Tidal Wetland Restoration and Sea-level Rise: Seed Bank Response to Changes in Tidal Flooding and Salinity

Sarah Kidd and Alan Yeakley
Portland State University
Columbia River Estuary Conference
May 2016

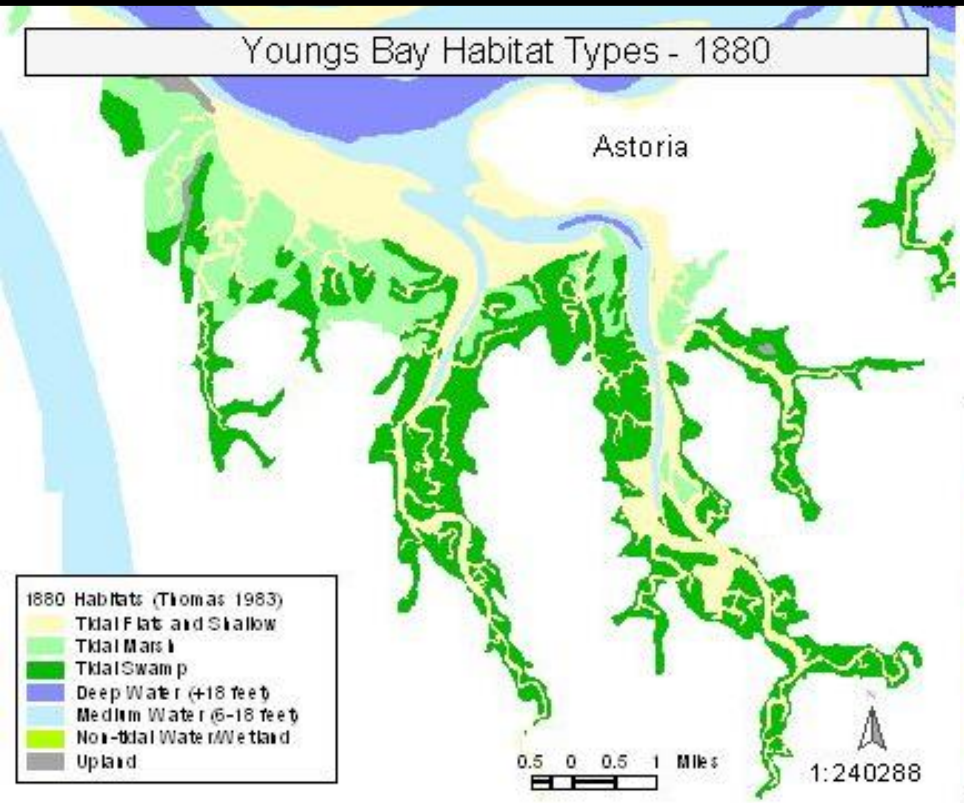
Columbia River Estuary

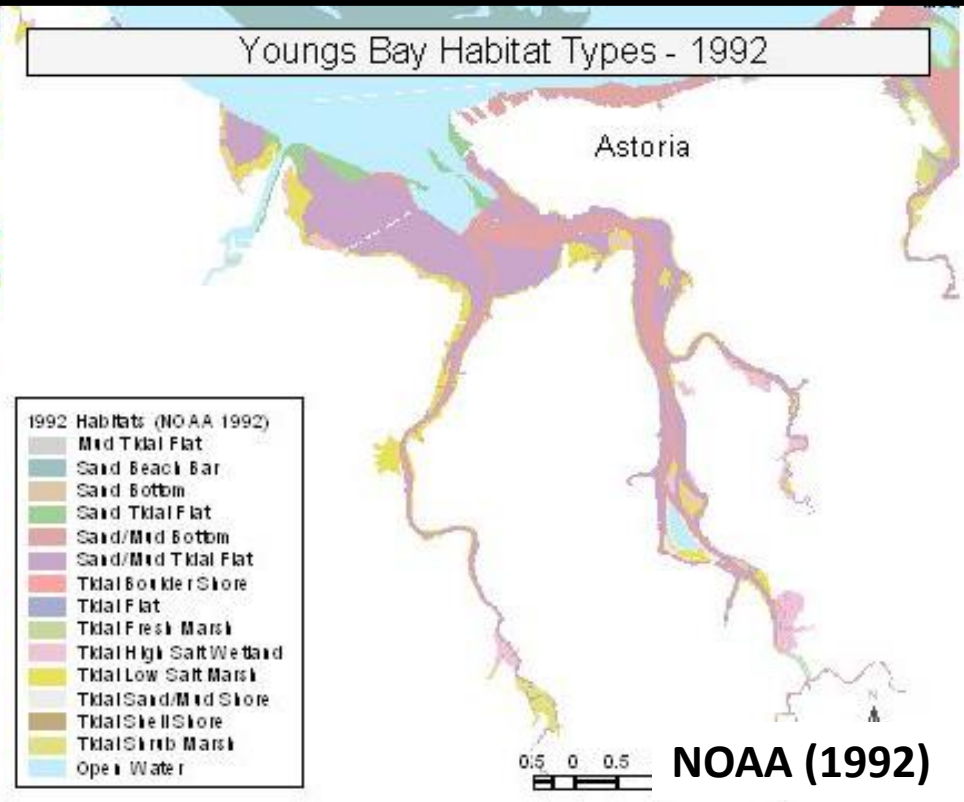
Map created by Sarah Kidd, 2015

KIDD & YEAKLEY 2016

Youngs Bay is oligohaline - low salinity (0.5-5ppt)

Young's Bay Watershed, Oregon - Land Conversion - 97% Loss of Tidal Wetlands



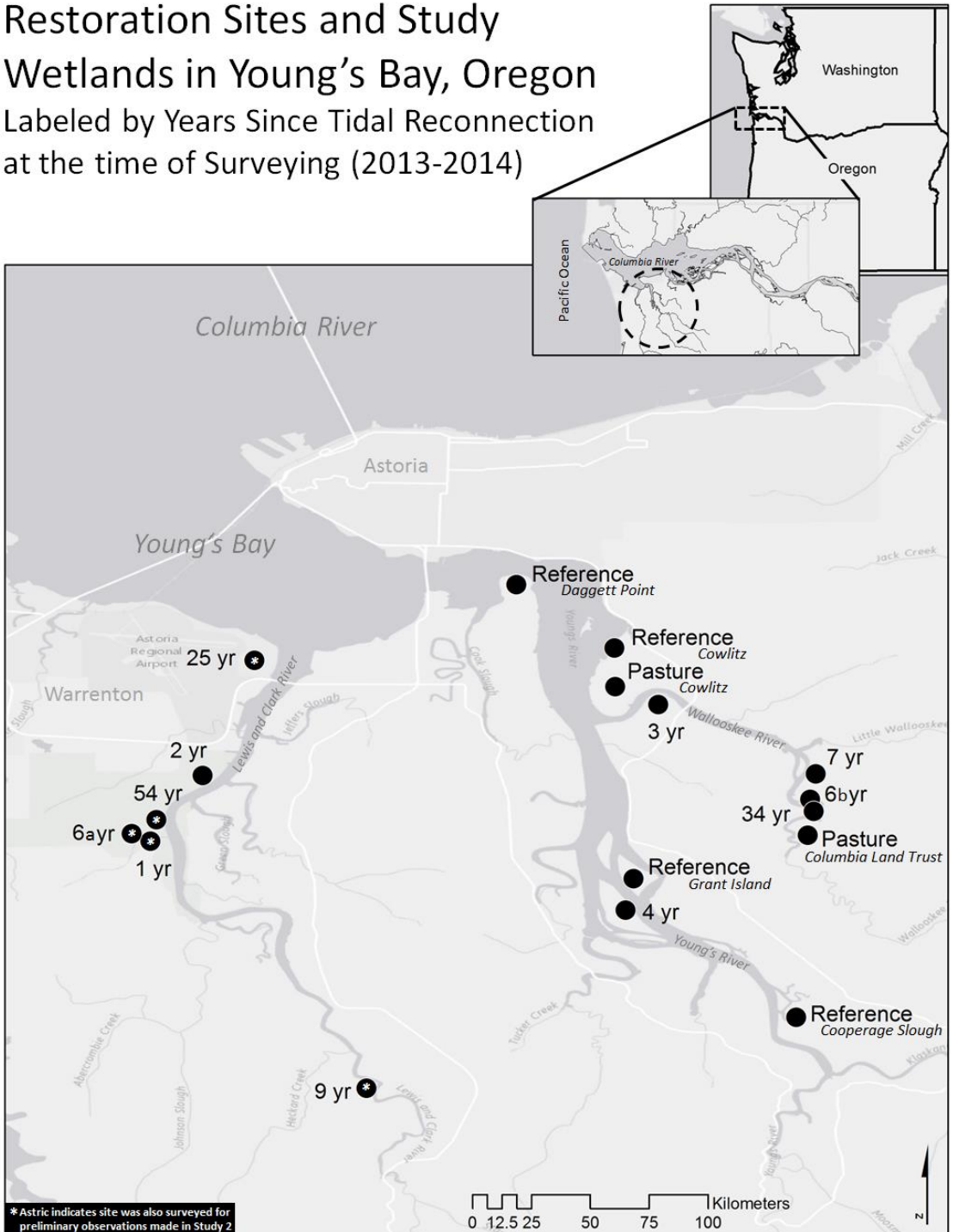


NOAA (1992)

KIDD & YEAKLEY 2016

Restoration Sites and Study Wetlands in Young's Bay, Oregon

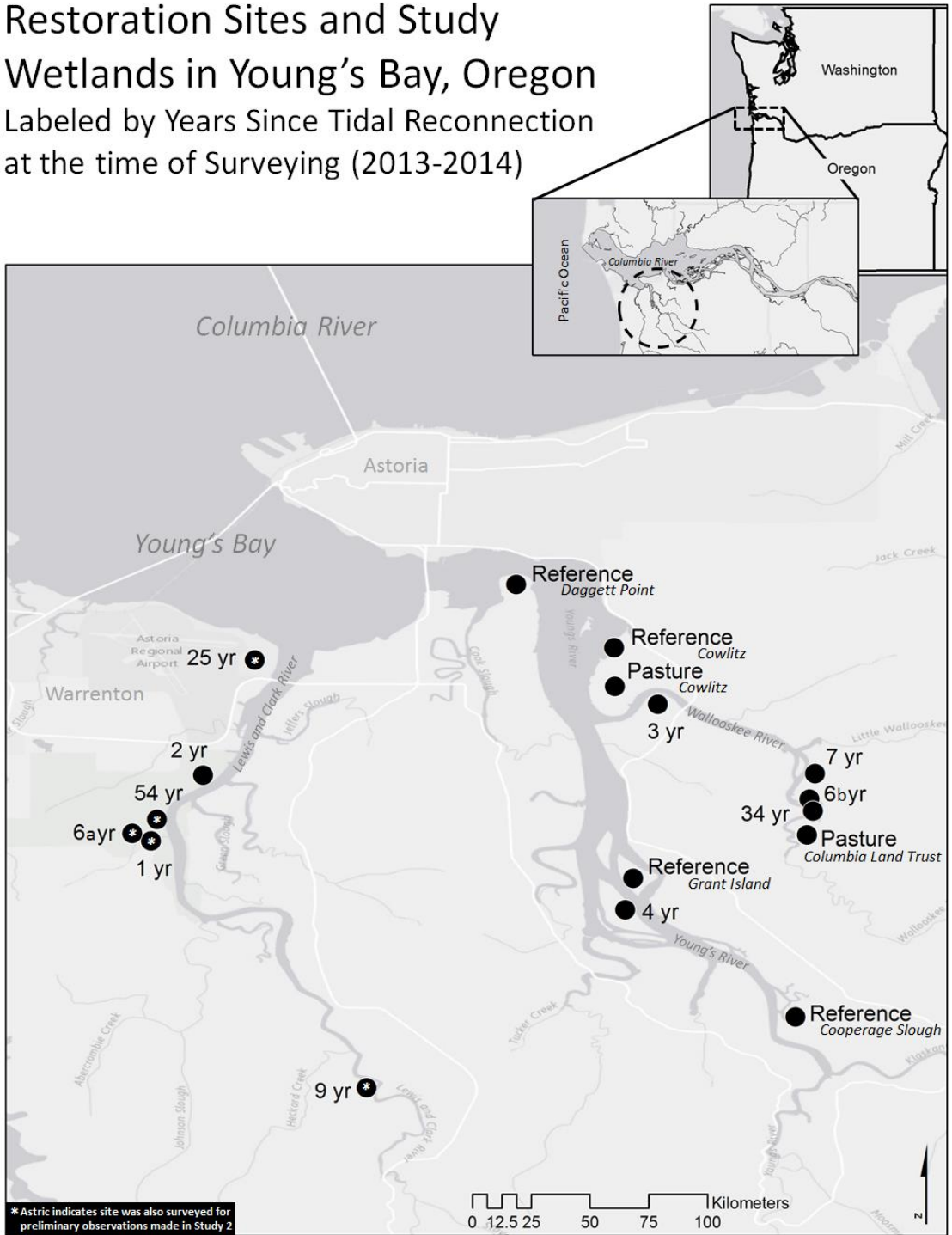
Labeled by Years Since Tidal Reconnection at the time of Surveying (2013-2014)



Tidal Reconnection

Restoration Sites and Study Wetlands in Young's Bay, Oregon

Labeled by Years Since Tidal Reconnection at the time of Surveying (2013-2014)



TRAJECTORY STUDY

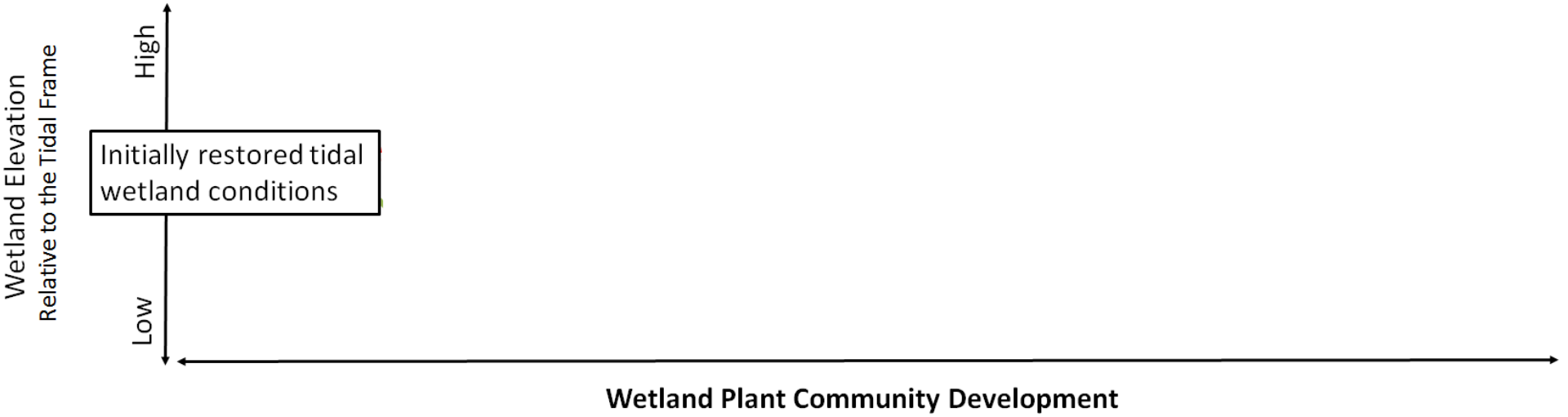
Research Sites Include:

- 11 Restored: 1-54yr Chronosequence
- 4 Reference Wetlands
- 2 Pasture (pre-restoration sites)
- Observed trajectories and patterns among the restoration sites

KIDD & YEAKLEY 2016

Restoration Trajectories of Tidal Wetland Ecosystems

Observed restored low elevation marsh areas had higher similarity to reference marshes and less non-native species than higher elevation marsh areas.

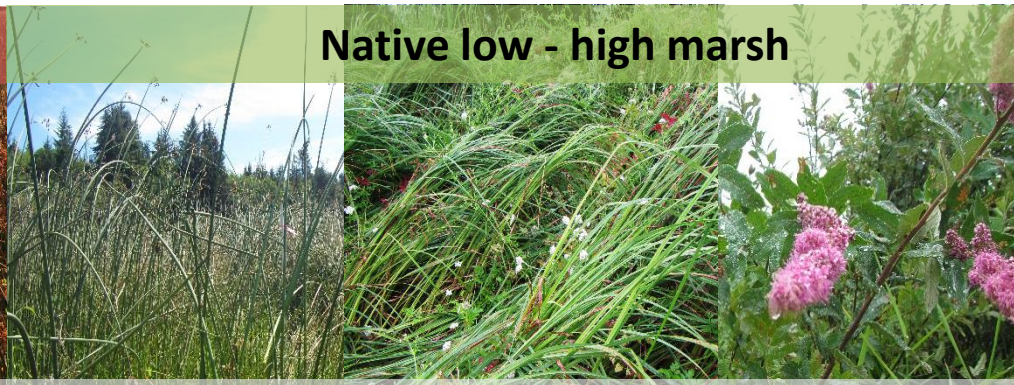


KIDD & YEAKLEY 2016

Non-native high marsh

***Phalaris arundinacea*, reed canarygrass, and *Juncus effusus subsp. effusus*, common rush**

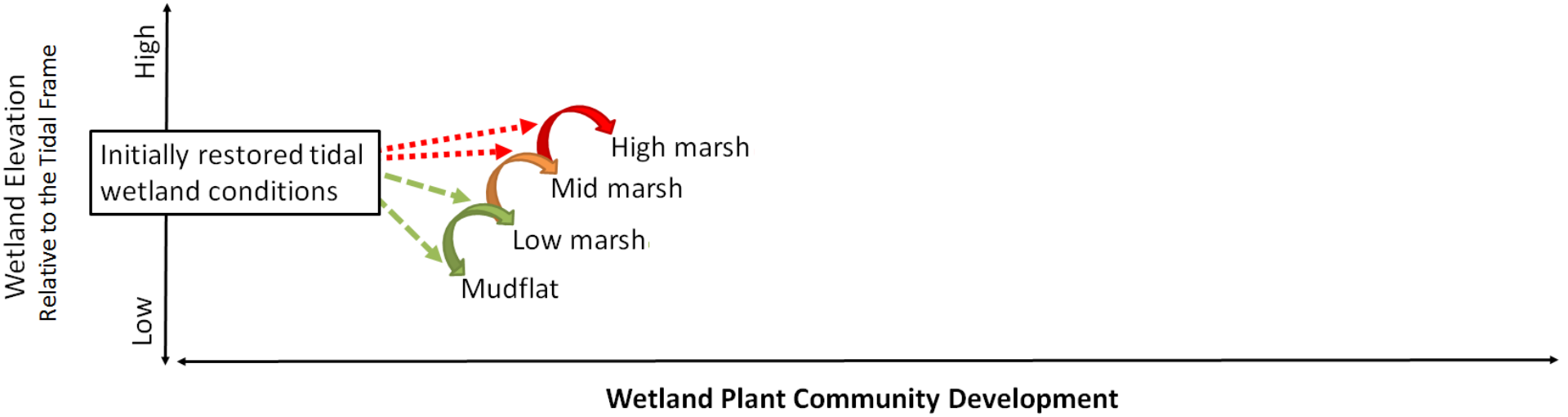
Native low - high marsh



***Carex lyngbyei* Hornem., lyngbye's sedge, *and Schoenoplectus lacustris* (L.) Palla, bulrush**

Restoration Trajectories of Tidal Wetland Ecosystems

Observed restored low elevation marsh areas had higher similarity to reference marshes and less non-native species than higher elevation marsh areas.

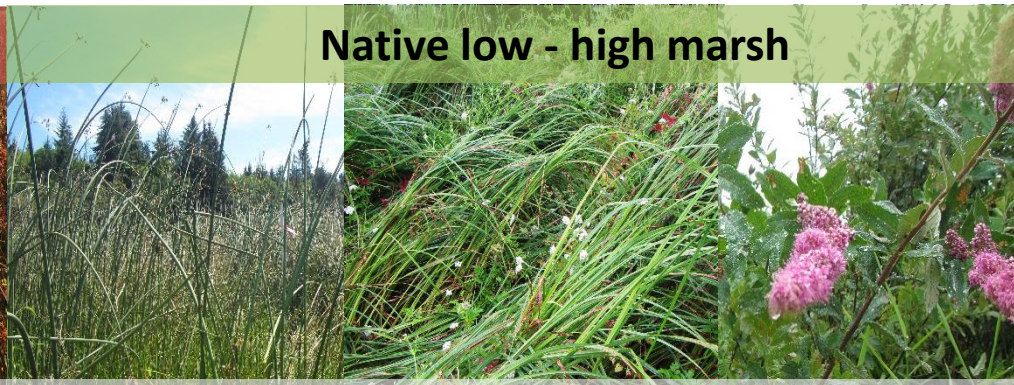


KIDD & YEAKLEY 2016

Non-native high marsh

***Phalaris arundinacea*, reed canarygrass, and *Juncus effusus subsp. effusus*, common rush**

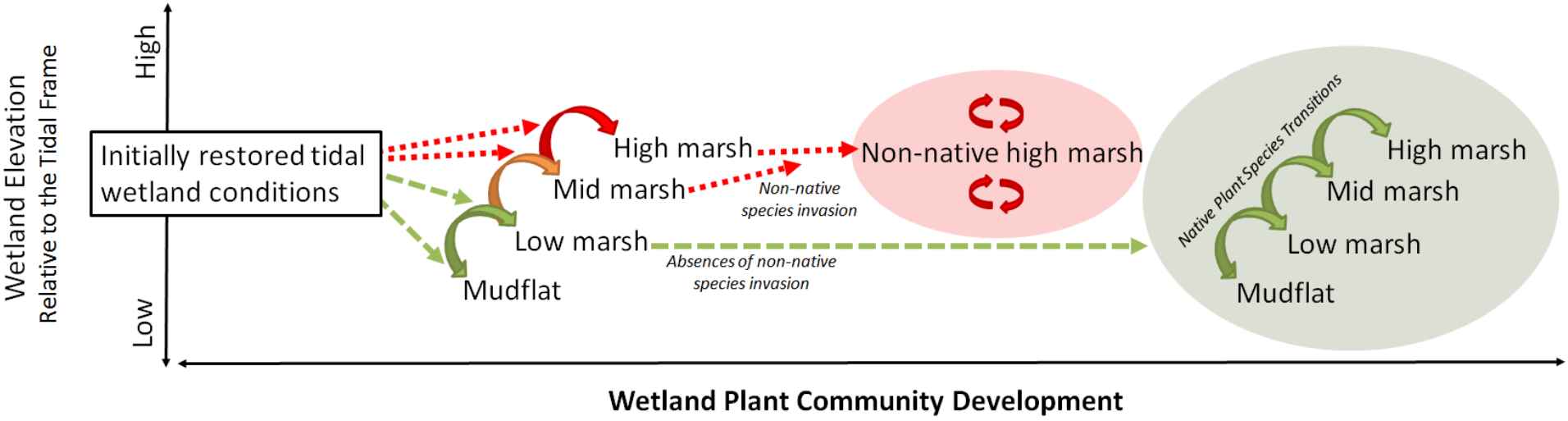
Native low - high marsh



***Carex lyngbyei* Hornem., lyngbye's sedge, *and Schoenoplectus lacustris* (L.) Palla, bulrush**

Restoration Trajectories of Tidal Wetland Ecosystems

Observed restored low elevation marsh areas had higher similarity to reference marshes and less non-native species than higher elevation marsh areas.

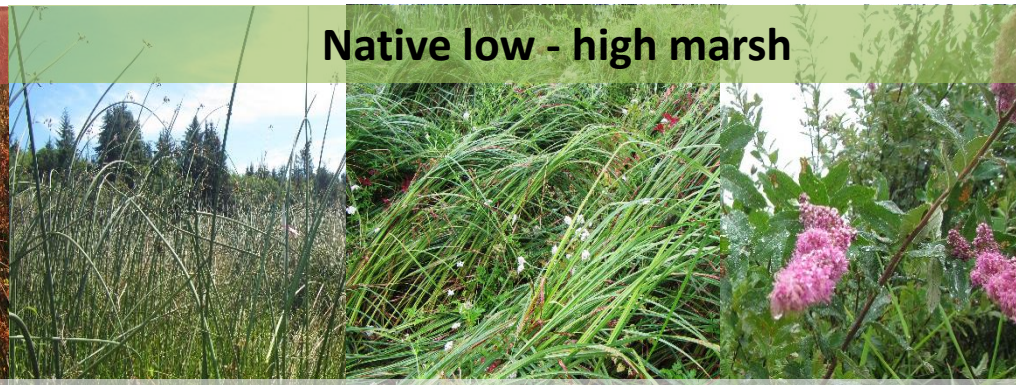


KIDD & YEAKLEY 2016

Non-native high marsh

***Phalaris arundinacea*, reed canarygrass, and *Juncus effusus subsp. effusus*, common rush**

Native low - high marsh



***Carex lyngbyei* Hornem., lyngbye's sedge, *and Schoenoplectus lacustris* (L.) Palla, bulrush**

Seed Bank Composition and Viability

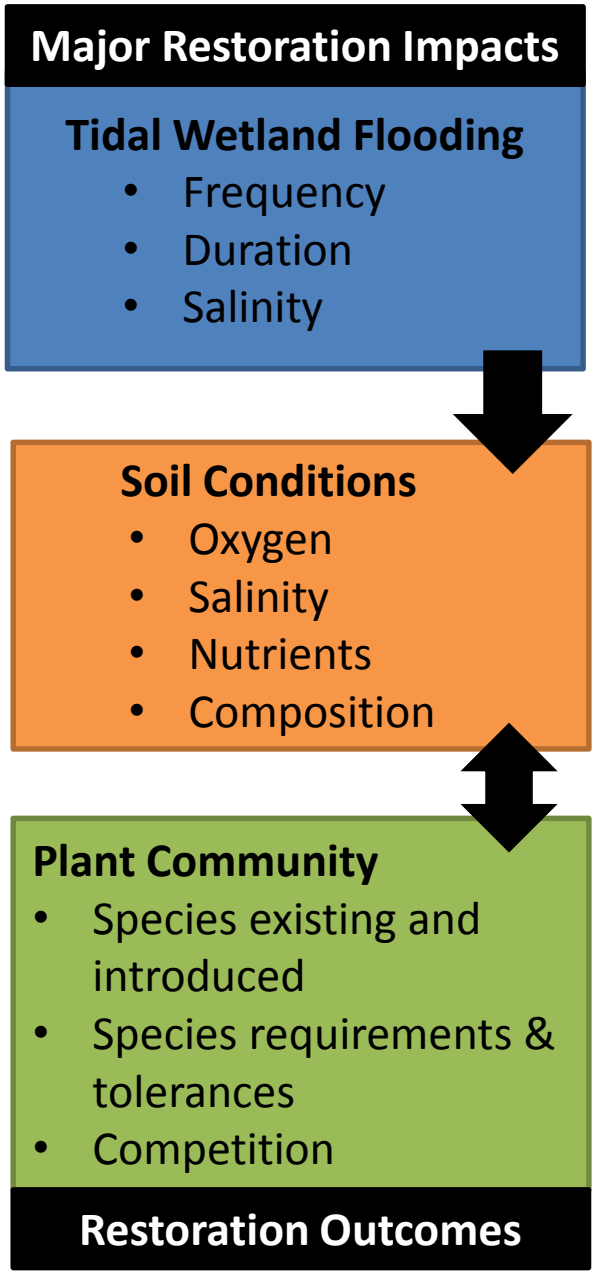
- A seed bank is the collection of seeds found in the soil
- **Seed germination is triggered by the right set of environmental conditions**

- A wetland's seed bank has been found to play an important role in wetland plant community development and resilience over time

Citations: van der Valk, A. G. 1981, Keddy 2004, Neff et al. 2009, McCormick and Gibble 2014

KIDD & YEAKLEY 2016

Drivers of Restoration Trajectories - Tidal Wetland Ecosystems

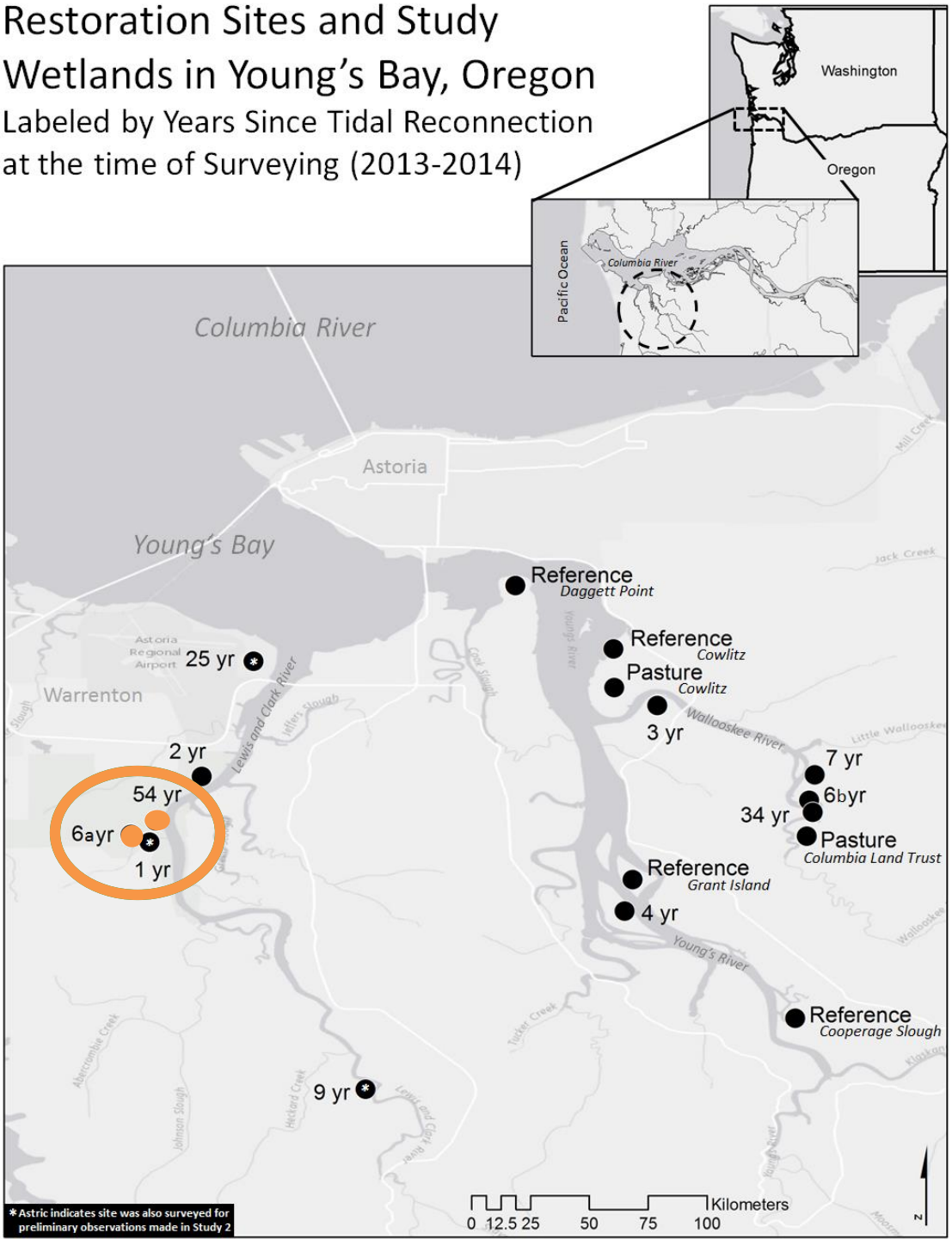


- How do **seed bank compositions** of restored **native and non-native** plant communities compare?

- How do these **seed banks** respond to different **tidal flooding and salinity** conditions?

KIDD & YEAKLEY 2016

Seed Bank Sampling

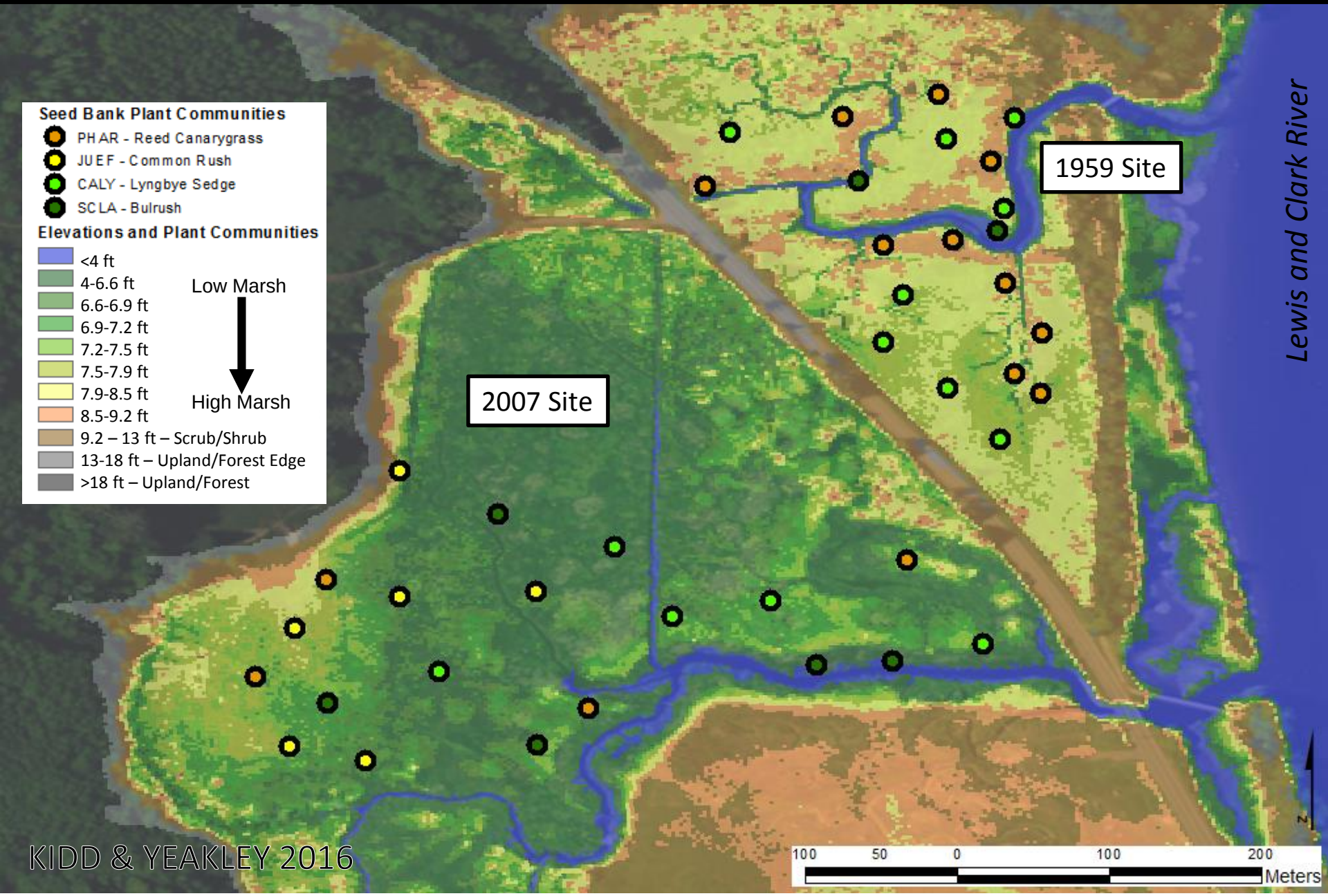


Seed Bank Sampling – April 2015

Dominant Native and Non-native Plant Communities Across 2 Restored Sites (1959, 2007)

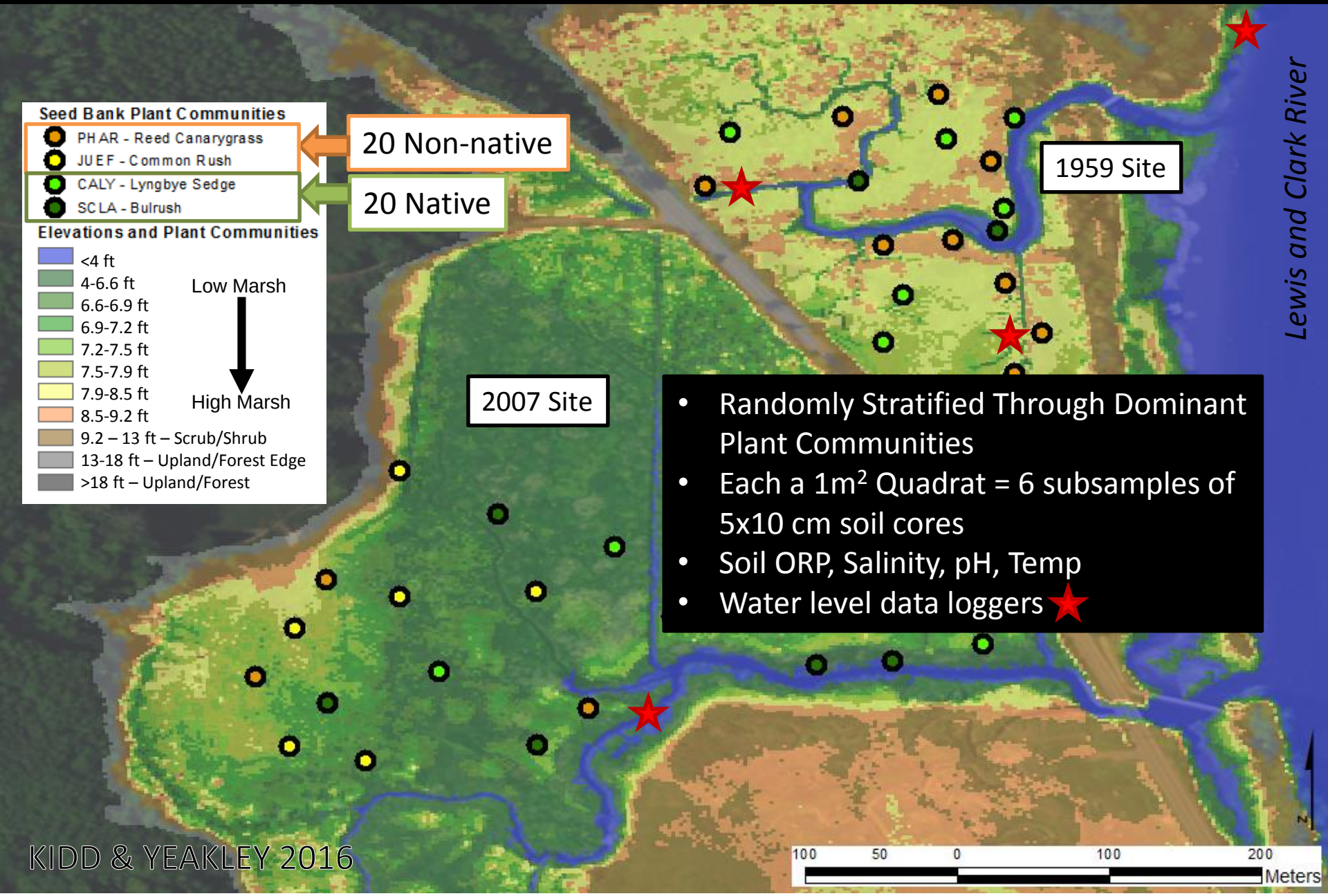
KIDD & YEAKLEY 2016

Lewis & Clark National Historical Park Restoration Sites
Seed Bank Sampling Locations & Elevation Map (2009 LiDAR - NAVD88)



KIDD & YEAKLEY 2016

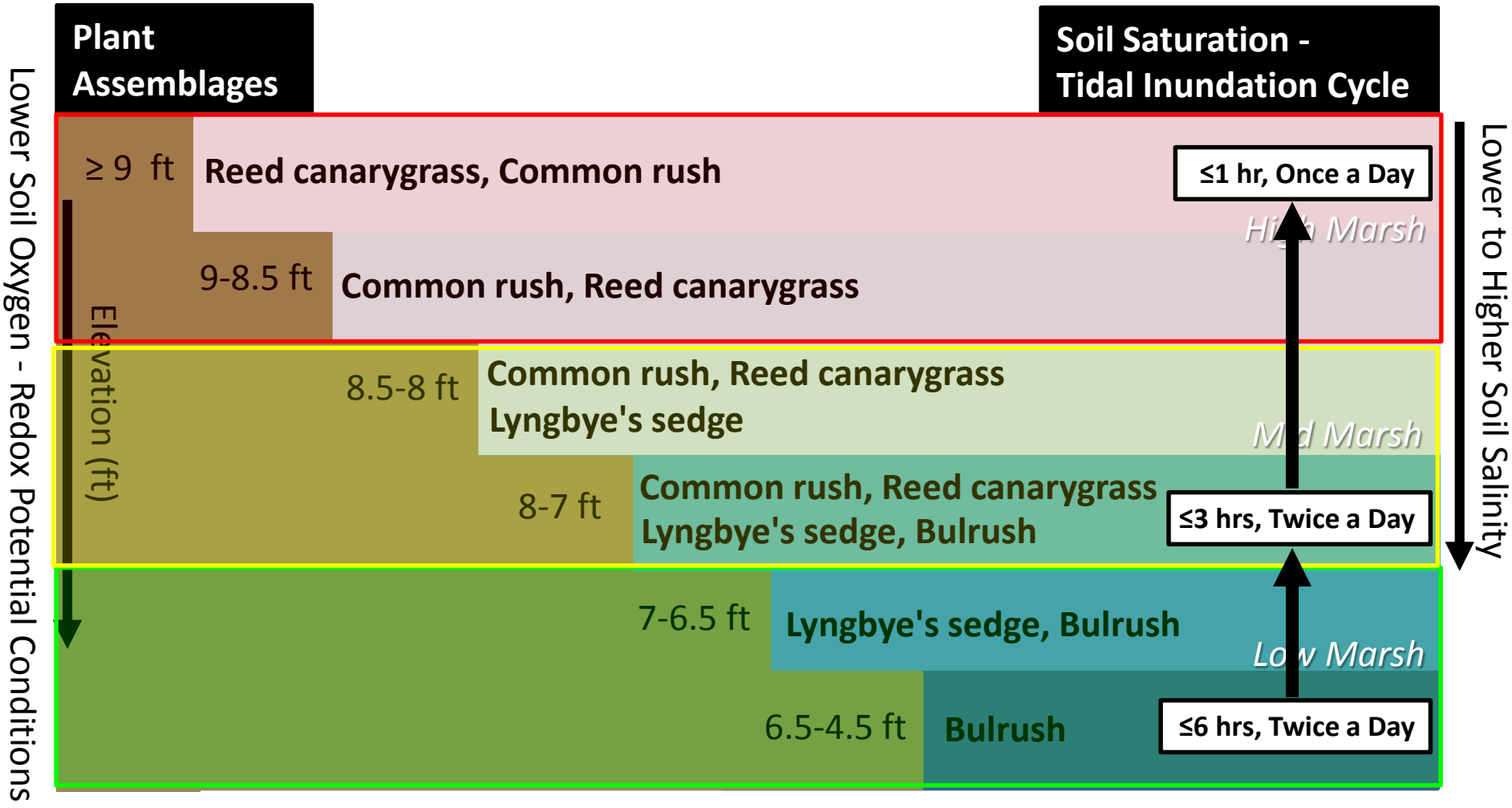
Lewis & Clark National Historical Park Restoration Sites
Seed Bank Sampling Locations & Elevation Map (2009 LiDAR - NAVD88)



KIDD & YEAKLEY 2016

Plant Assemblage Elevation Ranges

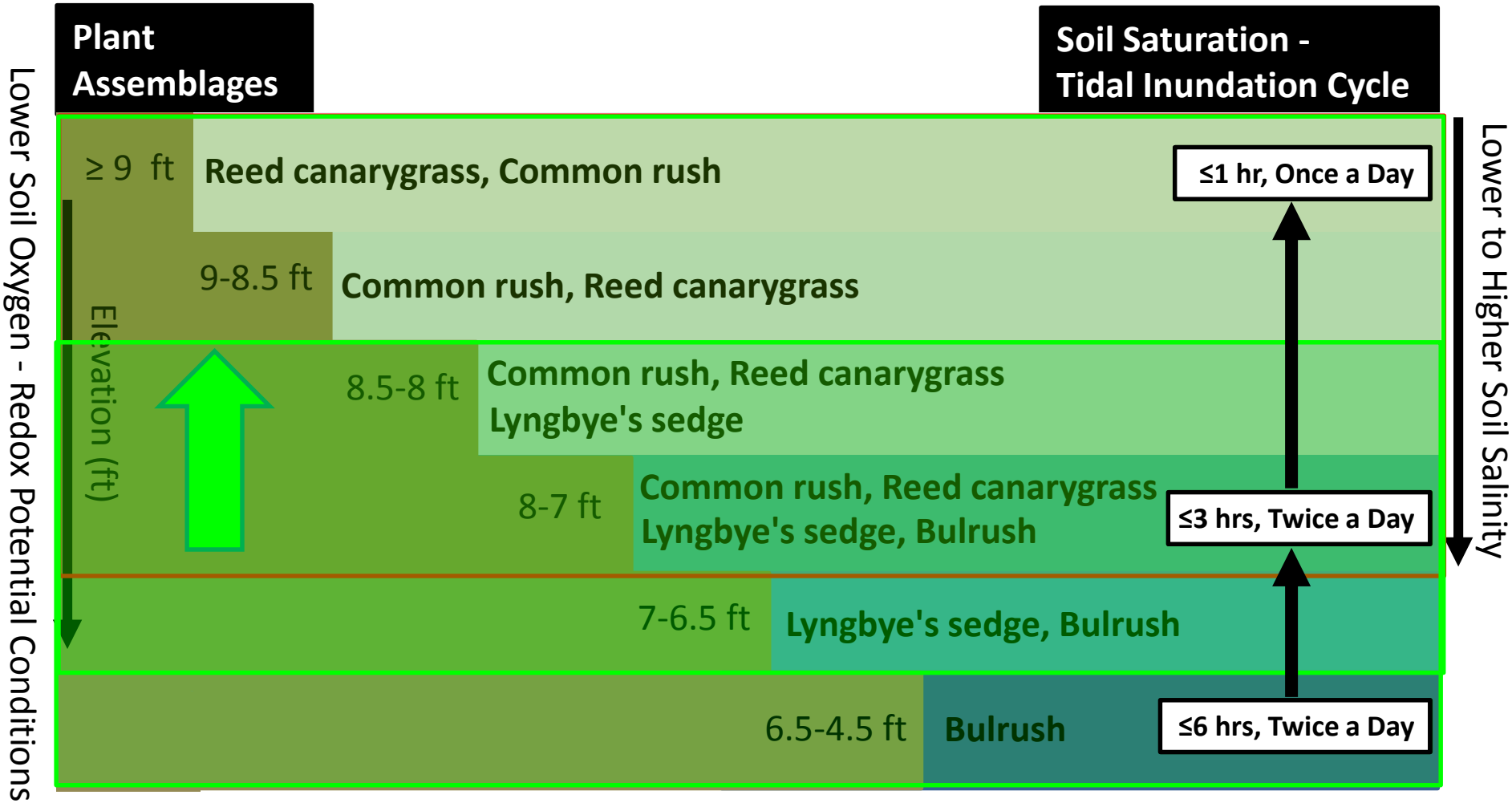
Frequency Analysis: Daily Mean Tidal Flooding Conditions March 2015



KIDD & YEAKLEY 2016

Plant Assemblage Elevation Ranges

Frequency Analysis: Daily Mean Tidal Flooding Conditions March 2015



By 2050 SLR is predicted to <u>increase local water levels up</u> to 1.12 ft (0.10-0.34 m) (Glick et al. 2007, Tebaldi et al. 2012)

KIDD & YEAKLEY 2016

KIDD & YEAKLEY 2016

GREEN HOUSE STUDY

Tidal Flooding Gradient	Salinity Gradient		
Treatments	**Fresh <1 ppt**	**Oligohaline 3 ppt**	**Brackish 10 ppt**
High Marsh (Flooded 1 hr x 1 day)			
Mid-Marsh (Flooded 3 hr x 2 day)			
Low Marsh (Flooded 6 hr x 2 day)			

- Seed bank samples processed to remove large debris and organic matter – these processed samples (~1,000 ml each) were then divided into 10 – 100ml sub-samples
- 9 of these sub-samples were distributed across the salinity x flooding treatments
- The 10^{th} sample was dried and evaluated for seed composition via direct seed ID

KIDD & YEAKLEY 2016

GREEN HOUSE STUDY

Tidal Flooding Gradient	Salinity Gradient		
Treatments	**Fresh <1 ppt**	**Oligohaline 3 ppt**	**Brackish 10 ppt**
High Marsh (Flooded 1 hr x 1 day)	Native n=20, Non-native n=20	Native n=20, Non-native n=20	Native n=20, Non-native n=20
Mid-Marsh (Flooded 3 hr x 2 day)	Native n=20, Non-native n=20	Native n=20, Non-native n=20	Native n=20, Non-native n=20
Low Marsh (Flooded 6 hr x 2 day)	Native n=20, Non-native n=20	Native n=20, Non-native n=20	Native n=20, Non-native n=20

- Seed bank samples processed to remove large debris and organic matter – these processed samples (~1,000 ml each) were then divided into 10 – 100ml sub-samples
- 9 of these sub-samples were distributed across the salinity x flooding treatments
- The 10th sample was dried and evaluated for seed composition via direct seed ID

METHODS: SEED BANK PROCESSING & GREEN HOUSE

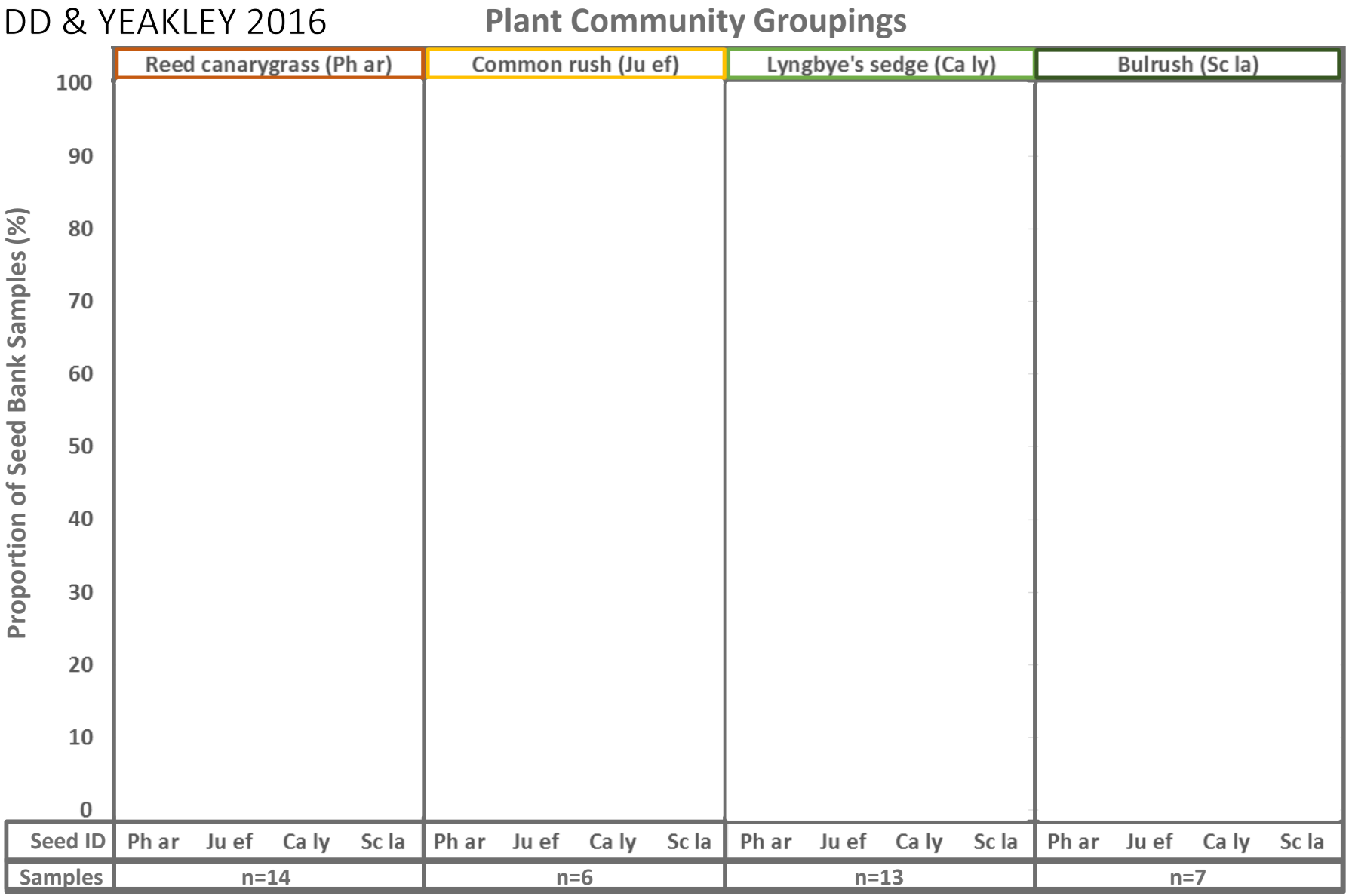
Results: Seed Bank Composition – Mean Relative Proportion (%±SE)

Dominant Species (seeds) Identified out of each Plant Community (per m^2)

KIDD & YEAKLEY 2016

Results: Seed Bank Composition – Mean Relative Proportion (%±SE)
Dominant Species (seeds) Identified out of each Plant Community (per m^2)

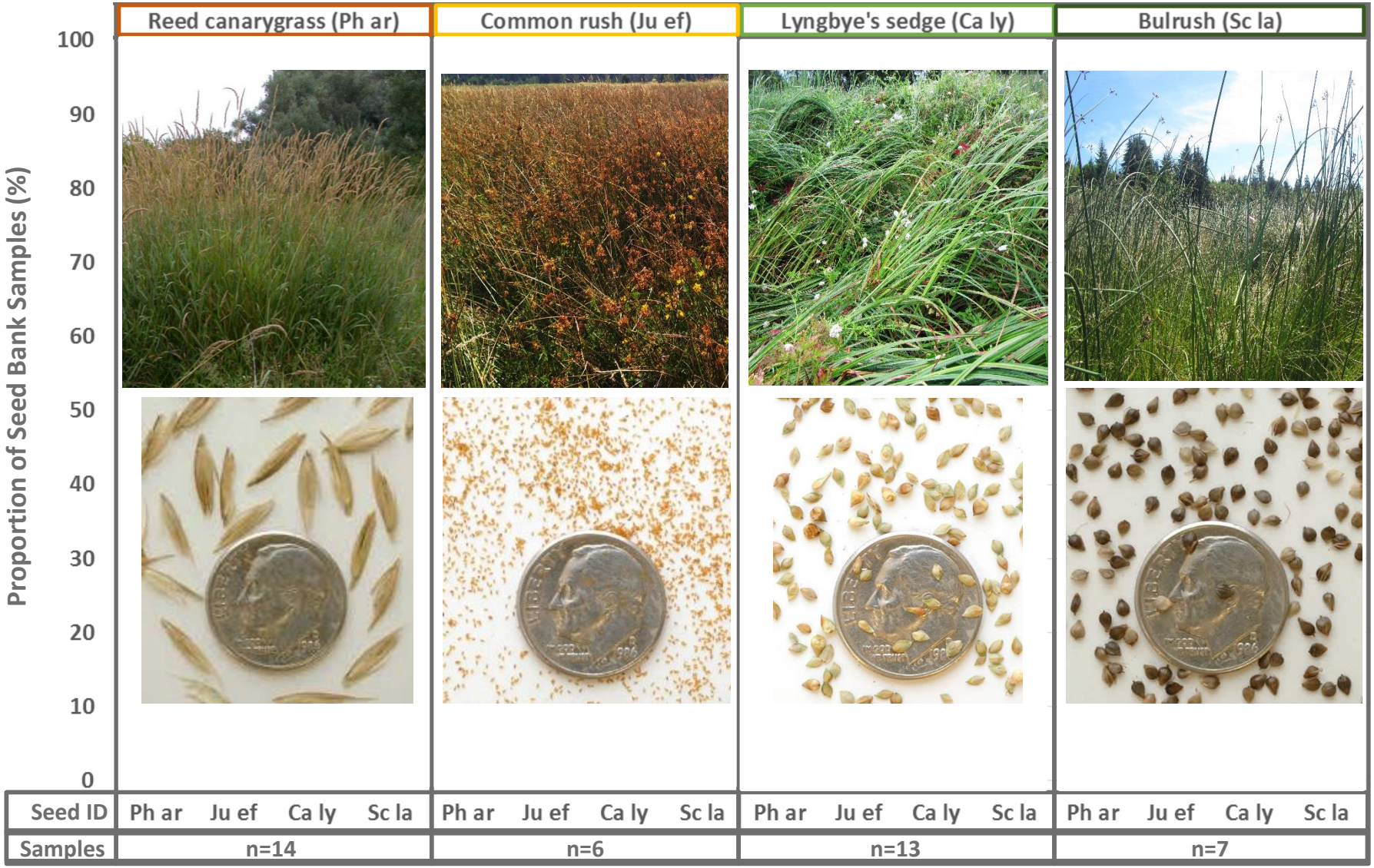
KIDD & YEAKLEY 2016



Results: Seed Bank Composition – Mean Relative Proportion (%±SE)
Dominant Species (seeds) Identified out of each Plant Community (per m^2)

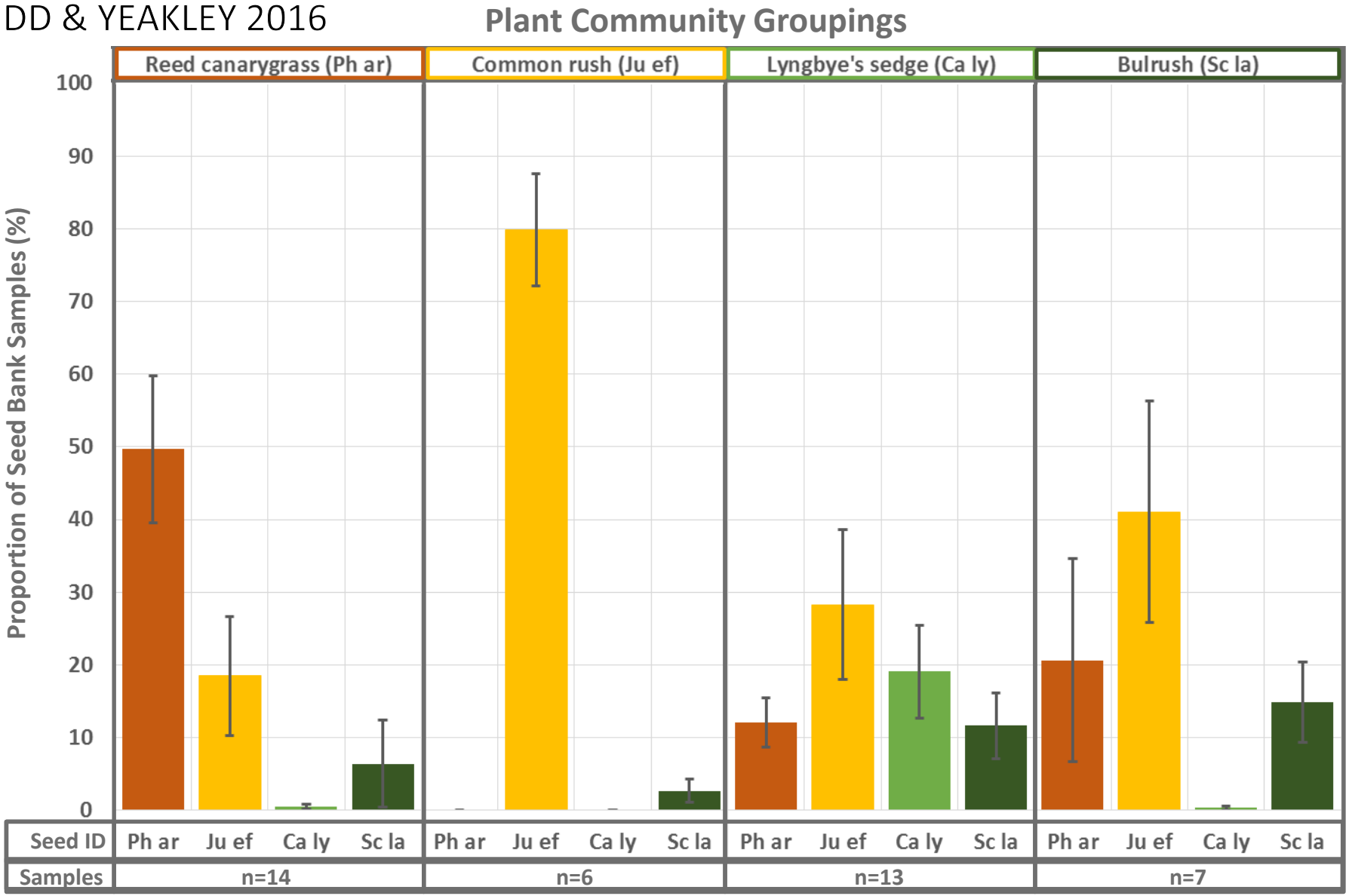
KIDD & YEAKLEY 2016

Plant Community Groupings



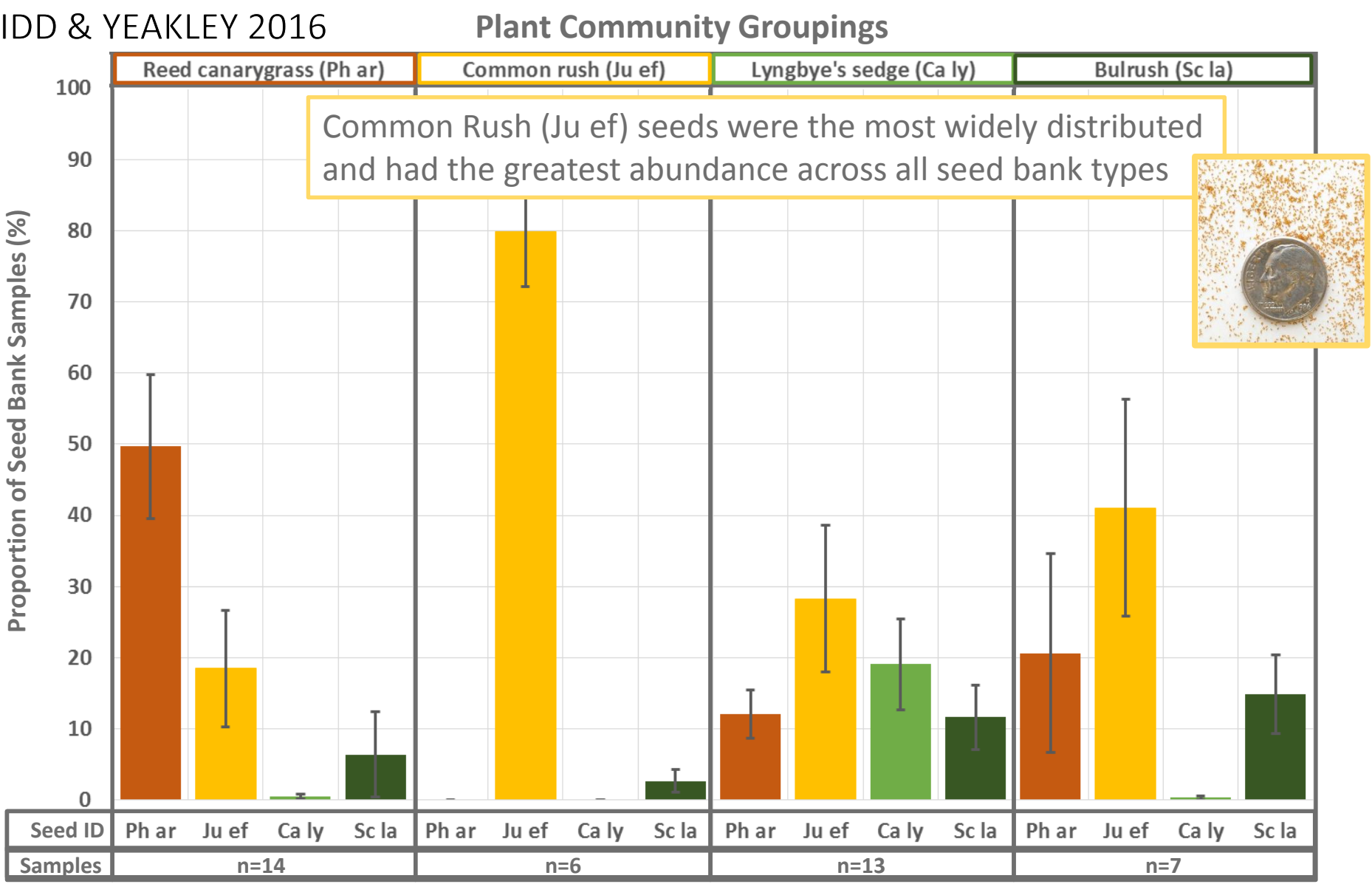
Results: Seed Bank Composition – Mean Relative Proportion (%±SE)
Dominant Species (seeds) Identified out of each Plant Community (per m^2)

KIDD & YEAKLEY 2016



Results: Seed Bank Composition – Mean Relative Proportion (%±SE) Dominant Species (seeds) Identified out of each Plant Community (per m^2)

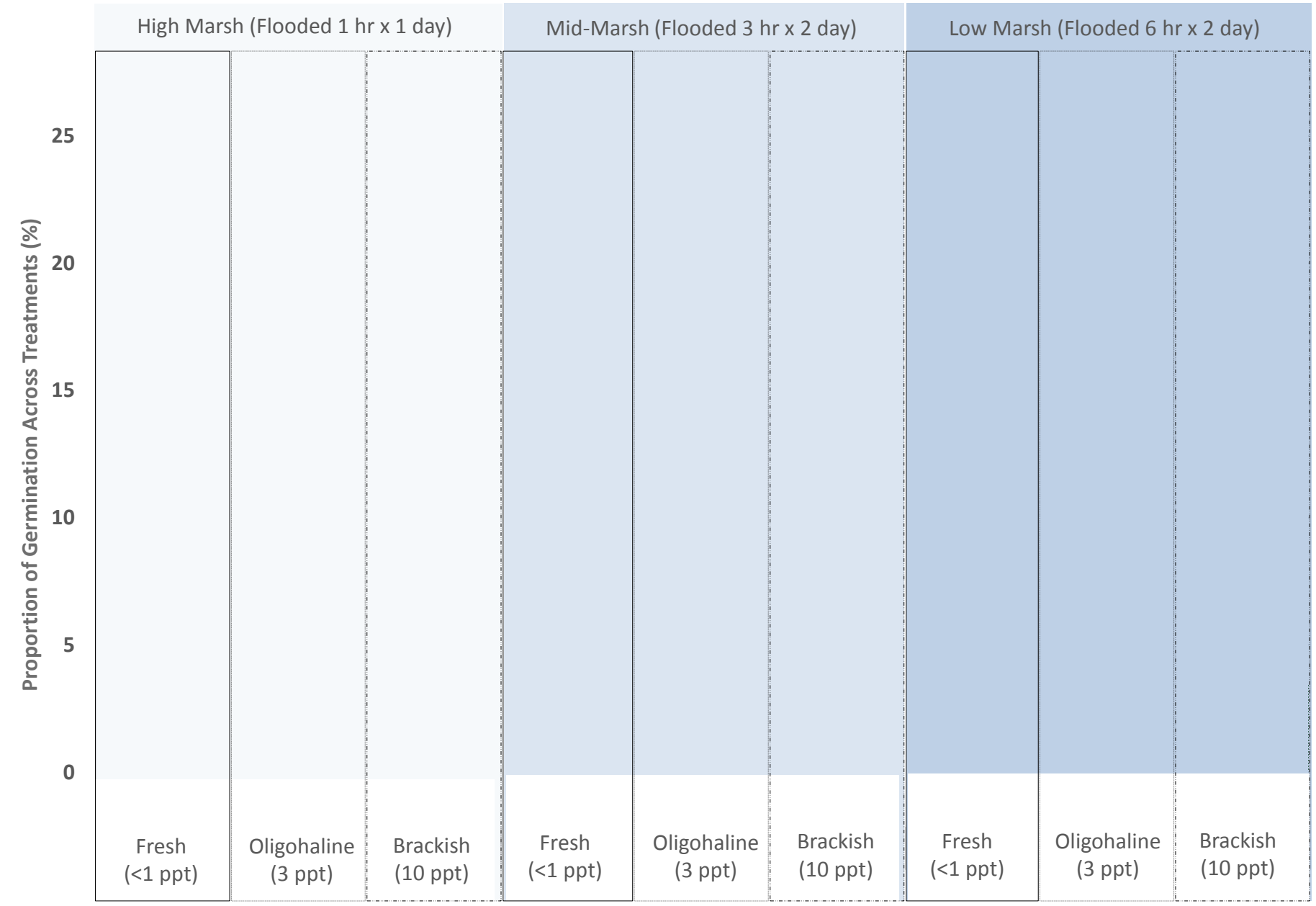
KIDD & YEAKLEY 2016



Seed Bank Response to Experimental Flooding & Salinity

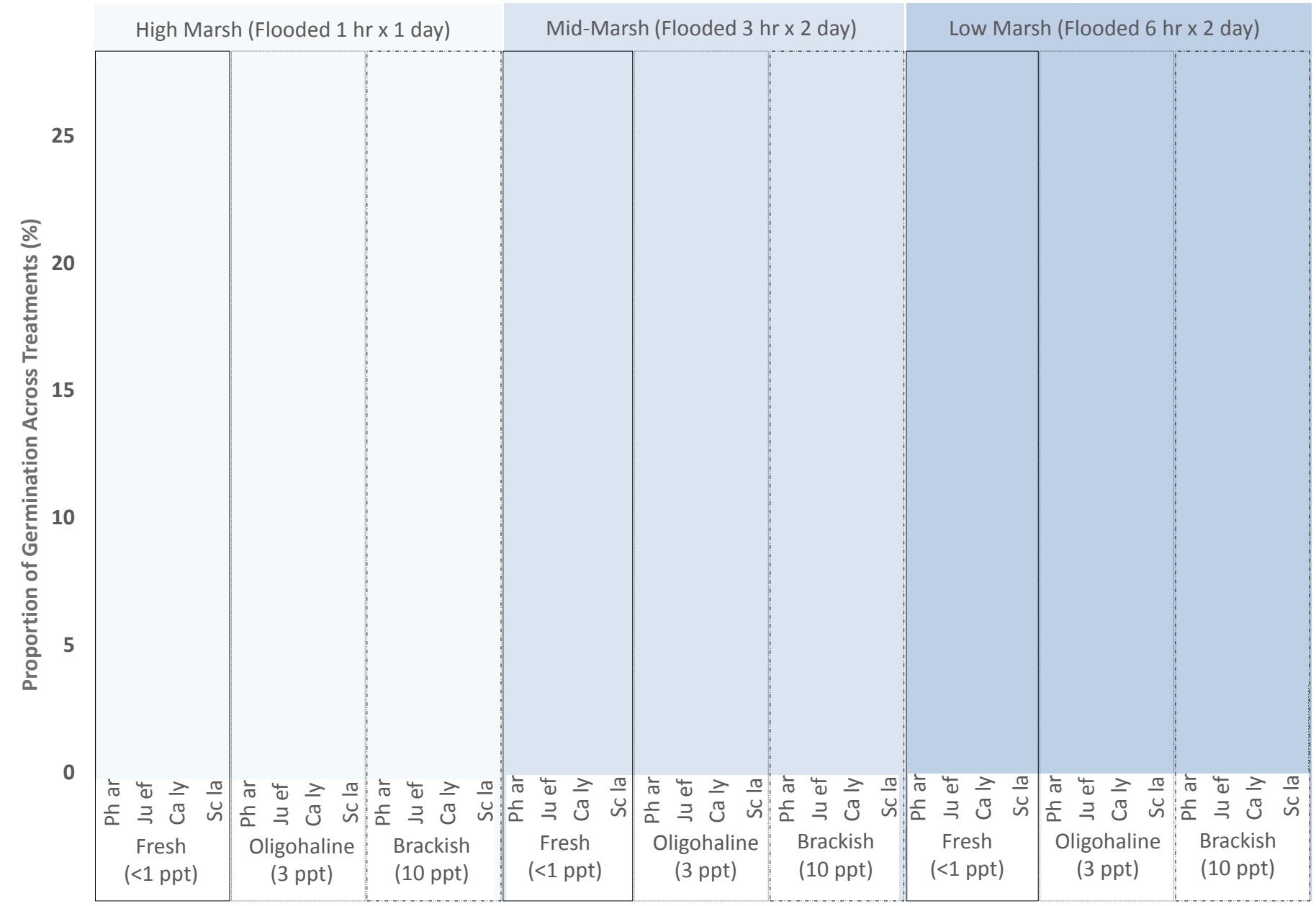
Mean Relative Proportion (%±SE)

KIDD & YEAKLEY 2016



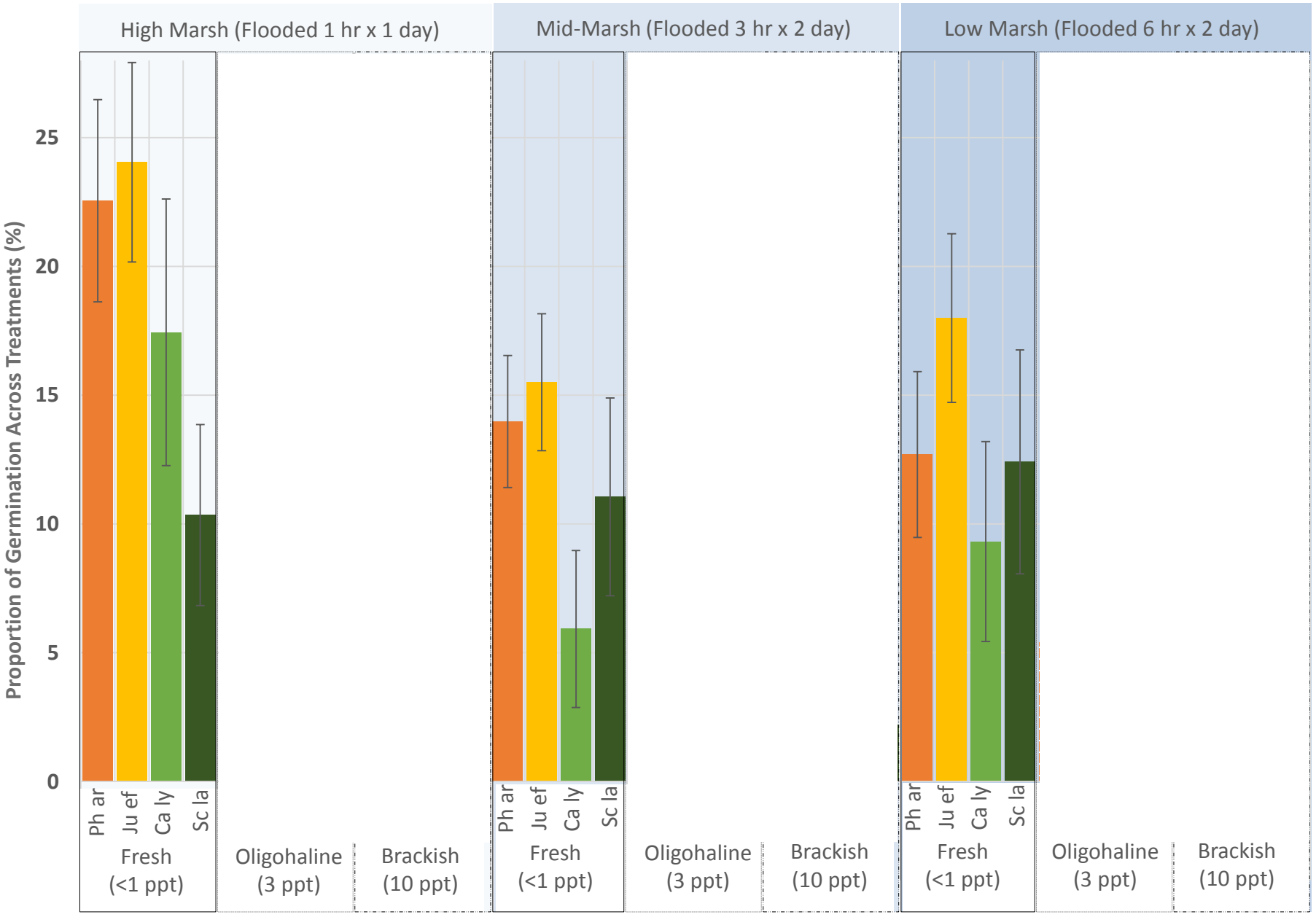
Seed Bank Response to Experimental Flooding & Salinity

Mean Relative Proportion (%±SE) KIDD & YEAKLEY 2016



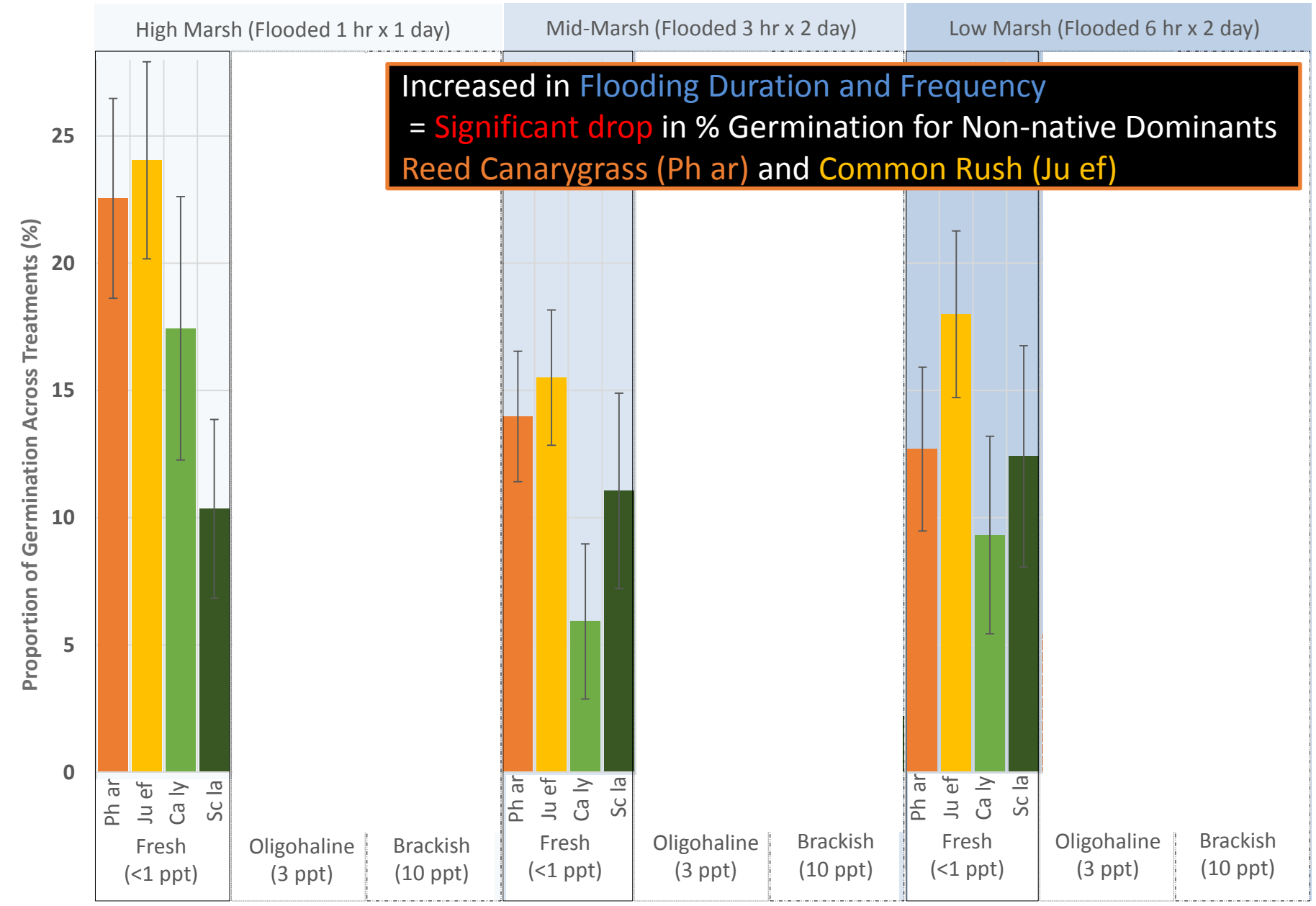
Seed Bank Response to Experimental Flooding & Salinity

Mean Relative Proportion (%±SE) KIDD & YEAKLEY 2016



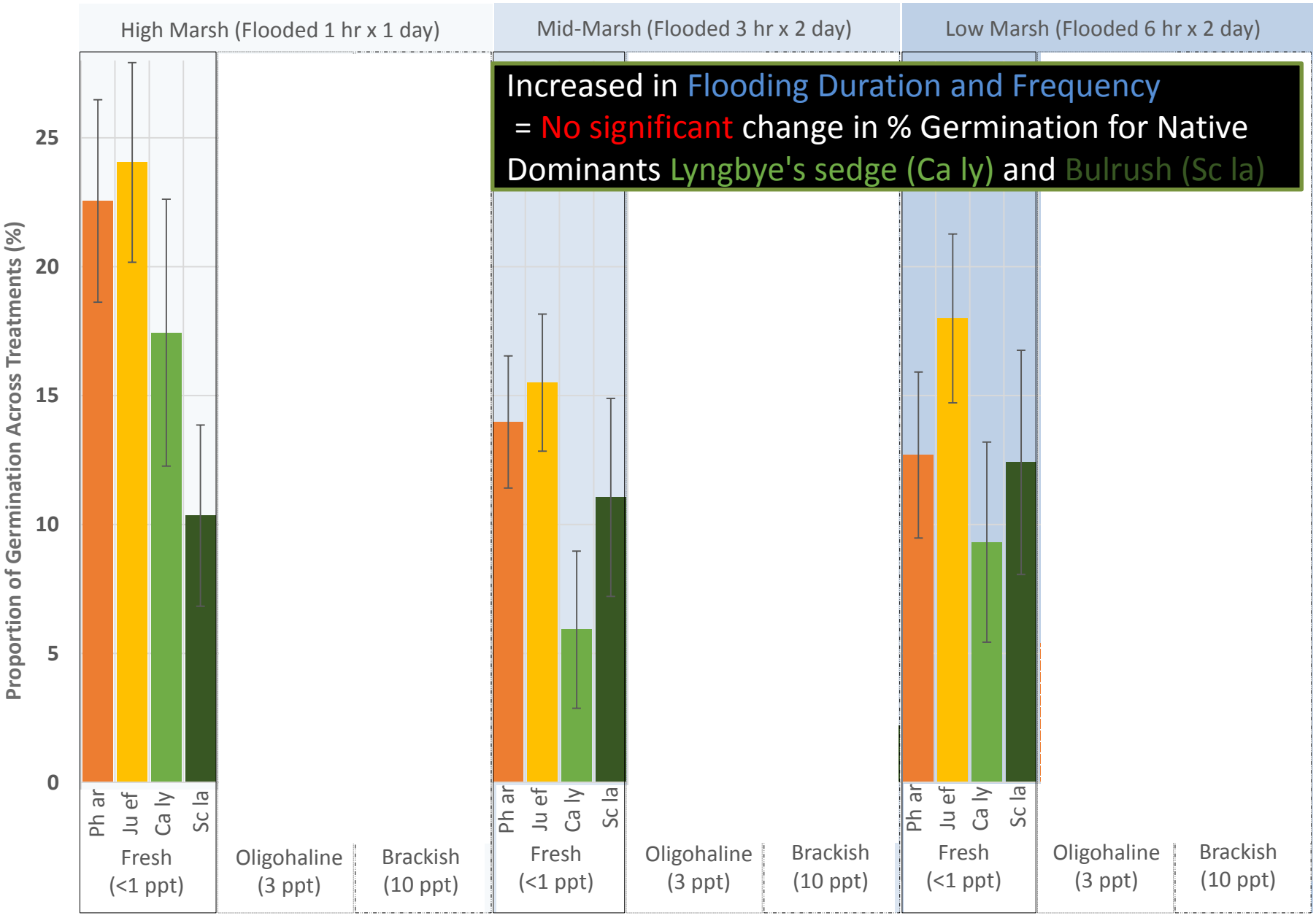
Seed Bank Response to Experimental Flooding & Salinity

Mean Relative Proportion (%±SE) KIDD & YEAKLEY 2016



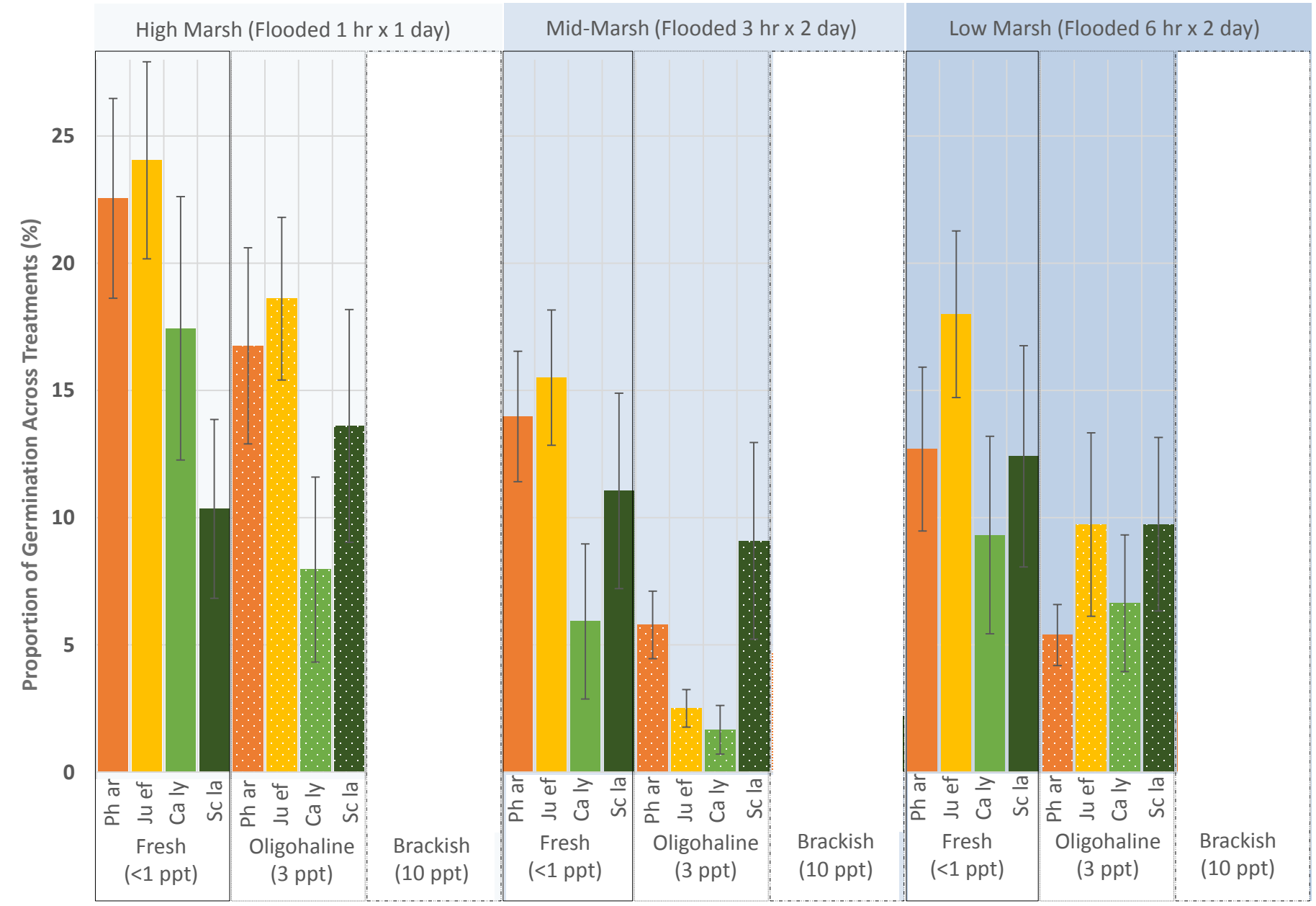
Seed Bank Response to Experimental Flooding & Salinity

Mean Relative Proportion (%±SE) KIDD & YEAKLEY 2016



Seed Bank Response to Experimental Flooding & Salinity

Mean Relative Proportion (%±SE) KIDD & YEAKLEY 2016



Seed Bank Response to Experimental Flooding & Salinity

Mean Relative Proportion (%±SE) KIDD & YEAKLEY 2016

High Marsh (Flooded 1 hr x 1 day) | Mid-Marsh (Flooded 3 hr x 2 day) | Low Marsh (Flooded 6 hr x 2 day)

Increased to 3 ppt Salinity + Flooding Duration and Frequency
= Further Significant drop in % Germination for Non-native Dominants Reed Canarygrass (Ph ar) and Common Rush (Ju ef)
- Overall No Significant Change for the Native Species

Proportion of Germination Across Treatments (%)

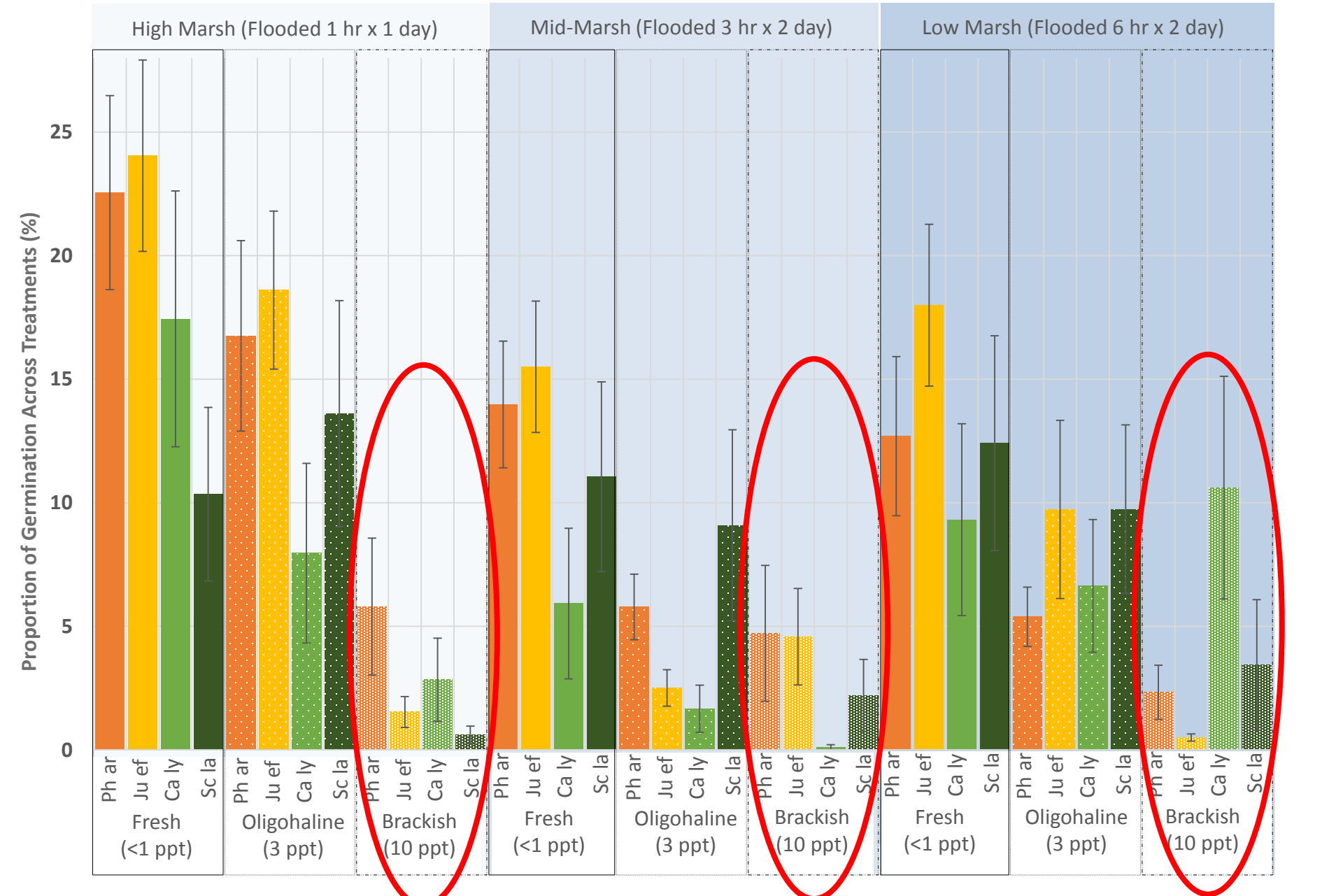
0 | 5 | 10 | 15 | 20 | 25

Ph ar | Ju ef | Ca ly | Sc la

Fresh (<1 ppt) | Oligohaline (3 ppt) | Brackish (10 ppt)

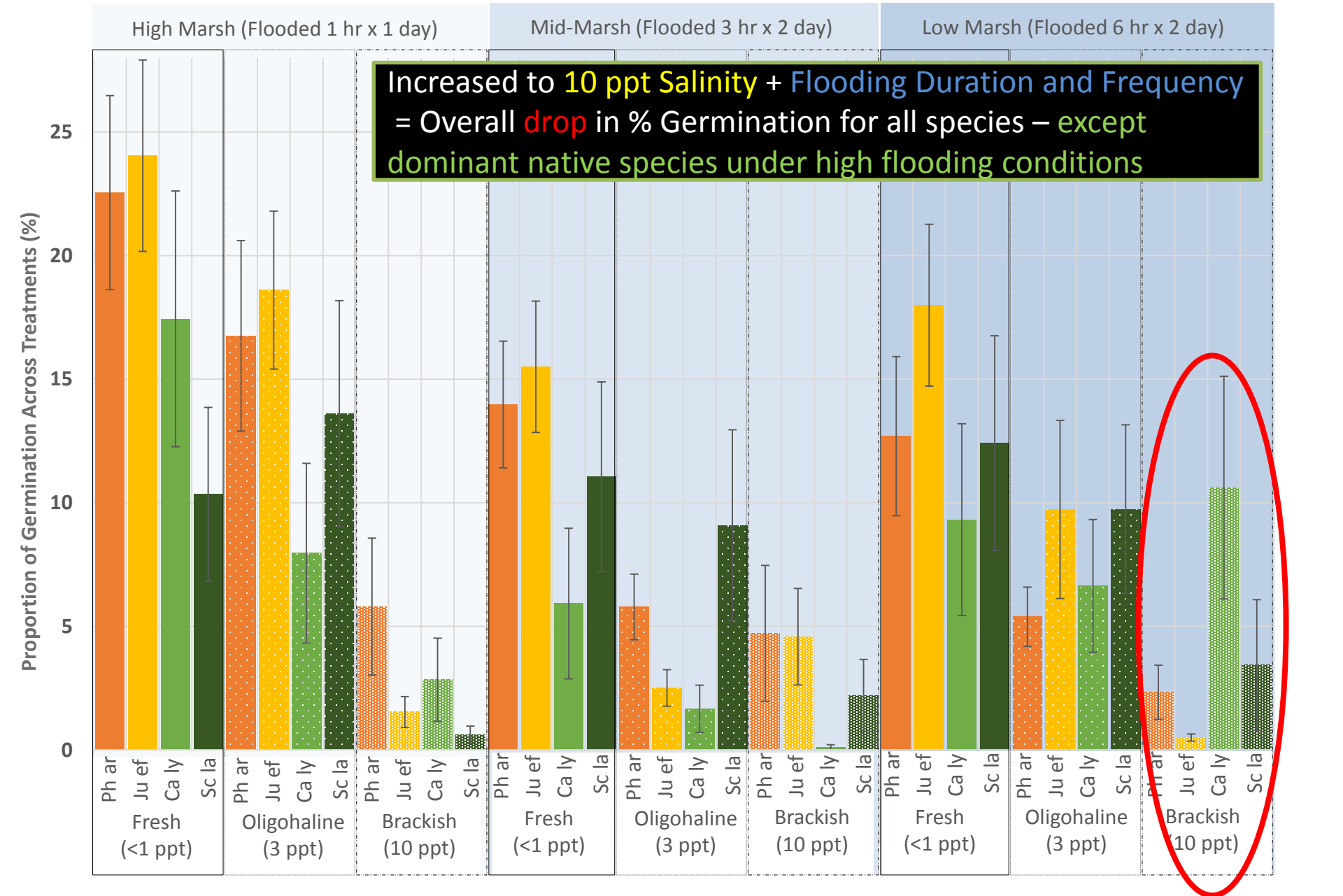
Seed Bank Response to Experimental Flooding & Salinity

Mean Relative Proportion (%±SE) KIDD & YEAKLEY 2016



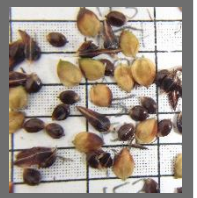
Seed Bank Response to Experimental Flooding & Salinity

Mean Relative Proportion (%±SE) KIDD & YEAKLEY 2016



Primary Drivers of Plant Community Development

KIDD & YEAKLEY 2016

Seed Bank Viability – Flooding and Salinity: Outcomes	**Similar** seed bank compositions (no more or less native/non-native) 	**Different** seed bank compositions (more or less native/non-native) 
Similar response to tidal/ salinity treatments 	**Plant competition**	**Initial establishment and plant competition**
Different response to tidal/ salinity treatments 	**Tidal flooding/salinity gradients**	**Initial establishment and tidal flooding/salinity gradients**

PRIMARY DRIVERS OF PLANT COMMUNITY DEVELOPMENT

KIDD & YEAKLEY 2016

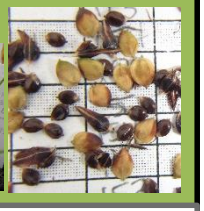
SEED BANK VIABILITY – FLOODING AND SALINITY	SEED BANK COMPOSITION		
OUTCOMES	**Similar** seed bank compositions (no more or less native/non-native)	**Different** seed bank compositions (more or less native/non-native) 	
Similar response to tidal/ salinity treatments 	**Plant competition**	**Initial establishment and plant competition** 	
Different response to tidal/ salinity treatments 	**Tidal flooding/salinity gradients**	**Initial establishment and tidal flooding/salinity gradients** 	

Primary Drivers of Plant Community Development

KIDD & YEAKLEY 2016

Seed Bank Viability – Flooding and Salinity

Seed Bank Composition

Outcomes	**Similar** seed bank compositions (no more or less native/non-native)	**Different** seed bank compositions (more or less native/non-native) 
Similar response to tidal/ salinity treatments 	Plant competition	Native Species **Initial establishment and plant competition**  
Different response to tidal/ salinity treatments 	Tidal flooding/salinity gradients	Initial establishment and tidal flooding/salinity gradients

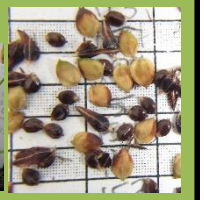
Fresh – Oligohaline
Low – High Flooding

Primary Drivers of Plant Community Development

KIDD & YEAKLEY 2016

Seed Bank Composition

Seed Bank Viability – Flooding and Salinity

Outcomes	**Similar** seed bank compositions (no more or less native/non-native)	**Different** seed bank compositions (more or less native/non-native) 
Similar response to tidal/ salinity treatments 	Plant competition	**Native Species** **Initial establishment and plant competition**  
Different response to tidal/ salinity treatments 	Tidal flooding/salinity gradients	**Non-native Species** **Initial establishment and tidal flooding/salinity gradients**  

Fresh – Oligohaline
Low – High Flooding

Primary Drivers of Plant Community Development

KIDD & YEAKLEY 2016

Seed Bank Viability – Flooding and Salinity	Seed Bank Composition	
Outcomes	**Similar** seed bank compositions (no more or less native/non-native)	**Different** seed bank compositions (more or less native/non-native) 
Similar response to tidal/ salinity treatments	Plant competition	Initial establishment and plant competition
Different response to tidal/ salinity treatments 	Tidal flooding/salinity gradients	Non-native Species Native Species **Initial establishment and tidal flooding/salinity gradients**  

Brackish
Low - High Flooding

PSU Undergrad Nathan Kossnar
Collecting Germination Data

KIDD & YEAKLEY 2016

Further Evidence
Direct Seed Planting Experiment

Ph ar, Ju ef, Ca ly, Sc la seeds

- **Collected Fall 2014**
- **Cold stratified 4 weeks**
- **Treated: Three flooding scenarios (fresh water)**
- **n=14 + 1 control for each treatment combo including 15 seeds of each species**

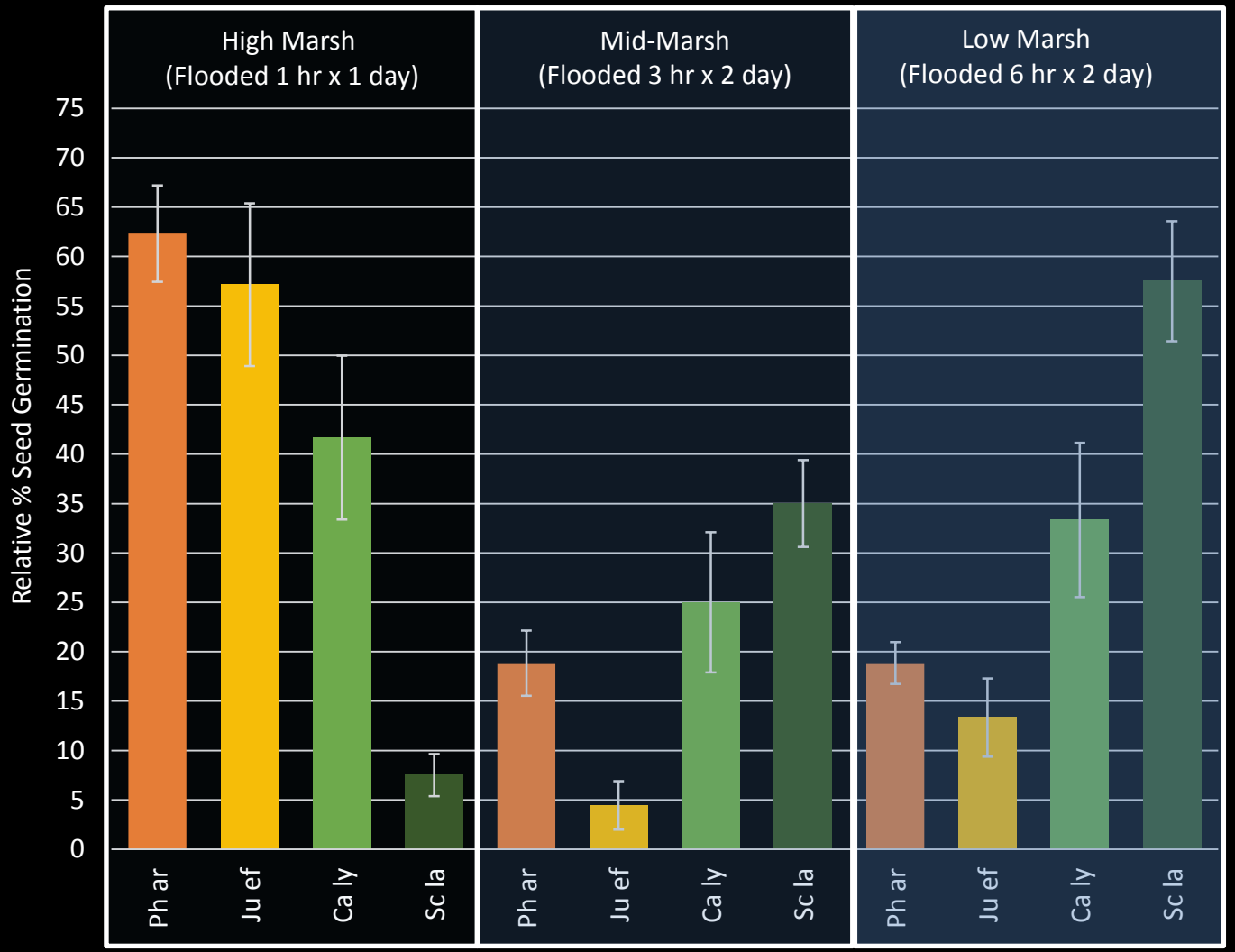
Ph ar, Ju ef, Ca ly, Sc la seeds

- **Collected Fall 2014**
- **Cold stratified 4 weeks**
- **Treated: Three flooding scenarios (fresh water)**
- **n=14 + 1 control for each treatment combo including 15 seeds of each species**

Direct Seed Planting Experiment

Relative % of Total Seed Germination for each Species (Mean ±SE)

KIDD & YEAKLEY 2016 **Across Flooding Treatments**



Very strong germination signal – significant decrease in Ph ar & Ju ef and increase in Sc la with increased flooding frequency and duration

Conclusions

- **Small Changes in Environmental Gradients: Flooding Frequency and Duration + Salinity** are important drivers of **Native and Non-native plant** community distributions
- **Existing Seed Banks** are important – especially in the **high marsh zone** if they contain non-native wetland species at the time of restoration

KIDD & YEAKLEY 2016

QUESTIONS?

Sarah Kidd
PhD Candidate, PSU
sarahkidd@pdx.edu
Instagram/Twitter:
@science_kidd
Website:
SarahKidd.info

BIG THANK YOU TO THE LEWIS AND CLARK NATIONAL HISTORICAL PARK
Cooperative Research Grant— Resources of the National Park System (CESU)

THANK YOU FOR LISTENING!

Research Sponsors

NSF
SWS
NATIONAL PARK SERVICE
SER SOCIETY FOR ECOLOGICAL RESTORATION

Land Owners & Partners

COWLITZ INDIAN TRIBE
NATIONAL PARK SERVICE
Columbia LAND TRUST
PORT OF ASTORIA
City of Seaside
crest COLUMBIA RIVER ESTUARY STUDY TASKFORCE
Lower Columbia Estuary Partnership
Northcoast Watershed Association