

USDA Plant Hunters
**Bring 'Em
Back Alive
and
Growing**

With the threat of extinction adding urgency to their efforts, ARS plant collectors gather snippets of the Earth's botanic diversity.

In this Colombian market are displayed white carrots, dark red sweet potatoes that are native to the Andes and now grown worldwide, and pink ellace, a traditional Andean potato not currently grown in the United States.

Somewhere up a tributary of the Amazon River on a 30-by 12-foot barge with 14 people aboard, 1947:

*About 5 AM there was jolt and a loud crashing and splitting of wood. The barge has run into a leaning tree along the river's edge and the already badly damaged cabin was smashed. With my flashlight, I saw that the tree was in young fruit, with a recently fertilized ovary that is, so I broke off a few branches.... When dawn came, I examined the plant—it was *Micranda minor* which I was especially anxious to collect!*

—From the journal of USDA plant explorer Richard Schultes.

During World War II, USDA sent botanist Richard Schultes exploring through South America in search of rubber trees that could be the basis for a New World rubber industry.

The attack on Pearl Harbor and the Philippines had sealed off the United States' access to the rubber plantations of the Pacific. Rubber would be particularly needed for airplane tires during the war; the synthetic rubber tires of the day could not handle the weight of a landing airplane.

"The reason there were no rubber plantations in the New World was the presence of a leaf disease," Schultes explains in a much more recent recounting of his plant explorations. "All commercial rubber plantations depend on one species of rubber tree, and there are nine others. One of them may have some resistance to the disease."

Seven of the nine species were collected for study, thanks to Schultes.

Schultes is one of many scientists that USDA has sent exploring through the years to enrich the variety of crops grown in this country. The plants that USDA explorers have collected have literally changed the face of agriculture and gardening worldwide.

CALVIN SPERLING



On the slopes of the Cayambe volcano in Ecuador, Head of Plant Exploration Office Calvin Sperling seeks wild relatives of the carrot.

Other countries have benefited as much as the United States. Plant exploration often develops into cooperation and exchange of plant germplasm between scientists and countries. ARS always shares its discoveries with host countries, each year sending abroad far more plant germplasm than it collects.

As a prominent plant explorer for USDA from 1941 to 1954, Schultes not only collected rubber plants and their relatives but he also brought back medicinal plants used by natives of the Amazon region to treat illnesses.

"There are over 1,600 species of plants used for medicinal purposes alone by people in the Colombian Amazon and only a few of them have ever been looked at by scientists," says Schultes. "Yet there is the destruction of millions and millions of acres each year, and plants are being lost. We need to learn what plants are out there and what they can do for us in agriculture and medicine."

During his career, which is far from over at age 78, Schultes has brought back nearly 24,000 plant specimens, 300 of them previously unknown to science.

He helped collect curare vines that provide the muscle relaxant now usually given patients before surgery.

Another example: he more recently collected a tree in the Colombian Amazon basin, called ucu uba, in the nutmeg family. Preliminary testing indicates that a resin from its bark may be a highly desired suppressant or even cure for skin fungal infection.

Discoveries Have Far Reaching Impact

- The rootstock on which many U.S. peaches are grown, originally collected in China in 1898.

- The naval oranges that created a California industry brought back from Brazil.

- The Durum wheats Kubanka and Arnautka that set the standard for the Northern Plains for decades, collected in southern Russia in 1900 by USDA researcher Mark A. Carleton .

- A peanut discovered in Peru that had the genes for resistance to two major diseases of that crop, collected in 1966.

- A wild oat that has resulted in one of the most disease-resistant oat varieties ever developed, found in Israel in the 1960's.

This sampling doesn't even scratch the surface of genetic treasures that USDA plant explorers have collected and shared with other nations through the years.

"Genetic diversity is the key to maintaining and improving agriculture, whether it's discovering new crops or finding the genes for resistance to diseases and insects, drought tolerance, better flavors, durability, or some other needed traits to be added to crops already being grown. What plant

explorers do is find and bring back that diversity," says Calvin Sperling, the current head of ARS' Plant Exploration Office.

The reservoir of genetic diversity that collecting has built has sometimes played a direct role in keeping crops safe from large-scale destruction.

"Many of the crops we take for granted in this country originated in other places, and their genetic base here is very narrow," Sperling explains. "The situation is similar in many countries."

A narrow genetic base means all varieties grown are closely related and may share disease and insect susceptibility, so a single disease could wipe out a crop.

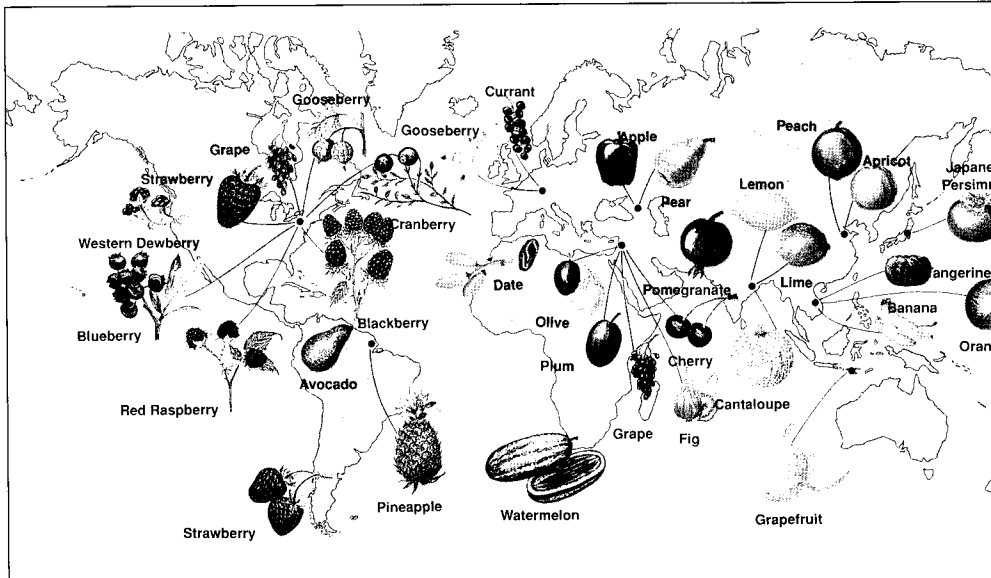
In 1970, southern corn leaf blight, which had up till then been a minor disease, suddenly became virulent, destroying almost \$1 billion worth of corn and reducing yields by as much as 50 percent. A single gene, *Tcms*, was responsible for corn's susceptibility to the new type of leaf blight and, back then, over 80 percent of the corn being grown in the United States carried the gene.

A crash breeding program shifting production to nonsusceptible strains succeeded in averting a major crisis.

When wilt and blight threatened to kill off the Virginia spinach industry in 1920, the genes for resistance to the diseases were found in a spinach that came from Manchuria around 1900.

Genes from the Manchurian spinach have spread far beyond the Virginia Savoy cultivar developed to meet that original disease outbreak. Today, the genes are present in almost every multi-disease-resistant spinach grown.

"Plant exploration has also provided new crop industries for the United States," Sperling says. A USDA plant explorer located germplasm which was the starting point for California's avocado industry during a collecting trip to Mexico, for example. Dates,



Centers of origin for some fruits.

sorghum, a variety of forage grasses, and tung oil were all new crops introduced through USDA exploration.

As ARS' chief plant explorer today, Sperling coordinates about 10 trips a year, with a budget of about \$207,000 for the 1991 fiscal year. He goes on two or three of them each

year himself; the rest are conducted by other ARS scientists or cooperating researchers.

When trips can take a plant explorer on horseback to 13,000 feet in the Andes, images of bold exploits come to mind.

But Sperling strongly demurs. "Plant explorers are just scientists, not adventurers. They go where the plants are—in that case, it was for the wild relatives of potatoes," he says.

Quick, Before It Disappears!

The need for plant collecting has become more urgent as plants are lost to the encroachment of modern civilization—either through the destruction of habitat or as traditional varieties grown by remote peoples are replaced by commercial varieties, Sperling points out. "We don't know what genes those traditional varieties may have," he says.

In southeast Turkey, Sperling collected "one of the scraggiest wheats I'd ever seen cultivated." But bread made from the wheat was "the best bread I've ever had."

JAMES BALLINGTON



Wild blueberry found in Ecuador by James Ballington of North Carolina State University.

But who knows how long it might be before farmers in that region replace it with a modern high-yielding wheat?

ARS plant geneticist Devon L. Doney might bring Indiana Jones to mind with his occasional exploits like rappelling down rocky cliffs to inaccessible beaches in Ireland and Wales after the wild relatives of sugar beets, in a race against time before their habitat disappears.

Sea beets grow only on rocky beaches near or in the saltwater near the high-tide line—wild habitats that are being lost in many areas to tourism and development. “Cement sea walls, constructed along Great Britain’s Atlantic seacoast to protect and maintain the coast, are destroying the natural habitat of wild sea beets,” Doney says. “We need to know what’s

there before it disappears forever.”

One of the wild sea beets collected may hold the genes for resistance to diseases like leaf spot, a major problem for sugar beet growers in the Northern Plains, Doney hopes. The crop’s current resistance to leaf spot can be traced to introductions from an Italian scientist, who developed leaf-spot-resistant varieties 60 years ago by crosses with wild sea beets. A change in the disease could find all of the sugar beets in the United States vulnerable.

Sea beets may also have genes that breeders could use to give sugar beets more frost and drought tolerance and most especially salt tolerance, Doney explains, “given where they grow.”

Collecting plants not only provides breeders with a larger pool of sources, but also helps taxonomists

get a better picture of how plant families are organized.

ARS botanist David Spooner found what appears to be a natural hybrid of two very different wild potatoes on one of his regular exploring and collecting trips to Latin America. Not only does Spooner spend 2 to 3 months each year in Latin America collecting potatoes, as part of his joint appointment between ARS and the University of Wisconsin Horticulture Department, but he also conducts research on taxonomic and evolutionary relationships in potatoes.

Spooner is using DNA analysis on the putative hybrid, and on other potatoes he has found, to uncover new taxonomic relationships between species. He often brings researchers back to this country from



Wild sea beets, which tend to grow on inaccessible beach cliffs, may hold the genes to improve U.S. sugar beets. ARS scientist Devon Doney and plant pathologist E.D. Whitney (now retired) are collecting specimens on the coast of southern Ireland.

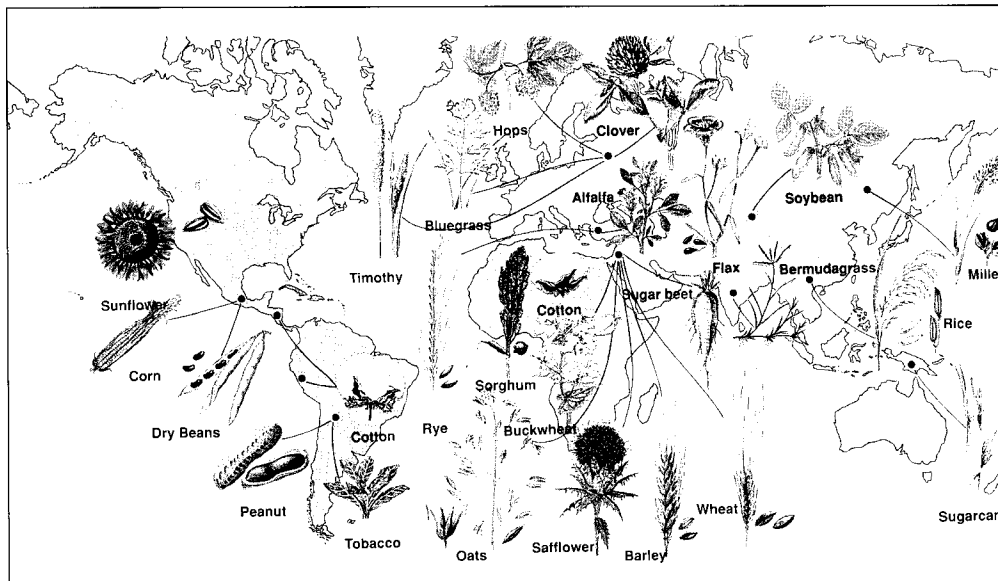
the countries he has collected in to conduct follow-up evolutionary studies. The foreign researchers share authorship on scientific papers as well as the germplasm collected.

Where To Go

One strategy that has historically been used in selecting sites to explore is to look along the same latitude.

John Ellis, a contemporary of Benjamin Franklin, pointed out in 1770 that "Philadelphia lies on the 40th degree of north latitude, the very same as Peking in China, and nearly the same with Madrid in Spain and part of California," and that these were therefore logical places to search for plants.

Other strategies call for looking at the centers of origin—where plants originally evolved. "That's where you are likely to find some of the greatest



Centers of origin for some grain and oilseed crops.

diversity—or in the part of the world where a crop was first domesticated," Sperling explains.

Spooner adds, "In planning an expedition, our first priority is to collect species that have no living representatives in our germplasm system. We expand our collections in as many geographical areas and ecological sites as possible in an attempt to capture diversity."

Wild potatoes are found from southern Chile to Nebraska, and a single variety may appear in many places in this range. A specimen from the highest elevation a variety exists at or one growing as an epiphyte on a tree when others of that type don't grow in that fashion may have traits not in the main genetic pool for a species. Spooner has found examples of both in his potato exploring and collecting trips to Latin America.

To date, Spooner and his international collaborators have collected over 300 wild relatives of potatoes from Mexico, Ecuador, Argentina, and Chile.

Locating plants in cultivated fields and in existing germplasm collections of other countries can be as rewarding as searching the wilds.

Sperling, ARS horticulturist David W. Ramming, and Maxine Thompson, a veteran plant explorer from Oregon State University, recently spent 3 weeks in the Soviet Union where they looked for apricots, mostly in orchards and botanic gardens. Some of their finds already appear to hold great potential.

Apricots came from central Asia, at least as the site of secondary origin—they may have first evolved farther east in China, Ramming says.

From the northern edge of the apricot's range, they collected one that appears to be frost-hardy. "In an area that has spring frosts, this apricot seemed to be doing very well," Ramming says. "That's a trait we'd like to have."

The group also found an apricot that had very high soluble solids, a trait important in making dried fruit and in flavor. "It had over 20 percent soluble solids, when we have considered 13 percent high before," Ramming says.

Another one produces sugar much earlier in the fruit's growth, which would make it possible to ship apricots earlier in the season while the fruit is still firm, again a most marketable trait.

KEVIN JENSEN



Now retired, ARS geneticist Douglas R. Dewey collects wheatgrasses and wild rye grasses in the Altai region of the Soviet Union. Dewey's plant collecting and research have helped make major improvements in forages in the United States.

Most exciting of their finds was a smooth-skinned apricot in Kazakhstan in the southern Soviet Union. "If the smooth-skinned trait can be incorporated here, it will significantly expand the apricot industry," Ramming says.

Commercial development of such an apricot is at least 15 to 20 years away. Before any such breeding project can begin, the samples that Ramming and Sperling brought back have to go through quarantine to ensure the samples do not introduce any foreign diseases into the United States, a process that can take up to 5 years.

The serendipity that helped Schultes find his elusive wild rubber relative continues to assist USDA plant hunters.

While Sperling and Thompson were examining an apricot orchard in Uzbekistan, they found a walnut tree that bore 50 percent more nuts per cluster than is typical. Ramming came across a mulberry that was so sweet "it tasted like someone had poured sugar over it." Unfortunately, the sample Ramming had collected died in quarantine. He hopes another one can be gained from the Soviets.

Even Before USDA

Plant exploration and collecting to benefit agriculture has a long history in the United States.

President John Quincy Adams sent a circular to all American consuls in foreign countries in 1827, directing them to send seeds and cuttings back home. The circular came complete with five pages of directions on packing and shipping plant materials, including protecting them from salt spray "especially when the waves have white, frothy curls upon them."

The first direct government funding for plant exploration came in 1839, 23 years before the Department of Agriculture was created. A \$1,000 appropriation was channeled through the Patent Office, which had charge

of agricultural matters at the time for the collecting of tea seeds.

When the federal Department of Agriculture was formed in 1862, the act creating it specifically required the department to *procure, propagate, and distribute new and useful varieties.*

The Grand Age of Exploration

The grand age of plant exploration began under the tenure of Secretary of Agriculture James Wilson in 1897. Wilson appointed David Fairchild to head a new USDA unit called the Section of Seed and Plant Introduction and gave him a budget of \$20,000. Fairchild was to serve in this capacity for 27 years, creating the first truly organized system for the introduction of new crops and keeping records on their progress.

Fairchild hired Frank Meyer as chief plant explorer. Together they have come to be regarded as the founding fathers of USDA plant collecting.

Although his name is not widely known, Meyer brought back an amazing variety of crops to the United States from barleys and chestnuts to the first ever introduction of zoysia grass.

It is hard to track the effect of some of Meyer's finds. Once he collected a plant, it entered breeding programs and germplasm repositories. By the time it emerged, decades later, as an important economic crop, his name was seldom still associated with it.

He was a pioneer in soybeans. Before Meyer went to China in 1905, only eight varieties of soybean were grown here, mainly as a forage crop. Between 1905 and 1908, Meyer added 42 new soybeans, which have given rise to thousands of varieties over the years.

Among those soybeans he collected was the first oil-bearing soybean, the basis of an industry worth billions of dollars today.

Guidelines for Plant Hunters

For modern plant hunters, collecting germplasm has become an activity of international cooperation. Today, collecting trips are arranged as collaborations between U.S. and host country scientists.

To ensure the maximum benefit for both the United States and foreign germplasm systems and to prevent any harm to the environment, ARS recently created guidelines for conduct and ethics during plant exploration trips.

The need to share all collected material is a major consideration in the guidelines. All collected germplasm and herbarium specimens are divided at least equally with the host country.

"And if a sample containing no more than three seeds were collected, two of them would go to the host institution and one to us," explains Calvin Sperling, head of ARS's Plant Exploration Office who drafted the guidelines. "An even better arrangement would be for the host country to grow out all three and later supply a small sample to us."

It is also important for a host country to understand before an expedition that all germplasm collected with the support of USDA is deposited in the National Plant Germplasm System (NPGS) and is freely available to all valid users, domestic or foreign. "Some countries have restrictions on the distribution of particular genetic resources," Sperling says. "While we respect their right to do that, the NPGS will not restrict access to any material in our system."

The U.S. NPGS sends out much more each year than it receives through collecting.

The guidelines also require that all plant collecting "be done with a conservation ethic in mind." Collecting must not endanger natural plant populations, and enough must always be left behind so that the plant population can regenerate naturally.—
By **J. Kim Kaplan**, ARS.

One contribution of his did not quite take. Meyer was ahead of his time in the early 1900's when he strongly advocated that the United States pick up on an Asian soybean industry and begin producing a food called tofu.

It took almost three-quarters of a century after Meyer brought the crops back from his Asian expeditions before American markets saw the worth of bean sprouts, Chinese celery-cabbage, and alfalfa sprouts.

The Meyer lemon is an important source of frozen lemon juice in Florida and is grown commercially in Texas, South Africa, and New Zealand. The northern wild peach he brought back energized the peach industry when it gave rise to a nematode-resistant rootstock released in 1961. That rootstock has also allowed apricots and plums to be grown in dry, alkaline soil, expanding those industries.

And of course there was the spinach Meyer brought back from

Manchuria that saved the Virginia spinach industry.

Landscape plants and ornamentals have also benefited from Meyer's collecting. His introductions are a source of genes in the hardy yellow roses that grow in New England.

Landscape trees, from the Amur cherry to the dwarf lilac and the Bradford pear, were developed from his gatherings. He was the first plant hunter in modern times to find the maidenhair tree—the ginkgo—in the temple gardens of China.

Most widely used of all the drought-resistant trees Meyer brought back were the Siberian and Chinese elms. When the drought of the 1930's threatened to turn the prairie states to dust, Meyer's elms formed a large part of the 17,000-mile shelterbelt that was created. This tree-lined windbreak planted between 1935 and 1942 helped reduce wind erosion and conserve soil for millions of acres.

Once Meyer's collected plants were brought to the United States, many of them were grown on a farm set aside for such cultivation. The 400 acres used for this purposes were known as the Arlington Farm. Today, instead of being home to such exotic crops as date palms and sugarcane, the acres are the south parking lot of the Pentagon.

Meyer helped open up the field of plant exploration in Asia. Few Western plant hunters had ever penetrated the outlying districts that he combed for plants. Not only the plants that he collected but also the techniques he developed for cataloging and shipping have had a lasting effect, literally changing the face of agriculture and landscaping in the United States and many other countries.

The Second Grand Age

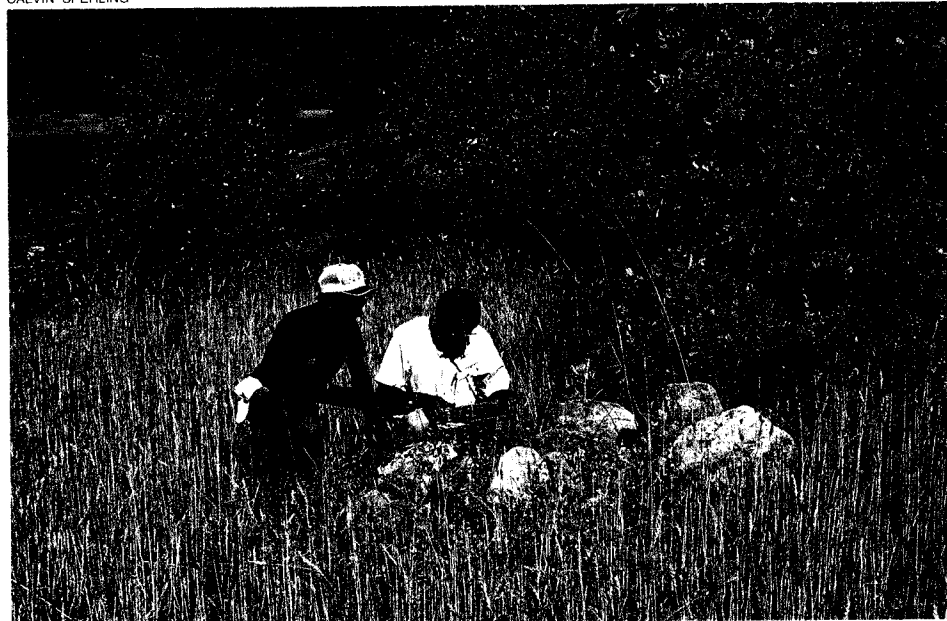
In 1946, a new mandate was handed down by Congress for USDA to collect and maintain genetic diversity. Richard Schultes was among several USDA plant collectors who made the 1940's and 1950's a second grand age of plant exploration.

Howard Scott Gentry, one of the country's most respected plant explorers, worked for USDA for 24 years until he retired in 1971.

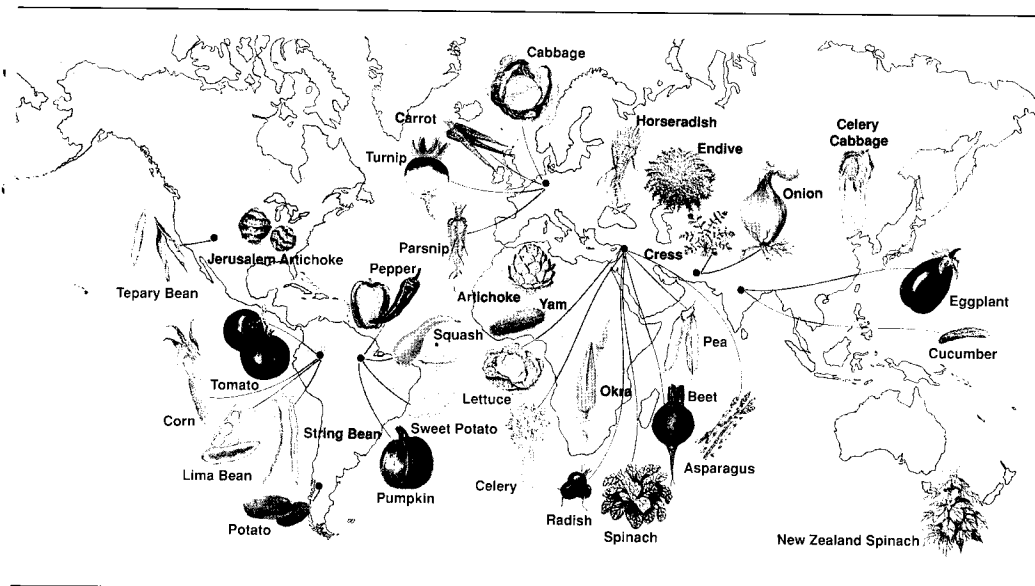
His contributions have had wide spread impact. Some of the wild beans he collected in Mexico and Central America have natural resistance to bean weevils and other insects. Others have shown a natural resistance to city smog.

He was involved also in USDA's search for plants that could serve as sources of steroids in the 1950's. He logged thousands of miles across the southwestern United States, Africa, and Asia exploring and collecting plants that might provide the raw materials for medicinal steroids. That program eventually analyzed about 7,000 plants. Wild yams that Gentry collected were found to be some of the best sources.

CALVIN SPERLING



ARS scientists Walt Kaiser (left) and Fred Muehlbauer look for wild lentils at the edge of a wheatfield in southeastern Turkey. The seeds are very small and fall to the ground as soon as they mature; they are collected by sieving the soil around the plants.



Centers of origin for some vegetables.

He is considered by many to be one of the country's top field botanists. Botanical expertise such as his is essential to plant collecting. Many yam species resemble each other on first sight. But only about a dozen of the more than 60 species of yams were significant steroid sources. Gentry could bring back what he was looking for.

"There is an unending need for new germplasm," he observes. "As new pests and new diseases develop, resistance to them will be needed. The germplasm that contains these resistances must be where the breeders and the geneticist can get at it."

Jack R. Harlan, who explored for plants for USDA in the forties and fifties, is best known for the powerful impact his wheat collecting has had.

Foremost of his introductions is a wheat known simply as PI178383 that Harlan and Turkish colleague Osman Tosun collected in 1948 from a field in Fakiyan Semdinli, Turkey.

The wheat looked terrible—it lodged, had no winter hardiness, and was susceptible to leaf rust. "It was a hopelessly useless wheat but was dutifully conserved," Harlan wrote of PI178383.

But 15 years later when stripe rust suddenly began making major incursions in the Pacific Northwest wheat crop, PI178383 was found to have resistance to 4 races of stripe rust, 35 races of common bunt, and 10 races of dwarf bunt. It also had tolerance to flag smut and snow mold.

T. R. DUDLEY



Wild viburnum from Anhui Province of China.

Today, PI178383 appears in the ancestry of virtually all of the wheats grown in the Pacific Northwest.

Oddly enough, it may turn out that PI178383 did not originate in southeastern Turkey. In 1986, Sperling went back to Fakiyan Semdinli to collect more of PI178383 and other possibly disease-resistant wheats of the area.

He discovered in conversations with the region's farmers that they were relatively recent immigrants, having moved there only in their grandfathers' time.

"The farmers came to Turkey from northern Iraq and brought their wheat along with them," Sperling says. "PI178383 and any other related varieties originated in northern Iraq."

Sperling had hoped to plan a collecting trip to northern Iraq, "but a war seems to have gotten in the way."

Unhappily, the area Sperling believes the farmers came from is within the area that has been the scene of major upheaval in the last few years, and "no one knows if the traditional varieties have survived."

Preservation in Place

A new idea for preserving wild relatives has begun to gain popularity, according to Sperling.

"We may not need to put all the wild relatives of a crop into a gene bank," he explains. "It may be more practical to preserve the plants in situ—on site in their native habitat as part of an ecological reserve."

Instead of collecting the diversity of wild species in a region and bringing it back, the wild species in that area are inventoried and left in place. Naturally, the idea only works if the inventoried area is kept undisturbed or managed as a reserve and someone is monitoring it, Sperling adds.

Of course, small samples of some of the diversity will need to be stored in a gene bank, where it will be accessible to scientists. If something promising is

found, scientists can hopefully collect additional samples from the reserve.

Sperling, along with Raul Castillo of the Ecuadorian Department of Resources, ARS botanist Jim Duke, and Shirley Keel from the Nature Conservancy, recently set up two test sites for in situ preservation in the Ecuadorian highlands.

They made a quick inventory of the wild relatives of agricultural crops present in two Ecuadorian reserves, one in the south and one in the north.

The group found wild relatives of potatoes, blueberries, currants, gooseberries, blackberries, beans and even papayas. Wild tomatoes and walnuts were found nearby. Only a few herbarium specimens were taken; the rest were simply cataloged.

"In some cases, it may be more cost-effective to re-collect what a researcher needs each time from the wild, once we know where it is, than to maintain the total diversity of wild relatives in a gene bank," Sperling says. "Gene banking is costly and requires long-term commitment to preserve seed from what is collected and then grow it out periodically to maintain viable seed supplies."

A side benefit of preserving plants in place is the additional justification for conservation efforts.

"Conservationists have rarely taken into account the potential value that wild relatives of crops may represent when creating a case for preserving an area," he says.

At least 29 of the 189 plant taxa now listed as endangered or threatened by the U.S. Fish and Wildlife Service may have some present or future potential as genetic resources of agronomic or horticultural crops.

While the plant exploration and collecting system does not function as a conservation agency, exploration and preservation do share common goals and the two can go hand in hand.

But in-place preservation will never be able to do the whole job. "It can

only be a complement to collecting germplasm and off-site preservation," Sperling says.

Closing the Gaps

Sperling is currently hard at work on a project that keeps him at his desk at the Beltsville, Maryland, Agricultural Research Center. He is trying to assign priorities as to which collecting trips are most needed.

"We need to systematically fill in the gaps in various collections and crops," Sperling says. "So the first need is to determine where the gaps are."

In the past, collections have primarily resulted from scientists who



David Fairchild, on exploration trip to Ceylon in February 1926, with an example of a King coconut. Fairchild is considered a father of modern plant collecting in USDA.

arranged to get or collect some material they were interested in working with. The materials would then be passed on to the germplasm system.

For instance, all of the cranberry cultivars grown today come from germplasm originally collected from just two areas in the United States.

Who knows what additional useful traits may be available in other areas," Sperling says. "Or wheat—we may have over a thousand samples of wild relatives, but they come from a relatively few areas. Many unexplored areas still exist in the Soviet Union, China, the western Mediterranean, and even North Africa."

To help set objectives, Sperling has prioritized planned acquisitions into four groups: land races of plants cultivated in the world's remaining remote areas, wild progenitors of domesticated plants throughout their geographical range, plants exhibiting unique chemical or biologically active properties, and plants of evolutionary rarity—including the evolutionary "dead end" taxonomic groups, and unique plant families that may contain novel genes not found elsewhere in the plant kingdom.

"By collecting from these groups, combined with in situ preservations, we may one day have a better knowledge of what plants have to offer," Sperling says.

Although Meyer probably did not use such terms as germplasm, gene pool, and in situ preservation, he certainly understood the need for continually improving the diversity of U.S. agriculture, for in 1908, he wrote:

"In the future we will create unheard-of strains of fruits and shrubs and trees and flowering plants. All we need now is to build up collections so as to have the material at hand.... We are only cutting out a few steps in the mountain of knowledge and others have to mount by our steps."—By **J. Kim Kaplan, ARS.**

For addresses or phone numbers of ARS scientists mentioned in this article, contact the Editor, Agricultural Research, Room 316, Bldg. 005, BARC-West, 10300 Baltimore Blvd., Beltsville, MD 20705-2350. Phone (301) 344-3280. ♦