RestoreNet: A field trial network to improve restoration outcomes across environmental gradients

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1: U.S. Geological Survey, 2: Northern Arizona University, 3: U.S. Forest Service, 4: Colorado State University, 5: Center for Natural Lands Management, 6: University of Arizona, 7: University of Montana, 8: University of California, Riverside, 9: New Mexico State University, 10: Washington Department of Fish & Wildlife

U.S. Department of the Interior
U.S. Geological Survey

RAMPS: Restoration Assessment & Monitoring Program for the Southwest

Mission

Strengthen restoration and rehabilitation outcomes in the Southwest U.S. by proving science and guidance on effective strategies

http://usgs.gov/sbsc/ramps

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Why RAMPS?

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RAMPS

Connecting
Science and Land Management
To Enhance
Southwest Ecosystems

3-Part Collaborative Approach to Restoring Ecosystems

3. Communication and Outreach

2. Research

1. Partner Engagement

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NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT


U.S.
FISH & WILDLIFE
SERVICE


NATIONAL
PARK
SERVICE


1824
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF INDIAN AFFAIRS


FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE


NORTHERN
ARIZONA
UNIVERSITY


CPNPP
COLORADO PLATEAU
NATIVE PLANT PROGRAM


DEPARTMENT OF FORESTRY AND FIRE MANAGEMENT
AZ


NAVAJO
FISH & WILDLIFE


UTAH
DNR
WILDLIFE RESOURCES


Tolani Lake Enterprises


UCDAVIS
UNIVERSITY OF CALIFORNIA


UC
RIVERSIDE


USDA
NRCS
U.S. Department of Agriculture
Natural Resources Conservation Service


CANYONLANDS
RESEARCH CENTER


XWN
CROSS WATERSHED
NETWORK


pca
plant conservation alliance


UNLV


BORDERLANDS
RESTORATION
NETWORK


The Nature
Conservancy


SWVMA
SOUTHWEST VEGETATION
MANAGEMENT ASSOCIATION


MCDOWELL
SONORAN
CONSERVANCY
Science is in our nature


ARIZONA


SER
SOCIETY FOR
ECOLOGICAL
RESTORATION
SOUTHWEST


CHICAGO
BOTANIC
GARDEN


CAZCA
CENTRAL ARIZONA CONSERVATION ALLIANCE


NM
STATE
UNIVERSITY


S E G A
Southwest Experimental Garden Array


Institute
for
Applied
Ecology


FRIENDS of
VERDE RIVER
GREENWAY


BABBITT RANCHES
ARIZONA


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Diablo Trust
A Northern Arizona Collaborative Grassroots Land Management Team

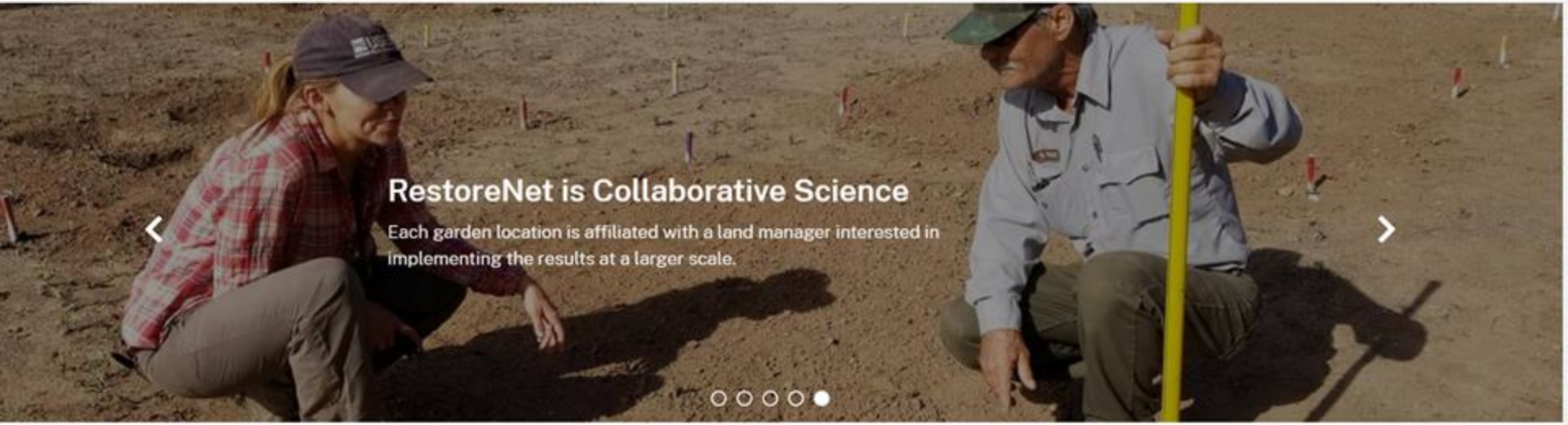

SWSP

SOUTHWEST BIOLOGICAL SCIENCE CENTER | SCIENCE

RestoreNet: Distributed Field Trial Network for Dryland Restoration

ACTIVE

By Southwest Biological Science Center August 5, 2017



RestoreNet is a co-produced research network that systematically tests dryland restoration treatments across environmental gradients in the Southwest

http://usgs.gov/sbsc/restorenet

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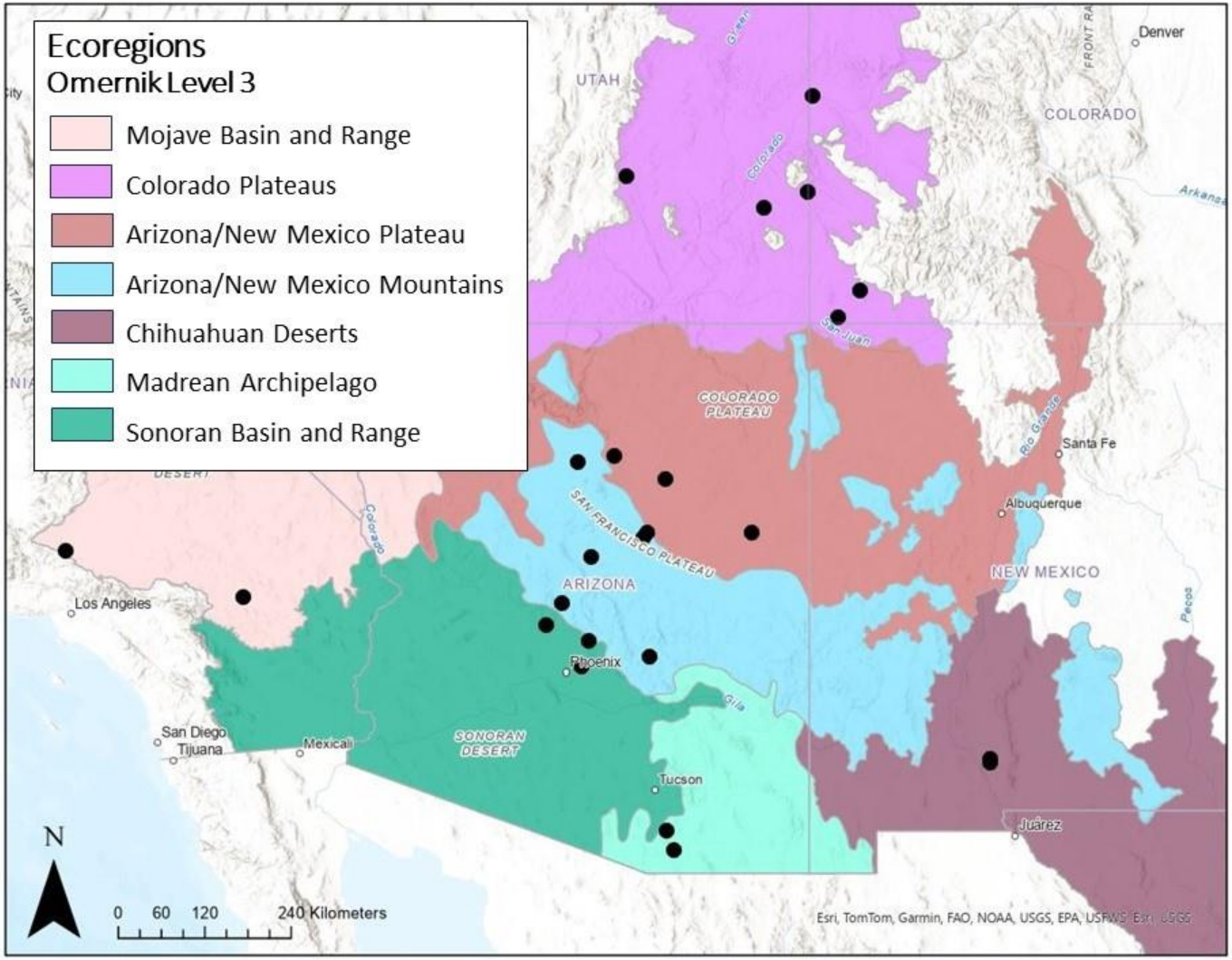

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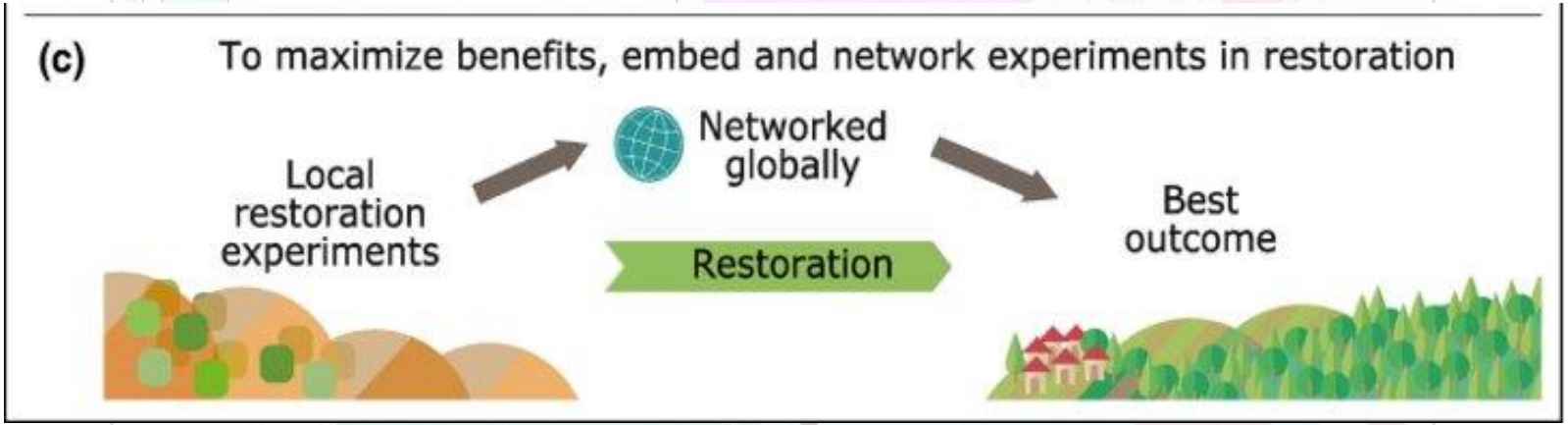

Gellie et al (2018) Front. Ecol. Environ.

RestoreNet benefits land managers

- Knowledge co-production
- Demonstration sites
- Low risk testing

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Treatments

Seed mixes

Soil surface modifications

Outplants

Seedballs

Live topsoil inoculation

Targeted livestock treatments

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Monitoring

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RestoreNet 1.0
2018-2022

Katie Laushman

Molly McCormick

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Seed x Soil Surface Treatments

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Outplanted Seedlings

RestoreNet 1.0: Seed mixes

- Native forbs, grasses, shrubs
- Cool vs. warm mixes (relative to each region)

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RestoreNet 1.0: Soil surface modifications

Soil Pits

Mulch

ConMods

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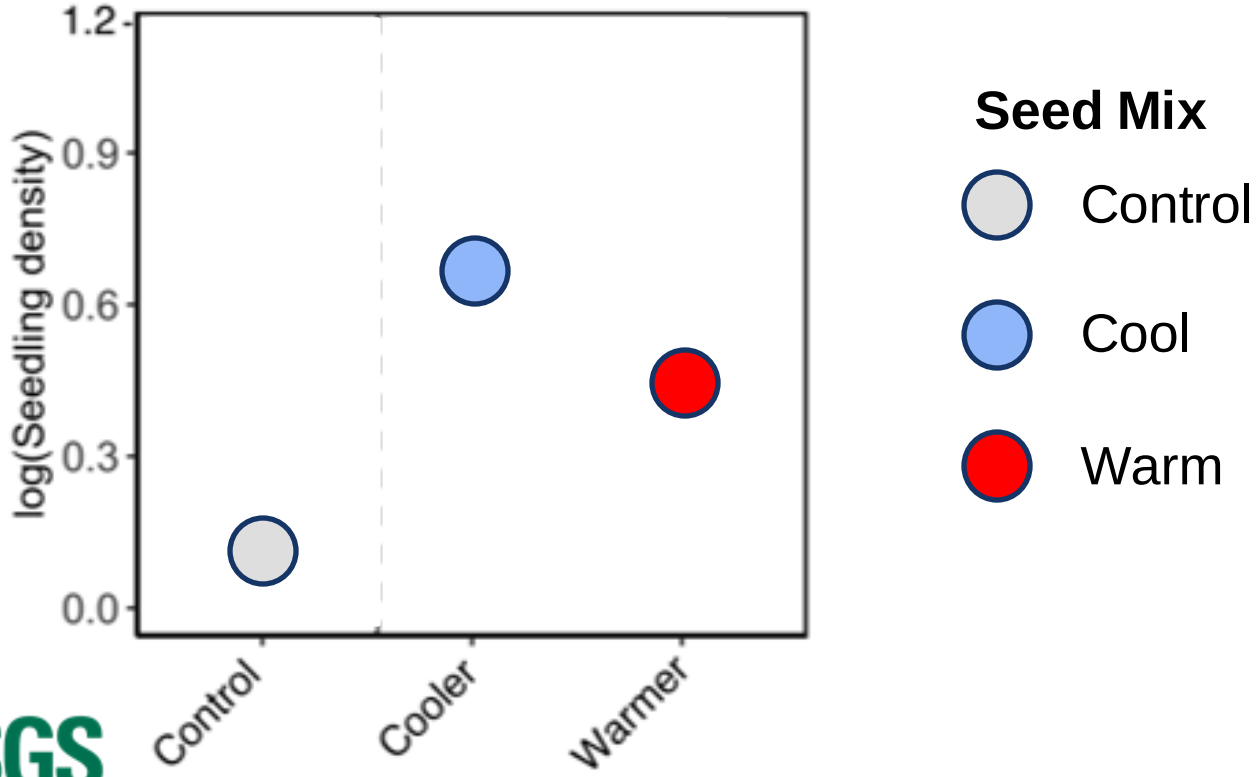
Cool seed mix outperformed warm



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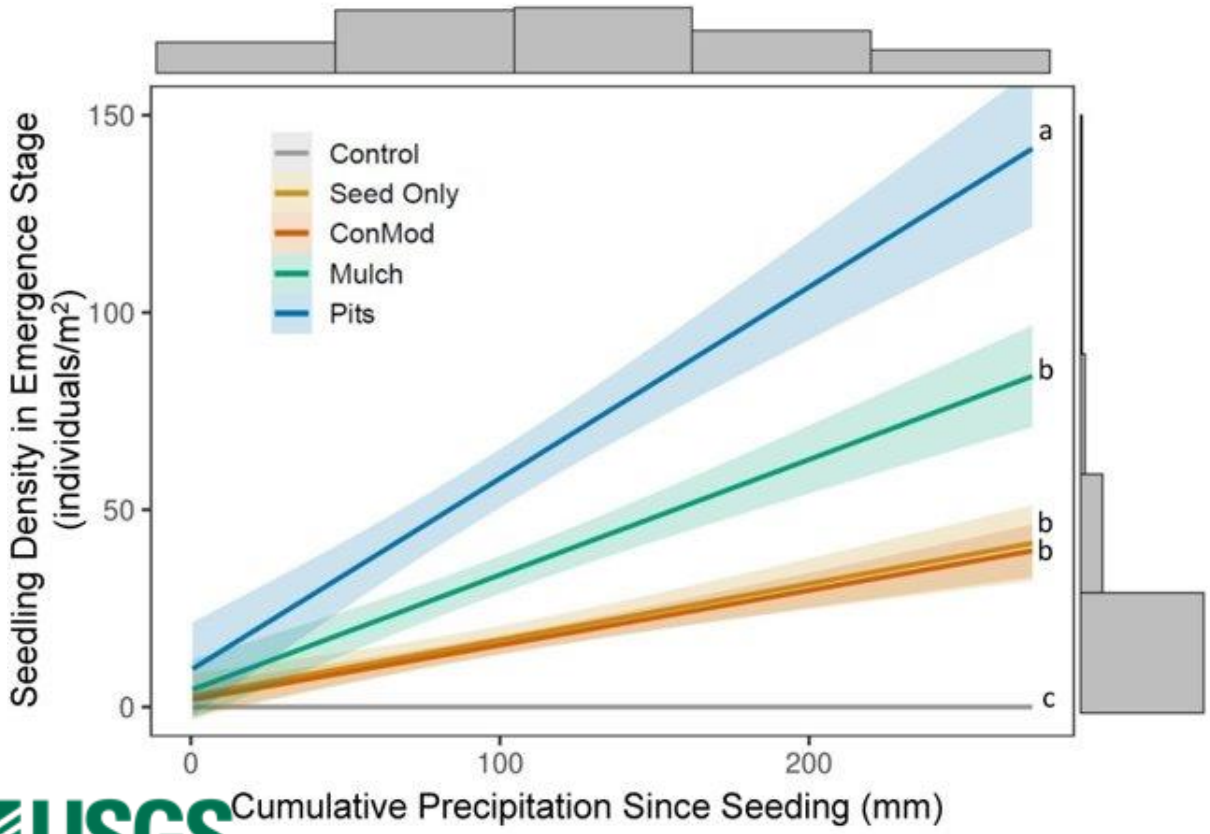
Havrilla et al. (2020) Journal of Applied Ecology 57(11)

Soil surface modifications improved seeding success



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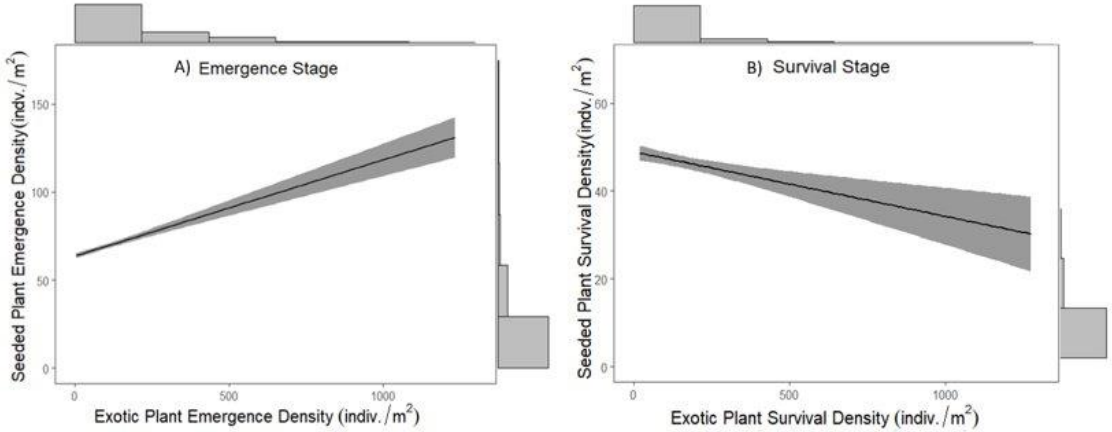
Farrell et al. (2023) Ecological Applications 33(4)

Invasive species limited seeded emergence, but not survival



Farrell et al. (2023) Ecological Applications 33(4)

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Key takeaways

Cool seed mix did best

Havrilla et al. (2020) Journal of Applied Ecology 57(11), Farrell et al. (2023) Ecological Applications 33(4)

Key takeaways

Cool seed mix did best

Pits improved seeding success

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Havrilla et al. (2020) Journal of Applied Ecology 57(11), Farrell et al. (2023) Ecological Applications 33(4)

Key takeaways

Cool seed mix did best

Pits improved seeding success

Precipitation matters

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Havrilla et al. (2020) Journal of Applied Ecology 57(11), Farrell et al. (2023) Ecological Applications 33(4)

Key takeaways

Cool seed mix did best

Pits improved seeding success

Precipitation matters

Exotic species lowered survival

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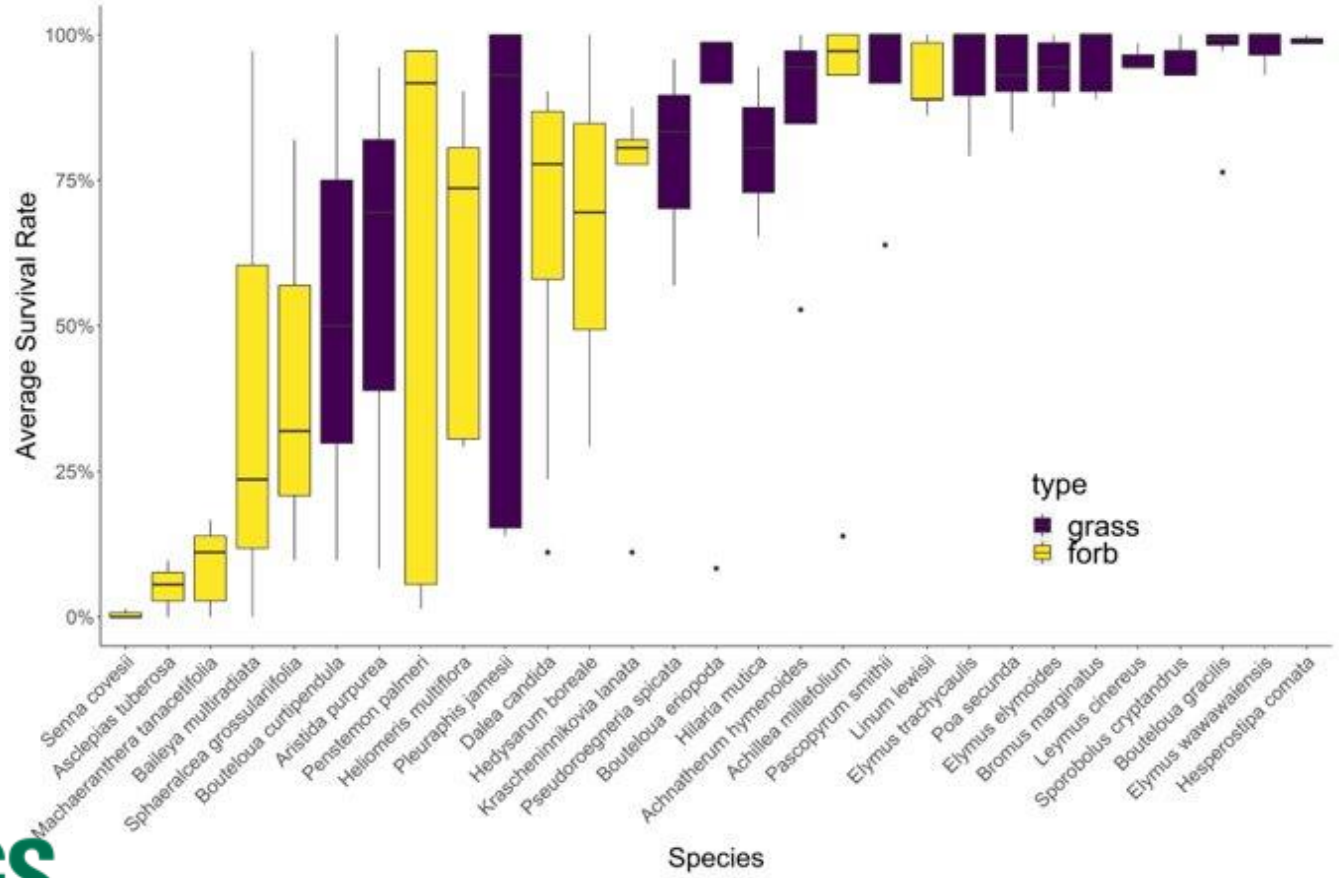
Havrilla et al. (2020) Journal of Applied Ecology 57(11), Farrell et al. (2023) Ecological Applications 33(4)

RestoreNet Outplants

- Same species as seeding experiments
- Seedlings grown in greenhouse then outplanted
- Some plants harvested for trait-screening in greenhouse

Kathleen Balazs

Survival differed by species, grasses had higher survival than forbs



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Balazs et al. (2022) Journal of Ecology 110(3)

Plant traits

- Influence plant x environment interaction
- Represent different strategies

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Successful traits across all environments

Successful

Dense leaves

Thin roots

Unsuccessful

Thin leaves

Thick roots

Balazs et al. (2022) Journal of Ecology 110(3)

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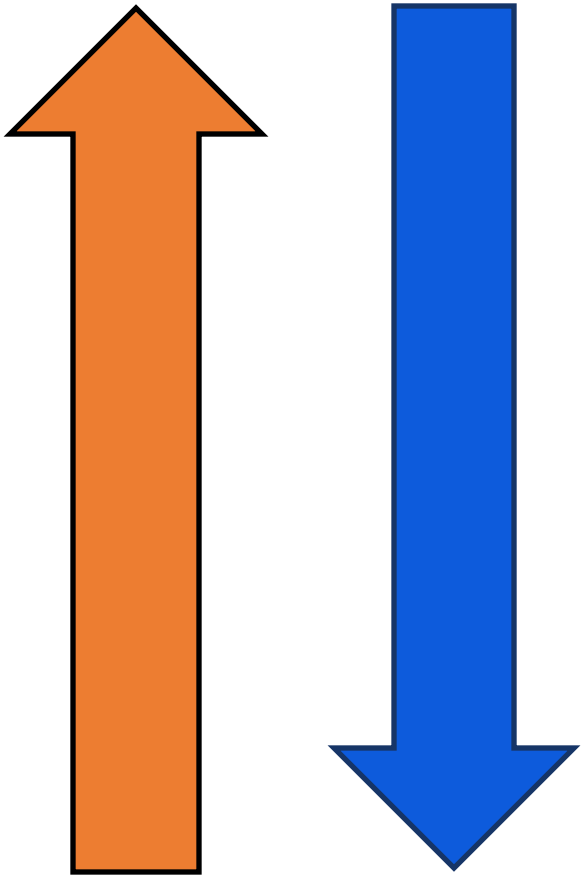
Aridity



Survival, trait variation

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Balazs et al. (2022) Journal of Ecology 110(3), Butterfield et al. (2023) Journal of Applied Ecology 60(6)

Key results and takeaways

Traits may predict outplant success

Balazs et al. (2022) Journal of Ecology 110(3), Butterfield et al. (2023) Journal of Applied Ecology 60(6)

Key takeaways

Traits may predict outplant success

Trait variation was restricted at the harshest sites

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Balazs et al. (2022) Journal of Ecology 110(3), Butterfield et al. (2023) Journal of Applied Ecology 60(6)

Key takeaways

Traits may predict outplant success

Trait variation was restricted at the harshest sites

Matching traits to environment may improve outcomes

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Balazs et al. (2022) Journal of Ecology 110(3), Butterfield et al. (2023) Journal of Applied Ecology 60(6)

RestoreNet 2.0
2022-present

Hannah Farrell

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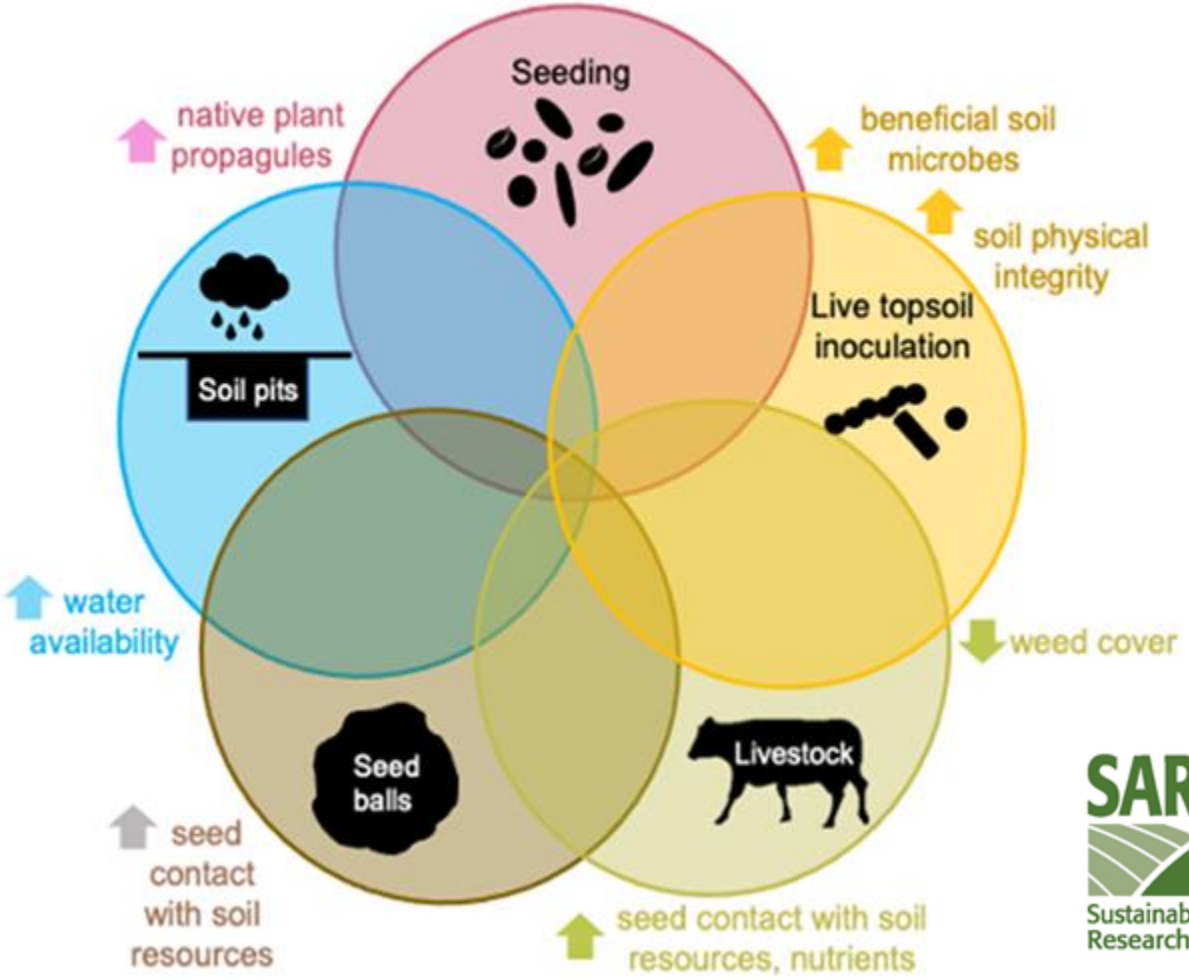
RestoreNet 2.0



Colorado State University

NAU

Arizona

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SARE Sustainable Agriculture Research & Education

Soil inoculation

- Restoration didn’t trigger soil microbe changes after 1 year[1]
- Testing site-specific microbiome restoration through soil inoculation
- Soil from reference site → bulked → applied

1:Yang et al. (2021) Journal of Applied Ecology 58(2)



RestoreNet site

Reference site

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Targeted livestock treatments

- Immediately after seeding
- Soil-seed contact
- Nutrients

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OCTOBER 27, 2023

RAMPS Newsletter - Fall 2023

In this edition:

Hello from new RAMPS coordinator, accomplishments from Fiscal year 2023, and upcoming projects.

Read Article →

APRIL 19, 2023

RESEARCH BRIEF: Lessons from five years of RestoreNet

RestoreNet is a networked ecological restoration experiment spanning drylands of the American Southwest to inform land management. Since 2017, we have...

Read Article →

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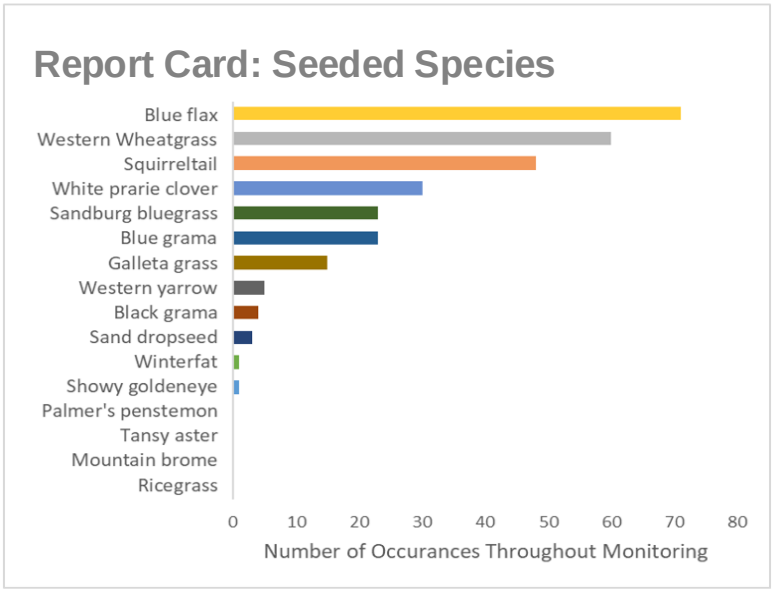

Contact:

Lshriver@usgs.gov

RAMPS: www.usgs.gov/sbsc/ramps

RestoreNet: www.usgs.gov/sbsc/restorenet

RAMPS newsletter:

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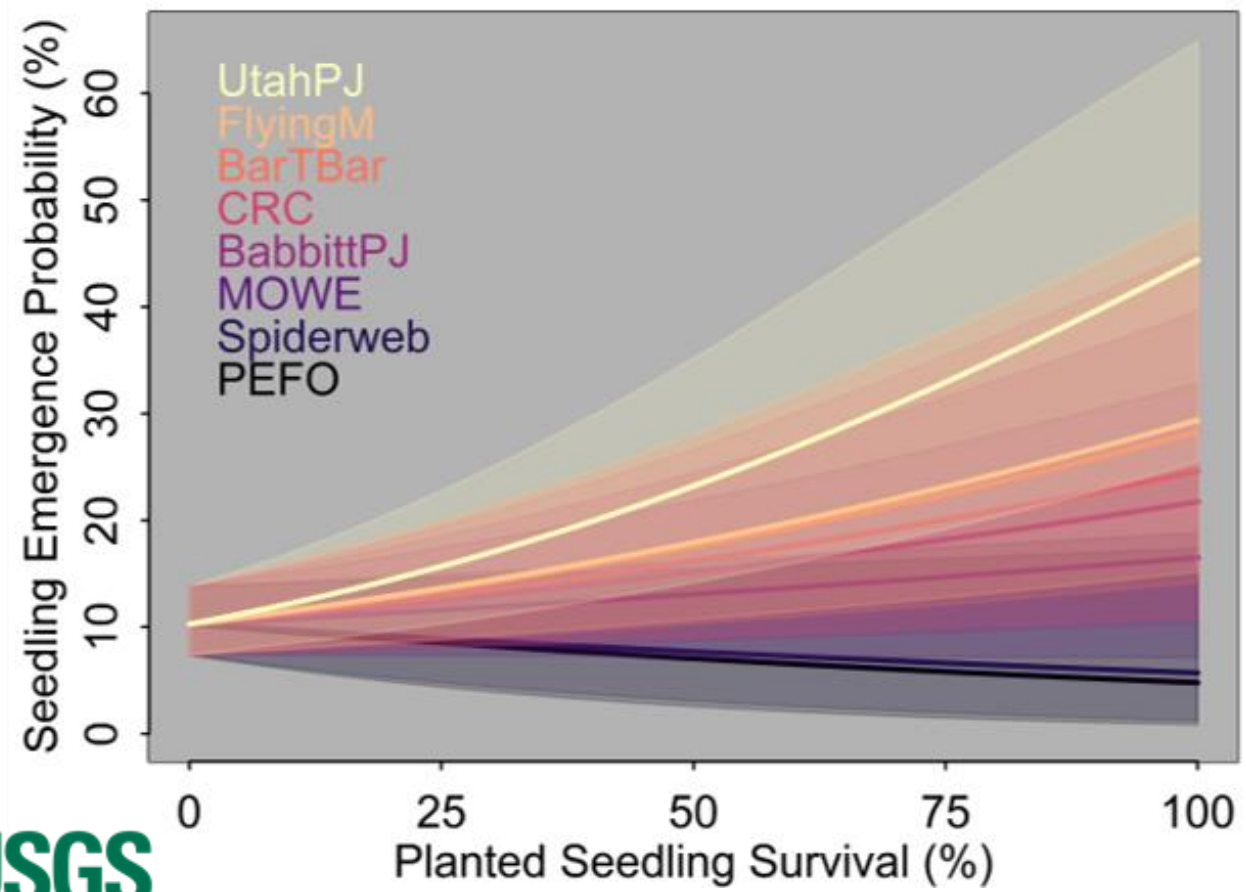
OPTIONAL SLIDES: used if presentation time is longer than 20 minutes or for site-specific presentations where managers may be interested in the species in hte seed mixes

Seedling emergence and outplant survival were correlated at cooler sites



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Butterfield & Munson, In Press, Appl Veg Science

Get involved!

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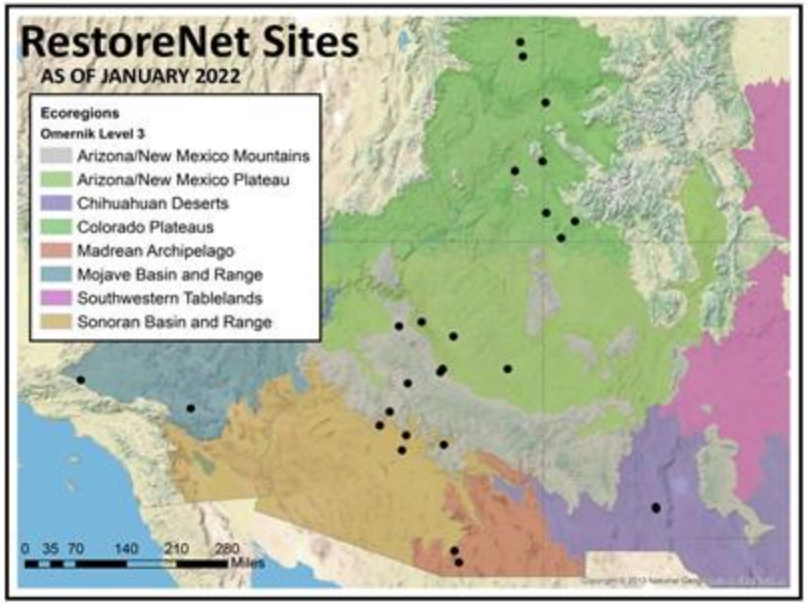

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Prepared in cooperation with Northern Arizona University

Protocol for Installing and Monitoring a RestoreNet Restoration Field Trial Network Site

Chapter 18 of
Section A, Biological Science
Book 2, Collection of Environmental Data

Techniques and Methods 2–A18

U.S. Department of the Interior
U.S. Geological Survey

RestoreNet 1.0: Seed mixes

Sporobolus cryptandrus
(sand dropseed)

Salvia columbariae
(chia)

Region	Scientific name	Common name	Seed mix
Sonoran Desert	*Ambrosia deltoidea*	Triangle-leaf bursage	cool
Sonoran Desert	*Baileya multiradiata*	Desert marigold	cool
Sonoran Desert	*Digitaria californica*	Sixweeks grama	cool
Sonoran Desert	*Lupinus sparsiflorus*	Coulter's lupine	cool
Sonoran Desert	*Muhlenbergia porteri*	Bush muhly	cool
Sonoran Desert	*Salvia columbariae*	Chia	cool
Sonoran Desert	*Sphaeralcea ambigua*	Apricot globemallow	cool
Sonoran Desert	*Sporobolus cryptandrus*	Sand dropseed	cool
Sonoran Desert	*Aristida purpurea*	Purple three-awn	warm
Sonoran Desert	*Bouteloua aristidoides*	Needle grama	warm
Sonoran Desert	*Bouteloua curtipendula*	Sideoats grama	warm
Sonoran Desert	*Bouteloua rothrockii*	Black grama	warm
Sonoran Desert	*Calliandra eriophylla*	Fairyduster	warm
Sonoran Desert	*Encelia farinosa*	Brittlebush	warm
Sonoran Desert	*Plantago ovata*	Desert indianwheat	warm
Sonoran Desert	*Senna covesii*	Silver senna	warm

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Photos by Max Licher and Patrick Alexander via SEINet

RestoreNet 1.0: Seed mixes

Bouteloua rothrockii (Rothrock's grama)

Senna covesii (desert senna)

Region	Scientific name	Common name	Seed mix
Sonoran Desert	*Ambrosia deltoidea*	Triangle-leaf bursage	cool
Sonoran Desert	*Baileya multiradiata*	Desert marigold	cool
Sonoran Desert	*Digitaria californica*	Sixweeks grama	cool
Sonoran Desert	*Lupinus sparsiflorus*	Coulter's lupine	cool
Sonoran Desert	*Muhlenbergia porteri*	Bush muhly	cool
Sonoran Desert	*Salvia columbariae*	Chia	cool
Sonoran Desert	*Sphaeralcea ambigua*	Apricot globemallow	cool
Sonoran Desert	*Sporobolus cryptandrus*	Sand dropseed	cool
Sonoran Desert	*Aristida purpurea*	Purple three-awn	warm
Sonoran Desert	*Bouteloua aristidoides*	Needle grama	warm
Sonoran Desert	*Bouteloua curtipendula*	Sideoats grama	warm
Sonoran Desert	*Bouteloua rothrockii*	Black grama	warm
Sonoran Desert	*Calliandra eriophylla*	Fairyduster	warm
Sonoran Desert	*Encelia farinosa*	Brittlebush	warm
Sonoran Desert	*Plantago ovata*	Desert indianwheat	warm
Sonoran Desert	*Senna covesii*	Silver senna	warm

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Photos by Sue Rutman and Max Licher via SEINet

RestoreNet 1.0: Seed mixes

Sporobolus cryptandrus
(sand dropseed)

Heliomeris multiflora
(showy goldeneye)

Region	Scientific name	Common Name	Seed mix
Madrean Archipelago	*Bouteloua gracilis*	blue grama	Cool
Madrean Archipelago	*Elymus elymoides*	squirreltail	Cool
Madrean Archipelago	*Heliomeris multiflora*	showy goldeneye	Cool
Madrean Archipelago	*Hesperostipa neomexicana*	New Mexico feathergrass	Cool
Madrean Archipelago	*Machaeranthera tanacetifolia*	tansey aster	Cool
Madrean Archipelago	*Poa secunda*	Sandberg bluegrass	Cool
Madrean Archipelago	*Sporobolus cryptandrus*	sand dropseed	Cool
Madrean Archipelago	*Aristida purpurea*	purple three-awn	Warm
Madrean Archipelago	*Asclepias tuberosa*	pleurisy root	Warm
Madrean Archipelago	*Baileya multiradiata*	desert marigold	Warm
Madrean Archipelago	*Bouteloua curtipendula*	sideoats grama	Warm
Madrean Archipelago	*Penstemon palmeri*	Palmer's penstemon	Warm
Madrean Archipelago	*Pleuraphis jamesii*	James galleta	Warm
Madrean Archipelago	*Senna covesii*	desert senna	Warm

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Photos by Max Licher via SEINet

RestoreNet 1.0: Seed mixes

Bouteloua curtipendula (sideoats grama)

Senna covesii (*desert senna*)

Region	Scientific name	Common Name	Seed mix
Madrean Archipelago	*Bouteloua gracilis*	blue grama	Cool
Madrean Archipelago	*Elymus elymoides*	squirreltail	Cool
Madrean Archipelago	*Heliomeris multiflora*	showy goldeneye	Cool
Madrean Archipelago	*Hesperostipa neomexicana*	New Mexico feathergrass	Cool
Madrean Archipelago	*Machaeranthera tanacetifolia*	tansey aster	Cool
Madrean Archipelago	*Poa secunda*	Sandberg bluegrass	Cool
Madrean Archipelago	*Sporobolus cryptandrus*	sand dropseed	Cool
Madrean Archipelago	*Aristida purpurea*	purple three-awn	Warm
Madrean Archipelago	*Asclepias tuberosa*	pleurisy root	Warm
Madrean Archipelago	*Baileya multiradiata*	desert marigold	Warm
Madrean Archipelago	*Bouteloua curtipendula*	sideoats grama	Warm
Madrean Archipelago	*Penstemon palmeri*	Palmer's penstemon	Warm
Madrean Archipelago	*Pleuraphis jamesii*	James galleta	Warm
Madrean Archipelago	*Senna covesii*	desert senna	Warm

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Photos by Max Licher and Sue Carnahan via SEINet

RestoreNet 1.0: Seed mixes

Sporobolus cryptandrus
(sand dropseed)

Achillea millefolium
(yarrow)

Region	Scientific name	Common Name	Seed mix
Chihuahuan	*Achillea millefolium*	western yarrow	Cool
Chihuahuan	*Bothriochloa barbinodis*	cane beardgrass	Cool
Chihuahuan	*Elymus trachycaulus*	slender wheat grass	Cool
Chihuahuan	*Eriogonum fasciculatum*	flat-top buckwheat	Cool
Chihuahuan	*Krascheninnikovia lanata*	winterfat	Cool
Chihuahuan	*Machaeranthera tanacetifolia*	tansy aster	Cool
Chihuahuan	*Pleuraphis jamesii*	galleta grass	Cool
Chihuahuan	*Sporobolus cryptandrus*	sand dropseed	Cool
Chihuahuan	*Atriplex canescens*	four-wing saltbush	Warm
Chihuahuan	*Baileya multiradiata*	desert marigold	Warm
Chihuahuan	*Bouteloua curtipendula*	side oats grama	Warm
Chihuahuan	*Gaillardia pulchella*	blanket flower	Warm
Chihuahuan	*Leptochloa dubia*	sprangletop	Warm
Chihuahuan	*Poa fendleriana*	mutton grass	Warm
Chihuahuan	*Ratibida columnifera*	Mexican hat	Warm
Chihuahuan	*Sporobolus airoides*	alkalki sacaton	Warm

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Photos by Max Licher via SEINet

RestoreNet 1.0: Seed mixes

Leptochloa dubia
(sprangletop)

Baileya multiradiata
(desert marigold)

Region	Scientific name	Common Name	Seed mix
Chihuahuan	*Achillea millefolium*	western yarrow	Cool
Chihuahuan	*Bothriochloa barbinodis*	cane beardgrass	Cool
Chihuahuan	*Elymus trachycaulus*	slender wheat grass	Cool
Chihuahuan	*Eriogonum fasciculatum*	flat-top buckwheat	Cool
Chihuahuan	*Krascheninnikovia lanata*	winterfat	Cool
Chihuahuan	*Machaeranthera tanacetifolia*	tansy aster	Cool
Chihuahuan	*Pleuraphis jamesii*	galleta grass	Cool
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Chihuahuan	*Baileya multiradiata*	desert marigold	Warm
Chihuahuan	*Bouteloua curtipendula*	side oats grama	Warm
Chihuahuan	*Gaillardia pulchella*	blanket flower	Warm
Chihuahuan	*Leptochloa dubia*	sprangletop	Warm
Chihuahuan	*Poa fendleriana*	mutton grass	Warm
Chihuahuan	*Ratibida columnifera*	Mexican hat	Warm
Chihuahuan	*Sporobolus airoides*	alkalki sacaton	Warm

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