Red Swamp Crayfish (*Procambarus clarkii*)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, February 2011
Revised May 2015

Photo: USGS

1 Native Range, and Status in the United States

Native Range
From Nagy et al. (2015):

"Gulf coastal plain from the Florida panhandle to Mexico; southern Mississippi River drainage to Illinois and southwest Indiana."

Status in the United States
From Nagy et al. (2015):

"Collected in a swamp in Kenai, Alaska (R. Piorkowski, Alaska Fish and Game, pers. comm.); established in San Francisco Bay, California (Ruiz et al. 2000) and collected from Sweetwater River in the San Diego National Wildlife Refuge (Cohen and Carlton 1995); established in

Delaware (Gherardi and Daniels 2004); reported from Hawaii (Benson and Fuller 1999, Gutierrez 2003) and Idaho (Benson and Fuller 1999, Mueller 2001); collected from areas of the Dead River near Lake Michigan and in the North Branch of the Chicago River, Illinois; relatively rare but documented tributaries of Lake Michigan in the area of the Grand Calumet River in northern Indiana, with collections from Lake Michigan in 2000 (Simon 2001); established in Chesapeake Bay and all 14 watersheds of the Coastal Plain of Maryland (Kilian et al. 2009, Ruiz et al. 2000); reported from Nevada (Benson and Fuller 1999); found on Long Island and in the lower Hudson River system, New York; established in the Neuse, Tar-Pamlico, Yadkin-Pee Dee, and Cape Fear river basins of North Carolina (Benson and Fuller 1999, Fullerton and Watson 2001); established and slowly spreading in the Sandusky Bay, Ohio area, with the first known collection dating back to 1967 and subsequent expansion to Bay, Rice, and Riley Township waterways connecting to Muddy Creek Bay and Margaretta and Townsend Twp tributaries of Lake Erie (R. Thoma, Midwest Biodiversity Institute, pers. comm.); established in Oregon, South Carolina, Utah, and Virginia (Benson and Fuller 1999, Mueller 2001); established or collected from several lakes in Washington (Mueller 2001, WDFW 2003); and established in a private subdivision pond in Germantown Wisconsin (Behm 2009)."

Means of Introductions in the United States

From Nagy et al. (2015):

"Nonnative populations in the United States are likely to have resulted as a release from aquaculture or from the aquarium trade (Simon and Thoma 2006, Thoma and Jezerinac 2000). This species' striking red color has lead to commercial advertisement as freshwater "lobster" for aquariums and may have sped up the species' advance on the west branch of the Grand Calumet River in Indiana and Illinois (Simon et al. 2005)."

"The red swamp crayfish is readily available though the biological supply trade and may be released following classroom or laboratory use (Larson and Olden 2008). It is also popular among anglers as bait for largemouth bass (WDFW 2003). Intended disposal via the sanitary system (being flushed down toilets) is likely to be ineffective, as many *P. clarkii* has been seen in urban zones around waste water treatment areas, having apparently survived treatment (Indiana Biological Survey 2008)."

"The Sandusky Bay, OH populations likely stem from an attempted introduction to see if they could get a harvestable population established for human consumption (R. Thoma, Midwest Biodiversity Institute, pers. comm.). This species is commercially cultured in the southern U.S., particularly in Louisiana, where industry profits exceed $150 million annually and the fishery is an integral part of the state's culture and economy (McAlain and Romaire 2011). Alternately, there is a remote chance these red swamp crayfish were introduced from infested Ohio State Fish Hatcheries during a fish stocking event (R. Thoma, Midwest Biodiversity Institute, pers. comm.)."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2015):

“Kingdom Animalia
  Subkingdom Bilateria
    Infrakingdom Protostomia
      Superphylum Ecdysozoa
        Phylum Arthropoda
          Subphylum Crustacea
            Class Malacostraca
              Subclass Eumalacostraca
                Superorder Eucarida
                  Order Decapoda
                    Suborder Pleocyemata
                      Infraorder Astacidea
                        Superfamily Astacoidea
                          Family Cambaridae
                            SubfamilyCambarinae
                              Genus Procambarus
                                Subgenus Procambarus (Scapulicambarus)
                                  Species Procambarus clarkii (Girard, 1852)”

“Taxonomic Status: valid”

Size, Weight, and Age Range

From Nagy et al. (2015):

“Adults range in length from 5.5 to 12 centimeters (or 2.2 to 4.7 inches) and may attain weights in excess of 50 grams in 3 to 5 months (GIS[D] 2011, [Henttonen] and Huner 1999).”

Environment

From GISD (2011):

“Agricultural areas, lakes, water courses, wetlands”

Climate/Range

From Nagy et al. (2015):

“It exhibits considerable ecological plasticity and is tolerant of a range of salinities (<12 ppt, 2-3 ppt for reproduction), pH (5.8-10), oxygen levels (>3 ppm), temperatures (as long as water in burrows neither freezes nor exceeds 95°C), and pollution levels (Huner and Barr 1991).”

Distribution Outside the United States

Native

From GISD (2011):

"Northeastern Mexico and the south-central United States (Henttonen and Huner, 1999; Boets et al, 2009)."

Introduced

From GISD (2011):

"Transcontinental introductions have been made in Africa, Asia, Europe, and South America (Hobbs III et al, 1989 in Holdich, 1999). In Europe only physical and, to some extent, climatic barriers limit the spread of *P. clarkii*, which is reported in reproductive populations in the cooler Netherlands, Germany, Italy, and Switzerland and in large, expanding populations in the warmer regions of Portugal, Spain and France."

Means of Introduction Outside the United States

From GISD (2011):

"Agriculture: *Procambarus clarkii* is a popular dining delicacy, accounting for the vast majority of crayfish commercially produced in the United States ([WDFW], 2003). It was the most dominant freshwater crayfish in the world during the 20th century and its commercial success led to intentional introductions throughout Spain, France and Italy during the 1970s and 1980s (Henttonen and Huner, 1999).
Biological control: In Kenya attempts have been made to use *P. clarkii* as a biological control agent to reduce the numbers of snails that act as intermediate hosts for the disease-causing organism that causes schistosomiasis (Bilharzia) (Hofkin et al., 1991, in Holdich, 1999). This may have encouraged the spread of *P. clarkii* within the Africa (Holdich, 1999).
Live food trade: Commerce in live crayfish from neighbouring Spain and more distant countries including the Far East, the USA and Kenya have been responsible for some of the introductions of *P. clarkii* into England, the Netherlands, France, Germany and Switzerland (Henttonen and Huner, 1999).
Natural dispersal: Natural dispersal from Spanish waters are thought to have facilitated the spread of *P. clarkii* into southern Portugal (Henttonen and Huner, 1999).
Other: *Procambarus clarkii* can spread to new areas by anglers using them as bait (Aquatic Non-native Species Update, 2000). Popular as a bait species for largemouth bass, this is believed to have been the most likely cause for their introduction into Washington ([WDFW], 2003).
Pet/aquarium trade: The habit of selling *Procambarus clarkii* alive as an aquarium or garden pond pet may have accelerated the spread of the species through natural waterways in Europe (Henttonen and Huner, 1999).
Smuggling: The crayfish that now occur in African freshwaters are thought to have been introduced without the knowledge and permission of the relevant authorities (Mikkola, 1996, in Holdich, 1999)."

Short description

From Nagy et al. (2015):

"The red swamp crayfish is typically dark red, with elongate claws (chelae) and head, a triangular rostrum tapering anteriorly without a central keel, reduced or absent spines on the side of the shell (carapace) between the head and thorax, and a linear to obliterate dorsal surface between the 2 carapace plates (areola), which converge (Boets et al. 2009, GISD 2011, NatureServe 2011). The first walking leg (cheliped) bears bright red rows of bumps (tubercles) on its side (mesial) margin and palm."

"Juveniles are not red and are difficult to distinguish from other *Procambarus* species (Boets et al. 2009)."

Biology

From Nagy et al. (2015):

"The red swamp crayfish is a physical ecosystem engineer, primarily constructing simple, two-crayfish burrows consisting of a single opening, which may be covered with a mud plug or chimney to reduce evaporative loss further from the water's edge, and a tunnel widening to an enlarged terminal chamber (Correia and Ferreira 1995, Huner and Barr 1991, Jaspers and Avault 1969). In periods of drought or elevated temperatures, these burrows can extend 40-90 cm down to water table (Ingle 1997). Burrow density is typically greatest in areas with fine sediments and lowest in areas of sand, gravel, or cobble (Barbaresi et al. 2004). Where present, *Myriophyllum* sp., fallen logs, and other vegetation may encourage greater burrow density (Correia and Ferreira 1995). Water hyacinth (*Eichhornia crassipes*) has also provided habitat for this crayfish in other introduced populations (Smart et al. 2002)."

"Like most crayfish, the red swamp crayfish is an opportunistic omnivore, consuming plant material, animals, detritus, and sediment (Alcorlo et al. 2004; Anastácio et al. 2005; Correia 2003; Gherardi and Barbaresi 2007, 2008; Gutiérrez-Yurrita et al. 1998; Hobbs 1993; Ilheu and Bernardo 1993; Pérez-Bote 2004; Smart et al. 2002). In terms of feeding preference, a few trends have emerged from studies of native and introduced populations. Plants and/or detritus tend to be consumed in greatest frequency and volume, with plant consumption highest in summer and detritus feeding intense year round (Correia 2003, Gherardi and Barbaresi 2008). It appears that crayfish may exhibit selectivity for particular plants but not among animal prey (Gherardi and Barbaresi 2007). The animal constituents of the red swamp crayfish diet tend to be dominated by insects (particularly chironomids), other crayfish, mollusks (snails), and fish (Ilheu and Bernardo 1993, Pérez-Bote 2004). Juveniles consume more animals than adults, which exhibit an ontogenic shift in diet to plants and detritus, but cannibalism is most apparent in adults and preadults (Correia 2003, Pérez-Bote 2004). Fish is also an important staple of the adult winter diet, and males may eat fish in a higher proportion than do females. This may be attributed to large claw size in some males and potentially also due to higher male mobility during the mating season (Ilheu and Bernardo 1993, Pérez-Bote 2004). However, the nutritional benefit of carnivory may be outweighed by the cost of active predation, leading to increased herbivory or detritivory in the field (Ilheu and Bernardo 1993). Overall consumption is highest in the fall and winter (Pérez-Bote 2004)."

“The life cycle of the red swamp crayfish is relatively short, with an onset of sexual maturity occurring in as few as two months and a total generation time of four and a half months (Huner and Barr 1991). Breeding typically taking place in the fall, though in warmer, wetter regions, there may be a second reproductive period in the spring. This species exhibits high fecundity: a 10 cm female can produce as many as 500 eggs, while a smaller female produces around 100 eggs (GISD 2011, Huner and Barr 1991). Egg production make take as short a period as six weeks, followed by a three-week period of incubation and maternal attachment and an additional eight weeks until egg maturation (GISD 2011). *Procambarus clarkii* females incubating eggs or carrying young may be found year-round, which contributes greatly to the success and abundance of this species, but optimal temperatures are 21-27°C; growth is inhibited below 12°C (Ackefors 1999, GISD 2011). Recently hatched crayfish remain in the burrow with their mother as long as eight weeks and must molt twice before being self-sufficient (Hunter and Barr 1991). Due to the cannibalistic nature of conspecifics in communal burrows, adult molting often occurs in the open, even in the presence of predatory fish (Hartman and O’Neill 1999). The adult red swamp crayfish exhibits cyclic dimorphism, alternating between sexually active and inactive periods, and in the wild typically does not live longer than two to five years (GISD 2011, Huner and Barr 1991, Smart et al. 2002).”

“The red swamp crayfish exhibits two types of behaviors—one a wandering phase which involves short peaks of high speed of movement, the other an immobile stage during which it hides in its burrow by day and only comes out at dusk to forage. Breeding male crayfish in the wandering phase may travel as far as 17 km from their site of origin within four days (GISD 2011). Nocturnal activity in the stationary phase does not appear to be driven by predatory avoidance (many of red swamp crayfish predators are also nocturnal) or prey capture (mostly herbivorous; Gherardi et al. 2000).”

Human uses

From Nagy et al. (2015):

“The red swamp crayfish is popular in the live trade market. This species’ striking red color has lead to commercial advertisement as freshwater “lobster” for aquariums (Simon et al. 2005). It is also popular among anglers as bait for largemouth bass (WDFW 2003) and is readily available though the biological supply trade (Larson and Olden 2008).”

“*Procambarus clarkii* has the potential to serve as a new food source in invaded ecosystems (Savini et al. 2010). In Europe, it has been suggested that high densities of the red swamp crayfish may lead to greater numbers of herons, egrets, and cormorants (Barbaresi and Gherardi 2000, Rodríguez et al. 2005).”

“The red swamp crayfish has been proposed for use as a bioindicator of heavy metals (As, Cd, Cr, Pb, Hg, Ni) and organic compounds (as found in fertilizers and pesticides, for example) due to its propensity to accumulate these environmental contaminants (Kouba et al. 2010, Richert and Sneddon 2007). Furthermore, this species may be used in biological control activities. It actively predates chironomid larvae, a rice pest (Correia and Anastácio 2008). In Kenya, *P.*

clarkii consumes and competes with the snail vector of schistosomiasis and has thus been used there as a biological control agent (Lodge et al. 2005)."

Diseases

From Thune et al. (1991):

"Systemic infections of the red swamp crawfish *Procambarus clarkii* with *Vibrio mimicus* and *V. cholerae* are described. Infections are favored by elevated temperatures and low dissolved oxygen. Mortality rates between 5 and 25% were observed, and affected crawfish were lethargic but exhibited no gross clinical signs."

From Diéguez-Uribeondo and Söderhäll (1993):

"*Procambarus clarkii* Girard, a native freshwater crayfish species of Lousiana, USA, was found to harbour the crayfish plague fungus, *Aphanomyces astaci* Schikora, in its cuticle as a benign infection."

From Wang et al. (2005):

"A novel disease of crayfish *Procambarus clarkii* appeared in the summer of 2004 in freshwater aquaculture in Jiangsu province of China. Light and transmission electron microscopy (TEM), molecular biological methods and in vitro culture were used to identify the pathogen. … The resultant 271 bp PCR product showed 99% identity with *Spiroplasma mirum* 16S rDNA, having a close relationship with the spiroplasma from the Chinese mitten crab *Eriocheir sinensis*. This is the second time a spiroplasma has been found in a freshwater crustacean."

From USDA APHIS (2007):

"On May 8, 2007, the National Veterinary Services Laboratories (NVSL) confirmed the presence of white spot syndrome virus (WSSV) in samples of freshwater farmed crawfish (*Procambarus clarkii*) from St. Martin Parish, Louisiana."

Crayfish plague and white spot disease are OIE-reportable diseases.

Threat to humans

From Nagy et al. (2015):

"The red swamp crayfish is classified as a pest in many countries (Hobbs et al. 1989)."

"In areas prone to water level fluctuation—such as around dams, levees, or irrigation systems—complex, deep burrows or numerous simple burrows are especially likely to damage these structures through bank destabilization."

"Predation on fish eggs (e.g., lake trout, Mueller et al. 2006), food competition with commercial fish species, and destruction of fishery nesting and nursing grounds can negatively affect the fishing industry (summarized in Geiger et al. 2005)."

"Through accumulation of heavy metals and cyanobacteria toxins (e.g., microcystin), the red swamp crayfish facilitates biomagnification of these harmful materials and their trophic transfer to humans (Gherardi and Panov 2006). In parts of the world, undercooked *P. clarkii* may transmit parasites to humans, including lung fluke (*Paragonimus westermani*) and rat lungworm (*Angiostrongylus cantonensis*) (Matthews 2004). Domestically, Louisiana populations of the red swamp crayfish have been found to harbor another lung fluke, *P. kellicoti* (Huner and Barr 1991)."

3 Impacts of Introductions

From GISD (2011):

"*Procambarus clarkii* is a successful colonizer which may quickly become established and eventually become a keystone species, a primary contributor to the ecosystem it inhabits. Its introduction may cause dramatic changes in native plant and animal communities (Schleifstein, 2003). *P. clarkii* may severely impact native crayfish through competition and transition of the crayfish plague, reduce macrophyte assemblages and diversity, alter water quality and sediment characteristics, accumulate heavy metals, interact with additional invasive species, damage agricultural irrigation systems, impact fishing industry, and reduce populations of invertebrates, mollusks, and amphibians through predation and competition."

"*P. clarkii* has contributed to the dramatic decline of the European native crayfish in the Astacidae family through its transmission of the crayfish plague (*Aphanomyces astaci*) and direct competition. Specifically threatened species include the endangered white clawed crayfish *Austropotamobius pallipes*), the "vulnerable" noble crayfish (*Astacus astacus*), and the stone crayfish *Austropotamobius torrentium* (García-Arberas et al, 2009; Dehus et al, 1999; Gherardi, 2006, Gil-Sanchez & Alba-Tercedor, 2006). *P. clarkii* is also known to compete with native crayfish in Japan (Kawai & Kobayashi, 2005)."

"Intense herbivory by *P. clarkii* often causes the reduction of macrophyte mass and biodiversity and has been recorded in the Lake Chozas, Spain (Rodríguez et al, 2003); Lake Naivasha, Kenya (Smart et al, 2002); Lake Massaciuccoli, Italy (Gherardi et al, 1999); Lake Doccia, Italy (Gherardi & Acquistapace, 2007); Mediterranean wetlands (Geiger et al, 2005); and the Iberian peninsula (Rodríguez et al, 2003 in Cruz & Rebelo, 2007). Affected species include *Nymphoides peltata*, *Potamopeton crispus*, *Ultricularia australis*, *Potamogeton* spp. (Gherardi & Acquistapace, 2007; Gherardi et al, 1999)."

"Another effect of the feeding, as well as burrowing, behavior of *P. clarkii* is altered water quality, increased bioturbation, and increased nutrient release from sediment (Angeler et al, 2001). These changes in water characteristics alter aquatic ecosystems and are believed to induce cyanobacterial blooms (Yamamoto, 2010). These effects have been recorded in Las Tablas de Daimiel National Park, Spain (Angeler et al, 2001); Alentejo, Portugal (Geiger et al, 2005); and Japan (Yamamoto, 2010)."

"*P. clarkii* is known to compete with, prey on, and reduce populations of a wide variety of aquatic species including amphibians, mollusks, macroinvertebrates, and fish. Competitive pressure and predation on native amphibians have been recorded from the Iberian Peninsula (Cruz & Rebelo, 2005), Sweden (Nystrom et al, 2002 in Ilheu et al, 2007), Europe (Gherardi, 2006). More specific reports include effects on *Rana* sp., *Bufo bufo*, and *Triturus vulgaris* in Italy (Gherardi et al, 2001; Renai & Gherardi, 2004 in Ilheu, 2007) and the Natterjack Toad (*Bufo calamita* in Donana Natural Park, Spain (Cruz et al, [2006]), and the California newt, *Taricha torosa*, in California (Gamradt & Kats, 1996 in Nystrom, 1999). Predation and competition pressure on mollusks include native snails in Doccia Lake, Italy (Gherardi & Acquistapace, 2007) and in the Iberian Peninsula (Cruz & Rebelo, 2007). *P. clarkii* preys on fish eggs and young as well and was found to consume lake trout (*Salvelinus namaycush*), gila chub (*Gila intermedia*), suckers (*Catostomus* spp.), and speckled dace (*Rhinichthys osculus*) in the laboratory (Mueller et al, 2006). It may also reduce macroinvertebrate populations and diversity (Correia [and Anastácio] 2008)."

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4 Global Distribution

Figure 1. Global distribution of *P. clarkii*. Map from GBIF (2013).

5 Distribution within the United States

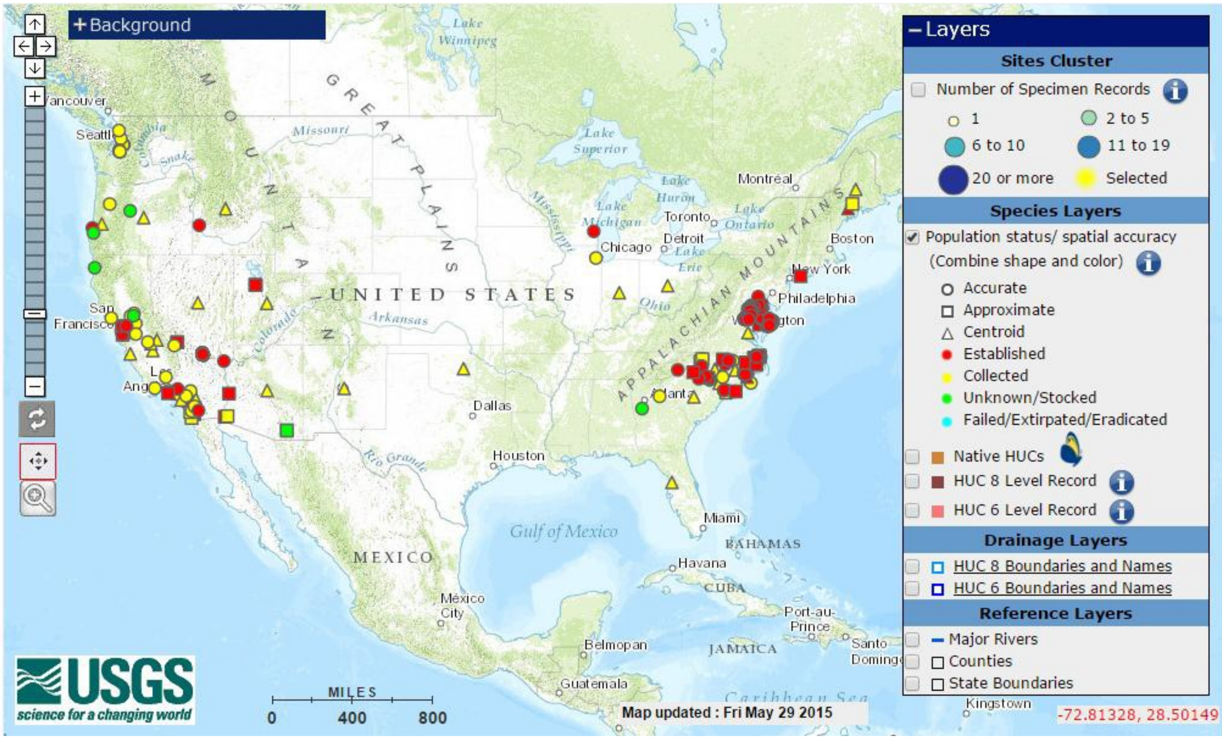

Figure 2. Distribution of *P. clarkii* in the US. Map from Nagy et al. (2015).

6 Climate Match

Summary of Climate Matching Analysis

The climate match (Sanders et al. 2014; 16 climate variables; Euclidean Distance) was high throughout the East, Midwest, and West. The areas with a low climate match were mostly mountainous areas in the West and East, as well as the far North Central region. Climate6 match indicated that the US has a high climate match. The range for a high climate match is 0.103 and greater; climate match of *P. clarkii* is 0.826.

Crayfishes have been observed to establish populations in climates different from that found within their native range (M. Hoff, U.S. Fish and Wildlife Service, personal communication). The climate match shown here may be an underestimate of climate suitability for the establishment of *P. clarkii*.

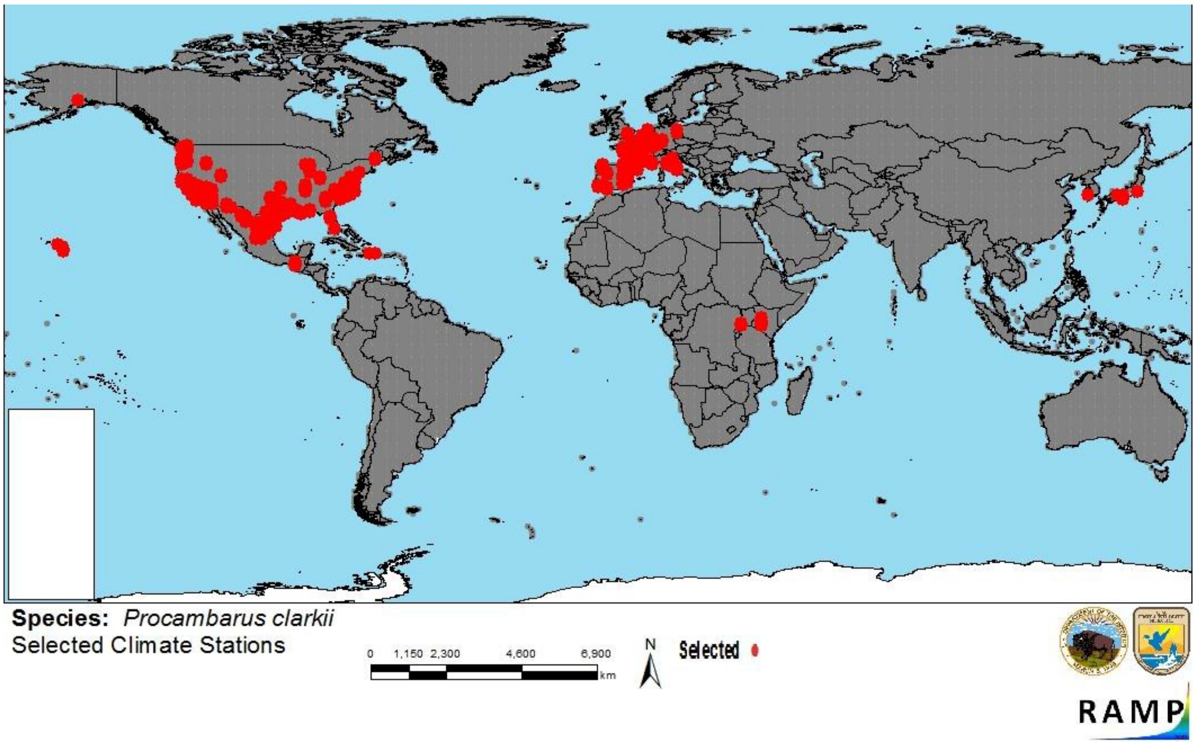

Figure 3. RAMP source map (Sanders et al. 2014) showing weather stations selected as source locations (red) and non-source locations (gray) for *P. clarkii* climate matching. Source locations from GBIF (2013). Only established locations were used.

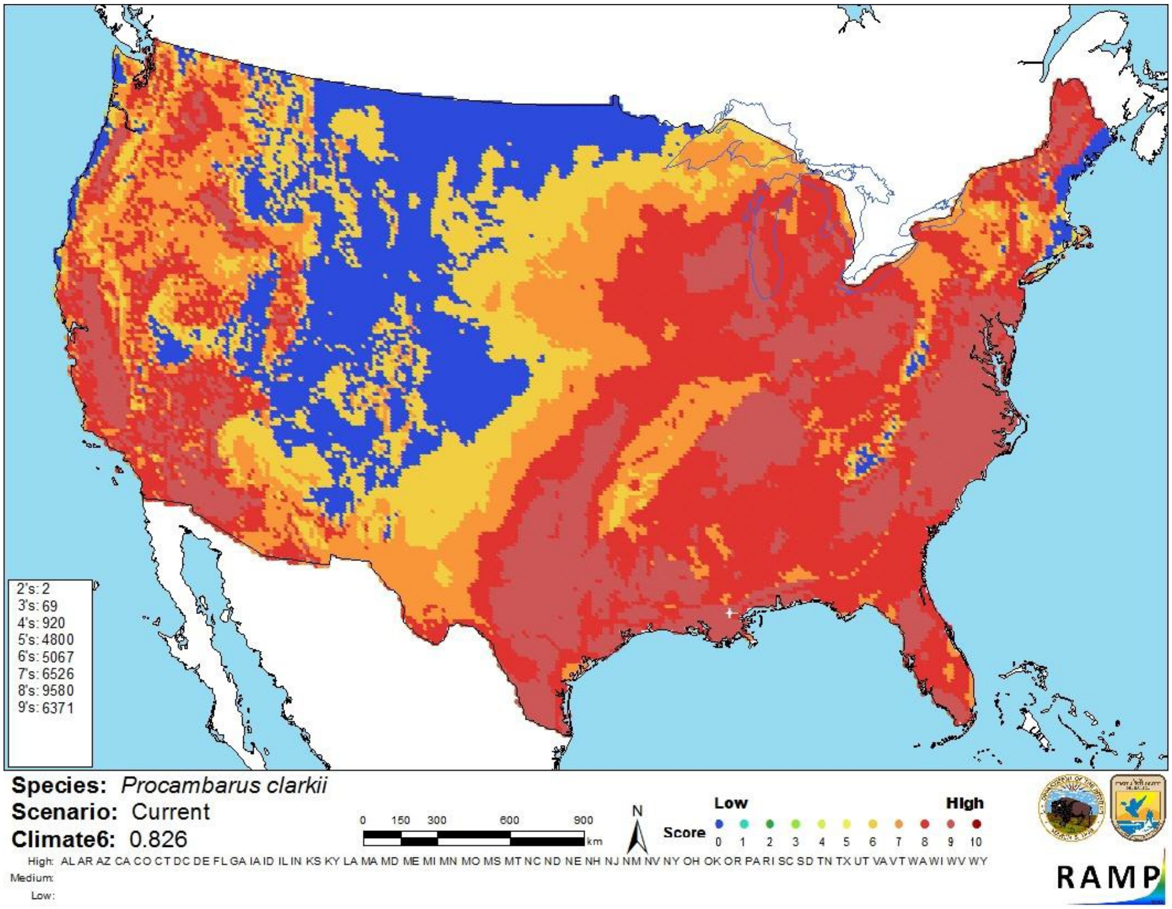

Figure 4. Map of climate matches (Sanders et al. 2014) for *P. clarkii* in the continental United States based on source locations reported by GBIF (2013). 0= Lowest match, 10=Highest match.

7 Certainty of Assessment

Information on the biology, distribution, and impacts of *P. clarkii* is readily available. Negative impacts from introductions of this species are adequately documented in the scientific literature. No further information is needed to evaluate the negative impacts the species is having where introduced. Certainty of this assessment is high.

8 Risk Assessment

Summary of Risk to the Continental United States

P. clarkii is known to outcompete native crayfish and rapidly take over habitat where it invades. It is an agricultural pest and has been shown to reduce populations of native macrophytes, amphibians, mollusks, macroinvertebrates, and fish. Furthermore, it alters the ecosystem it inhabits, changing water quality and sediment characteristics. *P. clarkii* is a vector for multiple OIE-reportable diseases. In the US, this species is an extremely popular food item, and has escaped from aquaculture in many areas. Climate match is high for every state in the contiguous US, and as this species is known to have adverse impacts, the overall risk is high.

Assessment Elements

- ☐ **History of Invasiveness (Sec. 3):** High
- ☐ **Climate Match (Sec. 6):** High
- ☐ **Certainty of Assessment (Sec. 7):** High
- ☐ **Important additional information:** Yue et al. (2008) suggest that *P. clarkii* is parthenogenic.
- ☐ **Overall Risk Assessment Category: High**

9 References

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 10.

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10 References

Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

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