Virile Crayfish (*Faxonius virilis*)

Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, December 2023
Revised, September 2024
Web Version, 8/27/2026

Organism Type: Crustacean
Overall Risk Assessment Category: High



Photo: Alan Schmierer. Public Domain. Available: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=215 (November 2023).

1 Native Range and Status in the United States

Native Range

From Durland Donahou (2019):

"Broadly, *F. virilis* is native to the Great Lakes, Missouri River, upper Mississippi River, and lower Ohio River and up to east of the continental divide in Montana (Taylor et al. 2015), with disjunct populations in the Black River in Missouri and Arkansas, the upper White River in

Oklahoma and Arkansas, the Red River in Texas and Oklahoma, and Lake Champlain in New York (C. Taylor, pers. comm.)."

From Adams et al. (2010):

"Canada (Québec, Alberta, Saskatchewan, Ontario, Manitoba); United States (Montana, Nebraska, Michigan, Indiana, Oklahoma, Illinois, Wisconsin, Colorado, Kansas, Wyoming, Ohio, Kentucky, Iowa, New York)"

Status in the United States

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"Broadly, *F. virilis* is native to the Great Lakes, Missouri River, upper Mississippi River, and lower Ohio River and up to east of the continental divide in Montana (Taylor et al. 2015), with disjunct populations in the Black River in Missouri and Arkansas, the upper White River in Oklahoma and Arkansas, the Red River in Texas and Oklahoma, and Lake Champlain in New York (C. Taylor, pers. comm.)."

"Its native range in Arkansas and Oklahoma is uncertain, but it is known to be native in the Upper Black River, Upper Illinois River, and Upper White River drainages in northern Arkansas and eastern Oklahoma (C. Taylor, pers. comm.) and possibly drainages along the Texas-Oklahoma border (D. Johnson, pers. comm.). Its native range in Texas is uncertain; probably includes northeastern Texas in Bois D'arc-Island, Denton, East Fork Trinity, Elm Fork Trinity, Farmers-Mud, Lake Texoma, and Upper Trinity drainages (D. Johnson, pers. comm.). *Faxonius virilis* is native east of the continental divide in Montana (Crocker and Barr 1968). Its native range in southern Missouri is uncertain, but it is probably in the Upper Black River drainage (C. Taylor, pers. comm.) and in the Mississippi River drainage north of the "Bootheel" (the southeastern corner of Missouri; B. Williams, pers. comm.). Its native range in New York includes the Ausable River, Chateaugay-English, Eastern Lake Erie, Lake Champlain, Salmon, Saranac River, and St. Regis drainages (Crocker 1957; C. Taylor, pers. comm.)."

"*Faxonius virilis* is established in 24 states: Alabama (Taylor et al. 2007), Arizona (Davidson et al. 2010), California (Ruiz et al. 2000), Colorado (Clark and Lester 2005; Hobbs 1989; Martinez 2012), Connecticut (Beauchene 2011), Idaho ([Clark and Lester] 2005; Idaho Species Catalog 2016), Maine (Crocker 1979), Maryland (Schwartz et al. 1963), Massachusetts (Crocker 1979; Taylor et al. 2007), west of the continental divide in Montana (Sheldon 1989), Nevada (Johnson 1986), New Hampshire (Crocker 1979; Taylor et al. 2007), New Mexico (Taylor et al. 2007), North Carolina (Cooper and Armstrong 2007; Simmons and Fraley 2010), Ohio (Thoma and Jezerinac 2000; Taylor et al. 2015), Pennsylvania (GBIF 2016; Smithsonian Institution 2014), Rhode Island (Crocker 1979; Taylor et al. 2007), Tennessee (Hobbs 1989; Illinois Natural History Survey 2017; Taylor et al. 2007), Utah (Taba et al. 1965; Johnson 1986; Clark and Lester 2005; Larson and Olden 2011), Vermont (Guarino et al. 2012; Taylor et al. 2007; Crocker 1979), Virginia (Virginia Fish and Wildlife Information Service 2016), Washington (Larson et al. 2010), West Virginia (Loughman and Welsh 2010), and Wyoming (Johnson 1986; Hubert 1988; Larson and Olden 2011). It is likely a failed introduction (no longer present) in Mississippi

due to no recent collections (S. Adams, pers. comm.). Its status is unknown in New Jersey (Hobbs 1989; Taylor et al. 2007), as the only reported introduction was from Hobbs (1989)."

Faxonius virilis is in trade within the United States (e.g., Toledo Goldfish 2023; Wholesale Koi Farm 2023).

Regulations

Faxonius virilis is regulated in Alaska (ADF&G 2023), Colorado (CPW 2023), Maryland (Code of Maryland Regulations 2022), and North Carolina (North Carolina DEQ 2022). It is regulated as part of the family Cambaridae in Arizona (Arizona Game and Fish Commission 2022), California (CDFW 2021), Nevada (Nevada Board of Wildlife Commissioners 2022), New Mexico (NMDGF 2023), Oregon (ODFW 2022), Utah (Utah DWR 2020), and Washington (Revised Code of Washington 2022). All species of crayfish are regulated in Pennsylvania (PFBC 2022) and Minnesota (Minnesota DNR 2022), and species not indigenous to New Hampshire (NHFG 2022), Rhode Island (Rhode Island DEM 2022), and Wisconsin (Wisconsin DNR 2022) are regulated in those respective States. 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 Ellis (2012):

"Many translocations within the USA and Canada have been attributed to anglers using the species as bait"

From Durland Donahou (2019):

"Probable introduction methods include bait bucket introduction (Larson and Olden 2011; Kilian et al. 2012) and intentional stocking for forage (Larson and Olden 2011). It has been stocked as forage in Montana by Montana Fish, Wildlife and Parks (Sheldon 1989) and in Utah (Johnson 1986) in several locations. Welsh and Loughman (2015) have shown that the *Faxonius virilis* is capable of using fish-specific dam passages to move upstream in areas in which they are introduced."

Remarks

This ERSS was previously published in June 2015 under the scientific name *Orconectes virilis*. Revisions were completed to incorporate new information and conform to updated standards. The previous scientific name, *Orconectes virilis*, is still commonly used throughout databases and publications and was used in searching for information on this species.

According to NatureServe (2023), *Faxonius virilis* is considered vulnerable within North Dakota.

From Ellis (2012):

“In some areas within the USA where historic data is not present there appears to be differing opinions of the native/introduced status of virile crayfish. The native range of the species covers a large part of North America, east of the continental divide (Larson and Olden, 2011).”

Faxonius virilis has been intentionally stocked outside its native range within the United States by State fishery managers to achieve fishery management objectives. State fish and wildlife management agencies are responsible for balancing multiple fish and wildlife management objectives. The potential for a species to become invasive is now one important consideration when balancing multiple management objectives and advancing sound, science-based management of fish and wildlife and their habitat in the public interest.

Mention of commercial products in this Ecological Risk Screening Summary does not entail endorsement by the U.S. Federal Government.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

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

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 virilis* (Hagen, 1870)

Size, Weight, and Age Range

From GISD (2023):

“The maximum lifespan of *Orconectes virilis* is 3 years. They undergo several molts in their first few months. *O. virilis* typically reaches a length of 23-56 mm in first year and a length of 58-84

mm by the second. They reach maturity during their second summer usually around 24mm. (ANSIS, 2007)."

From Ellis (2012):

"Within their introduced range in England, mean total length of *F. virilis* in established populations is 88mm (44mm carapace length), although in the build up phase of the population individuals were found up to 135mm total length (67mm carapace length (CL)). Within the northern part of their native range maximum carapace length (CL) is around 55mm (Weagle and Ozburn, 1972), however they have been reported up to 69mm CL in more southerly regions (Hazlett and Rittschof, 1985; Page, 1985)."

"Yearling males in a lentic environment in Michigan have a mean CL of 31.2mm and age 2 males have a mean CL of 36.5mm. Yearling females are 29.5mm (CL) and age 2 females 36.4mm (CL). However, variation in growth rate during the first growing season can be significant. Yearling males collected in May ranged from 16-25mm, females from 14-24mm. By August, males ranged from 24-33mm, females from 20-30mm (Momot, 1967). Another study in Michigan, this time with a lotic population extrapolated known growth in larger crayfish to estimate size/year classes for the population as: 0 (6-20mm), 1 (20-40mm), 2 (40-62mm), 3 (62-69mm) (Hazlett and Rittschof, 1985)."

Environment

From Durland Donahou (2019):

"*Faxonius virilis* is found in streams with moderate flow and turbidity, abundant cover, muddy, sandy, or rocky substrate and stable water levels (Crocker and Barr 1968; Maude and Williams 1983; Z. Barnett, pers. comm.). This species is inhibited by high velocity flow (Maude and Williams 1983)."

From GISD (2023):

"*Orconectes virilis* may inhabit rivers, streams, lakes, marshes and ponds that are permanent and well oxygenated (Collicut, 1998). They prefer warm waters of moderate turbidity with cobble or rocky substrates and abundant logs, rocks, vegetation, and other debris to use as cover. They are also known to dig pits in river banks and under rocks when water levels are low (ANSIS, 2007; Benson, 2010). *O. virilis* can survive a temperature range of 0-32°C and has a preferred temperature range of 24-25°C. Its movement is halted at temperatures below 10°C. It is unable to withstand acidic conditions and prefer locations with a pH of over 5.37. *O. virilis* is also untolerant of poor water quality and high salinity (ANSIS, 2007)."

From Ellis (2012):

"Water tolerances: Dissolved oxygen 5-9mg/L, Hardness 2.7-70 mg/L CaCO3, pH 6.5-9, water temperature 0°C -26 °C"

“France (1984) suggested that an average annual pH below pH5.5 could result in eventual population extinction in lentic systems. Newly hatched crayfish and juveniles are more susceptible to low pH than adults, possibly because of the higher number of moults in juveniles (France, 1984). In a 10 week study 25% of *F. virilis* died at pH5, 70% at pH4 and 95% at pH3 (Siewert and Buck, 1991).”

Climate

From Palomares and Pauly (2023):

“Temperate”

From Ellis (2012):

"Latitude 54 N 28 S"

“Air Temperature: 0°C -26 °C”

Distribution Outside the United States

Native

A portion of the species’ native range is within the United States, see section 1 for full description.

From Adams et al. (2010):

“Canada (Québec, Alberta, Saskatchewan, Ontario, Manitoba)”

Introduced

From Ellis (2012):

“In Europe, *F. virilis* is only known to be present in the Netherlands and the UK. […] In the UK, a population of the species was detected in the River Lee system of North London in 2004. The extent of its impacts and establishment remain unknown (Ahern et al., 2008).”

“It was deliberately introduced into France in 1897 and Sweden in 1960 but both attempts were unsuccessful.”

From GISD (2023):

“*Orconectes virilis* was first collected from the Saint John River at Couturier Siding, Madawaska of northwestern New Brunswick [Canada] in 1998. Further inspectio [sic] revealed *O. virilis* was established along 62 km of the Saint John and Saint Francois Rivers (McAlpine et al, [1999]). *O. virilis* was discovered also established along the Black River in Kent County. Further expansion is anticipated (McAlpine et al, 2007).”

Means of Introduction Outside the United States

From Ellis (2012):

"It is believed to have been introduced to the Netherlands via the aquarium trade and has only recently become established and widespread (Soes, 2007; Ahern et al., 2008)."

"The range extension of *F. virilis* across […] Canada appears to be largely linked to anglers using the species as fishing bait, and consequently moving crayfish between catchments and even states."

"Within Europe it is thought introductions are linked to accidental or deliberately released aquarium specimens."

Short Description

From Ellis (2012):

"Rostrum: Smooth, borders more or less parallel until shoulder region; acumen prominent, shoulders with prominent spine; median carina absent."

"Body: Carapace smooth, one pair of post-orbital ridges; areola very narrow; row of tubercles on shoulders behind cervical groove, one with prominent spine; hepatic spines absent; areola narrow. Females with annulus ventralis located between bases of posterior walking legs, cornified in sexually mature individuals. Hooks on each side of the second abdominal segment absent. Colour typically chestnut or chocolate, posterior end of carapace with a bowl shaped or wine glass shaped light brown pattern, which is not usually as clear as in *Faxonius immunis*. Abdomen without longitudinal or transverse bands."

"Appendages: Chelae broad, flattened, tuberculate: moveable finger with straight margin; prominent yellow tubercles typically arranged in two rows along the inferior margin of the propodus and dactylus; tips of the fingers yellow in colour, cutting edges with yellow teeth; upper surface same colour as body, under-side dirty white in colour. Prominent spur on inferior margin of cheliped carpus. Form I males have larger chelipeds than form II and have a distinct grasping hook on the ischium of the second pair of walking legs that are used during mating; form I gonopods become hardened."

Biology

From Durland Donahou (2019):

"Mating occurs during two periods: August to October and April to May, and eggs are laid in spring (Crocker and Barr 1968). Pflieger (1996) observed larger males than females in Missouri, while Z. Barnett (pers. comm.) reported no size difference in Alabama."

"*Faxonius virilis* does not burrow but may tunnel (Pflieger 1996)."

From Ellis (2012):

"*F. virilis* inhabit shallow river systems in their northern most range in Ontario, Canada. These rivers freeze in winter but *F. virilis* do not appear to have any physiological adaptation to allow them to survive freezing (Aiken, 1967). Nor are they thought to burrow to escape freezing temperatures but instead this species tends to hide in crevices under or between rocks, which may become silted over. Furthermore, both males and females move into deeper areas of the river as temperatures drop. Distribution of young of the year (YOY) and yearlings, however, appeared random, utilising both deep and shallow areas (Aiken, 1967)."

"*F. virilis* has been shown to actively graze on aquatic plants, with a preference for small, short bottom dwelling plants such as *Chara* and *Lemna* (Chambers et al., 1991; Dorn and Wojdak, 2004). It has been suggested that males may graze more heavily on some species of aquatic plants than females (Chambers et al., 1990b)."

"*F. virilis* was found to feed on Lake Trout eggs in Canada, the effect was more pronounced with larger substrate (Savino and Miller, 1991). A further study to see if crayfish could be used as a biological control for the invasive zebra mussel (*Dreissena polymorpha*) found that *F. virilis* would predate on zebra mussels, although trout eggs were preferred if available (Love and Savino, 1993). It was concluded that *F. virilis* preferred prey that provided the greater net benefit."

"Macro-invertebrates can play a significant part in the diet of *F. virilis*, a study in Canada found abundance of snails was greatly reduced in the presence of *F. virilis* (Hanson et al., 1990), the same study found the crayfish would show preference for macro-invertebrate food even when plant material was present. Within the River Lee (UK) the diet of *F. virilis* was found to consist of Molluscs and Crustaceans (*Pisidium* sp. (14%) and *Gammarus Pulex* (14%)) with detritus making up approximately 25% of their diet. Initial finding suggest *F. virilis* may have a lower degree of diet flexibility than the co-existing *P. leniusculus* (Jackson et al., Unpublished)."

Human Uses

From GISD (2023):

"Orconectes virilis is a popularly consumed food in the United States and increasingly more so in Europe (Collicut, undated). *O. virilis* a [sic] commonly used fish bait and is sold as such in bait shops. It is also sold commercially in the pet trade as pets or prey for predaceous aquarium fishes (Hunner, 1997). Beginning in approximately 1950 *O,* [sic] *virilis* was stocked as a biological control in the Colorado River watershed of western New Mexico and northeastern Arizona, primarily for vegetation control (Johnson, 1986)."

Diseases

***Faxonius virilis* has been documented as a carrier of *Aphanomyces astaci* (causative agent of crayfish plague) and white spot disease, diseases listed by the World Organisation for Animal Health (2023).**

From Velez-Gavilan (2024):

“It is a vector to the crayfish plague (*Aphanomyces astaci*), a protist which is lethal to European crayfish species.”

From Davidson et al. (2010):

“We explored bacteria, nematodes, and a virus as potential biological control agents for *O. virilis* while avoiding harm to native species. White Spot Syndrome Virus (WSSV) from shrimp was found to be highly pathogenic and readily passed by cannibalistic behavior but not by water transmission.”

According to Poelen et al. (2014), *Faxonius virilis* is known to carry *Paragonimus kellicotti*, (North American lung fluke).

Threat to Humans

From Dubey (2023):

“Infections with the lung fluke, *Paragonimus kellicotti*, have been diagnosed in a variety of domestic and wild animals and humans in USA and Canada. Although there are many species of *Paragonimus* in other parts of the world; *P. kellicotti* is the only species definitively diagnosed in USA and Canada. Fresh water snails (several species) and crayfish (mainly *Orconectes* spp.) are its intermediate hosts. Humans and animals become infected with *P. kellicotti* only by ingesting metacercariae encysted in the heart of crayfish.”

According to Poelen et al. (2014), *Faxonius virilis* is known to carry *Paragonimus kellicotti*, (North American lung fluke).

3 Impacts of Introductions

From Durland Donahou (2019):

“This species [*Faxonius virilis*] is known to eat juvenile reptiles and amphibians, fish eggs, and macroinvertebrates (Recsetar and Bonar 2015). In the Netherlands, water bodies that have been invaded by *F. virilis* have shown decreases in water quality and macrophyte (plant) biomass (Roessink et al. 2017). *Faxonius virilis* is the most abundant and widespread non-native crayfish in Maryland, and is associated with the decline of native spinycheek crayfish (*F. limosus*) and Allegheny crayfish (*F. obscurus*). Both native species are now extirpated from many watersheds where *F. virilis* is currently abundant (MDNR 2016).”

From GISD (2023):

“*O. virilis* is known to alter and reduce macrophyte biomass and diversity (Chambers et al, 1990; Davidson et al, 2010; Olden et al, 2009). It may displace native crayfish as in the case of the endangered *Pacifastacus nigrescens* in California (Light et al, 1995); *Orconectes obscurus* and *Cambarus bartonii* in North Carolina (Cooper et al, 1998); and *Orconectes limosus* and

Cambarus bartonii bartonii in Maryland (USA) (Schwartz et al, 1963). Field and laboratoy [sic] observations indicate that is may compete with and/or cause the decline of native fish species such as juvenile desert suckers (*Catostomus clarkii*), the Sonora sucker (*Catostomus insignis*), and the federally threatened Little Colorado spinedace (*Lepidomeda vittata*) in Arizona (Davidson et al, 2010; Bryan et al, 2002); the flannelmouth sucker (*Catostomus latipinnis*) in Colorado (Carpenter, 2005); and the White Sands pupfish (*Cyprinodon tularosa*) in New Mexico (Rogowski & Stockwell, 2006). It has been reported to contribute to the decline of the Chiricahua leopard frog (*Rana chiricahuensis*) in Arizona (Davidson et al, 2010). *O. virilis* is also known to cause the decline of native snails (ANSIS, 2007), as in the case of three forks spring snail (*Pyrgulopsis trivialis*) in Arizona (Davidson et al, 2010) and Canadian native snails *Stagnicola elodes* and *Physa gyrina* in laboratory studies (Hanson et al, 1990)."

From Martinez (2012):

"No crayfish species are native to the Colorado River Basin (CRB), including the portion of the state of Colorado west of the Continental Divide. Virile crayfish [*Orconectes virilis* (Hagen, 1870)], a recent invader in the middle Yampa River in northwestern Colorado, displayed an abrupt increase in abundance in the early 2000s, which coincided with a drought, a severe decline in the abundance of small-bodied and juvenile native fishes, and a dramatic increase in the abundance of nonnative smallmouth bass [*Micropterus dolomieu* (Lacepède, 1802)]. The annual density of virile crayfish was 6.4/m2 in 2005 and 9.3/m2 in 2006. The annual biomass density of virile crayfish was 9.0g/m2 in 2005 and 15.8 g/m2 in 2006, representing a riverwide biomass of 122 kg/ha, which equaled that of other macroinvertebrates and fish combined (120.7 kg/ha). Efforts to recover and preserve native fishes in the Upper Colorado River Basin (UCRB), particularly in the Yampa River, have been hampered by nonnative predatory fishes, but the implications of crayfish may have been overlooked and underestimated. Stream conditions during the drought apparently facilitated proliferation by virile crayfish in the middle Yampa River, likely contributing to hyperpredation on native fishes by invasive smallmouth bass."

From Carpenter (2000):

"The virile crayfish (*Orconectes virilis*), an aggressive polytrophic species, has been introduced into many Arizona streams. […] In Sabino Creek, I manipulated crayfish densities in isolated pools to examine effects of crayfish on growth, mortality, and recruitment of Gila chub (*Gila intermedia*). Regardless of crayfish density, Gila chub declined slightly in weight and condition. Mortality and recruitment did not differ between densities of crayfish. I examined crayfish effects on benthic macroinvertebrates, a submerged aquatic macrophyte and associated invertebrates, and three fish species in a small stream in the White Mountains by fencing eight stream sections to prevent movement. The three fishes were speckled dace (*Rhinichthys osculus*), Sonora sucker (*Catostomus insignis*), and desert sucker (*C. clarki*). Molluscs > 10 mm and macrophytes were less abundant at sites with a high density of crayfish than at sites with low crayfish densities. Insect diversity was lower in high- vs. low-density sites. No treatment effect was observed on growth or condition of individually marked fish. Short-term laboratory experiments demonstrated predatory interactions and competition for shelter between crayfish and Gila chub, desert sucker, and speckled dace. Crayfish used shelter more than fish, displaced fish from shelter, and frequently attacked fish. Fish never attacked crayfish, and only once

displaced crayfish from shelter. In predation experiments, crayfish preyed upon all species, but preyed most heavily upon desert suckers. Fish never altered use of the water column in the presence of crayfish. Density manipulation experiments in a laboratory measured food competition between crayfish and two native fishes. Growth of Gila chub was less affected by crayfish than by increased density of Gila chub. Thus crayfish are not strong competitors with Gila chub for food. However, growth of flannelmouth sucker (*Catostomus latipinnis*) was negatively impacted by presence of crayfish. These laboratory experiments provide evidence that introduced crayfish can reduce fish growth by competition for food, and that native fishes are vulnerable to crayfish predation."

The following States regulate possession of *Faxonius limosus*, the family Cambaridae, which includes *F. limosus*, or crayfish more generally: Alaska (ADF&G 2023), Arizona (Arizona Game and Fish Commission 2022), California (CDFW 2021), Colorado (CPW 2023), Maryland (Code of Maryland Regulations 2022), Minnesota (Minnesota DNR 2022), Nevada (Nevada Board of Wildlife Commissioners 2022), New Hampshire (NHFG 2022), New Mexico (NMDGF 2023), North Carolina (North Carolina DEQ 2022), Oregon (ODFW 2022), Pennsylvania (PFBC 2022), Rhode Island (Rhode Island DEM 2022), Utah (Utah DWR 2020), Washington (Revised Code of Washington 2022), and Wisconsin (Wisconsin DNR 2022). See section 1.

4 History of Invasiveness

Faxonius virilis is has been introduced and become established in Europe and outside its native range in the United States and Canada. Non-native establishment of *F. virilis* has been reported to negatively impact native species and habitats through competition, predation, and by altering habitat structure and quality. The History of Invasiveness for *Faxonius virilis* is classified as High.

5 Global Distribution

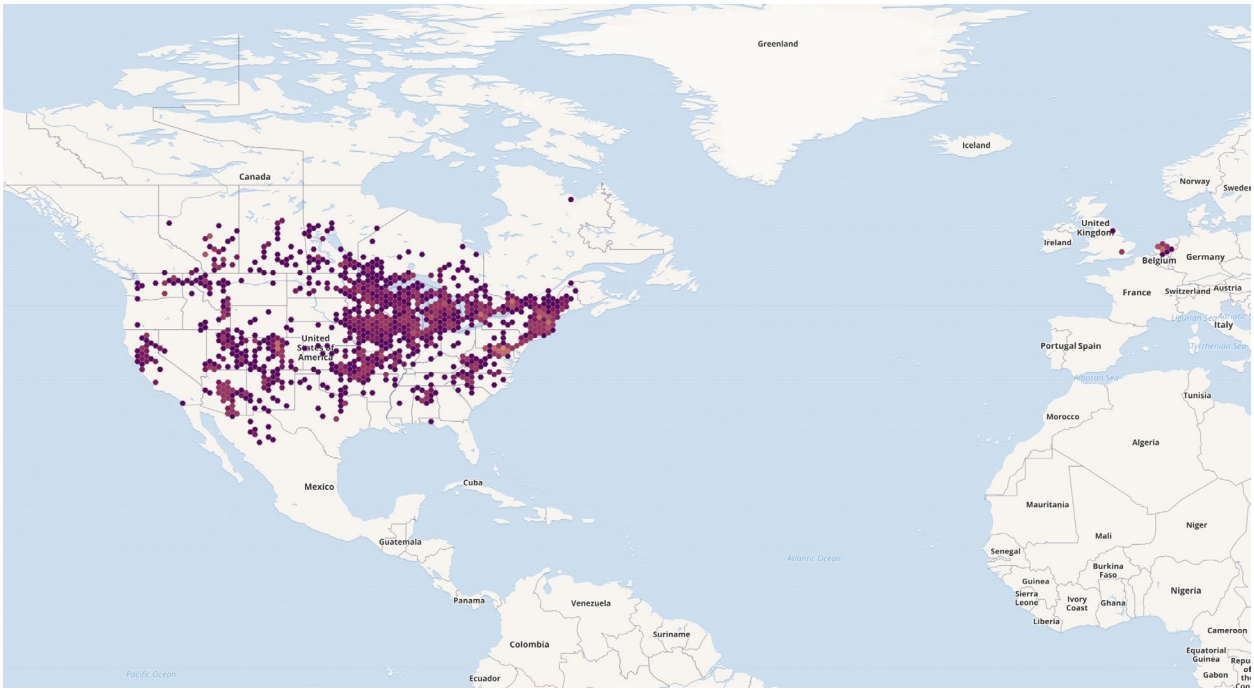


Figure 1. Reported global distribution of *Faxonius virilis*. Map from GBIF Secretariat (2023). Observations are reported from the United States, Canada, Mexico, the United Kingdom, and the Netherlands. The northernmost observation in the United Kingdom is of a cooked specimen and does not represent a wild population. A singular point in northcentral China was not included due to incorrectly recorded coordinates. Additionally, the point in northern Quebec was also excluded from climate matching analysis as it was not found to represent an established population.

6 Distribution Within the United States

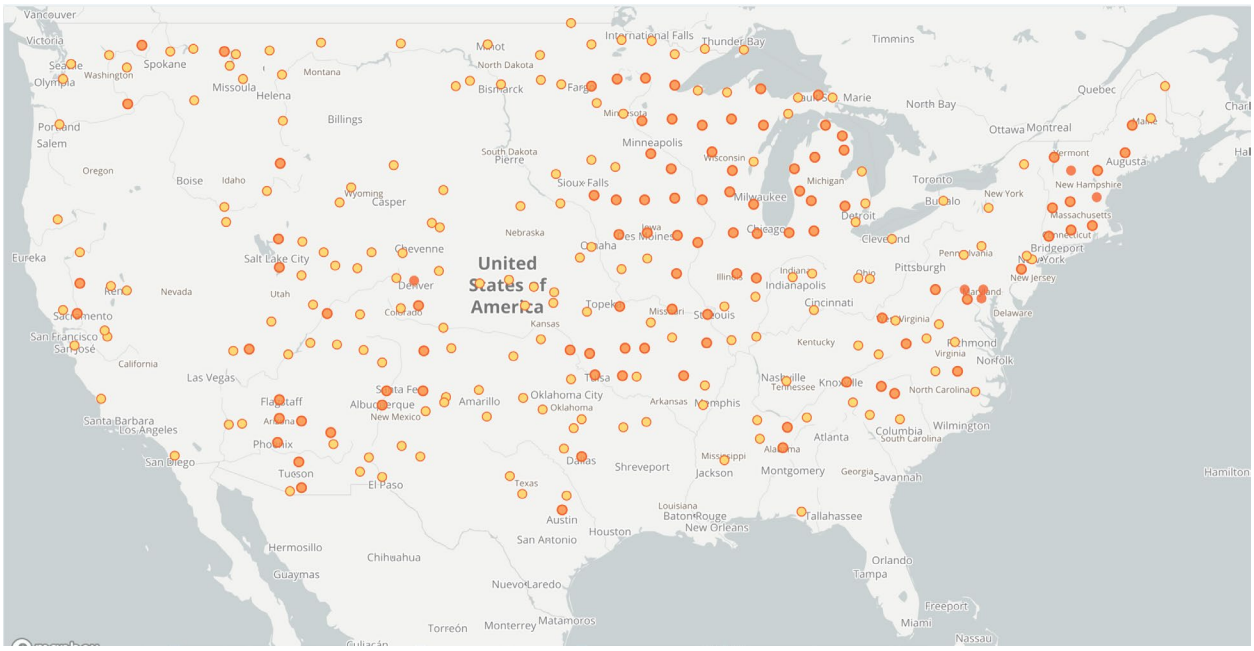


Figure 2. Reported distribution of *Faxonius virilis* in the United States. Map from GBIF-US (2023). Observations are reported from every state in the contiguous United States, other than Louisiana and Georgia. The single point in Florida is a material sample and does not represent an established population; it was not used in the climate matching analysis.

7 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Faxonius virilis* in the contiguous United States was generally high except for in southern Florida and in the Pacific Northwest. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.990, 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 ≥ 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 virilis* (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.

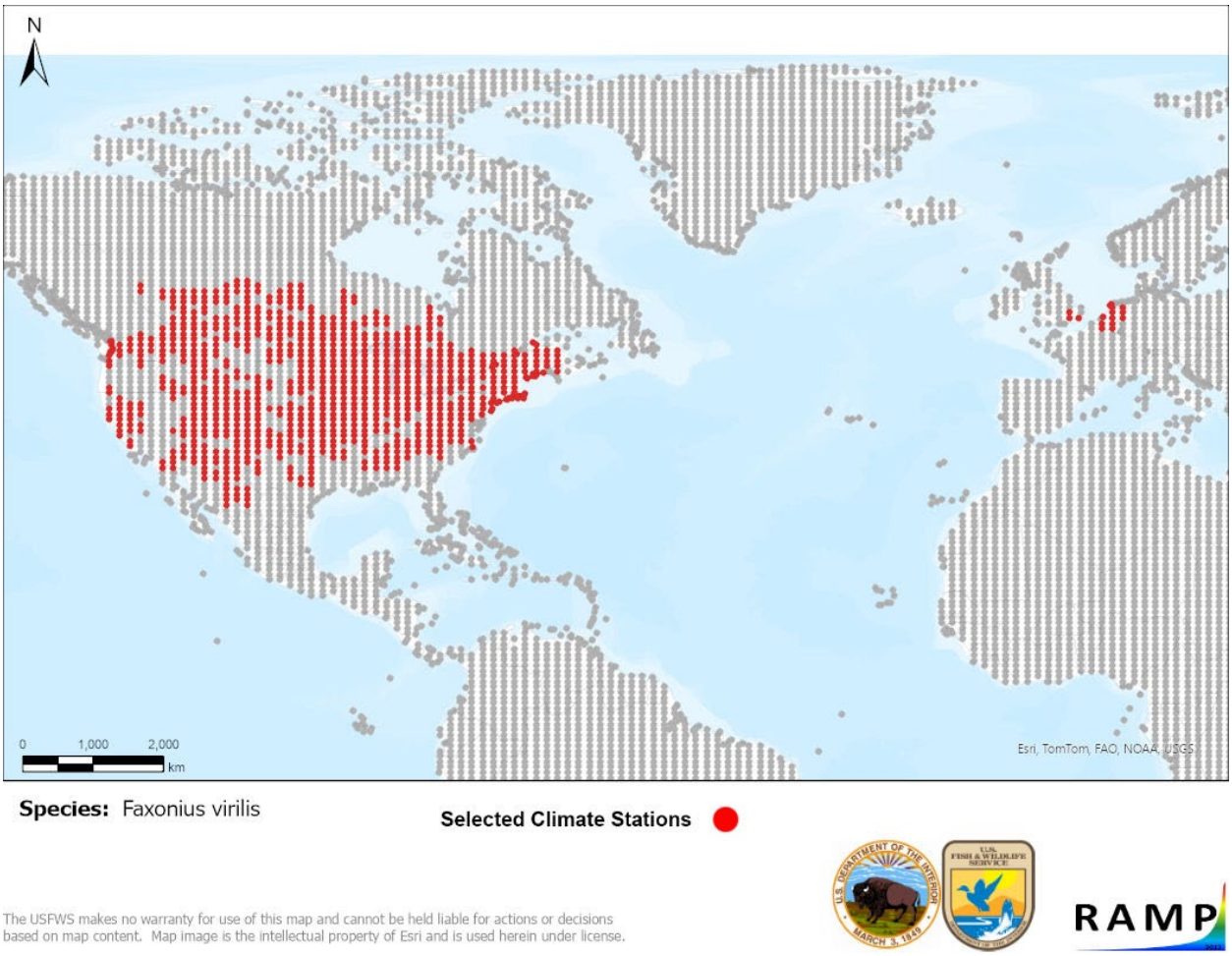


Figure 3. RAMP (Sanders et al. 2023) source map showing weather stations in North America and Europe selected as source locations (red; Canada, United States, Mexico, United Kingdom, the Netherlands) and non-source locations (gray) for *Faxonius virilis* climate matching. Source locations from GBIF Secretariat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

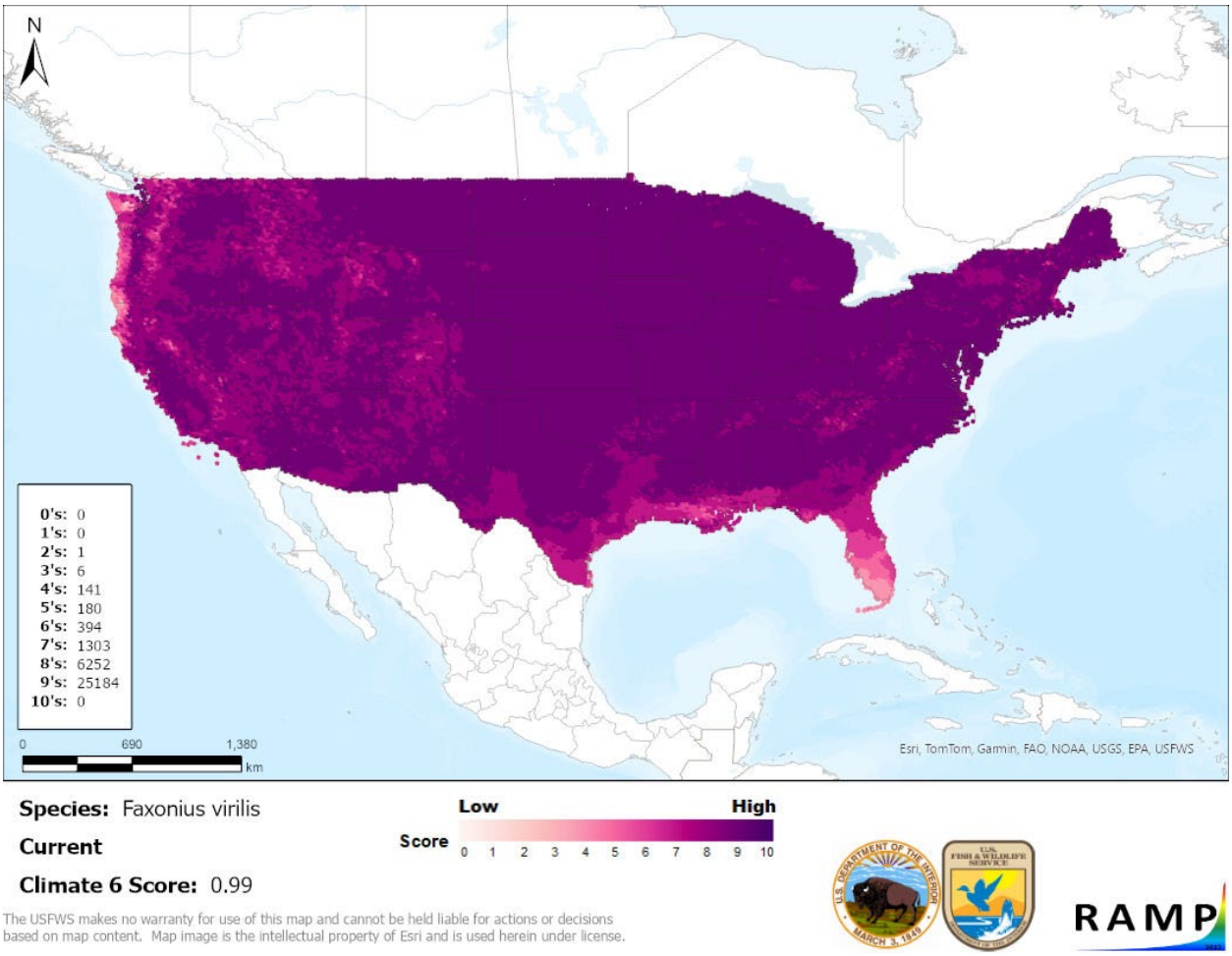


Figure 4. Map of RAMP (Sanders et al. 2023) climate matches for *Faxonius virilis* in the contiguous United States based on source locations reported by GBIF Secretariat (2023). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

The Certainty of Assessment for *F. virilis* is classified as High. Information on the biology, ecology, and distribution of the species was available, including records of introduction and establishment. There are numerous peer reviewed papers discussing the negative impacts that have been observed following establishment of *F. virilis*.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Faxonius virilis, the virile crayfish, is a crustacean that is native to the northern United States and portions of Canada that has been introduced to other parts of the contiguous United States, Canada, and Europe. *F. virilis* is omnivorous, preferring to consume smaller benthic macrophytes. Introduced populations have been associated with decreased macrophyte biomass and reduced water quality, as well as diminished mollusk populations. *F. virilis* is a popular live

food and present in the aquarium trade. It is believed that introductions in Europe are due to aquarium releases while in the United States, introductions are typically attributed to bait bucket releases. Many States prohibit use and/or possession of the species. *F. virilis* is a known carrier of *Paragonimus kellicotti*, a parasite which can be spread to humans through consumption of raw crayfish, in addition to crayfish plague and white spot disease, both listed by the World Organisation for Animal Health. The History of Invasiveness for *F. virilis* is classified as High due to extensive establishment outside of its native range and the well documented negative impacts on native species and habitats. The climate matching analysis for the contiguous United States indicates establishment concern for this species outside its native range, with high matches throughout the contiguous United States except for the coastal Pacific Northwest and the Florida Peninsula. The Certainty of Assessment for this ERSS is classified as High. The Overall Risk Assessment Category for *Faxonius virilis* 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: Documented as a carrier of *Aphanomyces astaci* (crayfish plague) and white spot disease, diseases listed by the World Organisation of Animal Health (2023). Carrier for *Paragonimus kellicotti*, a lung fluke.**
- **Overall Risk Assessment Category: High**

10 Literature Cited

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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 virilis* was projected to occur in nearly all regions of the contiguous United States. Under most scenarios, there was low match in Southern Florida. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.912 (model: UKESM1-0-LL, SSP5, 2085) to a high of 0.988 (model: GFDL-ESM4, SSP3, 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 (0.990, 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 all time step and climate scenarios only minor or no increases in the climate match relative to the current match were observed. Primarily under time step 2085 for both SSP3 and SSP5, areas within California, the Gulf Coast, and Southeast saw a large decrease in the climate match relative to current conditions. Under one or more time step and climate scenarios, areas within the Appalachian Range, Colorado Plateau, Great Basin, Mid-Atlantic, Northeast, Northern Pacific Coast, Northern Plains, Southern Atlantic Coast, Southern Plains, Southwest, 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).

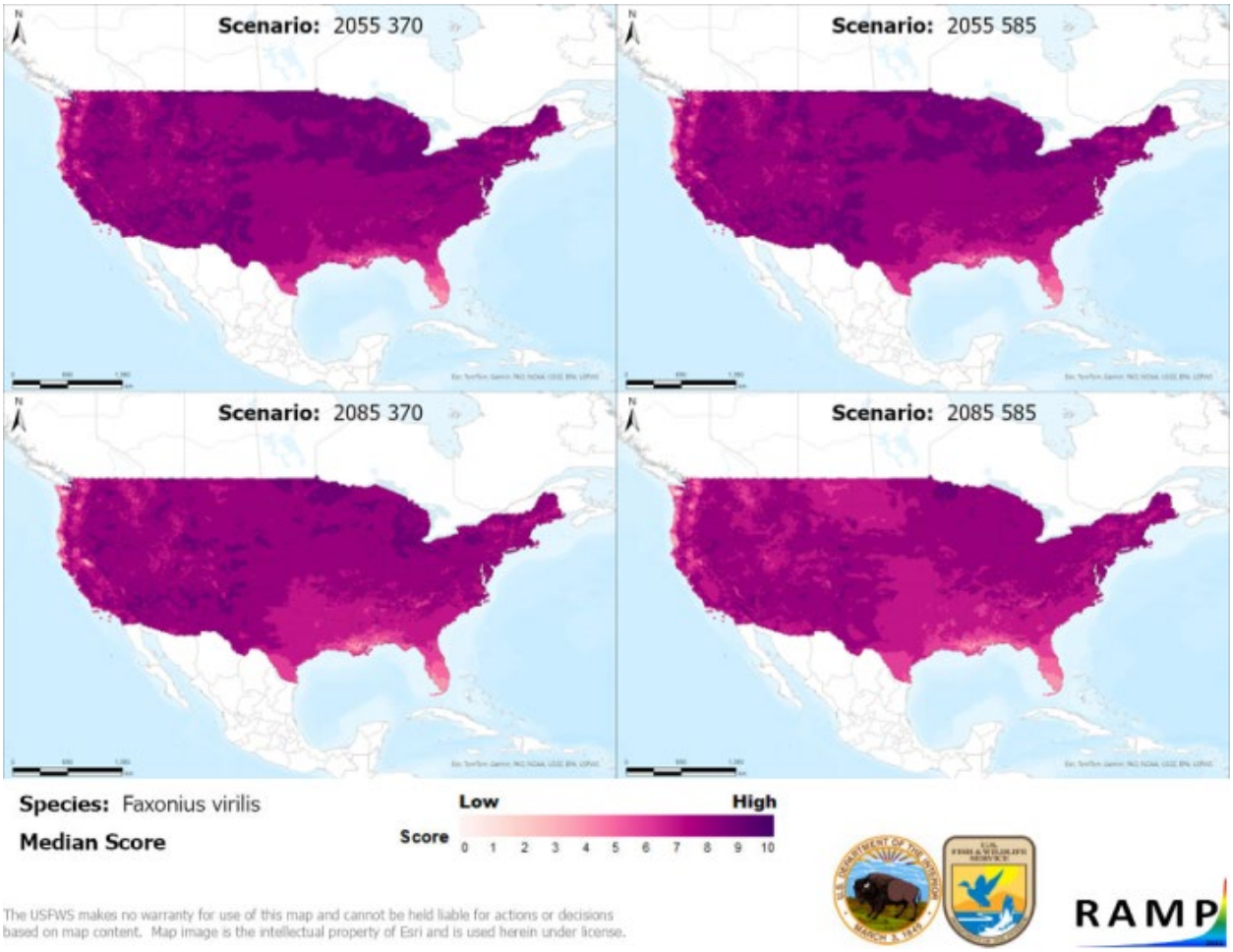


Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Faxonius virilis* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2023). Shared Socioeconomic 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.

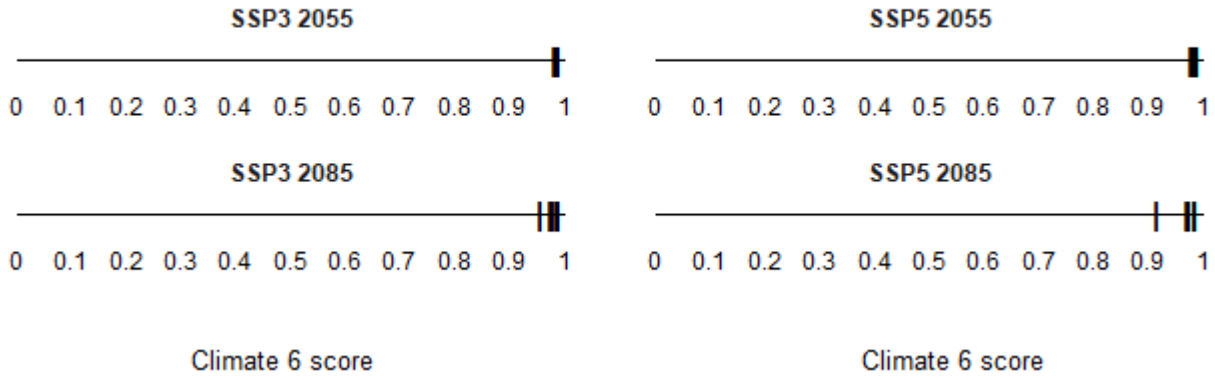


Figure A2. Comparison of projected future Climate 6 scores for *Faxonius virilis* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; IPCC 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.

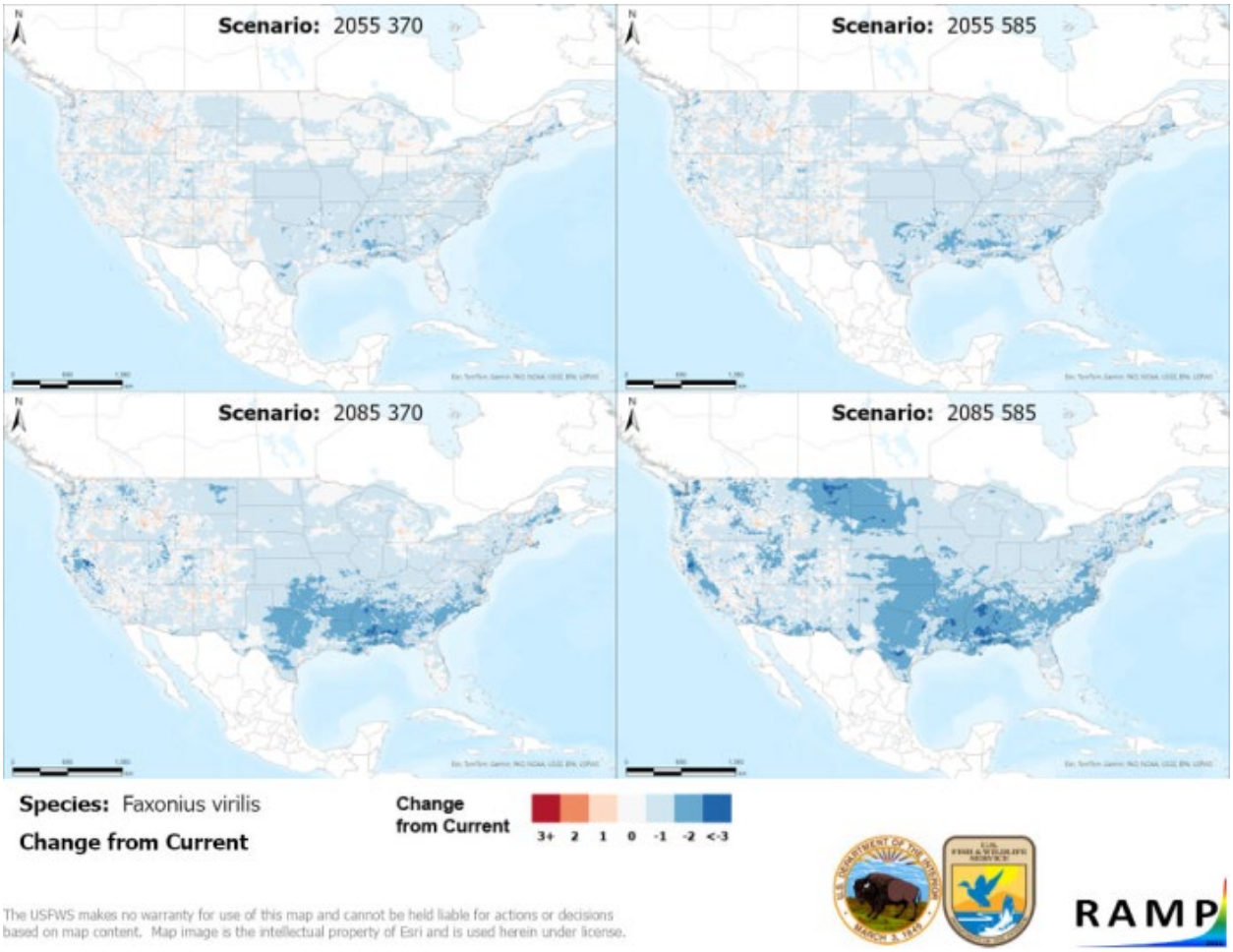


Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 4) and the median target point score for future climate scenarios (figure A1) for *Faxonius virilis* based on source locations reported by GBIF 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.

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