

2001

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Collecting landscape trees and shrubs in Ukraine for the evaluation of aesthetic quality and adaptation in the north central United States†

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Summary

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Past experiences with long-term evaluations of woody landscape plants from Slovenia, Croatia, and Bosnia-Herzegovina in the north central United States indicated that a relatively low proportion of these introductions were well adapted to climatic and soil conditions. Based on these results, criteria were developed to focus future exploration for landscape trees and shrubs from more analogous environments in eastern and central Europe. Application of these criteria identified the forest-steppe transition zone in the northern half of Ukraine as a region with great potential, because of similarities to the north central United States in climatic extremes, soil types and natural plant communities. In 1999, the National Plant Germplasm System of the United States funded a collaborative seed-collection mission involving researchers from the United States Department of Agriculture, Michigan State University and the National Agricultural University of Ukraine. The exploration trip took place between 7 and 26 September 1999 and encompassed ca. 3200 km of travel to wooded sites through the forest-steppe transition zone. Eighty-nine seed collections, including 26 genera and 45 species of trees, shrubs and herbaceous perennials were obtained. The mission, its collections and conditions at collection sites are described in this report.

Key words: Climatic analogue, forestry, genetic resources, ornamental, plant community, plant exploration

Résumé

Un assemblage des arbres et arbustes ornementaux dans l'Ukraine pour l'évaluation de l'esthétique et de l'adaptation dans la région nord-centrale des États-Unis

Certaines expériences avec les évaluations à long terme des plantes ligneuses de la Slovénie, de la Croatie, et de la Bosnie-Herzégovine dans la région nord-centrale des États-Unis ont indiqué qu'une portion relativement petite de ces introductions a été bien adapté aux climats et terroirs régionaux. Fondé sur ces résultats, quelques critères ont été développées afin de diriger l'exploration future pour les arbres et arbustes ornementaux des environnements plus analogues dans l'Europe orientale et centrale. L'application de ces critères a reconnu la zone de transition entre le bois et la steppe dans l'Ukraine du nord comme une région du potentiel considérable, à cause des ressemblances à la région nord-centrale des États-Unis en les extrêmes climatiques, les types de sols, et les associations naturelles de la végétation. En 1999, le Système National du Matériel Génétique Végétal a financé une mission collaborative afin de rassembler les semences, engageante les chercheurs du Département d'Agriculture des États-Unis, l'Université de l'État du Michigan, et l'Université Agricole de l'Ukraine. L'excursion d'exploration a eu lieu entre le 7 et le 26 septembre 1999 et a embrassé vers 3200 km des voyages aux bois à travers la zone de transition entre le bois et la steppe. Nous avons obtenu 89 échantillons de semences, contenant 26 genres et 45 espèces d'arbres, arbustes, et herbacées plantes vivaces. Dans notre rapport, nous décrivons la mission, ses collections, et les conditions aux lieux de collection.

Resumen

Colección de árboles y arbustos de paisaje en Ucrania para la evaluación de la calidad estética y adaptación en la parte central norte de Estados Unidos

Experiencias en el pasado con evaluaciones de largo plazo en plantas leñosas de paisaje provenientes de Eslovenia, Croacia y Bosnia-Herzegovina en la parte central norte de Estados Unidos, han indicado que una proporción relativamente baja de estas introducciones estuvieron bien adaptadas a las condiciones climáticas y de suelo. Con base en estos resultados, se desarrollaron criterios para enfocar futuras exploraciones de árboles y arbustos de paisaje de ambientes más análogos en el este y centro de Europa. Con la aplicación de estos criterios se identificó a la zona de transición bosque-estepa en la mitad norte de Ucrania como una región con gran potencial, debido a similitudes con la parte central norte de Estados Unidos con respecto a los extremos climáticos, tipos de suelo y comunidades naturales de plantas. En 1999, el Sistema Nacional de Germoplasma Vegetal de los Estados Unidos financió una misión colaborativa para colección de semilla involucrando investigadores del Departamento de Agricultura de Estados Unidos, la Universidad Estatal de Michigan y la Universidad Agrícola Nacional de Ucrania. El viaje de exploración se realizó entre el 7 y el 26 de septiembre de 1999 y abarcó aproximadamente 3200 km de recorrido a sitios arbolados a través de la zona de transición bosque-estepa. Se obtuvieron ochenta y nueve colecciones de semilla, incluyendo 26 géneros y 45 especies de árboles, arbustos y herbáceas perennes. En este reporte se describe la misión, sus colecciones y las condiciones de los sitios de colecta.

† Journal Paper No. J-19028 of the Iowa Agriculture and Home Economics Experiment Station, Ames, Iowa, Project No. 1018, and supported by Hatch Act and State of Iowa.

Introduction

The north central United States is a region of climatic extremes, and many parts of the region have alkaline soil that developed under grasslands. Because of these conditions, the diversity found in commercially available woody plants adapted to the region is considerably less than that found in many other parts of the United States.

Eastern and central Europe are potentially important sources of well-adapted landscape plants for the nursery industry in the United States. Many commonly produced shade trees and shrubs cultivated in urban areas in the eastern United States, such as *Acer campestre* and *platanoides*, *Ligustrum vulgare*, *Quercus robur* and *Tilia cordata*, are native throughout much of Europe, but are thought to be primarily of western European provenance because of previously restricted access to regions further east. Western European sources are often poorly adapted to the climatic and edaphic stresses found in the north central region, leading to plant loss and frequent replacement. But the native ranges of many valuable European landscape plants extend east into the more continental climates and grassland soils of central and eastern Europe, creating opportunities to acquire and evaluate plants that may be of direct utility in the north central region and that should also serve as a reservoir of stress-tolerant genotypes for plant improvement research.

The most comprehensive landscape-plant evaluation program in the north central region is the NC-7 Regional Ornamental Plant Trials, which were begun in 1954 with the ultimate goal of expanding the range of useful plants in the nursery trade in the north central region (Widrechner 1990). The emphasis in these trials is placed on detailed, long-term evaluations across a diverse array of sites and the broad sharing of such performance data rather than on direct promotion of new plants, with results made available to horticultural professionals and the general public via the Internet (Becker 2000). One of the first opportunities to evaluate landscape plants from central Europe occurred in the early 1970s, when a U.S. government-sponsored project resulted in extensive collections of horticultural germplasm throughout former Yugoslavia. Many of the tree and shrub collections made by that project were evaluated in the 1970s and 1980s in the NC-7 Regional Ornamental Plant Trials. A detailed analysis of the performance of these plants in relation to climatic variables at trial sites (Widrechner *et al.* 1992) indicated that a relatively low proportion of Yugoslavian plants were well adapted in the north central region and that climates at the collection sites were not analogous to those at the trial sites.

Based on these results, criteria were developed to focus a search for better-adapted landscape plants from more analogous environments in eastern and central Europe (Widrechner 1994a, 1994b). It became obvious from this research that the northern half of Ukraine met important climatic criteria and needed to be examined more closely. Thus, in 1994, Widrechner developed a list of woody plants native to the area in question and circulated that list widely among American botanical gardens, nursery professionals and academic horticulturists, as part of a survey to identify target species for collection. In 1995, more detailed climatic data (Slabkovich 1968) and soil maps (Anonymous 1960; Ganssen and Hädrich 1965) were obtained for Ukraine. And in

1996, distribution maps for many of the target species were located (Sokolov *et al.* 1977–1986). Taken together, the results of these efforts indicated that an exploration focusing on native tree and shrub populations adapted to the transition zone between the central European deciduous forest and the Ukrainian steppes should be most productive.

Most of the woody vegetation in the forest–steppe transition has been cleared for agriculture. A figure in Sheljag-Sosonko *et al.* (1982) indicates that remnant forests constitute 10% or less of the historic forest–steppe transition zone. Ukraine is densely populated (>100 inhabitants/km² in the target region) and, as land-use patterns change with changing economic systems, native vegetation will likely face new threats from both urbanization and the modernization of agricultural practices. The nation's two largest cities, Kyiv and Kharkiv, are also located in the target region.

A status report of the Woody Landscape Plant Crop Germplasm Committee (1996) identified Ukraine as a geographic priority for exploration. A survey of the Germplasm Resources Information Network (GRIN) database (<http://www.ars-grin.gov/npgs>) and of U.S. arboreta and botanical gardens also indicated that there was almost no landscape plant germplasm available from the target region. Academic exchange and collaboration agreements between Iowa State University (ISU) and the National Agricultural University of Ukraine (NAUU) led to the development of our team to conduct the exploration in 1998. We then collectively developed an itinerary for exploration to sample a broad range of sites on an east–west gradient ranging from small outliers of woody vegetation within the steppe zone in the east to rather diverse forests in the west. Sites focused on the forest–steppe transition zone in U.S. Department of Agriculture (USDA) hardiness zone 5 (mean minimum annual temperature between –23.4 and –28.9°C) with grassland and/or brown forest soils and moderate moisture deficits, avoiding podzolic soils in the north, cool, moist habitats of the Carpathian Mountains, and warm summer, mild winter habitats near the Black Sea.

Expedition and samples collected

The exploration trip was facilitated by an established collaboration between ISU and NAUU and was also aided by a Memorandum of Understanding between the National Plant Germplasm System (NPGS) of the United States and the National Center for Plant Genetic Resources of Ukraine. The trip took place between 7 and 26 September 1999 and encompassed approximately 3200 km of travel to collection sites (Fig. 1). NAUU served as our base, with excursions to the east and west. The first excursion went east through Pryluky towards Okhtyrka, southeast to Kharkiv, southwest through Poltava and Cherkasy to Uman and finally returned north to Kyiv. A second excursion involved traveling west through Zhytomyr to Rivne, south through Kremenets to Ternopil, southeast through Khmelnytskyi to Vinnitsa and returning northeast to Kyiv.

Military maps of each oblast (state) in 1:200 000 scale were extremely helpful in locating natural forests, potentially interesting topographic features, and navigating through both the cities and countryside. More exact locations for collection sites were verified by the use of a Global Positioning System (GPS) receiver

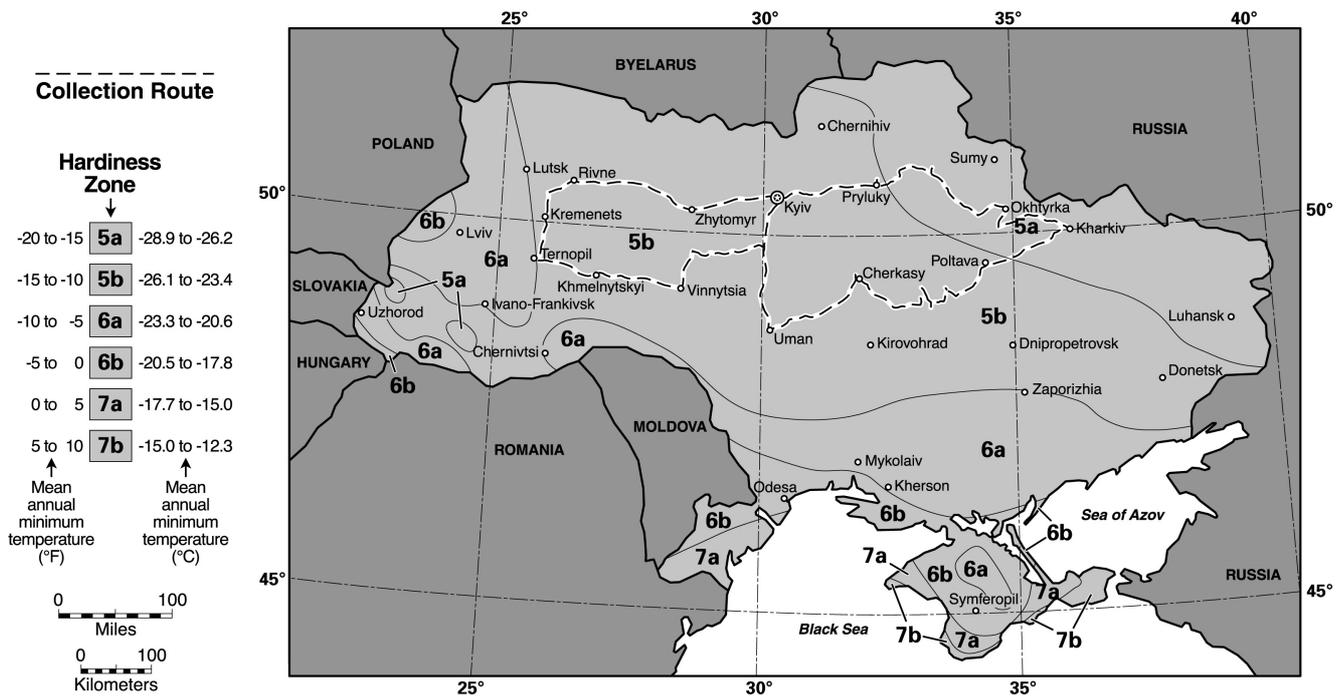


Fig. 1. Route map.

and occasional comparisons of elevational contours with a handheld altimeter. Positional data were also verified upon return to the U.S. by comparison with coordinates held by the GEONet Names Server (<http://164.214.2.59/gns/html/>).

Plant exploration focused on the forest–steppe transition zone. Eighty-nine seed collections (most with herbarium vouchers) including 26 genera and 45 species of trees, shrubs and herbaceous perennials were obtained (Table 1). Collections were made between 49°14' and 50°48' north latitude and between 25°43' and 35°48' east longitude. Elevations ranged from 80 to 370 m above sea level. Based on climatological data, collection sites correspond to USDA winter hardiness zones 5a and 5b (mean minimum temperatures between -23.4 and -28.9°C). Mean annual rainfall is highest in the west and decreases towards the east/southeast. Rivne, Kremenets and Ternopil receive ca. 575 mm of annual precipitation; Khmelnytskyi is between 550 and 575 mm; Zhitomir, Kyiv, Pryluky, and Sumy between 525 and 550 mm; Vinnitsa and Okhtyrka between 500 and 525 mm; and our driest collection areas were 475–500 mm through Kharkiv, Poltava, Cherkasy and Uman. Annual rainfall for 1999 was at 76% of normal levels according to the Agricultural Attaché at the U.S. Embassy in Kyiv, with slight regional variations. The crops and natural vegetation in the eastern oblasts often showed visible signs of drought stress, especially on sandy sites.

Soils throughout the region can be generally described as transitional between podzolic forest soils, more specifically, grey forest soils, and chernozem soils of the steppes. Soil texture classifications were predominantly sandy loams and clay loams, with isolated areas of sands near Poltava, Okhtyrka and Cherkasy.

Natural vegetation occupies approximately 18 million ha in Ukraine, with 8 million in forests, 1 million in steppes and the balance in meadows and marshes. Sixty-five percent of the for-

ests are in the Carpathian Mountains. In our travels, we encountered five basic forest types. The first was *Quercus–Carpinus* forest, with predominant species including *Quercus robur*, *Carpinus betulus*, *Corylus avellana*, *Cornus sanguinea* and *Euonymus verrucosus*. These species typically exist in conditions with 500–700 mm rainfall and annual January mean temperatures not lower than -6°C. A variant of this forest type was found in the hills above Kremenets, where *Q. petraea* and *Acer pseudoplatanus* were growing with many of the other species typically found in the *Quercus–Carpinus* association. The second type was *Quercus–Tilia* forest, with predominant species including *Q. robur*, *Tilia cordata*, *Corylus avellana*, *Cornus sanguinea*, *A. tataricum*, *Fraxinus excelsior*, *A. campestre* and *Crataegus* spp. Precipitation associated with this forest type is approximately 400–500 mm with a mean January temperature of about -4°C. A third type was riparian forest, with *Q. robur*, *F. excelsior*, *A. campestre*, *Ulmus glabra*, *Pyrus communis*, *Populus* spp. and *Alnus glutinosa* as dominant species. The fourth and fifth forest types were dominated by *Pinus sylvestris*, sometimes in nearly pure stands. On riverine sands, *P. sylvestris* were found growing in scrubby to impressive stands, depending upon water availability. Associated plants included *Betula pendula*, *Corylus avellana*, *Sambucus racemosa*, *Q. robur*, *Rosa* spp., *Chamaecytisus* spp. and *Genista tinctoria*. The other type of pine forest was observed in Zhitomir and Rivne states, where acid-soil indicator plants, such as *Vaccinium* spp., *Rhamnus frangula* and *Calluna vulgaris*, were growing among the pines. Tremendous diversity in *Salix* species was observed in or near poorly drained areas, and extensive populations of naturalized *F. pennsylvanica*, *Acer negundo*, *Parthenocissus quinquefolia* and *Robinia pseudoacacia* were commonly located along roadsides and in disturbed forests.

Two general types of steppe vegetation were seen on the eastern excursion. One type was associated with very sandy

Table 1. Species list (taxonomy following the GRIN database) and number of accessions collected

Species	No. accessions collected
<i>Acer campestre</i>	3
<i>Acer negundo</i>	1
<i>Acer platanoides</i>	4
<i>Acer pseudoplatanus</i>	4
<i>Acer tataricum</i>	5
<i>Acer tegmentosum</i>	1
<i>Betula pendula</i>	3
<i>Carpinus betulus</i>	4
<i>Chamaecytisus</i> sp.	1
<i>Cornus mas</i>	1
<i>Cornus sanguinea</i>	2
<i>Cotinus coggygria</i>	1
<i>Crataegus meyeri</i>	1
<i>Crataegus rhipidophylla</i>	1
<i>Crataegus sanguinea</i>	1
<i>Crataegus</i> x <i>kyrtostyla</i>	1
<i>Crataegus</i> sp.	1
<i>Daphne mezereum</i>	1
<i>Dianthus campestris</i>	1
<i>Dianthus carthusianorum</i>	1
<i>Euonymus europaeus</i>	4
<i>Euonymus verrucosus</i>	3
<i>Fragaria vesca</i>	1
<i>Fraxinus excelsior</i>	5
<i>Genista tinctoria</i>	2
<i>Juniperus communis</i>	1
<i>Juniperus sabina</i>	1
<i>Laburnum anagyroides</i>	1
<i>Ligustrum vulgare</i>	3
<i>Mentha longifolia</i>	1
<i>Pinus sylvestris</i>	2
<i>Quercus robur</i>	4
<i>Rosa canina</i>	2
<i>Rosa</i> sp.	1
<i>Rubus caesius</i>	1
<i>Sambucus ebulus</i>	2
<i>Sambucus nigra</i>	3
<i>Sambucus racemosa</i>	1
<i>Sorbus aucuparia</i>	2
<i>Sorbus torminalis</i>	2
<i>Staphylea pinnata</i>	1
<i>Tanacetum parthenium</i>	1
<i>Tanacetum vulgare</i>	1
<i>Tilia cordata</i>	4
<i>Tilia tomentosa</i>	1
<i>Viburnum opulus</i>	1

soils, often adjoining *P. sylvestris* stands. The other was found on more typical chernozem soils, usually in very small remnants or on steep, eroded slopes. Many interesting wildflowers, including *Dianthus*, *Limonium*, *Salvia*, *Campanula*, *Lavatera* and *Thymus*, could be found on the steppe remnants, but these were not the focus of the trip.

The vegetation around NAUU and Kyiv consisted of plantations of *P. sylvestris* edged with *A. tataricum*, *Cotinus coggygria* and other shrubs along the highways at the outskirts of the city. Boulevards and city streets were shaded by *Aesculus hippocastanum*, *T. cordata* and *Betula pendula*. Genetic diversity in *Aesculus* populations was obvious through their susceptibility to leaf blotch; damage varied from tree to tree throughout most of the country. *Quercus-Carpinus* forests surrounded the cultivated

landscapes of NAUU. Acorn collection was not very productive on campus or in the countryside due to damage by weevil larvae.

The Botanical Garden of NAUU was developed from the Golosiyeve Forest nursery in 1938. The grounds include a 9.5-ha arboretum and a 15-ha dendropark. The arboreal collections include 541 species, 60 forms and 22 hybrids. Samples were collected from several tree and shrub species from within these gardens. Directly south of the Botanical Garden lies small lakes and natural riparian forests, which produced interesting collections of *Sambucus*, *Cornus* and *Euonymus*. Kyiv is also home to the Central Botanical Garden of Ukraine, a 200-ha garden developed in 1935 under the direction of the Ukrainian Academy of Sciences. There, research has been conducted on three native species of *Daphne*, the rare and endangered *D. cneorum* and *D. sophia* and the somewhat more common *D. mezereum*. The decline of *D. cneorum* and *D. sophia* are related to the disruption and development of forested lands (Melnik 1996). Timing did not allow for seed collection; however, these species were observed and photographed in the rare plant collection. An accession of *D. mezereum* was collected earlier in the season from plants cultivated at NAUU.

Traveling east towards Pryluky, we observed large masses of *Chamaecytisus* growing along the roadsides; however, their seeds were already dispersed. Pryluky has approximately 22 000 ha of forest in the forest-steppe transition zone. Samples of *A. platanoides*, *T. cordata* and *Crataegus* spp. were collected along the edge of a dense-canopied *Quercus-Carpinus* forest. In the Romny forests, populations of *Quercus*, *Fraxinus*, *Acer* and *Corylus* were prevalent, but there was little or no seed production due to late spring frosts. Seed production increased in the region southwest of Kharkiv, with collections made of *Acer* spp. and *Fraxinus excelsior*. An expansive meadow with a combination of grasses, *Genista*, *Dianthus*, *Tanacetum* and other herbaceous plants was found as we travelled toward Kremenchuk. We suspected this to be a typical example of steppe vegetation.

Laburnum anagyroides was observed in three gardens in Ukraine. In two gardens, the plants had obviously suffered significant winter damage and produced no seeds. But at Ustimovka Dendrological Park, northwest of Kremenchuk, very large shrubs/small trees with heavy seed production and no obvious winter injury were observed. A large seed collection was made from these plants in the hope that they have increased minimum temperature tolerance.

Sofiyivka Park in Uman is a state preserve under the authority of the Ukrainian Academy of Sciences. It serves as a scientific research park with four units of operations: science, administration, reserve, and exhibitions. Presently, the park covers 157.6 ha, houses over 2000 species and is an important centre for plant introduction in Ukraine. Seeds of *Fraxinus excelsior* were abundant, *Carpinus betulus* and other trees towered overhead, and we were able to collect seeds of *Sorbus torminalis*, an extremely attractive, but uncommon tree native to Ukraine.

The western excursion passed through expansive forests. *F. excelsior* was the dominant species on moist sites, with occasional populations of *Quercus*, *Carpinus*, *Alnus* and *Ulmus*. Near Kremenets, collection occurred on rougher terrain that surrounds the historic city. *Carpinus*, *Fraxinus*, *A. pseudoplatanus*, *Betula* and

Tilia covered the hillsides. The route to Vinnitsa passed through a few natural forests with large *Tilia* specimens. Vinnitsa was locally considered to have the best growing conditions in Ukraine. Rich soils and abundant moisture contribute to excellent growth and development of the forest. Time did not allow for extensive collecting in Vinnitsa oblast, though attractive plants, such as *Sorbus torminalis*, are reportedly native in its forests.

We also observed opportunities for future germplasm exploration for plants other than landscape ornamentals. Collections from steppe remnants may yield useful forage and rangeland germplasm, and fruit and nut germplasm in the genera *Prunus*, *Pyrus*, *Corylus*, and *Juglans* was often abundant and may provide useful sources of genes for adaptation to extreme environments.

Seed samples were shared with the NAUU and have now been accessioned into the NPGS through the North Central Regional Plant Introduction Station, Ames, Iowa. These have also been shared with appropriate NPGS sites for maintenance. Herbarium vouchers were divided between Ukrainian and American institutions, with most deposited at the National Arboretum, Washington DC, and the National Agricultural University of Ukraine. Many of the seed collections will be propagated for long-term evaluation in the NC-7 Regional Ornamental Plant Trials. It is expected that many of them will possess superior genetic adaptation to climatic and edaphic stresses in comparison to germplasm of these same taxa from western and other central European provenances.

The sharing of landscape plant performance data from sites in the north central United States that experience climatic patterns and soil types resembling those in Ukraine and of theoretical and empirical models that relate climatic data to plant adaptation should benefit horticulturists and foresters in both Ukraine and the United States. We are confident that our experiences from this exploration serve as a first step in the development of more extensive collaboration and germplasm exchange.

Acknowledgements

We greatly appreciate the financial support and cooperation of the USDA-ARS National Plant Germplasm System, and especially of the Plant Exchange Office, in making this trip possible. In addition, there were many individuals both in the United States and Ukraine who gave generously of their time and expertise. They include Dr David Topel, Dr David Acker, Dr Victor Udin, Ms Lori Wilson-Voss, Dr Tatyana Shulkina, Dr Victor Ryabchoun, Dr Victor Melnik, Dr Victor Kalensky, Mr Larry Panasuk, Mr Dmitri Prikhodko, Ms Lois Simms, Mr V.M. Brezhnev, Mr Amalio Santacruz-Varela, Ms Simone Kimber, and Mr Rex Heer. Critical reviews of this report by Dr David Acker, Dr Edward Garvey and Dr Harold Pellett are also much appreciated.

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