NEW YORK
FISH & AQUATIC INVERTEBRATE INVASIVENESS RANKING FORM

Scientific name:	Orconectes rusticus
Common names:	Rusty Crayfish
Native distribution:	OH, MI, IN, KY
Date assessed:	01/03/13, 1/11/13
Assessors:	E. White
Reviewers:	
Date Approved:	Form version date: 3 January 2013

New York Invasiveness Rank: High (Relative Maximum Score 70.00-80.00)

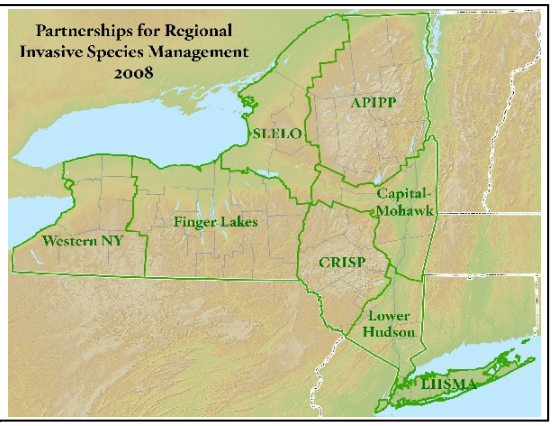
Distribution and Invasiveness Rank (*Obtain from PRISM invasiveness ranking form*)			
	Status of this species in each PRISM:	Current Distribution	PRISM Invasiveness Rank
1	Adirondack Park Invasive Program	Not Assessed	Not Assessed
2	Capital/Mohawk	Not Assessed	Not Assessed
3	Catskill Regional Invasive Species Partnership	Not Assessed	Not Assessed
4	Finger Lakes	Not Assessed	Not Assessed
5	Long Island Invasive Species Management Area	Not Assessed	Not Assessed
6	Lower Hudson	Not Assessed	Not Assessed
7	Saint Lawrence/Eastern Lake Ontario	Not Assessed	Not Assessed
8	Western New York	Not Assessed	Not Assessed

Invasiveness Ranking Summary (see details under appropriate sub-section)		Total (Total Answered*) Possible	Total
1	Ecological impact	30 (30)	30
2	Biological characteristic and dispersal ability	30 (30)	17
3	Ecological amplitude and distribution	30 (30)	25
4	Difficulty of control	10 (10)	6
	Outcome score	100 (100)[b]	78[a]
	Relative maximum score †		78
	New York Invasiveness Rank §	High (Relative Maximum Score 70.00-80.00)	

* For questions answered "unknown" do not include point value in "Total Answered Points Possible." If "Total Answered Points Possible" is less than 70.00 points, then the overall invasive rank should be listed as "Unknown."
†Calculated as 100(a/b) to two decimal places.
§Very High >80.00; High 70.00−80.00; Moderate 50.00−69.99; Low 40.00−49.99; Insignificant <40.00

A. DISTRIBUTION (KNOWN/POTENTIAL): Summarized from individual PRISM forms

A1.1. Has this species been documented in NY? (reliable source; voucher not required)	
☒	Yes – continue to A1.2
☐	No – continue to A2.1; Yes ☐ NA; Yes ☐ USA
A1.2. In which PRISMs is it known (see inset map)?	
☒	Adirondack Park Invasive Program
☒	Capital/Mohawk
☒	Catskill Regional Invasive Species Partnership
☒	Finger Lakes
☐	Long Island Invasive Species Management Area
☒	Lower Hudson
☐	Saint Lawrence/Eastern Lake Ontario
☐	Western New York



Documentation:
Sources of information:
iMapInvasives, 2013, 1/3/13, USGS 2013

A2.0. Is this species listed on the Federal Injurious Fish and Wildlife list?
☐ Yes – the species will automatically be listed as Prohibited, no further assessment required.
☒ No – continue to A2.1

A2.1. What is the likelihood that this species will occur and persist given the climate in the following PRISMs? (obtain from PRISM invasiveness ranking form and/ or Climatch score)

Very Likely	Adirondack Park Invasive Program
Very Likely	Capital/Mohawk
Very Likely	Catskill Regional Invasive Species Partnership
Very Likely	Finger Lakes
Very Likely	Long Island Invasive Species Management Area
Very Likely	Lower Hudson
Very Likely	Saint Lawrence/Eastern Lake Ontario
Very Likely	Western New York

Documentation:
Sources of information (e.g.: distribution models, literature, expert opinions):

If the species does not occur and is not likely to survive and reproduce within any of the PRISMs, then stop here as there is no need to assess the species.

A2.2. What is the current distribution of the species in each PRISM? (obtain rank *from PRISM invasiveness ranking forms*)

	Distribution
Adirondack Park Invasive Program	Not Assessed
Capital/Mohawk	Not Assessed
Catskill Regional Invasive Species Partnership	Not Assessed
Finger Lakes	Not Assessed
Long Island Invasive Species Management Area	Not Assessed
Lower Hudson	Not Assessed
Saint Lawrence/Eastern Lake Ontario	Not Assessed
Western New York	Not Assessed

Documentation:
Sources of information:

A2.3. Describe the potential or known suitable habitats within New York. Natural habitats include all habitats not under active human management. Managed habitats are indicated with an asterisk.

Aquatic Habitats	Wetland Habitats	Upland Habitats
☐ Marine	☐ Salt/brackish marshes	☐ Cultivated*
☐ Salt/ brackish waters	☐ Freshwater marshes	☐ Grasslands/old fields
☐ Freshwater tidal	☐ Peatlands	☐ Shrublands
☒ Rivers/streams	☐ Shrub swamps	☐ Forests/woodlands
☒ Natural lakes and ponds	☐ Forested wetlands/riparian	☐ Alpine
☐ Vernal pools	☐ Ditches*	☐ Roadsides*
☒ Reservoirs/ impoundments*	☐ Beaches/or coastal dunes	☐ Cultural*

Other potential or known suitable habitats within New York:
Found in permanent lakes, ponds and streams. Substrate type may vary and cover objects are preferred. They do not burrow to escape drying conditions.

Documentation:
Sources of information:
(Hobbs III *et al.* 1989, Gunderson 2008, U.S. Geological Survey 2013)

B. INVASIVENESS RANKING

1. ECOLOGICAL IMPACT

1.1. Impact on Ecosystem Processes and System-wide Parameters (e.g., water cycle, energy cycle, nutrient and mineral dynamics, light availability, or geomorphological changes (erosion and sedimentation rates).

A.	No perceivable impact on ecosystem processes based on research studies, or the absence of impact information if a species is widespread (>10 occurrences in minimally managed areas), has been well-studied (>10 reports/publications), and has been present in the northeast for >100 years.	0
B.	Influences ecosystem processes to a minor degree, has a perceivable but mild influence	3
C.	Significant alteration of ecosystem processes	7
D.	Major, possibly irreversible, alteration or disruption of ecosystem processes	10
U.	Unknown	

Score 10

Documentation:
Identify ecosystem processes impacted (or if applicable, justify choosing answer A in the absence of impact information)
Rusty crayfish reduce macrophyte abundance and increase periphyton activity.
"Orconectes rusticus has a range of ecological impacts on introduced environments that include competition and displacement of native crayfish, increased predation on snails, native and threatened bivalves, reduction of macrophyte abundance, reduction of sport-fish abundance, reduction of macroinvertebrate abundance, increases in periphyton activity, and other cascading trophic interactions. The wide range of impacts associated with O. rusticus, its aggressive nature, rapid expansion rates, dense populations, and ability to spread through bait trade make it a very problematic aquatic invasive." ISSG 2013
Sources of information:
(Charlebois and Lamberti 1996, Covich *et al.* 1999, Peters *et al.* 2008, Invasive Species Specialist Group (ISSG) 2013)

1.2. Impact on Natural Habitat/ Community Composition

A.	No perceived impact; causes no apparent change in native populations	0
B.	Influences community composition (e.g., reduces the number of individuals of one or more native species in the community)	3
C.	Significantly alters community composition (e.g., produces a significant reduction in the population size of one or more native species in the community)	7
D.	Causes major alteration in community composition (e.g., results in the extirpation of one or several native species, reducing biodiversity or change the community composition towards species exotic to the natural community)	10
U.	Unknown	

Score 10

Documentation:
Identify type of impact or alteration:
This species can reduce aquatic macrophyte abundance and species richness more than native crayfish. They are also important in structuring macroinvertebrate communities.

Sources of information:
(Lodge and Lorman 1987, Olsen *et al.* 1991, Hill *et al.* 1993, Wilson *et al.* 2004, Invasive Species Specialist Group (ISSG) 2013)

1.3. Impact on other species or species groups, including cumulative impact of this species on other organisms in the community it invades. (e.g., interferes with native

predator/ prey dynamics; injurious components/ spines; reduction in spawning; hybridizes with a native species; hosts a non-native disease which impacts a native species)

A.	Negligible perceived impact	0
B.	Minor impact (e.g. impacts 1 species, <20% population decline, limited host damage)	3
C.	Moderate impact (e.g. impacts 2-3 species and/ or 20-29% population decline of any 1 species, kills host in 2-5 years, ,)	7
D.	Severe impact on other species or species groups (e.g. impacts >3 species and/ or ≥30% population decline of any 1 species, kills host within 2 years, extirpation)	10
U.	Unknown	

Score: 10

Documentation:
Identify type of impact or alteration:
Out-compete (displace and replace) native crayfish species including O. propinquus and O. virilis, particularly O. propinquus in the Susquehanna watershed in NY. They accomplish this through aggressive and dominant behavior and increase the susceptibility of native crayfish to fish predation. They are known to hybridize with O. propinquus. They also impact invertebrate and macrophyte communities. They can harm fish populations by consuming fish eggs and decreasing the amount of invertebrate prey available.

Sources of information:
(Capelli 1982, Garvey *et al.* 1994, Perry *et al.* 2002, McCarthy *et al.* 2006, Kuhlmann 2008, Invasive Species Specialist Group (ISSG) 2013, U.S. Geological Survey 2013)

Total Possible: 30
Section One Total: 30

2. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

2.1. Mode and rate of reproduction (provisional thresholds, more investigation needed)

A.	No reproduction (e.g. sterile with no sexual or asexual reproduction).	0
B.	Limited reproduction (e.g., intrinsic rate of increase <10%, low fecundity, complete one life cycle)	1
C.	Moderate reproduction (e.g., intrinsic rate of increase between 10-30%, moderate fecundity, complete 2-3 life cycles)	2
D.	Abundant reproduction (e.g., intrinsic rate of increase >30%, parthenogenesis, large egg masses, complete > 3 life cycles)	4
U.	Unknown	

Score: 1

Documentation:
Describe key reproductive characteristics:
Complete one life cycle per year (USGS 2013). Hill et al. (1993) notes reproductive advantage over congeners and O. rusticus had higher fecundity than O. virilis (Corey 1987), but not significantly higher.
Sources of information:
(Corey 1987, Hill *et al.* 1993, U.S. Geological Survey 2013)

2.2. Migratory behavior

A.	Always migratory in its native range	0
B.	Non-migratory or facultative migrant in its native range	2
U.	Unknown	

Score: 2

Documentation:

Describe migratory behavior:
No migration has been described.
Sources of information:

2.3. Biological potential for colonization by long-distance dispersal/ movement (e.g., veligers, resting stage eggs, glochidia)

A.	No long-distance dispersal/ movement mechanisms	0
B.	Adaptations exist for long-distance dispersal, but studies report that most individuals (90%) establish territories within 5 miles of natal origin or within a distance twice the home range of the typical individual, and tend not to cross major barriers such as dams and watershed divides	1
C.	Adaptations exist for long-distance dispersal, movement and evidence that offspring often disperse greater than 5 miles of natal origin or greater than twice the home range of typical individual and will cross major barriers such as dams and watershed divides	2
U.	Unknown	

Score 0

Documentation:
Identify dispersal mechanisms:
Wisconsin study indicated a dispersal rate of 0.68 km per year.
Sources of information:
(Wilson *et al.* 2004)

2.4. Practical potential to be spread by human activities, both directly and indirectly – possible vectors include: commercial bait sales, deliberate illegal stocking, aquaria releases, boat trailers, canals, ballast water exchange, live food trade, rehabilitation, pest control industry, aquaculture escapes, etc.)

A.	Does not occur	0
B.	Low (human dispersal to new areas occurs almost exclusively by direct means and is infrequent or inefficient)	1
C.	Moderate (human dispersal to new areas occurs by direct and indirect means to a moderate extent)	2
D.	High (opportunities for human dispersal to new areas by direct and indirect means are numerous, frequent, and successful)	4
U.	Unknown	

Score 4

Documentation:
Identify dispersal mechanisms:
Authorities believe there have been multiple human introductions of rusty crayfish in non-native waters from bait-buckets, releases from aquaria, school projects, and commercial trappers. There is no indication in the literature as to the frequency or number of introductions.

Sources of information:
(Invasive Species Specialist Group (ISSG) 2013, U.S. Geological Survey 2013)

2.5. Non-living chemical and physical characteristics that increase competitive advantage (e.g., tolerance to various extremes, pH, DO, temperature, desiccation, fill vacant niche, charismatic species)

A.	Possesses no characteristics that increase competitive advantage	0
B.	Possesses one characteristic that increases competitive advantage	4
C.	Possesses two or more characteristics that increase competitive advantage	8
U.	Unknown	

Score 0

Documentation:
Literature indicates this species is not more resilient to low PH (Berrill et al. 1985) and not more resistant to heat than its native congener O. virilis (Claussen 1980).

Sources of information:
(Claussen 1980, Berrill *et al.* 1985)

2.6. Biological characteristics that increase competitive advantage (e.g., high fecundity, generalist/ broad niche space, highly evolved defense mechanisms, behavioral adaptations, piscivorous, etc.)

A.	Possesses no characteristics that increase competitive advantage	0
B.	Possesses one characteristic that increases competitive advantage	4
C.	Possesses two or more characteristics that increase competitive advantage	8
U.	Unknown	

Score: 8

Documentation:
Evidence of competitive ability:
Large claws and aggressive and dominant behavior. Require twice as much food as native crayfish. Native crayfish more susceptible to fish predation.

Sources of information:
(Capelli 1982, Hill *et al.* 1993, Olden *et al.* 2002, Invasive Species Specialist Group (ISSG) 2013)

2.7. Other species in the family and/ or genus invasive in New York or elsewhere?

A.	No	0
B.	Yes	2
U.	Unknown	

Score: 2

Documentation: (U.S. Geological Survey 2013)
Identify species:
Orconectes neglectus, Orconectes obscurus, MapInvasives 2013, Orconectes immunis, Orconectes virilis, Procambarus acutus acutus

Total Possible: 30
Section Two Total: 17

3. ECOLOGICAL AMPLITUDE AND DISTRIBUTION

3.1. Current introduced distribution in the northern latitudes of USA and southern latitude of Canada (e.g., between 35 and 55 degrees).

A.	Not known from the northern US or southern Canada.	0
B.	Established as a non-native in 1 northern USA state and/or southern Canadian province.	1
C.	Established as a non-native in 2 or 3 northern USA states and/or southern Canadian provinces.	2
D.	Established as a non-native in 4 or more northern USA states and/or southern Canadian provinces, and/or categorized as a problem species (e.g., "Invasive") in 1 northern state or southern Canadian province.	3
U.	Unknown	

Score: 3

Documentation:
Identify states and provinces: MD, MA, NJ, PA, CT, NY, WV, ME, IL, MN, WI, NE, Ontario and Quebec

Sources of information:
- See known introduced range at www.usda.gov, and update with information from states and Canadian provinces.

(Invasive Species Specialist Group (ISSG) 2013, U.S. Geological Survey 2013)

3.2. Current introduced distribution of the species in natural areas in the eight New York State PRISMs (Partnerships for Regional Invasive Species Management)

A.	Established in none of the PRISMs	0
B.	Established in 1 PRISM	1
C.	Established in 2 or 3 PRISMs	3
D.	Established in 4 or more PRISMs	5
U.	Unknown	

Score 5

Documentation:
Describe distribution:
Known from all PRISMS except western NY and Long Island
Sources of information:
(The Nature Conservancy 2013, U.S. Geological Survey 2013)

3.3. Number of known, or potential (each individual possessed by a vendor or consumer), individual releases and/ or release events

A.	None	0
B.	Few releases (e.g., <10 annually).	2
C.	Regular, small scale releases (e.g., 10-99 annually).	4
D.	Multiple, large scale (e.g., ≥100 annually).	6
U.	Unknown	

Score 6

Documentation:
Describe known or potential releases:
Many references to releases and potential releases, but didn't see reference to how many, seems like it is mentioned throughout the introduced area, which would be large scale. WI has state laws against introductions of this species (Hobbs et al. 1989).
Sources of information:

3.4. Current introduced population density, or distance to known occurrence, in northern USA and/ or southern Canada.

A.	No known populations established.	0
B.	Low to moderate population density (e.g., ≤1/4 to < 1/2 native population density) with few other invasives present and/ or documented in 1 or more non-adjacent state/ province and/ or 1 unconnected waterbody.	1
C.	High or irruptive population density (e.g., ≥1/2 native population density) with numerous other invasives present and/ or documented in 1 or more adjacent state/ province and/ or 1 connected waterbody.	2
U.	Unknown	

Score 2

Documentation:
Describe population density:
From statewide documentation; not population information.
Sources of information:

(U.S. Geological Survey 2013)

3.5. Number of habitats the species may invade

A. Not known to invade any natural habitats given at A2.3. 0
B. Known to occur in 2 or 3 of the habitats given at A2.3, with at least 1 or 2 natural habitat(s). 2
C. Known to occur in 4 or more of the habitats given at A2.3, with at least 3 natural habitats. 3
U. Unknown.

Score 2

Documentation:
Identify type of habitats where it occurs and degree/type of impacts:
Streams, lakes and ponds
Sources of information:
(Gunderson 2008)

3.6. Role of anthropogenic (human related) and natural disturbance in establishment (e.g. water level management, man-made structures, high vehicle traffic, major storm events, etc).

A. Requires anthropogenic disturbances to establish. 0
B. May occasionally establish in undisturbed areas but can readily establish in areas with natural or anthropogenic disturbances. 2
C. Can establish independent of any known natural or anthropogenic disturbances. 3
U. Unknown.

Score 3

Documentation:
Identify type of disturbance:

Sources of information:

3.7. Climate in native range (e.g., med. to high, ≥5, Climatch score; within 35 to 55 degree latitude; etc.)

A. Native range does not include climates similar to New York (e.g., <10%). 0
B. Native range possibly includes climates similar to portions of New York (e.g., 10-29%). 4
C. Native range includes climates similar to those in New York (e.g., ≥30%). 8
U. Unknown.

Score 4

Documentation:
Describe known climate similarities:
Native range includes Ohio, Michigan, Indiana and Kentucky.
Sources of information:
(Austrailian Department of Agriculture, Fisheries, and Forestry (ADAFF) 2013)

Total Possible 30
Section Three Total 25

4. DIFFICULTY OF CONTROL

4.1. Re-establishment potential, nearby propagule source, known vectors of re-introduction (e.g. biological supplies, pets, aquaria, aquaculture facilities, connecting waters/ corridors, mechanized transportation, live wells, etc.)

A. No known vectors/ propagule source for re-establishment following removal. 0
B. Possible re-establishment from 1 vector/ propagule source following removal and/ or viable <24 hours. 1

C. Likely to re-establish from 2-3 vectors/ propagule sources following removal and/ or viable 2-7 days. 2
D. Strong potential for re-establishment from 4 or more vectors/ propagule sources following removal and/or viable >7 days. 3
U. Unknown.

Score 2

Documentation:
Identify source/ vectors:
I see references to them being introduced in areas from pet trade and school use as well as bait fishing, but not a reference to how often this occurs
Sources of information:

4.2. Status of monitoring and/ or management protocols for species

A. Standardized protocols appropriate to New York State are available. 0
B. Scientific protocols are available from other countries, regions or states. 1
C. No known protocols exist. 2
U. Unknown

Score 1

Documentation:
Describe protocols:
Vermont and Wisconsin and Ontario all have crayfish monitoring programs and may have materials available upon request. Studies show trapping and enhanced fish predation reduce rusty crayfish populations. Education is best method for control as eradication from introduced sites not possible.

Sources of information:
(Hein *et al.* 2006, 2007, Gunderson 2008, Tenenbaum 2010, Invasive Species Specialist Group (ISSG) 2013, Reid *et al.* 2013, White River Partnership 2013)

4.3. Status of monitoring and/ or management resources (e.g. tools, manpower, travel, traps, lures, ID keys, taxonomic specialists, etc.)

A. Established resources are available including commercial and/ or research tools 0
B. Monitoring resources may be available (e.g. partnerships, NGOs, etc) 1
C. No known monitoring resources are available 2
U. Unknown

Score 0

Documentation:
Describe resources:
Studies show trapping and enhanced fish predation reduce rusty crayfish populations. Education is best method for control as eradication from introduced sites not possible. Vermont and Wisconsin and Ontario all have crayfish monitoring programs and may have materials available upon request. Some information is online.

Sources of information:
(Hein *et al.* 2006, 2007, Gunderson 2008, Tenenbaum 2010, Invasive Species Specialist Group (ISSG) 2013, Reid *et al.* 2013, White River Partnership 2013)

4.4. Level of effort required

A. Management is not required. (e.g., species does not persist without repeated human mediated action.) 0
B. Management is relatively easy and inexpensive; invasive species can be maintained at low abundance causing little or no ecological harm. (e.g., 10 or fewer person-hours of manual 1

effort can eradicate a local infestation in 1 year.)

C. Management requires a major short-term investment, and is logistically and politically challenging; eradication is difficult, but possible. (e.g., 100 or fewer person-hours/year of manual effort, or up to 10 person-hours/ year for 2-5 years to suppress a local infestation.) 2

D. Management requires a major investment and is logistically and politically difficult; eradication may be impossible. (e.g., more than 100 person-hours/ year of manual effort, or more than 10 person hours/year for more than 5 years to suppress a local infestation.) 3

U. Unknown

Score	3

Documentation:
Identify types of control methods and time required:
Restoration would include manual planting of macrophytes in invaded lakes (Rosenthal et al. 2006). Fish predation and intensive trapping can decrease crayfish population, but not extirpate them (Olden et al. 2011).
Sources of information:
(Rosenthal *et al.* 2006, Olden *et al.* 2011)

Total Possible	10
Section Four Total	6
Total for 4 sections Possible	100
Total for 4 sections	78

C. STATUS OF GENETIC VARIANTS AND HYBRIDS:

At the present time there is no protocol or criteria for assessing the invasiveness of genetic variants independent of the species to which they belong. Such a protocol is needed, and individuals with the appropriate expertise should address this issue in the future. Such a protocol will likely require data on cultivar fertility and identification in both experimental and natural settings.

Genetic variants of the species known to exist:

Hybrids (crosses between different parent species) should be assessed individually and separately from the parent species wherever taxonomically possible, since their invasiveness may differ from that of the parent species. An exception should be made if the taxonomy of the species and hybrids are uncertain, and species and hybrids can not be clearly distinguished in the field. In such cases it is not feasible to distinguish species and hybrids, and they can only be assessed as a single unit.

Hybrids of uncertain origin known to exist: Orconectes propinquus, Orconectes limosus

References for species assessment:

Austrailian Department of Agriculture, Fisheries, and Forestry (ADAFF). 2013. Climatch Mapping Tool. [Online]. Available: http://adl.brs.gov.au:8080/Climatch/climatch.jsp. [Accessed: 17-Jan-2013].

Berrill, M., L. Hollett, A. Margosian, and J. Hudson. 1985. Variation in tolerance to low environmental pH by the crayfish Orconectes rusticus, O. propinquus, and Cambarus robustus. Canadian Journal of Zoology 63:2586–2589.

Capelli, G. M. 1982. Displacement of northern Wisconsin crayfish by Orconectes rusticus (Girard). Limnology and Oceanography:741–745.

Charlebois, P. M., and G. A. Lamberti. 1996. Invading crayfish in a Michigan stream: direct and indirect effects on periphyton and macroinvertebrates. Journal of the North American Benthological Society:551–563.

Claussen, D. L. 1980. Thermal acclimation in the crayfish,< i> Orconectes rusticus and< i> O. virilis. Comparative Biochemistry and Physiology Part A: Physiology 66:377–384.

Corey, S. 1987. Comparative fecundity of four species of crayfish in southwestern Ontario, Canada (Decapoda, Astacidea). Crustaceana:276–286.

Covich, A. P., M. A. Palmer, and T. A. Crowl. 1999. The role of benthic invertebrate species in freshwater ecosystems: zoobenthic species influence energy flows and nutrient cycling. BioScience 49:119–127.

Garvey, J. E., R. A. Stein, and H. M. Thomas. 1994. Assessing how fish predation and interspecific prey competition influence a crayfish assemblage. Ecology:532–547.

Gunderson, J. 2008. Rusty Crayfish: A nasty invader. Minnesota Sea Grant. Duluth, MN. [Online]. Available: http://www.seagrant.umn.edu/ais/rustycrayfish_invader. [Accessed: 11-Jan-2013].

Hein, C. L., B. M. Roth, A. R. Ives, and M. J. Vander Zanden. 2006. Fish predation and trapping for rusty crayfish (Orconectes rusticus) control: a whole-lake experiment. Canadian Journal of Fisheries and Aquatic Sciences 63:383–393.

Hein, C. L., M. Vander Zanden, and J. J. Magnuson. 2007. Intensive trapping and increased fish predation cause massive population decline of an invasive crayfish. Freshwater Biology 52:1134–1146.

Hill, A. M., D. M. Sinars, and D. M. Lodge. 1993. Invasion of an occupied niche by the crayfish Orconectes rusticus: potential importance of growth and mortality. Oecologia 94:303–306.

Hobbs III, H., J. P. Jass, and J. V. Huner. 1989. A review of global crayfish introductions with particular emphasis on two North American species (Decapoda, Cambaridae). Crustaceana:299–316.

Invasive Species Specialist Group (ISSG). 2013. Global Invasive Species Database. [Online]. Available: http://www.issg.org/database/species/ecology.asp?si=217&fr=1&sts=sss&lang=EN. [Accessed: 11-Jan-2013].

Kuhlmann, M. L. 2008. Do invading rusty crayfish interfere with reproduction in a native congener? Journal of Crustacean Biology 28:461–465.

Lodge, D. M., and J. G. Lorman. 1987. Reductions in submersed macrophyte biomass and species richness by the crayfish Orconectes rusticus. Canadian Journal of Fisheries and Aquatic Sciences 44:591–597.

McCarthy, J. M., C. L. Hein, J. D. Olden, and M. Jake Vander Zanden. 2006. Coupling long□term studies with meta□analysis to investigate impacts of non□native crayfish on zoobenthic communities. Freshwater Biology 51:224–235.

Olden, J. D., D. A. Jackson, and P. R. Peres-Neto. 2002. Predictive models of fish species distributions: a note on proper validation and chance predictions. Transactions of the American Fisheries Society 131:329–336.

Olden, J. D., M. J. Vander Zanden, and P. T. J. Johnson. 2011. Assessing ecosystem vulnerability to invasive rusty crayfish (Orconectes rusticus). Ecological Applications 21:2587–2599.

Olsen, T. M., D. M. Lodge, G. M. Capelli, and R. J. Houlihan. 1991. Mechanisms of impact of an introduced crayfish (Orconectes rusticus) on littoral congeners, snails, and macrophytes. Canadian Journal of Fisheries and Aquatic Sciences 48:1853–1861.

Perry, W. L., J. L. Feder, and D. M. Lodge. 2002. Implications of hybridization between introduced and resident Orconectes crayfishes. Conservation Biology 15:1656–1666.

Peters, J. A., T. Kreps, and D. M. Lodge. 2008. Assessing the impacts of rusty crayfish (Orconectes rusticus) on submergent macrophytes in a north-temperate US lake using electric fences. The American Midland Naturalist 159:287–297.

Reid, S., T. Brooke, J. Devlin, and J. Nocera. 2013. Monitoring Rusty Crayfish in Southern Ontario Streams and Rivers. Applied Research and Development Branch, Ministry of Natural Resources, Ontario, Canada. [Online]. Available: http://www.trca.on.ca/dotAsset/126306.pdf. [Accessed: 11-Jan-2013].

Rosenthal, S. K., S. S. Stevens, and D. M. Lodge. 2006. Whole-lake effects of invasive crayfish (Orconectes spp.) and the potential for restoration. Canadian Journal of Fisheries and Aquatic Sciences 63:1276–1285.

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