U.S. Fish & Wildlife Service

Rusty Crayfish (*Faxonius rusticus*)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, November 2023
Revised, December 2023
Web Version, 5/6/2026

Organism Type: Crustacean
Overall Risk Assessment Category: High


Photo: Peterwchen. Licensed under CC BY-SA 4.0. Available: https://commons.wikimedia.org/wiki/File:Faxonius_rusticus-male_dorsal.jpg (November 2023).

1 Native Range and Status in the United States

Native Range

From Durland Donahou et al. (2023a):

"Ohio River basin, spanning tributaries in Western Ohio, Indiana, Kentucky, and Northern Tennessee; cryptogenic in Lake Erie (Creaser 1931, Hobbs 1974, Momot et al. 1978, Page 1985, Hobbs et al. 1989, Taylor 2000)."

From Pappas (2002):

"Native to the Ohio River Basin and Ohio, Kentucky, Tennessee, Indiana, and Illinois […]"

Status in the United States

From Durland Donahou et al. (2023b):

"*Faxonius rusticus* is established in twenty states: Colorado (Illinois Natural History Survey [2017]), Connecticut (Mills et al. 1997), Iowa (Leon et al. 2016); Illinois [MSU 2015]; Maryland (Maryland [DNR] 2012; Kilian 2013); Maine (Hobbs 1989; sighting reports); Michigan [MSU 2015]; Minnesota (Passe 2014); North Carolina [Fullerton and Watson 2001; NCWRC 2017]; eastern Nebraska (M. Wright pers. comm.); southern Nevada (sighting reports); northern New Jersey (Walker 2002); New York (Walker 2002; Dresser et al. 2016); Ohio (Peters 2010); Oregon (Sorenson et al. 2012); Pennsylvania (iMapInvasives 2016); South Dakota (South Dakota Game, Fish and Parks 2015); Vermont (Caduto 2011); Wisconsin (Wisconsin [DNR] 2015); and West Virginia (Jezerinac et al. 1994; Loughman 2012)."

"Its status is unknown in Massachusetts, New Hampshire, and Tennessee, as the only reported introductions are from Hobbs (1989)."

"Extirpated in Wyoming (Wyoming Game and Fish Department 2015)."

From Fofonoff et al. (2018):

"[…] populations are known from New Mexico […] (Hobbs and Jass 1988; Taylor et al. 1996)."

"*O. rusticus* has invaded streams in […] Missouri […] (Hobbs and Jass 1988)."

From Bouchard (1977):

"*Orconectes rusticus* is presently limited to Conchas Lake and Conchas Canal downstream to siphon number three, which passes under Saladito Creek [northeastern New Mexico]. […] it appears to have been recently introduced."

From Smith et al. (2022):

"[…] three individuals [in McPherson County Lake, Kansas] were identified as rusty crayfish (3.9% of the sample) […]"

USGS (2026) reports *F. rusticus* as established in Alabama and northeastern Tennessee.

No records of *Faxonius rusticus* in live trade in the United States were found.

Regulations

Faxonius rusticus is regulated in Idaho (IDDA 2022), Missouri (MDC 2023), and North Carolina (North Carolina DEQ 2022). It is regulated under its former scientific name, *Orconectes rusticus*, in Alaska (ADF&G 2023), Arkansas (AGFC 2022), Colorado (CPW 2023), Connecticut (Connecticut DEEP 2020), Illinois (Illinois DNR 2015), Iowa (Iowa NRC 2015), Kansas (KDWP 2023), Maryland (Code of Maryland Regulations 2022), Michigan (Michigan Compiled Laws 2022), Minnesota (Minnesota DNR 2022), Montana (Montana FWP 2023), Nevada (Nevada Board of Wildlife Commissioners 2022), New York (New York DEC 2022), North Dakota (North Dakota Game and Fish Department 2023), Oklahoma (ODWC 2023), South Carolina (South Carolina Code of Laws 2022), Vermont (The Vermont Statutes 2017), Virginia (Virginia DWR 2022), Wisconsin (Wisconsin DNR 2022), and Wyoming (WGFC 2022). It is regulated at the family level (Cambaridae) in Arizona (Arizona Game and Fish Commission 2022), Florida (FFWCC 2022), Hawaii (HDOA 2019), New Mexico (NMDGF 2023), Oregon (ODFW 2022), Utah (Utah DWR 2023), and Washington (WDFW 2022). *F. rusticus* is regulated under the common name "crayfish" in New Hampshire (NHFG 2022) and Pennsylvania (PFBC 2022). Please refer back to state agency regulatory documents for details on the regulations, including restrictions on activities involving this species. While effort was made to find all applicable regulations, this list may not be comprehensive. Notably, it does not include regulations that do not explicitly name this species or its genus or family, for example, when omitted from a list of authorized species with blanket regulation for all unnamed species.

Means of Introductions within the United States

From Durland Donahou et al. (2023a):

"Human activity best explains the presence of the rusty crayfish in areas outside of its native range. Angler bait bucket emptying is thought to be the primary cause of introduction and species spread (Berrill 1978, Crocker 1979, Butler and Stein 1985, Lodge et al. 1986, Hobbs et at. 1989, Lodge et al. 1994, Kerr et al. 2005; Kilian et al. 2012). The rusty crayfish is also commonly sold to schools and biological supply houses, leading to the potential for uninformed release into the wild (Gunderson 2008; Larson and Olden 2008; Kilian et al. 2012). Intentional release into water bodies by commercial crayfish harvesters is another suspected cause of its range expansion (Wilson et al. 2004). A further mechanism of human facilitated introduction is the intentional establishment of this species in lakes as a means of removing nuisance weeds (Magnuson et al. 1975). Once introduced to a new body of water, this species can move an average of 29 meters per day (Byron and Wilson 2001) and colonize the entire littoral zone up to 12 meters depth (Wilson et al. 2004)."

Remarks

This ERSS was previously published in May 2015 under the name *Orconectes rusticus*. Revisions were completed to incorporate new information and conform to updated standards.

From Durland Donahou et al. (2023a):

"*Orconectes rusticus* (Girard, 1852). *Faxonius rusticus* underwent a reclassification in August 2017, changing the genus of non-cave dwelling *Orconectes* to *Faxonius* (Crandall and De Grave 2017)."

From Durland Donahou et al. (2023b):

"In **Ontario**, live crayfish may only be used as bait in the waters from which they were caught; they may not be transported overland, including importation for use as bait, nor may they be sold or purchased if recreationally caught (OMNR 2011)."

From Smith et al. (2022):

"Wetzel et al. (2004) determined that many of the records of rusty crayfish in Iowa and Minnesota were in fact golden crayfish *F. luteus* (Creaser, 1933)."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2023):

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
                            Genus *Faxonius*
                              Species *Faxonius rusticus* (Girard, 1852)

According to WoRMS (2023), *Faxonius rusticus* is the current valid name for this species.

The following synonyms of *Faxonius rusticus* from ITIS (2023) were used to search for information for this report: *Orconectes rusticus*, *Cambarus rusticus*.

Size, Weight, and Age Range

From Durland Donahou et al. (2023a):

"**Size:** Reaches a maximum of 10 cm in length, with males tending to be larger than females. Reaches maturity at about 3.5 cm (Gunderson 2008)."

From Tricarico (2019):

"The life span of *Faxonius rusticus* is 3-4 years (Hamr, 2002)."

Environment

From Durland Donahou et al. (2023a):

"This species can thrive in areas of high flow or in standing water, but unlike other species of crayfish that can burrow in the sediment when water conditions decline, the rusty crayfish must have clear, well-oxygenated water year-round to survive (Capelli 1982 and Gunderson 2008). It is usually found at water depths < 1 meter, though it has been found as deep as 14.6 meters in Lake Michigan (Taylor and Redmer 1996). Adults typically occupy pool areas of >20 cm depth, while juveniles are usually found in shallower areas (<15 cm depth) bordering stream edges (Butler and Stein 1985)."

"In its native range within the Ohio River valley, *F. rusticus* may seasonally be exposed to water temperatures ranging from close to 0°C up to 39°C; however, it prefers water temperatures between 20 and 25°C (Mundahl and Benton 1990). The maximum growth rate of juveniles is thought to occur at water temperatures between 26 and 28°C, while the maximum juvenile survival rate occurs at temperatures between 20 and 22°C. Therefore, adults will often displace juveniles into warmer habitats to favor maximum growth rate as a means of improving fecundity and competitive abilities (Mundahl and Benton 1990)."

Climate

From Palomares and Pauly (2023):

"Temperate"

From Durland Donahou et al. (2023a):

"At [air] temperatures greater than 30°C, *F. rusticus* has been observed digging burrows in the sand beneath rocks near shore as a means of escaping the heat (Mundahl 1989)."

Distribution Outside the United States

Native

The native range of *Faxonius rusticus* is wholly within the United States, see section 1 for a complete description of the native range.

Introduced

From Tricarico (2019):

"[…] established in three provinces in Canada (Manitoba, Ontario and Quebec) (Phillips, 2010; Desroches et al., 2014)."

From Laffitte et al. (2023):

"We report here the first record of rusty crayfish *Faxonius rusticus* in the wild in France and in Europe so far. […] This study reports high densities of individuals from a pond along the Inières Brook [south-central France], where all size classes are represented, both adults and juveniles."

Means of Introduction Outside the United States

From Tricarico (2019):

"In Canada, *Faxonius rusticus* was first reported in Ontario in 1963 (probably introduced by anglers from Ohio -- Crocker and Barr, 1968), in Manitoba in 2007 (Invasive Species Council of Manitoba, 2019) and in Quebec in 2011 (Desroches et al., 2014; so far it is just known from one lake but there is concern that it could spread further)."

Short Description

From GISD (2023):

"*Orconectes rusticus* […] has robust claws and dark, rusty spots on either side of its carapace (Gunderson, 2008; USGS, 2010). The rusty spots are usually prominent and appear on each side of the posterolateral margins of the carapace but are reported to be not always present or well developed on rusty crayfish from some waters. A rust-colored band also appears dorsally down the center of the abdomen. Overall *O. rusticus* has a [sic] aquamarine, greenish color that is most pronounced on the walking legs (Wetzel et al, 2004; Gunderson, 2008). Its claws are grayish-green to reddish-brown with black bands at the tips and fairly smooth (Gunderson, 2008; ANSIS, 2007). Form I males [reproductive form] are characterized by large claws, a hook on one pair of their legs, and hardened gonapods. The hook and the larger claws are used for grasping females during mating. Males are usually larger than females of the same age (Gunderson, 2008)."

Biology

From Durland Donahou et al. (2023a):

"*Faxonius rusticus* inhabits lakes, ponds, and streams, preferring areas with rocks, logs, or other debris for shelter. Clay, silt, sand, gravel, and rock all serve as suitable bottom types. However, *F. rusticus* prefers cobble habitat, which allows it to hide if necessary (Taylor and Redmer 1996). […] Mature rusty crayfish mate in late summer, early fall, or early spring. The female stores sperm transferred from one or more males until its eggs are ready to be fertilized—usually by late spring when water temperatures begin to increase (Berrill and Arsenault 1984). Therefore, it is possible for a single mature female carrying viable sperm to begin a new population if she is released into a suitable habitat. Rusty crayfish females can lay between 80 and 575 eggs

(Gunderson 2008). Eggs hatch in three to six weeks depending on water temperature. Juveniles stay with the female for several weeks after hatching (Berrill 1978) and reach full maturity the following year upon completion of about eight to ten molt cycles. After maturity is reached, growth slows greatly, with males typically molting twice per year and females molting once. In the spring, the male molts into a sexually inactive from (Form II) and returns to its sexually active form (Form I) in the summer (Gunderson 2008)."

"*Faxonius rusticus* individuals feed as shredders, scrapers, collectors, and predators (Lorman and Magnuson 1978). This species is an opportunistic consumer of a variety of aquatic plants, benthic invertebrates, detritus (decaying plants and animals, including associated bacteria), periphyton (algae and microbes attached to objects submersed in water), fish eggs, and small fish (Lorman 1980). Juveniles tend to feed on benthic invertebrates, such as mayflies, stoneflies, midges, and side-swimmers, more often than do adults (Hanson et al. 1990, Momot 1992). Among the options of invertebrate prey for adults, snails are a primary target (Lodge and Lorman 1987)."

Human Uses

From Tricarico (2019):

"Although *Faxonius rusticus* is abundant and common (and has in some cases been spread by commercial crayfish harvesters -- Wilson et al., 2004), it has not been used extensively for commercial purpose (Hamr, 2002), although there is a limited amount of harvesting for food (Gunderson, 2008). It is often used as bait for anglers (Butler and Stein, 1985; Lodge et al., 1986; Hobbs et al., 1989; Lodge et al., 1994; Kerr et al., 2005; Kilian et al., 2012). […] it has been intentionally introduced in some lakes to remove weeds (Hamr, 2002; Phillips, 2010; Durland Donahou et al., 2019)."

From GISD (2023):

"Orconectes rusticus is a commonly used live fishing bait."

Diseases

***Faxonius rusticus* has been documented as a host of *Aphanomyces astaci*, causative agent of crayfish plague. Crayfish plague is a disease listed by the World Organisation for Animal Health (2023).**

From Panteleit et al. (2019):

"Our results clearly identify *F. rusticus* as a host of *A*[*phanomyces*] *astaci* in North America."

Poelen et al. (2014) report *Paragonimus kellicotti* as a parasite of *F. rusticus*.

From Tricarico (2019):

"List of Diseases and Disorders:
protozoan disease of American crayfish

Psorospermium"

Threat to Humans

From Tricarico (2019):

"Due to its greater conspicuousness during daylight hours than native crayfish species, *Faxonius rusticus* has resulted in a decline in recreational swimming in areas where it is present, as swimmers fear stepping on it and being pinched by its large claws (Gunderson, 2008)."

3 Impacts of Introductions

From GISD (2023):

"*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."

"*O. rusticus* aggressive nature, greater fitness, and large chelae and body size allow it to displace native crayfish from food and habitat (Byron & Wilson, 2001; Garvey et al, 2003; Garvey & Stein, 1993; Hill & Lodge, 1999; Klocker & Strayer, 2004). Displacement from food causes reduced fitness to its cogeners [sic] and displacement from habitat increases predation pressure (Hill & Lodge, 1994). *O rusticus* displaces native crayfish, *O. virilis*, and previous invader, *O. propinquus*, from lakes throughout northern Wisconsin (Byron & Wilson, 2001; Garvey & Stein, 1993; Hill & Lodge, 1994). Along with direct competition and displacement, research indicates that fish and other predators avoid *O. rusticus* because of its larger chelae and body size and this selective predation pressure is likely an important driver in the replacement of crayfish species by rusty crayfish (Roth & Kitchell, 2005; DiDonato & Lodge, 1999). *O. rusticus* is known to hybridize with native crayfish *O. propinquus* in Lake Michigan (Jonas et al, 2005). […] *O. rusticus* also preys on snails and in Trout Lake, Wisconsin snails declined from >10 000 to <5 snails•m2 in one of the initially invaded areas (Wilson et al, 2004). Relative to control treatments, rusty crayfish were found to reduce the biomass of northeastern US native *Lymnaea* and *Physa* snails by >90% (Johnson et al, 2009). Furthermore, *O. rusticus* has been found to co-occur with *Bellamya chinensis* [*Cipangopaludina chinensis*], an invasive snail with a thick shell that prevents predation by *O. rusticus*, in northern temperate lakes throughout the United States. The predation pressure of *O. rusticus* on native snail communities combined with competition and displacement by the *B. chinensis* [*Cipangopaludina chinensis*] has resulted in the reduction of native snail biomass (Johnson et al, 2009)."

"The reduction of macrophyte abundance is another important impact of *O. rusticus*. Small-scale, comparative, and multi-lake studies confirm that macrophyte species richness and abundance decline significantly in lakes invaded by *O. rusticus* (Alexander et al, 2008; Rosenthal et al, 2006; Roth et al, 2007; Wilson et al, 2004). In northern Wisconsin, studies found the proportion of sites with no macrohpyte [sic] cover to increase from 40-73% (Roth et al, 2007), and submerged macrophyte species richness to decline by as much as 80% with the invasion of *O. rusticus* (Wilson et al, 2004)."

"*O. rusticus* introduction is also believed to reduced sport fish populations especially pan-fish *Lepomis macrochirus* and *L. gibbossus* [sic] by either egg predation or competition with juveniles. Researchers have calculated fisheries damages of *O. rusticus* in Vilas County, Wisconsin to be about 1.5 million annually (Keller et al, 2008)."

"Additional cascading ecological impacts have been associated with *O. rusticus*. Decreasing macroinvertebrate densities and increasing periphyton productivity have been found to correlate with increasing *O. rusticus* densities (Charlebois & Lamberti, 1996). In Trout Lake, Wisconsin, mean abundance of Odonata, Amphipoda, and Trichoptera decreased significantly lake-wide with the invasion of *O. rusticus* (Wilson et al, 2004)."

From Smith et al. (2019):

"We also found that habitat selection by the two most widespread native species [in Michigan], *F. propinquus* and *F. virilis*, shifts when the invasive *F. rusticus* is present, suggesting a mechanism for biogeographic effects of this invader on native crayfishes."

From Hamr (2024):

"In the regions where it is established in Ontario, it has become the only crayfish species present and has attained very high densities (Momot 1992; Hamr 1999; Dube and Desroches 2007)."

Faxonius rusticus is regulated in the following U.S. States: Alaska (ADF&G 2023), Arizona (Arizona Game and Fish Commission 2022), Arkansas (AGFC 2022), Colorado (CPW 2023), Connecticut (Connecticut DEEP 2020), Florida (FFWCC 2022), Hawaii (HDOA 2019), Idaho (IDDA 2022), Illinois (Illinois DNR 2015), Iowa (Iowa NRC 2015), Kansas (KDWP 2023), Maryland (Code of Maryland Regulations 2022), Michigan (Michigan Compiled Laws 2022), Minnesota (Minnesota DNR 2022), Missouri (MDC 2023), Montana (Montana FWP 2023), Nevada (Nevada Board of Wildlife Commissioners 2022), New Hampshire (NHFG 2022), New Mexico (NMDGF 2023), New York (New York DEC 2022), North Carolina (North Carolina DEQ 2022), North Dakota (North Dakota Game and Fish Department 2023), Oklahoma (ODWC 2023), Oregon (ODFW 2022), Pennsylvania (PFBC 2022), South Carolina (South Carolina Code of Laws 2022), Utah (Utah DWR 2023), Vermont (The Vermont Statutes 2017), Virginia (Virginia DWR 2022), Washington (WDFW 2022), Wisconsin (Wisconsin DNR 2022), and Wyoming (WGFC 2022). See section 1.

4 History of Invasiveness

Faxonius rusticus has been introduced and established in several states outside its native range as well as Canada and France. Established populations compete with and displace native crayfish; increase predation on native snails and bivalves; and reduce macrophyte, sport fish, and native macroinvertebrate abundance. These impacts have resulted in other cascading trophic interactions such as increases in periphyton activity due to the reduction of macroinvertebrate richness and abundance. Impacts from the introduction and establishment of *Faxonius rusticus* have been well documented by reliable sources. Therefore, the History of Invasiveness for *Faxonius rusticus* is classified as High.

5 Global Distribution

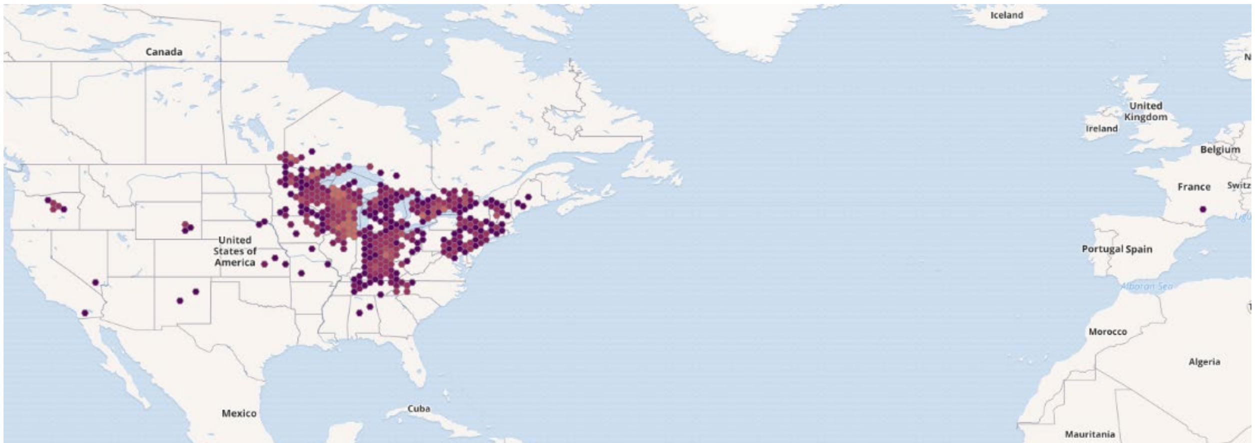

Figure 1. Reported global distribution of *Faxonius rusticus*. Map from GBIF Secretariat (2023). Observations are reported from Canada, France, and the United States. The population reported in Wyoming is presumed extirpated and was therefore not included among the source points for climate matching. Reported occurrences in California, Georgia, eastern Kansas, Massachusetts, Missouri, New Hampshire, and central New Mexico were excluded from the climate matching source points because they could not be confirmed to represent established populations.

6 Distribution Within the United States

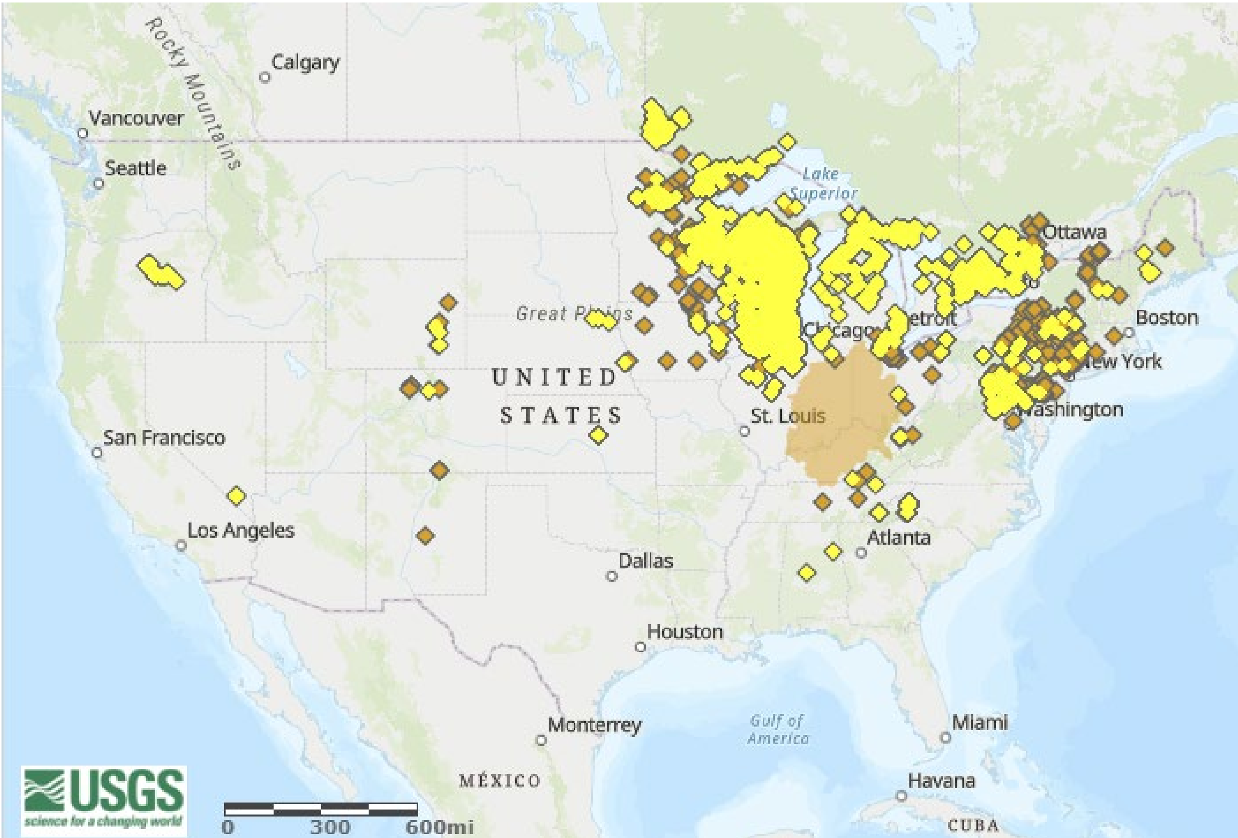

Figure 2. Reported distribution of *Faxonius rusticus* in the United States. Map from USGS (2026). The orange shaded polygon represents the native range of *F. rusticus*. Yellow points represent established nonnative populations of *F. rusticus* and orange points represent other reported nonnative occurrences. Only established populations and points in the native range were used to select source locations for the climate matching analysis. The population reported in Wyoming is presumed extirpated and was therefore excluded from the source points used for climate matching.

7 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Faxonius rusticus* to the contiguous United States was mostly high from the eastern edge of the Cascade Mountains and Sierra Nevada all the way to the Atlantic coast. Exceptions included peninsular Florida and the Gulf Coast (medium to low match) and southwestern Arizona (medium match). The areas with the highest climate match were located in the Midwest and Northeast, where the species is native or nonnative populations are abundant. Along the Pacific Coast and in the Cascade and Sierra Nevada ranges, the climate match was generally low, with medium matches predicted around Puget Sound in Washington and in the Central Valley and southern California. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.915, indicating that

Yes, there is establishment concern for this species outside its native range. The Climate 6 score is calculated as: (count of target points with scores $\geq$ 6)/(count of all target points). Establishment concern is warranted for Climate 6 scores greater than or equal to 0.002 based on an analysis of the establishment success of 356 nonnative aquatic species introduced to the United States (USFWS 2024).

Projected climate matches in the contiguous United States under future climate scenarios are available for *Faxonius rusticus* (see Appendix). These projected climate matches are provided as additional context for the reader; future climate scenarios are not factored into the Overall Risk Assessment Category.

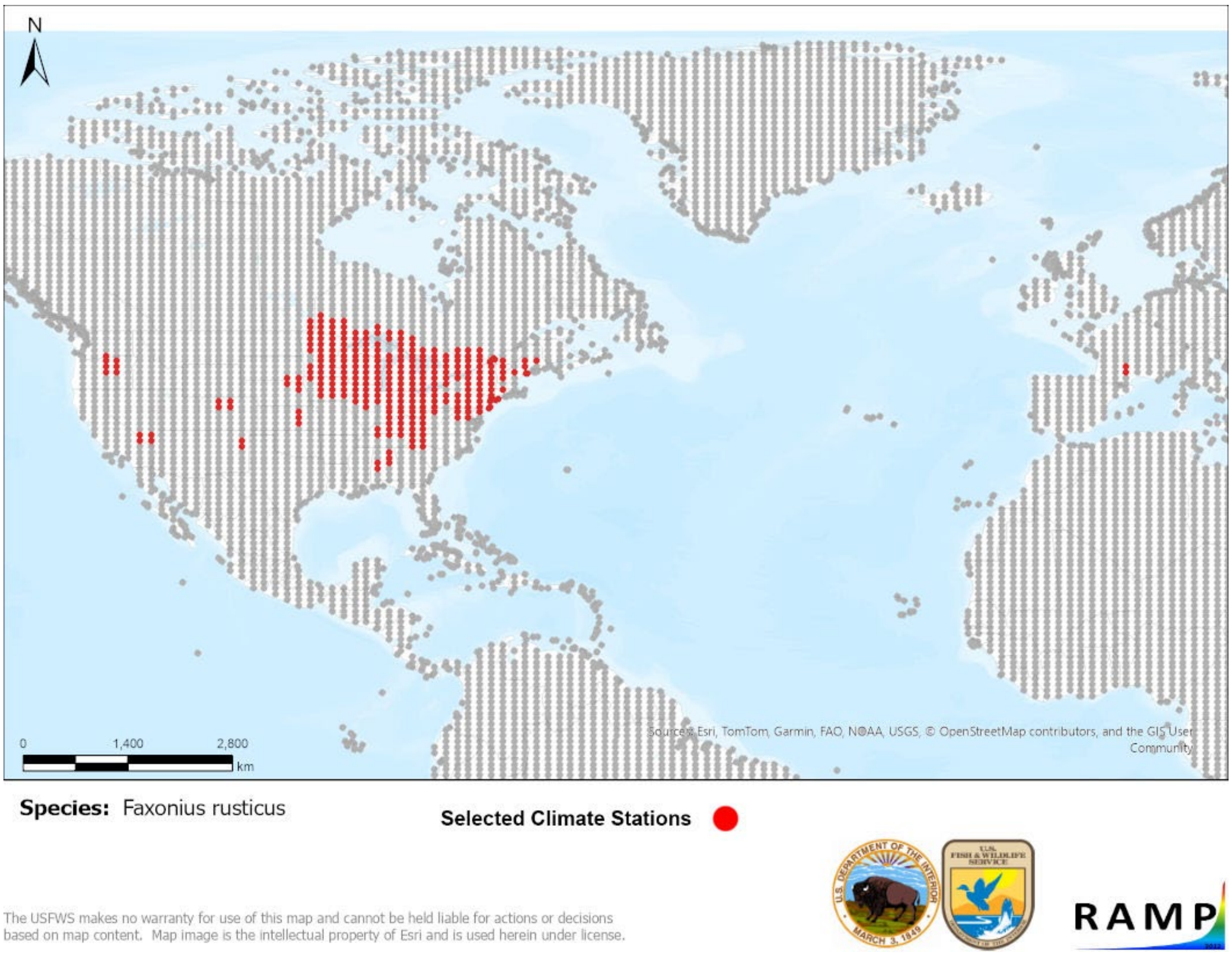

Figure 3. RAMP (Sanders et al. 2023) source map showing weather stations in North America selected as source locations (red; United States, Canada, France) and non-source locations (gray) for *Faxonius rusticus* climate matching. Source locations from GBIF Secretariat (2023). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

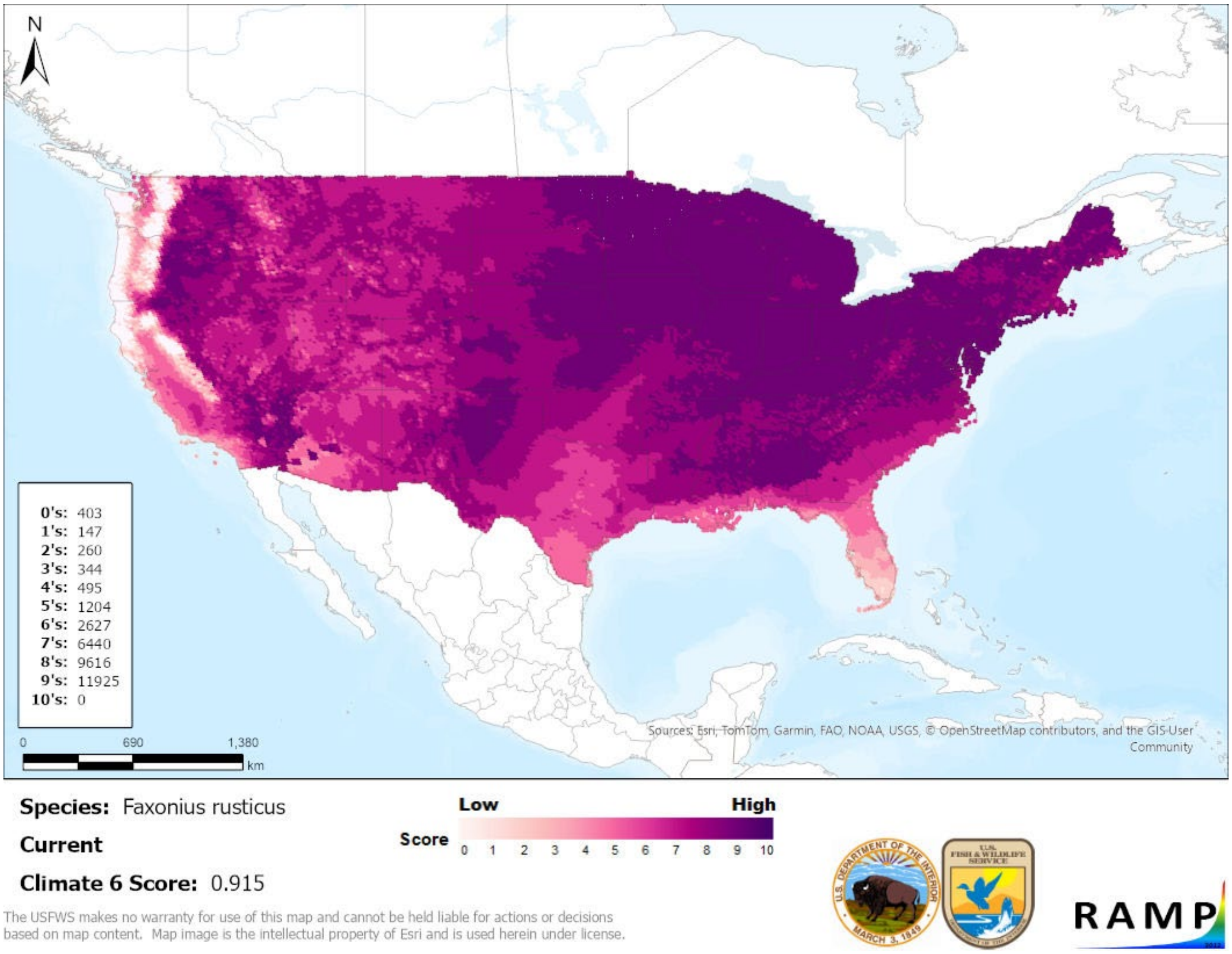

Figure 4. Map of RAMP (Sanders et al. 2023) climate matches for *Faxonius rusticus* in the contiguous United States based on source locations reported by GBIF Secretariat (2023). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

The Certainty of Assessment for *Faxonius rusticus* is classified as High. There is abundant information available on the biology and ecology of this species. Reliable sources confirm the existence of established populations outside of this species' native range and its negative impacts of introduction.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Faxonius rusticus, Rusty Crayfish, is a crustacean native to the Ohio River Basin in the United States. It can be found in a variety of aquatic habitats and is an opportunistic omnivore. A single female can produce over 500 eggs per reproductive cycle. No evidence was found of online trade of *F. rusticus* and many U.S. States have placed regulations on its possession and trade. This species has been widely introduced throughout the United States in addition to Canada and

France, likely through its use as fishing bait and through intentional release by schools, commercial harvesters, or for biological weed control. The History of Invasiveness for *Faxonius rusticus* is classified as High due to the existence of numerous established populations outside of its native range and documented negative impacts from those introductions. These negative impacts include competition with and displacement of native crayfish; increased predation on native snails and bivalves; and reductions in macrophyte, sport fish, and native macroinvertebrate abundance. The climate matching analysis for the contiguous United States indicates establishment concern for this species outside its native range. Most of the contiguous United States has a high climate match, excluding the Gulf and Pacific Coasts. The Certainty of Assessment for this ERSS is classified as High due to the abundance of peer-reviewed literature supporting the nonnative establishment and negative impacts of *F. rusticus*. The Overall Risk Assessment Category for *Faxonius rusticus* in the contiguous United States is High.

Assessment Elements

- **History of Invasiveness (see Section 4): High**
- **Establishment Concern (see Section 7): Yes**
- **Certainty of Assessment (see Section 8): High**
- **Remarks, Important additional information: *Faxonius rusticus* is a host of *Aphanomyces astaci*, causative agent of crayfish plague, a disease listed by the World Organisation for Animal Health.**
- **Overall Risk Assessment Category: High**

10 Literature Cited

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in section 11.

[ADF&G] Alaska Department of Fish and Game. 2023. General provisions. Collection, transportation, possession, propagation, or release of aquatic organisms; aquatic farming. 5 Alaska Administrative Code 41.070-41.075.

[AGFC] Arkansas Game and Fish Commission. 2022. Certain exotic species prohibited. Arkansas Game and Fish Commission Code Book 26.13.

Arizona Game and Fish Commission. 2022. Restricted live wildlife. Arizona Administrative Code R12-4-406.

Bouchard RW. 1977. Distribution, systematic status and ecological notes on five poorly known species of crayfishes in western North America (Decapoda: Astacidae and Cambaridae). Freshwater Crayfish 3:409–423.

Code of Maryland Regulations. 2022. Classification of nonnative aquatic organisms. Section 08.02.19.04.

Connecticut [DEEP] Department of Energy and Environmental Protection. 2020. Importation of fish, birds, and quadrupeds. Regulations of Connecticut State Agencies 26-55.

[CPW] Colorado Parks and Wildlife. 2023. Possession of aquatic wildlife. 2 Code of Colorado Regulations 406-0, Article VIII #012.

Durland Donahou A, Conard W, Dettloff K, Fusaro A, Sturtevant R. 2023a. *Faxonius rusticus* (Girard, 1852). Gainesville, Florida: U.S. Geological Survey, Nonindigenous Aquatic Species Database. Available: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=214 (December 2023).

Durland Donahou A, Conard W, Dettloff K, Fusaro A, Sturtevant R. 2023b. *Faxonius rusticus* (Girard, 1852). Gainesville, Florida and Ann Arbor, Michigan: NOAA Great Lakes Aquatic Nonindigenous Species Information System: U.S. Geological Survey, Nonindigenous Aquatic Species Database. Available: https://nas.er.usgs.gov/queries/greatLakes/FactSheet.aspx?SpeciesID=214&Potential=N&Type=0&HUCNumber=DGreatLakes (December 2023).

Fofonoff PW, Ruiz GM, Steves B, Simkanin C, Carlton JT. 2018. *Faxonius rusticus*. National Exotic Marine and Estuarine Species Information System. Edgewater, Maryland: Smithsonian Environmental Research Center. Available: https://invasions.si.edu/nemesis/species_summary/97424 (December 2023).

GBIF Secretariat. 2023. GBIF backbone taxonomy: *Faxonius rusticus* (Girard, 1852). Copenhagen: Global Biodiversity Information Facility. Available: https://www.gbif.org/species/8979506 (December 2023).

[GISD] Global Invasive Species Database. 2023. Species profile: *Orconectes rusticus*. Gland, Switzerland: Invasive Species Specialist Group. Available: http://www.iucngisd.org/gisd/speciesname/Orconectes+rusticus# (December 2023).

Hamr P. 2024. The real and potential impacts of invasive crayfish in Ontario Canada: a review. Freshwater Crayfish 29:9–22.

[HDOA] Hawaii Department of Agriculture. 2019. Non-domestic animal import rules. Hawaii Administrative Rules Chapter 4-71.

[IDDA] Idaho Department of Agriculture. 2022. Rules governing invasive species and noxious weeds. Idaho Administrative Code 02.06.09.

Illinois [DNR] Department of Natural Resources. 2015. Injurious species. 17 Illinois Administrative Code chapter 1, part 805.

Iowa [NRC] Natural Resource Commission. 2015. Aquatic invasive species. Iowa Administrative Code 571-90.

[ITIS] Integrated Taxonomic Information System. 2023. *Faxonius rusticus*. Reston, Virginia: Integrated Taxonomic Information System. Available: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=1133773#null (December 2023).

[KDWP] Kansas Department of Wildlife and Parks. 2023. Importation and possession of certain wildlife; prohibition, permit requirement, and restrictions. Kansas Administrative Regulations 115-18-10.

Laffitte M, Baudry T, Guilmet M, Andrieu T, Poulet N, Duperray T, Carine D, Collas M, Moumen B, Grandjean F. 2023. A new invader in freshwater ecosystems in France: the rusty crayfish *Faxonius rusticus* (Girard, 1852). BioInvasions Records 12:457–468.

Michigan Compiled Laws. 2022. Transgenic and nonnative organisms. Chapter 324, part 413.

Minnesota [DNR] Department of Natural Resources. 2022. Minnesota invasive species laws. Saint Paul: Minnesota Department of Natural Resources. Available: https://www.dnr.state.mn.us/invasives/laws.html (October 2022).

[MDC] Missouri Department of Conservation. 2023. Prohibited species. 3 Missouri Code of State Regulations 10-4.117.

Montana [FWP] Department of Fish, Wildlife, and Parks. 2023. Exotic wildlife. Administrative Rules of Montana 12.6.22.

Nevada Board of Wildlife Commissioners. 2022. Hunting, fishing and trapping; miscellaneous protective measures. Nevada Administrative Code 503.

[NHFG] New Hampshire Fish and Game Department. 2022. The importation, possession and use of all wildlife. New Hampshire Code of Administrative Rules Fis 800.

[NMDGF] New Mexico Department of Game and Fish. 2023. Director's species importation list. Santa Fe: New Mexico Department of Game and Fish. Available: https://www.wildlife.state.nm.us/download/enforcement/importation/information/Importation-Info-Directors-Species-Importation-List-1-3-2023.pdf (October 2023).

New York [DEC] Department of Environmental Conservation. 2022. Prohibited and regulated invasive species. 6 New York Codes, Rules and Regulations 575.3.

North Dakota Game and Fish Department. 2023. ANS species list. Bismarck: North Dakota Game and Fish Department. Available: https://gf.nd.gov/ans/species (October 2023).

North Carolina [DEQ] Department of Environmental Quality. 2022. Possession of certain fishes. 15A North Carolina Administrative Code 10C.0211.

[ODFW] Oregon Department of Fish and Wildlife. 2022. Importation, possession, confinement, transportation and sale of nonnative wildlife. Oregon Administrative Rules 635-056.

[ODWC] Oklahoma Department of Wildlife Conservation. 2023. Restriction on aquatic species introduction. 800 Oklahoma Administrative Code 20.

Palomares MLD, Pauly D, editors. 2023. *Orconectes rusticus*. SeaLifeBase. Available: http://www.sealifebase.ca/summary/Orconectes-rusticus.html (December 2023).

Panteleit J, Horvath T, Jussila J, Makkonen J, Perry W, Schulz R, Theissinger K, Schrimpf A. 2018. Invasive rusty crayfish (*Faxonius rusticus*) populations in North America are infected with the crayfish plague disease agent (*Aphanomyces astaci*). Freshwater Science 38:425–433.

Pappas J. 2002. *Orconectes rusticus*. Animal Diversity Web. Available: https://animaldiversity.org/site/accounts/information/Orconectes_rusticus.html (December 2023).

[PFBC] Pennsylvania Fish and Boat Commission. 2022. Aquatic invasive species. Harrisburg: Pennsylvania Fish and Boat Commission. Available: https://www.fishandboat.com/Resource/AquaticInvasiveSpecies/Pages/default.aspx (October 2022).

Sanders S, Castiglione C, Hoff M. 2023. Risk Assessment Mapping Program: RAMP. Version 5.0. U.S. Fish and Wildlife Service.

Smith JM, Klein ZB, Steffen C. 2022. Documentation of invasive rusty crayfish *Faxonius rusticus* (Girard, 1852) in Kansas. BioInvasions Records 11:766–775.

Smith KR, Roth BM, Jones ML, Hayes DB, Herbst SJ, Popoff N. 2019. Changes in the distribution of Michigan crayfishes and the influence of invasive rusty crayfish (*Faxonius rusticus*) on native crayfish substrate associations. Biological Invasions 21:637–656.

South Carolina Code of Laws. 2022. Protection of fish. Chapter 50-13.

Tricarico E. 2019. *Faxonius rusticus* (rusty crayfish). In CABI Invasive Species Compendium. Wallingford, United Kingdom: CAB International. Available: https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.72037 (December 2023).

[USFWS] U.S. Fish and Wildlife Service. 2024. Standard operating procedures: how to prepare an "Ecological Risk Screening Summary." Version 3. Available: https://www.fws.gov/media/standard-operating-procedures-how-prepare-ecological-risk-screening-summary-2024 (April 2026).

[USGS] U.S. Geological Survey. 2026. *Faxonius rusticus.* Gainesville, Florida: U.S. Geological Survey, Nonindigenous Aquatic Species Database. Available: https://nas.er.usgs.gov/viewer/omap.aspx?SpeciesID=214 (April 2026).

Utah [DWR] Division of Wildlife Resources. 2023. Collection, importation, possession (CIP). Administrative rule R657-3.

The Vermont Statutes. 2017. Aquatic nuisance control. Title 10, chapter 50.

Virginia [DWR] Department of Wildlife Resources. 2022. Importation requirements, possession, and sale of nonnative (exotic) animals. 4 Virginia Administrative Code 15-30-40.

[WDFW] Washington Department of Fish and Wildlife. 2022. Invasive/nonnative species. 220 Washington Administrative Code 640.

World Organisation for Animal Health. 2023. Animal diseases. Paris: World Organisation for Animal Health. Available: https://www.woah.org/en/what-we-do/animal-health-and-welfare/animal-diseases/ (December 2023).

Wisconsin [DNR] Department of Natural Resources. 2022. Invasive species identification, classification and control. Wisconsin Administrative Code NR 40.

[WGFC] Wyoming Game and Fish Commission. 2022. Regulation for aquatic invasive species. Wyoming Administrative Rules Chapter 62.

11 Literature Cited in Quoted Material

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.

Alexander ML, Woodford MP, Hotchkiss SC. 2008. Freshwater macrophyte communities in lakes of variable landscape position and development in northern Wisconsin, USA. Aquatic Botany 88:77–86.

[ANSIS] Aquatic Nuisance Species Information System. 2007. Species profiles: *Orconectes rusticus* - Rusty Crayfish summary. Available: http://el.erdc.usace.army.mil/ansrp/ANSIS/ansishelp.htm#html/orconectes_virilis_northern_crayfish.htm (February 2010).

Berrill M. 1978. Distribution and ecology of crayfish in the Kawartha Lakes region of southern Ontario. Canadian Journal of Zoology 56:166–177.

Berrill M, Arsenault M. 1984. The breeding behavior of a northern temperate orconectid crayfish, *Orconectes rusticus*. Animal Behavior 32:333–339.

Butler MJ, Stein RA. 1985. An analysis of the mechanisms governing species replacements in crayfish. Oecologia 66:168–177.

Byron CJ, Wilson KA. 2001. Rusty crayfish (*Orconectes rusticus*) movement within and between habitats in Trout Lake, Vilas County, Wisconsin. Journal of the North American Benthological Society 20:606–614.

Caduto MJ. 2011. Invasive crayfish has claws. The Bennington Banner 6(2).

Capelli GM. 1982. Displacement of northern Wisconsin crayfish by *Orconectes rusticus* (Girard). Limnology and Oceanography 27:741–745.

Charlebois PM, Lamberti GA. 1996. Invading crayfish in a Michigan stream: direct and indirect effects on periphyton and macroinvertebrates. Journal of the North American Benthological Society 15:551–563.

Crandall KA, De Grave S. 2017. An updated classification of the freshwater crayfishes (Decapoda: Astacidea) of the world, with a complete species list. Journal of Crustacean Biology 37:615–653.

Creaser EP. 1931. The Michigan decapod crustaceans. Papers of the Michigan Academy of Science, Arts and Letters 13:257–276.

Crocker DW. 1979. The crayfishes of New England. Proceedings of the Biological Society of Washington 92:225–252.

Crocker DW, Barr DW. 1968. Handbook of the crayfishes of Ontario. Toronto, Ontario, Canada: University of Toronto Press.

Desroches J, Gagnon L, Picard I. 2014. The invasion of the rusty crayfish in Lake Brome, Montérégie. [L'invasion de l'écrevisse à taches rouges au lac Brome, en Montérégie.] Le Naturaliste Canadien 138(2):46–49.

Dresser CM, Kuhlmann ML, Swanson BJ. 2016. Variation in native crayfish agonistic response to the invasion of the rusty crayfish *Orconectes rusticus* (Girard, 1852). Journal of Crustacean Biology 36:129–137.

Didonato GT, Lodge DM. 1993. Species replacements among *Orconectes* crayfishes in Wisconsin lakes: the role of predation by fish. Canadian Journal of Fisheries & Aquatic Sciences 50:1484–1488.

Dube J, Desroches JF. 2007. Les écrevisses du Quebéc. Longeuil, Quebec, Canada: Ministére des Ressources Naturelles et de la Faune. Available: https://mffp.gouv.qc.ca/wp-content/uploads/ecrevisses-duquebec.pdf.

Durland Donahou A, Conard W, Dettloff K, Fusaro A, Sturtevant R. 2019. *Faxonius rusticus* (Girard, 1852). Nonindigenous Aquatic Species Database. Gainesville, Florida: U.S. Geological Survey. Available: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=214.

Fullerton AH, Watson BT. 2001. New distributional records for two nonindigenous and one native crayfish in North Carolina. The Journal of the Elisha Mitchell Scientific Society 117:66–70.

Garvey JE, Rettig JE, Stein RA, Lodge DM, Klosiewski SP. 2003. Scale-dependent associations among fish predation, littoral habitat, and distributions of crayfish species. Ecology 84:3339–3348.

Garvey JE, Stein RA. 1993. Evaluating how chela size influences the invasion potential of an introduced crayfish (*Orconectes rusticus*). American Midland Naturalist 129:172–181.

Gunderson J. 2008. Rusty crayfish: a nasty invader. Duluth, Minnesota: Minnesota Sea Grant. Available: http://www.seagrant.umn.edu/ais/rustycrayfish_invader (June 2010).

Hamr P. 1999. The commercial harvest of the exotic rusty crayfish (*Orconectes rusticus*). Summer 1998. Report to the Ministry of Natural Resources, Peterborough Region, Peterborough, Ontario, Canada.

Hamr P. 2002. *Orconectes*. Pages 585–608 in Holdich DM, editor. Biology of freshwater crayfish. Oxford, United Kingdom: Blackwell Science.

Hanson JM, Chambers PA, Prepas EE. 1990. Selective foraging by the crayfish *Orconectus virilis* and its impact on macroinvertebrates. Freshwater Biology 24:69–80.

Hill AM, Lodge DM. 1999. Replacement of resident crayfishes by an exotic crayfish: the roles of competition and predation. Ecological Applications 9:678–690.

Hill AM, Lodge DM. 1994. Diel changes in resource demand: competition and predation in species replacement among crayfish. Ecology 75:2118–2126.

Hobbs HH Jr. 1974. A checklist of the North and Middle American crayfishes (Decapoda: Astacidae and Cambaridae). Smithsonian Contributions to Zoology 166(I-III):1–161.

Hobbs HH Jr. 1989. An illustrated checklist of the American crayfishes (Decapoda: Astacidae, Cambaridae, and Parastacidae). Smithsonian Contributions to Zoology 480:1–236.

Hobbs HH, Jass JP. 1988. Milwaukee, Wisconsin: Milwaukee Public Museum. [Source material did not give full citation for this reference.]

Hobbs HH III, Jass JP, Huner JV. 1989. A review of global crayfish introductions with particular emphasis on two North American species (Decapoda, Cambaridae). Crustaceana 56:299–316.

Illinois Natural History Survey. 2017. Illinois Natural History Survey collection databases. Illinois Natural History Survey. Available: https://biocoll.inhs.illinois.edu/portalx/collections/index.php. (August 2017).

iMapInvasives. 2016. [Source material did not give full citation for this reference.]

Invasive Species Council of Manitoba. 2019. Invasive plants & animals in Manitoba. Winnipeg, Manitoba: Invasive Species Council of Manitoba. Available: https://invasivespeciesmanitoba.com/site/index.php.

Jezerinac RF, Stocker GW, Tarter DC. 1994. The crayfishes (Decapoda: Cambaridae) of West Virginia. Columbus: Ohio Biological Survey, The Ohio State University, College of Biological Sciences.

Johnson PTJ, Olden JD, Solomon CT, Vander Zanden MJ. 2009. Interactions among invaders: community and ecosystem effects of multiple invasive species in an experimental aquatic system. Oecologia 159:161–170.

Jonas JL, Claramunt RM, Fitzsimons JD, Marsden JE, Ellrott BJ. 2005. Estimates of egg deposition and effects of lake trout (*Salvelinus namaycush*) egg predators in three regions of the Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences 62:2254–2264.

Keller RP, Frang K, Lodge DM. 2008. Preventing the spread of invasive species: economic benefits of intervention guided by ecological predictions. Conservation Biology 22:80–88.

Kerr SJ, Brousseau CS, Muschett M. 2005. Invasive aquatic species in Ontario: a review and analysis of potential pathways for introduction. Fisheries 30(7):21–30.

Kilian JV, Klauda RJ, Widman S, Kashiwagi M, Bourquin R, Weglein S, Schuster J. 2012. An assessment of a bait industry and angler behavior as a vector of invasive species. Biological Invasions 14:1469–1481.

Kilian J. 2013. [Source material did not give full citation for this reference.]

Klocker CA, Strayer DL. 2004. Interactions among an invasive crayfish (*Orconectes rusticus*), a native crayfish (*Orconectes limosus*), and native bivalves (Sphaeriidae and Unionidae). Northeastern Naturalist 11:167–178.

Larson ER, Olden JD. 2008. Do schools and golf courses represent emerging pathways for crayfish invasions? Aquatic Invasions 3:465–468.

Leon M, Merner MJ, Dreyer AA, Cooper A, Scott L, Berendzen PB, McCullough DA, Merten EC. 2016. Range expansion of the invasive rusty crayfish *Orconectes rusticus* (Girard, 1852) (Decapoda: Astacoidea) in northeastern Iowa (USA) rivers. Journal of Crustacean Biology 36:99–104.

Lodge DM, Kershner MW, Aloi JE, Covich AP. 1994. Effects of an omnivorous crayfish (*Orconectes rusticus*) on a freshwater littoral food web. Ecology 75:1265–1281.

Lodge DM, Kratz TK, Capelli GM. 1986. Long-term dynamics of three crayfish species in Trout Lake, Wisconsin. Canadian Journal of Fisheries and Aquatic Sciences 43:993–998.

Lodge DM, Lorman JG. 1987. Reductions in submersed macrophyte biomass and species richness by crayfish *Orconectes rusticus*. Canadian Journal of Fisheries and Aquatic Sciences 44:591–597.

Lorman. 1980. [Source material did not give full citation for this reference.]

Lorman JG, Magnuson JJ. 1978. Role of crayfishes in aquatic ecosystems. Fisheries 3:8–10.

Loughman Z. 2012. *Orconectes virilis* and *Orconectes rusticus* collection in West Virginia. [Source material did not give full citation for this reference.]

Magnuson JJ, Capelli GM, Lorman JG, Stein RA. 1975. Consideration of crayfish for macrophyte control. Pages 66–74 in Brezonik PL, Fox JL, editors. Proceedings Symposium on Water Quality Management through Biological Control, University of Florida, Jan. 23-30, 1975. Gainesville: University of Florida. Department Environmental Engineering Sciences.

Mills EL, Scheuerell MD, Carlton JT, Strayer DL. 1997. Biological invasions in the Hudson River basin: an inventory and historical analysis. New York State Museum Circular 57:1–51.

Momot WT. 1992. Further range extensions of the crayfish *Orconectes rusticus* in the Lake Superior Basin of northwestern Ontario. Canadian Field-Naturalist 106:397–399.

Momot WT, Gowing H, Jones PD. 1978. The dynamics of crayfish and their role in ecosystems. American Midland Naturalist 99:10–35.

Mundahl ND. 1989. Seasonal and diel changes in thermal tolerance of the crayfish *Orconectes rusticus,* with evidence for behavioral thermoregulation. Journal of the North American Benthological Society 8:173–179.

Mundahl ND, Benton MJ. 1990. Aspects of the thermal ecology of the rusty crayfish *Orconectes rusticus* (Girard). Oecologia 82:210–216.

[NCWRC] North Carolina Wildlife Resources Commission. 2017. Aquatic Wildlife Diversity Program database, collection records for nonindigenous aquatic species in North Carolina. Raleigh: North Carolina Wildlife Resources Commission.

OMNR. 2011. [Source material did not give full citation for this reference.]

Page LM. 1985. The crayfishes and shrimps (Decapoda) of Illinois. Illinois Natural History Survey Bulletin 33(I-VI):335–448.

Passe DJ. 2014. Rusty crayfish (*Orconectes rusticus*) and other exotic species in Minnesota (unpublished data). Ely, Minnesota: Lake County Soil and Water Conservation District.

Peters JA. 2010. Influence of habitat, predation, and spatial and temporal scales on species diversity and distributions: interactions involving crayfishes in the Laurentian Great Lakes and inland lakes. Unpublished Ph.D. dissertation. Notre Dame, Indiana: University of Notre Dame.

Phillips ID, 2010. Biological synopsis of the Rusty Crayfish (*Orconectes rusticus*). Page 17 in Canadian manuscript report of fisheries and aquatic sciences. Burlington, Ontario, Canada: Fisheries and Oceans Canada.

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

Roth BM, Kitchell JF. 2005. The role of size-selective predation in the displacement of *Orconectes* crayfishes following rusty crayfish invasion. Crustaceana 78:297–310.

Roth BM, Tetzlaff JC, Alexander ML, Kitchell JF. 2007. Reciprocal relationships between exotic rusty crayfish, macrophytes, and *Lepomis* species in northern Wisconsin lakes. Ecosystems 10:75–86.

Sorenson KL, Bollens SM, Counihan T. 2012. Range expansion of rusty crayfish *Orconectes rusticus* (Girard, 1852) in the John Day River, Oregon, USA. Aquatic Invasions 7:291–294.

South Dakota Game, Fish and Parks. 2015. Rusty Crayfish. Available: http://sdleastwanted.com/species/rustycrayfish.aspx.

Taylor CA, Redmer M. 1996. Dispersal of the crayfish *Orconectes rusticus* in Illinois, with notes on species displacement and habitat preference. Journal of Crustacean Biology 16:547–551.

Taylor CA, Warren ML, Fitzpatrick JF, Hobbs HH Jr, Jezerinac RF, Pflieger WL, Robison HW. 1996. Conservation status of crayfishes of the United States and Canada. Fisheries 21(4):25–37.

Taylor CA. 2000. Systematic studies of the *Orconectes juvenilis* complex (Decapoda: Cambaridae), with descriptions of two new species. Journal of Crustacean Biology 20:132–152.

[USGS] United States Geological Survey. 2010. *Orconectes rusticus*. Gainesville, Florida: USGS Nonindigenous Aquatic Species Database. Available: http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=214 (March 2010).

Walker J. 2002. Invertebrate database from the Smithsonian Institute. [Source material did not give full citation for this reference.]

Wetzel JE, Poly WJ, Fetzner JW Jr. 2004. Morphological and genetic comparisons of golden crayfish, *Orconectes luteus*, and rusty crayfish, *O. rusticus*, with range corrections in Iowa and Minnesota. Journal of Crustacean Biology 24:603–617.

Wilson KA, Magnuson JJ, Lodge DM, Hill AM, Kratz TK, Perry WL, Willis TV. 2004. A long-term rusty crayfish (*Orconectes rusticus*) invasion: dispersal patterns and community change in a north temperate lake. Canadian Journal of Fisheries and Aquatic Sciences 61:2255–2266.

Wisconsin [DNR] Department of Natural Resources. 2015. Rusty crayfish throughout the Great Lakes Basins. Available: http://dnr.wi.gov/lakes/invasives/AISLists.aspx?species=RUSTY_CRAYFISH&location=GREAT_LAKES&groupBy=County#footnote (May 2012).

Wyoming Game and Fish Department. 2015. [Source material did not give full citation for this reference.]

Appendix

Summary of Future Climate Matching Analysis

Future climate projections represent two Shared Socioeconomic Pathways (SSP) developed by the Intergovernmental Panel on Climate Change (IPCC 2021): SSP5, in which emissions triple by the end of the century; and SSP3, in which emissions double by the end of the century. Future climate matches were based on source locations reported by GBIF Secretariat (2023).

Under the future climate scenarios (figure A1), on average, high climate match for *Faxonius rusticus* was projected to occur in the Appalachian Range, Great Lakes, Mid-Atlantic, Northeast, and Northern Plains regions of the contiguous United States. There were also some areas of high match on the Arizona-California border and where the Southern Plains and the southern Rocky Mountains meet. Areas of low climate match were projected to occur in the Northern Pacific Coast and Southern Florida regions. The areas of low match remained consistent across scenarios but the areas of high match were reduced in extent under more extreme scenarios. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.624 (model: UKESM1-0-LL, SSP5, 2085) to a high of 0.898 (model: MPI-ESM1-2-HR, SSP5, 2055). All future scenario Climate 6 scores were above the Establishment Concern threshold, indicating that Yes, there is establishment concern for this species under future scenarios. The Climate 6 score for the current climate match (0.915, figure 4) falls above the range of scores for future projections. The time step and climate scenario with the most change relative to current conditions was SSP5, 2085, the most extreme climate change scenario. Under most time step and climate scenarios, areas within the Southwest—specifically southwestern Arizona—saw a large increase in the climate match relative to current conditions. There were no other regions in which the climate match increased notably under future scenarios. Primarily under scenario SSP5, 2085, areas within the Mid-Atlantic, Northern Plains, Southeast, and Southern Plains saw a large decrease in the climate match relative to current conditions. Additionally, under one or more time step and climate scenarios, areas within California, the Colorado Plateau, Great Basin, Great Lakes, Gulf Coast, Northeast, Southern Atlantic Coast, Southern Plains, and Western Mountains saw a moderate decrease in the climate match relative to current conditions. Additional very small areas of large or moderate change may be visible on the maps (figure A3).

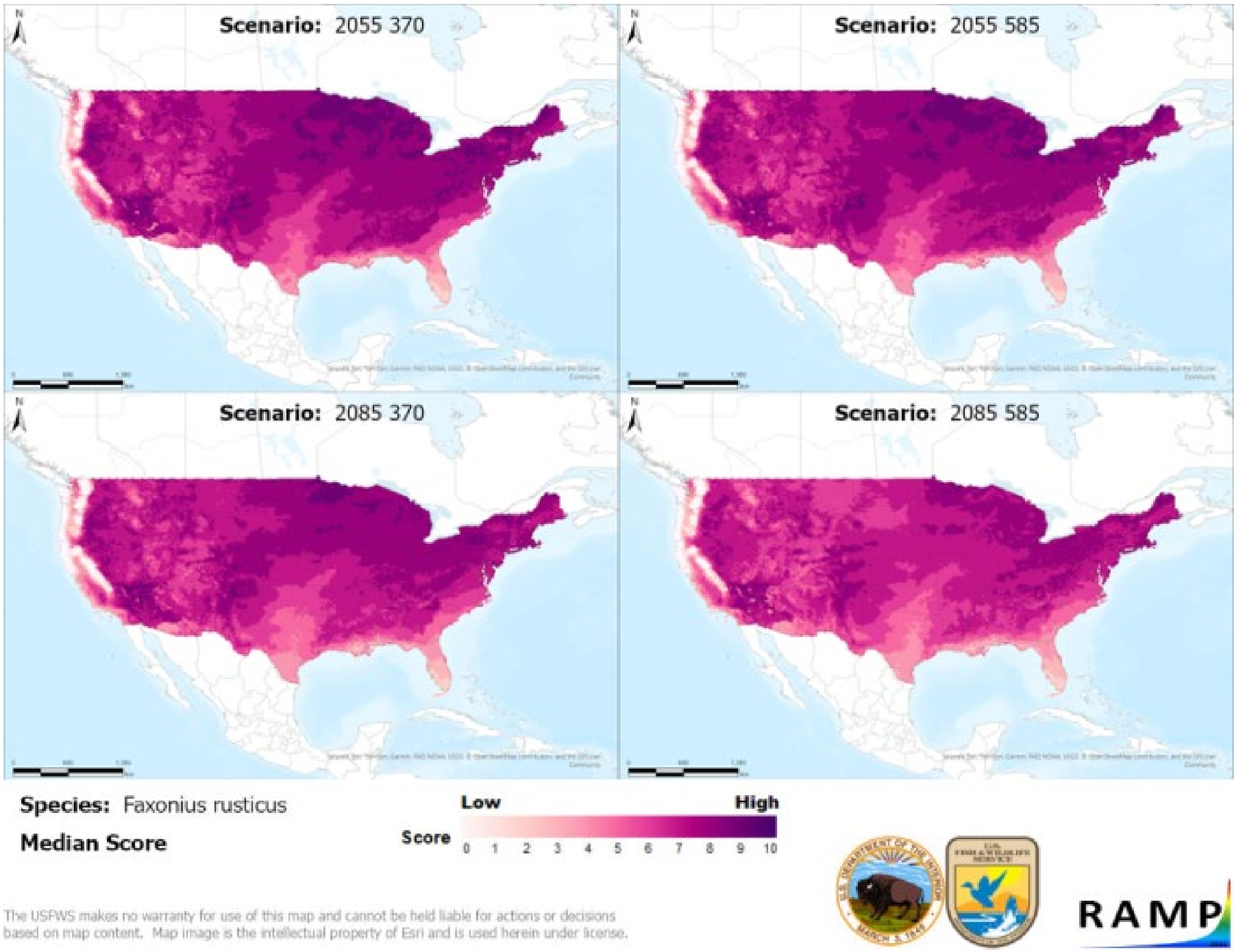

Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Faxonius rusticus* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2023). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

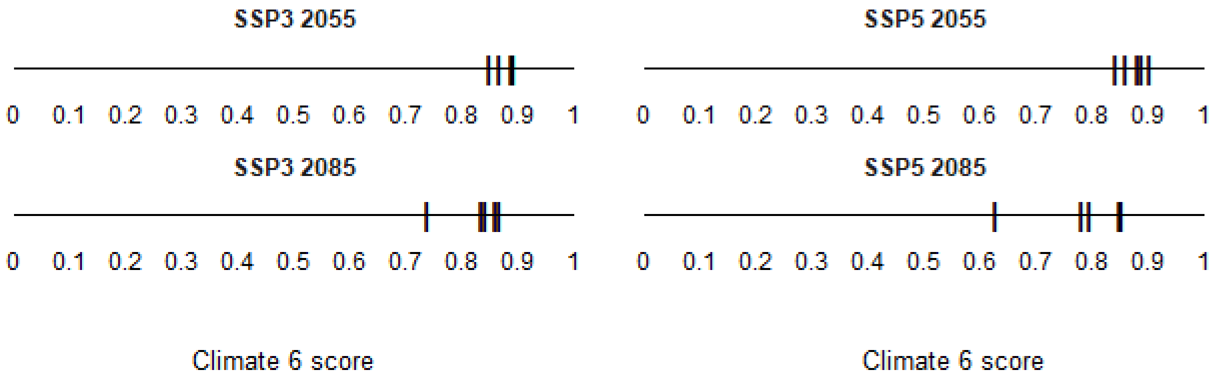

Figure A2. Comparison of projected future Climate 6 scores for *Faxonius rusticus* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0.

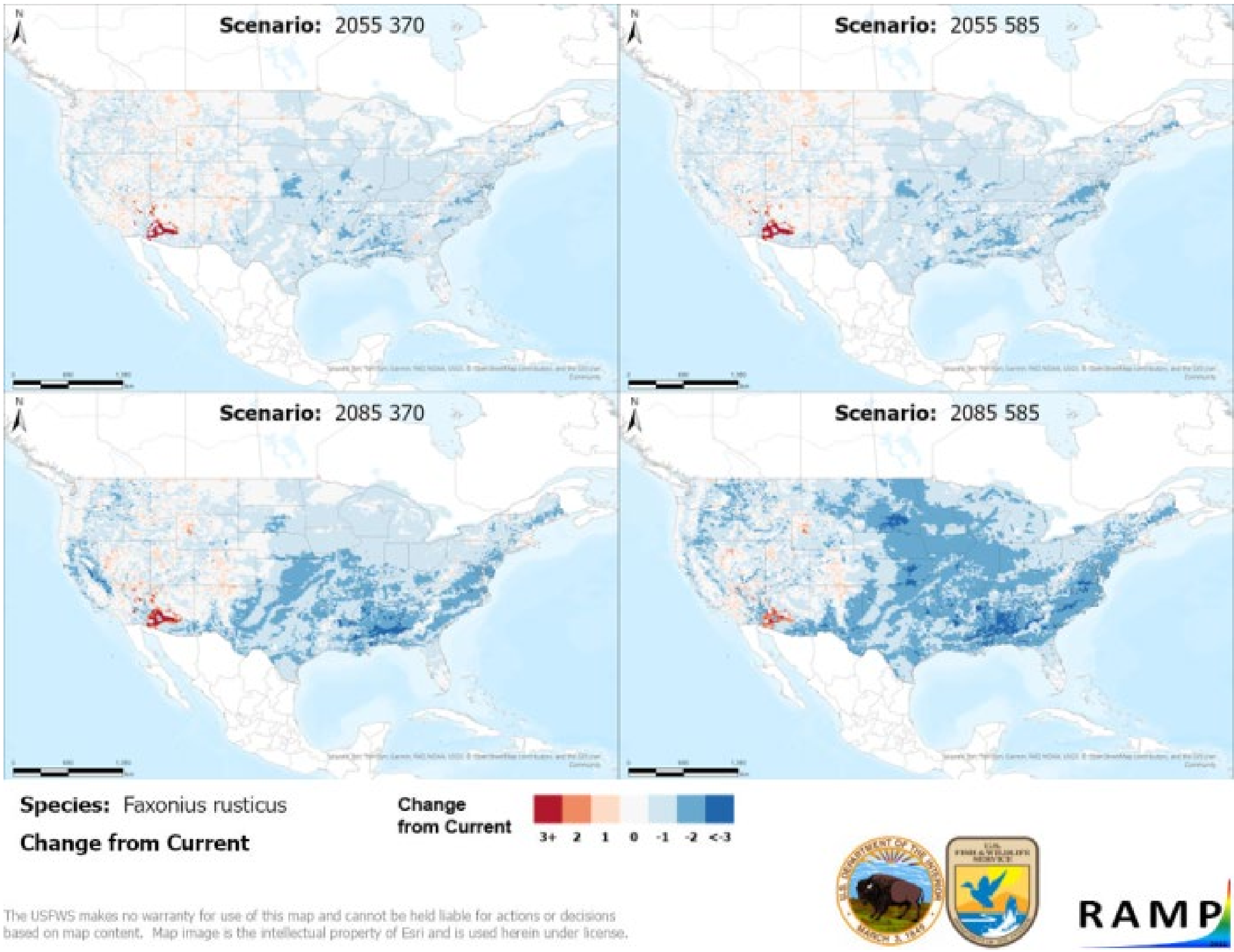

Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 4) and the median target point score for future climate scenarios (figure A1) for *Faxonius rusticus* based on source locations reported by GBIF Secretariat (2023). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. Shades of blue indicate a lower target point score under future scenarios than under current conditions. Shades of red indicate a higher target point score under future scenarios than under current conditions. Darker shades indicate greater change.

Literature Cited

GBIF Secretariat. 2023. GBIF backbone taxonomy: *Faxonius rusticus* (Girard, 1852). Copenhagen: Global Biodiversity Information Facility. Available: https://www.gbif.org/species/8979506 (December 2023).

[IPCC] Intergovernmental Panel on Climate Change. 2021. Climate change 2021: the physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Karger DN, Conrad O, Böhner J, Kawohl T, Kreft H, Soria-Auza RW, Zimmermann NE, Linder HP, Kessler M. 2018. Data from: Climatologies at high resolution for the earth's land surface areas. EnviDat. Available: https://doi.org/10.16904/envidat.228.v2.1.

Karger DN, Conrad O, Böhner J, Kawohl T, Kreft H, Soria-Auza RW, Zimmermann NE, Linder P, Kessler M. 2017. Climatologies at high resolution for the Earth land surface areas. Scientific Data 4:170122.

Sanders S, Castiglione C, Hoff M. 2023. Risk Assessment Mapping Program: RAMP. Version 5.0. U.S. Fish and Wildlife Service.