



# USDA's PLANT BREEDING ROADMAP

PRESENTED TO ESS/AES/ARD  
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United States Department of Agriculture  
Office of the Chief Scientist

## *Background:*

# USDA's Office of the Chief Scientist, OCS



**2008 'farm bill': USDA Chief Scientist,  
Under Sec'y for Research, Education, & Economics (REE)  
presently Dr. Catherine Woteki**

**OCS: Supports and advises Chief Scientist and Secretary;  
Fosters collaboration and coordination among USDA  
science agencies**



**OCS staff includes Director plus senior advisors in six areas:  
Plant Health, Production & Products // Animal Health, Production  
& Products // Natural Resources & Environment incl. Bioenergy //  
Food Safety & Nutrition // Agricultural Systems incl. Climate  
Change // Agricultural Economics & Rural Communities**



# Five USDA Agencies *Conduct or Support* Plant Breeding

## **Plant breeding, genetic resources, and related biological research:**

- Agricultural Research Service (ARS)
- Forest Service (FS)
- Natural Resource Conservation Service (NRCS)

## **Economic and policy analyses**

- Economic Research Service (ERS)

## **Capacity and competitive funds for Research, Education, and Extension** (i.e. *extramural* plant breeding)

- National Institute for Food and Agriculture (NIFA)





# What is Plant Breeding?

**“Human-aided development of plant cultivars  
with needed characteristics”**



The *organizing principle* of breeding is the genetic gain equation:

$$\Delta G = h^2 S$$

Gain in a desired trait ( $\Delta G$ , or “delta-G”) is a function of

- the *heritability* of that trait ( $h^2$ )
- the *intensity of selection* ( $S$ )

**Plant breeding “puts it all together”,  
using different resources, tools, and  
methods to maximize gain,  $\Delta G$ .**



# Role of USDA Plant Breeding

To provide plant breeding outcomes *that are needed to achieve USDA's Strategic Goals,*

*...When these have the nature of "public goods":*

E.g.,

- Breeding for long-term horizons -- too distant for private investment
- Important goals but probability of success is low or unknown
- Market size is small





# Increase in Stakeholder Attention to Plant Breeding

New groups; national meetings, including:

- Land-grant-univ. Plant Breeding Coordinating Committee 2007
- National Association of Plant Breeders (NAPB) (*publ+priv*) 2009
- American Seed Research Summit (*private-sector organized*) 2008
- USDA ARS stakeholder workshops 2011
- PCAST: Ag Preparedness & the Ag. Research Enterprise 2012
- Seeds & Breeds for 21<sup>st</sup> Century Agric. (*organic/sustainable*) 2014

Increasing number of stakeholders, incl. organic sector, engaging w/USDA officials to present plant breeding needs & priorities  
(since ~2010)



# USDA Response:

- Plant Breeding Working Group (PBWG) 2012
  - *Support to USDA Chief Scientist (REE UnderSecr.)*
    - *Interagency coordination; advise re issues & priorities*
- Public Plant Breeding Listening Session 2013
- USDA Plant Breeding Roadmap 2014/15

*Both documents posted at:*

[http://www.usda.gov/  
wps/portal/usda/usdahome?navid=OCS](http://www.usda.gov/wps/portal/usda/usdahome?navid=OCS)





# What We've Learned

What stakeholders—*both public and private*—  
see as USDA's core contributions to plant breeding:

- **The National Plant Germplasm System collections** (NPGS) incl.
  - Collection, curation, rejuvenation, characterization, and pre-breeding
  - Genetic Resources Information Network (GRIN):  
GRIN is an *Information management system* for genetic resources:  
Inventory, images, rejuvenation status, IPR status, requests/order status
  - GRIN-Global: USDA ARS with co-funding from Global Ag Diversity Trust  
Collaboration with Bioversity International  
For global needs: multiple languages  
Open-source software; scale-able databases (laptop version)







# What We've Learned, con't.

## Additional core contributions -- as seen by stakeholders:

### **USDA's breadth of geographic coverage, through partnerships** including:

- USDA sites (e.g. ARS, FS, and NRCS)
- Land-Grant Universities and State Agricultural Experiment Stations
  - ESS and ARD; co-funded through USDA
- Others, e.g.
- Long Term Agricultural Research sites (LTAR)  
(multi-partner)





# What We've Learned, cont'd.

Deliverables “by and for” public plant breeding  
cited by stakeholders as *needed from USDA*:

## **Intramural**

- **Cultivars** (varieties) for “public-goods situations”
- **New tools & methods**, publically available for any breeder to help maximize gain,  $\Delta G$ .
  - E.g. new tools / methods to :
    - Incorporate new genetic & biological understanding
    - Reduce breeding cycle time (from cross-to-variety release)

## **Extramural**

- Adequate and appropriate funding mechanisms,
  - for the long-term nature of plant breeding;
  - for education





# What We've Learned, cont'd.

## Heard from stakeholders: concerns about...

### *External funding thru' USDA*

- Low total funding + many proposals leads to low success rates in compet. programs (<10%, sometimes <5%)
- Short-duration (2-4 yrs); non-renewable

### *Education*

- Few funding opportunities for student stipends
- Even fewer for faculty to develop contemporary plant breeding curricula
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## Challenges for USDA's response

- Not enough competitive funding to respond to stakeholder concerns
- Plant breeding needs longer-term funding cycles

### *Solution?*

- Rely on intramural USDA plant breeding?  
**... leads to more questions:**
- Loss of university plant breeding?
- Loss of closeness to needs and opportunities of local farming?
- Whence opportunities for educating future breeders  
-- *within active breeding context?*



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*National Institute of Food & Agriculture, NIFA*  
is USDA's extramural funding agency.

NIFA funding programs that can include plant breeding :

### Capacity programs

<b>Hatch</b>	1862 state land-grant univ's.
<b>Evans-Allen</b>	1890 land-grant univ's.
<b>McIntire-Stennis</b>	State forestry schools

### Competitive programs

- AFRI** Agriculture & Food Research Initiative
- OREI** Organic Agriculture Research & Extension Initiative (started 2005)
- SCRI** Specialty Crops Research Initiative (2008)
- BRDI** Biomass Research & Development Initiative (2009)
- SBIR** Small Business Innovation Research



# How USDA plans to respond

## Next Steps in Plant Breeding

# *Agricultural Research Service (ARS)*

As foreseen in next 5-10 years



- Additional collections
- Efficient germplasm management and characterization
- Capacity to store and analyze massive datasets
- Pre-breeding with NPGS materials

- E.g., methods to increase speed and precision (genomic select'n., gene editing, others coming...)
- Cross-dataset coordination with other progr's./entities
- Transgenic research when critical

- When situations require public investment

- Lab and field experience





# Next Steps in Plant Breeding: *Forest Service (FS)*

*As foreseen in next 5-10 years*



- **Genetics** of critical forest-tree traits
  - For faster, more accurate breeding progress
- **Germplasm resources**
  - How to conserve diversity of those tree species that cannot be stored as seeds?
- **Data curation**
- **Collaboration** with ARS







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# Next Steps in Plant Breeding: *Natural Resource Conservation Service (NRCS)*

*As foreseen in next 5-10 years*

- **Landscape and ecosystem services;** cover crops; wildlife and pollinator habitat
- **Increasing needs** for selected plant material from NRCS Plant Material Centers
- **Collaboration** with ARS, FS, and Bureau of Land Management (BLM)  
e.g. Plant Conservation Alliance





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# Next Steps in Plant Breeding: *Economic Research Service (ERS)*

*Using crop genetic resources to help  
agriculture adapt to climate change:*

Economics and policy.

(EIB-139, Heisey & Day-Rubenstein, 2015)

**Other topics in progress, including**  
Implications of international agreements in  
the area of plant genetic resources





# Looking Further Ahead (> 10 yrs)

## Some anticipated future priorities for USDA plant breeding :

**Plant germplasm** – anticipated to remain a top priority for USDA

### **Plant breeding *per se*:**

- Transfer of *new knowledge* to plant breeding
  - Knowledge to increase speed and accuracy, lower costs
  - New horizons ... e.g. phytobiome...
  - New strategies, e.g. for phenotypic or participatory breeding
- Identification of *new traits*, e.g.
  - *Adaptation* to new environments, climates, and practices
  - Traits for *coexistence* of IP or organic crops, w/GE or others
  - Interactions between food, nutrition, and human *health*
- Breeding for *new situations* and *new crops*:
  - Varieties /traits for:
    - Organic systems / small farms / urban food systems
    - Perennial crops; trees;
    - Long-term ecosystem services





# Also from the Roadmap process: Issues broader than USDA

## Recruit / Educate

- Encourage more young people to be interested in plant breeding
- Education: K-12, CC's, undergrad.; grad.

## IPR

- Optimal understanding and use of intellectual property rights (IPR) and tech transfer mechanisms?

## Public / Private

- Most favorable balance of investment in plant breeding?

## Funding the model

- A joint endeavor: intra/extramural; capacity/competitive; public/private
- Funding the training pipeline

What are ways that USDA can respond?





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# RAISING THE PROFILE OF AGRICULTURAL SCIENCE AND EDUCATION INCLUDING PLANT BREEDING:

BASED ON USDA'S WORK IN THE PLANT BREEDING ROADMAP,  
THE WHITE HOUSE OFFICE OF SCIENCE AND TECHNOLOGY POLICY  
PLANS A PROFILE-RAISING EVENT  
ANTICIPATED FOR EARLY DECEMBER 2015 AND JAN/FEB 2016

*OSTP ARE KEENLY INTERESTED IN LEARNING ABOUT OTHERS  
PLANNING NEW OR EXPANDED INITIATIVES IN THIS AREA.*

IF INTERESTED IN LEARNING MORE:

PLEASE GET IN TOUCH WITH :

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THANK YOU FOR YOUR ATTENTION

