NRSP6
PROJECT RENEWAL PROPOSAL
for FY 2016-20

Title:

NRSP6 - the US Potato Genebank: Acquisition, classification, preservation, evaluation and distribution of potato (*Solanum*) germplasm

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-- OUTLINE --

Executive Summary

This renewal proposal for NRSP6 is similar to the FY11-16 project (and all previous ones since the early 1950's), because what the genebank does and how it does it continue to efficiently fill a strong and growing national need for germplasm support for potato research and breeding.

As the most consumed and most valuable US vegetable, potato substantially influences the farm economy and environment in many states. High value-added processing and high and regular consumption gives potato significant impact in all states with respect to the food economy and citizens' health.

Because potato has more useful exotic germplasm than any other crop, there is much activity in federal, state, and private breeding and research programs using genebank stocks. Potato is a high input crop with many opportunities of improvement that can be addressed by germplasm. Potato is a prohibited import crop, so genetic resources already in the US genebank are the only ones readily available to germplasm users. Continuing restrictions on international germplasm collecting and sharing make what we already have at NRSP6 even more precious. NRSP6 is one of the premier potato genebanks in the world, and the only program in the nation responsible for providing these potato genebank services.

NRSP6 has a technical advisory committee that meets annually to review a detailed annual report, and NRSP6 undergoes a mid-term review. Performance of Wisconsin and USDA/ARS staff is also comprehensively reviewed twice per year in the federal 5-year CRIS project that almost exactly duplicates NRSP6.

This document details robust accomplishments over the past 5 years:

Requests for NRSP6 germplasm were strong and were promptly filled. We not only preserved the materials, but conducted R&D that showed ways to make genebank techniques more efficient. We have cooperated with and assisted federal, state, and private scientists to discover, characterize, and evaluate traits of interest to the industry.

For the FY11-15 project, ESCOP requested that NRSP6 demonstrate relevance by obtaining significant financial contributions from Industry. This has been fulfilled.

We are asking for continuation of $150K per year in MRF funding. This maintains the *status quo*, being close to the average funding for the past 40 years. Of course, such long-term flat funding actually represents about a 50% reduction of historic support in terms of buying power.

Virtually all crop germplasm in the National Plant Germplasm System is genebanked in partnership with SAES. And although MRF funding of NRSP6 is only about one-fifth of total inputs from ARS, APHIS, UW, grants and gifts, about 27% of NRSP6 germplasm distributions go to SAES scientists. NRSP6 gives SAES ownership of a renowned genebank for one of the nation's main food crops, and its mission fills an ongoing national need with increasing returns on SAES investment.

A. PREREQUISITE JUSTIFICATION AND STATEMENT OF ISSUES

1. How is NRSP6 service consistent with the NRSP research support mission?

a. NRSP6 is the only practical source of potato germplasm for US researchers and breeders:

NRSP6 is designated the sole official NPGS project filling the role of working potato genebank for the US. A good way to understand the importance of NRSP6 is to imagine the situation if no genebank was present for an individual researcher wanting to use exotic potato relatives. He would first need to study taxonomic boundaries to understand his material and how it related to cultivars. He would need to determine breeding system, requirements for growth, and interspecific crossing. If it did not exist in the US or he could not find or obtain it from a fellow US researcher, he would need to organize an expedition to Latin America. Since potato is a "prohibited" plant for import, he would have to negotiate APHIS quarantine and wait one or two years. When finally in hand, would he propagate the germplasm disease-free, and advertise it for sharing with all potato researchers worldwide? NRSP6 does and coordinates all these things for the potato research community, avoiding the confusion, inefficiency and costs associated with duplication of these efforts by many individuals. This is not a static process, but must evolve with the advance of science and as needs and opportunities change over time.

b. NRSP6 provides enabling technologies and materials.

Germplasm stocks. As described above, providing the germplasm itself enables advances in potato research and breeding. In the past project term NRSP6 has met this need by freely and promptly distributing materials and doing the associated work that supports these distributions.

Germplasm data. NRSP6 provides users with a central source of current germplasm information: What is available in US and globally, taxonomic relationships, natural origin, characterization and evaluation data with respect to useful traits. To do this, NRSP6 must also develop and maintain acquisition; classification; seed increase, inventory, disease status and distribution data. All of this data pertinent to the needs of germplasm users is available 24/7 online.

R&D for best techniques and tools for germplasm collecting, preservation, and evaluation. The genebank is the focus of NRSP6, but we must keep in mind that the genebank has only a sample of what is available in the wild. Thus, study and appropriate action to make the genebank collection the best it can be is crucial. Diversity is the goal, but while the scope of potential diversity we could collect and keep is virtually unlimited, genebank funding is not. R&D that characterizes diversity richness and enables the most efficient techniques for collecting and preservation is of great importance for our own genebank and others worldwide. NRSP6 has become the world leader in developing such information and tools by examining specific practical questions with DNA markers, often using materials from collecting expeditions organized and conducted by genebank staff.

Custom materials for germplasm evaluation. It would not be appropriate for genebank staff to specialize in any one evaluation discipline. Instead, genebank staff expertise in germplasm genetics and handling is used to devise studies, then select and prepare materials for testing in partnership with various extramural scientists with the specific expertise and infrastructure for generating the data.

2. How does NRSP6 pertain as a national issue?

Widespread relevance, need and use of potato germplasm. Potato is the most widely grown and consumed vegetable in the US and world, being among the most palatable and versatile of foods. US and world production has grown impressively in the past five years. Worldwide production grew 13% from 323 to 365 million tons. Potato accounts for about 30% of all vegetable consumption in the US. US consumption has remained fairly steady for the past 40 years, but with percent fresh going from about 50% to about 70% (mostly due to more frozen products), with great economic added value in processing. In the past 5-year project term, production value in the US increased 27% from 3.3 to 4.4 billion dollars, increasing dramatically in many states (see Figure 1).

Exotic germplasm has had great genetic impact and opportunities. More exotic germplasm is available and used for potato than for any other major crop. Over 70% of potato varieties grown in the US have germplasm in their pedigrees from the genebank, and all varieties released in the past five years do. Some estimates have been made of the economic return from germplasm utilization. About 50% of the four-fold advance in potato yields have been due to genetic improvement and about 1% of annual value of all crops may be credited to exotic germplasm. Pro-rated, this is a total of $10-25 million per year for potatoes in the USA.

NRSP6 stocks and research have national value because they...

... appear in most of the improved new cultivars in the 10-15 year pipeline of conventional breeding.

... provide valuable genes in exotic potato that can be efficiently moved to modify popular existing cultivars already having consumer acceptance (e.g., transgenics and Simplot's *Innate* lines).

... will continue to provide novel technologies that enter the marketplace, like inbred diploid varieties developed by Solynta.

... have a positive impact on all citizens, not just members of the potato industry, since *every* state has a significant and direct involvement in marketing, transportation and consumption of potato as a major part of the diet of its population. Scientists in every state benefit from advance of knowledge published by researchers using NRSP6 germplasm.

... provide a platform for study and use of quality traits that enhance potato value at the consumer level, which has impact in all states.

... provide a platform for study of health traits like anti-cancer, anti-obesity, and anti-stroke which have great potential impact on economic status and citizen well-being and productivity.

Two thirds of Americans are overweight or obese. Inadequate potassium intake would prevent an estimated 100,000 annual deaths due to sodium-induced high blood pressure, not to mention mitigate non-lethal strokes that are the leading cause of chronic, severe disability. Cancer has surpassed heart disease as the leading cause of deaths of all individuals except the very old. Aging baby-boomers are expected to exacerbate these already severe challenges to national health and insurance costs. These medical issues cost US society hundreds of billions of dollars annually.

B. RATIONALE FOR NRSP6

1. Relevance to ESCOP challenges

Challenge 1: *We must enhance the sustainability, competitiveness, and profitability of U.S. food and agricultural systems*. This can be achieved through lower input costs keeping all other factors steady. Or, quality can improve to support higher prices at the same market share. The optimal scheme for the potato crop is to use germplasm to make gains in all three areas: less input costs, higher yield per area of land, and higher quality. Other initiatives that will contribute to these general goals are increasing *net* yield by reducing storage losses, and capitalizing on virtual demand by removing the physiological limits to potato production due to the climate, diseases and pests.

Challenge 2 . *We must adapt to and mitigate the impacts of climate change on food, feed, fiber, and fuel systems in the United States.* Potato is cultivated across a broader range of latitudes than any other major crop. Thus, the effects of climate change could be different in different growing regions, and require the screening for multiple new traits in exotic germplasm which can be incorporated into the crop. Genebank staff are actively working on modeling climate change and predicting impact on *in situ* populations.

Challenge 3: *We must support energy security and the development of the bioeconomy from renewable natural resources in the United States*. NRSP6 does not address this challenge.

Challenge 4: *We must play a global leadership role to ensure a safe, secure, and abundant food supply for the United States and the world*. This is the heart of what NRSP6 aims to promote. Genetic diversity of the exotics at NRSP6 represents the potential diversity of improvements in productivity, quality and resource use efficiency realized in new cultivars.

Challenge 5: *We must improve human health, nutrition, and wellness of the U.S. population*. As already mentioned, improved potato has outstanding potential to have a significant health and nutrition impact on a population basis because it already has a regular, high level of consumption across all demographic categories in the US. Compare, for example, to blueberries which have famous levels of antioxidants per serving, but are very expensive, and are eaten only in small quantities and irregularly. Potato has had obvious appeal—it is relatively cheap, good-tasting in many forms, and filling. Because of extensive potato cultivation of potato worldwide, reducing the need for chemical inputs in the potato crop through genetic means could significantly reduce the exposure to agrichemicals (manufacture, transport, storage, grower, consumer). Genetic improvements via NRSP6 germplasm are resulting in a more productive, versatile, profitable, nutritious and environmentally safe potato crop.

Challenge 6: *We must heighten environmental stewardship through the development of sustainable management practices*. Research supported by NRSP6 will continue to find ways to make a crop that is more efficient at using fertilizer and water inputs and can naturally resist pests and diseases. That means less impact on the environment through less use of pesticides.

Challenge 7: *We must strengthen individual, family, and community development and resilience*. NRSP6 can have an impact on primitive farmers in developing countries who could improve their standard of living and maintain their culture because germplasm inputs gave them a more marketable and nutritious crop (by increasing frost tolerance for high altitude farmers, for example). Food security in developing countries often has a favorable influence on political stability, which reduces the money US citizens must spend to maintain international relations and foreign aid. A healthy US populace can also have a higher standard of living due to more productivity and less need to spend the profits from that productivity on insurance, medical care and government intervention programs.

2. Relevance to stakeholders

NRSP6 stakeholders are researchers, breeders, those who use their product (producers), food suppliers, and, ultimately, consumers. Here are the reasons why there is a continued need and relevance of NRSP6 service to stakeholders, and why US scientists (and foreign ones) will depend on NRSP6 germplasm more in the future:

1) No other public or private programs have come forward to provide the unique services of NRSP6. Sixty-five years of public support of this genebank has resulted in the collection of over 5,000 items of germplasm for the world's most important non-cereal crop. At least 45% of these are unique.

2) The need for potato research and breeding is increasing. Development of technology has enhanced the quantity and impact of research and publications involving germplasm. There is a US-based international association of researchers devoted to potato with Breeding and Genetics taking a prominent role (The Potato Association of America). There are numerous breeders, hundreds of thousands of seedlings grown for yearly selection, more sophisticated facets of evaluation, and more varieties being released. There is increasing challenge to gather, format and distribute information with the greater speed and detail made possible with advances in data management technology.

3) Acquisition of germplasm from foreign genebanks or directly from the wild is becoming even less practical for US researchers. Other genebanks have faced financial problems or reorganization which has reduced their capacity to maintain availability of germplasm and services. Countries with native potato germplasm to share are doing so less freely due to policies reflecting feelings of national ownership and problematic expectations of "benefit sharing" that have delayed access from Latin America since 2000. So, dependence on raw materials we have in-country at NRSP6 is greater than ever.

4) Potato is listed as "prohibited" by APHIS, making quarantine testing of all imports for one-two years necessary, at an estimated cost of over $4,000 per item. To avoid the wasted time and expense of having quarantine repeatedly process the same material for multiple importers, we need the coordination, information and preservation provided by NRSP6.

5) We need to reduce agrichemical inputs that are costly and may threaten the health of humans and the environment. We need solutions to legal limitations to use of pesticides and water so producers can stay in business. For farmers and consumers, genetic solutions through germplasm are increasingly important.

6) Physiological constraints such as a need for cold tolerance (applied especially to the mountain growing regions like the Andes but everywhere subject to the global cycle of wider weather fluctuations), heat and CO_2 (global warming), water and fertilizer use efficiency (loss of water rights, phosphates in lakes, nitrates in groundwater, energy costs for pumping water and making fertilizer) have increased, as well as a general need to increase the adapted range of potato to production areas where it would increase food security and benefit the world economy. All these point to an increasing need for the "new blood" available in NRSP6 exotic germplasm.

7) Technology has increased the possibilities for germplasm use making it more valuable. The prospects of easily identifying and mining genes from exotic germplasm (reducing the long and expensive process of conventional breeding) makes the service of NRSP6 even more valuable to stakeholders.

C. IMPLEMENTATION

1. Outcomes/Impacts-- What was accomplished

Full documentation of the project accomplishments is provided on the project website link "Administrative Reports" : http://www.ars-grin.gov/nr6/admin.html. A summary text form is provided below, with formatted quantification in the cited Appendix. Note also that the titles of staff publications in Appendix B indicate how NRSP6 staff discovered attributes of the germplasm that make it more useful to germplasm cooperators.

Acquire germplasm to expand genetic diversity contained in the US *Solanum* germplasm collection**.** Over 175 new stocks were added by USA collecting, requests from cooperators, and requests from genebank staff (see Appendix A1).

Classify accessions with species names which will serve as stable identifiers, and promote efficient utilization. Species names were assigned to all new accessions. Taxonomic studies using both molecular and classical techniques were employed to determine stable species boundaries, condensing the over 200 species names of the past to less than 100. See Appendix A2 for species list and changes.

Preserve NRSP6 germplasm in secure, disease-free, and readily available form. The genebank now has nearly 6,000 stocks as seed populations and clones. These were preserved with maximum genetic integrity in viable, disease-free form available for distribution. This effort included maintenance of data, performing seed and in vitro increases, purity tests, disease tests, germination tests, chromosome counts, field grow-outs, better scheduling of pollination to catch parents at their peak (see Appendix A3).

Distribute germplasm, associated data and advice to all researchers and breeders in a timely, efficient, and impartial manner. Orders remained strong in the past project term, and were filled within one week of receipt. Details by state and region are presented in Appendix A4.

Evaluate the collection for as many important traits as possible. Unpublished screening data of experiments conducted by cooperators was summarized and uploaded to GRIN. Evaluation initiated by staff and done in-house or with cooperators covered a broad range of topics pursuant to more efficient mining of the value of NRSP6 germplasm. See Appendix A5 for scheme for systematic mining and study of germplasm traits.

2. Objectives -- Goals for the new project term

a. TECHNICAL

Objectives below represent the ongoing work of the genebank. When the new project anticipates pursuing particular goals and quantities, those are noted in [brackets].

Acquire germplasm.

Latin America. Most of Latin America is currently closed to US germplasm collecting. [We will continue work to better understand the status and vulnerability of the *in situ* germplasm resource, particularly related to climate change. We will also pursue new opportunities for research-oriented collecting in Peru and Mexico, and expand frost and wart resistance breeding with germplasm donor countries. We will pursue extension of clean tuber seed production systems in Latin American countries that need it to systematically evaluate NRSP6 germplasm.].

Collecting in the USA. Annual collection trips will be made to acquire new germplasm and to gather materials for research investigations on collecting methods and the relationship of *in situ* to *ex situ* genetic diversity. [We will study predicted impact of climate change models. We will test new collecting technologies for pollen, meristems in antibiotic medium, and anti-insect treatments, and more vigorously pursue opportunities for cooperation with local botanists.]

Germplasm donations. We will continue to survey researchers for their needs, and assess gaps in the collection, then initiate the corresponding imports from foreign genebanks; public and private germplasm developers. NRSP6 staff will continue to evaluate and develop mutants and other selections that will be formally deposited in the genebank.

Classify germplasm. The ARS taxonomist will continue to assign species names to all items in the genebank and do the research and evaluation work necessary to make the classification system stable and useful.

Preserve germplasm.

Propagate. Increase seedlots at the rate of greater than 200 per year for a 25-30 year cycle. Conduct in vitro transfers needed to maintain clonal collection viability.

Safeguard. Maintain on-site and remote backup collections at the National Center for Genetic Resources Preservation (NCGRP) at Ft. Collins, CO.

Maintain health. Continue vigorous, comprehensive testing to minimize the possibility of distribution of diseased stocks. [We will set up better local quarantined greenhouse and sanitation methods to contain any suspected infections. We will investigate and develop a program for virus-freeing any infected genebank or research stocks.].

Genetic diversity management. DNA-marker-based studies will show us where genetic diversity is concentrated and vulnerable to loss, so we can prioritize stocks for preservation and optimize techniques as needed. [We will continue to test methods of selecting core collections for more efficient germplasm sampling. We will continue DNA-marker-based studies aimed at understanding relative genetic heterogeneity of germplasm subgroups and how this impacts sampling when collecting, preserving and evaluating the germplasm. We will continue studies on efficiency of rapid visual categorization (cogs) for partitioning diversity within taxa.].

Technical research. Studies will be done to improve the efficiency of growing, mating, and storing the stocks, providing results that help the genebank and our clients. [We will investigate more porous potting medium for over-watering protection, techniques for promoting flowering, systems for training plant canopy for better growth, fine tune fertilization and germination methods. We will test fertilization effect on long-term germination. We will use our tissue culture facilities and expertise to start working on use of microbes for bioassays and as selection agents. We will systematically test bridge-crossing techniques to bring *S. jamesii* and similar primitive diploids into the breeding pool. We will continue breeding toward an ideal universal diploid cultivated *tuberosum* parent for introgressing diploid exotic wild germplasm.]

Records. Maintain local data records and those on-line in GRIN and Intergenebank databases [We will transition to the new GRIN. We will make photographs and tissue samples of the field tubers of the cultivar collection and post them online. We will digitize PTIS herbarium records and link them to GRIN provenance records. We will keep the PCGC Vulnerability Statement document updated and revise the NRSP6 Procedures Manual.].

Evaluate germplasm. Continue conducting preliminary screening and characterization for novel traits and novel applications of exotic germplasm. [We will do additional cooperative evaluation and development work on traits discovered/developed in the past project term: tuber pH, antioxidants, tomatine, anti-appetite and anti-cancer chemicals, folate, tuber calcium, frost tolerance, Zebra Chip resistance, tuber greening after illumination and associated glycoalkaloids, gibberellin and floral mutants. We will use our tissue culture facilities and expertise to start working on interaction of microbes and potato, particularly variation for potato as a prebiotic. We will genetically characterize the new floral mutant *Coronita*. We will test all raw and advanced germplasm for value in breeding orange-fleshed Colombian *Criolla*-style specialty potato, test these for nutrients and anti-nutrients, and pursue inbred *Criolla* lines. We are preparing tuber flesh samples from large subsets of the collection (like all the named cultivars) in preparation for contracted systematic evaluation panels of tuber quality and nutritional components. We will continue remote greenhouse and field growouts in Florida, Arizona, California, and Wisconsin that expand our capacity to produce tubers for destructive tests, or provide a shortcut to selecting best tuberizing seedlings of exotic hybrids from segregating families.]

Deliver germplasm and services. Continue the rapid delivery of high quality germplasm and information. Continue to advise on selection of research germplasm, and the most appropriate form and techniques by which to study or hybridize it. To do so, continue to invest time in keeping "in touch" with the science by studying the literature, training students, participating in professional societies and collaborating with many state and federal potato researchers in the US and with our counterparts in potato genebanks abroad. [We will expand the website offering of germplasm handling tips to include short video clips].

b. MANAGEMENT & BUDGET

Human resources. Project direction will be accomplished through a Technical Advisory Committee and USDA/ARS National Plant Germplasm System leadership. Local administration is by the ARS Project Leader, ARS and UW staff and associated ARS scientists and administration at Madison. We will: Manage staff time and budget to maximize efficiency and flexibility. Strive to make prudent decisions on what we should do in-house and what should be contracted or purchased. Direct experienced base staff to tasks requiring technical expertise and reserve routine work for part-time staff. Hold regular group meetings to make sure the team is working together cooperatively and safely. Conduct annual self-review of overall project progress each year with local staff, and individual staff performance evaluations. Hold TAC meeting on-site every other year to report, tour facilities, provide "face time" with all local staff, and solicit management input from national experts. Each year prepare the Annual Report, UW Hort Department Professional Activity Report, and ARS Performance Plan Appraisal, as ways to invite feedback on methods, focus and management.

ARS contributions. Associated base research budgets from ARS scientists and various sources of outside grant funds also support technical research, labor, supplies and equipment that directly enhance NRSP6 service. See Appendix E and F for details of structure and contributions. ARS administration costs at the Midwest Area and National Levels are also significant. USDA/ARS and USDA/APHIS also provide data management services through GRIN, and for quarantine, respectively.

University of Wisconsin contributions. The University of Wisconsin Department of Horticulture (HORT) will provide lab and office space for on-campus R&D that supports the NRSP6 service, with administrative and secretarial support for Madison personnel provided jointly by ARS and HORT. The University of Wisconsin Peninsula Agricultural Research Station at Sturgeon Bay (PARS) will continue to be the headquarters of NRSP6. PARS will contribute much of the needed facilities and associated resources: 10 greenhouses, 5 large screen houses, office and storage buildings, two labs, field plots, travel and farm vehicles, security and maintenance, utilities (including the major input of heat and light for greenhouses), plus some secretarial service. We will also use greenhouse and field resources at remote locations with cooperators at the UW-Hancock field station. HORT also provides administration of personnel for local state employees and graduate students associated with the genebank. UW provides accounting services for the NRSP6 budget.

Grants and Collaborators. ARS scientists will continue to seek grants and engage numerous state, federal, international, and industry collaborators who contribute expertise, facilities, equipment and funds to joint projects of mutual interest. Project Leader will continue as chairman of the Crop Germplasm Committee, which provides ~$10K in germplasm evaluation funds each year, expressly intended for evaluation of NRSP6 genebank stocks.

No fees for service. Charging fees for services has been suggested several times in the past, but always determined to be impractical and counterproductive because implementation would be costly and complicated, it would depress germplasm distribution and use, and, it would contradict USDA policy of free exchange and perhaps inhibit donations of germplasm to NRSP6.

MRF contributions. NRSP6 is the NPGS working genebank for the top vegetable, so is perpetual in nature and national in scope.   Over 25% of germplasm distributions go to ESCOP scientists. For over 65 years, the important elements of funding and administration for NRSP6 have developed as a partnership of SAES, USDA/ARS, and UW. Continued significant funding and technical/administrative inputs on a multistate basis are seen as necessary to keep this partnership healthy and maintain this project's impact and efficiency.

Industry contributions: Gifts from private companies prove the practical value of NRSP6, and keep us tuned to the needs of the industry. Such gifts totaled over $45K in each of the past two years. Robust support of this kind will continue to be sought.

c. BUSINESS PLAN

Plan: The FY16-20 budget proposal is to continue at a base $150K per year.   See budget tables and background in Appendix F for details.

d. INTEGRATION

There is a close working relationship among the genebank participants (ARS, PARS, UW). In brief: The Project leadership is composed of ARS employees who must interact with ARS administration and be subject to performance evaluation related to NRSP6 service appointments. ARS administration is part of the NRSP6 TAC. PARS provides the physical location of NRSP6, and coordination between the objectives of the two programs takes place on a daily basis. Local NRSP6 staff are both UW and ARS employees. Part time staff are UW. ARS staff share equipment and participate in cooperative research with their state HORT peers. Thus, the UW HORT potato research program is fully engaged in NRSP6 project activities pursuant to the enhancement of NRSP6 service. NRSP6 has led the effort to coordinate the activities of world genebanks through the Association of Potato Intergenebank Collaborators (APIC). NRSP6 is a fully-engaged member of the National Plant Germplasm System. Staff attend all meetings of the advisory committee for genebank directors (PGOC) and the committee for the national germplasm management database (GRIN). NRSP6 staff are fully engaged in state potato programs. We participate in scientific, grower meetings, and field days and conduct collaborative research with a view to better understanding the needs of the industry and getting input regarding how NRSP6 can meet them. NRSP6 maintains email contact with 437 active cooperator/germplasm users, a 17% increase over the past project term.

e. OUTREACH, COMMUNICATION and ASSESSMENT

Audience and visibility. The primary recipients of our service are breeders and the scientists doing research that supports breeding. We also serve researchers seeking to optimize germplasm management, and home gardeners and non-professional botanists. We have a general educational outreach through brochures, website, and popular press. NRSP6 staff routinely give tours, talks to public school classes and other groups. We give advice on germplasm use technology, or in personal correspondence associated with germplasm orders or cooperative research and evaluation projects.

NRSP6 staff:

Attract publicity in popular media and communicate to scientists through published scientific research papers involving NRSP6 germplasm.

Make collaborative partnerships with high-profile national and international potato experts and contribute to scientific meetings.

Serve in leadership roles in potato research associations and journals (Potato Association of America, *American Journal of Potato Research*, Crop Germplasm Committee).

Establish an email group and website with which to keep in regular contact with germplasm users and participate fully with GRIN.

Extend global outreach and awareness of NRSP6 through involvement in the Association of Potato Intergenebank Collaborators (APIC) and international cooperators on an *ad hoc* basis.

Train Summer Undergrad Student Interns on mini-research projects and general operations of a genebank. Some such work leads to formal publications.

Engage stakeholders. NRSP6 established an email group and offers stocks and services 3-4 times per year. We will continue to ask Potato Assn of America Breeding and Genetics section members for suggestions on how to improve service each year. Regional Tech reps annually poll germplasm recipients about satisfaction with service. As CGC chair, Project Leader must survey germplasm evaluation needs. We correspond meaningfully with recipients of *each order* to make sure their needs were completely met, ask for suggestions or other ways we could improve service.

Method to measure accomplishments and impacts. The most important documented evidence with which to measure impact is the advance of practical knowledge about germplasm reflected by formal research publications using NRSP6 stocks and the presence of exotic germplasm in pedigrees of new cultivar releases (that practical knowledge transformed into a better crop). NRSP6 publications and use of stock in new cultivars is documented in Appendix B.

Communication pieces. Locally generated brochures, web pages, posters at meetings.

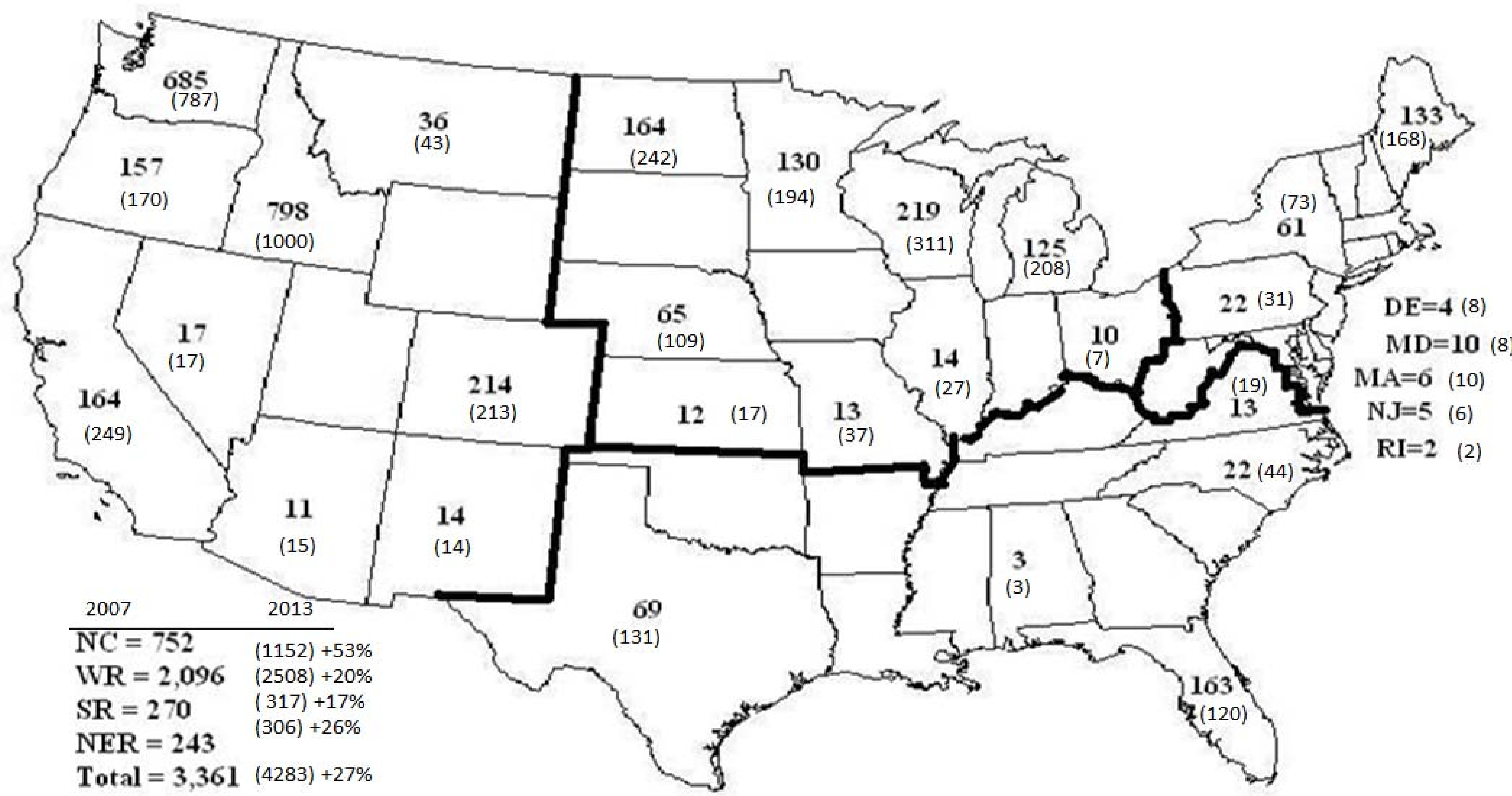
Mechanisms for reporting. Annual Report, notes of accomplishments and plans in preliminary pages of annual Budget Requests, and TAC meeting minutes are on the web. NRSP6 has always had the philosophy that the best and only way to catch the attention of germplasm users, communicate effectively with them, and understand their needs is to become their peers by being germplasm users ourselves and vigorously participating in all aspects of the science, including formal research that culminates in publication in peer-reviewed journals.

See Appendix B for further details.

APPENDIX -- Figure 1.

How does NRSP6 pertain as a national issue?

Potato production value in $M for states with data, 2007 and (2013)



APPENDIX A. Enabling Technologies and services accomplished in the past project term

A1. Acquire new germplasm (including five collecting trips to southwest USA organized and led by Project staff)

Foreign donated clones	62
USA wild species collections	114
	total 176

A2. Classify: Streamlining NRSP6 potato taxonomy

Abr.	Current recognized Species	Authority	Previous synonyms
abz	albornozii	S. albornozii Correll	
acg	acroglossum	S. acroglossum Juz.	
acl	acaule	S. acaule Bitter	acaule subsp. acaule, acaule subsp. palmirense, acaule subsp. punae
acs	acroscopicum	S. acroscopicum Ochoa	
adr	andreanum	S. andreanum Baker	paucijugum, solisii, tuquerrense
aem	x aemulans	S. x aemulans Bitter & Wittm.	acaule subsp. aemulans
agf	agrimonifolium	S. agrimonifolium Rydb.	
ajh	ajanhuiri	S. ajanhuiri Juz. & Bukasov	
alb	albicans	S. albicans (Ochoa) Ochoa	
ber	berthaultii	S. berthaultii Hawkes	tarijense
blb	bulbocastanum	S. bulbocastanum Dunal	bulbocastanum subsp. bulbocastanum, bulbocastanum subsp. dolichophyllum, bulbocastanum subsp. partitum
blg	blanco-galdosii	S. blanco-galdosii Ochoa	
blv	boliviense	S. boliviense Dunal	astleyi, megistacrolobum subsp. megistacrolobum, megistacrolobum subsp. toralapanum, sanctae-rosae
brc	brevicaule	S. brevicaule Bitter	alandiae, avilesii, gourlayi subsp. gourlayi, gourlayi subsp. pachytrichum, gourlayi subsp. vidaurrei, hondelmannii, hoopesii, incamayoense, leptophyes, oplocense, sparsipilum subsp. sparsipilum, spegazzinii, sucrense, ugentii
brk	burkartii	S. burkartii Ochoa	irosinum
bue	buesii	S. buesii Vargas	
chc	chacoense	S. chacoense Bitter	arnezii
chl	chilliasense	S. chilliasense Ochoa	
chm	chomatophilum	S. chomatophilum Bitter	pascoense

chq	chiquidenum	S. chiquidenum Ochoa	
cjm	cajamarquense	S. cajamarquense Ochoa	
clr	clarum	S. clarum Correll	
cmm	commersonii	S. commersonii Dunal	commersonii subsp. commersonii
cnd	candolleanum	S. candolleanum P. Berthault	abancayense, achacachense, ambosinum, aymaraesense, bukasovii, canasense, chillonanum, multidissectum, orophilum, pampasense, velardei
col	colombianum	S. colombianum Dunal	moscopanum, orocense, otites, subpanduratum, sucubunense, tundalomense
cop	coelestipetalum	S. coelestipetalum Vargas	
cph	cardiophyllum	S. cardiophyllum Lindl.	cardiophyllum subsp. cardiophyllum
crc	circaeifolium	S. circaeifolium Bitter	capsicibaccatum, circaeifolium subsp. circaeifolium, circaeifolium subsp. quimense, soestii
ctz	contumazaense	S. contumazaense Ochoa	
cur	curtilobum	S. curtilobum Juz. & Bukasov	
dcm	dolichocremastrum	S. dolichocremastrum Bitter	
dds	doddsii	S. doddsii Correll	
dms	demissum	S. demissum Lindl.	
edn	x edinense	S. x edinense P. Berthault	edinense subsp. edinense, edinense subsp. salamanii
ehr	ehrenbergii	S. ehrenbergii (Bitter) Rydb.	cardiophyllum subsp. ehrenbergii
etb	etuberosum	S. etuberosum Lindl.	
flh	flahaultii	S. flahaultii Bitter	neovalenzuelae
frn	fernandezianum	S. fernandezianum Phil.	
gab	garcia-barrigae	S. garcia-barrigae Ochoa	
gnd	gandarillasii	S. gandarillasii C rdenas	
grr	guerreroense	S. guerreroense Correll	
hcb	huancabambense	S. huancabambense Ochoa	
hcr	hypacrarthrum	S. hypacrarthrum Bitter	
hjt	hjertingii	S. hjertingii Hawkes	matehualae
hnt	hintonii	S. hintonii Correll	
hou	hougasii	S. hougasii Correll	
ifd	infundibuliforme	S. infundibuliforme Phil.	
imt	immite	S. immite Dunal	
iop	iopetalum	S. iopetalum (Bitter) Hawkes	brachycarpum
jam	jamesii	S. jamesii Torr.	
juz	juzepczukii	S. juzepczukii Bukasov	
ktz	kurtzianum	S. kurtzianum Bitter & Wittm.	

lbb	lobbianum	S. lobbianum Bitter	
les	lesteri	S. lesteri Hawkes & Hjert.	
lgc	longiconicum	S. longiconicum Bitter	
lgl	lignicaule	S. lignicaule Vargas	
lmb	limbaniense	S. limbaniense Ochoa	
lxs	laxissimum	S. laxissimum Bitter	santolallae
mag	maglia	S. maglia Schltdl.	
mcd	microdontum	S. microdontum Bitter	
mch	michoacanum	S. michoacanum (Bitter) Rydb.	
mcq	mochiquense	S. mochiquense Ochoa	chancayense
med	medians	S. medians Bitter	medians subsp. autumnale, sandemanii, weberbaueri
min	minutifoliolum	S. minutifoliolum Correll	
mlm	malmeanum	S. malmeanum Bitter	commersonii subsp. malmeanum
mrl	morelliforme	S. morelliforme Bitter & G. Muench	
mrn	marinasense	S. marinasense Vargas	
mtp	multiinterruptum	S. multiinterruptum Bitter	
ncd	neocardenasii	S. neocardenasii Hawkes & Hjert.	
nrs	neorossii	S. neorossii Hawkes & Hjert.	
oka	okadae	S. okadae Hawkes & Hjert.	
oxc	oxycarpum	S. oxycarpum Schiede	
pcs	paucissectum	S. paucissectum Ochoa	
pld	polyadenium	S. polyadenium Greenm.	
pls	palustre	S. palustre Schltdl.	brevidens
pnt	pinnatisectum	S. pinnatisectum Dunal	
pur	piurae	S. piurae Bitter	
rap	raphanifolium	S. raphanifolium C rdenas & Hawkes	
rch	rechei	S. x rechei Hawkes & Hjert.	
scb	scabrifolium	S. scabrifolium Ochoa	
sgr	sogarandinum	S. sogarandinum Ochoa	
smb	sambucinum	S. sambucinum Rydb.	
snk	schenckii	S. schenckii Bitter	
sph	stenophyllidium	S. stenophyllidium Bitter	brachistotrichum, nayaritense

sto	stoloniferum	S. stoloniferum Schltdl. & Bouchet	fendleri subsp. arizonicum, fendleri subsp. fendleri, leptosepalum, papita, polytrichon, stoloniferum subsp. stoloniferum
tbr	tuberosum	S. tuberosum L.	
tbr adg	tuberosum subsp. andigenum	S. tuberosum subsp. andigena Hawkes	paramoense, phureja subsp. phureja, stenotomum subsp. goniocalyx, stenotomum subsp. stenotomum
tbr tbr	tuberosum subsp. tuberosum	S. tuberosum L. subsp. tuberosum	
trf	trifidum	S. trifidum Correll	
trn	tarnii	S. tarnii Hawkes & Hjert.	
undet	undetermined	undetermined	
ver	verrucosum	S. verrucosum Schltdl.	macropilosum
vio	violaceimarmoratum	S. violaceimarmoratum Bitter	
vnt	venturii	S. venturii Hawkes & Hjert.	
vrn	vernei	S. vernei Bitter & Wittm.	vernei subsp. ballsii, vernei subsp. vernei

A3. Preserve seed populations and *in vitro* clones

Botanical seed populations		
90 wild species		3,942
3 cultivated species		1,060
	total	5,002
In vitro clones		
Named commercial cultivars		284
Primitive Andean cultivars		64
Genetic Stocks		280
Breeding Stocks		181
	total	809
	Grand total	5,811

Seed Increases (grow families of 20 parents in greenhouse, hand intermate 6-8 times, harvest berries, process and store seeds) = 1,030

Tissue culture maintenance transfers (take a nodal cutting from stock tube, transfer it to a tube with new media to revitalize) = 37,080

Supporting quality tests: ID growouts (field plants to confirm offspring are true to parental type) = 964, Virus and viroid tests = 3,963, Germination = 7,003, Viability (Tetrazolium) = 199, Ploidy = 245, Field plots characterization = 9,659.

A4. Distribute: Number of units and orders by state and region[1]

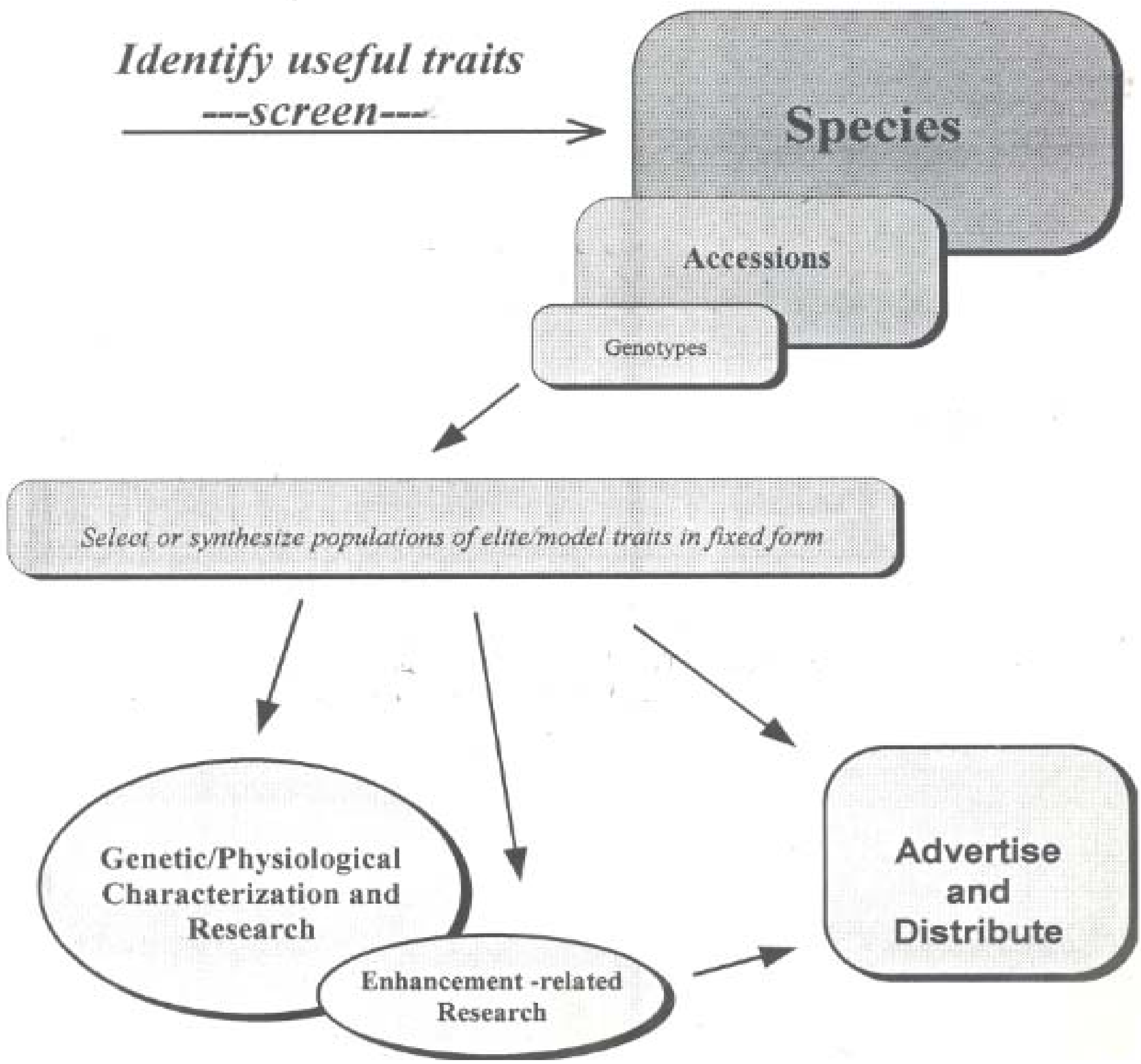
State	Region	Units	Orders	Regional Summary
Illinois	NC	40	9	
Indiana	NC	63	10	
Iowa	NC	7049	72	
Kansas	NC	14	3	
Michigan	NC	767	34	20,983 units = 65%
Minnesota	NC	894	18	474 orders = 47.4%
Missouri	NC	235	23	
North Dakota	NC	32	5	
Ohio	NC	31	15	
Wisconsin	NC	11858	285	
Connecticut	NE	27	3	
Delaware	NE	3	1	
District of Columbia	NE	30	2	
Maine	NE	199	13	

Maryland	NE	450	17	2300 units = 7% 113 orders = 11.3%
Massachusetts	NE	287	5	
New Hampshire	NE	36	5	
New Jersey	NE	12	4	
New York	NE	1015	29	
Pennsylvania	NE	226	30	
Rhode Island	NE	3	1	
Vermont	NE	12	3	
Alabama	S	58	7	1220 units = 4% 144 orders = 14.4%
Arkansas	S	104	9	
Florida	S	187	25	
Georgia	S	45	10	
Kentucky	S	93	11	
Louisiana	S	48	7	
Mississippi	S	21	3	
North Carolina	S	320	16	
Oklahoma	S	1	1	
Puerto Rico	S	37	8	
South Carolina	S	6	4	
Tennessee	S	101	13	
Texas	S	124	19	
Virginia	S	69	9	
West Virginia	S	6	2	
Alaska	W	3	1	7587 units = 24% 269 orders = 26.9%
Arizona	W	60	7	
California	W	1890	81	
Colorado	W	303	22	
Hawaii	W	233	6	
Idaho	W	552	38	
Montana	W	352	8	
Nevada	W	1	1	
New Mexico	W	292	3	
Oregon	W	1505	33	
Utah	W	11	4	
Washington	W	2385	65	
US Total		32,090	1000	

[1]Plus 29 foreign countries receiving a total of 5,128 units in 106 orders.

A5. Evaluate: General approach to mining the NRSP6 germplasm

Program for Progressive Fine Screening and Utilization of *Solanum* species germplasm at NRSP-6.



APPENDIX B. Outreach accomplished in past project term

Kept NRSP6 genebank website, GRIN database, Intergenebank Database up to date
Annual Technical Committee meetings organized = 5
Led *American Journal of Potato Research* as Editor in Chief
Led Potato Crop Germplasm Committee as Chairman including organizing grants
Foreign visitors hosted = 53, Domestic visitors hosted = many
Undergrad Summer Student Interns trained = 5

Information dissemination = 50 scholarly publications below from NRSP6 staff. An additional 624 publications by other users of NRSP6 stocks were cited in the annual reports of the past project term.

Bamberg del Rio, Martin, Suriano and coauthors: Five journal articles now available online will be documented in this report when in print: AFLP core set of microdontum, Zebra chip resistance screening in bulbocastanum, New Matryoshka floral mutant, Selection for tuber quality in a Superior x Atlantic hybrid population, History and origin of Russet Burbank.
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Impact of breeding with NRSP6 stocks

A total of 16 cultivars and advanced lines were published in *American Journal of Potato Research* in the past 5 years:

Yukon Gem, Classic Russet, Clearwater Russet, Alta Crown, Cooperation-88, Alpine Russet, Sentinel, Huckleberry Gold, Teton Russet, Elkton, M7 Germplasm Release, AmaRosa, Purple Pelisse, Owyhee Russet, Palisade Russet, Saikai 35.

All of these have NRSP6 exotic germplasm in their pedigrees, including species *S. andigena*, *acaule, chacoense, demissum, infundibuliforme, phureja,* and *vernei*.

APPENDIX C. Sample (2013) Annual Report (without title page or publications)

Other Annual Report found at http://www.ars-grin.gov/nr6/admin.html

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

A. Acquisitions and associated work

In 2013, we collected 16 germplasm accessions from the southwest USA under the BdRFK (Bambergs, del Rio, Fernandez, Kinder) prefix. Another major accomplishment was to collect DNA samples from *S. jamesii* Mega-populations at the top and bottom of the range, especially the huge population at Mesa Verde. We are using DNA markers to find out if such populations are such incubators for diversity that they are the only place one needs to collect. We also tested new ideas for collecting when propagules are poor: 1) collecting in *vitro* in PPM medium needs no sterile hood and rescues clones that will not root in soil, 2) AFLP data has shown that collecting pollen captures unique alleles, 3) simple insecticide application to collected fruit prevents fruit fly grubs from destroying seeds. We made the first reported discovery and collection of potato from the Dragoon mountains. We confirmed that *jamesii* still exists at the historic Faraway Ranch site, despite being unable to find it there since 1995. USDA/ARS/Plant Exploration Office supplied $5K and has again in 2014. Detailed trip report for 2013 and plan for 2014 are available on request.

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Mesa Verde *jamesii* mega-population-- millions of plants over 100+ acres

The genebank imported 7 elite breeding stocks from other countries and accepted 7 elite "M" clones from the Shelley Jansky program.

The NRSP-6 web page (http://www.ars-grin.gov/nr6) was updated to include all new stocks and screening information. Clients who have ordered from NRSP-6 within the past four years were contacted three times in 2013, informing them of new stocks of true seed, tubers, in vitro plantlets, or other samples. We used email and the website to extend technical instructions of various types. For example, a technique for breaking tuber dormancy was fine tuned to give reliable and uniform results, even for very deep dormancy tubers.

Better dormancy breaking

B. <u>Preservation and Evaluation</u>

A total of 170 accessions were increased as botanical seed populations and 1900 clonally. Over 720 potato virus tests were performed on seed increase parents, seedlots and research materials. Germination tests were performed on 1489 accessions, ploidy determinations were made on 60 accessions, and tetrazolium seed viability tests were done on 50 seedlots. Taxonomic status was assessed on all stocks grown. A total of 7122 units of germplasm were distributed in 249 orders. Orders were filled within one week of receipt. Nearly 200 field plots were planted to verify that seed multiplication efforts last year resulted in offspring seedlots that matched their parents. We used SNPs (cooperator Douches from MI) to assess partitioning of genetic diversity in model potato species with a view to understanding their best management.

With help of cooperators, we made progress evaluating and improving germplasm on several ongoing projects. Over 1800 field plots at USPG, about 1500 seedlings tuberized in two sites in CA (cooperators Serimian and Pearson), and 4 large screenhouses at USPG full of stocks supporting screening for improved *Criolla* or "egg yolk" style specialty potato with golden flesh (cooperator Douglass from FL), folate (cooperator Goyer from OR), glycoalkaloids (cooperator Navarre from WA), anti-obesity (cooperator Kemin from IA), greening, K-screening, new *Coronita* fr ce of anthers), Zebra Chip resistance in *bulbocastanum* (cooperator Cooper in WA).


Improved *Criolla* selections


Coronita male sterile

We detected a significant association of tuber pH (very fast, cheap and easy to screen) with glycoalkaloids and folate (much harder to screen) and organized an experiment to test this more systematically.


Zebra Chip resistance in

Zebra Chip resistance in

This year, work with J. Palta (UW), International Potato Center (CIP), and colleagues in the Peruvian national potato program (INIA) progress was made in the frost hardiness breeding project with *S. commersonii*. An elite selection was informally named *"Cola de gato"*. We also initiated a program to re-breed the non-bitter, frost hardy *S. ajanhuiri*, a primitive cultivated species with reputed progenitor *S. megistacrolobum* native to the Puno Altiplano.

Bamberg, Palta, del Rio, Gomez and locals at Potato Park near

Frost hardy *cola de*

Dr. Jansky's Enhancement:

The germplasm release of clone M6 was published in the Journal of Plant Registrations. M6 is an inbred line derived from seven generations of self-pollination. It is homozygous for the Sli gene that confers self-compatibility, and it is male and female fertile.

Jansky, S.H., Y.S. Chung, and P. Kittipadukal. 2014. M6: A diploid inbred line for use in breeding and genetics research. Journal of Plant 10.3198/jpr2013.05.0024crg.

Yong Suk Chung completed his Ph.D. thesis entitled "Bacterial soft rot resistance and calcium enhancement in wild and cultivated potato." A polymorphism in the *CAX3-like* candidate gene for calcium uptake by roots was found to be associated with tuber calcium levels. An additional 12 SSR markers also co-segregated with calcium in tubers. SSR4743 is located near the *CAX3* homolog on chromosome 7.
Predictivity of taxonomy and biogeography for late blight resistance was completed (Alexander Khiutti, visiting scientist, St. Petersburg, Russia).A collection of 143 accessions representing 34 wild *Solanum* species was screened for foliar late blight resistance using whole plants and for tuber late blight resistance using greenhouse-generated tubers. A manuscript is in preparation.

Recombinant inbred lines are being developed in populations derived from wild species carrying resistance to early blight (*S. raphanifolium*) and common scab (*S. chacoense*). In addition, an F2 population derived from self-pollinating a clone from a cross between DM1-3 and M6 is segregating for a number of agronomic and disease resistance traits. It is being genotyped using the SolCAP SNP array and will be used for trait mapping. RILs are also being developed in this population.

A population derived by crossing US-W4 with M6 has been grown in replicated field trials for three years. Yield comparable to that of cultivars is common among clones in this population. Phenotyping (tuber yield, size set; chip color) and genotyping are underway.

C. Classification

Dr. Spooner is working on monographs that will fully document the taxonomic reduction of the genebank's species to about 100 species.

D. Distribution service

Distribution of germplasm is at the heart of our service. The volume and types of stocks sent to various consignee categories are summarized in the table below. **We filled almost 1/3 more orders in 2013 than 2012**: 230 domestic orders to clients in 39 states of the USA and 19 foreign orders to 10 other countries. About ½ of domestic orders are for breeding and genetics, about ¼ for home gardeners, and the remaining ¼ for pathology, physiology, entomology, taxonomy, and education. In 2013 we maintained the popular offering of 100 cultivars as tubers by devising and implementing an iron-clad disease control and quarantine program for their production (full details available at our website).

	Units of Germplasm Sent[1]								
Category	Seed	TU	TC	IV	DNA	Plants	Herb	Total	PIs
Domestic	2,762	71	2,484	1,181	50	2	0	6,550	4,688
Foreign	480	0	12	80	0	0	0	572	501
Total	3,242	71	2,496	1,261	50	2	0	7,122	5,189

[1] Types of stocks sent/(number of seeds, tubers or plantlets per standard shipping unit): Seed= True Seeds/(50), TU = Tuber families/(12), TC = Tuber Clones/(3), IV = *in vitro* stocks/(3), DNA = dried leaf samples/(1), Plants = rooted cuttings /(1), Herb= herbarium specimens/(1).

E. Outreach

Undergrad intern
Jana Suriano, presenter

Media coverage, Tours, Teaching, TechTran and Trips with presentations done

Bamberg served as PhD committee member for Cinthya Zorrilla-C, and Yong Soek Jung.

Summer student interns participated in experiments: Ahna Keilar (seed germ and seedling transplant tech), Abe Keilar (crossing tech for jam and blb), Hannah Haight (prebiotic assay and nutrient microbial bioassays), Jana Suriano (*Matryoshka* floral mutant and tuber greening with publication authorship, attended and made formal presentation at PAA, participated in Arizona collecting).

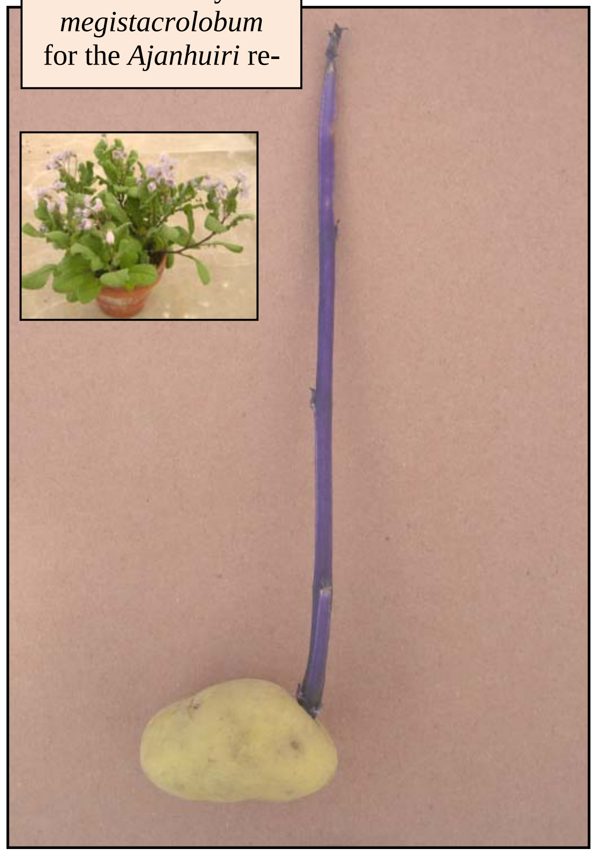
NCR potato genetics group in Chicago presentations; Potato Association of America meeting in Quebec-- four research presentations/abstracts.

Chinese, Russian, and Japanese potato scientists, UW River Falls Horticulture students, and Southern Door HS Spanish class tour genebank.

Leadership: Bamberg continued as Editor in Chief for the American Journal of Potato Research, and Chair of the USDA/ARS Potato Crop Germplasm Committee.

Reports & Plans: ARS: PGOC, CGC, CRIS, An dget. NRSP6: Annual Report, TAC meeting minutes. PAA: AJPR Editor in Chief report, Outstanding Paper. UW-Hort: Annual Performance. PARS: Tour guide & field book.

Frost hardy *megistacrolobum* for the *Ajanhuiri* re-



Management of Grants & Awards: Potato CGC grants, AJPR Outstanding Paper

IMPACT STATEMENT

In 2013, seed increase success was steady, and number of germplasm orders increased substantially, supporting the needs of the nation and world for resources to genetically improve the potato crop.

The payoff in funding the genebank is in discovering and deploying traits that are useful to the public and the industry. We participated in successful selection of better stocks for golden flesh, frost resistance in Peruvian highlands, folate, potassium, resistance to tuber greening, glycoalkaloids, and a natural appetite suppressing protein.

We continued work on improving germplasm management. We again collected germplasm in-country, finding and making available populations at sites never before reported or collected, and developing novel technology to improve the genebank's representation of diversity in the wild.

Salary and travel support plus cash gifts from industry totaled $45K in 2013.

The ability to efficiently evaluate traits is rapidly improving. We are on the brink of a leap forward in breeding through molecular markers and genetic technology. Potato is an increasingly important world food. Climate is changing, and health issues and their economic impact are increasing in our aging population. Because of these factors, there has never been a more important (or exciting) time to be involved in improving potato through mining the rich deposits of traits in the US Potato Genebank.

WORK PLANS / STAFF & FUNDING / ADMINISTRATION

In FY15, we plan to continue the service program to acquire, preserve, classify, and promptly distribute high quality germplasm and data to all requesters. We will endeavor to say "yes" to requests for custom service and advice whenever we are able.

We plan to restore the ½ position of A. del Rio that was cut due to funding shortfalls in recent years, thus rebuilding our program in the area of genetic diversity management research (making use of the new, more powerful DNA markers now available), collecting research (predicting sites likely threatened by climate

change), and benefit sharing collaborations with Andean germplasm donor countries (in particular, the successful frost resistance breeding effort in Puno described above).

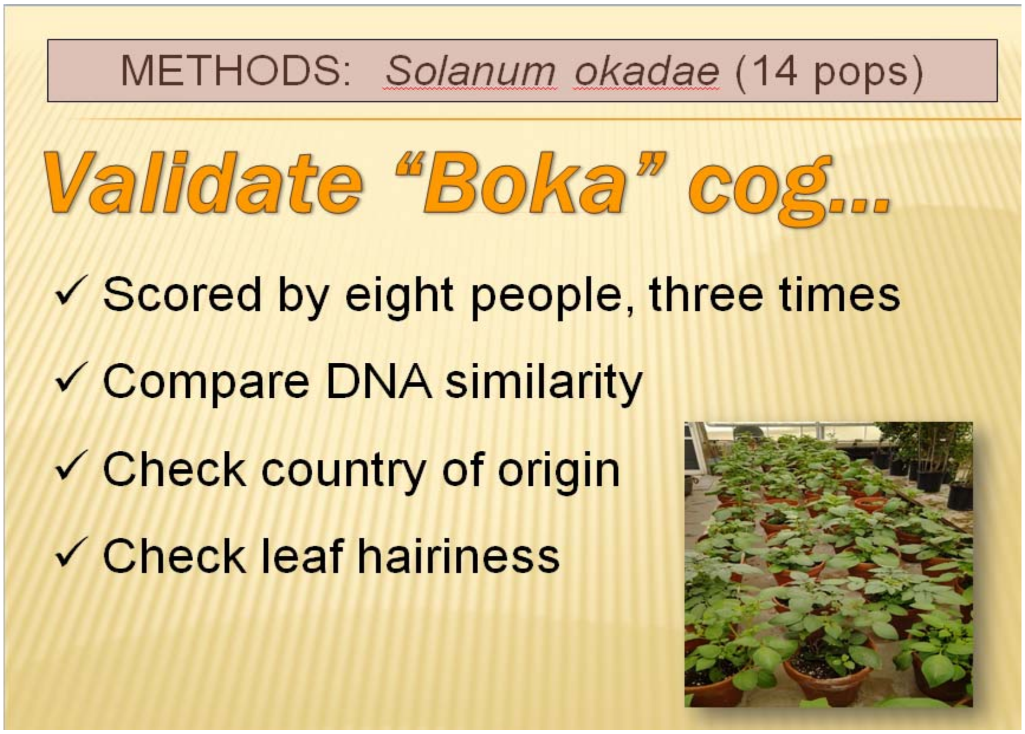
We expect to continue participation in "teaching" activities by hiring summer student interns who learn about potato science and help us explore promising new research and technology ideas (this has resulted in students participating in germplasm collecting, formal presentations at PAA, and authorship on peer reviewed publications). Rapport with potato science and scientists will be maintained by service as editor of American Journal of Potato Research, and participation in the Potato Association of America.

We expect to continue the service to industry partners that has been attracting their strong support, and similarly maintain strong ties with our sister genebanks around the world.

We intend to seek opportunities to evaluate and deploy germplasm in ways that impact the consumer, notably with respect to nutritional traits, thus enhancing the reputation, demand, and positive health and economic impact of the potato crop on society.

We expect to continue and expand approaches to evaluation and technology that multiply information gathering:

1) Multiple data collection schemes for a single grow-out
2) Synergistic cooperation with specialists in various disciplines
3) Testing for links between easily assessed traits and more difficult traits
4) Making use of our *in vitro* facilities and expertise to investigate microbial bioassays and selecting agents.
5) Characterizing visual (cog), genetic, geographic, and trait differences within species as predictors of germplasm application



S. okadae visual "cog" exercise demonstrates method for initial detection of difference within species (slide of presentation at PAA2013)

APPENDIX D. Executive 3-year summary for NRSP6 Midterm Review, CY2010-2012

A. Acquisition. A total of 74 new germplasm stocks were collected in the wild and 33 more imported from cooperators.

B. Preservation schedule was maintained and **Evaluation** was successful for many useful traits: Seed populations multiplied = 660, germination tests = 4014, virus tests = 2110. Over 3000 field plots were grown for evaluation and taxonomy. We worked with numerous cooperators, providing germplasm handling technology, custom samples and hybrids resulting in identification of elite new materials for antioxidants, anti-appetite proteins, orange flesh, folate, thiamine, starch balance, low acrylamide, anti-cancer, resistance to greening, frost tolerance and calcium use efficiency. We discovered a new floral mutant. We demonstrated that hotspots of genetic diversity can be identified in the wild for collecting, and that an AFLP-based core collection of model species will capture all of the known useful traits. We showed that pesticide overspray of wild populations near farmers' fields in Peru may reduce fecundity, but probably not genetic diversity of the wild populations.

C. Classification reduced the number of species to about 100, for a more stable and predictive taxonomy.

D. Distribution totals were strong showing continued interest and value in our germplasm:

Category	Seed	TU	TC	IV	DNA	Plants	Herb	Total	Populations
Domestic	6,709	13	7,681	4,435	123	586	11	19,558	13,236
Foreign	2,537	0	0	1,578	3	0	0	4,118	2,460
Total	9,246	13	7,681	6,013	126	586	11	23,676	15,696

[1] Types of stocks sent/(number of seeds, tubers or plantlets per standard shipping unit): Seed= True Seeds/(50), TU = Tuber families/(12), TC = Tuber Clones/(3), IV = *in vitro* stocks/(3), DNA = dried leaf samples/(1), Plants = rooted cuttings /(1), Herb= herbarium specimens/(1).

E. Outreach. A robust website including access to all NRSP6 stock data, ordering information, technology tips, mapping features, publications, and complete reference to administrative reports was maintained. We hosted numerous visiting scientists, were featured in two documentary films and a syndicated article by the Milwaukee Journal Sentinel, gave invited keynote lectures at the US Botanic Gardens (DC), and Latin American Potato Association (Cuzco); served as Editor in Chief for American Journal of Potato Research and chairman of the Potato Crop Germplasm Committee. We returned benefits to Peru by cooperatively selecting and testing productive frost hardy and calcium responsive lines in the highlands. We trained two summer interns attending UW-Madison and Princeton.

F. Impact. Ten cultivar releases were published, each having at least one of nine different exotic potato species in their pedigrees. No other crop matches potato in use of exotics in practical breeding. Staff published 55 scholarly research papers, and nearly 400 more were cited by others using NRSP6 species.

Work Plans / Staff & Funding / administration / Integration

Acquire wild germplasm in southwest USA and valuable germplasm from other genebanks and/or scientists
Preserve/multiply 200 populations per year, with associated maintenance of purity, germination, and health
Classify in a way that maximizes the groupings of germplasm by genetic value
Distribute germplasm and info rapidly to clients in a way that maximizes their research and breeding success
Evaluate traits already under study and engage new traits, especially nutritional ones (like anti-diabetes)
Publish results of evaluation and technical research (see above)
Lead Crop Germplasm Committee and American Journal of Potato Research
Maintain integration with UW-Madison as full professor in Dept of Horticulture
Maintain >$45K level of 2012 industry support and $150K maintenance level of Multistate Research Funds

APPENDIX E. Administration, NRSP6 staffing, Participation

COOPERATIVE AGENCIES AND PRINCIPAL LEADERS*

State Agricultural Experimental Stations		Representative
Technical Representatives		
Southern Region		C. Yencho
Western Region	Chair (2015)	D. Holm
North Central Region		D. Douches
Northeastern Region	Secretary (2015)	W. De Jong
Administrative Advisors		
Southern Region		C. Nessler
Western Region		L. Curtis
North Central Region	Lead AA	R. Lindroth
Northeastern Region		E. Ashworth
United States Department of Agriculture		
ARS		
Technical Representative	Vice Chair (2015)	C. Brown
National Program Staff		P. Bretting G. Wisler
Midwest Area		R. Matteri & P. Simon
NIFA		A. M. Thro
APHIS		J. Abad
NRSP-6 Project Leader		J. Bamberg
Agriculture & Agrifood Canada		B. Bizimungu

*Full contact information at: http://www.ars-grin.gov/nr6/techlst.html

Participation

Administrative and technical participation in NRSP6 is configured as per the first section of this appendix. Those individuals represent all of their respective SAES directors and germplasm users, as well as USDA/APHIS, -ARS, -NIFA, and Canada. Although not official participants, private industry is always represented at annual meetings and communications to the TAC. In addition, the RESOURCES and INTEGRATION sections of this document detail how local USDA/ARS and University of Wisconsin staff play a special participatory role in enhancing NRSP6 service. Concerning international support, NRSP6 partners with foreign scientists and foreign genebanks in various contexts like collecting; technical exchanges, training & research; data management. Finally, the multitude of germplasm users (represented in the distributions and publications data presented in Appendix A) may be considered participants since they use raw NRSP6 germplasm to create new breeding stocks and publish results of studies, all which eventually cycle back through NRSP6 to enable and inform germplasm use by future germplasm users.

APPENDIX F. Budget Request with History and Status details

a. History and status -- staff.

It is difficult to objectively apportion contributions from various associated programs, so this section presents only resources under the direction of the Project Leader.

Staff	Historic FTE	FY16-20 plan FTE
Lead & other SY Scientists	0.40 F	1.30 F
Research support	0.40 F	0.50 M
Project Assistant	1.00 W&M	0.80 M
Seed tech	1.00 M	0.75 F
IT tech	1.00 M	1.00 F
Gardener	1.00 W&M	1.00 F
Grad Student	0.50 M	
Labor & other Tech	0.80 M	0.80 M
Subtotals	5.30 W&M	2.10 M
	0.80 F	4.05 F
Total	6.10	6.15

NOTES

1. Employer: F=Fed, M=MRF, W=UWisc
2. In several pre-FY90 years, two Techs, two Grad Students, and Equipment were funded by NRSP6.
3. Since FY90, research support for Lead Scientist has not been provided by ARS as appointed TY, but paid by NRSP6 Grad student funds, grants, and ARS discretionary. In FY04, switched this research support position's employer with federal IT Tech for no net gain. ARS increased staff support represented in 0.75 Seed Tech.
4. In FY09, 1.2 FTE (0.40 Proj Asst + 0.80 Gardener) UWisc salary support lost.

Note that USDA also devotes substantial resources through USDA/APHIS quarantine services for potato imports, and development and maintenance the GRIN national germplasm data computerization system. Both of these are critical to NRSP6 success.

c. BUDGET REQUESTS SUMMARY
FY16-20

NRSP6 - the US Potato Genebank:
Acquisition, classification, preservation, evaluation and distribution of potato (*Solanum*) germplasm

NRSP-6 US Potato Genebank Project FY16-20										
MRF (in $K)										
MRF inputs	Proposed FY16 (year 1)		Proposed FY17 (year 2)		Proposed FY18 (year 3)		Proposed FY19 (year 4)		Proposed FY20 (year 5)	
	Dollars	FTE	Dollars	FTE	Dollars	FTE	Dollars	FTE	Dollars	FTE
SALARIES & Sal Fringe	116.0	1.30	116.0	1.30	116.0	1.30	116.0	1.30	116.0	1.30
WAGES & WageFringe	27.0	0.80	27.0	0.80	27.0	0.80	27.0	0.80	27.0	0.80
TRAVEL	2.0		2.0		2.0		2.0		2.0	
SUPPLIES & Maintenance	5.0		5.0		5.0		5.0		5.0	
EQUIPMENT/ CAPITAL IMPROVEMENT										
TOTAL	**150.0**	**2.10**	**150.0**	**2.10**	**150.0**	**2.10**	**150.0**	**2.10**	**150.0**	**2.10**

NRSP-6 US Potato Genebank Project FY16-20										
USDA/ARS (in $K)										
ARS inputs	**Proposed FY16 (year 1)**		**Proposed FY17 (year 2)**		**Proposed FY18 (year 3)**		**Proposed FY19 (year 4)**		**Proposed FY20 (year 5)**	
	Dollars	**FTE**	**Dollars**	**FTE**	**Dollars**	**FTE**	**Dollars**	**FTE**	**Dollars**	**FTE**
ARS employee SALARIES & Sal Fringe	284.0	4.05	284.0	4.05	284.0	4.05	284.0	4.05	284.0	4.05
Other SALARIES & Sal Fringe	0.0		0.0		0.0		0.0		0.0	
WAGES & WageFringe	0.0		0.0		0.0		0.0		0.0	
TRAVEL	10.0		10.0		10.0		10.0		10.0	
SUPPLIES & Maintenance	28.0		28.0		28.0		28.0		28.0	
Extramural Evaluation Contracts	125.0		125.0		125.0		125.0		125.0	
EQUIPMENT/ CAPITAL IMPROVEMENT	10.0		10.0		10.0		10.0		10.0	
TOTAL	**457.0**	**4.05**	**457.0**	**4.05**	**457.0**	**4.05**	**457.0**	**4.05**	**457.0**	**4.05**

NOTES

Resources directed by Project Leader given here. Contributions by cooperating fed and state projects are extra.
Industry: $45K
UW to continue contributions of facilities, utilities & related services, at least $50K.
Direct input proportions: MRF = 21%, ARS = 65%, UW = 7%, Industry = 6%.