

Native Early Seral Plants in Restoration at Canyon de Chelly National Monument



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Restoration Ecology Lab



Russian Olive
Elaeagnus angustifolia
Planted 1964



Salt Cedar
Tamarix sp.
Planted 1936







Early Seral
Native Seeds

Hard to Reverse
Expensive

Exotic's
colonize

Disturbance

Ecosystem
Function
Changed

Natives
Disappear

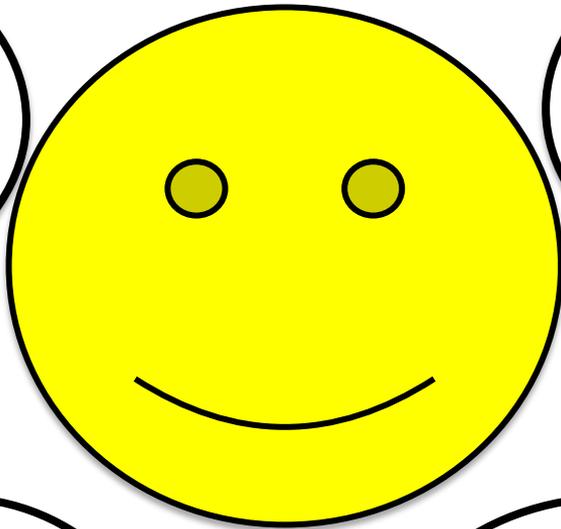
Exotic's
Persist



Early Seral
Native Seeds

NATIVES
colonize

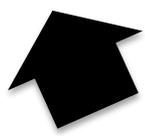
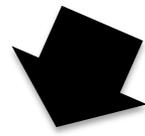
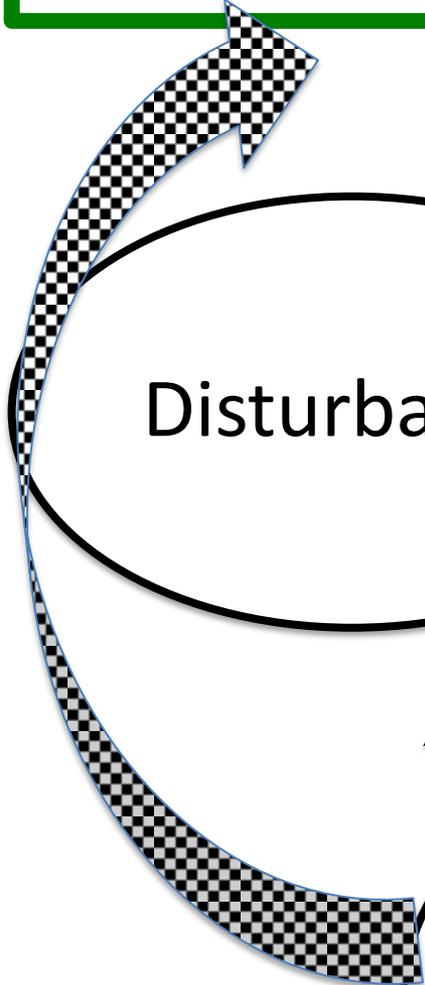
NATIVES
Redirect
Ecosystem
Function



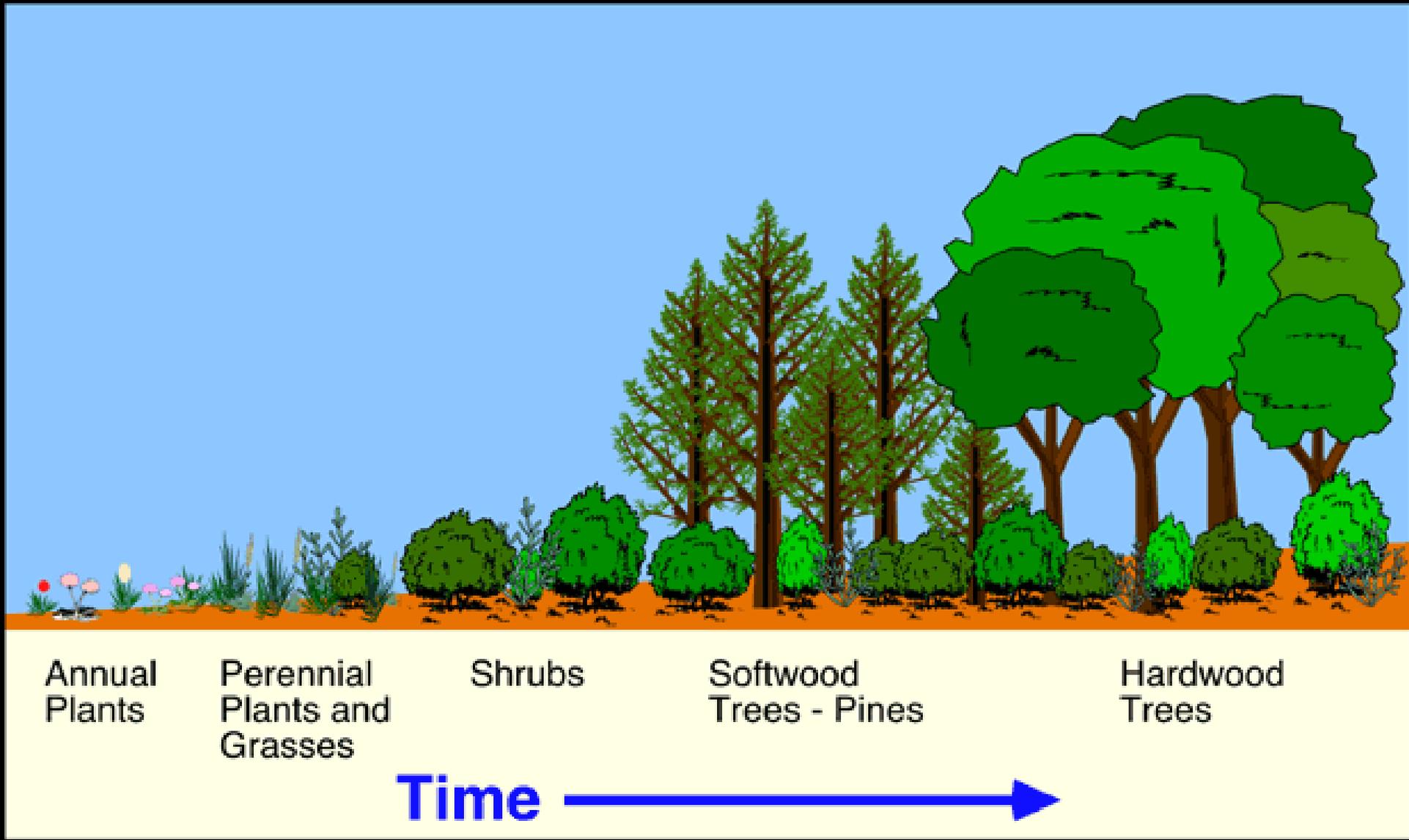
Disturbance

NATIVES
Persist

NATIVES
Replenish



Ecology 101



Native Early Seral Species ESS can *Redirect* Ecosystem Development

1. Compete with Invasive Herbaceous Species

- Native and invasive ESS share many life history traits
 - Affinity for high nutrient soils
 - Fast growth and reproductive output

2. Facilitate Restoration of a Persistent Native Community

- Soil microbiota
 - Arbuscular Mycorrhizal Fungi (Busby et al. (in press) Appl. Soil Ecol.)
- Wildlife??
 - Seed dispersal, Herbivory, Nutrient cycling
- Disturbance regime??
 - Fire, Flooding, Insect outbreaks

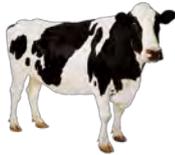
Overarching Hypothesis

Seeding early seral annual plants following exotic tree removal at Canyon de Chelly National Monument will facilitate native plant community development over time.

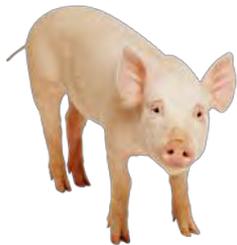
- Compete with herbaceous exotics
- Promote native plant establishment and **persistence**



Restoration Criteria



~~Weeds~~



Experimental Setup

Seed mix

- No Seed
- Standard Perennial
- Perennial plus Annuals

Seeding Rate

- Standard 650 PLS per m²
- ++ Hyper 2400 PLS per m²
(Hand broadcast)

Get them to grow!

- Branches
 - Sterile
 - Annual
 - Crossbred Wheatgrass



60 plots, 3m X 3m, established 2009

Standard Perennial Mix

Scientific Name	Common Name	Life Form
<i>Oenothera elata</i>	Hooker's evening primrose	Forb
<i>Oenothera pallida</i>	pale evening primrose	Forb
<i>Sphaeralcea coccinea</i>	scarlet globemallow	Forb
<i>Achnatherum hymenoides</i>	indian ricegrass	Grass
<i>Bouteloua gracillis</i>	blue gramma	Grass
<i>Distichlis stricta</i>	inland saltgrass	Grass
<i>Elymus trachycaulus</i>	slender wheatgrass	Grass
<i>Hesperostipa comata</i>	needle and thread	Grass
<i>Pascopyrum smithii</i>	western wheatgrass	Grass
<i>Sporobolus cryptandrus</i>	Sand dropseed	Grass
<i>Sporobolus airoides</i>	Alkali sacaton	Grass

Finding Native Annuals

- USDA PLANTS Database
 - Native
 - Forb or Graminoid
 - Annuals or Biennials
 - 4 county area
- Canyon de Chelly Checklist (Rink, 2005)
- Commercial availability
- Investigate species that
 - (grazing, upland, aesthetic)

The screenshot shows the USDA PLANTS Database Advanced Search and Download interface. The page is titled "Advanced Search and Download" and includes a navigation menu with options like Home, About PLANTS, Team, Partners, What's New, NPDC, Help, and Contact Us. The main content area is divided into two sections: "1. Distribution" and "2. Taxonomy".

1. Distribution

Field	Include	Options	Display
PLANTS Floristic Area or Not	include:	Any PLANTS Floristic Area --North America --Lower 48 U.S. States --Alaska --Canada	<input type="checkbox"/> Display
State and Province	include:	Any U.S. States --Alabama --Alaska --Arizona --Arkansas	<input type="checkbox"/> Display
County Distribution (Select a maximum of 256)	include:	Any Alabama: Autauga Alabama: Baldwin Alabama: Barbour Alabama: Bibb Alabama: Blount	<input type="checkbox"/> Display

2. Taxonomy

Field	Include	Options	Display
Category	include:	Any Green Alga Dicot	<input type="checkbox"/> Display
Symbol	include:	Wild cards are permitted.	<input type="checkbox"/> Display
Scientific Name	include:	Wild cards are permitted. Accepted Names and Synonyms	<input checked="" type="checkbox"/> Display by default <input type="checkbox"/> Display all Synonyms
Author	include:	Any Only Genus Epithet Only Species Epithet	Display Rank: Genus, Variety, Species, Subvariety, Subspecies, Forma Display Authors in Scientific Name
National Common Name	include:	Wild cards are permitted.	Display Authors and Scientific Name in separate fields Display
Genus	include:	Wild cards are permitted.	Display
Family	include:	Any Acanthaceae Acarosporaceae	Display
Family Symbol	include:	Any ACANTH ACAROS	Display
Family Common Name	include:	Any Acanthus family Achatocarpus family	Display
Order	include:	Any Agaricales Alismatales	Display
Subclass	include:	Any	Display

More Native Annual Plants Please!

- ~350 Species From USDA PLANTS Database
- 53 of 350 species available (15%)
 - From 9 Suppliers (more searched)
- 27 Species Suitable to Site
- 11 Annual plants in mix
 - More grasses!!
 - Final Criteria:
 - Cost
 - Quantity available
 - Restoration value
 - Grazing

Annual Early Seral Species

Scientific Name	Common Name	Life Form
<i>Bahia dissecta</i>	ragleaf bahia	Forb
<i>Cleome serrulata</i>	Rocky Mountain beeplant	Forb
<i>Coreopsis tinctoria</i>	golden tickseed	Forb
<i>Gaillardia pulchella</i>	firewheel	Forb
<i>Helianthus annuus</i>	common sunflower	Forb
<i>Machaeranthera tanacetifolia</i>	tansyleaf tansyaster	Forb
<i>Monarda citriodora</i>	lemon beebalm	Forb
<i>Phacelia crenulata</i>	cleftleaf wildheliotrope	Forb
<i>Verbesina encelioides</i>	golden crownbeard	Forb
<i>Aristida purpurea</i>	purple three-awn	Grass
<i>Triticum aestivum x Secale cereale</i>	Quickguard, sterile wheat	Grass
<i>Vulpia octoflora</i>	six-weeks fescue	Grass



Plant Biomass by Year

Increasing Seeding Rate

Increasing Species Richness



Unseeded

Standard

Standard ++

Annual Standard

Annual Standard ++

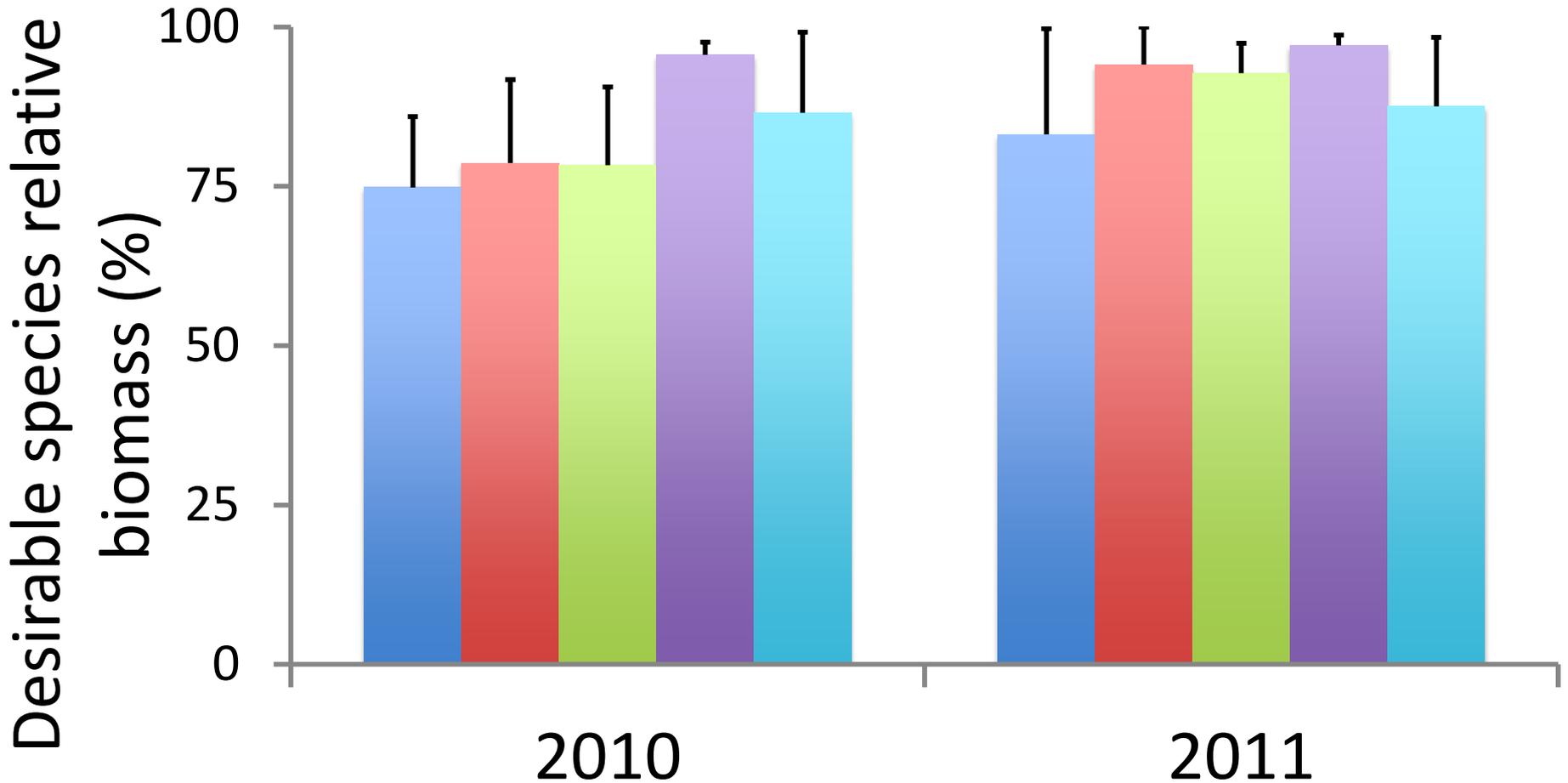
*Significantly different from unseeded control in same year

Plant Biomass by Year

Increasing Seeding Rate
Increasing Species Richness



Unseeded **Standard** **Standard ++** **Annual Standard** **Annual Standard ++**



*Significantly different from unseeded control in same year

Species Richness by Year

Increasing Seeding Rate
Increasing Species Richness



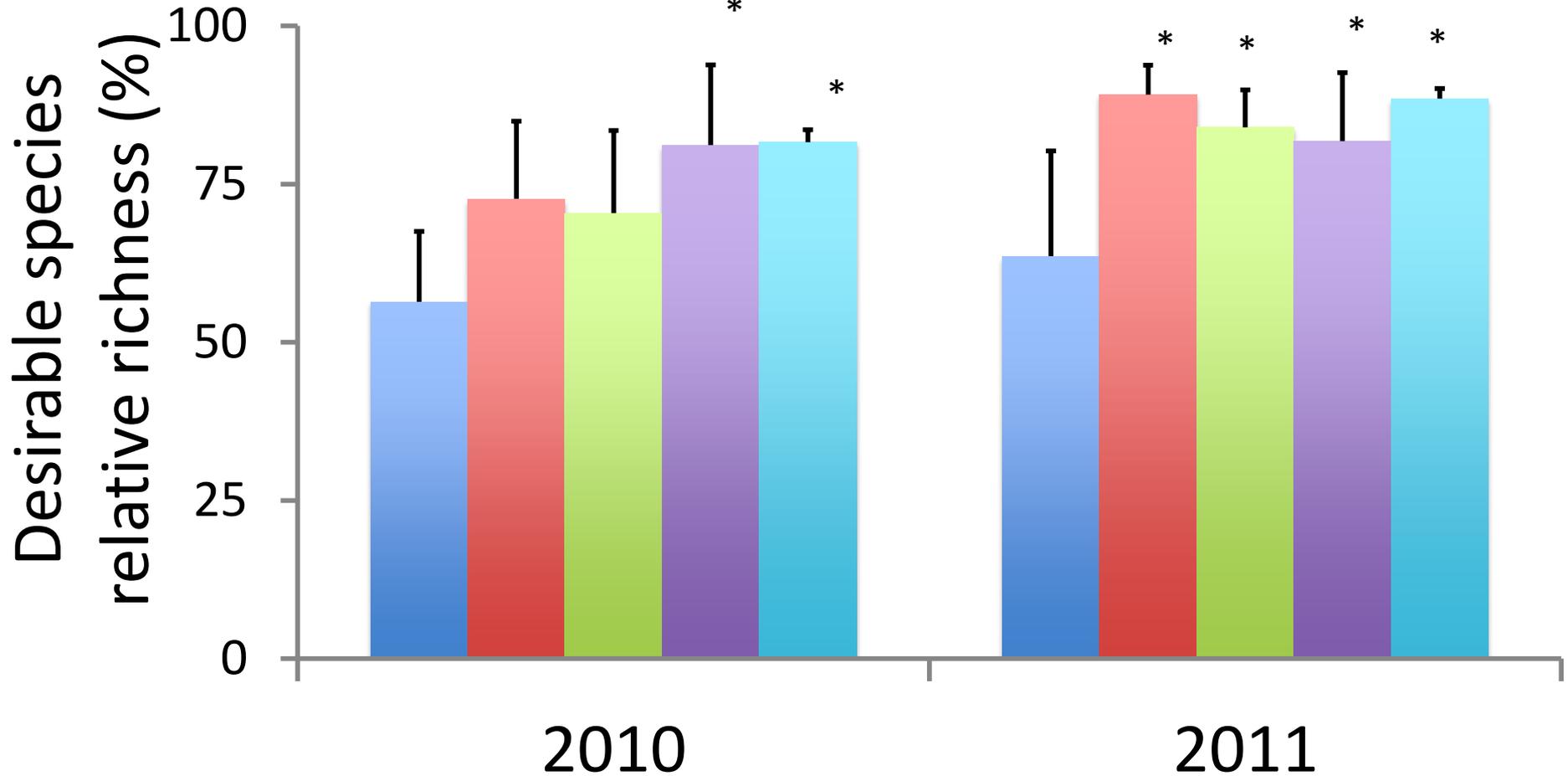
Unseeded

Standard

Standard ++

Annual Standard

Annual Standard ++



*Significantly different from unseeded control in same year

Goals Accomplished? Are Native Early Seral Species *Redirecting* Ecosystem Development

- 1. Branches bad here – maybe good other places?**
 - Residual cottonwood leaves
- 2. Compete with Invasive Herbaceous Species**
 - Few invasives. Lucky...or genius?
- 3. Facilitate Restoration of a Persistent Native Community**
 - Wait and see

Teaching Restoration



Acknowledgements



Acknowledgements



Inside the Ivory – How a Restoration Research Project develops from paper to plants

- Project started – CACH wanted to take action for trees > Tess Johnstone.
- needed help – David Cooper > Lindsay Reynolds > Greg and Mark
- Inhabited for a long time > white People came, Planted trees 1900's
- Also brought weeds – russian thistle, cheatgrass, knapweed, trees too
- Can get rid of trees, but what's left? Bare ground or weeds. Russian Olive – N fixer
- Restart system – restoration following natural progression – native annuals
 - Show seed list (or pics)
- Land leased to native peoples, working landscape
 - Plants important for NPS goals, Tourism, and livestock
- Applied seeding treatments w/native annuals, mulch treatments – Low budget and easy
- First year – more seeds = more plants AP-Hyp highest biomass
- Second year – P-Hyp highest biomass
 - Not many differences between rates/mixes, seeded better than not
- Annual biomass lower where not seeded first year, no difference second year.
- After 2 years: More residual trees than expected, branch trt = leaf collectors, smothered plants = lower biomass and species richness
- Conclusions:
 - Mulch no good, but maybe elsewhere, plants need microsites!
 - Seeding is good, but not sure which ones.

Restoration Process

Desired Target Community:

- Native
- Grazing tolerant
- Tourist friendly / Historical



Developing Seed Mix

Get Seeds to Grow



Results: First Two Years

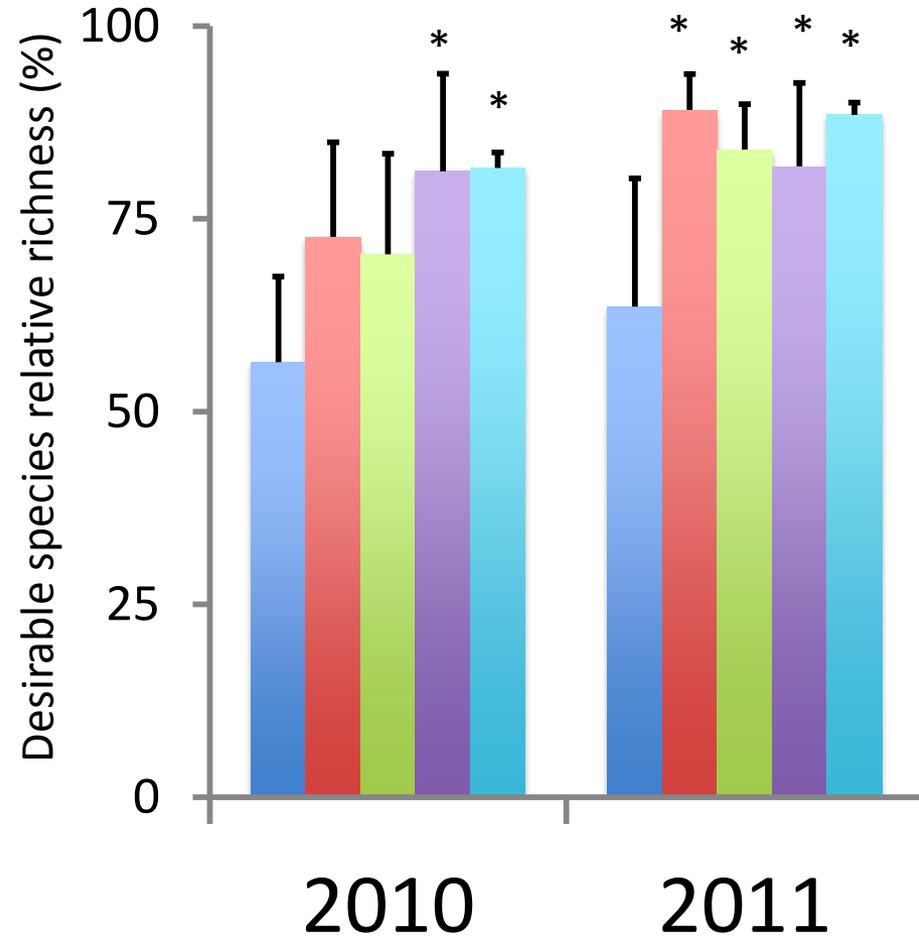
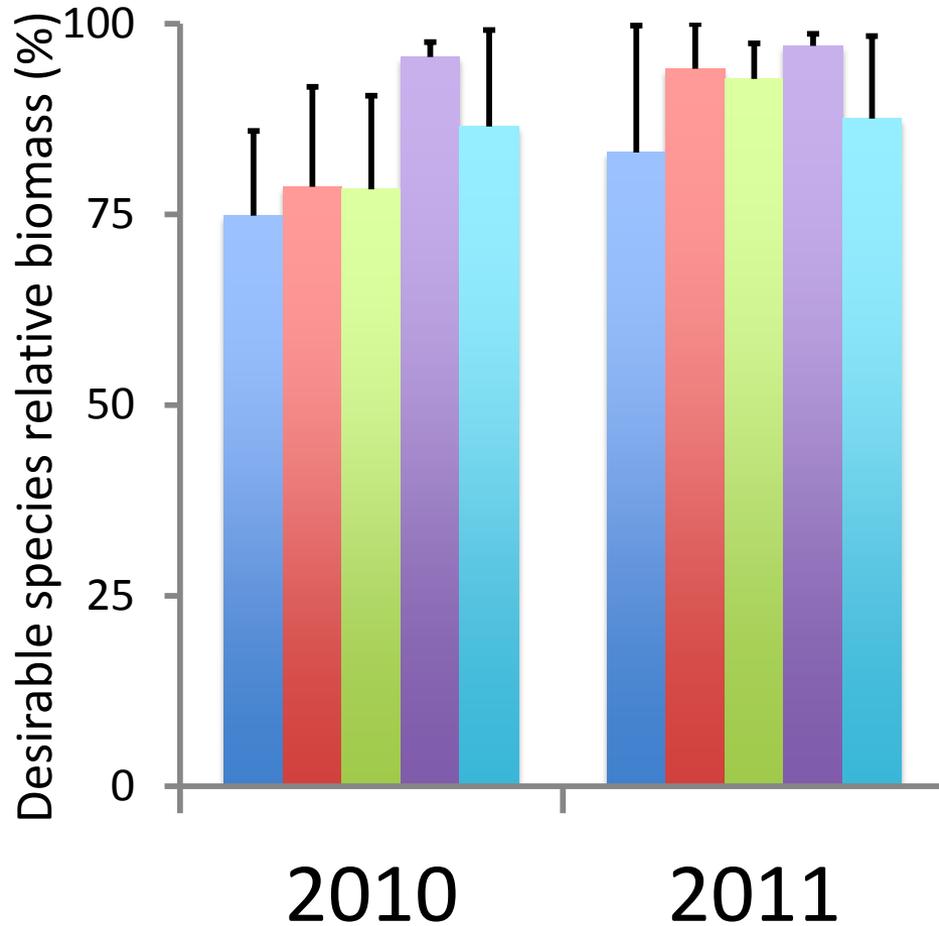
Unseeded

Standard

Standard ++

Annual Standard

Annual Standard ++



*Significantly different from unseeded control in same year

















Why Care About Annuals?

- Problem: Restoration seed mixes tend to be dominated by late seral plants or non-natives
 - May not compete as well against invasive species
 - Low resistance to exotic plant reinvasion
 - Low **resilience** to future disturbance



