Redear Sunfish (*Lepomis microlophus*)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, May 2016,
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1 Native Range and Status in the United States

Native Range
From Fuller et al. (2016):

"The native range for this species is Atlantic coast of North America (USEPA 2008). Page and Burr (1991) report the range as Atlantic and Gulf Slope drainages from about the Savannah River, South Carolina, to the Nueces River, Texas; north in the Mississippi River basin to southern Indiana and Illinois. Rohde et al. (2009) also conclude that the native range includes the

Savannah River in Georgia and extends south through Florida and west to the Rio Grande River, and north in the Mississippi River Valley to southern Illinois and Indiana. Jenkins and Burkhead (1994) cite Bailey (1938) in reporting that the native range on the Atlantic slope may not be any farther north than Georgia."

Status in the United States

The native range of *Lepomis microlophus* is contained within the United States (Fuller et al. 2016). There have been many introductions of this species outside of its native range in the United States (Fuller et al. 2016).

From Fuller et al. (2016):

"This species is known from the lower Colorado River, Roosevelt Lake on the Salt River, and other reservoirs in central Arizona (Minckley 1973; Grabowski et al. 1984; Rinne 1995; Miller and Lowe 1967) and the Bill Williams River National Wildlife Refuges (USFWS 2005); many drainages within the Sacramento-San Joaquin, Death Valley, Tulare-Buena Vista , Southern California regions, the Yolo Bypass, Suisun Marsh, and the Colorado River in California (Smith 1982; Douglas 1974; Moyle 1976; Moyle and Daniels 1982; Grabowski et al. 1984; Moyle and Randall 1999; Sommer et al. 2001; Matern et al. 2002); the Platte, Republican, and Arkansas drainages (Walker 1993; Rasmussen 1998), and College Lake in Larimer County in the Cache La Poudre system in Colorado (Horak, personal communication); Wagamons Pond, Sussex County, Delaware (Raasch, personal communication); the northern two-thirds of Illinois, including the Lake Michigan, Illinois, Kaskaskia, Sangamon, Embarras, and Vermilion drainages (Smith 1979; Burr and Page 1986); southern farm ponds and reservoirs and northern Indiana, including the Tippecanoe, White, and lower Wabash drainages, and the Anderson River (Gerking 1945; Nelson and Gerking 1968; Burr and Page 1986; Mills et al. 1993); artificial recreational lakes and interior streams in Iowa (Harlan et al. 1987); the Kansas River drainage and numerous counties in Kansas (Cross 1967; Cross and Collins 1995); locations east of the lower Green River in Kentucky, including the Licking, Kentucky, upper Levisa , Salt and Rolling Fork drainages (Burr and Page 1986; Burr and Warren 1986; Powers and Ceas 2000); The Chesapeake and Ohio Canal National Historical Park, Washington County, and the mainstem Potomac River near Plummers Island, Maryland (Tilmant 1999; Starnes et al. 2011); Branch, Calhoun, Hardin, Jackson, Oakland, Hillsdale, and Washtenaw counties, Michigan (Bailey and Smith 1992; UMMZ specimens; Michigan DNR); the lower Missouri drainage, and reservoirs and ponds outside its native range in Missouri (Pflieger 1971, 1975, 1997; Cross et al. 1986); the Platte-Niobrara drainage, the Elkhorn River in Dodge and Washington counties, and West Oak Lake in Lancaster County, Nebraska (Morris et al. 1974; Cross et al. 1986); lower Colorado River and Ft. Churchill ponds, Lyon County, Nevada (Deacon and Williams 1984; Insider Viewpoint 2001; Vinyard 2001); the Pecos drainage in New Mexico (Koster 1957; Lee et al. 1980 et seq.); the Susquehanna and Allegheny drainages in New York (Hocutt et al. 1986); Tennessee, Roanoke, French Broad-Holston, and Dan drainages, probably introduced in the Neuse and Tar drainages, and regarded as native but possibly introduced in the Catawba, Yadkin, Lumber, and Waccamaw drainages in North Carolina (Hocutt et al. 1986; Menhinick 1991); Honey Creek at Buckeye Lake, Greter's Lake in Richland County, Pippen Lake in Portage County, the Scioto and Great Miami drainages, and other locations in Ohio (Lee et al. 1980 et seq.; Trautman 1981; Burr and Page 1986; Hocutt et al. 1986; Underhill 1986); non-specific, widely distributed in Oklahoma (Hall 1956; Miller and Robison 1973; Douglas 1974); parts of western Oregon including ponds in the Willamette Valley (Bond 1994) and Benton and Marion Counties (Logan 1994; Anonymous 2001); at least eight lakes in Pennsylvania, seven in the Susquehanna drainage and one in the Allegheny drainage; and the Monongahela drainge *[sic]* (Denoncourt et al. 1975a; Cooper 1983; Hocutt et al. 1986), Lee et al. (1980 et seq.) also mapped collections in eastern Pennsylvania in the Delaware drainage; in the Garzas, Guajataca, and Loiza Reservoirs and at non-specific locations in Puerto Rico (Erdsman 1984; Lee et al. 1983); all drainages of South Carolina except the Savannah River. Introductions have occured *[sic]* throughout the state in the Pee Dee, Santee-Cooper, Edisto, Combahee, Broad, and Saluda drainages (Loyacano 1975; Hocutt et al. 1986; Rohde, personal communication; Rohde et al. 2009); non-specific localized populations in Tennessee (Etnier and Starnes 1993); western Texas (Lee et al. 1980 et seq.; Red River Authority 2001); Holmes Creek Reservoir, Davis County, Utah (Sigler and Miller 1963); two lakes in Caledonia County, northeastern Vermont (Whittier and Hartel 1997); Appomattox, Potomac, Rappahannock, York, James, Dan, Banister, Chowan, Roanoke, and Big Sandy drainages and the Occoquan Reservoir in Virginia (Hocutt et al. 1986; Jenkins and Burkhead 1994; Starnes et al. 2011); and although Stauffer et al. (1995) listed the redear as native, collections in the Ohio River in West Virginia would be based on introductions according to Lee et al. (1980 et seq.) and Jenkins and Burkhead (1994). Established in Ohio River Islands National Wildlife Refuge (USFWS 2005)."

"Established in most locations, but extirpated in New Mexico (Sublette et al. 1990) and Utah (Sigler and Sigler 1996). The Delaware population at Wagamons Pond was discovered in October 1994 (Raasch, personal communication). Not established in Missouri (Pflieger 1997). Established in at least one of the two lakes in Vermont (Whittier and Hartel 1997). Results of a 1995 survey show that redear natural reproduction has been highly successful in Clear Lake in Jackson County, MI (Herman 1996)."

"Robison and Buchanan (1988) reported Redear Sunfish as widely stocked in Arkansas in ponds and reservoirs, presumably in native waters. Menhinick (1991) listed this species as "regarded as native but possibly introduced" and "introduced" into the Catawba, Yadkin, Lumber, and Waccamaw drainages. Stauffer et al. (1995) differed with other authors (Lee et al. 1980 et seq. and Jenkins and Burkhead 1994) in reporting this species as native to the Potomac, Big Sandy, Kanawha, and Little Kanawha drainages, and Ohio basin. No records exist for New York (Whittier and Hartel 1997)."

Means of Introductions in the United States

From Fuller et al. (2016):

"Intentional stocking for sportfishing. In Iowa, fish found in interior streams are believed to be escapes from stocked lakes (Harlan et al. 1987). The species' recent (1991) discovery in Vermont is somewhat of a mystery. It appears the most likely means of introduction there is stock contamination of privately stocked Micropterus (Whittier and Hartel 1997)."

Remarks

From CABI (2016):

"All cases of *L. microlophus* introduction have been due to intentional stocking for sport fishing purposes. Therefore any further introduction is likely to be related to stocking, or the unaided spread of the species through interconnected water systems in individual watersheds."

Lepomis microlophus hybridizes with other *Lepomis* spp. (Scribner et al. 2001 in Fuller et al. 2016).

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

According to Eschmeyer et al. (2017), *Lepomis microlophus* (Günther 1859) is the current valid name for this species. *Lepomis microlophus* was originally described as *Pomotis microlophus* Günther 1859 and has been previously known as *Pomotis speciosus* Holbrook 1855.

From ITIS (2016):

"Kingdom Animalia
 Subkingdom Bilateria
  Infrakingdom Deuterostomia
   Phylum Chordata
    Subphylum Vertebrata
     Infraphylum Gnathostomata
      Superclass Osteichthyes
       Class Actinopterygii
        Subclass Neopterygii
         Infraclass Teleostei
          Superorder Acanthopterygii
           Family Centrarchidae
            Genus *Lepomis*
             Species *Lepomis microlophus* (Günther, 1859)"

Size, Weight, and Age Range

From Froese and Pauly (2016):

"Max length : 43.2 cm TL male/unsexed; [IGFA 2001]; common length : 19.2 cm TL male/unsexed; [Hugg 1996]; max. published weight: 220.00 g [International Game Fish Association 1991]; max. reported age: 7 years [Hugg 1996]"

From CABI (2016):

"*L. microlophus* has a lifespan of about 7 years (Mills et al., 2004), with a maximum reported age of 8 (Twomey et al., 1984). It matures between 1 and 2 years, although reproductive maturity is attributed to size rather than age and can be dependent on the overall age distribution within a fish population (Twomey et al., 1984)."

From Barbee (2011):

"At sexual maturity they are approximately 224 mm and can weigh as much as 454 g. (Jenkins and Burkhead, 1993; Page and Burr, 1991; Ross and Brenneman, 2001; Twomey, et al., 1984)"

"Growth rates appear to be dependent on turbidity as redear sunfish grow more rapidly in less turbid water. Different age classes can be identified according to size. First year fish range from 50 to 100 mm in total length (TL), and second year fish range from 110 to 140 mm TL. Fish that are 5 to 6 years old range from 200 to 250 mm TL. (Moyle, 2002; Simon and Wallus, 2008; State of California, 2004; Trautman, 1981)"

Environment

From Froese and Pauly (2016):

"Freshwater; demersal."

From Barbee (2011):

"They commonly live in low salinity waters (less than 4 ppt) but have been found in waters with salinities as high as 12 ppt. (State of California, 2004; Twomey, et al., 1984)"

"Optimal incubation temperatures for redear sunfish eggs range from 22°C to 24°C."

Climate/Range

From Froese and Pauly (2016):

"Subtropical; 40°N - 26°N"

Distribution Outside the United States

Native

The native range of *Lepomis microlophus* is contained within the United States (Fuller et al. 2016). See Section 1 for a description.

Introduced

Froese and Pauly (2016) list *Lepomis microlophus* as introduced and established in Morocco, U.S. Virgin Islands, and Puerto Rico. It is listed as introduced and not established in Mexico and listed as introduced and establishment unknown in Panama and Mauritius.

From FAO (2016):

"*Lepomis microlophus* introduced to Panama from United States of America
Date of introduction:
Status of the introduced species in the wild: Established"

From CABI (2016):

"*L. microlophus* has also been stocked in South Africa, Morocco and Panama (Mills et al., 1993)."

Means of Introduction Outside the United States

From FAO (2016):

"Reasons of Introduction: 1) forage"

From Barbee (2011):

"Redear sunfish have been introduced as game fish throughout the United States, as well as in Morocco, South Africa, Panama, and Puerto Rico. (Fuller and Jacobs, 2007; Moyle, 2002; Page and Burr, 1991; Whittier and Hartel, 1997)"

Short Description

From Fuller et al. (2016):

"Deep-bodied, olive colored, with darker spots and flecks of red, and occasionally vertical bars along the sides. The hind end of the gill flap is black with a white border and has a red spot on the tip (hence its name). The chest color is yellowish to cream colored. The mouth is small and when closed barely reaches only to the front margin of the eye. The pectoral fins are long and more pointed than those of other sunfish; the first dorsal fin contains 10 sharp spines, followed by 10 to 12 rays. Moyle (1976); Hubbs et al. (1991); Page and Burr (1991); Etnier and Starnes (1993). *Lepomis microlophus* is composed of two unnamed subspecies; one in Florida, Georgia, and southern Alabama, the other throughout the rest of its range. The two subspecies may no longer be distinguishable due to interbreeding caused by stocking programs (Page and Burr 1991)."

From Barbee (2011):

"Redear sunfish have laterally compressed bodies that are green, grey, or black. They can be distinguished from other sunfish via 3 different characteristics: 1) the red or orange margin on the opercular flap, 2) cheeks without conspicuous orange and blue streaks, and 3) pectoral fins that are greater than a third of the length typically found in sunfish. They often have small green specks on their heads and grey or black specks covering their bodies. Their pectoral fins have 13 to 14 pectoral rays, which taper to a terminal point. Their dorsal fin has 10 to 11 spines, and the anal fin has 3 spines. The terminal end of the opercular flap is marked by a large black spot, accompanied by two smaller white spots. The brightly colored terminal margin on the opercular flap is red in males and orange in females. […]

Redear sunfish are similar in appearance to their close relative, pumpkinseed sunfish (*Lepomis gibbosus*). As a result, the two species are often confused for one another. However, pumpkinseed sunfish have a number of wavy iridescent lines along the check *[sic]* and opercular flap that are not present in redear sunfish. (Page and Burr, 1991)"

Biology

From Froese and Pauly (2016):

"Has a preference for mollusks as food thus has potential for the control of snail vectors of schistosomiasis [Welcomme 1988; Etnier and Starnes 1993]. Oviparous [Breder and Rosen 1966]."

"Breed in shallow ponds, lakes or creeks [Breder and Rosen 1966]. Distinct pairing [Breder and Rosen 1966]."

"Inhabits ponds, swamps, lakes; and vegetated pools, usually with mud or sand bottoms, of small to medium rivers. Also occurs in warm, clear and quiet waters rich in vegetation and snags."

From Fuller et al. (2016):

"Redear, and to a lesser extent pumpkinseed, are the only known morphologically and behaviorally specialized molluscivores in the sunfish family (Huckins et al. 2000). The ability of these sunfish to crush hard-shelled organisms provides a set of food resources that are less effectively used by other sunfishes, facilitating cohabitation with other sport fish such as bluegill and bass (VanderKooy et al. 2000)."

From CABI (2016):

"The start and duration of the spawning period for *L. microlophus* in the USA varies with geographical location (Twomey et al., 1984). The observed spawning periods are concentrated in the spring and the summer months between April and August (Mills et al., 2004). In warmer regions, such as Florida, *L. microlophus* has been observed to spawn between February and October, whereas in colder regions the spawning period is much shorter (Twomey et al., 1984).

Spawning temperature was reported to range from 20 to 21°C by Stone (2008) and 21 to 24°C by Mills et al. (2004).

Spawning habitat, nest depth and location also vary and show no consistent pattern in the species' reproductive biology. Spawning and nesting can occur in gravel, sandy or clayey sediment bottoms (Twomey et al., 1984; Mills et al., 2004). The nests are fanned of debris and usually located in sheltered places amongst, or on the edges of, vegetation and large woody debris. Nests have been spotted in extremely shallow regions between 5 and 10 cm and deeper ranges between 4 to 6 m. Males remain with the eggs, fanning and guarding the nest for about 6 to 10 days until they hatch. Observations show that the optimal hatching temperature which results in the highest hatching percentage is between 21 and 24°C (Twomey et al., 1984)."

"*L. microlophus* is a specialized molluscivorous species (Minckley, 1982; VanderKooy et al., 2000; Wang et al., 2003; Fuller et al., 2014). The presence of upper and lower pharyngeal teeth inside the mouth provide it with the ability to crush molluscs (Minckley, 1982; Lauder, 1983; French III, 1993). Its shell crushing ability has also been connected to the consumption of gastropods (snails), first observed in Martin et al. (1992). *L. microlophus*' affinity towards snails has since been extensively documented (VanderKooy et al., 2000; Wang et al., 2003; Ledford and Kelly, 2006; Noatch and Whitledge, 2011).

VanderKooy et al. (2000) observed that large *L. microlophus* predominantly focus on hard-shelled prey such as ostracods, hydrobiid snails and mussels throughout the entire year. In the same field investigation it was observed that smaller fish tended to also consume zooplankton, amphipods, chironomid and certopongonid larvae and cladocerans, with varied distributions depending on the season. Similar organism remains were found in the stomach contents of *L. microlophus* predominantly feeding on quagga mussels (Wong et al., 2013).

It has been observed that *L. microlophus* exhibits a higher (ca. 2x) crushing efficiency of hard-shelled prey than competing species such as the pumpkinseed, *L. gibbosus* (Huckins, 1997). The crushing efficiency is due to the strength differences between the species, which has led to a shift in the feeding assemblages of the species when both are present, resulting in a higher consumption of hard-shelled prey by *L. microlophos [sic]* (Huckins, 1997). A detailed description of the branchial musculature of sunfish species (and the singularities in the separate species) is presented in Lauder (1983)."

From Barbee (2011):

"The riverine habitats in which they are found, tend to be large and slow flowing with moderate amounts of aquatic vegetation. Redear sunfish are mainly found in water that is at least 2 m deep."

"Redear sunfish that share habitat with largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*) are forced to compete for food as fry and juveniles. They eat insect larvae until their jaws are strong enough to crush the shells of their primary prey, aquatic snails. Once their jaws are strong enough, competition for food decreases due to an abundance of snails. Redear sunfish are crepuscular and tend to rest during the day. (Gothreaux, 2008; Moyle, 2002; Page and Burr, 1991; Wang, 1986)"

Human Uses

From Froese and Pauly (2016):

"Gamefish: yes"

From Fuller et al. (2013):

"Redear sunfish has been used as a research organism to measure uptake levels of chemicals and toxins in other parts of the U.S. (e.g., Bettoli and Clark 1992, Campbell 1994, Eller 1969, Ghent and Grinstead 1965, Melwani et al. 2009, Pickhardt et al. 2006, Saiki et al. 2005, Sorensen 1988)."

From Barbee (2011):

"Redear sunfish have several predators, including humans (*Homo sapiens*). They are considered a sport-fish species and are stocked in many lakes and streams. Humans commonly consume them […]"

From CABI (2016):

"The use of *L. microlophus* as a biocontrol agent for quagga mussels avoids the implementation of other invasive/nuisance species, such as black carp (*Mylopharyngodon piceus*)."

"Experimental studies have provided evidence that shows that *L. microlophus* can be implemented as a biocontrol agent for invasive ramshorn snails (Ledford and Kelly, 2006)."

Diseases

No records of OIE reportable diseases were found.

From Barbee (2011):

"Redear sunfish are host to the non-native parasitic copepod, *Neoergasilus japonicus*. *Neoergasilus japonicus* attaches to the outer surface of its host, likely feeding on the dermal tissue underlying the scales. Gut content analysis, however, shows that the primary diet of free-swimming *N. japonicus* consists primarily of blue-green algae. (Hudson and Bowen, 2002)"

Threat to Humans

From Froese and Pauly (2016):

"Harmless"

3 Impacts of Introductions

From Fuller et al. (2016):

"Redear is highly molluscivorous. Direct impacts on invertebrates and indirect impacts on vegetation are associated with *L. microlophus* in Tennessee (Ruiz et al. 1999). In inland lakes of southern Michigan, introduced redear is associated with ecological changes in populations of pumpkinseed *L. gibbosus*, a native molluscivore. Effects of introduced redear on pumpkinseed include reduced consumption of snails and reduced population densities (Huckins 1997). The effects appear to be driven by differences in pharyngeal morphology and competitive ability;

redear exert greater crushing forces and consume more snails than sympatric pumpkinseeds (Huckins 1997). When introduced into a water body, Huckins et al. (2000) found that competition between the two species resulted in a 56% reduction in pumpkinseed abundance, and a 69% reduction in average snail biomass when compared with lakes without redear. Hybridizes with other *Lepomis* species (Scribner et al. 2001)."

From CABI (2016):

"The widespread stocking of *L. microlophus* has led to its establishment in watersheds outside of its native range, where it overlaps with other fish species that fill the same tropic niche in those areas. The majority of the impacts associate *[sic]* with *L. microlophus* are competitive interactions due to a shared food source, as well as due to its foraging habits. None of these impacts have been documented as a nuisance and it continues to be stocked for sport fishing.

Impact on Habitats

Martin et al. (1992) experimentally tested the direct and indirect effects of fish on macroinvertebrate communities. The results showed that predation of gastropods by sunfish reduced the population of snails in aquatic systems. Snails act as grazers for aquatic flora such as macrophytes (Martin et al., 1992); therefore, *L. microlophus*' direct consumption of snails may have an indirect effect on the aquatic fauna (Ruiz et al., 1999). Experimental systems with *L. microlophus* population showed a marked increase in macrophyte density (Martin et al., 1992). However, experimental trials were conducted under high fish abundances and the results do not necessarily translate for regions with lower *L. microlophus* densities, which are observed in natural systems where the fish has been introduced (Ruiz et al., 1999).

Impact on Biodiversity

One of the US regions most affected by the introduction of non-native fish species is California. Out of California's 133 documented species of fish, 38% have been introduced and are not native to the region (Moyle, 1976). Because of California's unique geological makeup 30% of its native fish species are found in no other state, and the proliferation of introduced species such as *L. microlophus* puts pressures on these endemic populations and could push them towards becoming endangered (Moyle, 1976).

Because of *L. microlophus*' higher specialization for hard-shelled prey compared to pumpkinseed sunfish (*Lepomis gibbosus*), it has the potential to outcompete the latter (Huckins et al., 2000). Huckins (1997) observed that *L. microlophus*, in the presence of *L. gibbosus*, consumed more hard-shelled prey than their counterpart. Analyses in Huckins (1997) showed that the crushing strength exhibited by *L. microlophus* was significantly greater than that for *L. gibbosus*, likely contributing to its higher effectiveness as a molluscivore.

Lentic systems where both *L. microlophus* and *L. gibbosus* are present exhibit lower *L. gibbosus* population densities than expected, as well as a reduced molluscivory in the *L. gibbosus* population (Huckins, 1996). These negative effects were confirmed in Huckins et al. (2000), as well as the impacts of *L. microlophus* introduction on snail populations (Martin et al., 1992;

Huckins, 1996; Huckins et al., 2000). Huckins et al. (2000) observed that the *L. gibbosus* population declined on average by 56% in lakes where *L. microlophus* were introduced, and snail biomass declined by almost 70%."

"*L. microlophus* has been shown to successfully mitigate an invasive quagga mussel (*Dreisena rostriformis bugensis*) population in a lake system in southwest USA (Wong et al., 2013). Wong et al. (2013) observed that *L. microlophus* stocked at high densities (0.42 fish/m3) reduced the quagga mussel population density by 90% within 3 months of stocking. The use of *L. microlophus* as a biocontrol agent for quagga mussels avoids the implementation of other invasive/nuisance species, such as black carp (*Mylopharyngodon piceus*).

L. microlophus has also been observed to consume significant amounts of zebra mussels (*Dreissena polymorpha*), with some specimens exhibiting a dietary composition of 100% (Magoulick and Lewis, 2002). Unfortunately, their implementation as a biocontrol agent for zebra mussels is projected to be unsuccessful due to the zebra mussels' prolific reproduction rates (Magoulick and Lewis, 2002).

Experimental studies have provided evidence that shows that *L. microlophus* can be implemented as a biocontrol agent for invasive ramshorn snails (Ledford and Kelly, 2006). *L. microlophus* have also been observed to reduce snail densities in aquaculture systems, where snails are carriers of harmful diseases and can affect the health of cultivated fish (Noatch and Whitledge, 2011). However, snail populations have been observed to rebound; therefore, Noatch and Whitledge (2011) recommended the use of biocontrol methods in conjunction with other attenuation methods (such as chemical control) to achieve higher effectiveness."

From Barbee (2011):

"Introduced redear sunfish have significantly impacted native fish populations. For example, when introduced into habitats occupied by pumpkinseed sunfish (*Lepomis gibbosus*), pumpkinseed populations significantly declined. Redear sunfish have strong jaws, which allow them to crack mollusk shells more easily than pumpkinseed sunfish can. As a result, redear sunfish likely decrease food availability for pumpkinseeds. (Fuller and Jacobs, 2007)"

4 Global Distribution

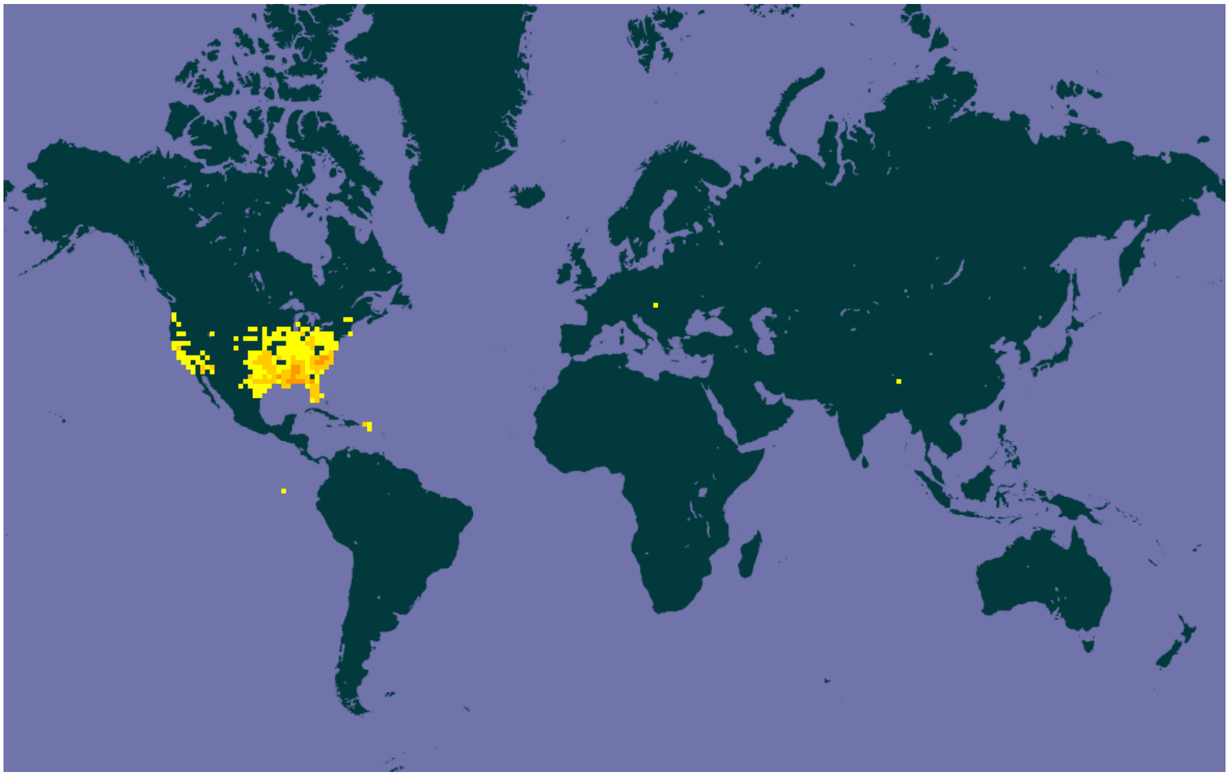

Figure 1. Known global distribution of *Lepomis microlophus*. Collection locations are in North America and the Caribbean with some erroneous points in Europe and China. Map from GBIF Secretariat (2016).

The location in China was not used as a source point for the climate match. The record indicated that the specimen was collected in Houston (USA) and not China (GBIF Secretariat 2016).

The location in Hungary could not be verified elsewhere and was not used as a source point for the climate match.

The location in the Galapagos Islands off the Pacific Coast of northern South is the result of a citizen science observation in a marine environment (GBIF Secretariat 2016). This observation is not reliable and was not used as a source point in the climate match.

5 Distribution Within the United States

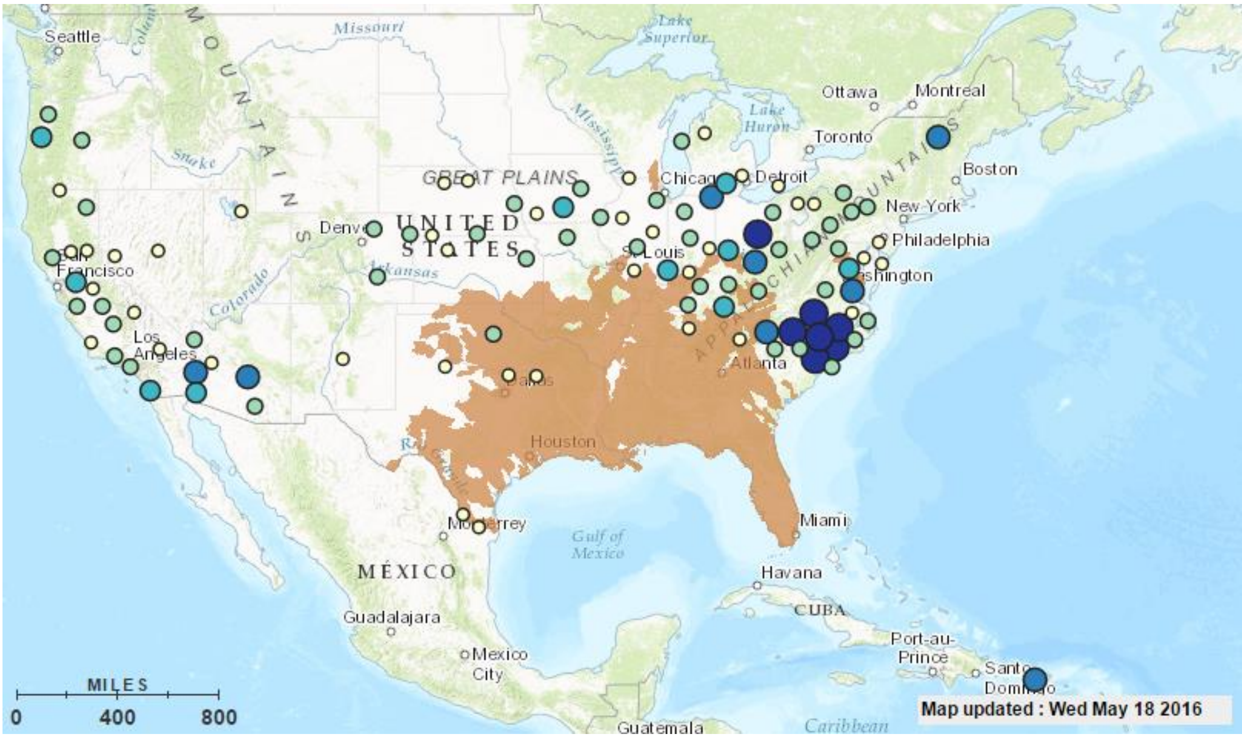

Figure 2. Known distribution of *Lepomis microlophus* in the contiguous United States and Puerto Rico. Brown area indicated the native range of the species. Map from Fuller et al. (2016).

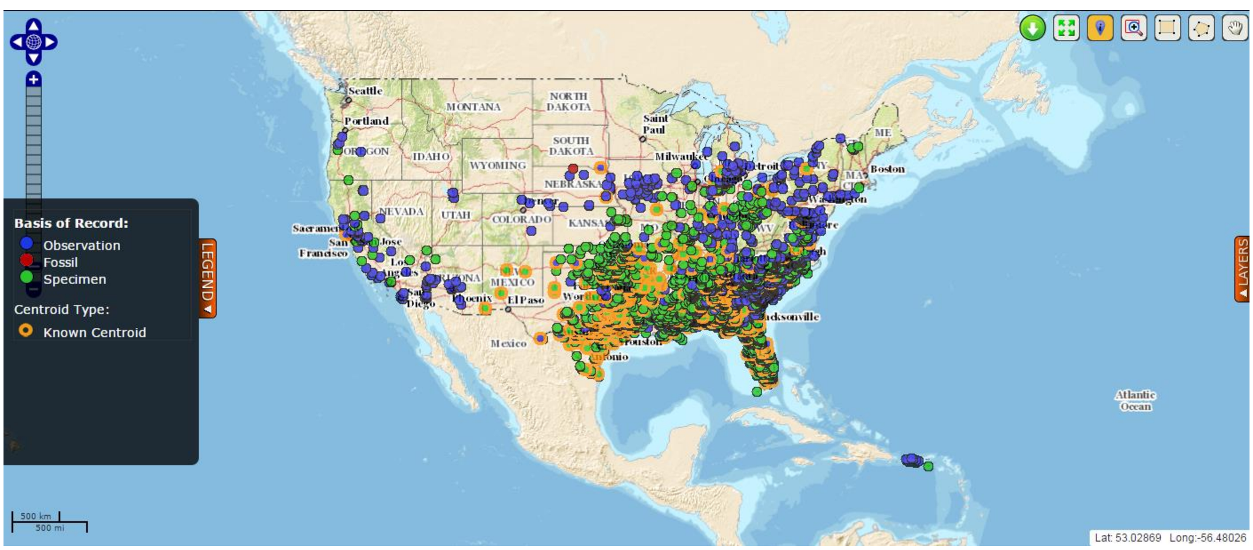

Figure 3. Known distribution of *Lepomis microlophus* in the contiguous United States and Puerto Rico. Map from BISON (2017).

Locations shown in New Mexico and Utah were excluded from the climate match because *L. microlophus* populations have not persisted in those areas Fuller et al. (2016).

6 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Lepomis microlophus* was high in almost every part of the country. There are very small pockets of low match in the Great Plains and along the Pacific Northwest Coast. It should be noted that the native range of this species encompasses much of the southeast (Figure 1, Fuller et al. 2016). The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean distance) for the contiguous United States was 0.968, high, and every state had an individually high climate match.

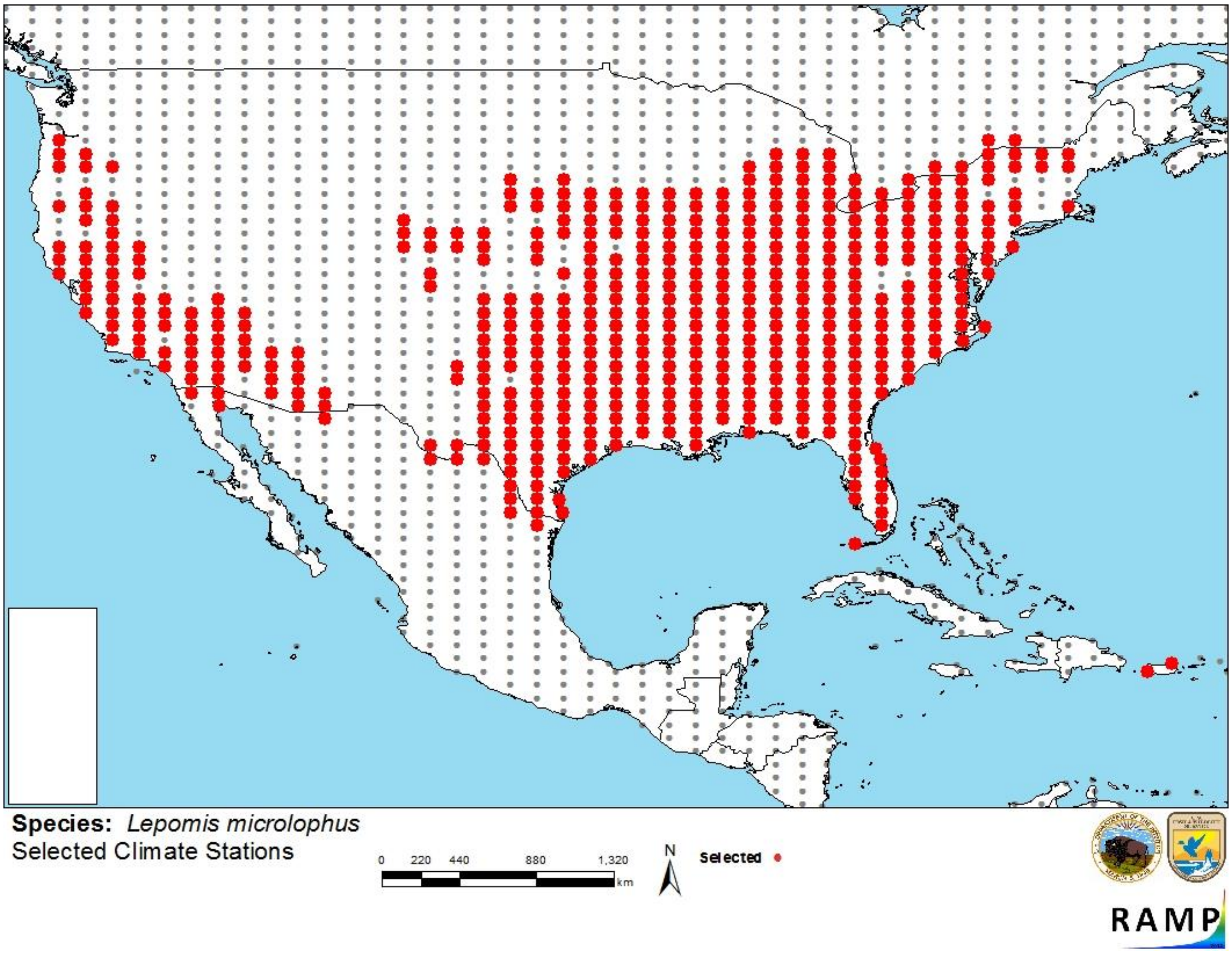

Figure 4. RAMP (Sanders et al. 2014) source map showing weather stations in the contiguous United States, Puerto Rico, and northern Mexico selected as source locations (red) and non-source locations (gray) for *Lepomis microlophus* climate matching. Source locations from Fuller et al. (2016), GBIF Secretariat (2016), and BISON (2017).

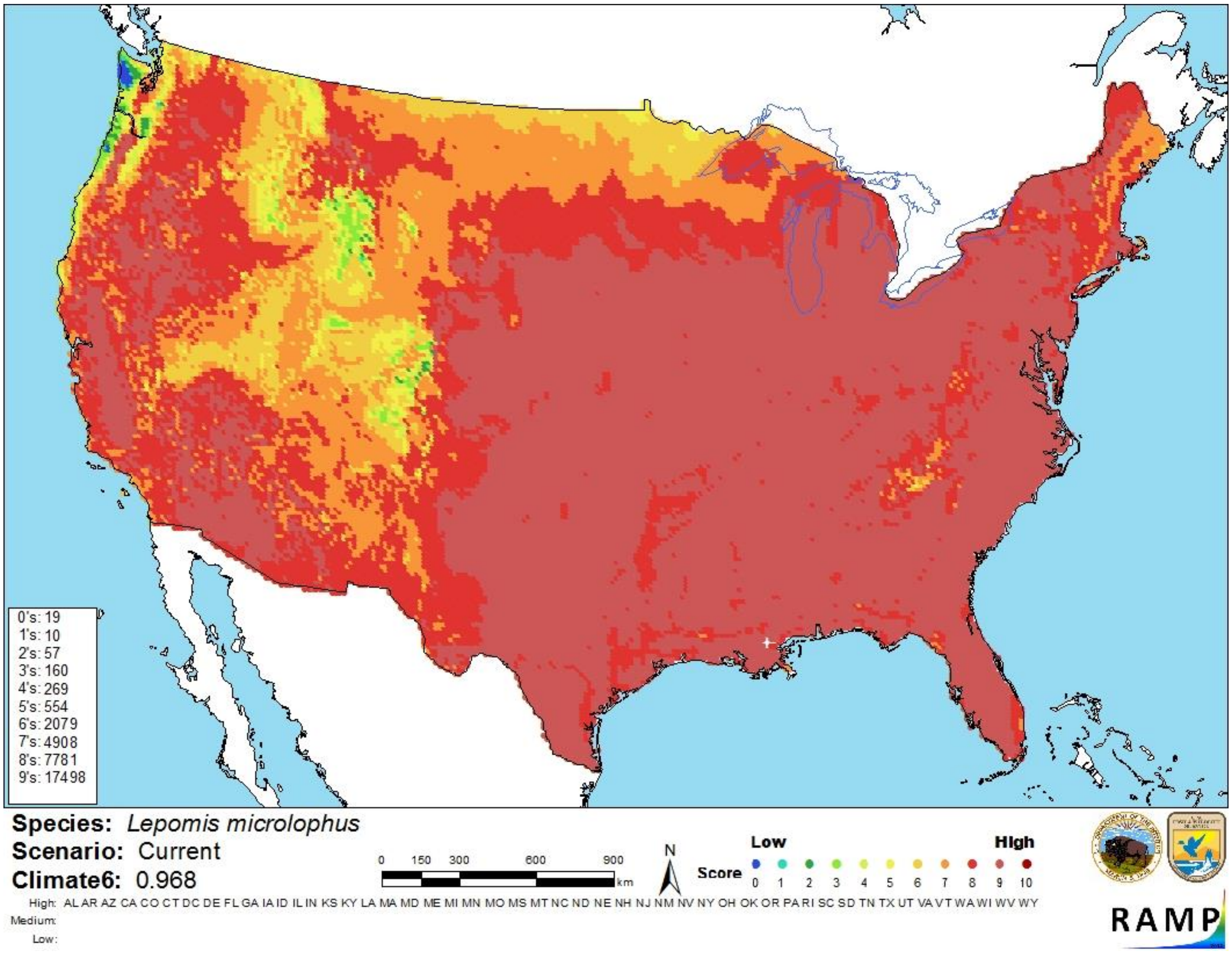

Figure 5. Map of RAMP (Sanders et al. 2014) climate matches for *Lepomis microlophus* in the contiguous United States based on source locations reported by Fuller et al. (2016), GBIF Secretariat (2016), and BISON (2017). 0 = Lowest match, 10 = Highest match.

The High, Medium, and Low Climate match Categories are based on the following table:

Climate 6: Proportion of (Sum of Climate Scores 6-10) / (Sum of total Climate Scores)	Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

7 Certainty of Assessment

The certainty of this assessment is high. There is an abundance of high quality ecological and biological information available for *Lepomis microlophus*. There are many well-documented instances of introductions that resulted in established populations and several well-documented studies demonstrating the negative ecological impacts of those populations.

8 Risk Assessment

Summary of Risk to the Contiguous United States

The native range of Redear Sunfish (*Lepomis microlophus*) is in the southeastern United States. *L. microlophus* is used in environmental contaminant studies. *L. microlophus* feeds on mollusks and gastropods and has been introduced as a biocontrol for mollusks and gastropods with mixed results. The history of invasiveness for *L. microlophus* is high. *L. microlophus* has been introduced as a game fish in much of the rest of the United States. There are multiple documented instances of introductions of *L. microlophus* becoming established populations and the negative impacts that resulted. It has been known to reduce the population of other native *Lepomis* species. The climate match is very high across the whole contiguous United States. The certainty of assessment is high. The overall risk assessment category is high.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): High**
- **Remarks/Important additional information No additional information.**
- **Overall Risk Assessment Category: High**

9 References

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