Phragmites management strategies

Karin M. Kettenring and Christine B. Rohal

S.J. & JESSIE E. QUINNEY COLLEGE of NATURAL RESOURCES
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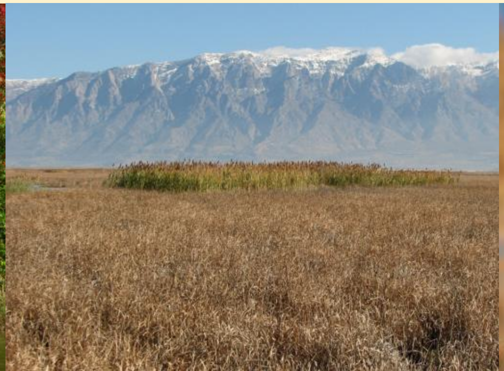
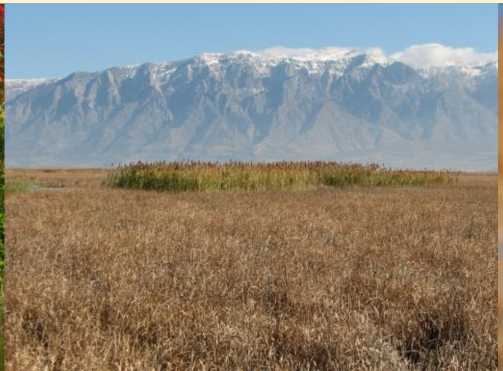



Outline of talk

1. Key aspects of *Phragmites* ecology that affects management
2. Management options
3. Revegetation within invasive species management
4. Collective effort and landscape management

- *Building on our research in the Chesapeake Bay since 2006 and the Great Salt Lake since 2008*
- *Supported by our published research and others (see citations)*

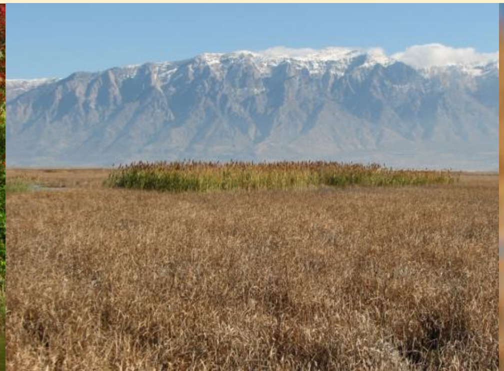





Outline of talk

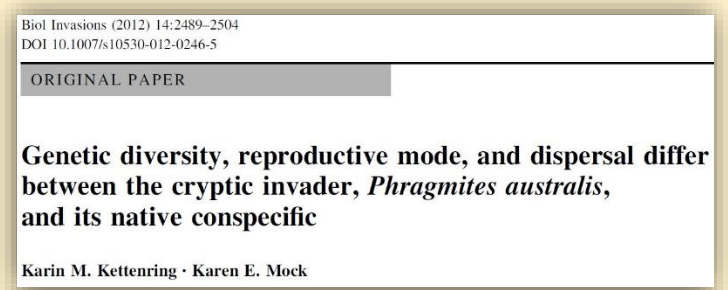
1. Key aspects of *Phragmites* ecology that affects management
    - Major forms of reproduction
    - The role of genetic diversity in viable seed production
    - Disturbance
    - Nutrient effects on growth and spread
2. Management options
3. Revegetation within invasive species management
4. Collective effort and landscape management






Major forms of reproduction

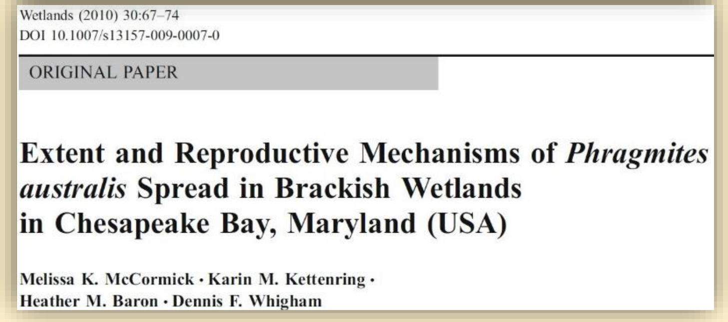
- Seeds important for long and short-distance dispersal
- Rhizomes / stolons more important for patch expansion


Biol Invasions (2012) 14:2489–2504
DOI 10.1007/s10530-012-0246-5

ORIGINAL PAPER

Genetic diversity, reproductive mode, and dispersal differ between the cryptic invader, *Phragmites australis*, and its native conspecific

Karin M. Kettenring · Karen E. Mock


Wetlands (2010) 30:67–74
DOI 10.1007/s13157-009-0007-0

ORIGINAL PAPER

Extent and Reproductive Mechanisms of *Phragmites australis* Spread in Brackish Wetlands in Chesapeake Bay, Maryland (USA)

Melissa K. McCormick · Karin M. Kettenring · Heather M. Baron · Dennis F. Whigham

D. Walters and C. Southwick


ophis (flickr)


MI SeaGrant (flickr)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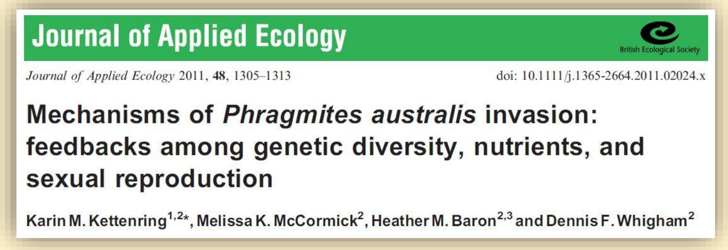
Genetic diversity and viable seed production

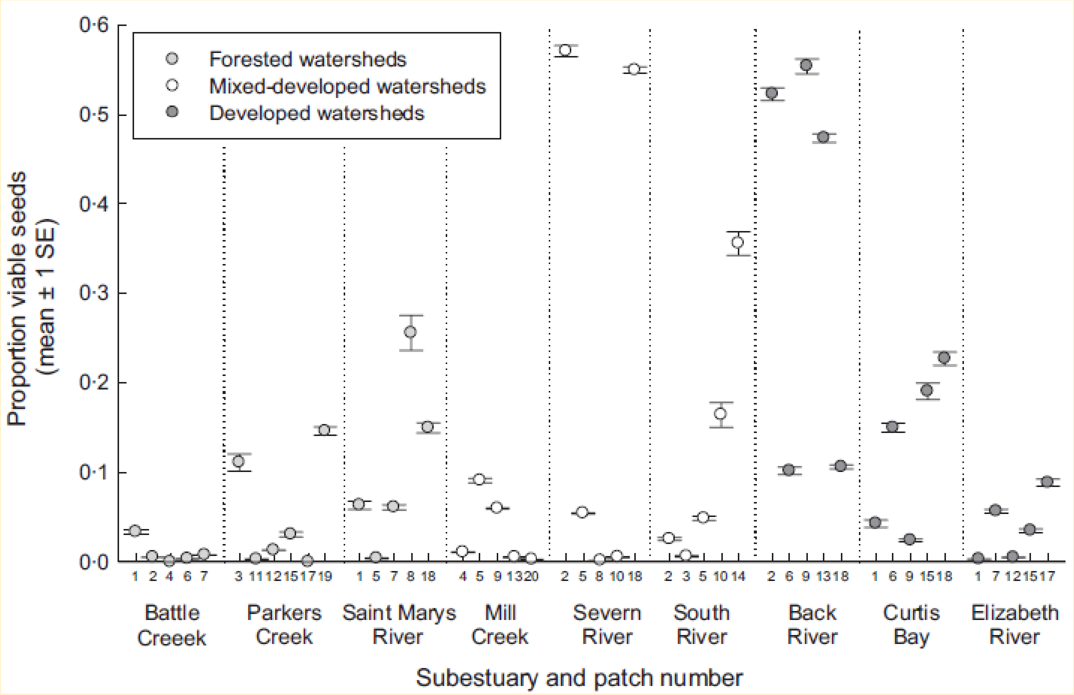
- Spread is largely by seed but seed viability is highly variable
- More genetically diverse patches produce more viable seed
- Depends on availability of out-crossed pollen

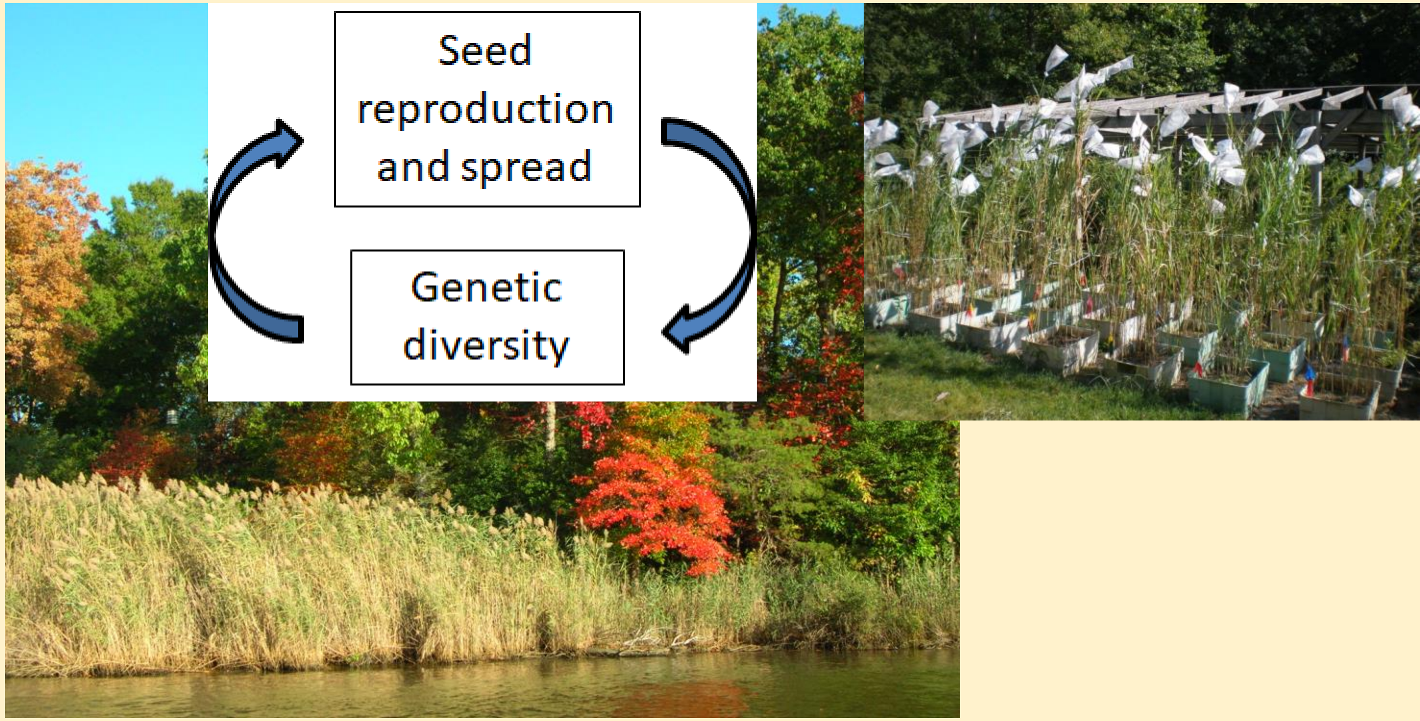

Journal of Applied Ecology

Journal of Applied Ecology 2011, **48**, 1305–1313 doi: 10.1111/j.1365-2664.2011.02024.x

Mechanisms of *Phragmites australis* invasion: feedbacks among genetic diversity, nutrients, and sexual reproduction

Karin M. Kettenring[1,2]*, Melissa K. McCormick[2], Heather M. Baron[2,3] and Dennis F. Whigham[2]





Disturbance and invasion by seed

- *Phragmites* seeds are light limited
- Disturbances facilitate germination
- *Phragmites* occurrence associated with disturbances overall
  - Agricultural and (sub)urban land-use
  - Shoreline development
    - Riprap, shoreline hardening, docks

Ecological Applications, 25(2), 2015, pp. 466–480

Biotic resistance, disturbance, and mode of colonization impact the invasion of a widespread, introduced wetland grass

Karin M. Kettenring,[1,2,3] Dennis F. Whigham,[2] Eric L. G. Hazelton,[1,2] Sally K. Gallagher,[2,4] and Heather M. Weiner[2,5]

Shoreline Development Drives Invasion of *Phragmites australis* and the Loss of Plant Diversity on New England Salt Marshes

Brian R. Silliman* and Mark D. Bertness

Estuaries and Coasts Vol. 30, No. 3, p. 469–481 June 2007

Threshold Effects of Coastal Urbanization on *Phragmites australis* (Common Reed) Abundance and Foliar Nitrogen in Chesapeake Bay

Ryan S. King[1,*], William V. DeLuca[2,†], Dennis. F. Whigham[2], and Peter P. Marra[2,‡]

Biol Invasions
DOI 10.1007/s10530-016-1136-z

PHRAGMITES INVASION

Local and regional disturbances associated with the invasion of Chesapeake Bay marshes by the common reed *Phragmites australis*

M. Benjamin Sciance · Christopher J. Patrick · Donald E. Weller · Meghan N. Williams · Melissa K. McCormick · Eric L. G. Hazelton

WETLANDS, Vol. 28, No. 4, December 2008, pp. 1097–1103

NOTE

COMMON REED *PHRAGMITES AUSTRALIS* OCCURRENCE AND ADJACENT LAND USE ALONG ESTUARINE SHORELINE IN CHESAPEAKE BAY

Randolph M. Chambers[1], Kirk J. Havens[2], Sharon Killeen[2], and Marcia Berman[2]





Nutrients and growth / spread

- *Phragmites* is a high nutrient specialist
- Occurs in areas associated with higher nutrient inputs
- ↑ nutrients result in:
  - ↑ inflorescence and floret production
  - ↑ seedling size, growth rates, # of stems
  - ↑ mature plant size

Journal of Ecology
British Ecological Society
Journal of Ecology 2010, **98**, 451–458 doi: 10.1111/j.1365-2745.2009.01625.x

Ecophysiological differences between genetic lineages facilitate the invasion of non-native *Phragmites australis* in North American Atlantic coast wetlands

Thomas J. Mozdzer*† and Joseph C. Zieman

Wetlands (2017) 37:45–57
DOI 10.1007/s13157-016-0838-4

ORIGINAL RESEARCH

Distribution and Drivers of a Widespread, Invasive Wetland Grass, *Phragmites australis*, in Wetlands of the Great Salt Lake, Utah, USA

A. Lexine Long[1,3] · Karin M. Kettenring[1] · Charles P. Hawkins[1] · Christopher M. U. Neale[1,2]

Journal of Applied Ecology
British Ecological Society
Journal of Applied Ecology 2011, **48**, 1305–1313 doi: 10.1111/j.1365-2664.2011.02024.x

Mechanisms of *Phragmites australis* invasion: feedbacks among genetic diversity, nutrients, and sexual reproduction

Karin M. Kettenring[1,2]*, Melissa K. McCormick[2], Heather M. Baron[2,3] and Dennis F. Whigham[2]

Ecological Applications, 13(5), 2003, pp. 1400–1416

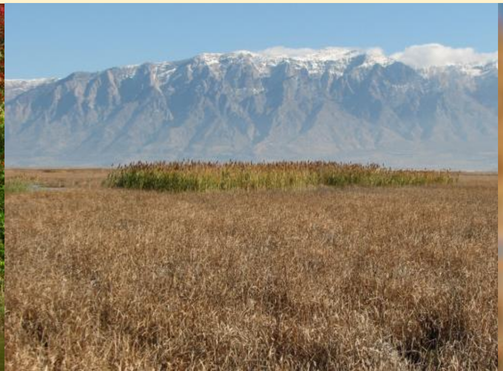
DISTURBANCE-MEDIATED COMPETITION AND THE SPREAD OF *PHRAGMITES AUSTRALIS* IN A COASTAL MARSH

TODD E. MINCHINTON[1] AND MARK D. BERTNESS

Outline of talk

1. Key aspects of *Phragmites* ecology that affects management
2. Management options
   - Major approaches (herbicide, grazing, mowing, burning, etc.)
   - Synthesis of research findings
   - Efficacy of different approaches
   - Environmental context driving effectiveness
   - Logistical challenges
   - Negative effects and unintended consequences
3. Revegetation within invasive species management
4. Collective effort and landscape management



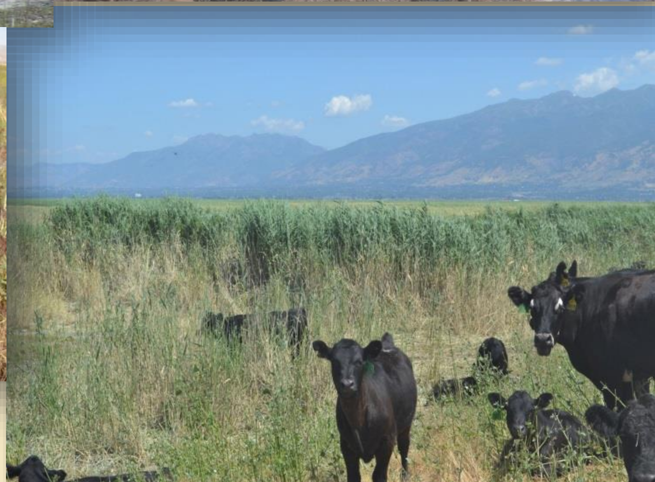



Management approaches overview

- Herbicide (97% managers Utah; 95% Martin & Blossey 2013)
  - Glyphosate
  - Imazapyr
- Biomass removal
  - Mowing
  - Burning
  - Grazing
- Mechanical removal without herbicide

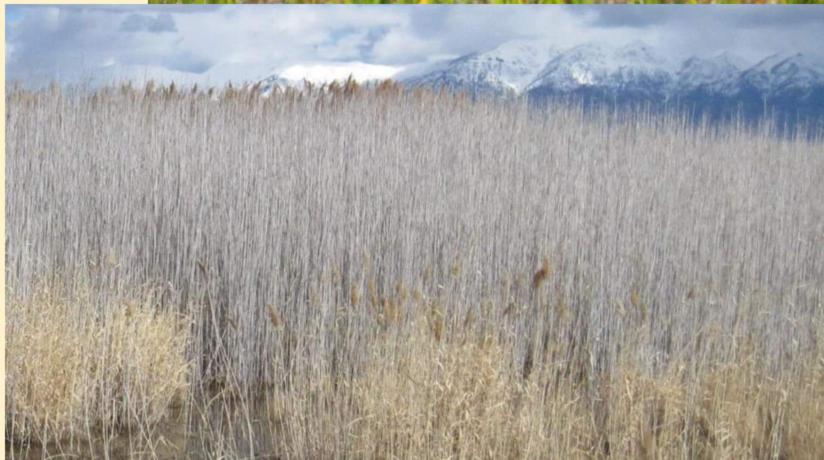






Glyphosate

- Potential desirable outcomes
- How it is applied
  - Airplane/ helicopter, marsh-capable vehicle
  - Rate: 1-2% or 3 quarts per acre with surfactant
  - Follow-up treatments necessary (at least 3 years)
- Logistical challenges
  - Limitations of accessibility, especially for follow-up treatments
- Negative effects and unintended consequences
  - Non-target plant mortality
  - Marsh subsidence
  - Human health concerns

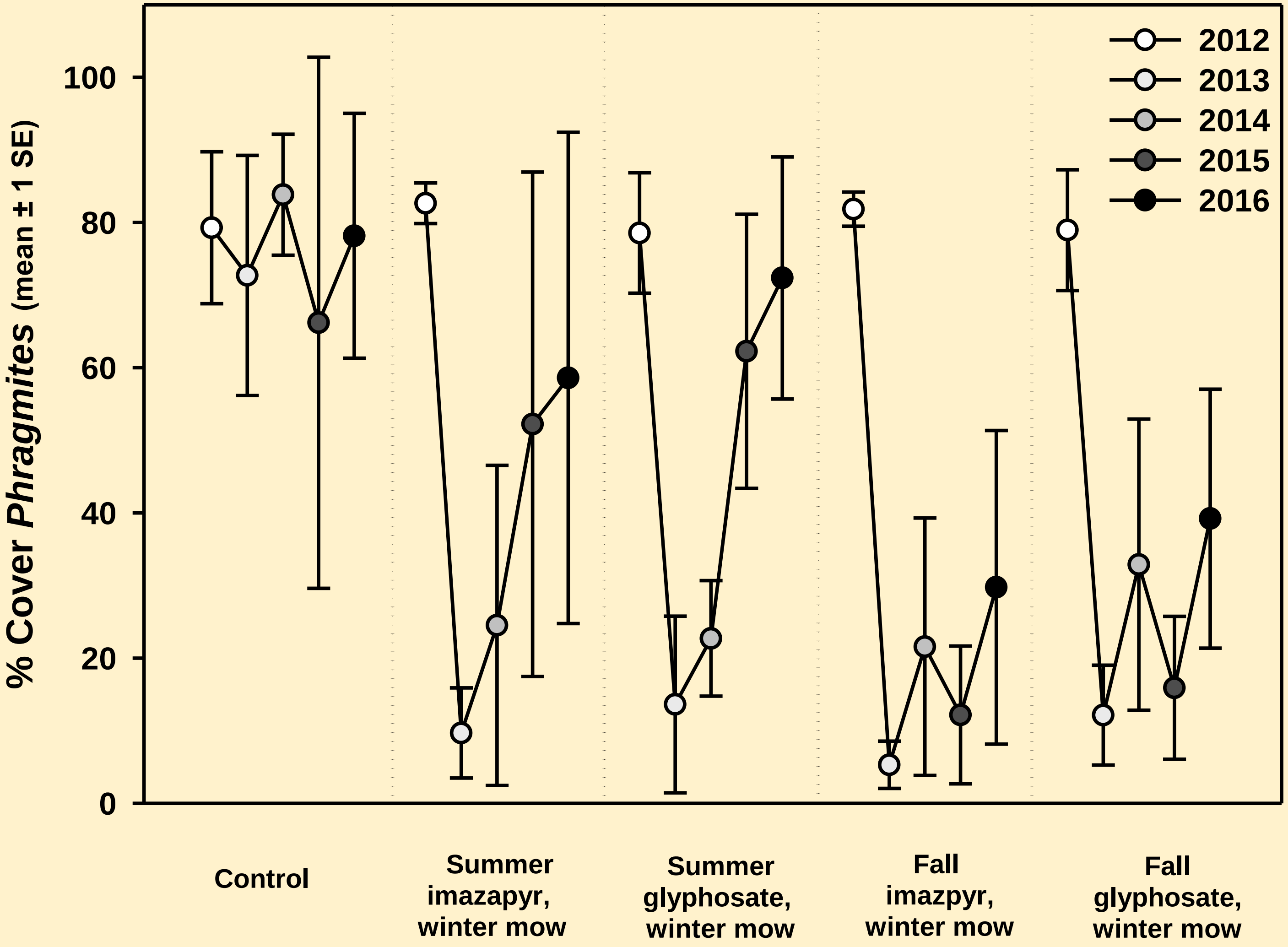


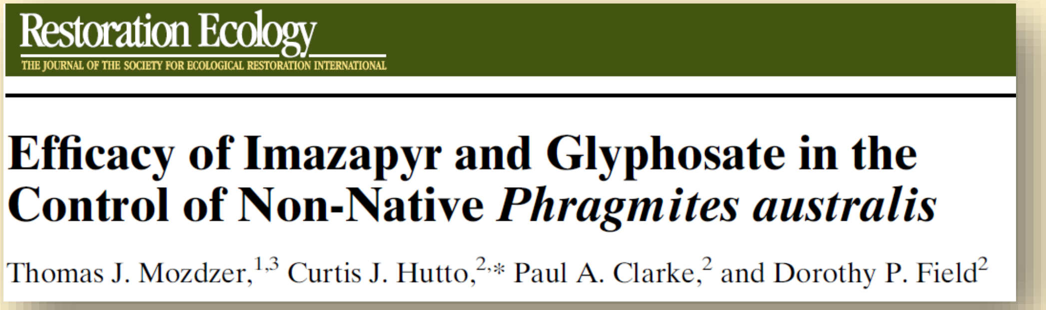
Imazapyr

- Potential desirable outcomes
- How it is applied
  - Airplane, marsh-capable vehicle
  - Rate: 1-2% or 3 quarts per acre with surfactant
  - Follow-up treatments necessary (at least 3 years)
- Logistical challenges
  - Limitations of accessibility, especially for follow-up treatments
  - More expensive than glyphosate
- Negative effects and unintended consequences
  - Non-target plant mortality
  - Longer residence time in soil, possible implications for revegetation (esp. in drier soils)

Herbicide timing: evidence from the literature

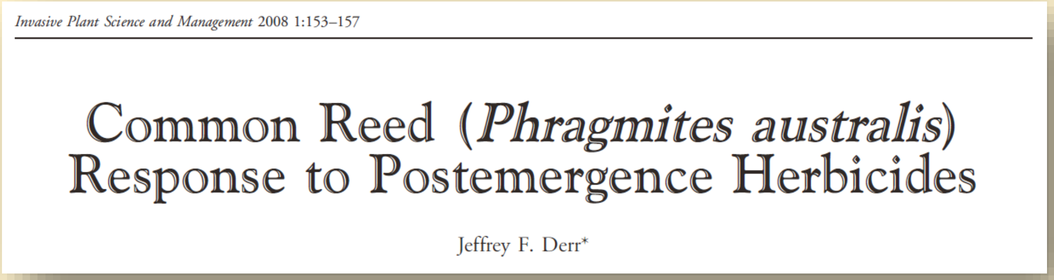
Experiments from Utah




Restoration Ecology
THE JOURNAL OF THE SOCIETY FOR ECOLOGICAL RESTORATION INTERNATIONAL

Efficacy of Imazapyr and Glyphosate in the Control of Non-Native *Phragmites australis*

Thomas J. Mozdzer,[1,3] Curtis J. Hutto,[2,*] Paul A. Clarke,[2] and Dorothy P. Field[2]


Invasive Plant Science and Management 2008 1:153–157

Common Reed (*Phragmites australis*) Response to Postemergence Herbicides

Jeffrey F. Derr*


Restoration Ecology
THE JOURNAL OF THE SOCIETY FOR ECOLOGICAL RESTORATION
Explore this journal >

Common Reed *Phragmites australis*: Control and Effects Upon Biodiversity in Freshwater Nontidal Wetlands

M. Stephen Ailstock, C. Michael Norman, Paul J. Bushmann

Glyphosate vs. imazapyr overview

- Fall application much better than summer over long term
- Imazapyr not significantly superior to glyphosate in practice
- Long-term application necessary
- *Phragmites* often reinvades when management ceases

Mowing

- Potential desirable outcomes
  - Open up marsh surface
  - Accelerates litter decomposition when done in summer
  - Reduce seed production
- How / when it is applied
  - Possible year round, common in summer and winter
- Logistical challenges
  - Marsh mowers can get stuck in soggy conditions
- Negative effects and unintended consequences
  - Leaves deep litter layer that impedes quick native plant recovery
  - Concerns about soil compaction

Burning

- Potential desirable outcomes
  - Removal of dead biomass
  - Opens up marsh surface
- How / when it is applied
  - Most common in spring
- Logistical challenges
  - Often need permits, controlled-burn training
  - Challenges near populated areas
- Negative effects and unintended consequences
  - Air quality concerns
  - Leaves sharp *Phragmites* stubble

Grazing

- Potential desirable outcomes
  - reduce *Phragmites* cover / biomass; trample litter
  - reduce seed production
  - Brittany Duncan's M.S. thesis research at USU
- How / when it is applied
  - High intensity grazing often with paths mowed in to increase access
  - Only during growing season
- Logistical challenges
  - Widespread fencing, water accessibility for animals
  - Finding or training "marsh-capable" animals
- Negative effects and unintended consequences
  - Nutrient availability
  - Compaction

Livestock as a potential biological control agent for an invasive wetland plant

Brian R. Silliman[1], Thomas Mozdzer[2], Christine Angelini[3], Jennifer E. Brundage[4], Peter Esselink[5,6], Jan P. Bakker[5], Keryn B. Gedan[7], Johan van de Koppel[5,8] and Andrew H. Baldwin[4]


Decrease in biomass


Changes in structure

Other treatments

- Mowing and black plastic
- Mowing and flooding
- Restoring hydrology – changing porewater sulfide concentrations

Hydrologic and chemical control of *Phragmites* growth in tidal marshes of SW Connecticut, USA

Randolph M. Chambers[1,*], David T. Osgood[2], Ned Kalapasev[3]

Ecology of Phragmites australis *and Responses to Tidal Restoration*

RANDOLPH M. CHAMBERS, LAURA A. MEYERSON, AND KIMBERLY L. DIBBLE

Recommended treatment combinations

- Removal:
  - Mowing / intense grazing in summer, herbicide in fall
  - Herbicide in fall, burning or mowing in winter or spring
- Containment:
  - Grazing, burning, or mowing during growing season can help contain the spread of *Phragmites* (reduces seed production and clonal expansion)
- Prevention:
  - Limit factors that contribute to *Phragmites* expansion at landscape scale (nutrient enrichment, shoreline hardening, etc.)
  - Shoreline buffers / hydrologic restoration

Shoreline Development Drives Invasion of *Phragmites australis* and the Loss of Plant Diversity on New England Salt Marshes

BRIAN R. SILLIMAN* AND MARK D. BERTNESS

COMMON REED *PHRAGMITES AUSTRALIS* OCCURRENCE AND ADJACENT LAND USE ALONG ESTUARINE SHORELINE IN CHESAPEAKE BAY

Randolph M. Chambers[1], Kirk J. Havens[2], Sharon Killeen[2], and Marcia Berman[2]

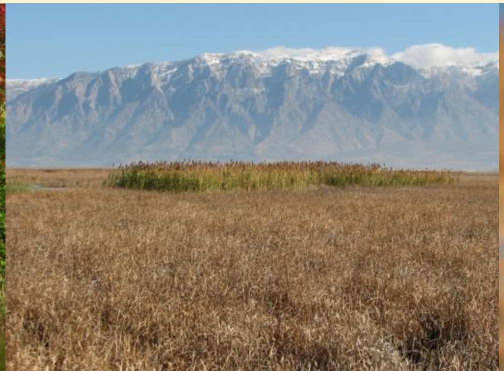
Environmental context drives effectiveness

- Stressed *Phragmites* limits herbicide effectiveness
  - Drought
  - Recently managed
- Landscape context influences native recovery
  - *Phragmites* removal near intact native species increases success (more later)
  - Subsidence limited with quick native establishment

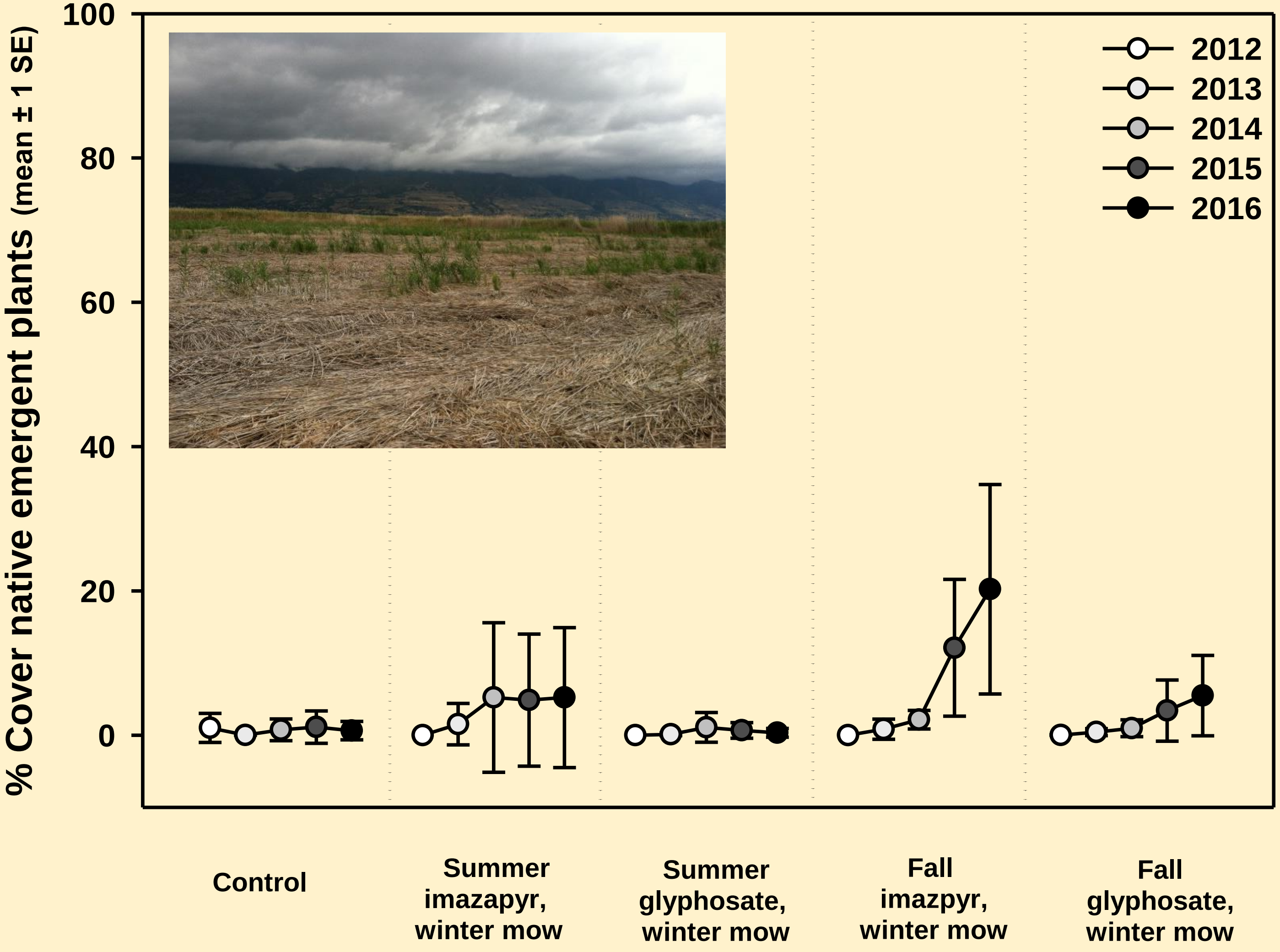

Outline of talk

1. Key aspects of *Phragmites* ecology that affects management
2. Management options
3. Revegetation within invasive species management
    - Lack of native plant recovery
    - Seed bank potential
    - Remnant vegetation
    - Active revegetation – why and how?
    - Role of diversity at species *and* genetic levels
4. Collective effort and landscape management



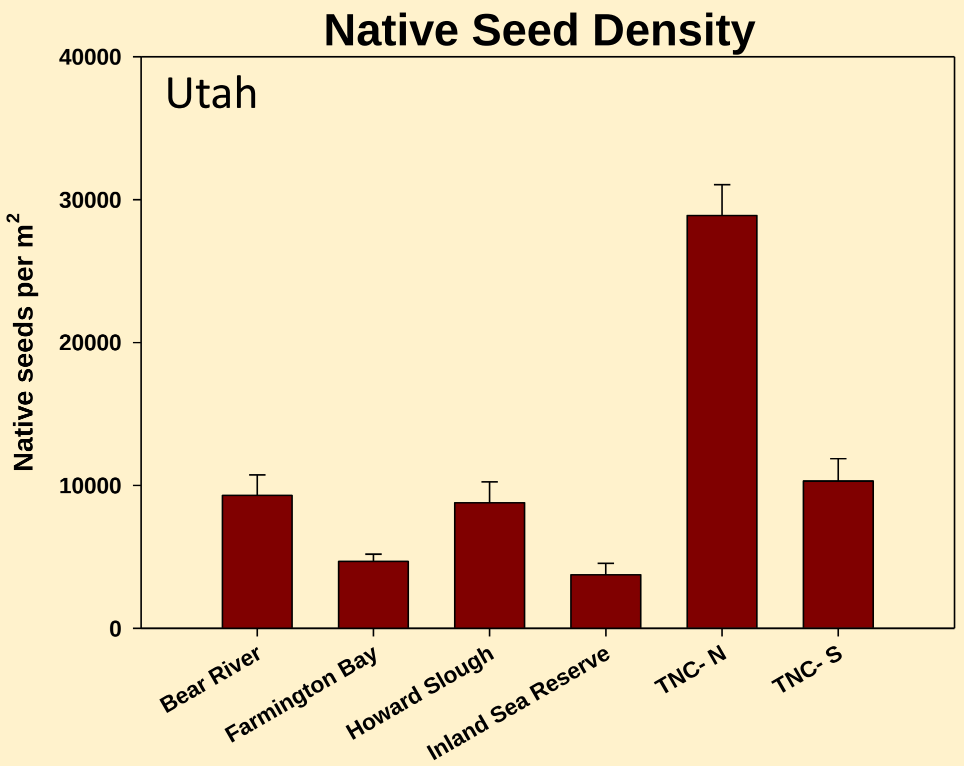


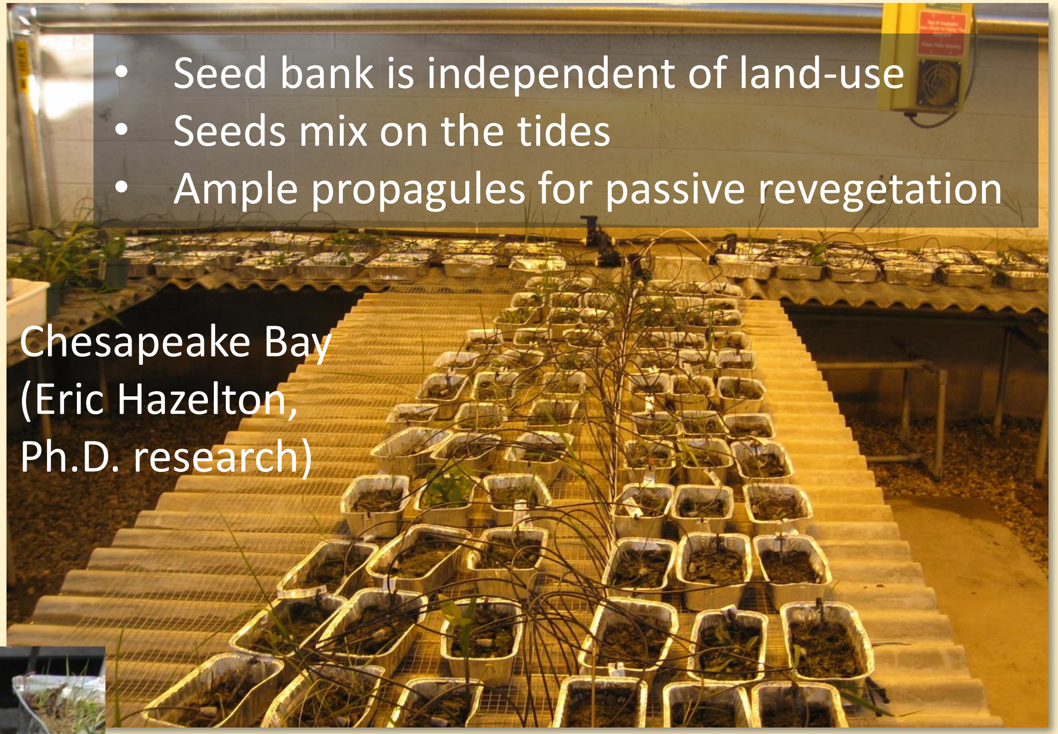

Lack of native plant recovery common. Why?



Seed bank potential

- Diverse native seed banks exist
- Lots of inter-site variability
- Similar results in Chesapeake Bay





Remnant native vegetation

- Greater recovery when remnant native vegetation persists
- Contributes to inter-site variability in recovery

Salicornia dominated following intentional drought

S. americanus rapidly expanded, prevented *Phragmites* reinvasion

Typha and native forb rapidly recovered marsh surface, minimized *Phragmites*

Diversity community rebounded

Active revegetation

- Why?
  - More quickly recover native species and habitat
  - Limit *Phragmites* invasion by seed
- How?
  - *Phragmites* litter removal
  - (Hydro)seeding – less expensive, cover broad areas
    - Tackifier to keep seeds in place?
- Planting rhizomes and plugs – more costly, possibly higher establishment

M/R = mow and remove

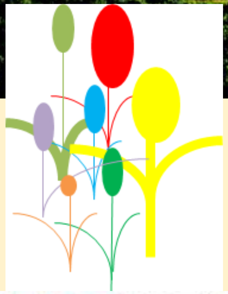
R/C = roll and crush

Experimental hydroseeding in Utah

Bulrush seedling plug, North Fork Native Plants, Idaho

Role of diversity at species *and* genetic level

- Critical for plant establishment, persistence, and limiting invasion



Estuaries and Coasts (2010) 33:1225–1236
DOI 10.1007/s12237-010-9328-8

Can Plant Competition and Diversity Reduce the Growth and Survival of Exotic *Phragmites australis* Invading a Tidal Marsh?

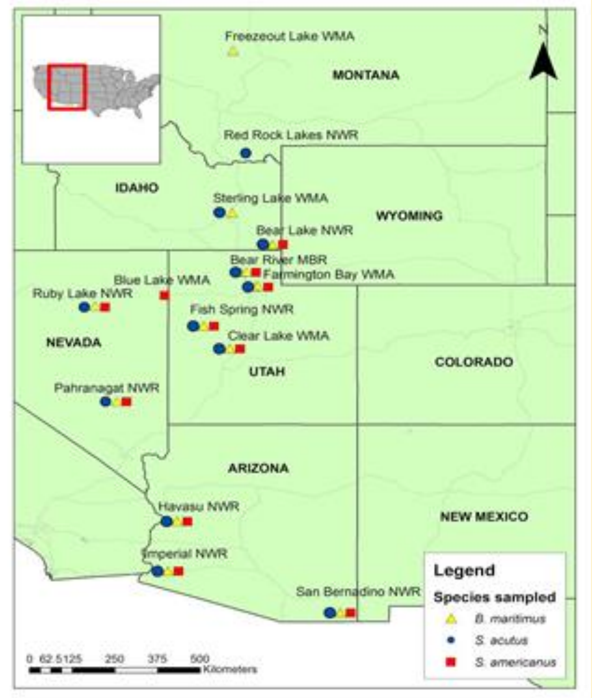
Christopher Robert Peter · David M. Burdick

100 YEARS Journal of Ecology
British Ecological Society
Journal of Ecology 2013, **101**, 128–139 doi: 10.1111/1365-2745.12016

Plant functional group identity and diversity determine biotic resistance to invasion by an exotic grass

Chaeho Byun[1,2], Sylvie de Blois[1,3]* and Jacques Brisson[2]

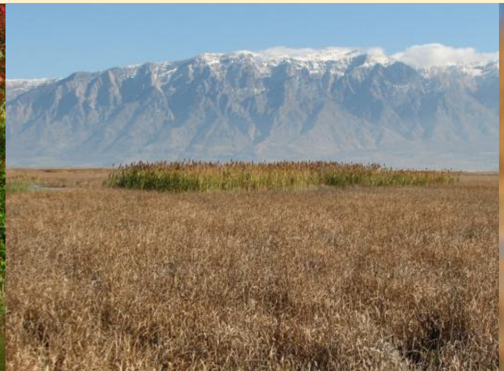
B. maritimus	*S. acutus*	*S. americanus*
		
	(image: R. Hager)	(image: N. DeBarros)
• **Stems**: triangular, 0.2-1.5m tall, leaves up to 60-85cm • **Seeds produced**: mid-Aug to mid-Sept • **Habitat**: Temporary to permanent, shallow flooding	• Firm, round, 1-3m tall, leaves few, short (≤8cm), and near stem base • Mid-July to late Aug • Shallow to deep flooding	• Deeply concave, 0.5-1.5m tall; leaves few, short (≤10cm), and near stem base • Early July to early Aug • Shallow flooding



Outline of talk

1. Key aspects of *Phragmites* ecology that affects management
2. Management options
3. Revegetation within invasive species management
4. Collective effort and landscape management
    - Developing and fostering relationships
    - Coordinated and strategic landscape management






Developing and fostering relationships

- Scientific research as impetus for meetings – co-design of research
- Evaluate techniques feasible for managers to implement

Developing and fostering relationships

- Manager survey for collecting baseline data – "co-design" of research

IV. Invasive *Phragmites* control and management.

16. Have you or your organization managed invasive *Phragmites* on your property?
☐ Yes ☐ No (if no, skip to Section V)

16a. If yes, in what year did you **first** attempt invasive *Phragmites* control? ________

16b. If yes, in what year did you **last** attempt invasive *Phragmites* control? ________

17. What were your **broad goals** for invasive *Phragmites* control **over the last 5 years including 2012**? (check all that apply)
☐ Eradication of all *Phragmites* on our property.
☐ Stop the expansion of *Phragmites* to other areas on our property.
☐ Reduction of *Phragmites* to ________ acres or ________ % of our land.
☐ Other, please describe: ________________.

17a. What are your **specific objectives** for invasive *Phragmites* control on an annual basis (**averaged over the last five years including 2012**)? (check all that apply)
☐ Treat ________ acres of *Phragmites*.
☐ Treat ________ % of our *Phragmites*.
☐ Treat ________ % of our wetlands.
☐ Other, please specify: ________________.

18. What species, vegetation type, or habitat type would you like to see **replace** invasive *Phragmites* after your control efforts? (check all that apply)
☐ Alkali bulrush (*Schoenoplectus/Scirpus maritimus*)
☐ Hardstem bulrush (*Schoenoplectus/Scirpus acutus*)
☐ Common threesquare (*Schoenoplectus/Scirpus pungens*, *americanus*, or *olneyi*)
☐ Native broadleaf cattail (*Typha latifolia*)
☐ Non-native narrowleaf cattail (*Typha angustifolia*)
☐ Hybrid cattail (*Typha x glauca*)
☐ Rushes (*Juncus* spp.)
☐ Spikerushes (*Eleocharis* spp.)

Coordinated and strategic landscape management

- Cooperation among diverse landowners
  - Requires shared goals
  - Open lines of communication
  - Commitment to action

Controlling invasive species in complex social landscapes

Rebecca S Epanchin-Niell[1*], Matthew B Hufford[2], Clare E Aslan[3], Jason P Sexton[2], Jeffrey D Port[4], and Timothy M Waring[5]

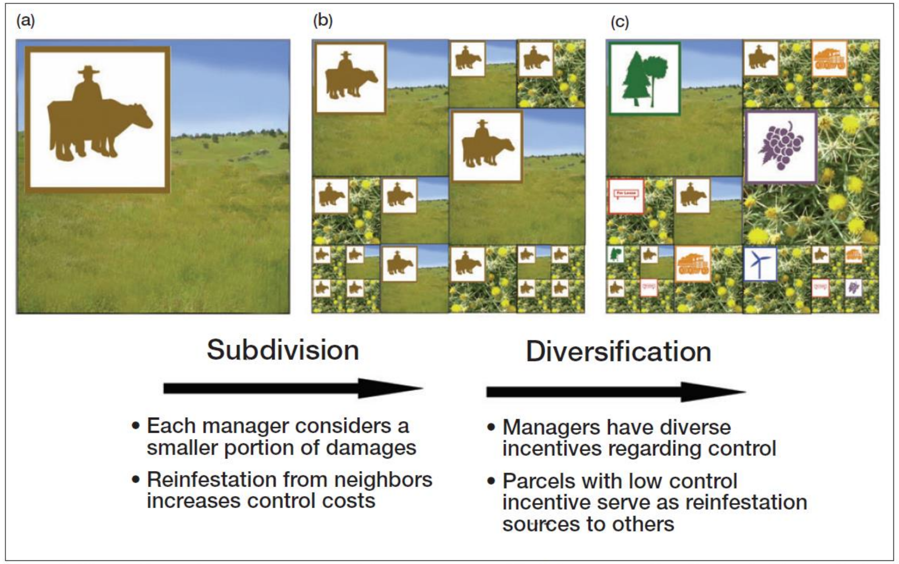
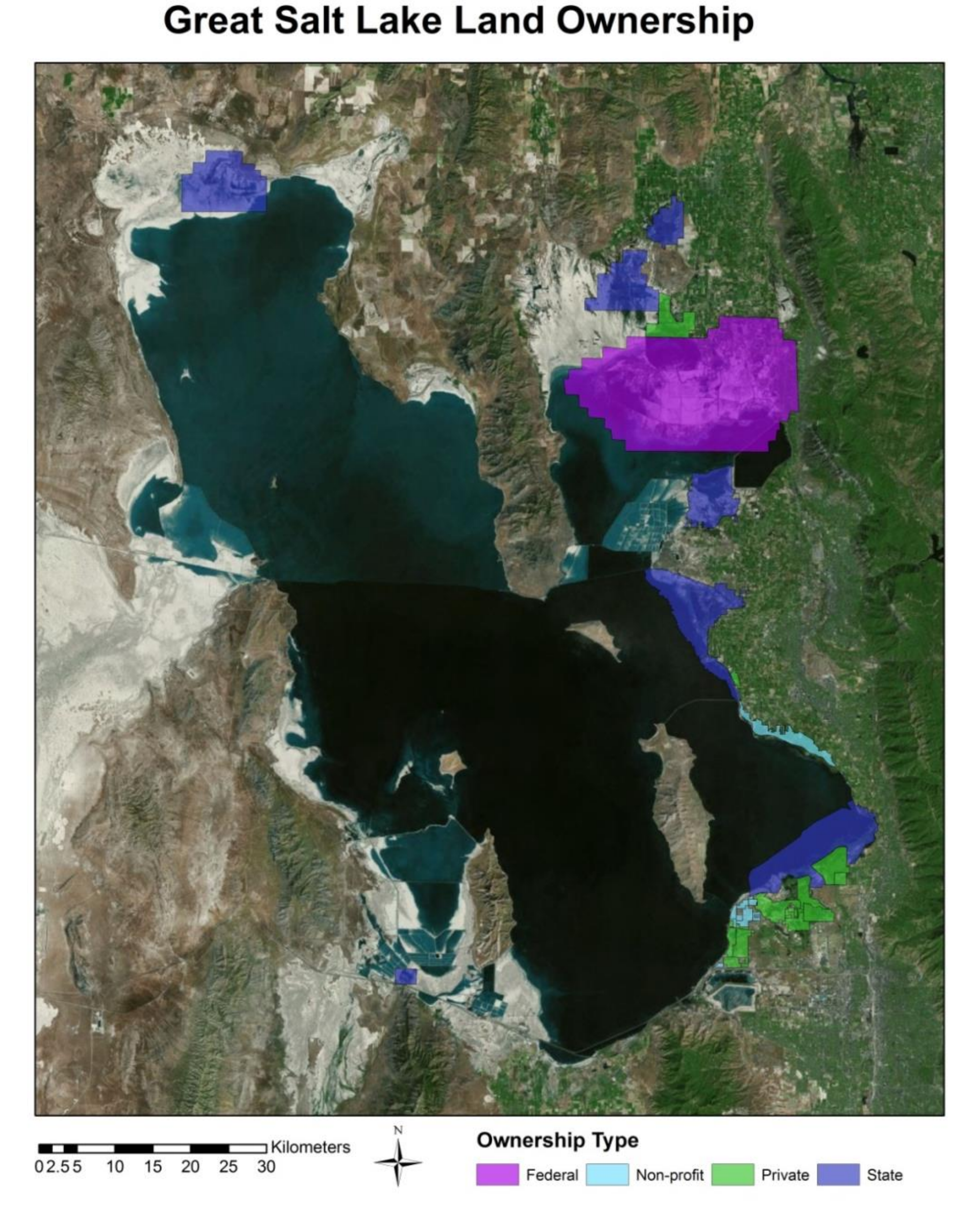


Figure 1. *The complexity of a management mosaic (a) increases as it is subdivided into more and smaller parcels (b) and as land use diversifies (c). Increasing complexity of this social landscape can reduce managers' incentives to control invasions, leading to over-invasion of the landscape.*



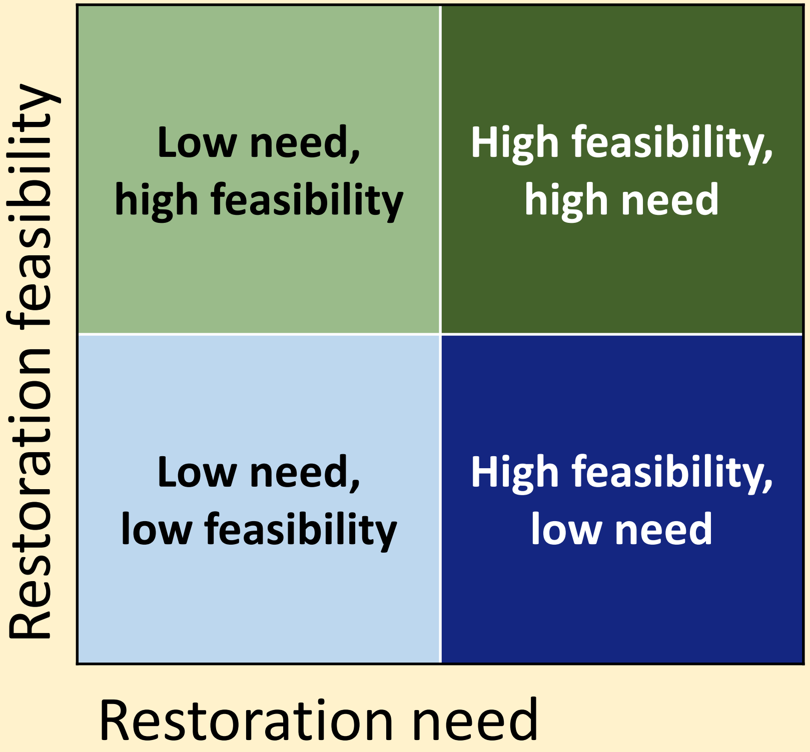
Coordinated and strategic landscape management

- Where are you most likely to succeed?
  - Smaller, newer invasions
    - Some areas are so heavily invaded that not worth the effort
  - Less disturbed areas
  - Ease of site access
  - Water management capabilities
- Whole watershed approach
  - e.g., forested watersheds in the Chesapeake Bay = scale of entire subestuary

Coordinated and strategic landscape management

Multi criteria GIS analysis

- Simple scoring and weighting

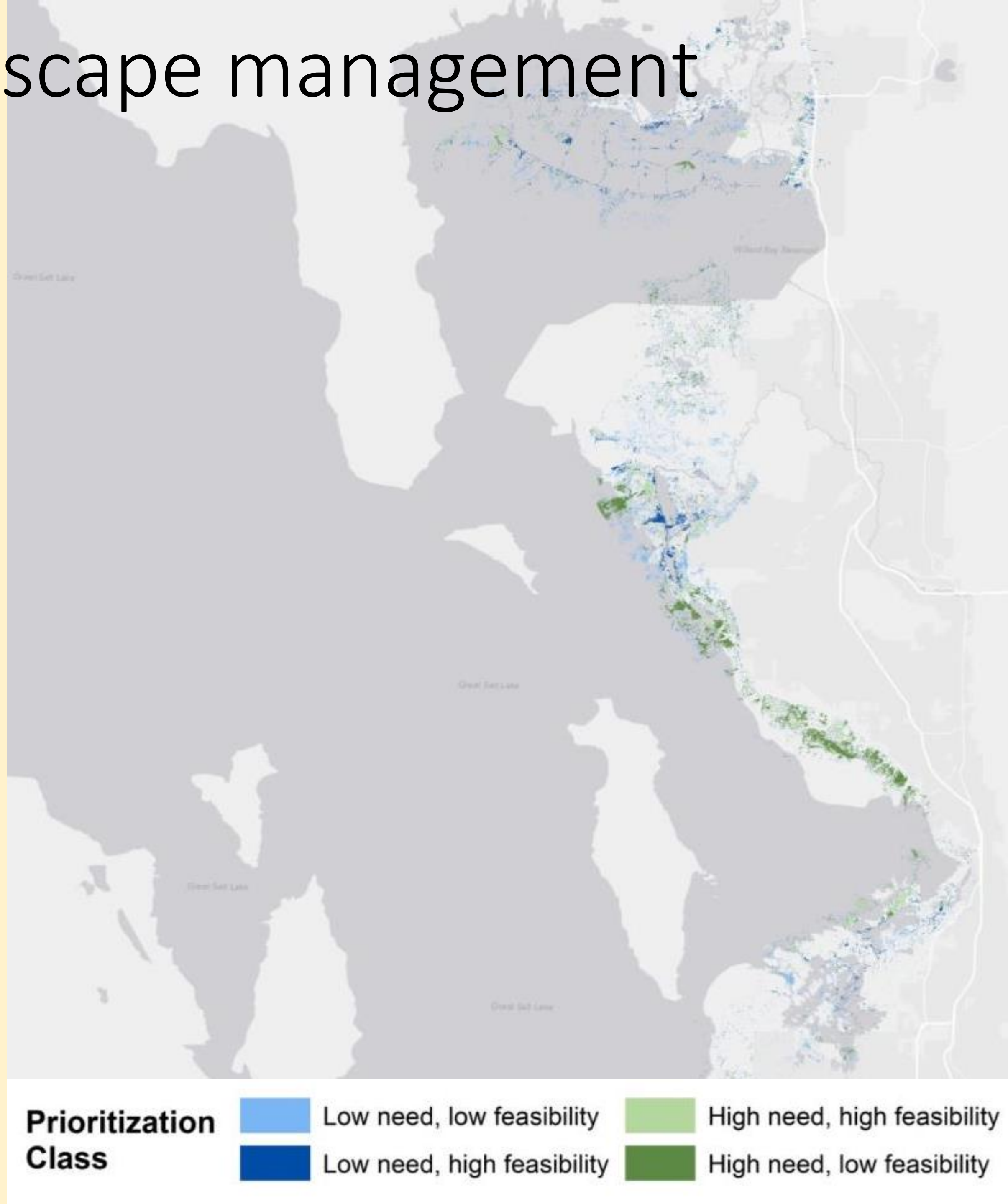


<u>Restoration Need</u>
***examples*:**

- Proximity to areas vulnerable to invasion
- Proximity to recreation

<u>Restoration Feasibility</u>
***examples*:**

- Water level manipulation
- Site access

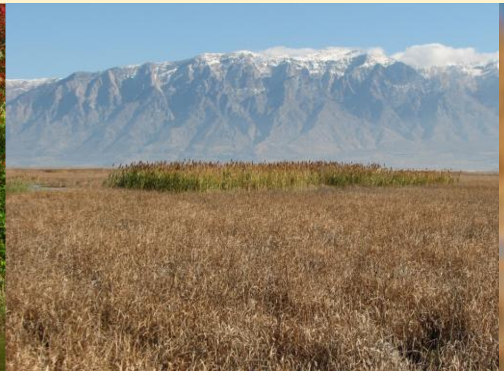


Lexine Long, MS thesis

Summary

- Critical factors facilitating spread
  - Seeds, genetic diversity, nutrients, disturbance
- Best management practices
  - Fall glyphosate, but still address seed production in summer and litter layer
  - Active revegetation
  - Focus on areas / sites where more likely to succeed and need is greater
    - Smaller, newer invasions
    - When remnant native vegetation and/or robust seed banks exist
    - Moisture / flooding for good *Phragmites* control and native plant recovery
    - Watershed scale when possible
  - Prevent (re)invasions when possible
  - Science / manager partnerships; coordinated and strategic landscape management



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  - Chad Cranney, Brittany Duncan, Eric Hazelton, Emily Martin, David England, Rachel Hager, Lexine Long
- Collaborators
  - Dr. Dennis Whigham, Dr. Melissa McCormick, Dr. Karen Mock
- Funding