



## **Aquatic Invasive Species (AIS) Control Plan: Red Swamp Crayfish and White River Crayfish**

This control plan is a living document and will be updated, as needed, to reflect the status of the species within Pennsylvania.

### **Natural History**

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**Description:** Red Swamp Crayfish (*Procambarus clarkii*) are medium to large crayfish (up to 12 cm total length) usually typified by a dark red (“boiled lobster”) coloration in adults.

White River Crayfish (*Procambarus acutus*) are medium to large crayfish (up to 13 cm total length) with variable coloration and typically possess a black stripe on the dorsal portion of the abdomen.

### **Taxonomy**

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Common name: **Red Swamp Crayfish**  
Family: **Cambaridae**  
Species: *Procambarus clarkii*  
Integrated Taxonomic Information System (ITIS) Serial Number **97491**

Common name: **White River Crayfish**  
Family: **Cambaridae**  
Species: *Procambarus acutus*  
ITIS Serial Number: **650438**

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**Morphology:** Adult Red Swamp Crayfish are typically dark red in coloration with elongate claws and an absent or substantially reduced areola (this is helpful for distinguishing this species from other members of the genus *Procambarus*).

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Adult White River crayfish possess elongate chelae that close completely, and a narrow but present areola (Durland Donahou 2021). Coloration is variable, but adults typically are tan to light red with a black stripe on the dorsal portion of the abdomen (Durland Donahou 2021). Examination of the gonopods of Form I (reproductively active) males is necessary to distinguish this species from its congener *Procambarus zonangulus* (Southern White River Crayfish), which usually requires specific taxonomic training.

For both species, confirmation of identification typically may require the use of taxonomic keys and consultation with taxonomic experts. Juveniles of both species are variable in coloration and typically difficult to distinguish from other *Procambarus* species (Durland Donahou 2021; Nagy et al. 2021).



**Figure 1.** Red Swamp Crayfish. Source: Missouri Department of Conservation.



**Figure 2.** White River Crayfish. Source: Tennessee Wildlife Resources Agency.

Origin: Red Swamp Crayfish are native to portions of the southern United States in the Gulf Coastal Plain drainages and lower Mississippi River Basin and Northeastern Mexico (Fig. 3; Gerhardi 2006; Nagy et al. 2021). White River Crayfish are native to portions of the southern and eastern United States within much of the Mississippi River basin, Great Lakes Basin, and Atlantic Slope drainages (Fig. 4; Durland Donahou 2021).

Food Preferences: Studies examining gut contents of introduced Red Swamp Crayfish suggest this species is a generalist feeder which appears to consume a broad variety of detritus, aquatic vegetation, animal material (e.g., other macroinvertebrates as well as conspecifics) and some terrestrial vegetation (Gutiérrez-Yurrita et al. 1998; Alcorio et al. 2004). This species may also be a seasonally important predator of small fishes during the cooler months when vegetation is less available (Nagy et al. 2021).

Little study appears to have been done on the feeding preferences of White River Crayfish in the wild (Durland Donahou 2021). Presumably, the diet of this species is generally similar to other members of the genus *Procambarus*.

Reproduction: Red Swamp Crayfish typically breed in the fall but females in some populations (particularly in warmer regions) may produce eggs multiple times per year (Nagy et al. 2021). Mating typically takes place in the fall and spring. Individuals may reach sexual maturity in just two months and total generation time is estimated to be only several months. Fecundity is high in this species with larger females in some cases producing over 900 eggs (Alcorio et al. 2008). Eggs and subsequently hatched young are carried by females for several weeks.

White River Crayfish reproduce once a year, with mating occurring in spring and fall and eggs carried by females in the late spring (Durland Donahou 2021). Larger females may lay over 500 eggs in optimum conditions (Mazlum 2005). Females of this species may construct and occupy burrows while carrying eggs (Loughman 2006).

Notable Characteristics: Both the Red Swamp Crayfish and White River Crayfish are important aquaculture organisms (typically reared for human consumption) due to their relatively fast rates of growth, tolerance of multiple habitats, and high rates of fecundity (Durland Donahou 2021; Nagy et al. 2021).

Both species also may create burrows with nondescript openings or mud “chimneys” several inches in height in the vicinity of freshwater habitats including wetlands. These burrows are typically constructed and occupied seasonally during dry periods (Loughman 2006; Nagy et al. 2021).

Historic/Current Vectors: Due to the popularity of both Red Swamp Crayfish and White River Crayfish in aquaculture,



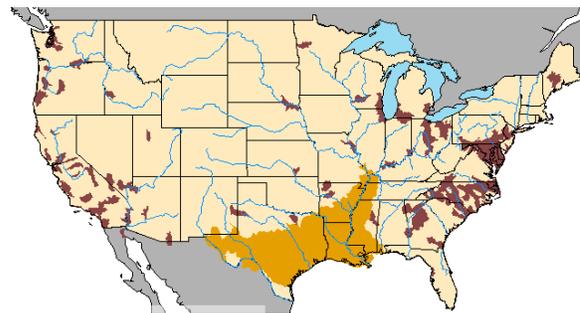
introductions of both of these species in many parts of their non-native range may be attributed to escapees from aquaculture or the aquarium trade (Durland Donahou 2021; Nagy et al. 2021) including parts of Pennsylvania (Bouchard et al. 2007; Lieb et al. 2011a). Additionally, prior to recent (2015) regulatory action regarding crayfish possession and import in Pennsylvania (see “Pennsylvania Legal Status” below), Red Swamp Crayfish and White River Crayfish introductions also may have occurred by farm pond stocking through mail order businesses (PFBC, unpublished data). However, it is likely that the most important recent risk vector for spread of non-native crayfish in Pennsylvania such as Red Swamp Crayfish and White River Crayfish is via “bait bucket” introductions by anglers (Lieb et al. 2011b). Both these and other non-native crayfish species may escape or also be released by educational institutions using them for biology labs or research. For example, several populations of Red Swamp Crayfish in Pennsylvania are located on, or in close proximity to, college campuses (Bouchard et al. 2007).

**Preferred Habitat:** Red Swamp Crayfish can inhabit a broad variety of freshwater habitats including seasonally inundated pools or ditches, wetlands, ponds, lakes, rivers, and canals, with a preference for lentic or low-velocity lotic habitats (Nagy et al. 2021). This species tends to prefer warmer waters (i.e.,  $>21^{\circ}\text{C}$ ) but may adapt to cooler temperatures and is also tolerant of brackish waters (Nagy et al. 2021). Invasive Red Swamp Crayfish have also been documented inhabiting cave ecosystems in Europe (Souty-Grosset et al. 2016). White River Crayfish are generally similar in their habitat preferences, preferring ponds, lakes, wetlands, and streams and rivers with low flow velocities (Durland Donahou 2021).

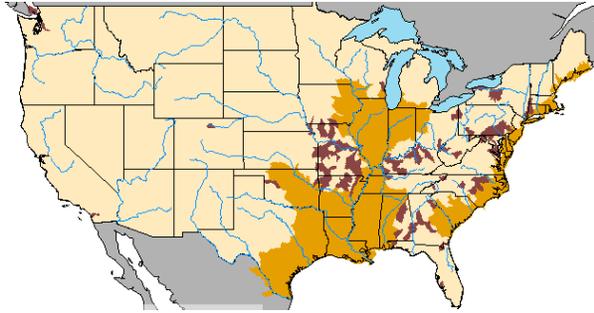
Red Swamp Crayfish and White River Crayfish can occur in slower current areas of faster flowing streams and rivers along shorelines and in pools (D.A. Lieb, unpublished data). Loughman (2006) found introduced populations occupying seasonally dry, fishless, wetland pools in West Virginia. Both species may persist within relatively polluted or degraded habitats (Gerhardi 2006; Durland Donahou 2021).

### **Distribution and Status**

**Distribution:** Both the Red Swamp Crayfish and the White River Crayfish are native to portions of the eastern and southern United States and northeastern Mexico (Figs. 3 and 4; also see “Origin” above). Non-native Red Swamp Crayfish have been reported from at least 34 U.S. States (Fig. 3; Nagy et al. 2021) and non-native White River Crayfish have been reported from at least 20 U.S. States (Fig. 4; Durland Donahou 2021). Both species have been introduced widely in other parts of the world (Garhardi 2006; Sheers et al. 2020).

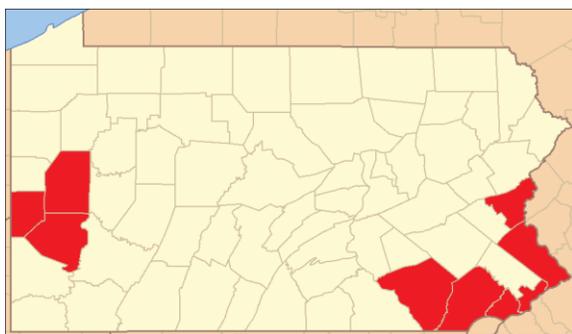


**Figure 3.** Distribution of Red Swamp Crayfish in the continental United States. Native range is shaded in yellow and introduced range is shaded in red. Source: USGS.



**Figure 4.** Distribution of White River Crayfish in the continental United States. Native range is shaded in yellow and introduced range is shaded in red. Source: USGS.

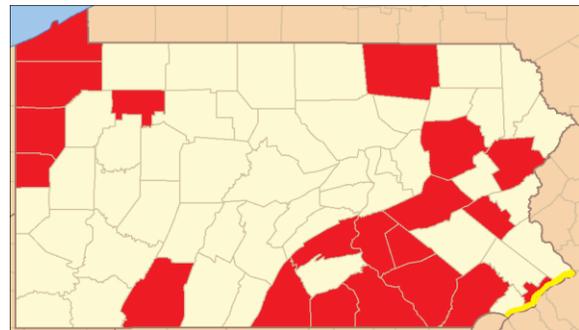
Red Swamp Crayfish are not native to any parts of Pennsylvania, but introduced specimens have been collected primarily in southeastern Pennsylvania in Bucks, Chester, Delaware, Lancaster, and Montgomery and Northampton counties as well as the city of Philadelphia (Bouchard et al. 2007; Lieb et al. 2011a; Glon et al. 2018; Nagy et al. 2021) with records for western Pennsylvania in Allegheny County, Beaver County and Butler County (Bouchard et al. 2007; Loughman et al. 2017, Loughman et al. 2020).



**Figure 5.** County-level distribution of Red Swamp Crayfish in Pennsylvania (October 2022).

White River Crayfish are native to extreme southeastern Pennsylvania in the Atlantic

Coastal Plain, consisting of a thin strip approximately 5 miles wide bordering the lower Delaware River (Bouchard et al. 2007; Lieb et al. 2011a). Collections outside of the native range of this species in Pennsylvania are scattered throughout much of the southeastern and western portions of the Commonwealth and include records within Adams, Bedford, Chester, Crawford, Dauphin, Erie, Lancaster, Lawrence, Lebanon, Lehigh, Luzerne, Franklin, Forest, Mercer, Monroe, Perry, Philadelphia, Schuylkill, Somerset, and York counties (Bouchard et al. 2007, Lieb et al. 2011a; Loughman et al. 2017; Loughman et al. 2020, Durland Donahou 2021; Mark Lethaby, pers. comm.).



**Figure 6.** County-level distribution of White River Crayfish in Pennsylvania (October 2022). Approximately native range of this species in the geographic portion of Pennsylvania’s Atlantic Coastal Plain is shaded in yellow. Non-native range counties are shaded in red.

Pennsylvania Legal Status: Red Swamp Crayfish and White River Crayfish are regulated with all crayfish species within 58 Pa. Code §71.6 and §73.1. It is unlawful to possess, introduce, import, or transport in or through the Commonwealth all crayfish species, except when they are either possessed and used as bait on, in or about the water from which taken or possessed or imported for testing and scientific purposes



or restaurant consumption and adequate measures have been taken to prevent their escape and they are accompanied by documentation stating the point of origin and the destination to which they are to be delivered. The head of all crayfish species collected as bait must be removed above the eyes unless used as bait within the water from which they were taken.

## Threats

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Ecological: Red Swamp Crayfish have been identified as among the most negatively impactful invasive species in many European countries (Souty-Grosset et al. 2016). Studies assessing the impacts of introductions of this species have identified major threats to native crayfish communities via displacement and disease transmission (the latter is a greater risk to native crayfish in Europe than in the United States), impacts on other macroinvertebrates such as gastropods and insect larvae, major risk to aquatic macrophyte communities via foraging, and potential risks to fisheries via predation on forage fish and juvenile sport fish (Gerhardi 2006; Gerhardi and Acquistapace 2007; Ilhen et al. 2007; Elio Siesa et al. 2014; Souty-Grosset et al. 2016). Red Swamp Crayfish have also been identified as a major threat to native amphibians, primarily due to predation on amphibian larvae in seasonal fishless wetlands such as vernal pool ecosystems (Cruz et al. 2006; Gerhardi 2006). Within Pennsylvania, species of conservation concern including several native crayfish species and vernal pool breeding amphibian species may be particularly at risk from Red Swamp Crayfish introductions. Additionally, this species may pose some degree of risk towards rare cave arthropods in Pennsylvania due to its facultative

occupancy of caves. Furthermore, Red Swamp Crayfish have been shown to degrade ecosystems by increasing turbidity/sediment load in aquatic ecosystems both by the reduction of macrophyte cover and by burrowing behavior (Barbaresi et al. 2004; Gerhardi 2006).

In contrast, little study appears to have been done assessing the ecological impacts of White River Crayfish (DiStefano et al. 2015; Durland Donahou 2021). However, this species may have generally similar ecological impacts to that of the Red Swamp Crayfish given the similarity in size, behavior, and life history (DiSefano et al. 2016).

Economic: Red Swamp Crayfish may have significant economic impacts on sport fisheries via predation of fishes and depletion of native crayfish stocks (Gerhardi 2006; Souty-Grosset et al. 2016). This species also can cause significant costs in agricultural damage and water management structures (e.g., significant damage to dams and flood control structures) due to its burrowing behavior and consumption of crops such as rice (Souty-Grosset et al. 2016). In Europe, the estimated costs of control/economic damage caused by this species are equivalent to several hundred million U.S. dollars annually (Souty-Grosset et al. 2016).

No data appear to be available on the estimated economic costs of White River Crayfish; however, due to the general similarities in size, behavior, and life history of this species to the Red Swamp Crayfish, some economic costs attributed to this species may be similar. Allert et al. (2016) suggested infestations of this species in



warmwater fish propagation ponds may contribute to increased operational costs.

## Management

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Management Goals: At present, both Red Swamp Crayfish and White River Crayfish appear to have relatively limited distributions in Pennsylvania. Because little can be done following establishment of nonindigenous crayfish in aquatic ecosystems, the management primary goal should be to prevent the introduction of these species and other nonindigenous crayfish to novel watersheds.

### Containment and Prevention Actions:

- Coordinate with appropriate agency partners to conduct early detection surveys within uninvaded waters, particularly those near introduced populations or at high risk of illicit transfer (e.g., popular fishing areas).
- Bolster public education efforts to acquaint the populace with the threats of non-indigenous crayfish and means to prevent their spread. Because one main spread vector of nonindigenous crayfish in Pennsylvania appears to be primarily via illicit bait release, specifically target anglers for education/awareness through presentations, literature, and targeted signage. Furthermore, as White River Crayfish and Red Swamp Crayfish are commonly propagated for sale, coordinate with the aquaculture community to prevent release from closed systems and to prevent illicit stocking. Additionally, because classroom animal/pet release may be another spread vector in Pennsylvania (Bouchard et al. 2007), create additional

educational efforts to target biology educators and pet store owners on issues associated with illicit crayfish release.

- Initiate/support research on the biology of Red Swamp Crayfish and White River Crayfish populations in the Commonwealth and the impacts of these species on native aquatic species in Pennsylvania, particularly towards species of greatest conservation need (SGCNs). This is especially pertinent regarding the White River Crayfish as little data appears to have been published on the potential ecological impacts of this species throughout its introduced range.
- Because dams may provide barriers to the upstream dispersal of nonindigenous crayfish species (Lieb et al. 2011a; 2011b), coordinate with dam removal planning activities to ensure that dam removal will not facilitate the spread of nonindigenous crayfish.
- Strictly enforce crayfish regulations within 58 Pa Code §71.6 and §73.1.
- Encourage the incident reporting of aquatic invasive/nuisance species such as Red Swamp Crayfish and White River Crayfish within Pennsylvania. Online reporting can now be conducted at the following PFBC web site: <https://pfbc.pa.gov/forms/reportAIS.htm> as well as PA iMapInvasives at: <https://www.paimapinvasives.org/> and at the national level, USGS Nonindigenous Aquatic Species website: <https://nas.er.usgs.gov/SightingReport.aspx>



Rapid Response Options:

- Few studies appear to have evaluated control mechanisms for invasive Red Swamp Crayfish or White River Crayfish following establishment. Allert et al. (2016) found that chemical treatments (cypermethrin) were successful at killing adult and juvenile White River Crayfish within lab treatment tanks, and thus may be applicable to small waterbodies. However, elimination or significant reduction by chemical treatments or removal (e.g., trapping) may not be successful in larger waterbodies or in flowing waters. Aquiloni et al. (2010) suggested predation by stocking of native fish may be a possible means of Red Swamp Crayfish population control. A combination of management techniques informed by risk analysis including trapping, chemical controls, native predator stocking, and the installation of physical barriers has been proposed for harm reduction of invasive Red Swamp Crayfish populations in Europe (Souty-Grosset et al. 2016).

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