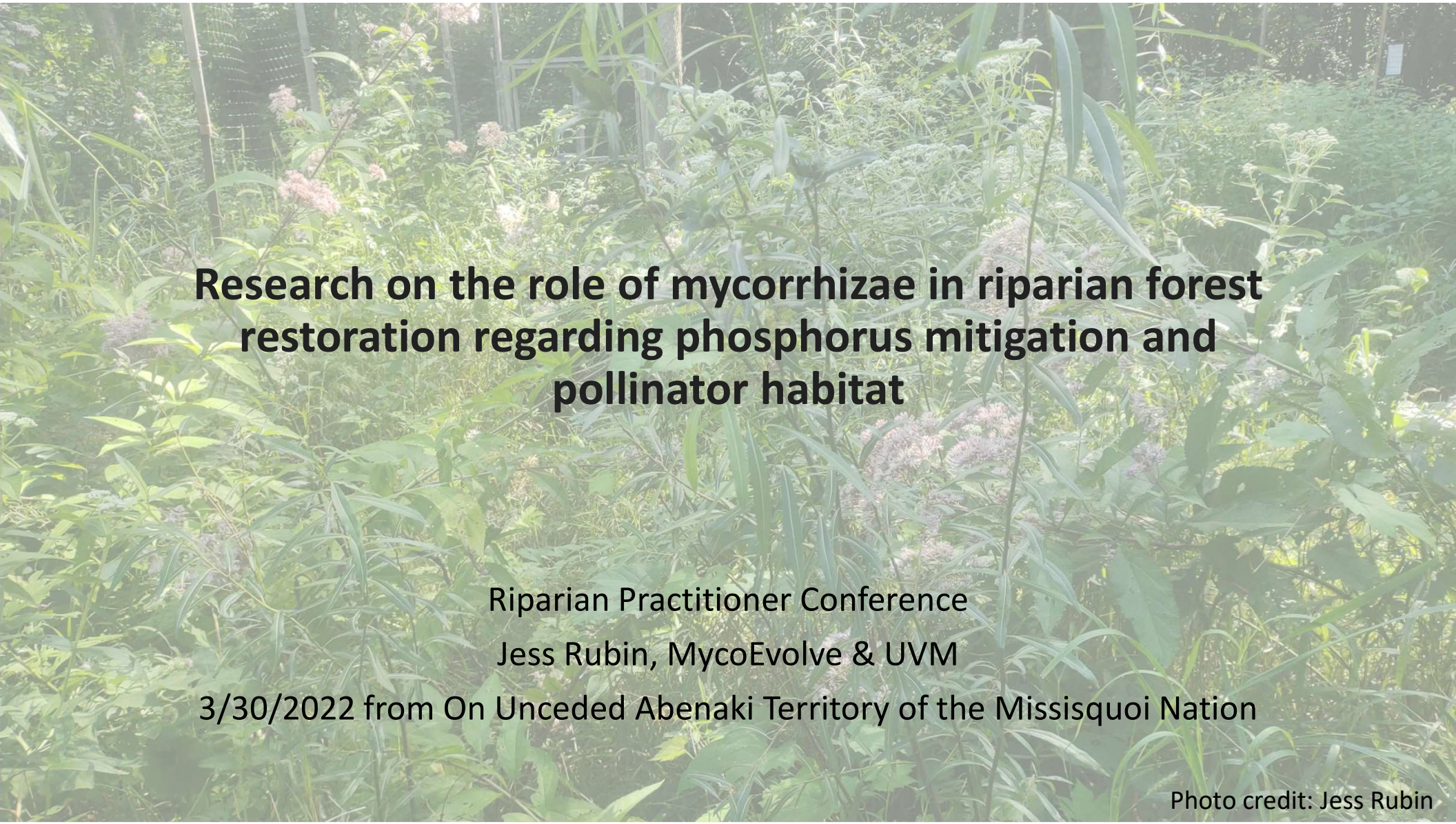

Research on the role of mycorrhizae in riparian forest restoration regarding phosphorus mitigation and pollinator habitat

Riparian Practitioner Conference

Jess Rubin, MycoEvolve & UVM

3/30/2022 from On Unceded Abenaki Territory of the Missisquoi Nation

Photo credit: Jess Rubin


Photo credits: Kim Marie Glynn & Jess Rubin

Case Study at Shelburne Farms

Research how to reduce legacy P by restoring riparian areas now dominated by buckthorn *(Rhamnus cathartica)* to a plant community which existed around the Wabanaki renaissance time.

Potential for Mycorrhizae-Assisted Phytoremediation of Phosphorus for Improved Water Quality

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Research Questions:

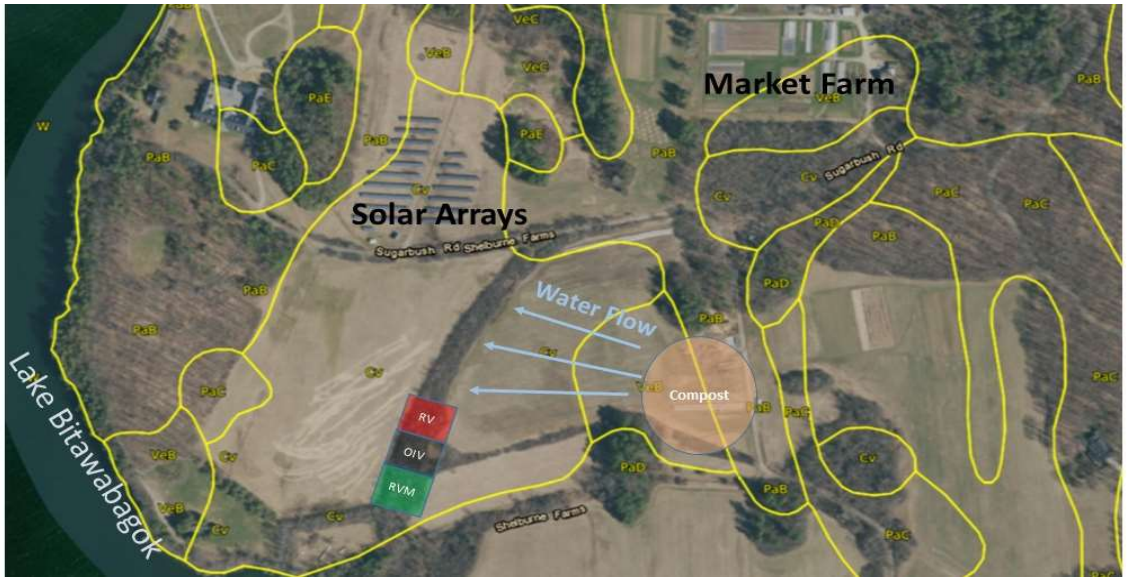
1. Do mycorrhizae improve **legacy P mitigation**?
2. Do mycorrhizae increase **harvestable P amounts**?
3. Do mycorrhizae support a **diverse pollinator plant community**?

Hypotheses combined:

- Soluble Reactive P (SRP) in soil water, Water Extractable P (WEP) & Total P (TP) decreases
- corresponding plant P uptake
- restored plant community stability amidst diversity

Photo credit: Jess Rubin

Case Study at Shelburne Farm
Design



In 2020, installed 3 research plots along drainage way with:

- unaltered buckthorn dominated vegetation (OIV)
- restored vegetation without mycorrhizae (RV)
- restored vegetation with mycorrhizae (RVM).

(Rubin and Görres, 2022, under review)

Case Study at Shelburne Farms

Plant palette

Scientific Name	English Names	Abenaki Uses	#/ plot	Flowering Month (F M A M J J A S O N)	Mycorrhizae	Hosts
Trees						
Acer rubrum	Red maple	e,m	1		AMF	Native & honey bees, Crecopia moths, other moth larvae, birds
Acer saccharum	Sugar maple	e,m	1		AMF	Crecopia moth, birds
Alnus incana	Speckled Alder	m,c	10		ECM/AMF	Song & water birds
Carya ovata	Shagbark Hickory	e,a	2		ECM	Insectivorous birds
Cornus Sericea	Red Osier Dogwood	m,a	19		AMF	Butterflies, Spring Azure, marsh & shore birds
Quercus bicolor	Swamp White Oak	e	1		AMF	Song, ground & water birds
Salix nigra	Black Willow	m	1		ECM/AMF	Mourning Cloak, Viceroy, Red Spotted Purple, Tiger Swallowtail, song birds
Salix petiolaris	Meadow Willow	a	8		ECM/AMF	Native bees, bumblebees, honeybees, Mourning Cloak, Viceroy
Tilia americana	Basswood	e,a,u	1		ECM	Native & honey bees, birds
Ulmus americana	American Elm	a,m	10		AMF	Mourning Cloak, Columbia Silk moth, Question Mark, Painted Lady, Comma Butterfly
Shrubs						
Cephalanthus occidentalis	Buttonbush	m	9		AMF	Native bumblebees, honey bees, butterflies, Titan Sphinx, Hydrangea Sphinx
Ilex verticillata	Winterberry	m	4		AMF	Honey bees, butterflies, Elf larvae host, birds
Sambucus nigra	Elderberry	m	8		AMF	Native, bumble and honey bees, butterflies, Titan Sphinx, Hydrangea Sphinx
Viburnum dentatum	Arrowood	a,u	4		AMF	Native bees, bumblebees, butterflies, Spring Azure, birds
Viburnum lentago	Nannyberry	e,c,m	4		AMF	Butterflies, Spring Azure, birds
Perennials						
Asarum canadense	Wild Ginger	m	9		AMF	Butterflies, Pipeline Swallowtail
Carex comosa	Longhair Sedge		18		AMF	Nesting for insects & birds
Chelone glabra	Turtlehead	m	20		AMF	Hummingbirds, butterflies, Baltimore Checkerspot
Eupatorium perfoliatum	Boneset	m	14		AMF	Native bees, butterflies. Birds
Eutrochium purpureum	Joe Pye Weed	m	21		AMF	Native bees, butterflies, birds
Iris versicolor	Blue Flag Iris	m	18		AMF	Hummingbirds, birds
Symphyotrichum novae-angliae	NE Aster	m, e	9		AMF	Butterflies, birds
Wild Seed mix						
Panicum virgatum	Switch Grass				AMF	Butterflies, Delaware & Dotted Skipper, birds
Elymus virginicus	Virginia Wild Rye				AMF	Butterflies, Branded Skippers and Satyr, birds
Festuca rubra	Red Fescue				AMF	Birds
Carex vulpinoidea	Fox Sedge				AMF	Birds
Scirpus cyperinus	Wool Grass	m,e,a			AMF	Dion Skipper, birds
Scirpus atrovirens	Green Bullgrass				AMF	Song, shore & water birds
Bidens cernua	Nodding Bur-Marigold	m			AMF	Native bees, birds
Eupatorium perfoliatum	Common Boneset	m			AMF	Native bees, butterflies, moths, birds
Eupatoriadelphus maculatus	Joe Pye Weed	m			AMF	Butterflies, Moth caterpillars,
Juncus effusus	Soft Rush	a			AMF	Birds
Onoclea sensibilis	Sensitive Fern	m				Birds
Verbena hastata	Blue Vervain				AMF	Native Bees
Symphyotrichum novae-angliae	NE Aster	m,e			AMF	Native bees, bumblebees, honey bees, Pearl Crescent

(Rubin and Görres, 2022, in press)

(Newman and Reddell, 1987; Brundrett and Kendrick, 1988; Cooke and Lefor, 1998; Clark et al., 1999; Oliveira et al., 2001; Bauer et al., 2003; Vandenkoornhuyse et al., 2003; Scagel, 2004; Wang and Qiu, 2006; Weishampel and Bedford, 2006; Wolfe et al., 2006; Brundrett, 2009; Rudgers and Swafford, 2009; Comas et al., 2014; Bunyard, 2020; "Lady Bird Johnson Wildlife Center," 2021; "National Wildlife Federation - Native Plant Finder," 2021) * Indicates species that are potential dual mycorrhizae of ECM & AMF

Plant palette designed & installed for two restored plots indicates: flowering time, species hosted, & which type of mycorrhizal partner with flora.

3rd column added to by Abenaki: Grandmother and artist, Carol McGranaghan, Missisquoi, John Hunt, artist of the Nulhegan Band, Charlie D. Megeso of the Nulhegan band & Alnobaiwi Council Elder, Fred Wiseman, teacher & scholar of the Abenaki Nation of the Missisquoi.

The initials in third column stand for m-medicinal; e-edible; a-artisanal; c-ceremonial; u-utilitarian

Case Study at Shelburne Farms
Preparation for Research Installation

- low, 0.16%-P pasteurized compost (Vermont Compost, Montpelier, VT, USA)
- bareroot plants & wetland herbaceous seeds aimed for RVM were inoculated with mycorrhizae
- Left to equilibrate for 6 weeks

(Photo credits: Jess Rubin)

Case Study at Shelburne Farms
Site Preparation & Installation

- Buckthorn was cut winter 2020 at belt height
- Spring work parties manually removed stumps more than 4 ft from the drainage
- Fence was erected around restoration sites.
- Native plants and trees on site were left undisturbed.
- Jute erosion control matt was laid down over seeds, cut & planted into

Photo credits: Jess Rubin & Mary Robideau

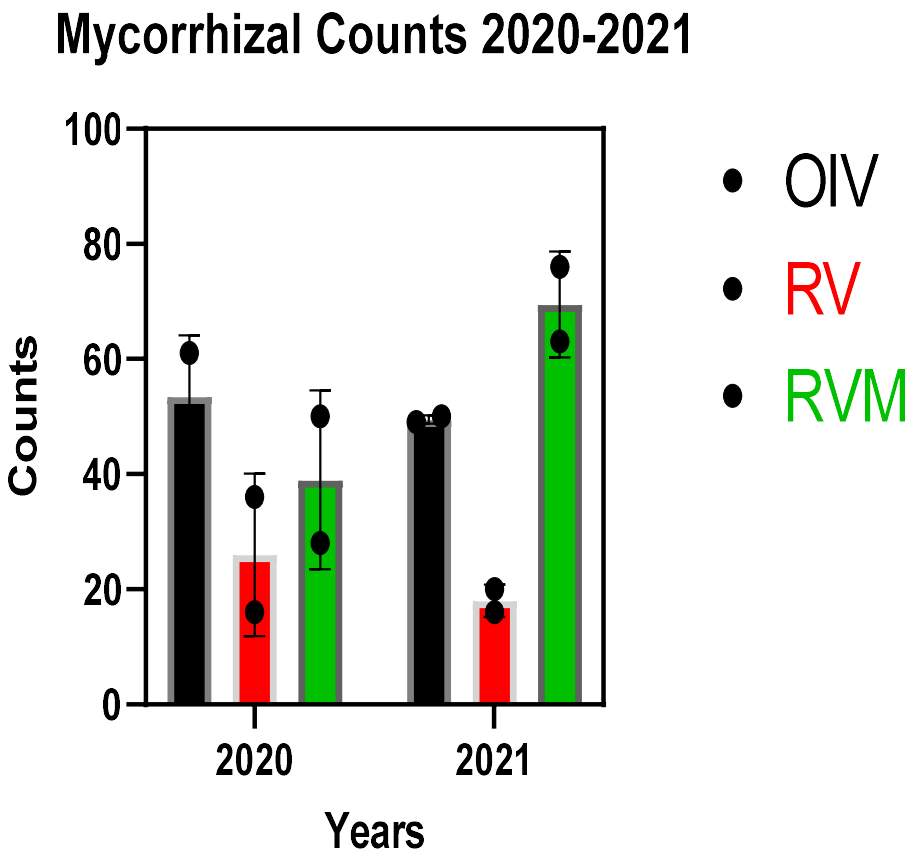
Case Study at Shelburne Farms
Maintenance

- Irrigation
- Removing nonnative species regrowth
- Scything grass herbaceous vegetation

(Photo credits: Jess Rubin)

Case Study at Shelburne Farms

Data



(Rubin and Görres, 2022, in press)

Hyphal density followed this order, RVM > OIV > RV.

Buckthorn associates with specific AMF

- exudes phytotoxin emodin: reduces germination & mycorrhizal associations (Pinzone et al. 2018).
- Plants in RV had few mycorrhizae with which to associate.
- Adding mycorrhizae to RVM resulted in greater hyphal densities

Project scope & budget prohibited mycorrhizal ID to species

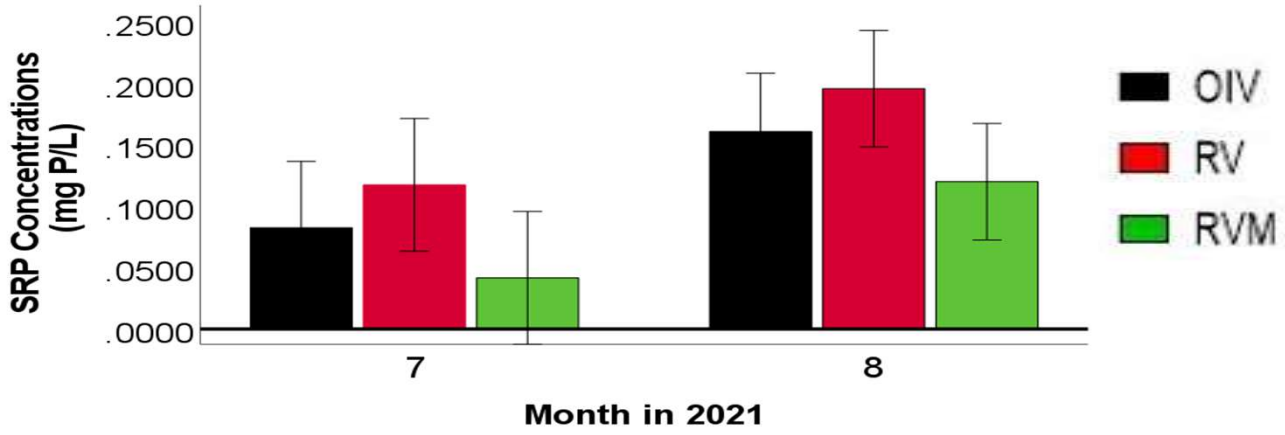
Future mycorrhizal research:

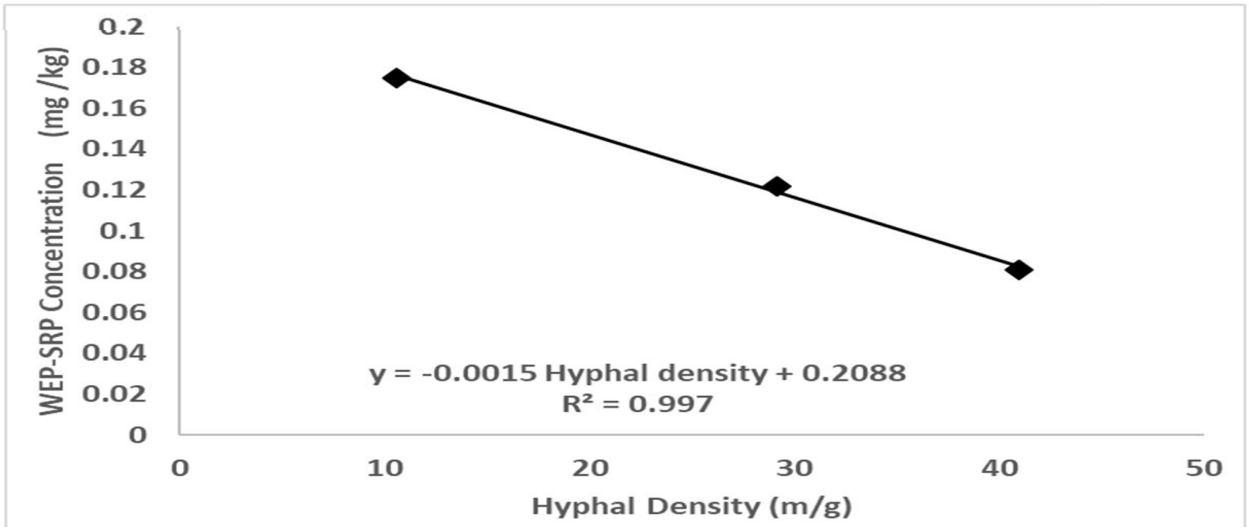
molecular identification to understand restoration plant associations

- track succession and diversity
- role in above ground community & corresponding ecosystem functions

Case Study at Shelburne Farms

Data; Soluble Reactive Phosphorus (SRP) in soil via Water Extractable Phosphorus (WEP)





No significant differences among treatments

- A trend: WEP-SRP follows this pattern: RV>OIV>RVM

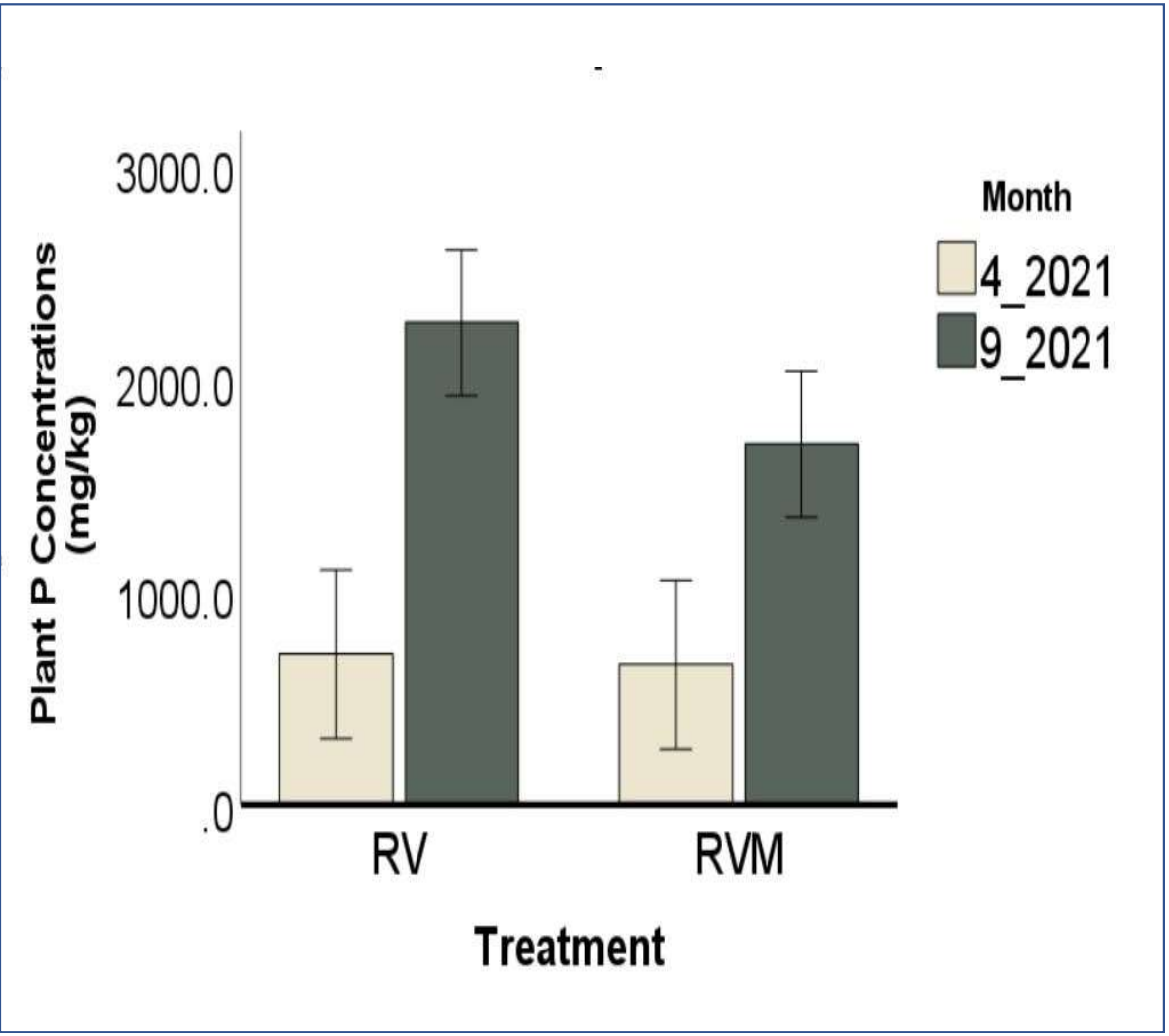
p=.038 for statistically significant inverse relationship between SRP & hyphal counts

- The more mycorrhizal hyphae, the less SRP in soil area

(Rubin and Görres, 2022, in press)

Case Study at Shelburne Farms

Data; Plant Phosphorus Uptake



Comparison of harvested willow biomass P between RV & RVM plots show biomass harvested in autumn had 3x P than in spring

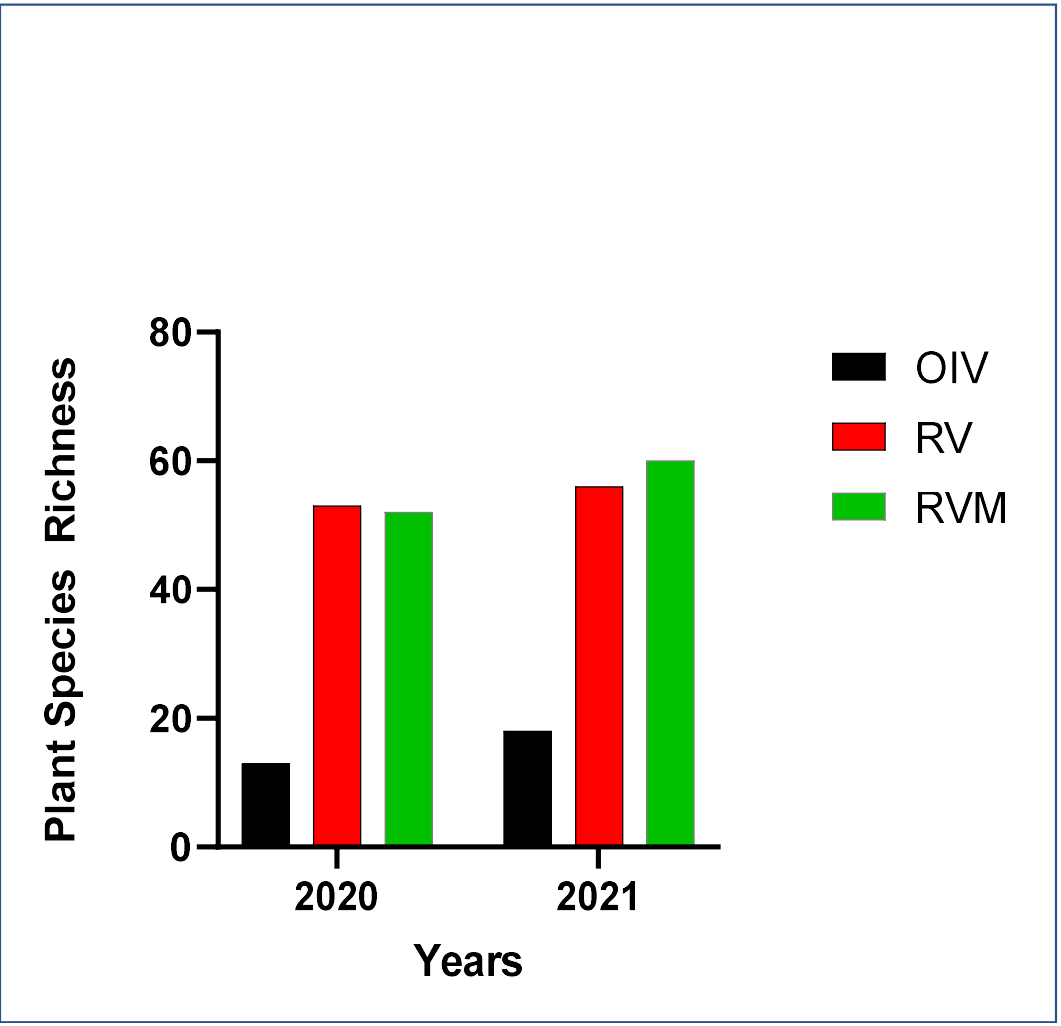
- Timing of coppicing for P removal matters
- Just before autumn is ideal time to coppice for maximum P removal

For pollinator habitat resilience, cyclical coppicing is suggested

(Rubin and Görres, 2022, in press)

Case Study at Shelburne Farms

Data; Pollinator habitat: Richness



Comparisons of plant species counts (richness) among treatments show a higher species count in restored plots than in control

- 1.7 x more pollinator plants were found in restored plots than were planted
- 4x more plants in the restored compared to buckthorn control

(Rubin and Görres, 2022, in press)

Case Study at Shelburne Farms

Data; Plant Phosphorus Uptake

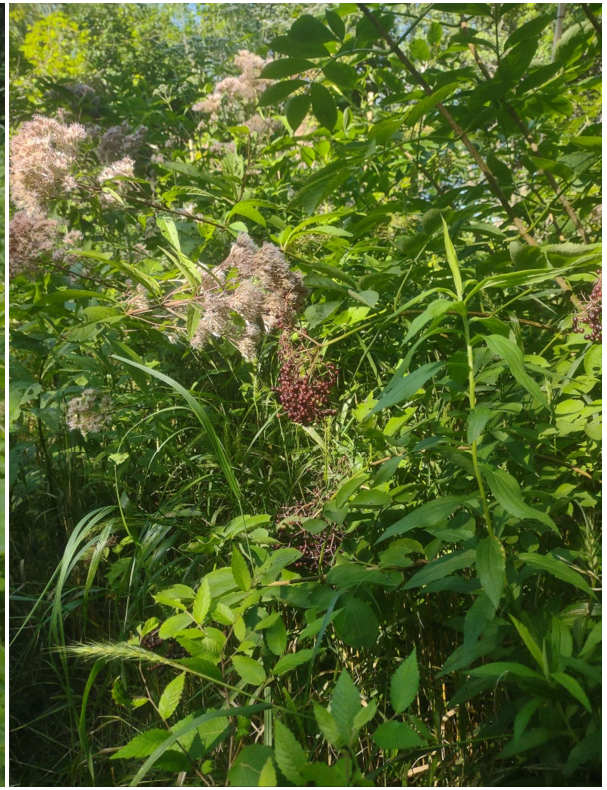
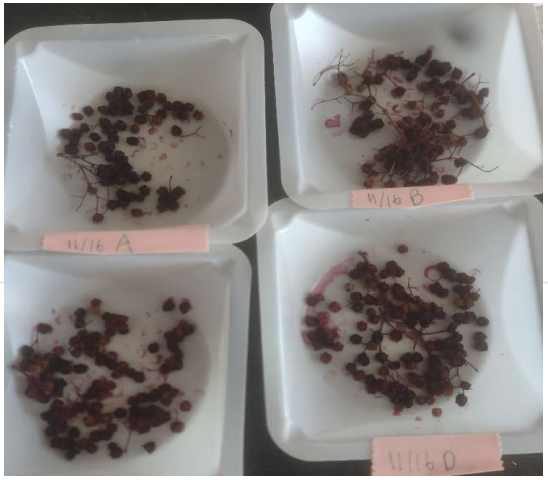


Photo credits: Jess Rubin



Biomass harvest can involve other plants.

Elderberries harvested from restored plots had 3598 mg P /kg of dry mass

Elderberry can offer economic return (Wilson 2016) & Abenaki harvestways

(Rubin and Görres, 2022, in press)

Recommendations

based on 2 years of field research & 2 mesocosm studies

- Remove nonnative species manually with 3 cut in 2 season approach; leave stems in place for habitat
- Design site specific, native polycultures, with local Original Peoples' guidance, access & use in mind
- Inoculate plantings with native soil from local wild area
- Cyclically coppice woody species late summer for P removal (5 - 45 range kg P/ha) depending upon planting density (Schroeder, 2013) & species
    - Consider tradeoff

(Rubin and Görres, 2022, in press)

Photo credit, Jess Rubin

Acknowledgments

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Photo credits: Jess Rubin & Red Fox Media






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Questions

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