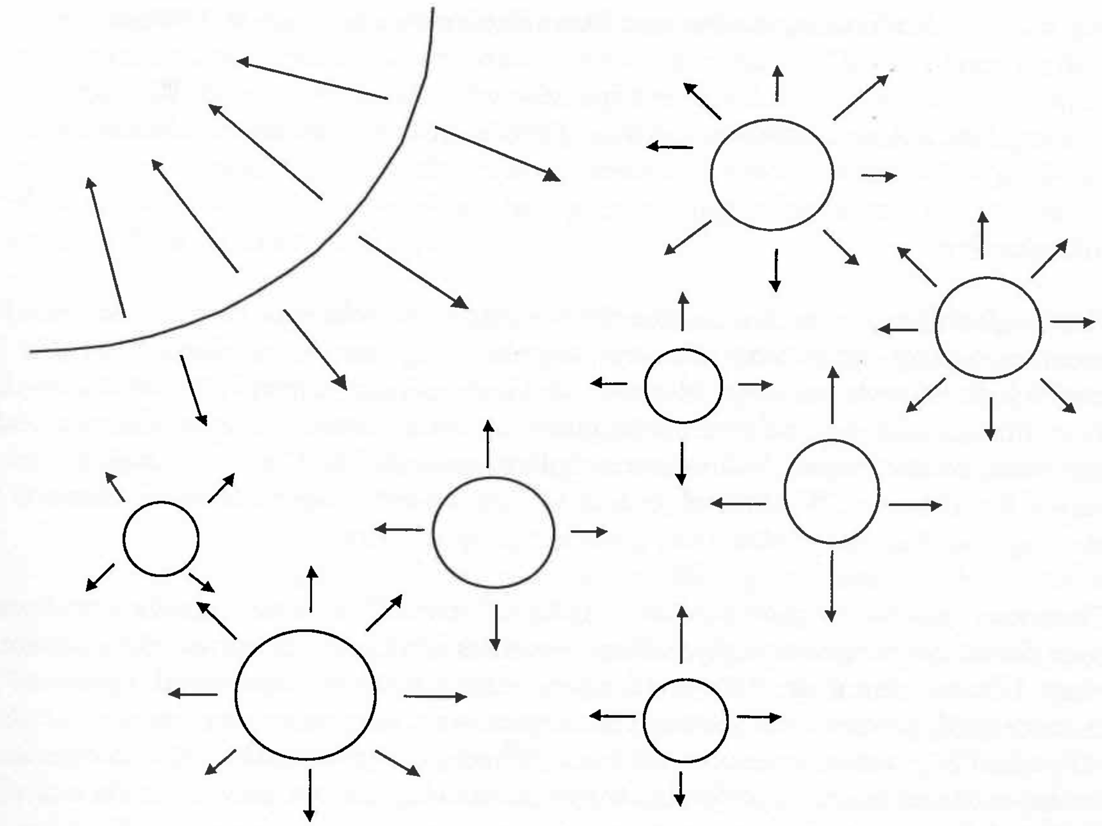

Figure 2. Circles represent populations of an invasive species; arrows indicate outward and inward dispersal of seeds.

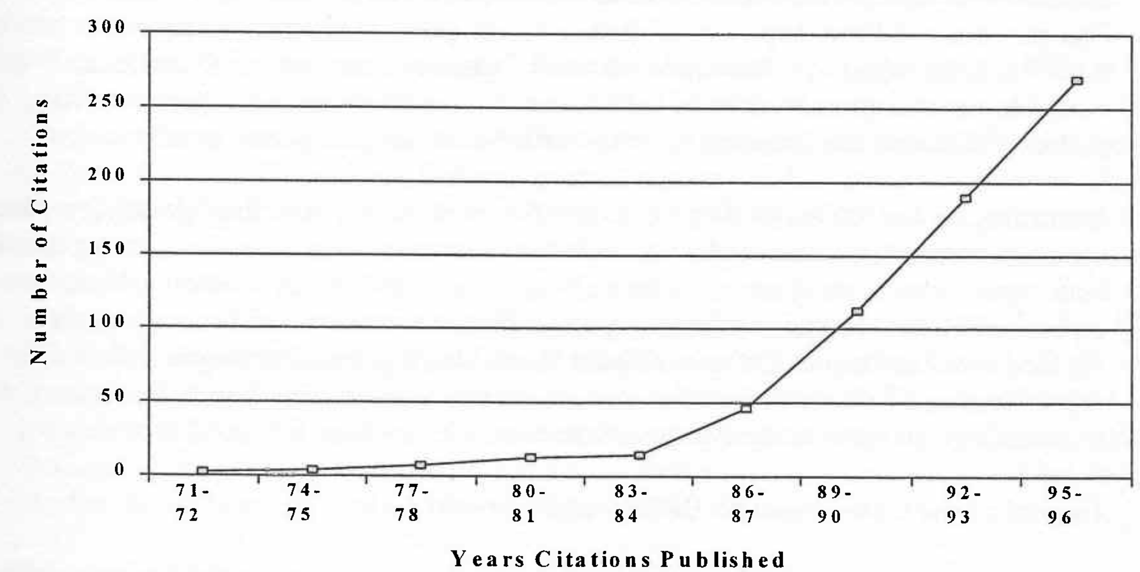

Figure 3. Results of a Lexis-Nexis search to determine the increase in articles published on invasive species.

Embracing the Future: Plant Exploration in the New Millennium

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Introduction

Plant exploration has served an enormously important role especially in the past two centuries, acting as the conduit to jump-start the long process of introduction that has resulted in the widespread development and cultivation of virtually all of the modern food, fiber, medicinal, and ornamental plants we enjoy today. For most knowledgeable horticulturists and botanists, the names of plant explorers like Bartram, Douglas, Nuttall, Farrer, Rock, Meyer, Wilson and many others are legendary for their contributions to the seemingly endless list of plants that grace our gardens today.

These early adventurers and explorers of the 18^{th} and 19^{th} centuries found a world wide-open for discovering seemingly endless quantities of plants. There are many stories of plant hunters returning with crate upon crate of newly discovered plants to be characterized, studied, and grown. This adventurer's passion was at the core of much early plant exploration, even into the early 20^{th} century. In the past few decades, though, we have begun to see a profound change in the way nations view their natural plant biodiversity.

Today, plant exploration and introduction continue to be an integral part of the search for new and underused plants. Each year a wide range of plant explorers from government, universities, arboreta, botanical gardens, commercial nurseries, and private enterprises conduct trips to observe, document, and sample plant populations in their native habitats. The purposes of these trips are as diverse as the plant explorers. Expeditions conduct field work in support of biological diversity studies, ethnobotanical research, floristic research, *ex situ* preservation in cultivation, long-term storage for gene banking, and potential selection and breeding for commercial development, just to mention a few.

Interestingly, the advances that have resulted in a more accessible global community have also benefitted plant explorers, including convenient air and ground transportation, better communication systems, improved commodity and political relationships, broader cultural and intellectual exchange, improved environmental and mapping data, and detailed local and regional floras. These "tools" have proven invaluable in building our understanding of where to look for specific sources of plant diversity and provided ways to reach habitats previously inaccessible regions.

Impact of the Convention on Biological Diversity

At the same time, though, the political arena in which plant exploration is conducted continues to change. With the Convention on Biological Diversity in Rio de Janeiro in 1992 and eventual signing by more than 170 countries, a broad international consensus

has emerged on the ownership rights of indigenous people and nations over their genetic resources (including plants) and products derived from them. This has been particularly evident in the case of medicinal plants where potentially millions of dollars in ownership rights are at stake as bio-prospectors representing pharmaceutical companies and universities scramble for the right from countries to evaluate the medicinal properties of their plants. Even ornamental plants are under scrutiny as the impact of the Convention on Biological Diversity broadens.

The intent of the Convention on Biological Diversity was to promote global partnerships with the objectives of conserving biological diversity, promoting sustainable use of its components, and developing standards for fair and equitable sharing of the benefits arising out of the utilization of genetic resources. This and subsequent meetings established a new playing field regarding access to and acquisition of plant genetic resources in countries throughout the world (Lesser, 1998).

For modern plant explorers, the Convention on Biological Diversity has established ethical and legal responsibilities to consider before working in another country. The reality of these declarations is that for plant explorers there is an emphasis on developing working relationships with host countries based upon informed and mutually agreeable benefits. In many cases this may complicate plant exploration, requiring much more careful and detailed negotiations, planning, and follow-up mechanisms. The unfortunate side of these policies, as Dr. Ned Garvey, USDA/ARS, Plant Exchange Office points out, is that "It will continue to be a challenge in the short term to develop collaborations for joint collecting in some countries without benefit sharing policies because of the difficulties in accessing the proper offices and procedures; the results will inevitably be continued losses of valuable plant genetic resources until countries have these policies in place." Most plant explorers agree, though, that working with hosts and building long-term constructive relationships is at the heart of successful plant exploration activities.

While the Convention on Biological Diversity has been in force since 1993, other guidelines also exist to promote ethical practices in plant exploration among nations. The United Nations, Foreign Agriculture Office (FAO), developed the "International Code of Conduct for Plant Germplasm Collecting and Transfer" (FAO, 1993), which provides a set of principles for modern plant collectors. The International Code promotes the "...rational and sustainable use of genetic resources, to prevent genetic erosion and protect the interest of both donors and collectors of germplasm..." and is based on the recognition of "...national sovereignty over plant genetic resources." The USDA and many other organizations have used these guidelines as a foundation for planning. The North American-China Plant Exploration Consortium (NACPEC), an affiliation of arboreta and botanical gardens, also used these guidelines to build a highly successful, cooperative relationship with several institutions in the People's Republic of China and to conduct seven plant exploration trips during the 1990s.

The impact of the Convention on Biological Diversity on future research and commercial introduction of plants remains uncertain. While some countries will probably continue to allow collaboration at the local level, it is clear that more pressure will be exerted by countries to limit access to all plant resources, regardless of use, without formal regional or national agreements. Some commercial growers of garden plants such as Tony Avent, owner of Plant Delights Nursery and a seasoned plant explorer, feel that under the rules of the Convention on Biological Diversity there will be "...a framework of non-workable solutions that were originally intended for medicinal plants with potentially high economic value and never designed for small profit margin products such as perennials, shrubs and trees." Further, he fears that this could inevitably create a situation where there are no winners in a game of continued loss of valuable species as their habitats are destroyed.

Loss of Biological Diversity and Habitat Destruction

Another important challenge to plant exploration during the next century is the continued loss of species diversity and habitats through poor land management and unscrupulous collecting practices. The human impact on the natural environment has dramatically altered the function and viability of natural systems. Our increased awareness of the limited amount and fragile state of our natural habitats has resulted in serious concerns over the loss of biological diversity. Many plant explorers have reported that the greatest species diversity can only be found in the most remote and inaccessible places because of extensive deforestation and conversion of land to agriculture. This has resulted in fewer places of refuge for potentially useful garden plants, a narrower gene pool from which to sample, and a greater risk to populations from harmful collecting practices.

During our plant exploration work in China with NACPEC since the early 1990s, we have seen dramatic examples of habitat loss resulting in the need to travel further and further into remote mountainous regions to observe and sample from declining forest populations surrounded by vast cultivated regions. In areas like the Qinling Mountains of Shaanxi Province and eastern Gansu Province, the mountains of Beijing Municipality, and the forests of Anhui, Jiangxi and Fujian Province, only the steepest, most inhospitable and inaccessible habitats unable to support cultivated crops contain plant diversity worth sampling. Sometimes we are fortunate to visit forest preserves or nature preserves that provide protected habitat to wildlife. Yet, next to these places, large tracts of land are being harvested for lumber products and converted to monoculture forest farms or terrace agriculture.

Because of continued loss of diversity, even on our own continent, we need to be advocates for *in situ* preservation efforts. This activity is essential to maintain biological diversity and to insure habitats for future collecting. It is also crucial for plant explorers to adhere to biologically sound collecting practices (Guarino, *et al*, 1995). While theories of sampling vary widely depending upon habitat conditions and species, sound collecting practices based on knowledge of plants will help to insure the viability of populations that may be under biological, environmental, or human-induced stresses (Falk and Holsinger, 1991).

In addition to habitat loss, some countries have experienced enormous pressure on natural populations due to unscrupulous collecting practices for commercial horticultural and medicinal purposes. More than 25 years ago the international community recognized the

potential for over-exploitation of plants and wildlife from commercial collecting and so ratified a treaty, the Convention on the International Trade of Endangered Species of Wild Fauna and Flora (CITES), to which more than 150 countries are now signatories. While the Convention on Biological Diversity focuses on building relationships between parties from different countries and encourages benefit sharing, CITES seeks to ban commercial international trade on an agreed list of endangered species as well as regulate and monitor trade in others that might become endangered (CITES, 1999). CITES has been responsible for dramatically reducing or eliminating the international trade in a number of wild-collected ornamental plants including many species of bulbs and orchids. Periodically, additions are made to the list of CITES plants, and theoretically, the lists will continue to expand as more plants and habitats become threatened.

In the end, fewer viable habitats for collecting and more restrictions on trade of plants through CITES regulations are going to result in more constraints for plant explorers during the next century. At times these policies will undoubtedly result in limited sampling opportunities, higher access and site fees, access to fewer sites, observation-only privileges, and occasionally, even the need to return plant genetic resources to hosts after collection because of uncontrollable political factors. These can be frustrating components of plant exploration that test our resolve to maintain ethical standards.

Building Relationships

Even so, plant explorers have the opportunity and responsibility to develop strong working relationships with host countries and institutions that can provide invaluable guidance on plant distribution and the biological/legal status of target plants. Hosts can also provide crucial assistance and support to acquire officially sanctioned site access and collecting permits, arrange transportation, and provide an important cultural link with indigenous people. In short, hosts can serve as the bridge that provides for fewer misunderstandings and difficulties when conducting plant exploration activities.

Of course, the evolving role of plant exploration offers new opportunities for collaboration and mutual benefit sharing, while promoting rational and sustainable use of plant genetic resources. As plant explorers and horticulturists, we have the opportunity to build integrated strategies in support of a broad range of goals from garden use to plant conservation by providing information and assistance to maintain, preserve, and propagate plants of concern. In effect, we can use our skills for bringing plants to the home garden to also help protect plants in their native habitats. In many cases this may involve continued activities after the completion of fieldwork through technology transfer, training opportunities or equipment grants.

An example of continuing collaborative initiatives began in 1997 when the Morris Arboretum of the University of Pennsylvania and the USDA initiated a multi-year program to study the genetic diversity of hemlock (*Tsuga*) in China as part of a larger effort to assess resistance in hemlock species to the hemlock wooly adelgid, which is devastating eastern North American hemlock species. The primary focus of this project was to identify, collect, and grow hemlocks from China to provide broader genetic diversity for USDA plant breeders attempting to hybridize native and Asian hemlock species. In addition, it was intended to assess the long-term adaptability of Chinese hemlock species to the climate and soils of eastern North America. In an effort to address important questions about the distribution, genetic diversity, population condition, and taxonomic relationships of hemlocks throughout their native ranges in China, the project was broadened to more comprehensively address issues of taxonomic, genetic, and conservation interest to our Chinese hosts.

Where plant exploration of a century ago was largely a one way street, the increasing collaboration and exchange of today can become the foundation for a much broader program in the future where the benefits are truly mutual. Many current plant explorers have developed programs with well-defined benefits-sharing components like those of NACPEC; however, others have not. Activities that exclude the indigenous people and/or governments of a region will almost certainly create a "ripple effect" with undesirable consequences for all plant exploration and introduction.

Non-Native Invasive Species

The introduction of plants and other organisms into cultivation from around the world, both intentionally and unintentionally, has created another serious challenge for plant explorers as society struggles with issues of conservation and biological diversity. Natural areas managers, ecologists, conservation biologists, horticulturists, and even home owners have become increasingly aware of the biological invasion of our remaining natural systems by non-native invasive plant species. In the U.S. this has reached serious proportions and has drawn a response from the highest levels of government with the issuance of the President's Executive Order on Invasive Species on February 3, 1999, mandating the development of a National Invasive Species Management Plan to address the issue of non-native invasive plants and other non-native organisms (Clinton, 1999).

For plant explorers, this raises other ethical and practical concerns in the next century. How do we encourage the discovery, development, and introduction of "well-behaved" garden plants and still prevent the introduction of the next serious weed? Furthermore, will there be restrictions on plant introductions from plant exploration in the future? There appear to be no simple answers to these questions, but many people are working toward developing solutions that will undoubtedly involve a more systematic and comprehensive process of evaluation prior to the commercial introduction of new plant species and hybrids. Some professionals have already begun to address this issue pro-actively. Tony Avent noted, " We have an extensive trial system where we test plants for up to five years before releasing them. Sometimes we just have to rip out plants that are too aggressive, no matter how much we like them." Unfortunately, there is no widespread and accepted evaluation system in place. Even so, plant explorers and the organizations they represent may be compelled to consider all of the characteristics of plants they collect — including invasive potential — before bringing them into widespread cultivation in the future.

Assessing Our Cultivated Resources

Finally, the most difficult challenge for plant explorers may be asking, "When have we collected enough?" During just the past hundred years, thousands of species have been collected and brought into cultivation in the U.S. through private collectors, government, botanical gardens, and arboreta. With all of the potential complexities and challenges of conducting plant exploration in the next century, we need to comprehensively assess the resources already in cultivation.

The USDA/ARS National Plant Germplasm System (NPGS) maintains nearly 10,000 plant species for developing new and improved varieties of plants and international exchange; however, the NPGS has historically focused primarily on agricultural crops and crop relatives. Recently, though, the American Association of Botanical Gardens and Arboreta (AABGA) has developed a program known as the North American Plant Collections Consortium (NAPCC). The goal of NAPCC is to develop a network of botanical gardens that will take official responsibility for collecting and preserving specific plant groups and the genetic resources they represent (AABGA, 1999). Using the living collections of AABGA member institutions as repositories, projects such as NAPCC can make substantial gains toward broadening the genetic diversity of collections and sharing the responsibility for worldwide plant preservation with programs such as the NPGS, while also benefitting industry professionals, scientists, and the general public. As a tool, NAPCC collections will also be able to help plant explorers make informed decisions about future priorities based upon knowledge of available genetic diversity of particular plant groups in cultivation.

Additionally, analytical tools aimed at characterizing genetic diversity are becoming more widely available and less expensive. Although these techniques have been used widely by conservation biologists to study population genetics (Falk and Holsinger, 1991), they also have the potential to contribute to our understanding of the genetic diversity of cultivated plants. These analytical tools may offer significant insights into the diversity or lack of diversity in cultivated plant groups, offering more objective tools for targeted plant exploration efforts in the future.

Moving Forward into a New Century

This new century is certain to provide new challenges and limitations for conducting plant exploration, at least in some regions of the world. As countries restrict access to plant genetic resources, plant exploration is almost certainly going to depend upon greater collaboration among people and governments. Whether we agree with the practical application of the Convention on Biological Diversity, issues of sovereign rights over natural resources and mutual sharing of benefits will become more common themes for plant explorers in the future. In the final analysis, we must also become better stewards of our natural resources to protect their integrity for the future. And we will need to ask ourselves if traditional plant exploration really is the most important and effective way of obtaining plant resources. Despite the challenges facing plant explorers in the next century, I have great hope that plant exploration will continue contributing to both our knowledge of the world's rich natural diversity and the enrichment of our gardens.

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Collectors, Start Your Engines

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Introduction

Plant hunters, plant explorers, and plant collectors all need to follow basic steps to ensure a safe and successful expedition. The time spent in the field collecting seeds or plants is often disproportionately small compared to the amount of time spent in preparation for the trip. I will cover the steps in planning a wilderness expedition from conception to departure. This is purely a practical approach, and the easiest way to do this is chronologically. Because of my background and experience, my remarks will be focused on collecting plants of ornamental value and those that grow in north temperate zones.

Time Frame for Tasks to Accomplish

Two Years to One Year in Advance

Working backwards from the day of departure, you will need at least one year to complete all the necessary tasks, while two years is better. Thus, I will begin two years prior to take-off. The first step is to determine the rationale and purpose of the proposed trip. Are you interested in getting germplasm, or are you doing floristic studies, or are you just surveying potential sites for a longer and more detailed trip? You developed the idea that you want to get plants from their native source. Why? What makes these plants so special? Is it new germplasm from areas where these plants have not been previously collected? Or is it new germplasm that will better represent a population? Or is it even new germplasm that might not yet have been described? Are you looking for plants that tolerate greater climate extremes; plants that may be new or can be reintroduced commercially; plants that are more ornamental than those presently being marketed; plants that can be used in a breeding program; or plants that may be new taxonomically?

Where should you go to fulfill the purpose you determined? A typical method is to determine your latitude and find the countries that lie within the same one. In another presentation at this symposium, Peter Del Tredici showed us how China overlays on the U.S. Another method is to look at what plants are already growing in your climate zone and compare their native distribution with your climate. A model to be emulated is an investigation done by Mark Widrlechner of the USDA. He studied areas in Yugoslavia, Ukraine and Japan and compared January mean temperatures, July mean temperatures, moisture deficits, and elevation with Midwestern U.S. climatic data. He has also published a hardiness map of China. As we saw earlier in the symposium, Paul Meyer has compared temperatures and rainfall in China with those in Philadelphia. In place of similar latitude, it has been suggested to collect from high elevations. From my own experience, the statement that a higher elevation equals higher latitude is false. Higher elevations may have similar cold temperatures, but other factors such as summer heat, humidity, and insolation are not equal.

Now is the time to think about the team that will be going on the trip. Most important is the team leader. The day when one plant hunter spends a year or two in the field is over. The expense of human resources is just too great. Today institutions band together to share the expense and time of organizing a trip that will be both cost-effective and timely. Equally important is the sharing of seeds to help ensure the success rate of germinating and growing plants. The number of participants on the team can vary. In my experience three to four is optimal for getting the pre-trip work done as well the collecting and processing of seed and herbarium specimens. The composition of the team should include individuals who have experience in taxonomy, herbarium processing, and seed processing. The number of team members is often limited due to the number of vehicles to which the host institution has access.

The leader, with the help of the team, develops the preliminary list of species or genera that occur in the area. Look at publications of flora, *Index Semina,* or consult with botanists who are from your target country and are visiting in the U.S. Search the USDA Germplasm Repository's records for plants that are already in the U.S. from your target area.

Having developed your preliminary target list, your next approach is to find contacts within the country chosen. The leader begins the negotiation with an individual whom the host institution appoints to be the liaison with the U.S. team. The Agricultural Research Service's Plant Exploration Office has done extensive work with both economic food crops and ornamentals, and is an excellent resource for developing contacts. Botanical gardens in the selected country are also excellent sources. Sometimes there is an advantage to working directly with a government agency such as a department of agriculture or a department of forestry; and sometimes it is easier to work with peer organizations.

The leader shares preliminary lists with the host, who in turn should provide suggestions or lists of flora to refine the target list and should indicate specific areas in which to collect. Once an agreement is reached with the host as to collecting areas, create a tentative budget and an agreement on method of payment. There are essentially three methods for payment: a lump sum at the beginning of the trip, pay as you go, and pay at the end of the trip. I have done all of these, and the easiest and best is the lump sum pre-payment, hopefully paid by check and not cash. The pay-as-you-go and at-the-end methods often results in a new fee structure part way through the trip, which usually increases the cost. Carrying around quantities of cash is not recommended and is dangerous.

Now that there is a preliminary budget, the team members can begin to raise the funds, which can come from numerous sources. With special overseas airfares and low expenses in the host countries, some trips can be paid for from personal funds. Often, if a team member is from an institution, that member can raise funds through subscriptions and from benefactors. Two government agencies receive grant requests: the USDA Scientific Cooperation Program and Agricultural Research Service Office of Plant

Exploration. Both of these offices prefer to have an endorsement from the Crop Germplasm Guidance Committee appropriate to the target genera.

Six Months to One Year in Advance

The team leader works with the host to determine the exact sites and the best dates for field collecting. Spring may be elected for scouting and herbarium collecting; fall for seed, herbarium, and plant collecting. To best determine the time line for collecting, answer the following questions. How much time will be spent getting from the host institution to the collecting site base camp; how much time will be needed if the base camp changes; and how far are the collecting sites from the base camp? By developing a time line, the leader can calculate the total length of the trip. Usually everything can get done in a month, including some down time for the team.

When considering the expense of setup and travel to and from the host country, you will want to make the trip as worthwhile as possible. Projects to consider when calculating time in-country are: 1) upon entry in the host country, set aside time to get over jet-lag, time to purchase supplies, time to research the host's herbarium and library for more floristic data, and time to organize materials for the field. 2) After every three or four days of field collecting, set aside one half to one day to process herbarium specimens and clean seed. 3) Upon completion of the fieldwork, set aside time for final processing of specimens, packing seed for the return home, and building relations with host institution leaders.

Usually the seeds are packed in duffels or regular suitcases, not special boxes that draw the attention of the customs agents as you leave the country. Even if "permits were granted," there are sometimes complications during the rush to board the plane. The bulky herbarium specimens are either shipped out or left at the host institution to ship at a later date. The two areas where there are the most complications are getting the seeds out of the host country and getting the seeds into the U.S.

Knowing the sites, the team can now develop a detailed and thorough target list, which will be used by the host to secure the necessary permits to collect and to export from the country. Any species listed in the host country's red book are usually not to be collected or a special permit is needed to collect.

The final costs are negotiated with the host so an in-country budget is complete. The costs for the pre- and post-trip expenses are added. The pre-trip expenses include costs for supplies, gifts, and cash advances. Post-trip expenses are for seed and herbarium processing and expenses related to writing and printing the report. Also include expenses in-country not covered by the host. We have found when dividing the costs among the participants it is easier to leave the airfares out of the total. Each participant should be responsible for booking and paying for his own flight and arriving at the host city at the designated time.

The team leader assigns responsibilities to the team members. This is best done during this time period because team members will need the time to organize their area of responsibility. The areas of responsibility are: 1) Treasurer or accountant, who is responsible for paying the host and any in-country expenses not covered by the host. At the end of the trip a report of the expenses should be made and added to the trip report. 2) Supply coordinator, who makes sure the supply purchasing is equally delegated to all members of the team so the extra luggage load is evenly spread. 3) Trip report writer, who is responsible for collecting all the journals and field notes from the members as well as the plant documentation. Each member is responsible for writing a journal and assisting the trip report writer in generating the final report. 4) An institution is selected to process the seeds once returned to the U.S. 5) One institution is selected to process the herbarium specimens. These latter institutions may or may not have participants on the trip.

Six months to a year in advance is the time team members need to begin their personal preparation for the trip. They should participate in a physical training program, see a doctor for a physical exam, and if needed get a doctor's permission to go on the trip. Discuss with your physician the medications and prescriptions you should take. The Center for Disease Control has the latest recommendations for immunizations for countries visited. For general precaution, my physician recommended vaccinations for diphtheria/tetanus, hepatitis A, hepatitis B, typhoid, and a polio booster, and in some cases malaria pills and a cholera vaccination. Keep a record of immunizations you are given in case you are questioned upon entry into the U.S. You can contact the Center for Disease Control at (404) 639-3311 or on the Internet at www.cdc.gov/travel/travel.html. To help in emergencies every team member should be certified in First Aid and CPR. Accidents can happen at any time especially in countries that have lax regulations for road conditions and driving skills. Often collecting sites are substantially remote from quality medical care.

Get a passport. If you have a passport already, be sure that the passport does not expire prior to six months after you return from the trip. Some countries will not issue a visa if your passport is due to expire in six months.

This is the time to consider reading and studying about the social customs and history of the host country. Learning some of the language is advantageous and much appreciated by your hosts. In order to establish lasting relationships with your hosts, knowing and respecting their customs is important. Monitor the political and economic climate. You should be fully aware of any hazardous situations.

Check your insurance coverage. Does Workman's Compensation cover you for injuries incurred overseas? Does your medical plan cover overseas medical problems? You may want to get an inexpensive short-term life insurance policy. This often comes with travel insurance, which I recommend you get. This policy will cover you for lost luggage, emergency evacuation, and other medical emergencies. Two firms that offer this service are: Travelex Insurance Services, Inc. PO Box 9408, Garden City, NY 11530, (800) 228-9792 or Access America International c/o Access America, PO Box 90315, Richmond, VA 23286-4991, (800) 284-8300.

Six to Three Months in Advance

If the host country requires a visa, begin this process. Some countries require a letter from the host institution with the visa application. The trip leader should be sure the host institution delivers this letter in a timely manner so the team members can get their visas on time.

If the host institution is willing to accept supplies without incurring a customs fee, now is the time to send off the boxes. In my experience, if you do ship boxes, send them as small parcels via U. S. Postal Service airmail. These may sometimes be delivered to the institution without custom fees. The best success, however, is to hand carry everything and pay an extra-luggage fee. Try to keep the extra bags to one per person. Appended is a sample list of supplies that I have found useful.

This is the time the final itinerary is set and the plane tickets can be ordered. Usually the team will meet in a U.S. city and leave on the same plane. This way the supplies can be divided among the extra luggage of the team. Carefully select the airport of re-entry into the U.S. You will be carrying seed, which will need to be inspected. Not every international airport has the facilities to do the inspection. Contact the Animal and Plant Health Inspection Service (APHIS) to tell them which airport you will return to so they are alerted about the importance of the material you are carrying. Try to arrive during regular working hours of the work week. It is advisable to carry return address labels from a shipping firm so if seeds are detained they can be shipped to you without inconveniencing the inspectors. Be sure the host institution has the necessary permits to collect and to export the seeds.

Three Months to Take Off

Gather up gifts to give to the host institution. Small gifts are often shared with guides, drivers, and people you meet along the way. You should also have information packets about your organization and even information about the area in which you live. You may even be asked by the host institution to give a brief lecture about your institution and what the climate is like. A box of slides showing your institution and a 3" x 5" card with metric data takes very little room in your luggage.

Gather up important papers, and put duplicate copies into an envelope in case anything is lost or stolen. These include:

- Visa
- Passport
- List of contacts in host country
- Itinerary
- Plane tickets
- Any wallet items such as credit cards, driver's license, etc.
- Lists of items in baggage
- Shipping firm return address label with institution's account #
- Import/quarantine papers

Conclusion

You are now ready to leave. You know how to select the appropriate site to go to that has the flora to meet your goal. You know that you have developed strong relationships with a host institution and its staff in the country of choice and that institution has responsibilities to help make the trip successful, and you in turn have responsibilities for providing lists, direction, and financial support. You now know what you need to take along that will help to make the trip run smoothly and safely. A successful trip is one that is over planned and that often starts two or more years in advance.

SUPPLY LIST

A. Documentation
- Field notebooks and computer with BG-Base or Kew Gardens collection program.
- Global Positioning Unit (GPS)
- Altimeter for measuring tree heights
- DBH tape
- Compass

B. Herbarium
- blotters
- foams
- ventilators
- plant presses with straps
- flexible plastic labels (see seed collecting supplies)
- duffel/gym bag

C. Seed/plant collecting supplies
- binoculars
- ziplock bags with white block id
- paper and plastic grocery bags
- vinyl gloves
- heavy-duty hand cleaner
- fine and extra-fine Sharpies
- flexible plastic labels
- cut and hold pole pruners
- saw or pole saw
- pruners
- plastic marking tape
- trowel or entrenching tool
- duffel/gym bag

D. Seed processing
- paper plates (heavy-duty, unfinished)
- nesting bowls
- colanders, strainers, riddles
- vinyl gloves
- sphagnum moss for packing seeds requiring moist storage
- *Dursban* (Chlorpyrifos) for soaking seed prone to insect infestation
- Spear envelopes

E. General supplies
- filament packing tape
- packing tape
- glue stick for envelopes without glue
- scissors
- cotton string
- 100' nylon rope
- large plastic bags
- tarps (especially useful when tenting or traveling in open transport)
- rubber bands
- Scotch tape

F. Medical Supplies – these are only suggestions. Be sure to also discuss with your physician.
- First-Aid kit
- Alcohol swabs for cleaning plates, glassware, and eating utensils
- Antibacterial hand cleaner – *Purell.*
- Spare prescription glasses
- Personal medical prescriptions
- Travel kit (purchased at Travel Clinic at University Hospitals, Cleveland, Ohio)
  a) Athlete's foot - powders or ointments
  b) Blisters – mole skin
  c) Strains, sprains – *Ace* bandage
  d) Sun protection
  e) Toothache – oil of cloves
  f) Water purification tablets
  g) Motion sickness – *Marezine*
  h) Constipation – *Senokot*
  i) Indigestion/Heartburn – *Alamag* Antacid Tablets
  j) Colds – *Sudafed*
  k) Cough – *Robitussin*
  l) Muscle aches/Headaches – *Tylenol*
  m) Sore Throat – *Sepo* throat lozenges
  n) Indigestion/upset stomach/mild diarrhea – *Pepto-Bismol* – a must for stomach ailments. May be prescribed as a daily prophylactic
  o) Diarrhea – *Imodium*
  p) Dehydration – *Electrol*
  q) Sunburn/uninfected insect bites – Hydrocortisone Cream 1% or *Benadryl* 25 mg.
  r) Insect Repellent – *Deet* Towelette
  s) Insect Bites – *Stingkill* Swabs
  t) Abrasions – Triple antibiotic ointment, antiseptic towelettes, Band-Aids
  u) Thermometer – *Temp•Dot* disposable thermometer

Above brand-named items are examples and not necessarily endorsements.

Challenges in Plant Exploration: Building and Maintaining Relationships in Host Countries

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Successful plant exploration and introduction are built on a foundation of sound research in advance of collecting, and the development and maintenance of relationships in host countries. The two are closely related; it is easier to do useful research if you have the right sources in a host country, and sound research combined with the right relationships produces the best field results.

Public gardens and botanical gardens frequently argue that they are uniquely equipped to conduct research into promising collecting locations, and to develop effective relationships in host countries. Sometimes this argument is extended to the point of suggesting that only public institutions should do this work, and that efforts by commercial enterprises are bound to be less effective and perhaps harmful in some way.

I have been actively involved in plant exploration for both commercial enterprises and public gardens for more than 25 years. I believe that public gardens and government agencies routinely overstate their advantage, and in some cases, neglect some of the most important aspects of successful plant introduction.

Much of my work has been in Japan, where few of the people who know important information that can assist in conducting original work speak English well. Yet I do not know of even one person from any academic institution or public garden that has done fieldwork there who knows even rudimentary Japanese. Can we imagine an academic in, say, French literature, going to France to conduct original research without a working knowledge of the French language, and producing credible results? If representatives of academia and public gardens really want to justify their claim of being able to do superior work in countries where the first language is not English, they must first become at least somewhat conversant in the local language.

Most Americans from public institutions and academia rely on their counterparts in host countries to glean information and guide their work. In Asia at least, this is often an unproductive strategy. Many Asian academics in plant science, even taxonomists, do little or no fieldwork, and many hold their positions for reasons completely unrelated to knowledge about plants and where they might be found. In many Asian countries, anyone connected to the government is viewed by those in the countryside with great suspicion, even hostility, and many academics are viewed as arrogant. Sometimes local people take considerable pleasure in appearing to be helpful while subtly sabotaging the effort.

Not too long after I started collecting regularly in Japan, I was visiting a remote island location that I had visited a few times before, a location with several interesting endemic species. One day I was telling a farmer there that I had always wanted to see wild populations of a certain flowering tree that was reported to be essentially extinct, based on a lengthy field study performed by an American academic and his companion, a Japanese professor who was a man of considerable learning. The farmer I was talking to had driven these men around the island during their long and fruitless search for this tree. The farmer said he could show me mountainsides covered with the tree I wanted to see. I thought that he must be mistaken, or that one of us had misunderstood the other, but went with him the next day and found that he was right, that there were literally mountainsides covered with the tree I wanted. I asked him why, if he knew about these wonderful sites, he had not mentioned them to the other visitors. He laughed and said that, in all the time they had spent together, no one had asked him.

This experience was a kind of epiphany for me. I never again ignored the claims of local, supposedly ignorant, people, and I became highly skeptical of information in academic publications. I have never found it necessary to adjust this view. Years later, when I was looking for hardier camellias on the west coast of Korea, I was discouraged by academics who said that the "tongbaek" reported by local people was not camellia but *Lindera*, because "tongbaek" is the colloquial name for both plants in that part of Korea. It turned out that they were talking about camellias, and if I had listened to the experts, I would have missed some good opportunities for fieldwork.

Another problem associated with planning based on academic sources is the rather narrow view of some academic specialists. It is possible to be entirely correct and still be extremely misleading on really important points. An example is a research approach often used today in which a climate map of North America is superimposed on a map of Asia to identify promising areas for exploration. This data is no doubt correct and sometimes useful, but it does not account for the dramatic changes in climate over even the past thousand years. A scientist working with a planning group for plant exploration in China once told me that my suggestions for collection sites were rejected because the climate was not right for the target plants. I pointed out that very many species native at those sites were already extremely successful in the target climate in the United States, but he could not see past the current climatic data. Good research has to include the kind of practical information that is gathered by people who actually work with ornamental plants in real-life garden situations.

So how does one develop relationships that will be useful in fieldwork? It is really not very difficult. The first step is to realize that all of those relationships do not have to be with plant experts. Most of the challenges of fieldwork are logistical, and any reasonably capable person of good will can be helpful. Hobbyists, nurserymen, and students are useful when some plant knowledge is needed. These people can be found through plant societies, hobbyist organizations, foreign student groups at universities, and more and more through the Internet. If you already are active in any international group, you might be able to find a member of that group who is knowledgeable or interested in plants in the country where you want to work. Keep in mind that it is your job to do the advance research; if you do this well, you don't need an expert to help you.

Once you start doing fieldwork in any area, you will find it easy to meet local people who are interested in your work. Just keep an open mind. Unlikely groups such as soldiers, farmers, and locals of all types have proved to be incredibly helpful to me. Tending these relationships can be time-consuming over the years, but if you want to work effectively in any remote area, it is the only way to do it well. Most people know the importance of carrying gifts when they travel. Keep in mind the enormous benefits to be realized by always bringing gifts for the wives of male contacts.

There are some dangers associated with fieldwork in other countries, especially in developing countries, but most people don't understand where the greatest dangers lie. By far the most dangerous aspect of foreign fieldwork is not disease or criminal attack, but traffic accidents. Accident rates in developing countries are often extremely high, and most vehicles don't have many safety features. In one day traveling up the Sindh River in Pakistan, I saw the burned-out skeletons of three public buses at the bottom of ravines where they had recently crashed. It seems unlikely that anyone could have survived. In Korea, in an empty parking lot half the size of a football field, the public bus I was in collided with the only other vehicle in the lot, another public bus. Both drivers had been sitting around smoking for a half-hour, but decided to leave at the same moment and neither would yield to the other leaving the lot. All the windows on one side were ripped out and the passengers showered with debris.

Other dangers are more often remarked upon. Attacks by unfriendly locals are a matter of concern to many travelers, but I think such attacks are not a common problem. Even in countries that are supposed to be unfriendly to Americans, I have seen little hostility; in fact, considering the behavior of many Americans and Europeans in Asia, we are treated with extraordinary deference. I was in Kunming last spring just after the bombing of the Chinese embassy by NATO forces in Serbia. The television images of Chinese mobs attacking U.S. facilities in China were a little frightening. I traveled alone for 10 days and never had even one person (including soldiers) mention the issue, or show any hostility whatsoever. The three most common questions I fielded were: "How much is your salary?", "Do you know Bill Gates?", and "Can you get my son/daughter into an American university?". Even in the local markets, where overcharging foreigners is the most popular sport, I was treated with kindness.

Still, there are social dangers everywhere, and it is a good idea to read up on the peculiarities of the country you are visiting. Many modern guidebooks such as the *Lonely Planet* guides give bluntly honest information about real dangers. Before I visited Pakistan, I read about the ever-popular "put-the-luggage-into-the-taxi-and-drive-off-before-the-passenger-gets-in" scam and the "impersonate-a-policeman-and-grab-the-wallet-while-examining-the-passport" scam. Both were tried on me, and both failed because I knew what to expect. If you know about the most common dangers, you will likely not have any serious problems.

Accommodations in the field are often less than ideal, although it is becoming easier all the time to find relatively clean places to sleep. Crummy lodgings are generally not dangerous, but mostly annoying. Lightweight sleeping bags and inflatable pillows help.

Take all the amenities with you, and a few unconventional items such as a simple door lock or alarm and a roomy money belt you can wear all the time.

Food and water are where real dangers are found, and this is very tricky because sharing meals is an important, even essential, part of building relationships. Being able to eat local food and at least appear to enjoy it helps to build personal relationships. Still, there are dangers well beyond an upset stomach. My personal view is that I am willing to risk stomach upset but not much more. Know in advance the possible consequences of eating risky foods such as raw shellfish or raw vegetables. Unless you have religious dietary restrictions, you should be willing to eat any hot cooked food offered and appear to enjoy it. Information is power. What is fine in Japan might be potentially lethal in Peru. Fortunately, it is now possible to get bottled water almost everywhere, and where it is not available, tea or other hot beverages can be substituted. Portable water purification is now practical and easy.

Perhaps the most difficult social area involves alcohol. In many countries, especially in Asia, drinking is still considered an essential element in social bonding, and it is considered good manners to drink until one is nearly unconscious. It is possible to opt out of these events, but it is still true that "bad girls get more dates." There are many situations in which participation in these bonding activities will pay off in useful enduring relationships. There are some defenses. Once you really get to know someone, you can be more open about discussing your real feelings about these events. I have found that many Asians also don't really enjoy them either and are happy to have an excuse not to participate once the relationship is formed. If you are a good actor, you can pretend to be extremely drunk before you really are, and avoid the hangover. And of course there is the old dump-the-drink-in-the-potted-palm routine. Fortunately no one seems to mind foolish behavior when you are thought to be drunk. If you just can't deal with the alcohol issue, there are a number of Muslim countries where you won't be faced with the problem at all.

Plant exploration has been accomplished mostly by men, in part because of sexual roles and stereotyping, especially in Asia. This is changing, and it is now possible for women to be effective in this work too. Still, most of the social bonding is still male bonding, and women do not fit well or are not accepted in these situations. On the other hand, it is easier for women to opt out of such festivities without criticism.

I have often wondered what people in other countries really think is the most offensive thing about the way we Westerners conduct ourselves in Asia. I have gotten to know some people well enough to expect an honest answer to that question, and the most frequent response was a surprise to me. In Asia at least, very many people are greatly offended by the way we dress. Dirty blue jeans, shorts, and sweaty t-shirts are too common on foreign visitors, even some who should know better. In many Muslim countries it is considered shameful for even men to wear short pants or sleeves in public. Even when the temperature was 115 degrees F in Pakistan, every man I saw was covered from neck to ankle. There are plenty of easy-care, lightweight fabrics available, and there is no excuse not to be neat, modestly dressed, and reasonably clean.

In 26 years of plant exploration, I have been the recipient of far more kindness and consideration than anyone deserves. I imagine that this is true for most travelers. A little research, a few good contacts, and a little more common sense are the only essentials.

Documenting Your Collections

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Introduction

Why Documentation Is Important

One could ask the question "why is the documentation of collections so important?" To answer this, one must first understand what "documentation" actually means. The proper documentation of collections involves the comprehensive gathering and accurate recording of pertinent data about a plant sample and the habitat from which the plant was collected. This information is important both immediately and over the longer term as it:

- creates an inventory record of the collection, one that can be maintained in perpetuity if needed
- facilitates the determination of the plant's identification
- records specific information on the collecting location and important characteristics of the habitat (sun exposure, latitude, elevation, slope, soil type, etc.)
- documents the associated plants growing in proximity to the plant collected

A thoroughly documented collection increases its scientific value. The field data provides critical information for scientists, who can incorporate this information in to their research activities such as breeding, evaluation, and selection of genetically superior specimens, and *ex situ* and *in situ* conservation. This information can also provide useful clues regarding how a plant can be propagated, as well as its inherent climatic and edaphic tolerances and adaptations.

How Documentation Is Useful

There are many practical and interesting examples of the importance of documenting collections. One recent example involved USDA researchers searching for wild populations of rock grape (*Vitis ruprestris*). Rock grape is a prized rootstock because of its resistance to grape root phylloxera, a serious pest of cultivated grape varieties throughout the world. After this North American pest was introduced into Europe in the late 1800's, wine production was nearly wiped out. Interested in finding wild populations of rock grape, USDA researcher Dr. Diane Pavek performed an exhaustive search through regional and local herbaria collections to identify previously discovered locations of this species. Using the specific locality data found on the herbarium specimens, the rock grape populations still in existence were relocated and subsequently screened for their genetic diversity for future breeding programs.

Another outcome of Pavek's work was the knowledge that many of the previously known populations of rock grape were no longer in existence. Of the 60 sites in 10 states that rock grape was originally described from according to the U.S. herbarium collections, only 24 populations in nine states were found to still exist. This information can be very useful in ultimately determining a plant's risk of being threatened or endangered.

A second example of the importance of proper documentation relates to an interesting ornamental plant from the People's Republic of China (P.R.C.), *Heptacodium miconioides*, known as seven-son flower. E. H. Wilson of the Arnold Arboretum first collected this plant in July and October of 1907 in western Hupeh Province (Wilson collection #2232). It was documented to be very rare in this locality, growing among cliffs at 900 meters in elevation. At the time, its identification was not known.

Subsequently, in 1916 Alfred Rehder, Wilson's colleague at the Arnold Arboretum, upon examining Wilson's herbarium specimen, described the plant as a new genus of shrub in *Plantae Wilsonianae*, his hefty enumeration based on the plants collected by Wilson during his expeditions to western China in the early 20th century. The next reference to the genus did not occur until 36 years later. In 1952, Henry Kenneth Airy Shaw, a taxonomist at the Royal Botanic Garden at Kew, described what he thought was a second *Heptacodium* species from two previously undetermined herbarium specimens; he named it *Heptacodium jasminoides*.

Living plants were not seen by Westerners again until scientists participating in the 1980 Sino-American Botanical Expedition observed plants that originated from wild populations growing at a botanic garden. One of the participants on the expedition, Dr. Dudley from the U.S. National Arboretum, recognized it from his research on the Caprifoliaceae family and knowledge of Rehder's taxonomic description of Wilson's herbarium specimen. This plant was subsequently introduced into cultivation in the United States from seeds collected during this 1980 expedition.

It was not until 1988 that the nomenclature of these plants was verified as belonging to one species, *Heptacodium miconioides*, as confirmed by a Chinese botanist after a careful comparison of the herbarium samples reputedly representing both species. These findings are recorded in the *Flora of China* series (*Flora Reipublicae Popularis Sinicae*, Volume 72).

Preparing for Collecting in the Field

Thorough pre-trip planning and preparation are important steps for all aspects of a successful plant collecting expedition. This is particularly true as it relates to documentation. Thoroughly familiarizing oneself ahead of time with as many plants as possible from the region to be explored significantly increases the likelihood that the preliminary in-the-field identification of a collected specimen will be correct. This will considerably reduce the likelihood of an initial identification error, and it will aid taxonomists re-examining the collections during their more thorough examination after the expedition. The pre-trip preparation can be broken into two tasks: home-site preparation and host-site preparation.

Home Site Preparation

When preparing to go on a collecting trip, there are several avenues that can be pursued to gain knowledge of the plants one will encounter in the field. Each of these should be initiated at least several months prior to the departure date.

Literature Review

There is usually a wealth of published information about the collecting site. Some of the publications may take time to procure, so it is essential to begin gathering this information early in the trip preparation process. These publications include graduate student reports and theses, popular and scientific articles, floras of the region, monographs of a particular group of plants, and books written by individuals who previously collected in the region. Oftentimes, publications by graduate students from the host region are available; many from foreign countries are now available in English. If not written in English, obtaining a translation of all or a portion of the work can provide valuable information.

Herbarium Specimens

As described previously, herbarium specimens can provide valuable information regarding morphological characteristics of the plants of interest, and also information on the particular habitats and locations in which the plants occur. Many botanic gardens, arboreta, and universities maintain herbarium collections; with sufficient advance notice it is possible to visit these institutions to view their specimens or to request them as a loan for review.

Review of Arboreta and Botanic Garden Living Collections

The living collections of many arboreta and botanic garden collections are impressively rich. For example, the collections of The Morton Arboretum include over 41,000 individual plants from more than 3,700 different kinds of trees, shrubs, and vines. Time spent studying these living collections can be invaluable for improving the ability to identify the plants subsequently observed in the field.

Host Site Preparation

Typically, the time available for familiarizing oneself with the plants upon arrival in the host country is limited. Despite this, it is often time well-spent because it allows one to focus on the actual species that will likely be encountered in the field. The avenues used to gain this knowledge are similar to those used during home site preparation, but each offers the opportunity to focus more closely on the target list of plants. Items that have proven to be particularly useful to the author are discussions with the host's professional colleagues and local tour guides, and local reference booklets.

Professional Colleagues and Local Tour Guides

The host's professional colleagues can be particularly knowledgeable regarding aspects of the regional flora that the host may not be familiar with. This has been particularly true during expeditions the author has taken to the P.R.C. Many of the older Academicians possess a tremendous depth of knowledge on the flora of the region, but because they are not proficient in English, they are often not directly involved with the expedition. Frequently at social events or formal meals, these individuals can be engaged in conversation and information exchange through their English-speaking colleagues. These discussions are often very informative and interesting.

Local tour guides can also provide a wealth of useful information. Although many of these individuals have no formal training in botany or horticulture, they are often thoroughly familiar with the local flora. This familiarity is generally based on medicinal or culinary experiences. While they may not know the scientific names of the plants, they likely know the local colloquial names, which in itself is valuable information not always attainable from the botanical literature. These individuals can frequently recognize the plants one is interested in finding from photographs or line drawings.

Local Reference Booklets

The staff of botanic gardens often have only-locally-available books, brochures, or pamphlets on the plants in their gardens. Commonly, simple line drawings are included in these publications. Although the works are usually written in the local language, the scientific names are often included in English. These publications are useful and easy to carry in the field.

Collecting Data in the Field

There are several crucial facts that need to be determined and recorded in order to compile quality records. The most important and first record assigned to a collection is an accession number. This number, usually assigned in sequential order, is the specific and permanent reference number assigned to the collection. The accession number and other data collected are recorded in a field data notebook. A sample of a North America – China Plant Exploration Consortium (NACPEC) field data notebook is included at the end of this paper. Most of the information can be gathered by recording the collecting activities (e.g., seed collected, photographs taken, soil sample taken, etc.) and by recording observations at the site (e.g. field identification, sun exposure, latitude, etc.). Information can also be provided by the your local host, e.g., local name and special notes on the plant's use.

Special equipment is needed to gather much of the data for other information fields. This equipment includes an altimeter to record altitude, a Global Positioning System (GPS) recording unit to record longitude and latitude, and a compass to record the direction of exposure. In steep terrain or dense tree-canopied areas, the GPS unit may not be able to record data accurately. When this is the case, Tactical Pilot Charts have proven to be helpful in identifying the collecting locations. These maps clearly identify land contours and prominent features in the landscape. Because of the detailed contour information these charts provide, they are also useful for locating specific habitats. Tactical Pilot Charts are available from Aviation Publications Service, AD&C, Inc.; 1327 Maiden Lane • P.O. Box 400 • Del Mar, CA 92014-0400; Phone lines: 800-869-7453 (USA & Canada) 858-755-1190 FAX 858-755-5910; http://www.apscharts.com.

Several blank copies of the field data notebook should be included in the expedition's supply inventory. Periodically begin to use a new book and store the partially completed book in a safe place. This procedure helps ensure that if the book currently in use is lost or seriously damaged, a minimum of information is lost.

Documenting Seed and Herbarium Collections

The original accession number should stay with the sample in perpetuity or until the collection is reaccessioned (e.g., when the collection is incorporated in the records of an arboretum or botanic garden that participated in the expedition). Coupling the accession number and the collection in a way that they cannot be separated ensures the information on the collection is not lost. This is particularly crucial during the elaborate process of cleaning the seed from fleshy-fruited plants (see Tubesing's paper in this proceeding), as the seed will come in contact with water and likely be moved from container to container. Oftentimes, it is best if the number is affixed to the sample using several different methods.

With dry seed or fruit samples, write the accession number on the outside of the bag or label attached to the bag. Also include the accession number on a wooden or plastic label and place it in the bag. With wet or fleshy-type fruit, it is important to use a permanent marker to avoid the accession number becoming illegible due to the moisture of the fruit. Write the accession number on the outside of the plastic bag; include a plastic label and place it in the bag. When the seeds are being cleaned from the fruit, write the accession number on the blotters or newspapers being used to dry the seed.

For herbarium collections taken in the field, bind the samples together with a rubber band or string, and affix at least one label with the collection's accession number. The sample is then placed in a large plastic bag to retain its moisture, which helps preserve its condition. After returning to the base station, the samples are separated and placed in a herbarium press. During processing, each individual sample is folded between newspaper sheets. The sample's accession number should be written on each individual sheet.

When preparing to leave the host site, a thorough accounting of the seed and herbarium collections should be conducted. This involves cross-referencing the field data notebook's information with the actual collections made. Any discrepancies or inaccuracies in the number of samples collected should be corrected at this time.

Post-Trip Documentation Activities

The expedition's collections should be thoroughly studied by a competent taxonomist to confirm or change the initial determinations made in the field. This professional will have the most comprehensive and up-to-date references available as a resource. Also, adequate time is available to investigate difficult determinations. If necessary, samples of plants for which identification cannot be determined can be sent to nationally or internationally recognized experts for study.

As plants are propagated from the collected seed, the integrity of the documentation should be maintained through the use of the accession number assigned to the plant. The number may be the one initially assigned to the plant, or more likely, the new number

assigned to the plant upon its entry into the institution's inventory system. The field collection information should be entered as part of the institution's permanent database.

Finally, a comprehensive trip report should be compiled to make a thorough recording of the expedition. The report should include a listing of the participants, objectives, overview, maps of the region, expedition bibliography, itinerary, collection field notes, list of germplasm collected (alphabetic and numeric by accession number), and special notes of interest. A copy of the trip report should be kept in each of the participating institutions' libraries to ensure its long-term safekeeping.

Conclusion

By following standardized procedures in the field when the samples are collected, and again when the samples are processed during post trip activities, the integrity of the collections' information will be preserved. Thorough and accurate documentation is one of the most important means to ensure the long-term value of one's collections.

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Field Collecting Notebook

1996 NACPEC/Xian Botanical Garden
Plant Exploration Trip
Shaanxi Province
People's Republic of China

Participants:

Jim Ault
Director or Research
Chicago Botanic Garden

Kunso Kim
Curator of Plant Collections
Norfolk Botanical Garden

Kevin Conrad, Co-Leader
Herbarium Curator
U.S. National Arboretum

Rick Lewandowski,
Co-Leader\Director of Horticulture
Morris Arboretum of the
University of Pennsylvania

Ostrya japonica Sarg.

Figure 1. The cover from the Field Collecting Notebook used on the 1996 NACPEC trip to China.

Scientific Name | **Country** (ISO.CODE)

State/Province *(SUB.CNT1)* | **District/County** *(SUB.CNT2)* | **County/Township***(SUB.CNT3)*

National Grid*(NAT.GRID)* | **Local Name** *(LOCALITY)* | **Habitat Code** *(HAB.CODE)*

Habitat Notes*(HABITAT)*

Slope *(0 to 90°)* | **Aspect** *(N, S, E, W, etc.)* | **Soil Type**

Plant Description *(COLL.NOTE)* **Life Form; Habit** *(Annual; biennial; perennial; tree; shrub; spreading; ascending; fastigiate prostrate;decumbent)*

Height | **D.B.H.** | **Bark** *(color; texture)* | **Leaves** *(color; luster; hairs; odor; flavor)*

Flowers *(regular or irregular; size; corolla; calyx; anther color; odor)*

Fruit *(color; size; shape; hairs; odor; flavor)*

Biomass Type
☐Seeds ☐Plants ☐Cuttings ☐Herbarium Specimen ☐Other (Specify)________
| **Origin** *(PROV.TYPE)* ☐ Wild *(W)* ☐ Cultivated *(G)* ☐ Cultivated of Wild Origin *(Z)* | **Photograph** ☐ yes ☐ no

Special Notes *(sap color; pollinators; economic/medicinal use; pith color; local/common name, etc.)*

Altitude ______ meters | **Latitude** ______°______'______"______ | **Longitude** ______°______'______"______

Collectors *(COLL.NAME)* | **Field, P.I. or N.A. No.***(COLL.NUM)* | **Date** *(COLL.DT)* | **No.Herb.Spec.**

created by R.J.Lewandowski—revised 8/96

Figure 2. A page from the Field Collecting Notebook used on the 1996 NACPEC trip to China.

Legal and Ethical Issues in Introducing Plants into The United States

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Introduction

Though the focus of many of the presentations at this symposium seems to be the ramifications on plant importation and exploration of the Convention on Biological Diversity (CBD), there are other legal and ethical issues that must be considered when one wants to bring plants into the United States. In place are numerous national and international regulations and treaties governing the movement of plant materials across borders. This is the legal issue. Conversely, it is not unheard of for persons who are fully aware of these restrictions to deliberately proceed through U.S. customs without declaring the germplasm and therefore not having it inspected. This is the ethical issue. This presentation will focus mainly on the legal issues.

U.S. Regulations

The legal and ethical issues in introducing new plants into the U.S. is of great concern to many in the botanical garden community. It is of equal concern to those of us in the USDA-managed National Plant Germplasm System (NPGS). The NPGS is a network of organizations and people dedicated to preserving the genetic diversity of crop plants. The national system collects plant germplasm from all over the world, including the United States. Curators and other scientists preserve, evaluate, and catalog this germplasm and distribute it to people with a valid use. The members of the NPGS include Federal, State, and private organizations and research units. Through the various offices within the system, approximately 6,000 plant accessions are added to the NPGS each year. On average, 75% of these new accessions are obtained from sources outside the United States. The new accessions are most often obtained through exchanges, usually professional exchanges between scientists, while between 10-20 % are obtained as a result of collaborative plant explorations. Most of these explorations and many of the exchanges are coordinated and supported through the USDA/ARS Plant Exchange Office. More information can be obtained on the U.S. NPGS and its accessions at www.ars-grin.gov.

It needs to be accepted that countries have the right and the responsibility to monitor and control their borders. This monitoring and control includes plants, plant propagules, insects, diseases, soil etc. The purpose of this is to exclude potentially harmful exotic agricultural pests and diseases from entering the United States. Guarding U.S. borders and the enforcement of U.S. quarantine regulations is the responsibility of the USDA Animal and Plant Health Inspection Service (APHIS). All plants or plant parts entering the U.S. must be inspected by the APHIS officials at the port of entry for evidence of insects and diseases. Restricted plants must be held in approved post-entry quarantine facilities for the designated time periods. Prohibited taxa will be destroyed unless the

introducer has a permit specific for the taxon. For a more thorough understanding of all the rules and regulations visit the APHIS web site at: www.aphis.usda.gov.

The introduction of noxious weeds into the U.S. is also a great concern of many botanical gardens as well as the NPGS. Though some crops and crop relatives are listed as noxious weeds, they can also be considered desirable germplasm for the NPGS. This is especially true for herbaceous and woody ornamentals, forage grasses and legumes, new crops, sugarcane, rice, oats, and wheat. It is therefore very important to know which taxa are considered to be noxious weeds and obtain the necessary permits to grow this prohibited germplasm under the appropriate controlled conditions. The U.S. Noxious Weed program is also enforced by APHIS at the port of entry.

The ethical components of this legal issue would be to make sure the germplasm is declared at the port of entry; to evaluate any new or unlisted taxa for potential weediness; to remove from the field plots of introduced germplasm growing at your facility any taxa that appear to be weedy; and to not willfully distribute any known or suspected weedy germplasm even if it is not on a state or federal noxious weed list.

International Regulations

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is another "pre-CBD" issue affecting plant introduction. CITES was established 25 years ago and now has more than 115 member countries. This international convention bans from commercial trade an agreed-upon list of endangered species. It also regulates and monitors trade in other species that might become endangered, and it established a worldwide system of controls by stipulating that government permits are required for such trade. The U.S. is one of the member countries of the convention. In the U.S., the CITES program is maintained through the US Fish and Wildlife Service (USFWS). The USDA/APHIS is the inspecting agency in the U.S. (addressed on their Web page given earlier). The CITES Web page, which is maintained through the World Conservation Monitoring Centre, is at www.wcmc.org.uk.

In 1983, the Commission on Plant Genetic Resources was established through the Food and Agriculture Office (FAO) of the United Nations. It was designed to be a global forum where donors and users of germplasm could meet on an equal footing to try to resolve germplasm issues. The commission has met every two years since that time. One of the main tasks of the Commission is monitoring the implementation of the International Undertaking on Plant Genetic Resources. This is a non-binding agreement, drawn up by the FAO in 1983, with the aim to ensure that plant genetic resources are identified, collected, conserved, evaluated, and made available without restrictions. As stated in the International Undertaking, plant genetic resources were considered the "common heritage of humankind." Efforts are now underway to bring the International Undertaking more inline with the Convention on Biological Diversity. The earlier statement that plant genetic resources were the "common heritage of humankind" is now expressed by this Commission as being the "common concern of humankind."

This FAO commission also developed and approved the International Code of Conduct for Plant Collecting and Transfer. This is a voluntary code that recognizes that nations have sovereign rights over their plant genetic resources. The code is primarily addressed to national governments and identifies the responsibilities of curators, sponsoring organizations, host countries, and germplasm users. The basic provision is that countries should regulate germplasm collecting and exchange through the issuing of permits. In this aspect it closely parallels Article 15 of the Convention on Biological Diversity. The U.S. is an active, full member of the FAO Commission on Plant Genetic Resources.

The United Nations Conference on Environment and Development (UNCED), held at Rio de Janeiro, Brazil, in June 1992 developed the Convention on Biological Diversity (CBD). The CBD was opened for signature at UNCED. It entered into force on 29 December 1993, when the 30th country ratified it. The U.S. representatives signed the CBD, but it was not ratified by the U.S. Senate because of concerns related to domestic land use issues. The CBD recognizes biodiversity as a "common concern" of humanity. Article 15 of the CBD states that States have sovereign rights over their natural resources and that the authority to determine access to genetic resources rests with the national governments and is subject to national legislation. It adds that access to genetic resources, where granted, shall be subject to the "prior informed consent" of the donor of the genetic resources. National legislation should promote the fair and equitable sharing of benefits from the commercial use of resources on mutually agreed terms. The CBD distinguishes between germplasm already collected and germplasm to be collected in accordance with its provisions.

It is not my intent here to argue the various points that surround the CBD as well as the International Undertaking, such as farmer rights, intellectual property rights, origins of plant genetic resources, etc. But the U.S. National Plant Germplasm System, like many U.S. botanic gardens, recognizes the sovereign rights of States over their natural resources and their authority to determine access to these resources. Further it supports the equitable sharing of benefits derived from genetic resources.

Even now, almost six years after the CBD was ratified, it is often difficult to obtain permission to collect germplasm from national authorities in many countries that ratified the CBD. Reasons for this could be that the appropriate office has not been established, or is not well known, or even that it may not be staffed. But now all plant explorations funded through the NPGS are required to have national authorization by the host country if it is a requirement of the country. While it is not possible to have a standard procedure for obtaining this authorization because of the uniqueness of each country and because most countries are in the process of developing their access legislation, we try to follow some basic guidelines. All trips must have a host in the target country. This host is often with either an educational or government institute. Ideally, the host is a scientist working on the same crop that is targeted for collection and would equally benefit from the collected germplasm. Most often the host is asked to identify the national authority for obtaining the access permission. It is not unusual for the host to be unaware of the necessity of obtaining permits and may even tell the U.S. colleague it is unnecessary. For botanic gardens, oftentimes contact with the director of the National Botanic Garden of

the host country will direct them to the appropriate authority. We have also been successful in contacting the regional offices of the International Plant Genetic Resources Institute (IPGRI) to identify the national authority responsible for granting access to plant genetic resources.

Benefit sharing is another important issue supported by both the CBD and the International Undertaking. Though not recognized by some, it should be acknowledged that the significant funding the U.S. Government provides to the International Agriculture Research Centers, other international plant germplasm programs, crop specific international programs, international cooperative research, and breeding projects benefits all countries including the U.S. Another significant benefit to many countries is the maintenance and support of the U.S. National Plant Germplasm System that freely distributes annually approximately 25,000 seed packets of plant germplasm to researchers throughout the world.

But to negotiate access to a country's plant genetic resources, specific benefit sharing components are required. It is the policy of the NPGS not to patent germplasm it has obtained from outside sources. Therefore, it is not possible for us to include as a benefit the sharing of patent royalties. This could be an option for botanic gardens and other individuals and institutes. The focus of our negotiations is to develop "up-front," non-monetary benefits that will help develop the national or local plant genetic resource programs. An example would be paying for training in some aspect of management of plant genetic resources such as seed handling, tissue culture, or data management. This training can be in the U.S. or in another country. Another possibility would be to purchase certain laboratory or field equipment. Hosting a national meeting of apple researchers at the host institute in the PRC at the end of a collaborative collection for *Malus* was very successful and considered beneficial to the PRC. Other benefits could be paying the host to do additional collecting at other times, and paying the host to increase the collected seed at their institute when relatively few seeds were collected. While these are "non-monetary" in that we do not exchange cash, they can be expensive and have increased the cost of our plant collecting trips by about 25 to 30%. Additional benefits standard to most of our collecting trips in less developed countries include our paying all the expenses for the trip, including the host's expenses, and equally sharing the collected germplasm and information.

Conclusion

So in summary, for the introduction of plants into the U.S. there are legal and ethical issues, which include quarantine regulations, noxious weeds regulations, CITES, the FAO International Undertaking and the UNCED Convention on Biological Diversity. With the Internet it is now much easier to obtain information on all of these programs. While we are legally required to obey the first three issues, there are still unresolved issues surrounding both the IU and the CBD. However, most of us at this symposium agree with the key tenets of the latter two and recognize the need to align our activities so that continued access to plant genetic resources is supported.

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Bring 'Em Back Alive!

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Introduction

A primary goal of plant exploration today is to add living plants to our collections and gardens. Once seeds have been collected, it is essential that they be processed and stored appropriately so that their viability is maintained until they are in the hands of the propagator. This paper discusses procedures for extracting seeds from different fruit types, and details the processing and storage requirements for major categories of seeds.

Processing Seeds

Usually it is not seeds alone, but fruits that are collected. In most cases, this means that there are structures or tissues that are present in addition to the seeds. It is desirable to extract the seeds, or separate them from these extraneous parts for several reasons. First, the process of extraction reduces the volume that must be transported. Second, by cleaning the seeds of flesh or other foreign matter, sources of mold are greatly reduced. Third, cleaned seeds are more easily scrutinized by the plant health inspectors during importation; consequently, they are less likely to find a cause for confiscating and destroying the seeds.

Handling Fleshy Fruits

For convenience in discussion, fruits may be divided into three broad categories: fleshy fruits, dry fruits, and nuts. Fleshy fruits are those in which the seeds when ripe are enclosed in tissues that contain a high percentage of water. This includes taxa with fruits that are loosely referred to as "berries," which may contain one seed per fruit, as in *Viburnum* species, to many seeds per fruit, as in *Rubus* (raspberries), and pome fruits such as *Malus* (flowering crabapples). For these, the first step in seed extraction is to crush the fruits, or at least to break the skin. The purpose is to enhance decomposition of the flesh or fruit pulp by breaching the barrier presented by the skin of the fruit. Next, the fruits are mixed with water and put in a warm place to encourage decomposition to proceed. If the collector will remain at one location for several days, an open container may be used for this process. If the collector will be changing location regularly, then it is more convenient to place the seed/water mixture in a self-sealing bag (*Ziploc*), which can be left open to vent fermentation gases in between moves, but which can be quickly sealed for transport.

This practice of soaking fruits to soften the pulp and permit its removal is called maceration. After a few days to a week, depending on a number of factors, the flesh will have softened and loosened sufficiently to permit its separation from the seeds. Then the fruits are rubbed over a colander or screen under running water to remove the pulp. If the seeds are quite small, such as those of the brambles (*Rubus* sp.), a mesh size larger than the seeds may be selected, so that when the seeds are rubbed over the screen they pass through and are collected in a container underneath. Then what remains atop the screen is discarded. With larger seeds, a mesh size too small for the seeds to pass through is chosen, and all that passes through the screen is discarded. The seeds and remaining pulp and skin are then placed back into a container of water.

In either case, there now is a mixture of partially cleaned seeds, pulp, skin etc. in water. These mixtures should be placed in a cylindrical container, preferably three to four times tall as wide. The container is then filled with water and stirred. The filled seeds (i.e., those with embryos) are allowed to settle to the bottom of the container; then the water containing the lighter pulp and fruit skins is poured off. This procedure, called separation by flotation, is repeated several times, until most of the pulp and skins have been eliminated. (Please note that before relying on flotation to separate the seeds, it is necessary to establish that the particular seeds you are working with are dense enough to sink. Sometimes viable seeds are not completely filled, and will float on water. If you do not check, you may pour all of your seeds down the drain in the first round of flotation).

Once the flotation water is essentially clear, the seeds are screened out, spread thinly on an absorbent surface, and left to partially dry, or enough to eliminate the water around the seeds. For spreading out larger volumes of seed to dry in the field, use herbarium blotter sheets, also called felts. For smaller quantities of seed, the heavy, plain, Chinet-type of paper plates without a plastic coating are very effective. These are substantial and absorbent enough to wick water away from the seeds. After use, they can be dried and re-used.

Further handling of the now partially dried seeds is determined by what is known of that species' tolerance for dry storage. Wyman (1971) provides extensive lists of temperate woody plant genera segregated according to the tolerance of their seeds to being dried. Seeds that can be safely dried without loss of viability, such as those of *Cotoneaster* and *Viburnum* species, should be left to dry in the open air for several more days. The seeds are then placed in paper packets and stored in heavy paper (Spear) envelopes. For "recalcitrant" seeded species, such as *Lindera* (spicebush) and *Magnolia*, where thorough drying would lead to a rapid loss of viability, the seeds should be mixed with damp sphagnum moss and placed in 2-or 4-mil, self-sealing polyethylene bags.

Sphagnum moss is the medium of choice for two reasons. One, it is universally recognized as an acceptable packing medium for plant importation, and so may be left mixed with the seed for inspection. Two, it has fungistatic properties (Fleming and Hess, 1965), and so inhibits the growth of mold. Care should be taken to keep seeds that are in moist storage out of direct sunlight or other situations where overheating may occur. If available, refrigerated storage is advantageous, particularly for seeds collected early in the expedition. If for any reason it should become necessary at the trip's end to leave the bulk of your seeds behind for shipment after you depart, or to ship them separately, then priority should be given to carrying the recalcitrant seeds back with your personal

baggage. These seeds are the most perishable, and so success greatly depends upon getting them back without delay.

Handling Dry Fruits

Dry fruits can be divided into two categories, those from which the seeds are normally extracted for propagation and those in which the whole fruit is handled as a seed. In the first group belong such genera as *Rhododendron*, *Deutzia*, and *Weigela*, which bear capsules containing multiple seeds; cone-bearing conifers such as *Pinus* (pine) and *Picea* (spruce); *Syringa* (lilac) with no more than two seeds per capsule; and legumes such as *Cercis* (redbud) and *Maackia*, with seeds carried in flattened pods. An example in which the whole fruit is handled as a seed is *Acer* (maple). In all cases, after collection the fruits should be spread out in a single layer to dry. Weather and circumstances permitting, the seeds can be placed outdoors during the day and brought in at night. Failing that, a windowsill will serve the purpose. Often, a few days of drying will lead to the opening of capsules. Once most of the capsules in a lot are open, they can be placed in a paper bag and shaken vigorously to release their seeds. Then sieves are used to separate the seeds from the capsules and larger fragments, followed by handpicking to eliminate smaller bits of debris still mixed with the seeds.

In the case of a number of the conifers, air-drying will lead to opening of the cones, and the seeds can be tumbled and shaken out. In some of the pines, the cone scales are bound by resin, and heat must be artificially applied to soften the pitch. In the case of *Pinus koraiensis* (Korean pine), the seeds of which are used for food, the locals beat the large cones with small clubs in order to extract the large seeds.

With lilacs (*Syringa* sp.) we have on occasion noted a reluctance of the capsules to release their seeds, possibly because the fruits were not fully ripe when picked, or because of the presence of a seed parasite. In such cases, it is necessary to pry apart the valves of the capsule with the fingernails and pick out the seeds. This process, though tedious, results in very clean seeds ready for storage and treatment.

Seeds that are borne in pods are dried as described above. In some cases, drying will cause the sutures of the pods to split, revealing the seeds and permitting them to be dislodged with the fingers. If the pods do not open, then they must be crushed, and the seed separated from the pieces of pod by screening or winnowing.

Winnowing is a useful means of separating seeds from less dense matter that they are mixed with. This is accomplished by dropping the seeds from one container into another through a moving stream of air. The air stream can be supplied by a fan or by mouth. If all goes well, the denser, filled seeds fall into the container, while empty seeds, bits of fruit wall, etc., fall farther away. The greater the density of the seeds in relation to the chaff, the easier it is to separate the two by this process.

Another method of separating seeds from chaff involves sliding them down a slight grade over a roughened surface. This works particularly well for rounded seeds with smooth surfaces that roll easily. The seeds are placed in a shallow container such as a paper plate, which is tilted slightly and gently vibrated until the seeds fall to the bottom edge, leaving most of the unwanted bits behind. The chaff, now separated from the seeds, can be brushed or blown away with a carefully focused puff of air. This procedure usually must be repeated several times, eliminating more detritus each time.

My colleagues and I had the opportunity to witness an expert perform the latter procedure at the Nanjing Botanical Garden in September, 1997. We were assisted in cleaning the last of the seeds from our Changbai Shan expedition by a staff member of the botanical garden, a man in his 70's. He used a shallow, nearly flat, tightly woven basket, and with a practiced wrist action easily worked the seeds to one side of the basket while leaving most of the chaff behind.

Dry fruits that are handled whole as seeds often contain considerable moisture. If these are held in a large enough mass, particularly in a moisture-tight container, they can heat up like a compost pile. As soon as possible after collection it is advisable to spread these out to dry for a few days, even if the intent is to subsequently put them into moist storage.

At this point, we again have seeds that have been cleaned and partially dried. Further handling is determined, such as for seeds carried in fleshy fruits, by our knowledge of the tolerance of seeds of that particular genus for drying. Seeds of genera such as *Rhododendron, Deutzia, Picea* (spruce), *Pinus* (pine), *Syringa* (lilac), and *Cercis* (redbud) are not harmed by drying, and so are left to dry thoroughly before being packed into paper envelopes. Viability of the seeds of elm (*Ulmus*) and maple (*Acer*) is reduced by prolonged dry storage, and these are best mixed with damp sphagnum and stored in polyethylene bags under cool conditions until they can be sown or stratified. Again, it is recommended that such seeds be carried home with your personal baggage, should it be necessary to ship the bulk of the seeds separately.

A special case is presented by *Salix* (willow), *Populus* (poplar), and related taxa, where viability is maintained at best for only a few days under normal conditions. Here the goal must be to sow the seeds as soon as possible after collection. If express shipment home is available, then it should be used in the case of short-lived seeds such as these. If it is not, then perhaps the best course would be to sow the seeds onto a medium of sphagnum moss while still in the field.

Handling of Nuts

Nuts are discussed separately because of their peculiar combination of characteristics that affects how they are processed and stored. In comparison to seeds of other temperate-zone woody plants, nuts are large individually, and contain a larger quantity of stored reserves as fats (most nuts) or carbohydrates (*Castanea*, chestnut). They are prone to infestation by seed parasites, chiefly weevils. Nut-type seeds, including acorns from the oaks (*Quercus*), are considered recalcitrant, and should not be dried thoroughly.

The first step in nut processing is to extract the nut from its husk, involucre, etc. For those species of *Juglans* (walnut) with a persistent husk, extraction is achieved by a process much like that recommended for fleshy fruits; the seeds are soaked in water to soften the husks, which are then removed mechanically by abrasion. Considerable effort is often required to scrub the last of the husk from each nut. For other nuts, the fruit are spread out in a shallow layer to dry for a few days, allowing the husks to split or otherwise loosen which releases the nuts or permits their ready extraction by hand.

Once the nuts have been extracted, they should be checked for the presence of holes made by exiting weevil larvae. Any seeds with such holes should be discarded. When seeds undergo import inspection, if a single larva or nut with an exit hole is found, it is considered sufficient justification for confiscating and destroying all of the nuts in that lot. In order to prevent the subsequent emergence of any weevil larvae, the nuts should be soaked for 15 to 20 minutes in a solution of *Dursban* (chlorpyrifos) insecticide, diluted to label specifications. Afterwards, the seeds should be allowed to drip-dry; then they may be packed with damp sphagnum into polyethylene bags.

No matter what procedure for seed extraction, cleaning, and storage is followed, it is essential that the identification, particularly the collection number, remains with the seeds through the entire process. Frequently, multiple collections of a species are made at different locations. If an identification number is lost from a batch of seeds, it may be difficult to reestablish with confidence to what collection number it belongs. Because some of the steps in extraction involve moisture, a plastic label marked with an indelible pen is recommended as a reliable, durable means of labeling seeds.

Conclusion

Because for today's nursery or public garden plant explorer the principal aim of a collecting trip is to introduce live plants into gardens, special emphasis should be given to the handling of seeds after they are collected. Seeds, though designed for dispersal, are perishable to varying degrees. Awareness of this and attention to the specific needs of individual taxa will help to insure that viable seeds reach the hands of the propagator.

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The U.S.A./U.S.S.R. (Russia) Botanical Exchange Program

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Introduction

Sometimes positive actions emerge from times of adversity. The United States and the (former) Soviet Union were archrivals and seemingly locked in an ever-escalating race to develop and place in readiness large weapon systems capable of destroying the other country. In the midst of this, a highly successful, field-oriented botanical exchange program was one of the many activities that resulted from an historic agreement between the Soviet Union and the United States. This program, which began in 1976 and continued for over 20 years, resulted in the planning and execution of 45 exchange trips, approximately half of them by scientists of the U.S.S.R./Russia to various regions of the United States, and the remaining ones to the Soviet Union by North American botanists and horticulturists.

These efforts opened the doors for greatly improved communication between specialists in both countries; facilitated the exchange of plant materials (seeds, bulbs and other propagules), books, information, and photographs; supported emerging conservation efforts; and supported fundamental basic research in both countries. Most importantly, it helped bring the botanical and horticultural communities of the two countries closer together, and clearly demonstrated that successful cooperation and collaboration could occur despite the political and ideological differences that existed for most of the period of these activities between the Soviet Union and the United States.

On May 23, 1972, President Richard Nixon and Soviet President Nikolai Podgorniy signed a bilateral agreement facilitating scientific cooperation in the field of environmental protection. This agreement, entitled *U.S./U.S.S.R. Agreement on Protection of the Environment,* was divided into 11 program areas. These major program areas focused on air and water pollution, climate changes due to environmental modifications, protection of nature, organization of national parks and preserves, soil and soil fertility in Arctic and Antarctic ecosystems, control of pollution on the high seas, and enhancement of the urban environment. Following the signing, high level officials began a series of meetings in both countries to identify and define the various activities which would take place under the different areas. Dr. Howard S. Irwin, President of the New York Botanical Garden, participated in these discussions and together with Dr. Peter Lapin, Deputy Director of the Main Botanical Garden in Moscow, developed the initial program for the botanical exchange activity.

Area V, *The Protection of Nature*, contains numerous projects relating to various faunal topics such as fish, marine mammals, Holarctic mammals, and migratory birds. Initially, only a single botanical program focusing on threatened and endangered species of plants and the introduction of exotic taxa was also included. During the first 20-year history of

Area V, some programs were discontinued and new ones initiated. Among the activities being carried out today are: Aleutian Chain Biodiversity; Cooperation in Wildlife Trade and Law Enforcement; Ecoregional Biodiversity; Protected Natural Areas/Conservation and Education; Marine Mammals, Ichthyology and Aquaculture, and the Ecology, Dynamics of Arctic Marine Ecosystems; and the Conservation of Wild Species of Fauna and Flora and the Protection of Natural Areas. The Environmental Protection Agency was the lead agency within the U.S. Government for the bilateral agreement; however, the Fish and Wildlife Service of the U.S. Department of Interior was given administrative responsibility for Area V. Within Area V, most plant-related work came under the activity *Threatened or Endangered Species of Plants and the Introduction of Exotic Species*.

Dr. Irwin asked if I would organize a 21-day field trip to the Adirondack and Appalachian Mountains for three Soviet scientists, and then three days following that trip, head a three-member expedition team to Moscow and the Major and Minor Caucasus Mountains in southern Russia, Georgia, and Armenia. Since that first exchange, I have had the privilege to serve as the coordinator for this activity. This has taken me to the Soviet Union (and now Russia) and its former republics over 20 times. In addition, I have traveled and worked with delegations from the U.S.S.R./Russia in many regions throughout the United States.

Purpose and Background

The first exchange took place in the spring of 1976 with the arrival of three Soviet scientists from the Main Botanical Garden in Moscow. This and the following trip of three Americans to the U.S.S.R. was undertaken with enthusiasm and also with a degree of uncertainty, due in part to the political differences. After all, we were their enemy and they were ours. Both trips experienced some minor logistic problems because we had not been able to sit down together prior to their arrival in the U.S., or before our own trip there, and discuss our mutual goals. Following that first reciprocal visit, we discussed the two trips and agreed that we should try a second set of exchanges the following year. We were also able to better determine what the goals of the exchange should be. Both sides agreed that the purposes of the exchange program should be:

- organization of joint botanical expeditions to diverse areas of floristic significance in the two countries;
- exchange of seeds and other propagules of species native to each country for experimental cultivation in the other country in conformance with regulations governing introduction of exotic plants and parts thereof;
- exchange of information on the threatened and endangered species of plants in each country;
- exchange of scientific investigators interested in the comparative evolution of plant taxa occurring in both countries, in causes of and methods to remedy species endangerment; and
- development of specific programs relating to the cultivation in both countries of threatened and endangered species of plants, wild relatives of cultivated plants, and other species that may be useful in meeting human needs. These efforts will be in

conformance with the endangered species regulation of each country and the International Union for the Conservation of Nature.

These principles or goals guided our exchanges for the 20-year program, although different ones may have been emphasized from one year to the next, depending upon the area to be visited and the specific goals for each trip. For instance, two information gathering trips were made to Moscow and Leningrad (St. Petersburg) by professional librarians from the New York Botanical Garden and the Missouri Botanical Garden. Occasionally, shorter, non-field oriented trips were undertaken for research on a special topic, i.e., endangered species, or for review and general planning. Each year or two, we entered into a brief written-protocol agreement that reviewed recent progress and identified the plans for the coming year. All of the exchanges occurred within the parameters of the botanical activity under Area V and within the bilateral agreement. This gave the exchanges an official, high-level umbrella to operate under. Having the exchanges occur as part of the official activities of the Russian Academy of Sciences was extremely important because of the access to otherwise closed areas, the ability to travel to non-tourist approved sites, and in obtaining logistical support in the Soviet Union.

The exchange trips were organized on a "receiver-side pays" basis. That is, when the Russian specialists arrived in the United States, usually New York City or Washington, D.C., the American side would pay all their expenses and provide them with a modest per diem for their meals and incidentals. Arrangement for lodging and travel, plus the needed collecting supplies, would be provided by the receiving side. Although each delegation would typically bring its own specialty equipment – seed bags, journals, cameras, film and other similar items – the host side was expected to have plant presses, corrugates for ventilating the presses, papers, drying facilities, and other equipment and supplies too bulky to readily bring on an airplane.

The host side was also responsible for arranging the necessary permits for any collecting activity. This arrangement was particularly valuable, for it would have been extremely difficult, if not impossible, for us to arrange for field vehicles, hotels, and other logistical support in the Soviet Union from the United States. In the days of the Soviet Union, the Academy of Sciences had access to facilities, vehicles, and equipment that were not available to foreign visitors. Since we were there as guests of the Academy, we were not restricted to the Intourist facilities that all tourists were required to use, but instead could travel to areas and stay in facilities not available to regular visitors from western countries. The field-oriented trips were four to eight weeks in length in order to maximize the time spent in the field and make them worthwhile. Non-field oriented trips ranged from one to two weeks in duration.

Accomplishments

Detailed accounts of the exchanges and their accomplishments can be found in Lapin *et al* (1986) and in Andreev *et al* (1992). The highlights of the more significant results of the 20-year program are presented here.

Organization of Joint Botanical Expeditions to Diverse Areas

There have been a total of 45 botanical exchanges (23 to the U.S.A. and 22 to the U.S.S.R. or Russia and its former republics) directly involving over 80 people. Most of the exchanges have been field-oriented expeditions to investigate different floristic regions of the United States and the Soviet Union. The first exchange occurred in the summer of 1976 when three scientists (Drs. Alexei Skvortsov, Valery Nekrasov, and Boris Golovkin) from the Main Botanical Garden in Moscow arrived in New York to begin a 21-day field trip to the Adirondack Mountains in upstate New York and then to the Appalachian Mountains in North Carolina and Virginia. Three days later, Drs. Jane Bock, Dale McNeal, and I flew to Moscow for an initial meeting, then to conduct field work in the Major and Minor Caucasus of Armenia, Georgia, and southwestern Europe.

Both teams collected herbarium specimens, seeds, and a few bulbs, and took numerous photographs. The trips provided the first opportunity to begin learning about the organization and structure of the All-Union Council of Botanical Gardens and Arboreta of the U.S.S.R., to understand their approach to the conservation and preservation of threatened and endangered species, and to begin collecting pertinent books, journals and reprints. It was apparent from this first exchange how little accurate botanical and horticultural information each of us had about the other's flora, and what each country was doing to conserve threatened and endangered species. Both sides immediately realized the potential value of continuing the exchanges. We agreed to move forward with another exchange the following year and to work as best we could with the limitations imposed by the fact that we were from ideologically warring countries.

The second exchange in 1977 took three Americans to the Central Asian region, where they conducted fieldwork in the Hissar and Tian Shan Mountains in the Tajik, Uzbek, and Kirghiz republics. The U.S. delegation consisted of Mr. Robert Hebb, Horticulturist of the Cary Arboretum, Dr. Theodore Crovello of Notre Dame University, and Dr. Dieter Wilken of Colorado State University. Hebb collected, cleaned, and brought back to the Cary Arboretum and New York Botanical Garden 357 lots of seeds and bulbs, along with cuttings of two intergeneric hybrids between *Catalpa* and *Chilopsis*. This represented one of the most comprehensive collections of living plant materials brought to the United States in modern times.

Three Russian scientists worked for an equal amount of time in the Rocky Mountains in Colorado and Wyoming. During this time, they had the opportunity to visit and work in the Grand Teton Mountains and Yellowstone and the Rocky Mountain National Parks. This trip, along with subsequent trips to the Altai Mountains in southern Siberia, provided scientists the opportunity to confirm the amazing floristic similarities between the floras of these two mountain chains, especially in the high elevation species of Gentianaceae, Poaceae, Asteraceae, Ranunculaceae, and Crassulaceae, found in the alpine and subalpine regions.

The second set of exchanges was more productive and was carried out in a more relaxed environment. Each year, the atmosphere surrounding these exchanges and the exchange program moved steadily towards a more cordial and collegial one, as both sides realized that we shared genuine mutual interests and goals, and as friendships were established and built. Subsequent field trips to the U.S.S.R./Russia and its former Republics were made to:

- the European regions including the Moscow region, Lower Volga River, Caucasus Mountains, Moldavia, Ukraine, and especially the Crimea;
- the Central Asia region, including the Tian-Shan and Pamir Mountains;
- the western, central, and eastern portions of Siberia including the Altai and Eastern Sayan Mountains, Lake Baikal, the steppes, Tannu-Ola Mountains, and the Tuva Republic; and
- the Far Eastern region, including Khabarovsk and Amur River, the Vladivostok and extreme southern Far East deciduous forests, and Magadan and the Kolyma Plateau in the northern Far East.

Field trips were mounted to most of the significant floristic regions of the Soviet Union and Russia. The vast majority of the botanical diversity occurs in the southern portions of the country, particularly in the mountainous areas. Expeditions were not organized to the more northern and Arctic regions or, unfortunately, to the Ural Mountains, which form the geographic boundary between the European and Siberian portions of Russia.

Unlike North America, most of the principal mountain ranges in the former Soviet Union run in a general east-to-west position. The Caucasus, Pamir-Alai, the Tannu-Ola, Stanovoy, and Yankan-Tukeringa-Dzhagdy Ranges are examples of this orientation. Because of their position, they provide dramatically different habitats on the north sides of their slopes than on the southern flanks, where there are more protected environments and, generally, a more diverse flora. Likewise, the southern slopes provide opportunities for the migration and establishment of species from floristic regions south of the former Soviet Union. The long and extensive border between the former Soviet Union and the countries in southwestern Asia, Mongolia, China, and Japan has provided avenues for plant migration prior to, during, and following the last periods of major glaciation. Thus, many elements from these more southern floras can be found in the extreme southern regions of the former Soviet Union. This helps explain why the U.S.S.R. has a vascular flora of nearly 18,000 species, despite having a latitude more comparable to Canada than to the United States.

The Russian delegations likewise traveled across the United States, gathering living and dried specimens, books, and information about our gardens and arboreta, as well as how we were working to protect threatened and endangered species. They made field trips to:

- the Northeastern region, including the Adirondack, Green, and White Mountains in New York, Vermont, and New Hampshire, and Acadia National Park in Maine;
- the Southeastern region, including the Everglades in Florida, Great Smoky Mountains National Park, national forests and adjacent areas in Georgia, Tennessee, and North Carolina;
- the Midwestern regions, including the Ozark Plateau and mountains in Southern Illinois, Arkansas, and Missouri, the northern Great Plains and Black Hills of South Dakota, and the forests and prairies of Wisconsin;
- the Western regions, including the Arizona deserts; national parks and national forests in Utah; grasslands in Colorado; northern, central, and southern California; and the coastal mountains and forests of the Pacific Northwest; and other regions, including the Brooks Range, Kenai peninsula, Denali Highway and Hatcher Pass in Alaska, and Kauai in Hawaii.

The number of specimens, both living and dried, and the information collected from these expeditions is immense and still being studied today. The U.S. participants in turn collected and distributed approximately 52,000 herbarium sheets throughout the United States. This represents the largest collection of plant specimens from the former Soviet Union during the last 100 years. Of all the temperate areas of the world, the Soviet Union was the most poorly represented in the major herbarium collections in North America. Today, the largest collections of herbarium specimens from the former Soviet Union can be found at The New York Botanical Garden and Rancho Santa Ana Botanical Garden, while older, more historic collections are located at the Smithsonian Institution and the combined herbaria of Harvard University. This material has supported phytogeographic, monographic, and revisionary studies as well as investigations into specific taxa, for example, see Elias (1986) and Liston *et al* (1989).

Exchange of Seed and Other Propagules

The exchange program provided a long-term opportunity for American scientists to grow, evaluate, and introduce a wide range of temperate Eastern European and Asian species of gymnosperms and flowering plants. Living plant introductions from the Soviet Union were meager when compared to the vast amount of materials brought to Europe and North America from China, and Japan. Most of the major plant collecting expeditions to Asia in the 1700s and 1800s were to the South Pacific Islands, India, Tibet, China and Japan. Relatively few ventured into Russia. After the 1917 Revolution vast areas of the Soviet Union were closed to Westerners, thus greatly limiting the amount of germplasm being brought to the United States.

Approximately 1,500 distinct lots of seeds, bulbs, and other propagules were brought to the U.S. from the different republics of the Soviet Union. The seeds were made available to botanical gardens and arboreta domestically and internationally through a series of *Index Semina* issued by the Cary Arboretum of The New York Botanical Garden. A large living collection of wild-collected, documented Russian taxa was assembled at this arboretum prior to its conversion into The Institute for Ecosystem Studies in 1984. The germplasm introduced over the first 20 years of the botanical exchange program has been widely used in breeding programs for the development of new ornamental plants, especially as breeding stock for disease resistance, pest resistance, and cold hardiness, and in aiding theoretical research projects.

Many of the gymnosperms introduced from these trips were collected from more than one native population in Russia. Some of these conifers have considerable economic importance as ornamental trees or shrubs, such as the Caucasian fir, *Abies nordmanniana.* Three different populations of this beautiful fir were introduced into cultivation. Both species of yew, *Taxus baccata* and *T. cuspidata,* have been introduced, along with several other species of fir (*Abies*), spruce (*Picea*), pine (*Pinus*), and larch (*Larix*). Several juniper (*Juniperus*) species from the Caucasus, Crimea, Central Asia, and the Far Eastern region were also collected and introduced.

Seeds of numerous deciduous flowering tree and shrub species were also included among the material brought to the United States: maple (*Acer*), hornbeam (*Carpinus*), oak (*Quercus*), bladdernut (*Staphylea*), mountain ash (*Sorbus*), cherry (*Prunus*), pear (*Pyrus*), serviceberry (*Amelanchier*), rhododendron and azalea (*Rhododendron*), and bridal wreath (*Spiraea*). Numerous species of willow (*Salix*) and birch (*Betula*), including *B. litwinowii, B. microphylla, B. pamirica, B. exilis,* and *B. rotundifolia,* also provided valuable new germplasm for American scientists and horticulturists.

A vast number of hardy perennial plants were introduced during this exchange. These included three species of *Ligularia*, a *Rhaponticum*, several *Dracocephalum*, *Paeonia, Aconitum, Delphinium*, and *Goniolimon*, and the beautiful *Bergenia crassifolia*.

Numerous species of iris (*Iris*), along with several species of tulip (*Tulipa*), crocus (*Crocus*), onion (*Allium*), and a smaller number of *Colchicum*, *Erythronium*, *Muscari*, *Eremurus, Asparagus, Fritillaria, Paris, Polygonatum*, and *Arum* were among the bulbous or rhizomatous plants grown at and introduced by the Cary Arboretum in Millbrook, New York.

Melinda Denton (1980) described the results of a field trip to Siberia under the auspices of the botanical exchange program. In her paper she identified nearly 60 species of flowering plants from Siberia suitable for cultivation in Pacific Northwestern gardens. She and her colleagues brought back viable seed of many of these species for testing and evaluation as ornamental plants for this region of the United States.

Exchange of Information on Threatened and Endangered Species

Information exchange was one of the most important aspects of the program, and considerable attention was devoted to this topic. To gain an accurate understanding of how the former Soviet Union approached this subject, numerous interviews were scheduled with various officials, books and articles written in Russian were assembled, and their laws were examined. The results were summarized and reported to different audiences (Elias, 1978; Elias 1983). At the same time, the status of the protection of threatened and endangered species in the United States was published in a leading Russian journal (Elias, 1984). This, along with a growing understanding of the All-Union Council of Botanical Gardens and Arboreta of the U.S.S.R., eventually allowed us to more fully understand the status of endangered plant protection in the former Soviet Union.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) brought worldwide attention to the growing plight of species that are threatened and endangered due to commerce. Both the United States and the Soviet Union became signatories to the convention in 1973 and 1976 respectively. This became a legal, binding document on July 1, 1975, 90 days after the 10th country ratified the convention. A great deal of new attention to this subject was triggered in both countries; however, the

responses to it were quite different. The Soviet Union embarked on a long process to identify and verify the extent and number of threatened and endangered species prior to passing laws protecting them. Conversely, the United States passed the Endangered Species Act of 1973 first, then identified the threatened and endangered species and added them to the list of protected species as sufficient information became available and as individual species successfully completed the listing process. For a more complete account of the early history of the work in the Soviet Union to protect and preserve threatened and endangered plant species, see Elias (1983), Borodin (1978), and Takhtajan (1975). (Note: in the 1950's and 1960's, the Soviet Union concentrated much of its resources to building a large, powerful, and diverse industrial and agricultural base, often at considerable cost to the environment. To help understand the magnitude of the work to be done in the Soviet Union, readers are referred to Komarov's *The Destruction of Nature in the Soviet Union* (1980). The author, a Russian-born scientist writing under a pseudonym, eventually left Russia to live in Israel.)

In addition to the development of a national Red Data Book of threatened and endangered species, each of the Soviet republics was authorized to develop its own regional Red Data Book. This goal was eventually accomplished and led to an even better and more accurate understanding of the status of rare plant species as regional specialists who were more familiar with the individual plants were involved in the process. Examples of more regional works include Golovanov (1988), Vintergoller (1976), Sitnik (1980), and Malyshev and Sobolevskaya (1980). These early publications are steadily being replaced with newer editions with updated information. Copies of these publications were obtained during the exchange visits and brought back to the U.S.

Habitat protection may in the long run be more important than protecting individual species. Our efforts at data gathering were by no means limited to work at the species level, but also included information at the habitat, preserve, and ecosystem levels. One of the results was a comprehensive and detailed account of the protected natural areas in the Crimea (Newcombe, 1985). This excellent account also gives readers a lengthy list of valuable references which would have been difficult to include if not for the access to the information and materials provided during the exchange visits.

The All-Union Council of Botanical Gardens of the U.S.S.R. once consisted of nearly 120 botanical gardens and arboreta. The Main Botanical Garden in Moscow served as the coordinating body, and its Director served as President of the Council. Each of the republics had a central garden for its respective region, and under that central garden were a number of subordinate regional gardens. The Council often set policies and guidelines for the network of gardens and arboreta. In 1974, a special committee of the botanic gardens council was formed and presented with the responsibility of developing a program relating to threatened and endangered species. This committee initiated a large-scale national effort to collect and bring into cultivation in the member gardens throughout their country many endangered species for the purpose of conservation and education. Thus, the gardens and arboreta of the U.S.S.R. were able to move quicker in developing a national collection of living rare species than were the equivalent institutions in the United States able to do. Regrettably, in recent years the botanical institutions in the former Soviet Union and the former republics have suffered financially, and so have lost large numbers of staff and the ability to maintain their grounds and collections as they once did. This, accompanied by the occasional theft of medicinal or other economically important plants from these gardens, has led to a general decline in the size and scope of their Russian collections of threatened and endangered species.

Exchange of Scientific Investigators
Several American scientists were keenly interested in the relationships of the floras of the Soviet Union and North America. Viable seeds of selected taxa were brought back for different scientists at universities and gardens in support of specific systematic, phylogenetic, and bio-geographic studies. One such study involved the intercontinental disjunct genus *Datisca*. There are only two species in this genus, one in California and adjacent Baja California and the other in southwest and central Asia. Seed of *D. cannabina* L. was collected from one of the expeditions to the Tajik Republic and compared to plants of *D. glomerata* (Presl.) Baill., native to the Californias. Molecular studies of these two taxa provided evidence for an ancient origin of the disjunction, and that dispersal may have occurred across the Atlantic (Liston *et al.*, 1989).

Another study involved branch and stem samples brought back as part of the herbarium collections. Carlquist (1992) used these in a study of the wood, stem, and pith anatomy of the Old World Species of *Ephedra*, an ancient coniferous genus.

As expected, other American scientists had research interests in different disciplines and geographic areas. Dr. Jane Bock, Department of Environmental, Population, and Organismic Biology at the University of Colorado in Boulder, studies ecological aspects of alpine vegetation. She participated in several of the exchanges, working in the higher elevations of the Caucasus in the southern European part of the Soviet Union. This allowed her to conduct comparative studies of the alpine vegetation in the Rocky Mountains of the western U.S. and the Caucasus Mountains (Bock & Nakhutsrishwili, 1986; Bock, Jolls & Lewis, 1995).

Soviet scientists were especially interested in the introduction of new plant materials and in learning how we handled and managed long-term viable seed storage. Visits were arranged to the USDA. Plant Introduction Station in Beltsville, Maryland, and Geneva, New York, and the National Seed Storage Laboratory in Fort Collins, Colorado. Historical records of plant introductions were studied at the Bailey Hortorium at Cornell University and at the Arnold Arboretum of Harvard University.

One of the most significant accomplishments achieved by the non-field oriented exchanges was a great increase in the amount of published botanical literature reaching the United States from Russia. American librarians twice traveled to Moscow, Leningrad, and Novosibirsk to meet with their counterparts. The first library-oriented trip was made in 1980, followed by the second in 1987, during which librarians from the New York Botanical Garden and the Missouri Botanical Garden met with the heads of several major science libraries to facilitate an increase in the size and scope of existing exchange programs of botanical and horticultural literature. The major botanical libraries

in the United States, particularly at the two above-mentioned gardens, now have nearly all the pertinent botanical literature relating to systematics, floristics, ecology, physiology, and conservation in the U.S.S.R. In many cases, new library exchange programs were established with the gardens in the different republics.

The exchange program also functioned as an intermediary in obtaining scientific publications for U.S. and Soviet institutions that were not available at the time. For example, for a period the Russian institutions could not receive scientific publications from the People's Republic of China. Likewise, we were unable to obtain similar literature from Cuba and Vietnam. Since we had ready access to the People's Republic of China and could obtain their scientific publications, we sent many duplicate Chinese publications to the libraries in Moscow and Leningrad. They in turn would send us botanically oriented publications from Cuba and Vietnam for our libraries. The flow of scientific and technical literature between research institutions was maintained via this exchange program despite the official government sanction against direct contact between the Soviet Union and China, and the United States with Cuba and Vietnam.

Cultivation of Plants

Even though the focus of the program was on threatened and endangered species, participants did seize upon the opportunities to collect other plants of human interest and use. One example was the introduction in 1977 of cuttings from two hybrid selections that displayed potential value as ornamental plants. These artificial intergeneric crosses (registered as *Chitalpa tashkentensis*) between *Catalpa bignonioides* Walt. and *Chilopsis linearis* (Cav.) Sweet in the family Bignoniaceae, were made by Nikolai F. Rusanov at the Uzbek Academy of Sciences Botanical Garden in Tashkent. Rusanov described his crosses as suitable new ornamental plants for use in landscaping in the Middle Asia region of the U.S.S.R. (Rusanov 1964, 1971, 1976, and 1981). Horticulturist Robert Hebb, on the second botanical exchange trip to the U.S.S.R. in 1977, noticed these new hybrid plants growing in the garden in Tashkent and obtained permission to take cuttings back to the Cary Arboretum of The New York Botanical Garden. Here they were rooted and grown, and a testing and evaluation program was initiated.

The trees came into flower at a very early age and remained in flower throughout the summer. Based upon the early successful test, rooted cuttings were distributed to botanical gardens and arboreta throughout the U.S. for further testing. In the Southeast, these two forms were susceptible to mold and mildew pathogens. However, in the drier Southwest, these small flowering trees proved to be quite suitable to the climate and provided beautiful large clusters of flowers in the summer and autumn months when most other trees were not flowering. The bicolored forms especially became increasingly popular and entered the commercial nursery trade. Elias and Wisura (1991A, 1991B) formally described the hybrid genus and the two cultivars. The bicolored forms of *Chitalpa tashkentensis* Elias & Wisura, 'Pink Dawn' and 'Morning Cloud', became some of the best-selling flowering trees in southern California and the Southwest. In other areas it is grown as a large container plant.

Another example of a plant benefitting human needs involves one of the Russia's threatened and endangered species, *Taxus baccata*. This yew is relatively rare in southern Russia and is officially listed in their Red Book (Takhtajan, 1975; Golovanov, 1988). The discovery of taxol from the bark of the Pacific Yew tree, *Taxus brevifolia* Nutt., provided the world with an exciting new anti-cancer drug. This new compound proved to be effective against solid tumors, especially as found in breast and ovarian cancers. Regrettably, it had to be obtained from the bark of this yew tree, which meant that trees had to be destroyed to obtain the drug. This touched off a worldwide search of other *Taxus* species to see if they too had the compound taxol and if so at what levels.

The National Cancer Institute had obtained samples from various species of *Taxus* throughout its worldwide range except for the Soviet Union, where they did not have any sources of material. The botanical exchange program provided a suitable mechanism for obtaining the material. Armed with a grant from the National Cancer Institute, I collected populations of *Taxus* in Soviet Georgia, southern Russia, and southern Ukraine. The samples were analyzed and demonstrated that in all of the populations, samples contained taxol and related compounds not only in the bark, but also in the leaves and twigs. This information (Elias & Korzhenevsky, 1992) provided the Russians and Ukrainians with valuable information to aid them in protecting the remaining stands of *Taxus* and to initiate efforts to cultivate the plants in nurseries for the eventual domestic production of taxol.

Other economically useful plants introduced included wild relatives of rhubarb, perennial sweet onion, and wheat.

Conclusions

This was the largest and one of the most successful long-term botanical exchange programs in the 80-year history of the Soviet Union (later Russia) with the United States. Despite the tensions and restrictions existing during the "Cold War," the coordinators on both sides were able to plan, organize, and carry out a largely field-oriented exchange of scientists and other specialists between Russia and the United States. Forty-five exchanges occurred, directly involving over 80 people and indirectly, several hundred others. This program opened the door for greatly improved communications between people and institutions and brought people together for the first time.

From this, participants developed several related exchanges and activities. The U.S. side collected and distributed over 52,000 herbarium specimens; collected over 1,500 seed lots and distributed over 10,000 smaller seed packets; established important exchanges of library materials between major scientific institutions; introduced plants of ornamental, agronomic and medicinal merit; and conducted individual, specific research projects both theoretical and applied. Russian scientists took a comparable quantity of specimens, seeds, books, and information back to their respective institutions. The participants published numerous papers and books in both English and Russian summarizing the results or presenting data gathered during or after the exchanges.

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A program of this magnitude is impossible to carry out without the dedication and commitment of many people and organizations, and the mutual desire of our respective countries to improve environmental conditions. First and foremost is the Office of International Affairs of the U.S. Fish and Wildlife Service. They have provided valuable help regarding coordination, logistical, financial, and moral support. Steven G. Kohl, head of the Russia/China program for this office and leading specialist on environmental matters relating to the Soviet Union and Russia, spearheaded the efforts to insure that the Area V programs are active, vibrant, and successful. Lydia Newcombe, friend and colleague, worked closely with me for many years to plan and coordinate many of the field trips, participated in several of them, and also served as translator for many Russian scientists. The late Peter Lapin, Deputy Director of the Main Botanical Garden in Moscow, played a paramount role in the launching and early years of the exchange. Later, and after being appointed as the new Director of the Main Botanical Garden, Academician Lev Andreev and Igor Smirnov, Head of the Seed Laboratory at the same Garden, were the leaders on the Russian side. Academician Igor Koropachinskiy, Director of the Central Siberian Botanical Garden, worked closely with Andreev and Smirnov in supporting the exchange program. Finally, numerous colleagues in universities, botanical gardens, national parks, national forests, field stations, preserves, and other organizations in both countries all opened their doors to receive and help delegations and work to make their respective visits successful.

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Figure 1. USSR: Siberia: Altai Mountains. Seeds and shoes drying in the Siberian sun.

Figure 2. USSR: Siberia: Altai Mountains. Unloading camping gear from trucks used on longer field expeditions.

Figure 3. USSR: Far East: Several hundred kilometers north of Magadan. Unloading helicopter at field station Contact.

Figure 4. *Xchitalpa tashkentensis* 'Morning Cloud' developed at the Tashkent Botanical Garden.

Figure 5. USSR: Far East: Contact Field Station. Drying herbarium specimens.

Figure 6. USSR: Siberia: Altai Mountains. Breaking for lunch.

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