



Seeds for Restoration: Managing Seed Resources

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Greenbelt Native Plant Center
Mid Atlantic Regional Seed Bank
City of New York, Department of Parks

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Invasive Species Symposium
June 20, 2019

Parks

What is the Greenbelt Native Plant Center?



General Information

Owned & operated by the City of New York, Department of Parks & Recreation

Largest Municipal Native Plant Nursery in the U.S.

Located on Staten Island; 13 acres; former family farm; greenhouse business

Purchased in 1992; In operation since 1994

Division of Natural Resources Group- land management oversight



Mission

To provide native plants and seeds from local and regional plant populations in support of the conservation, restoration and management of the City's natural resources



Seed Collection and Banking

- 100 mile radius
- 2 Fulltime Seed Collectors
- 500+ species
- Collect using internationally accepted protocols for conservation and for maximizing genetic diversity
- Active Seed banking; on average, 2000 accessions banked; 12,000 accessions to-date
- ~15%RH ~60°F



Propagation and Greenhouse Operations



- Pre-treatment coolers for breaking dormancy's
- Cold frames for natural, multi-cycle dormancy treatment
- Propagation Range for controlled germination (heat + misting)
- 5 Production greenhouses
- **–Have developed protocols for 500+ species**
- **On average, 100's of species in production at any one time**

Nursery Production

- 5 acres of irrigated, container grow space;
- Multi-year container-based tree and shrub production (3 months to 7 year grow times)
- **Trees and shrubs**
 - Starter material: 2" tubes
 - Finished material: 1 Gallon pots
- **Herbaceous material**
 - Starter plugs
 - Tube trays



Foundation Seed Development



- Three grow sites; different soil types; 5 Acres; 1,000 sq. ft. plots
- **60 Species of Foundation Seed developed– goal is 90+**
- **Genetically rich; locally sourced;**

- **Basis for commercial bulk seed increases for NYC**
- **Basis for 6-7 Seed mixes**
 - Wet meadow mix
 - Early Successional Meadow Mix
 - Coastal Maritime Mix
 - Woodland Mix
 - Urban Soils Mix
 - Custom Mixes also available

Foundation Seed Production

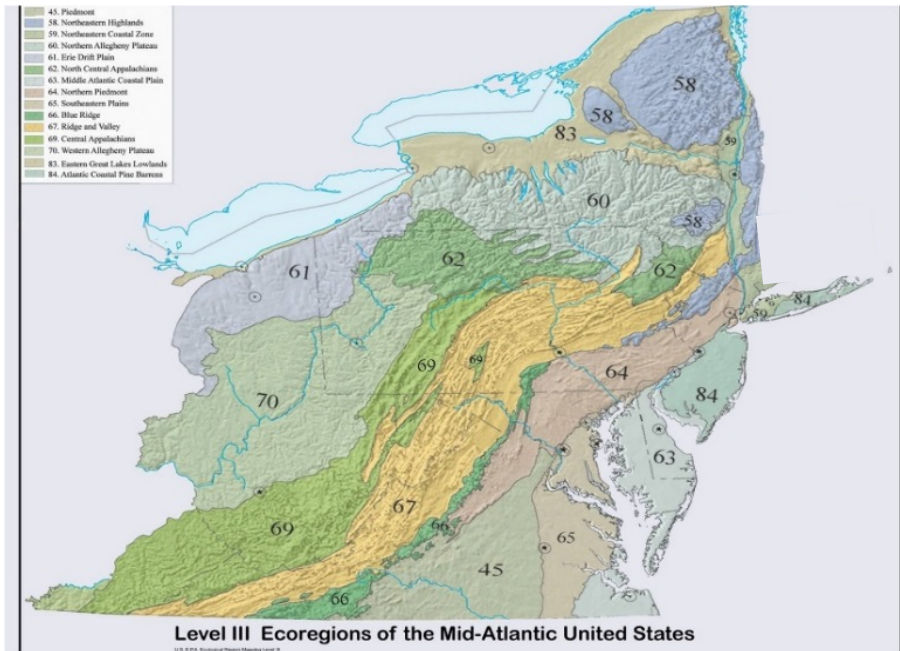
- Starts with wild collected seed – 3 to 5 populations per plot; has to serve many sites in NYC area
- Hand harvested in multiple phases; conserve genetic richness
- Seed cleaning is almost all mechanical



Regional Seed Collecting and Banking



- **Mid-Atlantic Regional Seed Bank – 2012**
- **7.5 states, 16 Level III and 90 Level IV Ecoregions**
- **Multiple Collection Programs**
- **Outreach and Development**
 - Trained collectors for MARSB and SOS
 - Support of other regional programs needing seed
- **~1,000 collections to date**



Level III Ecoregions of the Mid-Atlantic United States



Why Does Locally Sourced Matter?



Negative Genetic Impacts of Using Non-Local Plant Materials

- On existing populations on site
- On new plantings on site (over several to many generations)
- On existing populations off-site (but within distance to exchange genetic material)



Negative Genetic Impacts of Using Non-Local Plant Materials

- Three genetic phenomena:
 - Founder effects
 - Genetic swamping
 - Outbreeding Depression (loss of vigor)

Hufford and Mazer (2003)

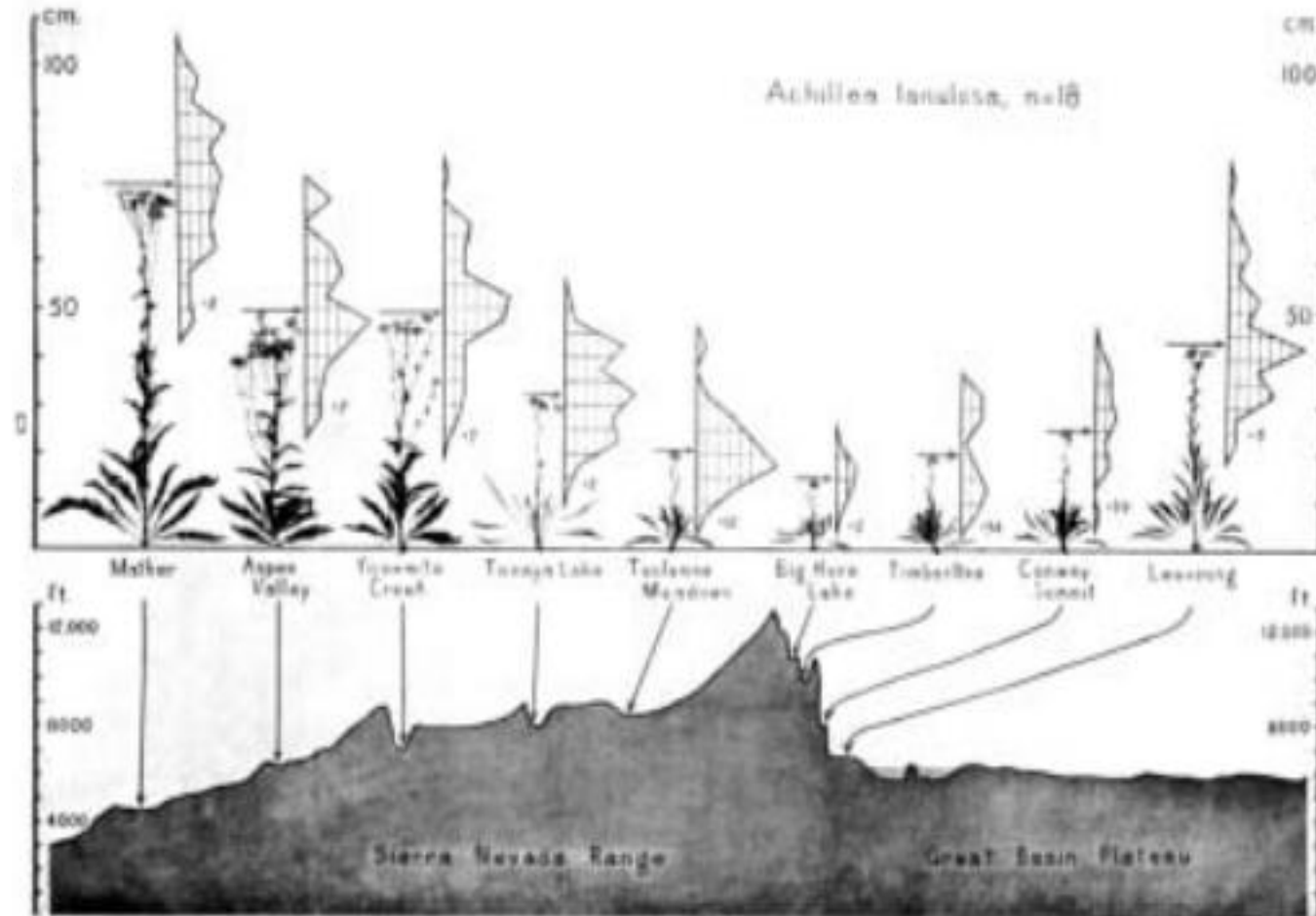


Plants from Local Seed Sources:

- Increase long- and short-term sustainability of project sites; most cost effective in long-term
- Fully integrate with local ecosystems
- Avoid negative impacts to native plants on and off-site

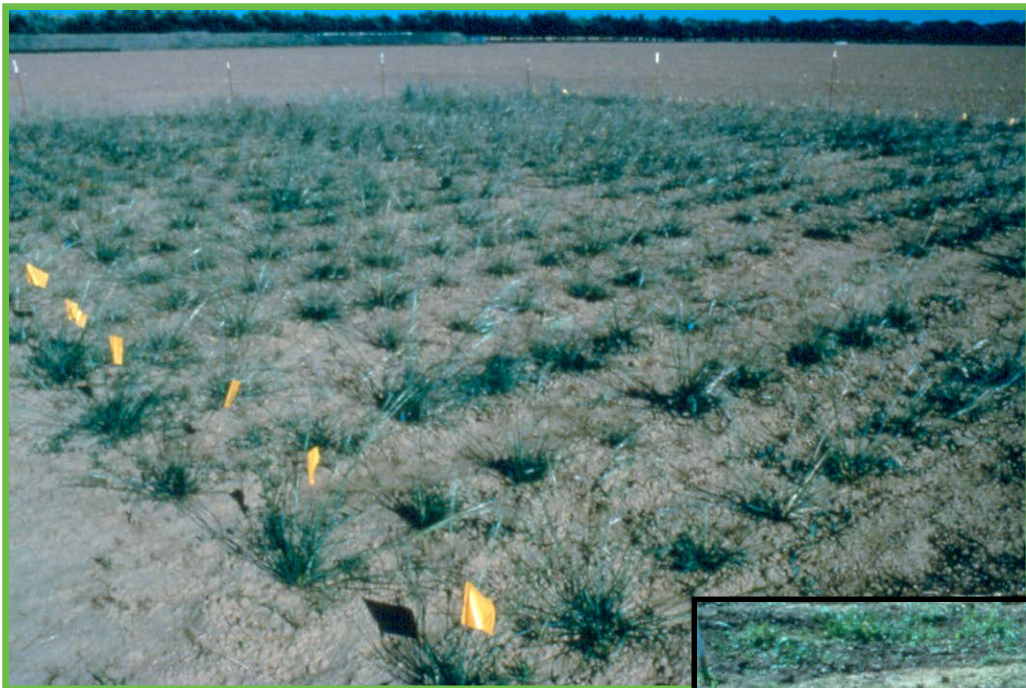


Genetic variation and phenotype



Clausen et al. 1948

Traditional Common Garden



Nassella pulchra, purple
needlegrass

Elymus glaucus



Basic model: $V_P = V_G + V_E$

In common garden:

$$V_P \approx V_G$$

Where 'V' = Variability

'P' = Population

'G' = Genetic

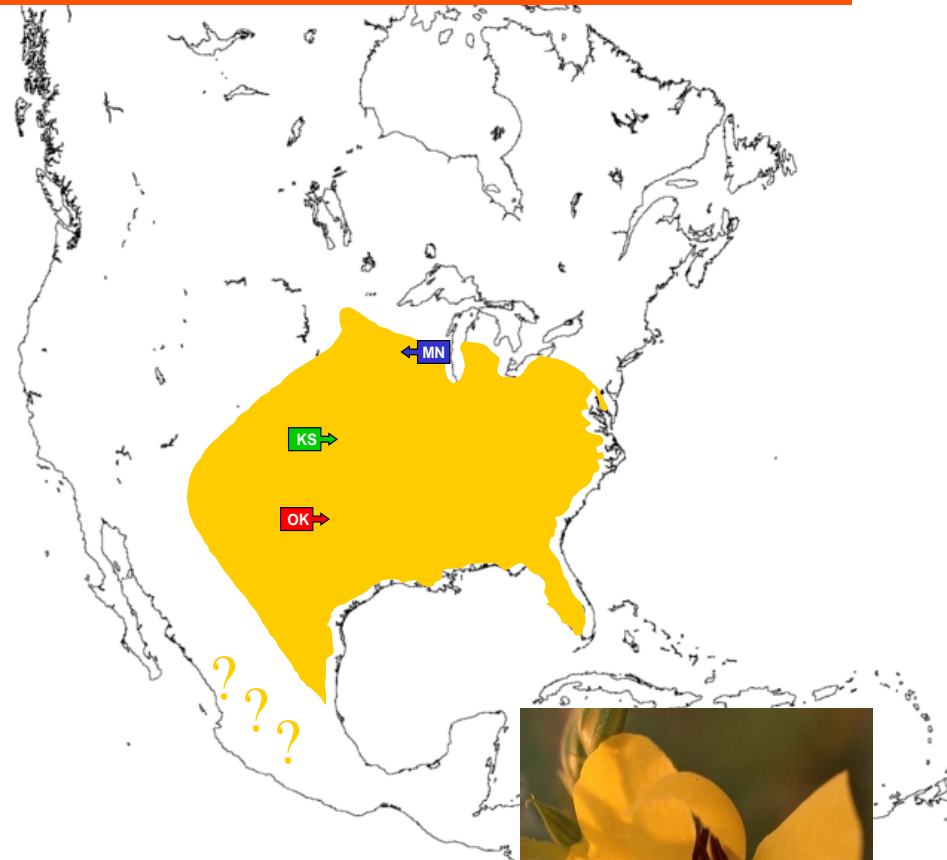
'E' = Environmental



NYC Parks

(Knapp & Rice; Erickson & Sorenson)

Reciprocal Transplant Studies

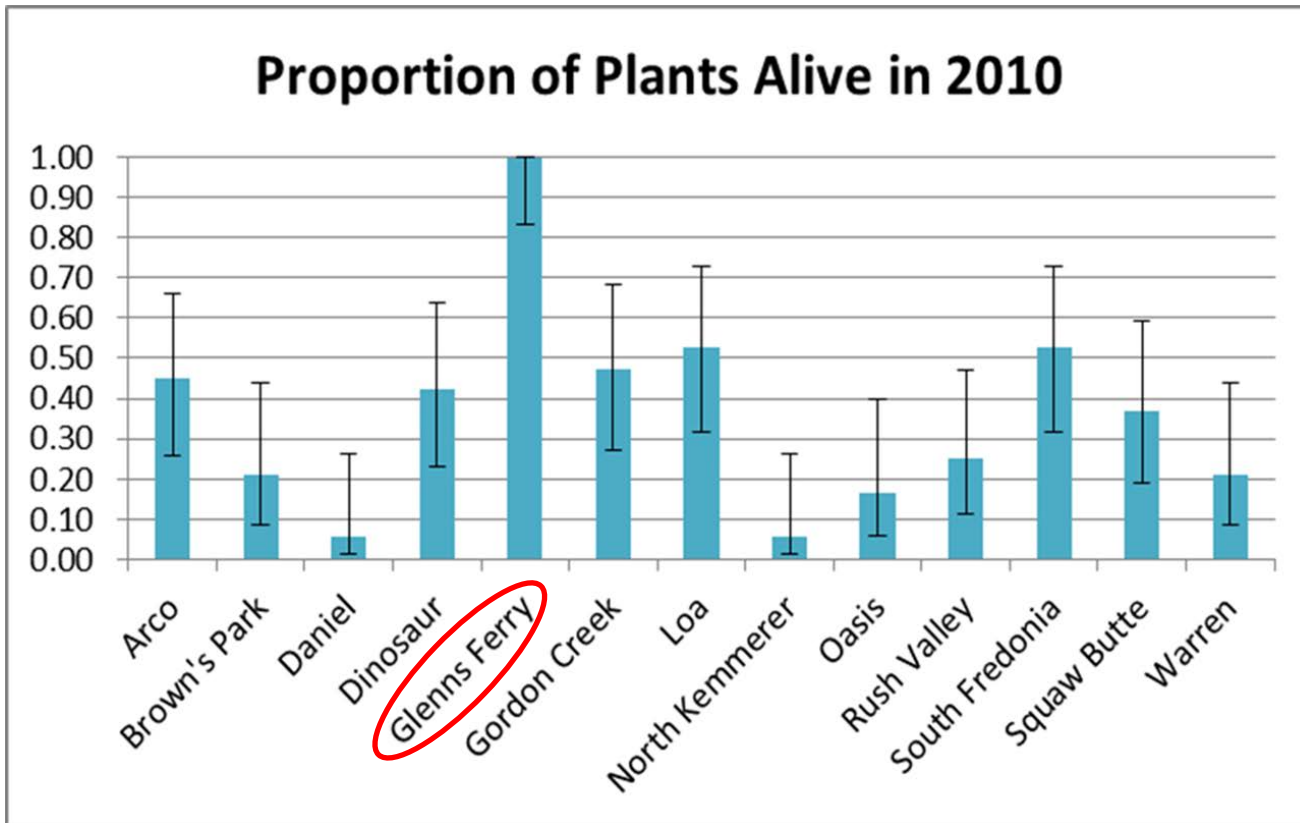


Chamaecrista fasciculata
Partridge Pea



Wyoming Big Sagebrush

from 13 Locations Planted in Glens Ferry, ID in 1987



Environmental and Edaphic Conditions Drive Local (Population Level) Adaptations



Pollinators



Climate



Soil

Predators and pathogens

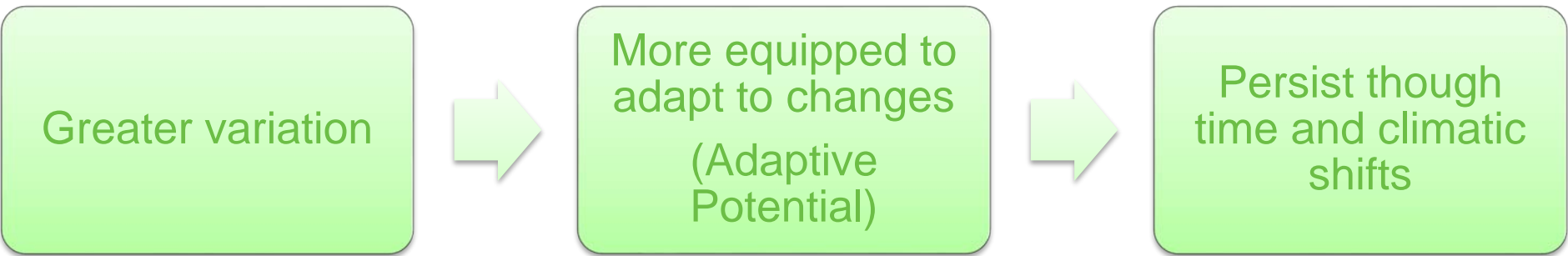


Elevation



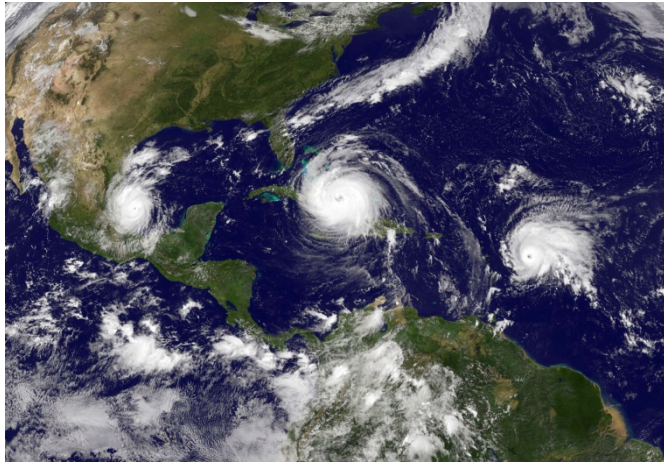
Seed dispersers

Genetic Variation and Adaptive Potential



True on a species level as well as on a population level

Why is adaptive potential important?



Diverse ecosystems are essential for their adaptation and survival for our biotic environment under changing global conditions.

“Having a seed bank of ecologically and genetically diverse, source-identified native seed keeps our options open for future projects as restoration science catches up with restoration needs” – Havens et. al. 2015

Why collect seed?

- Restoration
- Conservation
- Reclamation
- Enhancement



Genetic Variation

- individuals and population differ over space phenotype, and some functions, are determined by genetic composition, environment, and the combination of the two

Seed Collection

- **Good Sampling Techniques**
 - Maximize capture of genetic diversity within the sampled population
 - Maintain each collection as a unique accession; Record keep and database each accession
- **Translocation**
 - Use Seed Transfer Zone Rules when available; Provisional Seed Zones; Other Mapping Tools
 - Otherwise collect as conservatively as possible; Risk Management Approach- do as little damage as possible
 - Match restoration site to collection site



Seed Collection



- Ecological and geographical data for each collection— stays linked through production to final product
- Multiple accessions per species (time; populations)
- Many populations; protection from over-taxing seed resources
- Protocol:
 - Sample from ~50 individuals at least;
 - sample randomly;
 - no more than 20% or populations;
 - sample entire population



Seed Banking



Types of Seed Banking

Short term – ‘Active’



65°F and ~15% RH

Greenbelt Native Plant Center

Viability – a few decades

Long Term – ‘Conservation’



-4°F and 35%RH

Millennium Seed Bank, National Center
for Resources Preservation

Viability – indeterminate – several
hundred years

Can all seed be banked?

Orthodox

Can be desiccated - ~80% of plant species

Recalcitrant

Can not be desiccated or frozen
- ~20% of species



When are collections made?



When are collections made?



Field Cues for Collection:

Change in color

Change in texture

Evidence of natural dispersal within the population

How is seed collected?

Make sure you sample the entire area and spread out while collecting

To maximize genetic diversity in a collection, randomly collect from 30 individuals of an out-breeding spp. and 59 individuals of a self-fertilizing species (general rule: randomly collect from at least 50 individuals.)

Do not discriminate against seed because of the way a plant might look.



How is seed collected?

Seeds of Success Protocol

- At least 50 individuals
- No more than 20% of available seed on any given day
- Random sampling
- Wild populations only
- Different populations are kept as separate accessions
- Ideally 10,000+ seeds



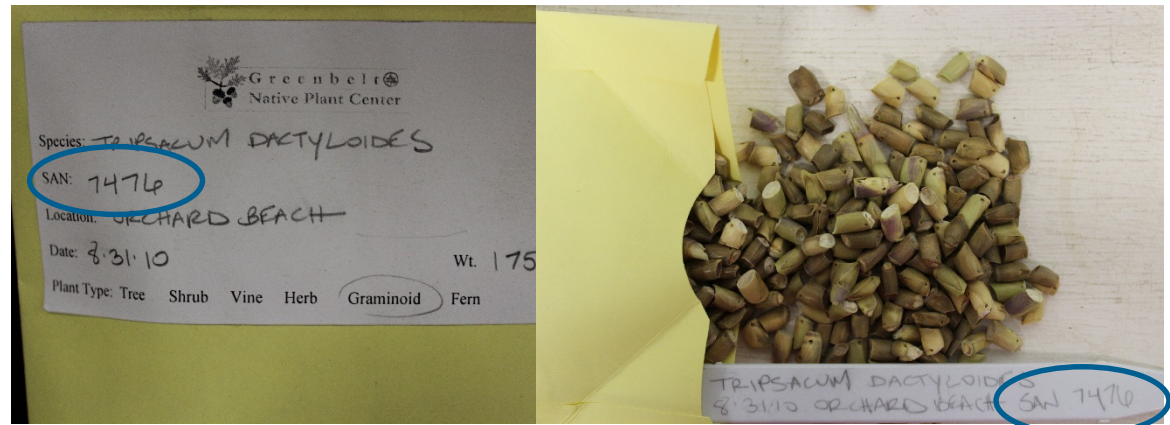
BLM SEEDS OF SUCCESS FIELD DATA FORM

SOS Seed Collection Ref. Number:	<input type="text"/>	Alternate Collection Number:	<input type="text"/>
Date(s) Collected (MM/DD/YYYY):	<input type="text"/>	NBCS PLANTS Code:	<input type="text"/>
Collector(s):	<input type="text"/>		
Ecoregion (Overseas Level III):	State:	County:	<input type="text"/>
Location Details:			
Lat. (degrees) (ex. 49 34 19.7'N):	<input type="text"/>	N	GPS UTM: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> If no, please see other side.
Long. (degrees) (ex. 107 30 31.54'W):	<input type="text"/>	W	GPS Datum: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> Other: <input type="text"/>
Elevation (feet):	<input type="text"/>	Landowner:	<input type="text"/> Non-BLM Permission <input type="checkbox"/>
HABITAT DATA			
Associated Species (Scientific Name): <input type="text"/>			
Modifying Factors: <input type="checkbox"/> Mowed <input type="checkbox"/> Burned <input type="checkbox"/> Grazed <input type="checkbox"/> Flooded <input type="checkbox"/> Seeded <input type="checkbox"/> Trampled <input type="checkbox"/> Other: <input type="text"/>			
Land Form:	<input type="text"/>	Slope (degrees):	<input type="text"/>
Land Use:	<input type="text"/>	Aspect:	<input type="text"/> N <input type="text"/> NE <input type="text"/> E <input type="text"/> SE <input type="text"/> S <input type="text"/> SW <input type="text"/> W <input type="text"/> NW
Geology:	<input type="text"/>		
Soil Features:	<input type="text"/> Clay <input type="text"/> Sil <input type="text"/> Sand <input type="text"/> Other: <input type="text"/>	Soil Color:	<input type="text"/>
COLLECTION DATA			
Family:	<input type="text"/>	No. of Plants Sampled (max. 50):	<input type="text"/>
Genus:	<input type="text"/>	No. of Plants Examined (approx.):	<input type="text"/>
Species:	<input type="text"/>	Area Sampled (m ²):	<input type="text"/>
Subspecies/Variety:	<input type="text"/>	Seeds Collected From: <input type="checkbox"/> Plant <input type="checkbox"/> Ground <input type="checkbox"/> Both	
Plant Habit:	<input type="checkbox"/> Tree <input type="checkbox"/> Shrub <input type="checkbox"/> Forb <input type="checkbox"/> Succulent <input type="checkbox"/> Grass/Grasslike	Plant Height (feet):	<input type="text"/>
Native plant materials development & research (this accession will be used for): <input type="text"/>			
Observational field notes to assist in identification of pressed specimens (e.g. flower color, etc.): <input type="text"/>			
Common Name(s) of Plant(s): <input type="text"/>			
Photograph Checklist (at minimum): <input type="checkbox"/> Habitat <input type="checkbox"/> Plant <input type="checkbox"/> Seed <input type="checkbox"/>			

Revised 12 March 2012

Seed Accessioning

- Every Collection gets a Seed Accession Number (SAN #)
- Every collection is accompanied by a field data form; databased; geo-referenced
- Nursery inventory tracking system- GroWare (custom, proprietary software)
- GroWare tracks seed through entire production process



Seed Accessioning- GroWare

	A	B	C	D	E	F	G	H	I	J	K	L
1	Item or Sku ID	Item Description	Slip Description	Summary Description	Location ID	Avail.	Committed Qty	On Hand Qty	Available Qty	Lot ID	Availability Comment	Ready Date Description
2	SCCY-2IN	Scirpus cyperinus - 2 inch	woolgrass	2016-12-05 - JLa / JPL	Q20-RB	Y	0	4096	4096	7777	Available for any project	2014 January
3	JUGE-2IN	Juncus gerardi - 2 inch	saltmeadow rush	2017-05-05 - TP - SAN# 8645 - FLAT# 16-137	Q12-RM	Y	0	3744	3744	10293	Available for any project	2017 May
4	DISP-2IN	Distichlis spicata - 2 inch	saltgrass	2017-04-18 - TP - SAN# 9735 - FLAT# 16-469	Q12-RB	Y	0	2376	2376	10251	Available for any project	2017 April
5	DISP-2IN	Distichlis spicata - 2 inch	saltgrass	2017-04-12 - TP - SAN# 6493 - FLAT# 16-469	Q12-RB	Y	0	2016	2016	10244	Available for any project	2017 April
6	JUGE-T50	Juncus gerardi - Tube 50	saltmeadow rush	2016-04-06 - TP - SAN# 4921 - FLAT# 12-89	Q12-RB	Y	0	1591	1591	9881	Available for any project	2016 April
7	DEFL-T50	Deschampsia flexuosa - Tube 50	wavy hairgrass		Q17-LB	Y	0	1550	1550	9982	Available for any project	2016 May
8	GLST-2IN	Glyceria striata - 2 inch	fowl mannagrass	2014-02-28 - TP - SAN# 4173 - FLAT# 11-179	Q20-LB	Y	0	1536	1536	9414	Available for any project	2014 February
9	EUMA9-T50	Eutrochium maculatum - Tube 50	spotted joe pye weed	2016-07-15 - TP - SAN# 5921 - FLAT# 12-163	Q15-LB	Y	0	1424	1424	10115	Available for any project	2016 July
10	MOPU-T50	Monarda punctata - Tube 50	spotted beebalm	2017-04-19 - TP - SAN# 8800, 9221 - FLAT# 17-171	Q16-RB	Y	712	2050	1338	10252	Available for any project	2017 April
11	CACR6-2IN	Carex crinita - 2 inch	fringed sedge	2017-06 - P La	Q20-RB	Y	0	1200	1200	9411	Available for any project	
12	DEFL-T50	Deschampsia flexuosa - Tube 50	wavy hairgrass		Q17-LB	Y	676	1800	1124	9981	Sunset Cove / EMP	2016 May
13	ASSY-T50	Asclepias syriaca - Tube 50	common milkweed	2017-05-24 - TP - SAN# 5444 - FLAT# 17-173	Q12-LF	Y	0	1050	1050	10288	Available for any project	2017 May
14	ASSY-T50	Asclepias syriaca - Tube 50	common milkweed	2016-04-12 - TP - SAN# 5141 - FLAT# 16-51	Q17-LM	Y	150	1006	856	9901	Available for any project	2016 April
15	CAS16-T50	Carex silicea - Tube 50	beach sedge		Q16-LB	Y	0	600	600	10013	Available for any project	2016 May
16	POCO14-3IN	Pontederia cordata - 3 inch	pickereel weed	2016-04-19 - TP - SAN# 10001 - FLAT# 15-162	P1	Y	0	552	552	9914	Available for any project	2016 April
17	EUMA9-T50	Eutrochium maculatum - Tube 50	spotted joe pye weed	2016-06-09 - TP - SAN# 5921 - FLAT# 12-163	Q15-LB	Y	300	850	550	10043	Available for any project	2016 June
18	JUTE-T50	Juncus tenuis - Tube 50	poverty rush	2016-06-09 - TP - SAN#4927 - FLAT# 12-97	Q12-RF	Y	0	530	530	10056	Available for any project	2016 June
19	LEMA-T50	Lechea maritima - Tube 50	beach pinweed		Q16-RM	Y	0	500	500	9975	Available for any project	2016 May
20	SALA2-3IN	Sagittaria latifolia - 3 inch	broadleaf arrowhead	2016-05-02 - Division - SAN 7544 - FLAT 15-115	P1	Y	0	495	495	9729	Available for any project	2015 June
21	ASSY-T50	Asclepias syriaca - Tube 50	common milkweed	2016-04-11 - TP - SAN# 7116 - FLAT# 16-53	Q17-LM	Y	0	487	487	9898	Spring Ephemeral	2016 April
22	EUMA9-2375	Eutrochium maculatum - 2-3/8 Inch	spotted joe pye weed	2014-04-03 - TP - SAN# 6081 - FLAT# 12-162 - d	Q13-RF	Y	0	480	480	9438	Available for any project	2014 April
23	SPAN-3IN	Sparganium angrocladum - 3 inch	branched bur-reed	2016-05-02 - TP - SAN 8794 - FLAT 13-325	P1	Y	0	465	465	9733	Available for any project	2016 April
24	CYGR2-T50	Cyperus grayi - Tube 50	Gray's flatsedge		Q16-RB	Y	0	450	450	10009	Available for any project	2016 May
25	CAS16-2IN	Carex silicea - 2 inch	beach sedge	2015-06-30 - TP - SAN 8681 - FLAT# 15-25	Q16-LB	Y	0	440	440	9781	Available for any project	2015 June
26	SPPA-T50	Spartina patens - Tube 50	saltmeadow cordgrass	2016-07-18 - TP - SAN# 8910 - FLAT# 15-121	P1	Y	0	430	430	10131	NAC	2016 June
27	CASC11-T50	Carex scoparia - Tube 50	broom sedge		Q12-LM	Y	100	422	322	10103	Available for any project	
28	SOSE-T50	Solidago sempervirens - Tube 50	seaside goldenrod	2017-03-22 - TP - SAN# 5527 - FLAT# 16-74	Q16-LF	Y	800	1074	274	10210	Available for any project	2017 March
29	IRPR-T50	Iris prismatica - Tube 50	slender blue iris		Q15-RF	Y	0	265	265	10024	Available for any project	
30	DICL-T50	Dichanthelium clandestinum - Tube 50	deertounge	2016-06-22 - TP - SAN# 7574 - FLAT# 11-305	Q14-LF	Y	0	260	260	10078	Available for any project	2016 June
31	MOFI-T50	Monarda fistulosa - Tube 50	wild bergamot	2017-03-15 - TP - SAN# 8300 - FLAT# 17-42	Q12-LM	Y	250	500	250	10199	Available for any project	2017 March
32	ASIN-T50	Asclepias incarnata - Tube 50	swamp milkweed	2017-04-13 - TP - SAN# 4599 - FLAT# 16-488	Q15-RF	Y	0	250	250	10246	Available for any project	2017 April
33	PYVI-T50	Pycnanthemum virginianum - Tube 50	Virginia mountainmint	2016-08-17 - TP - SAN# 5882 - FLAT# 10-362	Q15-RM	Y	250	500	250	10169	Available for any project	2016 August
34	IRVE2-T50	Iris versicolor - Tube 50	harlequin blueflag	2017-04-13 - TP - SAN# 7479 - FLAT# 16-438	Q12-LM	Y	58	280	222	10243	Available for any project	2017 April
35	SCPU5-T50	Schoenoplectus pungens - Tube 50	common threesquare		Q12-LB	Y	0	215	215	9944	Available for any project	2016 April
36	COAM2-G	Cornus amomum - Gallon	silky dogwood		Q24-LB	Y	0	213	213	9011	Available for any project	2015 November
37	CEOC-G	Celtis occidentalis - Gallon	common hackberry		Q25-RM	Y	0	199	199	9407	Available for any project	2016 June
38	CACOB-2IN	Carex comosa - 2 inch	longhair sedge	2014-04-24 TP DATE - SAN# 5204 - FLAT# 11-25	Q13-LF	Y	0	192	192	9474	Available for any project	2014 April
39	BEPO-G	Betula populifolia - Gallon	gray birch	2015-07-08 StepUp Date	Q24-LM	Y	0	191	191	9232	Available for any project	2015 July
40	RUPE3-G	Rubus pensilvanicus - Gallon	Pennsylvania blackberry	2017-04-11 - Step Up	Q52-RB	Y	0	187	187	9923	Available for any project	2017 April



How is seed collected?

Hand stripping

Picking

Small garden clippers

Minimize inert material

Seeds of Success Protocol

- 10,000+ seeds
- Data Form
- 3 Photos – Plant, Habitat, Seed
- Herbarium Specimens



Post Collection Care



Lay seed out in a cool, dry and shady area to get rid of excess moisture – 1-2 weeks

Store in a cool dry area

Avoid your hot car!

Seed Cleaning

Wet Seed -

Fleshy Fruits should be kept in a refrigerator until soft but not moldy!



Dry Seed -

Should be stored in a cool dry environment pre and post cleaning



Seed Cleaning

Fleshy Fruits – ex.
Blueberries, Raspberries,
Cornus sp, *Ilex sp*, *Rosa*
sp.

Make a smoothie

Use colander

Lay flat to dry – thin layers
are best, turn over twice
daily



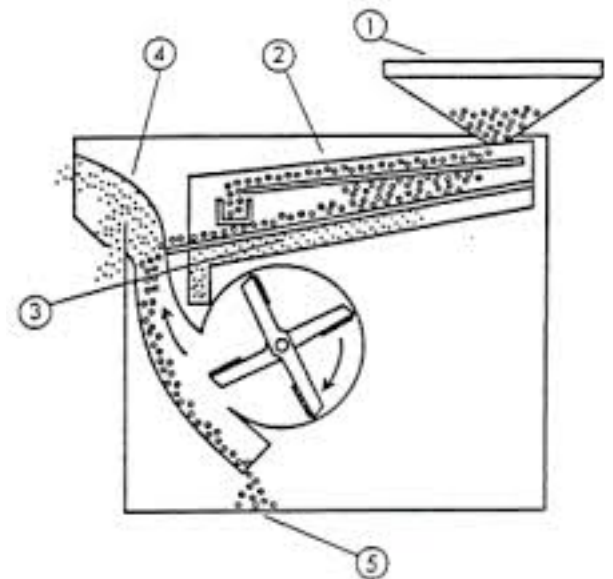
Seed Cleaning

Everything else – grasses, asters, sedges, etc.

Separate the wheat from the chaff!

Rubber stair tread, sieves, aspirators, tapping, blowing

Be careful not to rub too hard – don't break the seed coat



How Do I know What is Locally Adapted Seed?



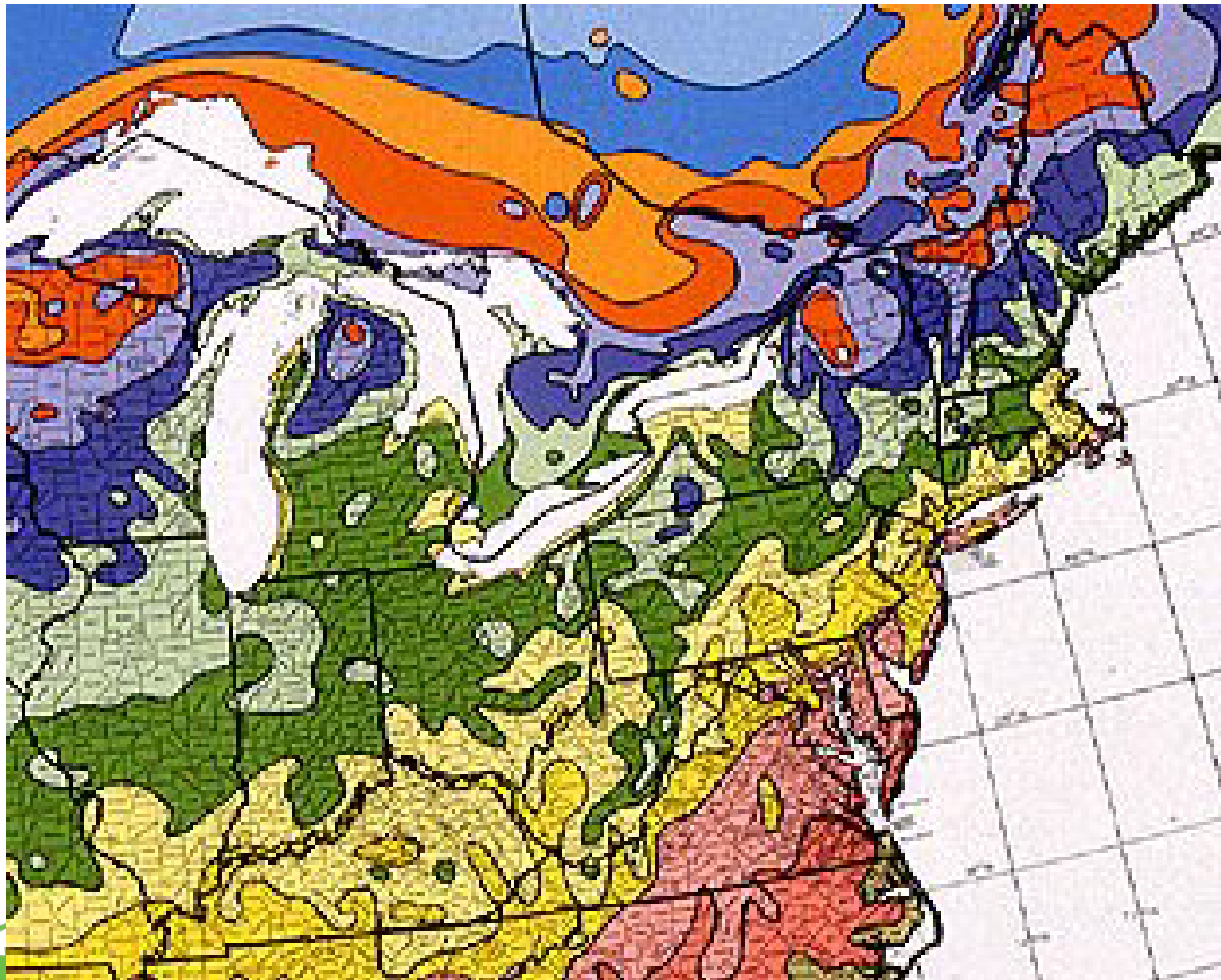
Seed Transfer Zones

Regions within which plants can be moved with little or no consequence for plant population fitness.

- **How do we identify populations? Three complimentary tools:**
 1. **Common Garden Studies**
 2. **Reciprocal Garden Studies**
 3. **DNA Analysis**
- **Need to be determined species by species**
- **Only a handful of STZ's have been worked out in the U.S. (cost and time)**

Mapping

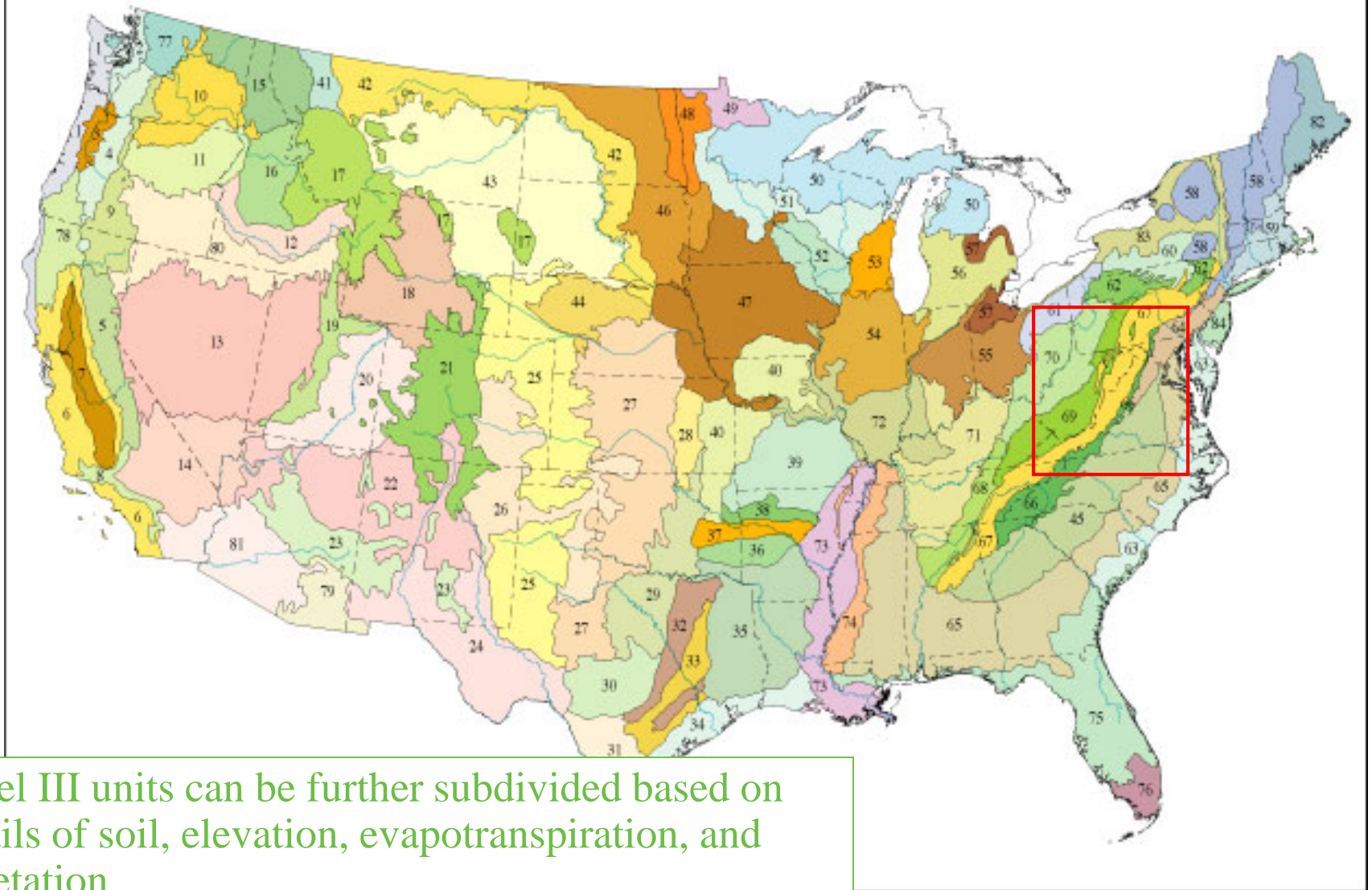




Average Annual Minimum Temperature

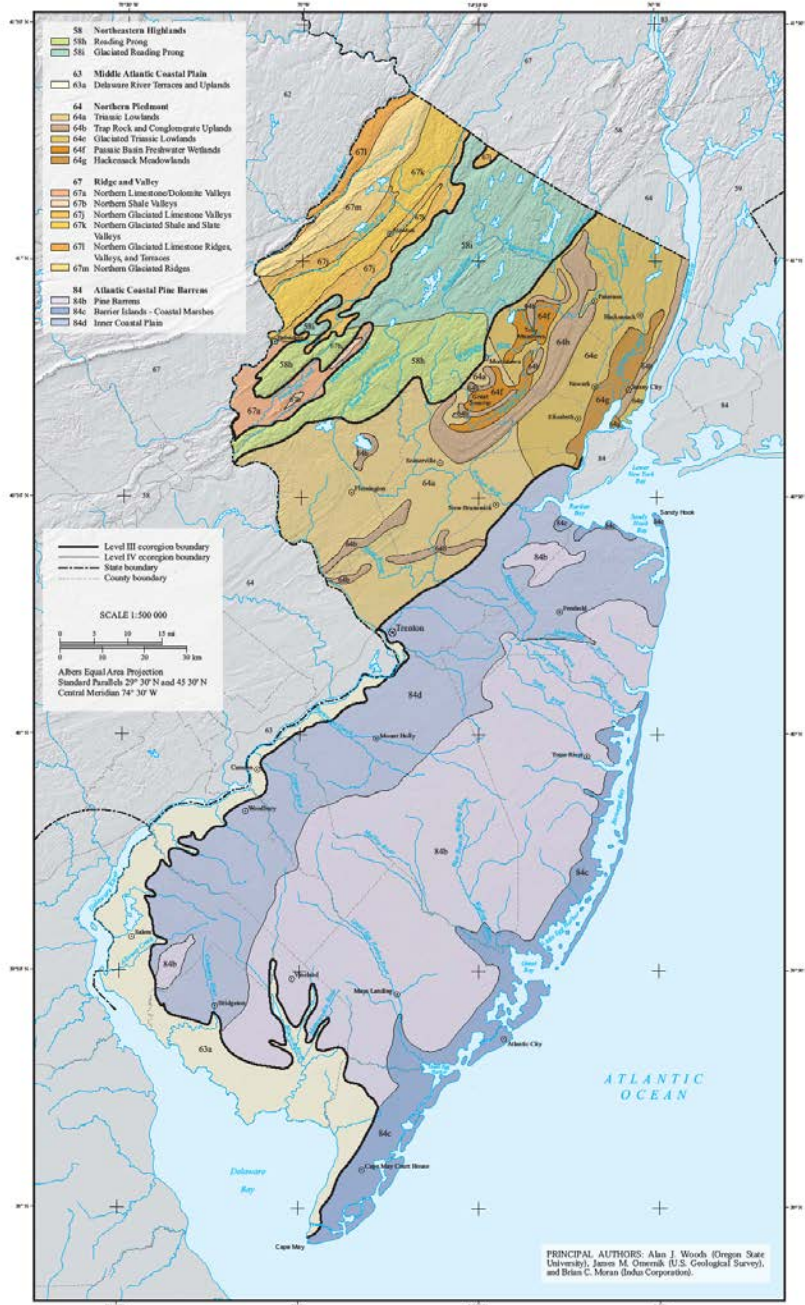
Temperature (F)	Zone
Below -50	1
-45 to -50	2a
-40 to -45	2b
-35 to -40	3a
-30 to -35	3b
-25 to -30	4a
-20 to -25	4b
-15 to -20	5a
-10 to -15	5b
-5 to -10	6a
0 to -5	6b
5 to 10	7a
10 to 15	7b
15 to 20	8a
20 to 25	8b
25 to 30	9a
30 to 35	9b
35 to 40	10a
40 to 45	10b
45 +	11

Level III Ecoregions of the Conterminous United States



Level III units can be further subdivided based on details of soil, elevation, evapotranspiration, and vegetation

DRAFT LEVEL III AND IV ECOREGIONS OF NEW JERSEY



*Level IV
Ecoregional
Map of New
Jersey*

Combining Ecoregion Mapping with Climate Data





Regional Examples of Provisional Seed Zones

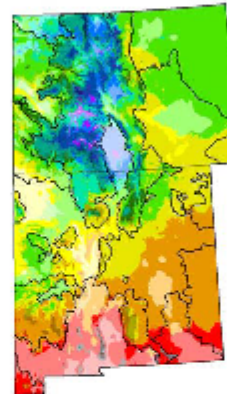
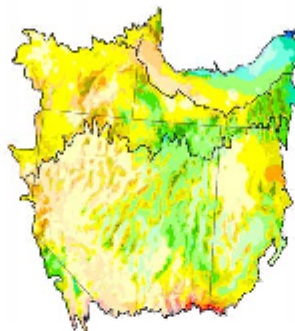
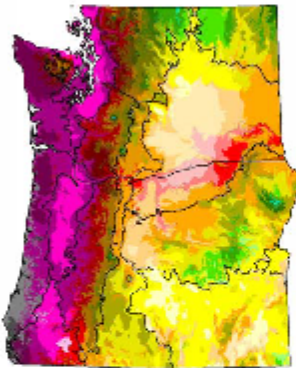
Andrew Bower
Brad St. Clair
Vicky Erickson

Pacific Northwest

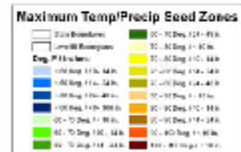
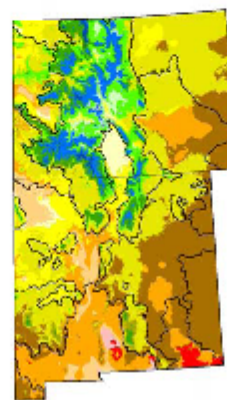
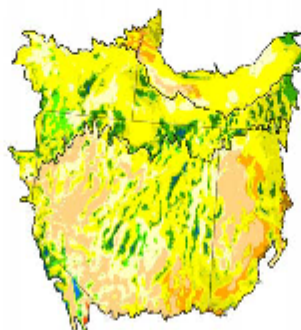
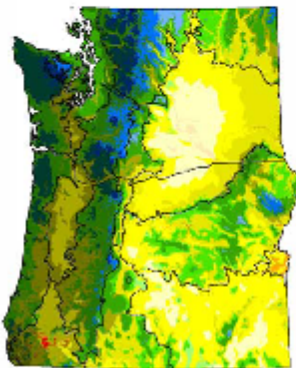
Great Basin

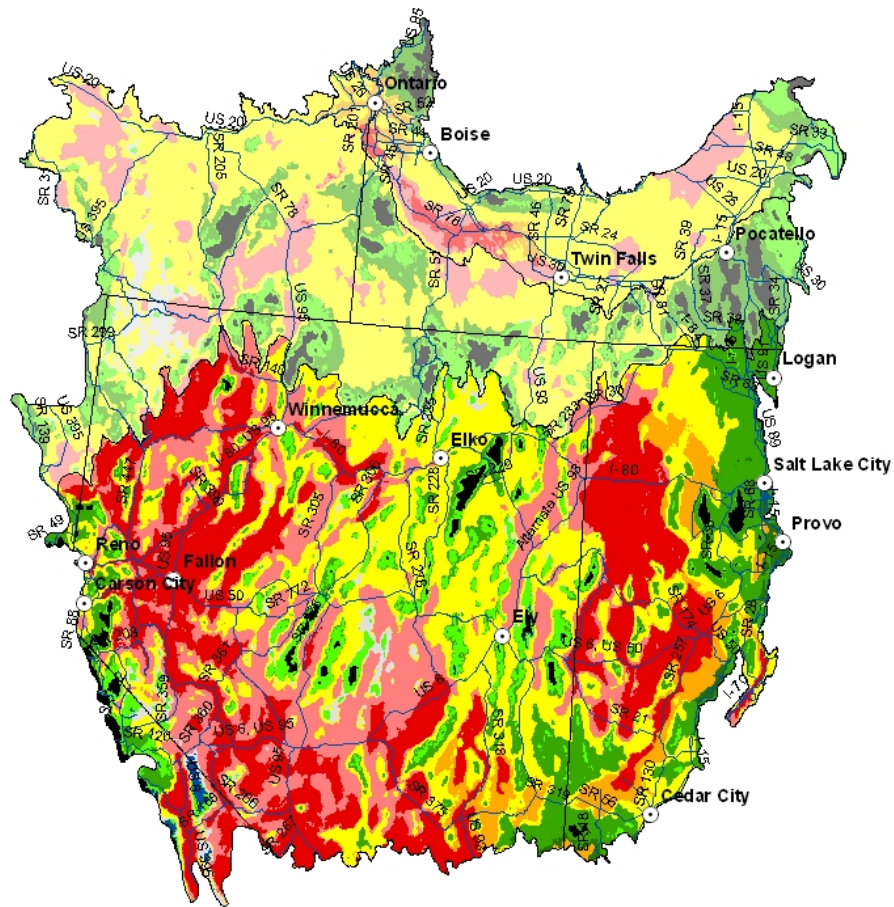
Colorado Plateau

Winter Min. Temp/
Annual Precip












Avg. Maximum
Temp/ Annual Precip





Legend

Great Basin Provisional Seed Zones	 10-14 in. precip. / 80-90 Deg.
Annual precip. / Degrees F.	 14-24 in. precip. / <70 deg.
 <10 in. precip. / >80 Deg.	 14-24 in. precip. / 70-80 deg.
 <10 in. precip. / <80 deg.	 14-24 in. precip. / 80-90 Deg.
 10-14 in. precip. / <70 deg.	 <60 deg.
 10-14 in. precip. / 70-80 deg.	 >24 in. precip.

Conservative Approach



Until these protocols are developed at the local and regional levels, a conservative approach to providing genetic stock for ecological restoration projects is warranted. (a Risk Management Approach)

Use of local ecotypes, properly sampled to maximize genetic diversity

- **From extant population at project site**
- **From neighboring population(s)**
- **From translocated ecotypes as a last resort**

*What will it take to see that
there is an adequate supply
across New York State?*



Seed is a Critical Natural Resource



Seed is **largely unprotected and undermanaged.**

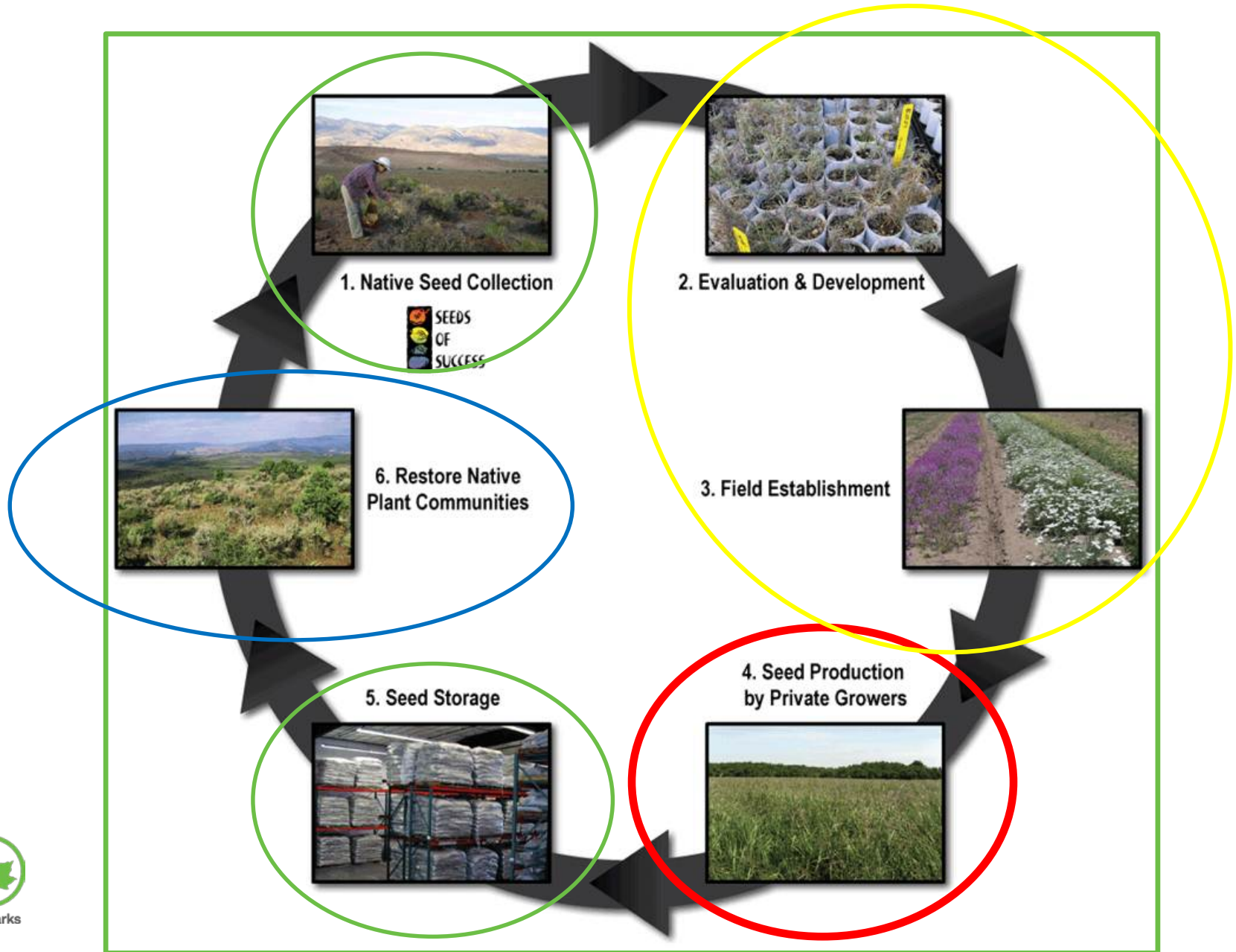
Locally adapted seed sources are **critical for restoration and management**

Our nation's seed resources are in danger not only from **extirpation and overuse** but also **from misuse** when non-local source seed is used, **lowering genetic diversity, introducing maladapted seed** into local populations

Native Plant Material Development (NPMD)



Plant Material Development



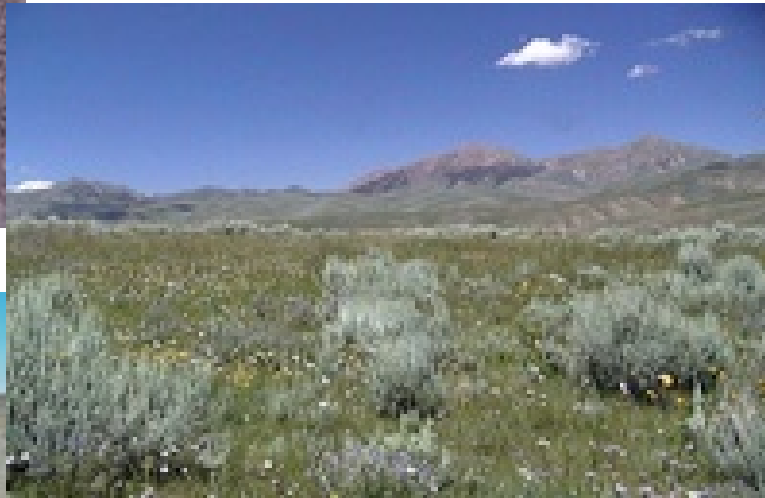
SEED NETWORKS

- **Education**
- **Regional and Local Sharing of Information and Resources**
 - **Collaboration on Seed Collection across jurisdictional lines**
 - **Collaboration on setting priorities for species to collect and bank**
 - **Common or Keystone Species**
 - **Species of Special Concern**
 - **Development of Markets**
 - **Collaboration on development of protocols; On NPMD**
 - **Coordination and Collaboration on Research on Seed Transfer Zones;**
- **Sharing of seed resources based on protocols**

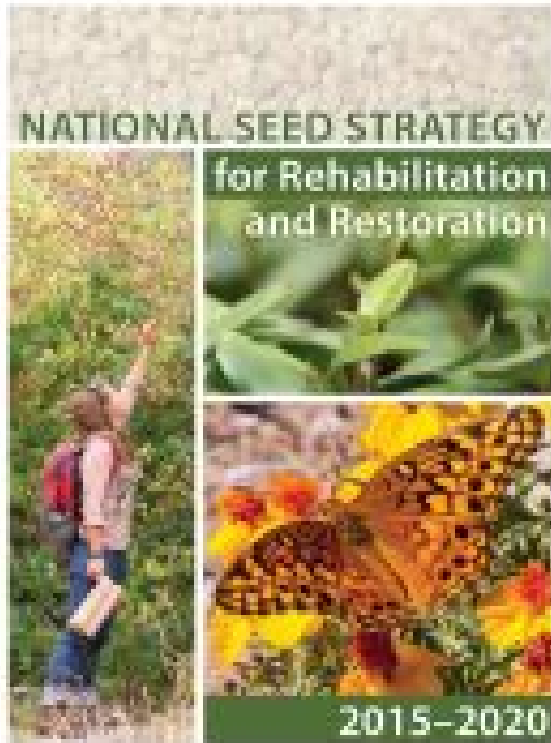




- 20 Cooperators; 55M hectares of western desert
- Increasing the availability of native spp. for restoration efforts
- Wildland seed collection
- Species screening
- Cultural practice trials
- Germplasm evaluation
- Partnership w private sector seed producers



National Seed Strategy for Rehabilitation and Restoration: 2015-2020



- 12 Federal Agencies + Plant Conservation Alliance (300 Non-Federal Partners)
- Calls for the coordinated establishment of a **nationwide network of native seed collectors, growers, seed banks and seed storage facilities**
- Renewable in 5-Year Cycles

www.blm.gov/seedstrategy

A close-up, top-down view of a large quantity of lentils. The lentils are densely packed and show a variety of colors, including shades of green, brown, and tan. Some lentils appear to have small, light-colored spots or imperfections. The overall texture is granular and repetitive.

THANKS !