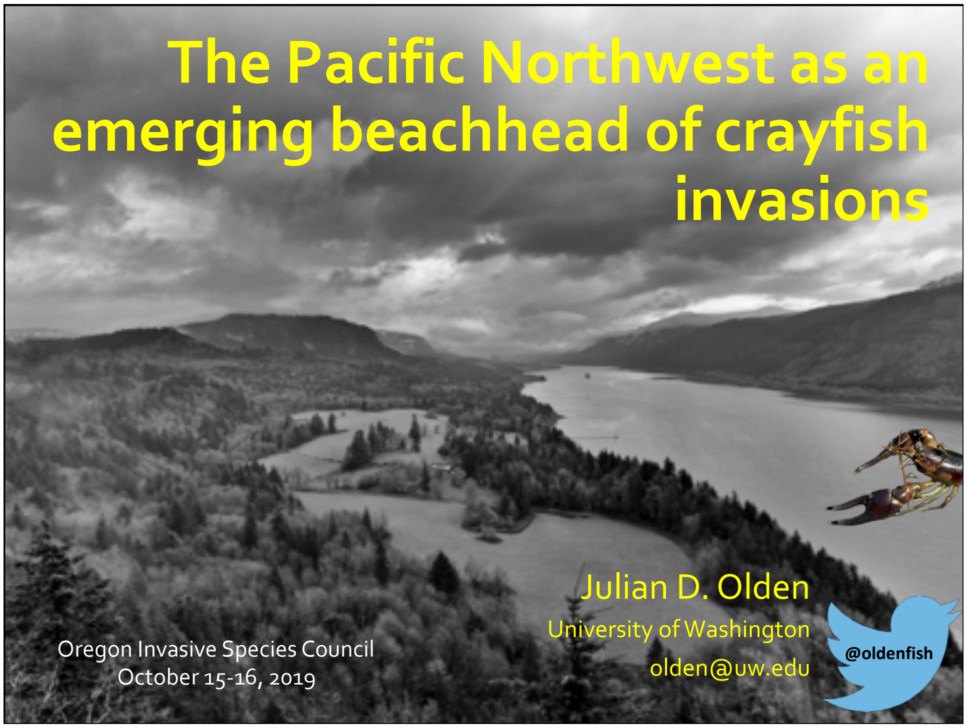
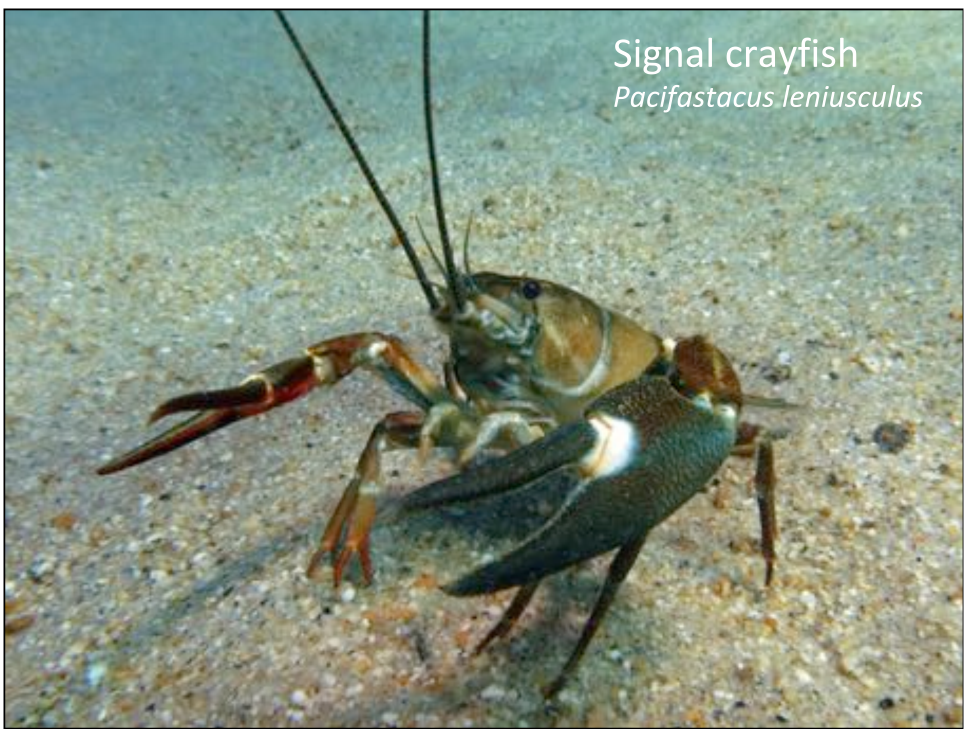
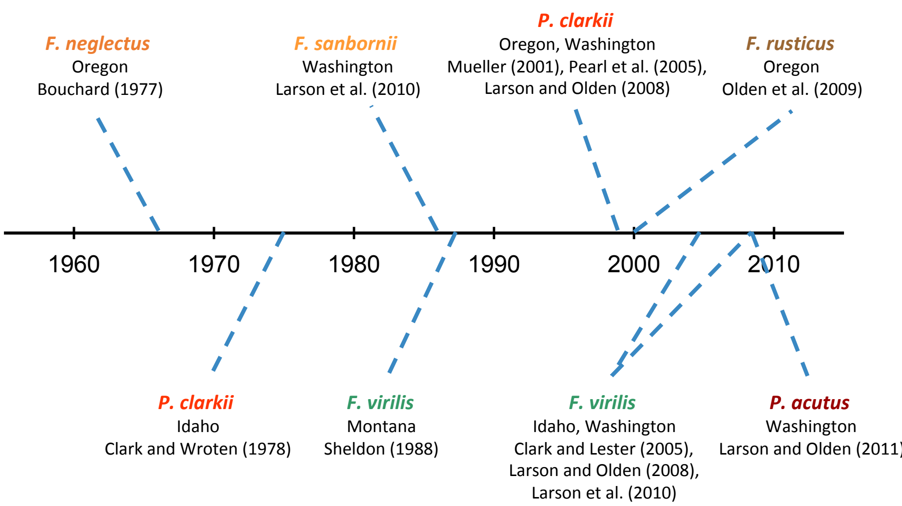

The Pacific Northwest as an emerging beachhead of crayfish invasions
Julian D. Olden
University of Washington
olden@uw.edu
@oldenfish
Oregon Invasive Species Council
October 15-16, 2019


Signal crayfish
Pacifastacus leniusculus

Chronology of crayfish invasions in the western U.S.



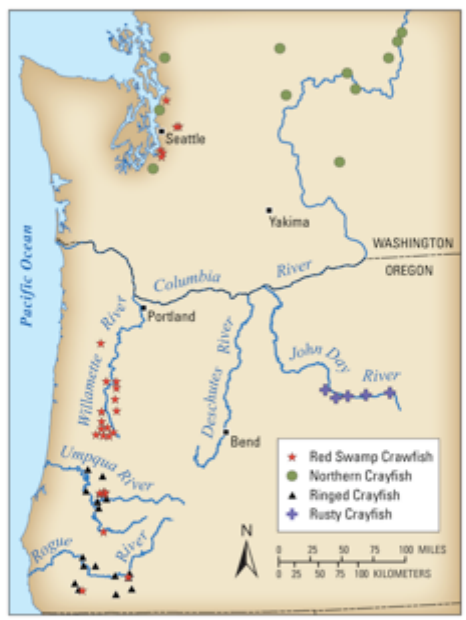
Non-native Crayfish in the PNW

Red swamp crawfish
Procambarus clarkii

Northern crayfish
Faxonius virilis

Ringed crayfish
Faxonius rusticus

Rusty crayfish
Faxonius rusticus



Distribution of four invasive crayfish in Oregon and Washington. Data are from USGS surveys in western Oregon and from Larson and Olden (2011) in Washington and John Day River, Oregon.

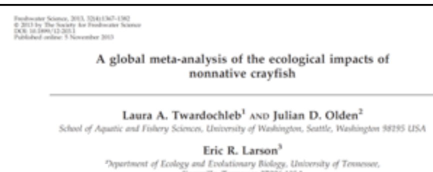
Pathways of Crayfish Introductions

- Release as live bait associated with angling
- Release after educational use in classroom
- Release associated with pet aquariums

- Intentional introduction as forage for sportfish
- Intentional introduction to golf course ponds
- Intentional introduction to create harvest opportunities

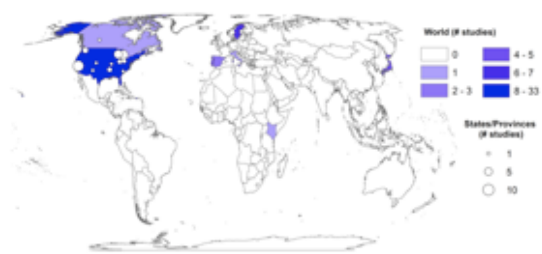
- Secondary spread from existing populations

Impacts of Invasive Crayfish

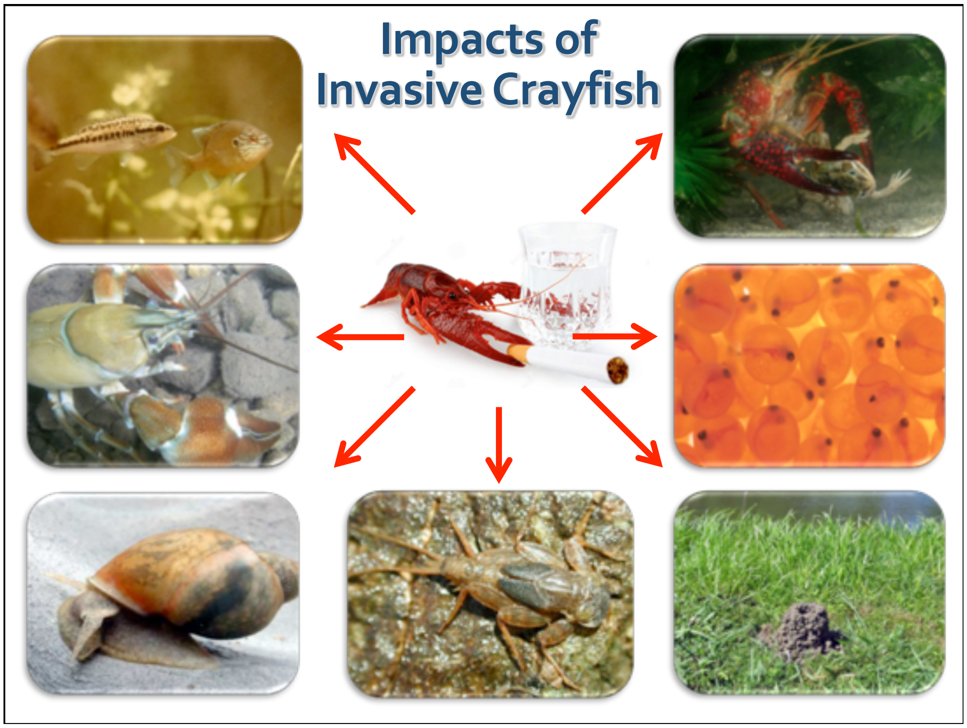

A global meta-analysis of the ecological impacts of nonnative crayfish

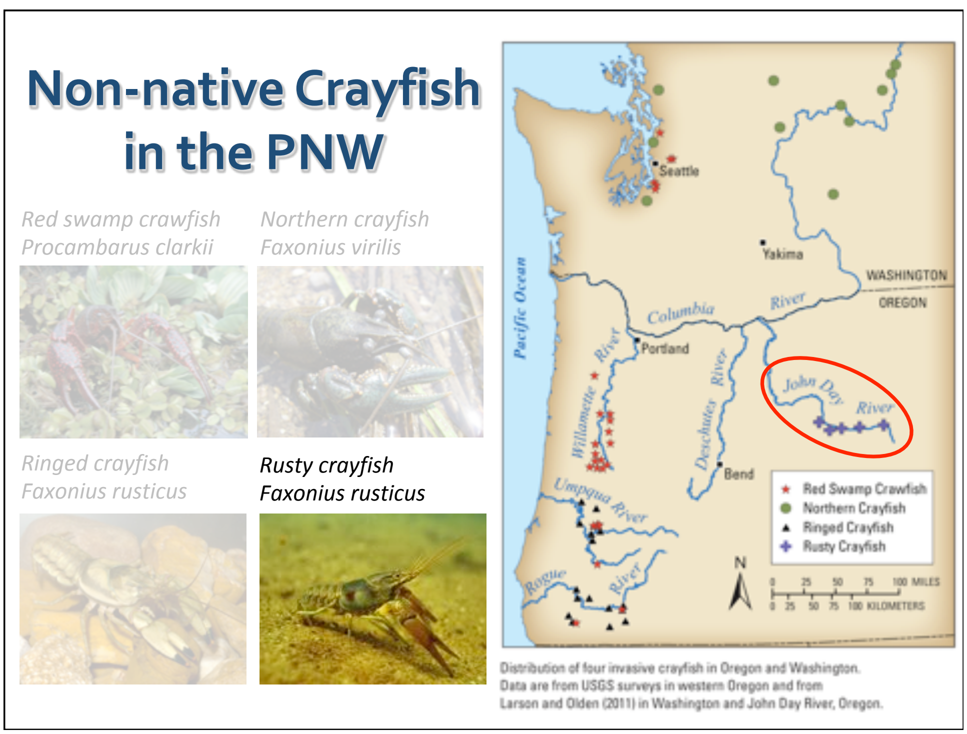
Laura A. Twardochleb[1] and Julian D. Olden[2]
School of Aquatic and Fishery Sciences, University of Washington, Seattle, Washington 98195 USA

Eric R. Larson[3]
Department of Ecology and Evolutionary Biology, University of Tennessee, ...ville, Tennessee 37996 USA

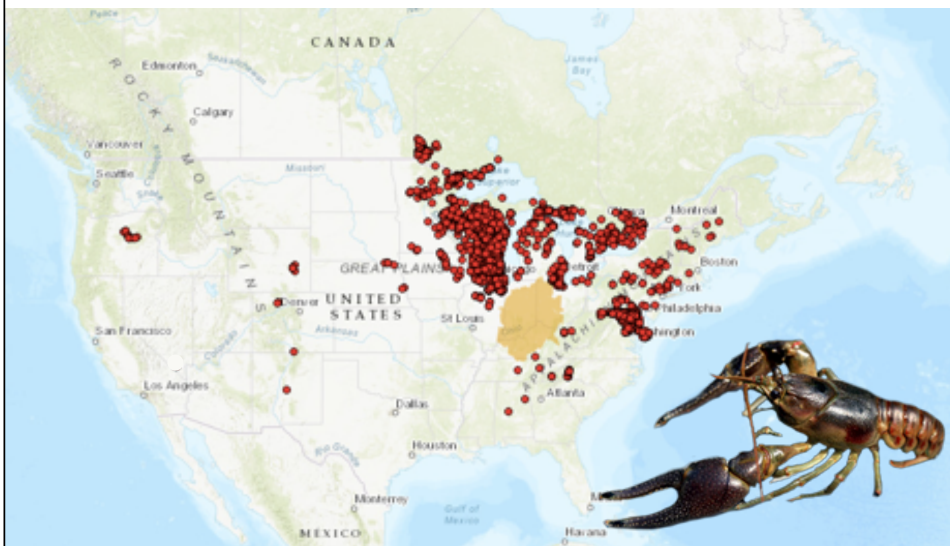


Meta-analysis of the published literature demonstrates that invasive crayfish are strong interactors in food webs, imposing significant effects due to polytrophic, generalist feeding habits.


Impacts of
Invasive Crayfish

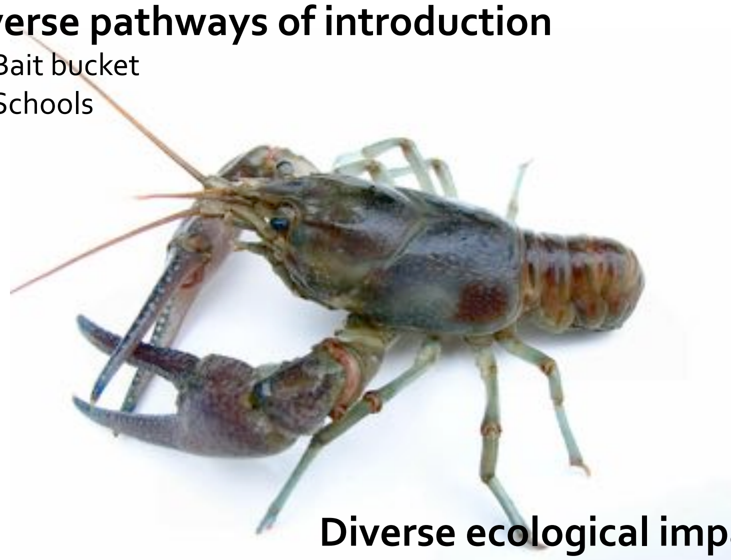

Non-native Crayfish
in the PNW
Red swamp crawfish
Procambarus clarkii
Northern crayfish
Faxonius virilis
Ringed crayfish
Faxonius rusticus
Rusty crayfish
Faxonius rusticus
Seattle
Yakima
WASHINGTON
OREGON
Columbia River
Portland
Pacific Ocean
Willamette River
Deschutes River
John Day River
Bend
Umpqua River
Rogue River
Red Swamp Crawfish
Northern Crayfish
Ringed Crayfish
Rusty Crayfish
N
0 25 50 75 100 MILES
0 25 50 75 100 KILOMETERS
Distribution of four invasive crayfish in Oregon and Washington.
Data are from USGS surveys in western Oregon and from
Larson and Olden (2011) in Washington and John Day River, Oregon.

Rusty Crayfish Distribution



Diverse pathways of introduction

- Bait bucket
- Schools



Diverse ecological impacts

- Polytrophic diet
- Extremely high densities

Twardochleb et al. 2013, Hansen et al. 2017

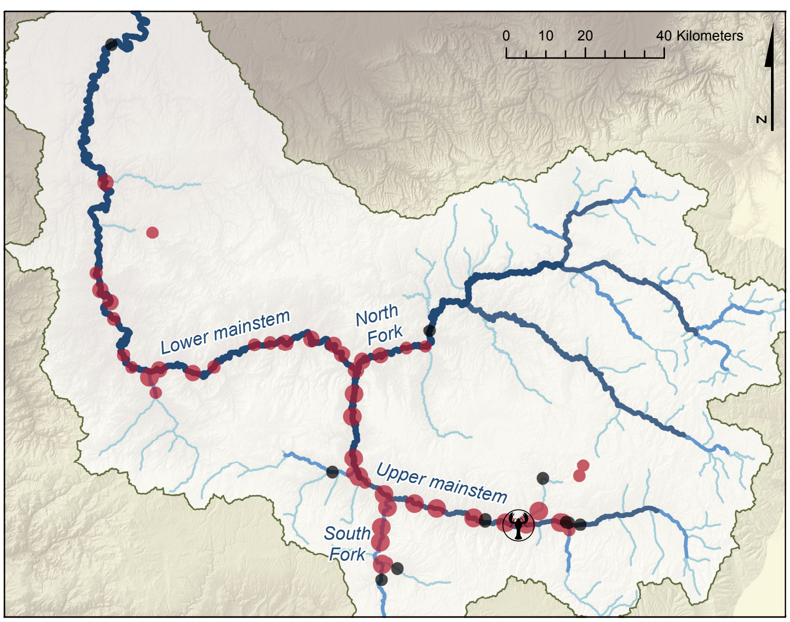
John Day River, OR

Rusty crayfish distribution

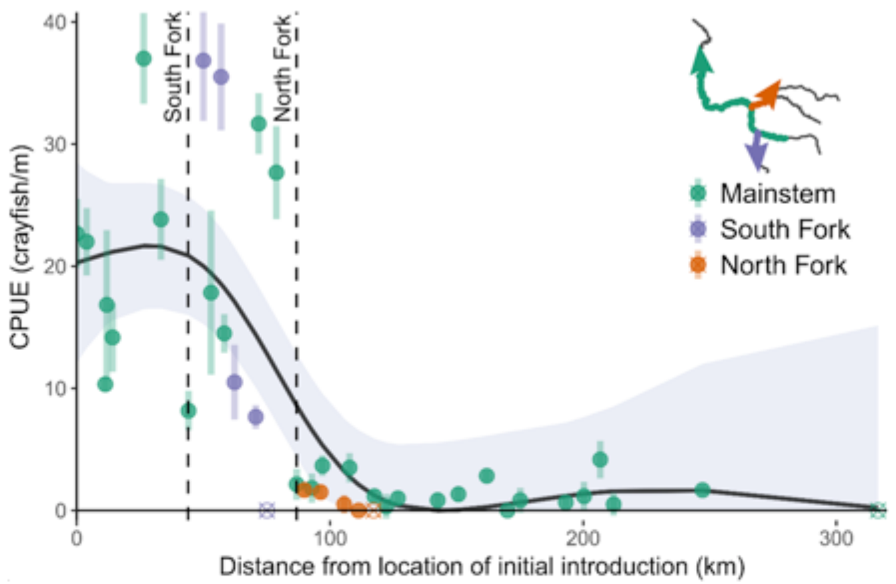
2005
Olden et al. (2009)

2010
Sorenson et al. (2012)

2016
Messager and Olden (2018)

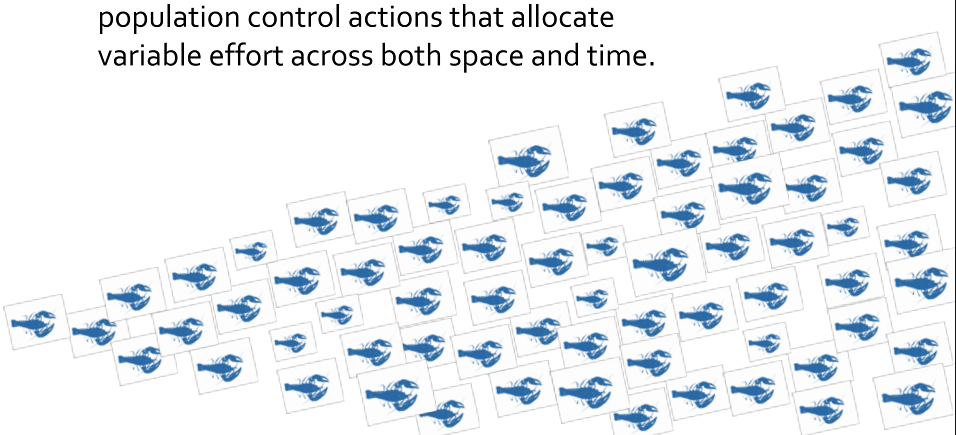


Rusty Crayfish Densities



Objectives

1. Quantify recent and project future spread of rusty crayfish in the John Day River.
2. Evaluate the management efficiency of population control actions that allocate variable effort across both space and time.

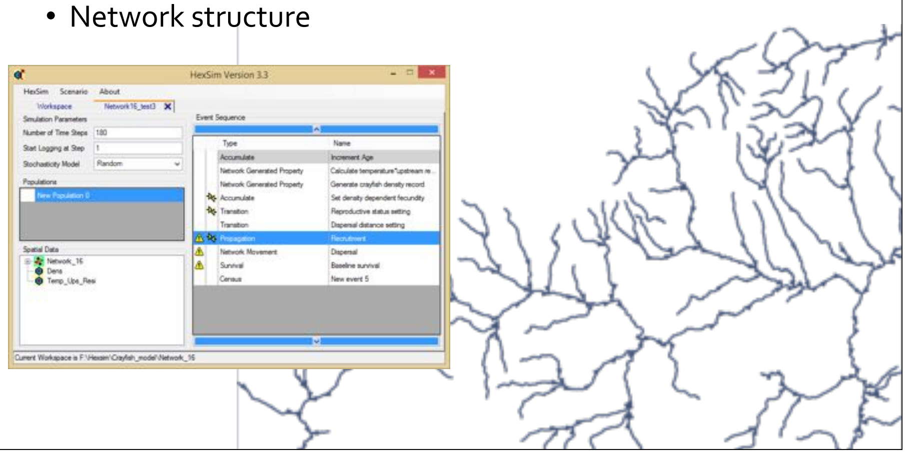


Approach

Spatially-explicit individual-based model

HexSim

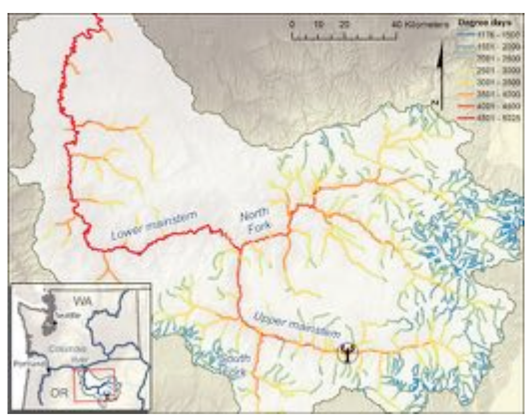
- Sequential event architecture
- Network structure



Approach

Environmental Context

- **Hydrography (NHD+ v2)**
  - Flow direction
  - Reach gradient
  - Estimated mean monthly discharge
  - August flow > 0.25 ft^3/s
- **Wetted width**
- **Water temperature**
  - Daily land surface temperature
  - Watershed area
  - Elevation
  - Calendar day



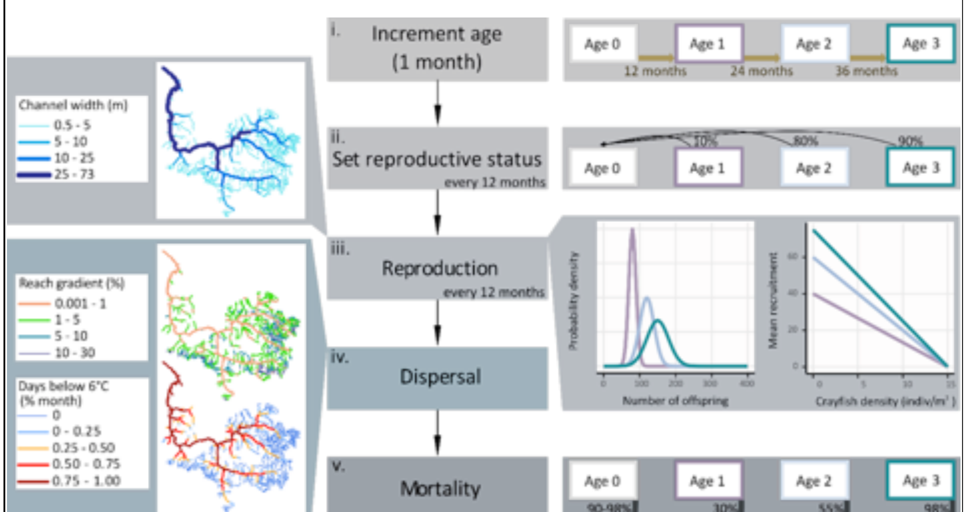
Water temperature expressed as degree days > 6° C

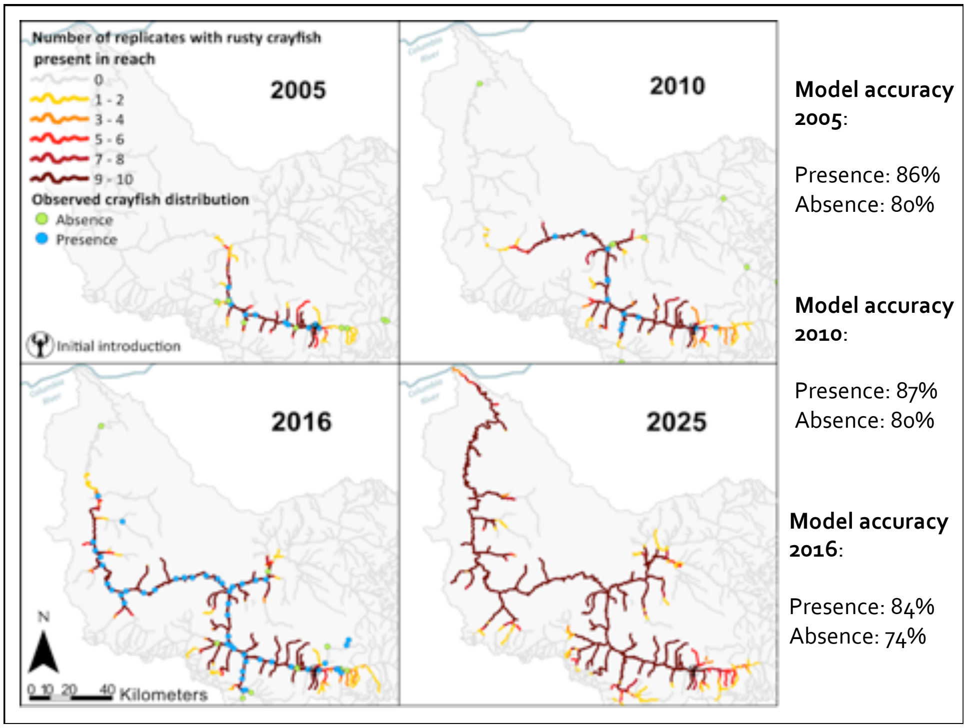
McNyset et al. 2015, Data from ISEMP

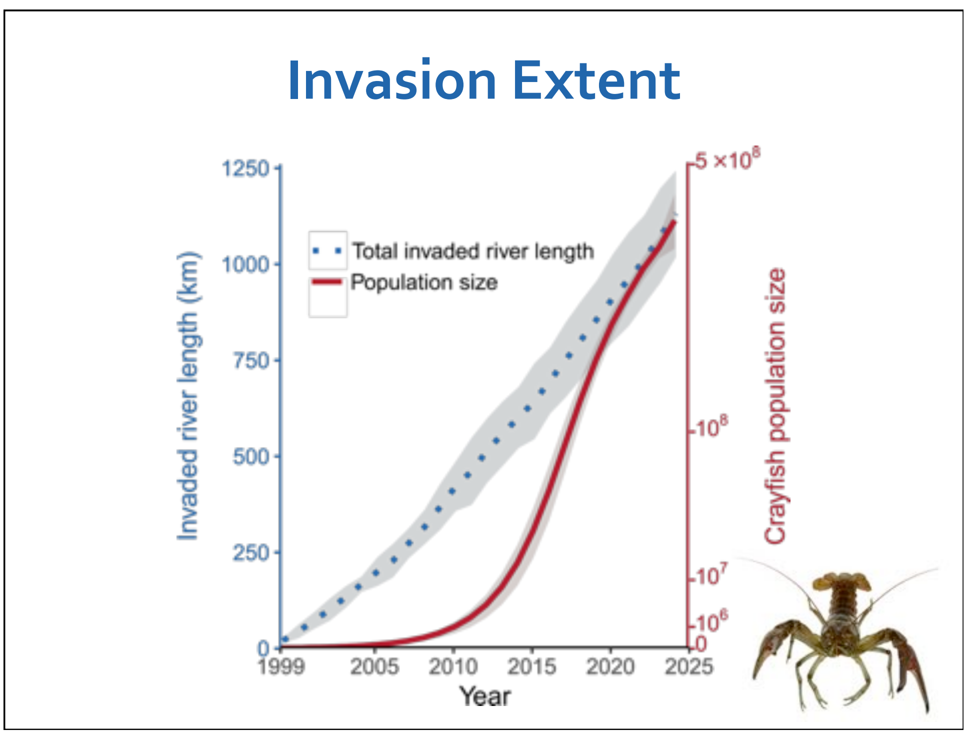
Approach
Modeling Process

- Model development based on literature review and rusty crayfish distribution in 2005 (Olden et al. 2009) and 2010 (Sorenson et al. 2012)
- Forecast to 2016 and model validation test
- Re-calibrate and forecast to 2025
- Assess management scenarios

Model structure
HexSim

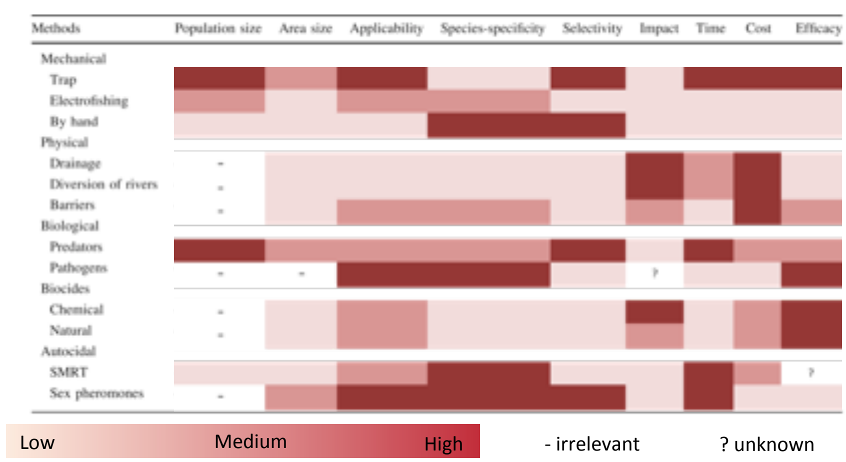



Number of replicates with rusty crayfish present in reach
0
1 - 2
3 - 4
5 - 6
7 - 8
9 - 10
Observed crayfish distribution
Absence
Presence
Initial introduction
2005
2010
2016
2025
N
0 10 20 40 Kilometers
Model accuracy 2005:
Presence: 86%
Absence: 80%
Model accuracy 2010:
Presence: 87%
Absence: 80%
Model accuracy 2016:
Presence: 84%
Absence: 74%


Invasion Extent
Total invaded river length
Population size
Invaded river length (km)
1250
1000
750
500
250
0
Crayfish population size
5 ×10⁸
10⁸
10⁷
10⁶
0
1999
2005
2010
2015
2020
2025
Year

Preventing New Introductions

Controlling or Eradicating Existing Populations



Modified from Gherardi et al. (2011)

Physical Removal


Control of Nuisance Populations of Crayfish with Traps and Toxicants

T. D. Bills and L. L. Marking

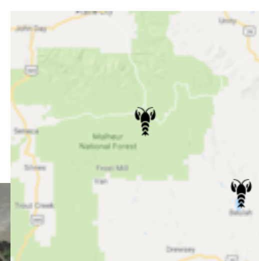

APPLIED ISSUES

Intensive trapping and increased fish predation cause massive population decline of an invasive crayfish

CATHERINE L. HEIN, M. JAKE VANDER ZANDEN AND JOHN J. MAGNUSON

SUMMARY

Additional infestations of rusty crayfish



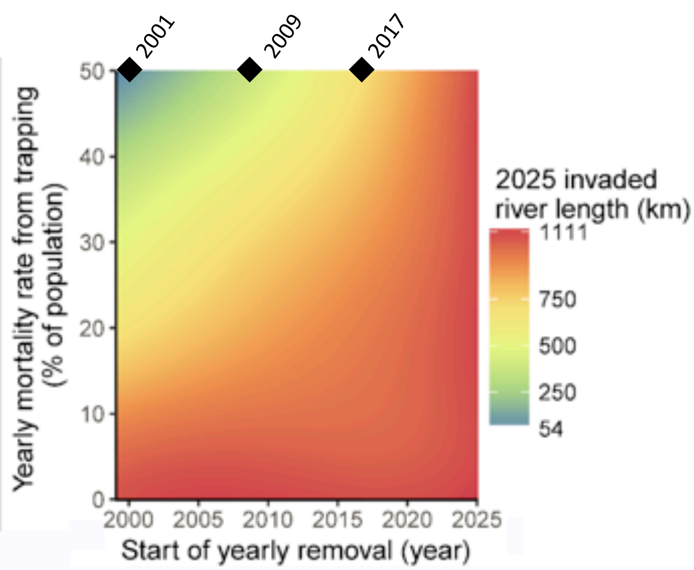
Summit Prairie Pond

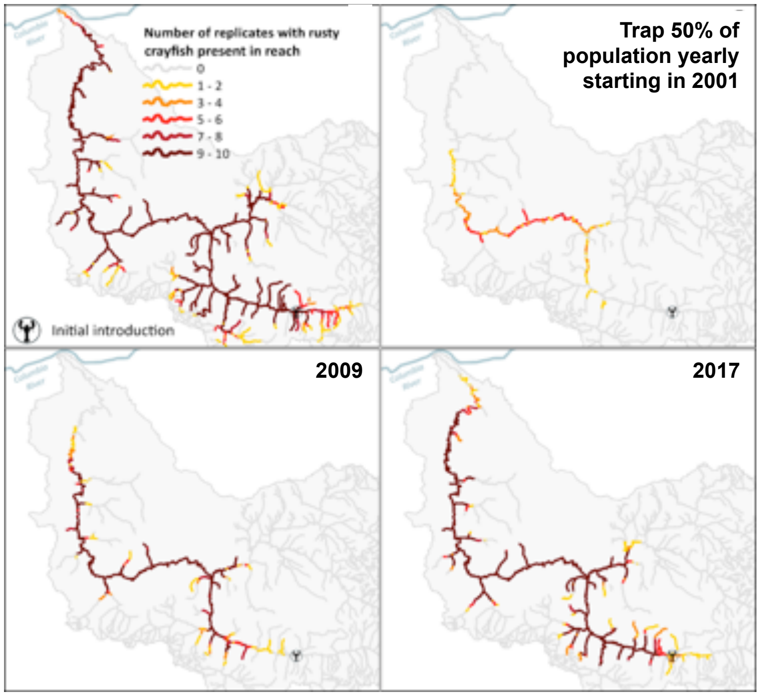
Beulah Reservoir

Management strategies

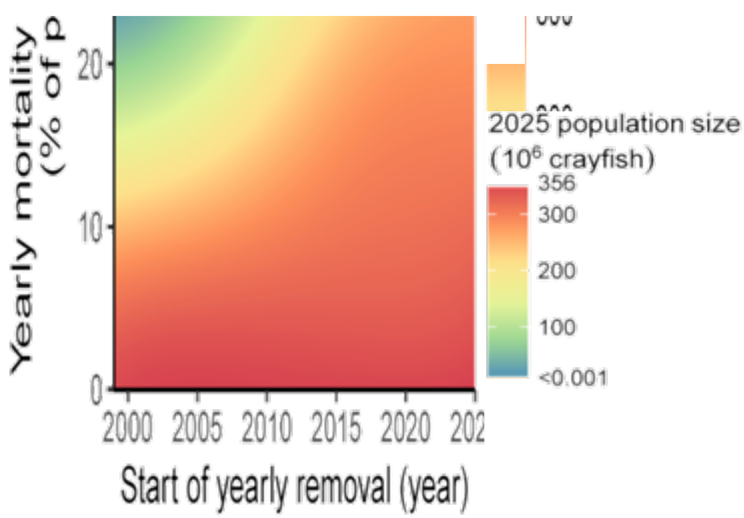
- Explored different control strategies that involved varying levels of crayfish removal occurring at different starting years
- Estimated required trapping effort to achieve management outcomes

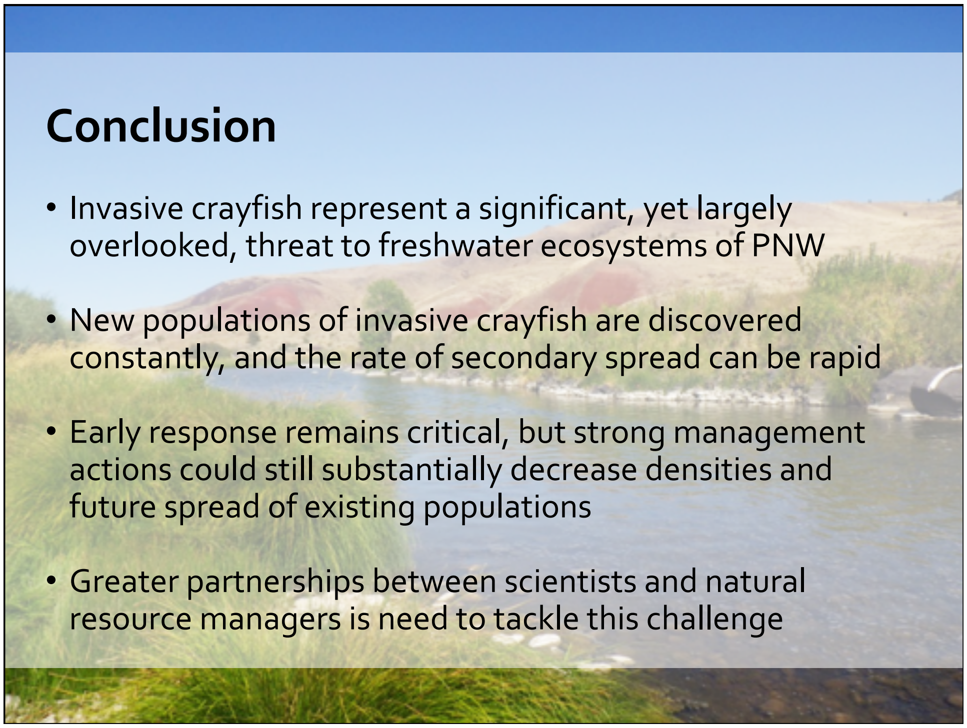
Controlling rusty crayfish spread

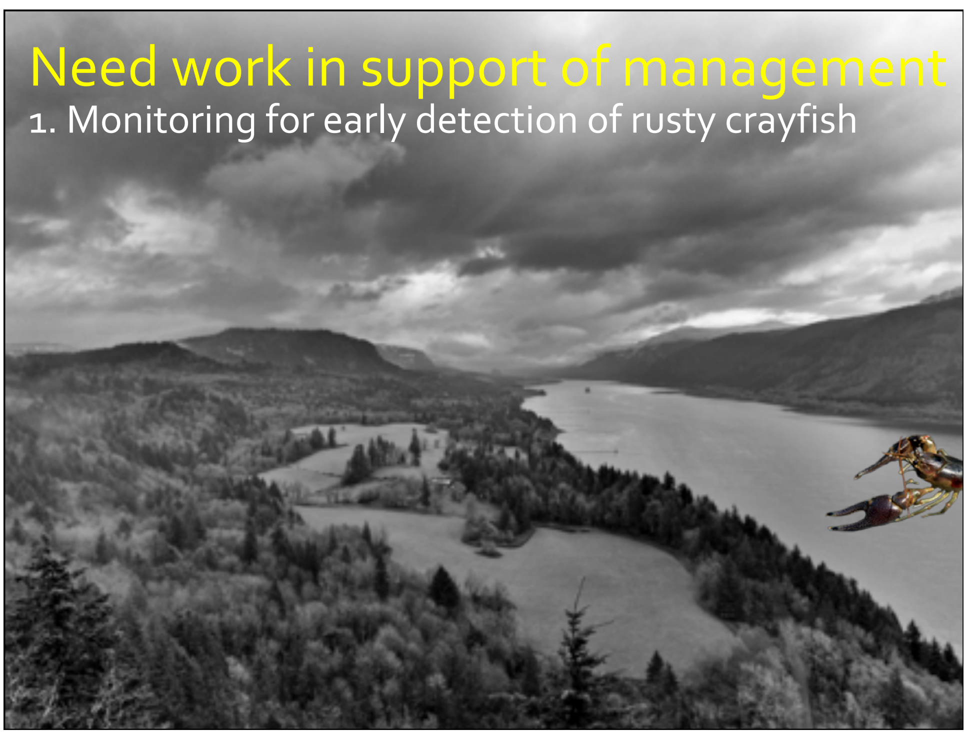


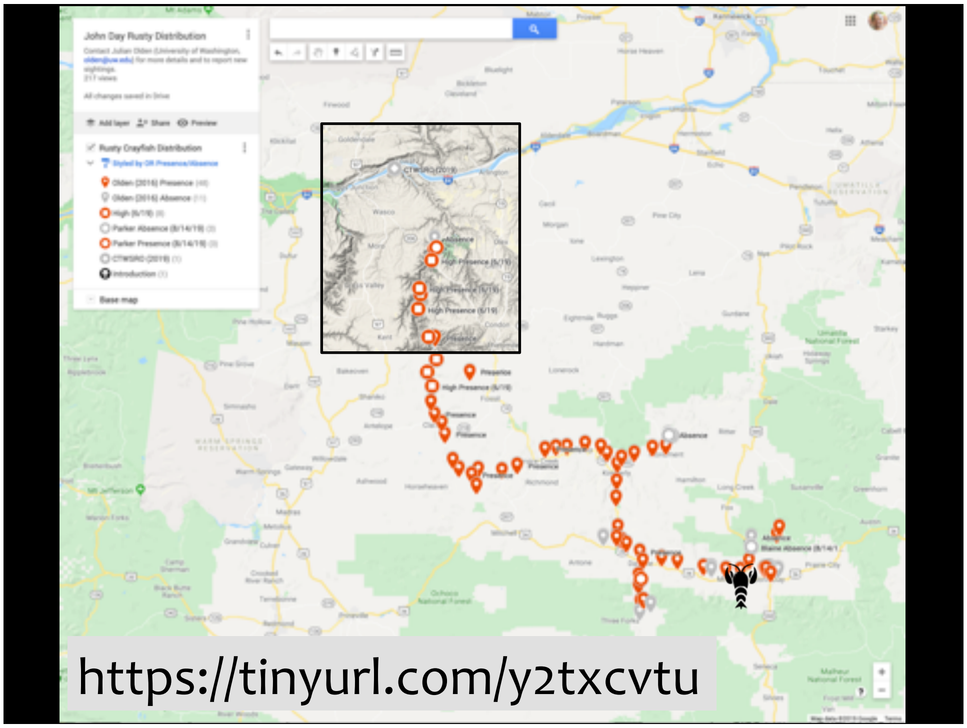


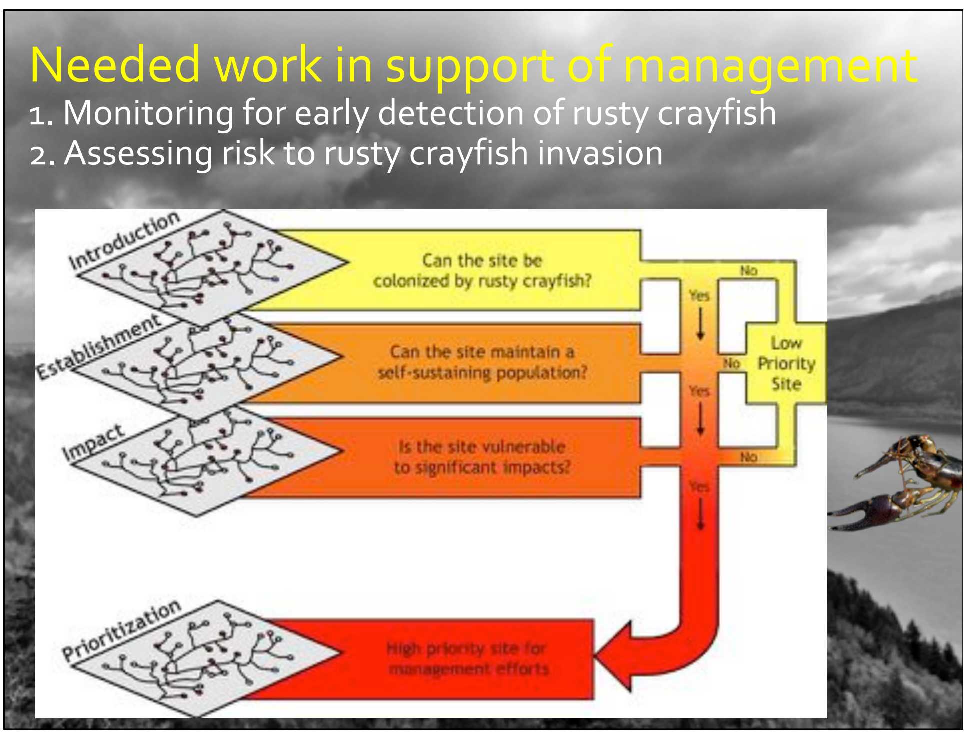
Controlling population size

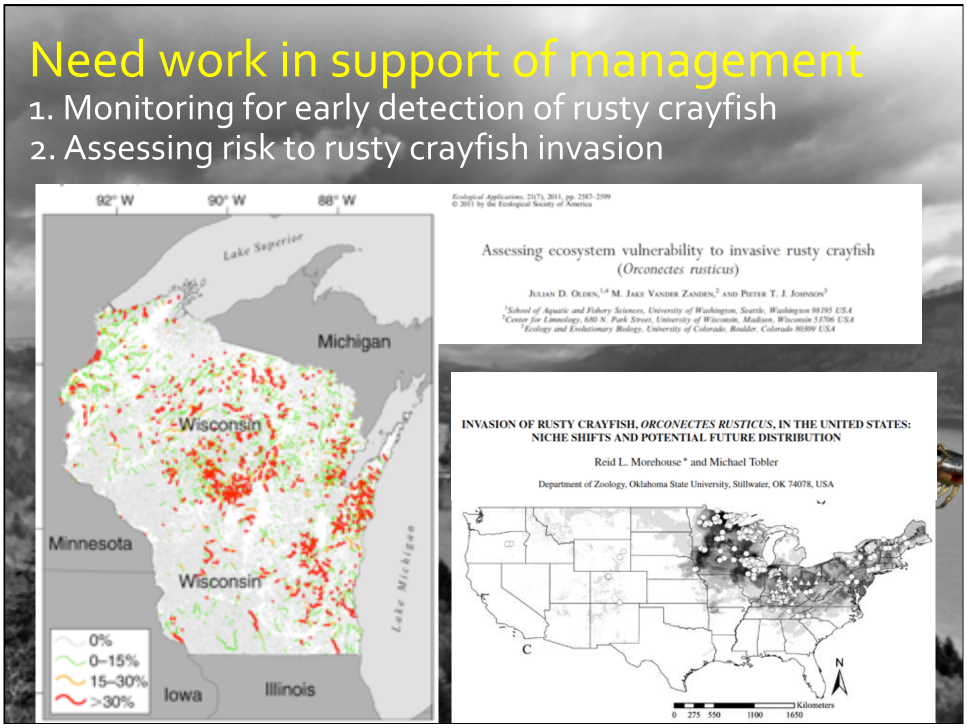



Conclusion
• Invasive crayfish represent a significant, yet largely overlooked, threat to freshwater ecosystems of PNW
• New populations of invasive crayfish are discovered constantly, and the rate of secondary spread can be rapid
• Early response remains critical, but strong management actions could still substantially decrease densities and future spread of existing populations
• Greater partnerships between scientists and natural resource managers is need to tackle this challenge


Need work in support of management
1. Monitoring for early detection of rusty crayfish


John Day Rusty Distribution
Rusty Crayfish Distribution
Olden (2016) Presence
Olden (2016) Absence
High (6/19)
Parker Absence (6/14/19)
Parker Presence (6/14/19)
CTWSRO (2019)
Introduction
Base map
https://tinyurl.com/y2txcvtu

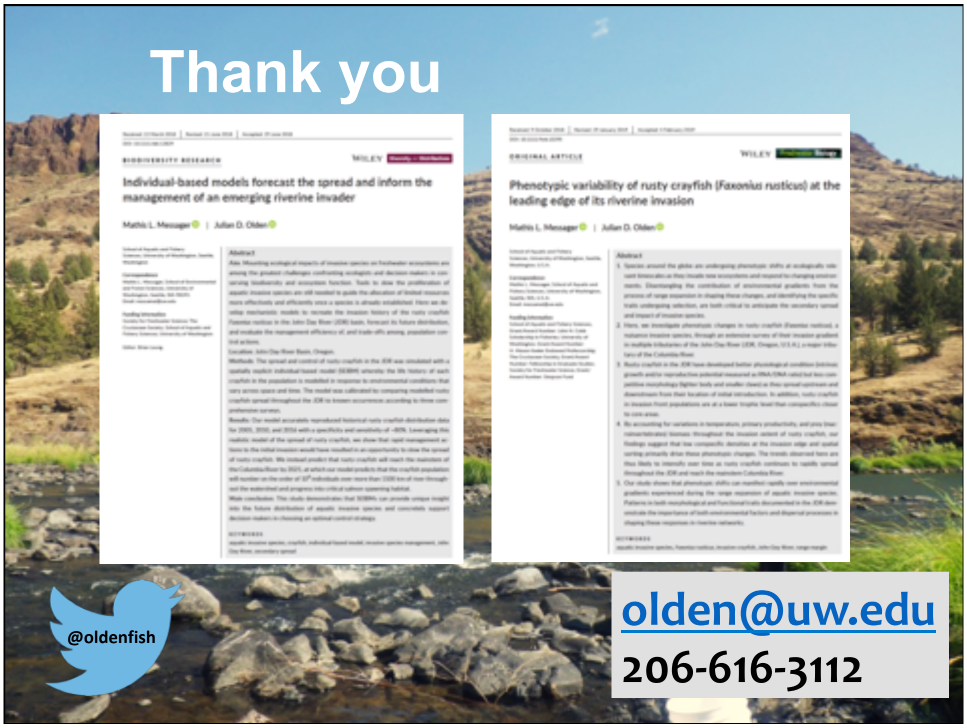

Needed work in support of management
1. Monitoring for early detection of rusty crayfish
2. Assessing risk to rusty crayfish invasion
Introduction
Can the site be colonized by rusty crayfish?
Establishment
Can the site maintain a self-sustaining population?
Impact
Is the site vulnerable to significant impacts?
Prioritization
High priority site for management efforts
Yes
No
Low Priority Site


Need work in support of management
1. Monitoring for early detection of rusty crayfish
2. Assessing risk to rusty crayfish invasion
92° W
90° W
88° W
Lake Superior
Michigan
Wisconsin
Minnesota
Wisconsin
Lake Michigan
0%
0–15%
15–30%
>30%
Iowa
Illinois
Ecological Applications, 21(7), 2011, pp. 2587–2599
© 2011 by the Ecological Society of America
Assessing ecosystem vulnerability to invasive rusty crayfish (Orconectes rusticus)
Julian D. Olden,1,4 M. Jake Vander Zanden,2 and Pieter T. J. Johnson3
1School of Aquatic and Fishery Sciences, University of Washington, Seattle, Washington 98195 USA
2Center for Limnology, 680 N. Park Street, University of Wisconsin, Madison, Wisconsin 53706 USA
3Ecology and Evolutionary Biology, University of Colorado, Boulder, Colorado 80309 USA
INVASION OF RUSTY CRAYFISH, ORCONECTES RUSTICUS, IN THE UNITED STATES: NICHE SHIFTS AND POTENTIAL FUTURE DISTRIBUTION
Reid L. Morehouse * and Michael Tobler
Department of Zoology, Oklahoma State University, Stillwater, OK 74078, USA
C
N
Kilometers
0 275 550 1100 1650


Need work in support of management
1. Monitoring for early detection of rusty crayfish
2. Assessing risk to rusty crayfish invasion
3. Quantify food-web impacts


Need work in support of management
1. Monitoring for early detection of rusty crayfish
2. Assessing risk to rusty crayfish invasion
3. Quantify food-web impacts
4. Test effectiveness of local-scale control


Need work in support of management
1. Monitoring for early detection of rusty crayfish
2. Assessing risk to rusty crayfish invasion
3. Quantify food-web impacts
4. Test effectiveness of local-scale control
5. Complete an Invasive Species Action Plan
Eager to collaborate!!!!



Acknowledgements

Collaborators
- Eric Larson (University of Illinois)
- Mathis Messager

Crayfish data
- Jeff Adams (Sea Grant)
- Keith Sorenson and Steve Bollens (Washington State University)
- Keith DeHart (ODFW)

River access
- Grant County Assessor's office
- John Day Fossil Beds National Monument staff
- Landowners
- Burns Paiute Tribe
- Western Rivers Conservancy

Modeling
- Nathan Schumaker (EPA)
- Mark Armour (EPA)
- Chris Jordan (NOAA)
- Kristina McNyset (South Fork Research)

Field and lab help
- Jacob Crunk (Puget Sound U)
- Ethen Whattam (SAFS)

SAFS School of Aquatic and Fishery Sciences

Society for Freshwater Science

The Crustacean Society

Mason Keeler Endowed Professorship