Blackfin Sucker (*Thoburnia atripinnis*) Species Status Assessment

June 15, 2017

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Executive Summary

This species status assessment describes the analytical process used by the U.S. Fish and Wildlife Service Kentucky Field Office to assess blackfin sucker viability. In this process we evaluated the three conservation biology principles of resiliency, representation, and redundancy (or the “3Rs”) as they pertain to the blackfin sucker.

We summarized the species ecological needs, at the individual, population, and species levels. The blackfin sucker is endemic to the Upper Barren River watershed where it typically occupies spaces under bedrock ledges, crevices, large rock slabs, and boulders in small streams dominated by bedrock substrates. We collected data from a variety of sources to create a database of blackfin sucker occurrence records. Collection records suggest the species is tolerant of a wide range of water quality and habitat conditions.

Streams with blackfin sucker records can be divided into 9 sub-basins separated by the area inundated by Barren River Lake. Recent records (2007-2016) support that the species is extant in 24 streams and likely extant in 3 streams across 9 sub-basins. There are 2 streams with historical records (pre-2007) to which we are assigning “unknown” status for the presence of the species. There are no streams in which we conclude that the species has been extirpated.

The major current stressors to the species are sedimentation and population fragmentation. The occurrence of the species may be affected by excess sedimentation, which can fill in the habitat that blackfin suckers use. Sedimentation originates from a variety of sources. Predominant sources of sedimentation in the Upper Barren River basin are agricultural activities that have been pervasive in the region for at least 150 years. Fragmentation and subsequent isolation of populations can result in decreased genetic diversity and a subsequent decreased ability of a species to adapt to changing conditions. The completion of the impoundment creating Barren River Lake in 1964 reduced the connectivity between the 9 sub-basins in which the blackfin sucker occurs. Although sedimentation and population fragmentation have been present in the range of the blackfin sucker for decades, the species has persisted. We do not expect these stressors or the blackfin sucker’s response to these stressors to change significantly in the future.

We evaluated the species based on the 3Rs. The persistence of the blackfin sucker throughout its historical range and in a variety conditions demonstrates a moderate to high resiliency. The blackfin sucker has a naturally-narrow geographic range; however, the species’ ability to persist across its range over time, suggests that it has the necessary genetic and ecological diversity to withstand changing environmental conditions. The species’ “extant” or “likely extant” status in 27 streams in 9 sub-basins provides a moderate to high level of redundancy to withstand catastrophic events. Our estimation of the species’ moderate to high resiliency, redundancy, and representation suggest that it has the ability to sustain its populations into the future (viability).

Table of Contents

1. Introduction, Analytical Framework, and Methods

This report summarizes the results of a species status assessment (SSA) conducted for the blackfin sucker (*Thoburnia atripinnis*). We, the U.S. Fish and Wildlife Service, were petitioned to list 404 aquatic, riparian, and wetland species, including the blackfin sucker, as endangered or threatened under the Endangered Species Act (ESA) on April 20, 2010, by the Center for Biological Diversity, Alabama River Alliance, Clinch Coalition, Dogwood Alliance, Gulf Restoration Network, Tennessee Forests Council, West Virginia Highlands Conservancy, Tierra Curry, and Noah Greenwald. In September of 2011, the Service found that the petition presented substantial scientific or commercial information indicating that listing may be warranted for 374 species, including the blackfin sucker. In accordance with the National Listing Workplan schedule, we have conducted an SSA to compile the best available data regarding the species' biology and factors that influence the species' viability. The SSA will be the biological underpinning of the Service's decision on whether blackfin sucker warrants protection under the ESA.

The SSA assesses the ability of the blackfin sucker to maintain its populations over time (*i.e.*, viability). To assess blackfin sucker viability, we used the three conservation biology principles of resiliency, representation, and redundancy (or the "3Rs"). These principles are generally described later in this chapter, and they are described more specifically for the blackfin sucker in section 2 (Species Ecology).

To assess the viability of the blackfin sucker, we first described the species' ecology in terms of the 3Rs. Specifically, we identified the ecological requirements for survival and reproduction at the individual, population, and species levels. We then assessed the current condition of the species using the ecological requirements previously identified. We evaluated the species' historical and current condition in relation to the 3Rs and identified past and ongoing factors affecting the species that led to the species' current condition. We predicted how those factors may change in the future, based on human population census data and anticipated land use trends, to assess the species' future condition.

Analytical Framework

As stated above, we used the 3 Rs of conservation biology to assess the viability of the blackfin sucker. Viability is the ability of a species to sustain its populations in the wild over a given period of time. Generally, the more resiliency, representation, and redundancy a species has, the more protected it is against the vagaries of the environment, the more it can tolerate stressors (one or more factors that may be acting on the species or its habitat, causing a negative effect), the better able it is to adapt to future changes, and thus, the longer it can persist over time. The 3Rs framework (assessing the health, number, and distribution of blackfin sucker populations relative to the frequency and magnitude of environmental stochasticity, catastrophic events, and exposure to stressors across its historical range) is useful for describing a species' degree of viability through time. Viability is not a single state – viable or not viable; rather, there are degrees of viability – less to more viable or low to high viability.

1.1 Resiliency

Resiliency is the ability of populations to withstand stochastic events. Resiliency is positively related to population size, growth rate, and fecundity and may be influenced by connectivity among populations. Generally, populations need sufficient numbers of individuals within habitats of adequate area and quality to maintain survival and reproduction in spite of disturbance.

1.2 Representation

Species-level representation is an indicator of the ability of a species to adapt to near and long-term changes in the environment (the evolutionary capacity or flexibility of a species). Representation is the range of variation found in a species. Representation can be measured through the breadth of adaptive diversity of a species. The greater the adaptive diversity, the more responsive and adaptable the species will be over time.

Maintaining adaptive diversity includes conserving both the phenotypic diversity and genetic diversity of a species. Phenotypic diversity is the physiological, ecological, and behavioral variation exhibited by a species across its range and genetic diversity is the number and frequency of unique alleles within and among populations. By maintaining these two sources of adaptive diversity across a species' range, the responsiveness and adaptability of a species over time is preserved.

In addition to preserving the breadth of adaptive diversity, maintaining evolutionary capacity requires maintaining the processes that drive evolution, namely, gene flow, genetic drift, and natural selection. Gene flow is expressed through the physical transfer of genes or alleles from one population to another through immigration and breeding. The presence or absence of gene flow can directly affect the size of the available gene pool. Gene flow will generally increase genetic variation within populations by bringing in new alleles from elsewhere, but decrease genetic variation among populations by mixing their gene pools (Hendry *et al.,* 2011). Genetic drift is the random change in the frequency of alleles in a population. Genetic drift always occurs, but its effects are typically more pronounced in smaller populations and populations that are isolated from one another. In these populations, genetic drift often results in lower genetic diversity. Natural selection is the process by which heritable traits can become more (selected for) or less (not selected for) common in a population based on the reproductive success of an individual with those traits. Natural selection influences the gene pool by determining which alleles are perpetuated in particular environments. This selection process generates the unique alleles and allelic frequencies that reflect specific ecological, physiological, and behavioral adaptations optimized for survival in different environments.

1.3 Redundancy

Species-level redundancy is an indicator of the ability of a species to withstand catastrophic events. Redundancy protects species against the unpredictable and highly consequential events for which adaptation is unlikely. In short, it is about spreading the risk. Generally speaking, redundancy is best achieved by having multiple populations widely distributed across the species' range. Having multiple populations reduces the likelihood that all populations are affected simultaneously, while having widely distributed populations reduces the likelihood of populations possessing similar vulnerabilities to a catastrophic event. Given sufficient redundancy, single or multiple catastrophic events are unlikely to cause the extinction of a species. Therefore, the greater redundancy a species has, the more viable it will be. Furthermore, the more populations and the more diverse or widespread that these populations are, the more likely it is that the adaptive diversity of the species will be preserved. Having multiple populations distributed across the range of the species will help preserve the breadth of adaptive diversity, and hence, the evolutionary flexibility of the species.

2. Species Ecology

In this chapter, we briefly describe the blackfin sucker's taxonomy and discuss the species' life history characteristics at the individual, population, and species levels. This information provides the ecological basis for the 3Rs analysis.

2.1 Species description

The blackfin sucker, *Thoburnia atripinnis* (Bailey), is a relatively small sucker (Family Catostomidae), with a maximum total length of about 140 mm (5.5 in.) (Timmons et al. 1983, p. 539). It has a distinctly-patterned body with two dark, brownish-black horizontal lines below the lateral line (a faint line of sense organs extending from the gill cover to the tail) and six or seven additional lines in the dorsolateral area, with intervening olive-gold stripes (Etnier and Starnes 1993, p. 287; Bailey 1959, p. 8-9) (Figure 1). The body surface ventral to (below) the lowest lateral stripe and the belly are white (Bailey 1959, p. 9). The dorsal (top of body), anal (single belly fin near the tail), and pelvic (paired belly fins near the head) fins are white; the dorsal fin has a conspicuous black blotch on the distal half of the anterior 5 or 6 rays (Etnier and Starnes 1993, p. 287; Bailey 1959, p. 8-9). The pectoral fins (paired side fins near the head) are pinkish olive (Bailey 1959, p. 9).

During the spawning season, breeding males exhibit nuptial tubercles (rounded projections or bumps) that are most pronounced on the anal and caudal fins and also occur on the pelvic fins (Bailey 1959, p. 9). Minute tubercles are distributed on the body and the head. (Bailey 1959, p. 9). Females exhibit minute tubercles on the snout, top of the head to the occiput (the back and top of the head), urosome (area posterior to the vent), and anal rays (rays of anal fin) (Bailey 1959, p. 9).

Figure 1. Left lateral view of a Blackfin Sucker. (Photo taken by Dr. Matthew Thomas, Kentucky Department of Fish and Wildlife Resources).

2.2 Taxonomy

This species was first described as *Moxostoma (Thoburnia) atripinne* (Bailey 1959, p.6) based on specimens collected in 1947 by Reeve M. Bailey and Norman J. Wilimovsky from Salt Lick Creek, Macon County, Tennessee. Several subsequent studies challenged the inclusion of *Thoburnia* within *Moxostoma*, asserting that it is more appropriately placed as a subgenus within *Hypentelium* or as its own distinct genus (Jenkins and Burkhead 1993, p. 484-485; Robins and Raney 1956; Jordan 1917, p.88). Recent genetic evaluations by Harris et al. (2002, p. 1444) supports removing *Thoburnia* from the tribe Moxostomatini and considering it a separate genus, *Thoburnia*, within the tribe Thoburniini. Harris et al. (2002, p. 1448) acknowledged that further studies are needed to fully understand the phylogenetic relationships of *Thoburnia* species.

The two other species assigned to the genus *Thoburnia*, *T. rhothoeca* and *T. hamiltoni*, are known from Virginia and West Virginia. They are physically more similar to each other than to *T. atripinnis*, exhibiting adaptations to swift water habitats (Bailey 1959, p. 16).

2.3 Genetics

There have been no genetic studies conducted on the blackfin sucker. Stringfield (2013, p.5) collected fin clips from each of the blackfin suckers collected during his survey; however, these tissues have not been analyzed.

2.4 Reproduction

Blackfin suckers are sexually mature by year three, if not earlier (Bailey 1959, p. 540); Timmons et al. (1983, p. 540) observed some males maturing in years one or two and did not observe any mature females prior to year three. Observations by Timmons et al. (1983, p. 540) and Bailey (1959, p. 16) indicate a spawning period of approximately March – April. Each gravid female contains an estimated 1,070-1,755 eggs, ranging in diameter from 1.7-2.5 mm (Timmons et al. 1983, p. 541).

2.5 Survival and Longevity

Based on observations by Bailey (1959, p. 541), Timmons et al. (1983, p. 540), and Stillings and Harrel (2010, p. 13), the blackfin sucker reaches a maximum age of five years. Timmons et al. (1983, p. 540) calculated a weighted mean standard length of 65.5 mm at the end of year one, 95.1 mm at the end of year two, 122.8 at the end of year three, and 137.4 at the end of year four. Stillings and Harrel (2010, p.13) reported similar results.

2.6 Habitat

Blackfin suckers inhabit clear headwater streams (Bailey 1959, p.16; Timmons et al. 1983, p. 538), generally ranging from 1.5 – 9 m in width and with flows ranging from 0.1 – 1.4 m^3/s (Timmons et al. 1983, p. 538). Blackfin suckers are typically observed near bedrock ledges, slabrock boulders, rootwads, and undercut banks in pools and slow runs (Figures 2 and 3) (Timmons et al. 1983, p. 538-540; Etnier and Starnes 1993, p. 287; Stringfield 2013, p.11). Stringfield (2013, p. 11), Stillings and Harrel (2010, pp. 14-15) and USFWS (2016, unpublished data) observed a strong association between adults and bedrock ledges, crevices, large rock slabs, and boulders (Fig. 2-3). Stringfield (2013, p. 11) reported that blackfin suckers were found in deeper water (43.9 ± 5.5 cm) than sites where the species was not found (28.9 ± 1.4 cm). Timmons et al. (1983, p. 538) observed schools of young-of-year blackfin suckers in pools with moderate current and shallower (0.3 – 1.0 m) than pools occupied by adults (1.0 – 1.5 m).

Reproductive males are associated with swift riffles (Bailey 1959, p. 16; Stillings and Harrell, 2010; p.11; Timmons et al. 1983, p. 540), where they occupy areas under or behind large rocks, several weeks before the females are ready to spawn (Timmons et al. 1983, p. 540). During spawning, the females occupy pools and are occasionally found under flat rocks at the edges of riffles (Timmons et al. 1983, p. 541).

Common associates of the blackfin sucker include bluntnose minnow (*Pimephales notatus*), rock bass (*Ambloplites rupestris*), bluegill (*Lepomis macrochirus*), and longear sunfish (*L. megalotis*) (Timmons et al. 1983, p. 540). Stillings and Harrell (2010, p. 12) found a positive correlation between the occurrence of blackfin suckers in the Barren River and the elegant madtom (*Noturus elegans*) and a negative correlation with the creek chub (*Semotilus atromaculatus*).

 

Figures 2 and 3: A bedrock ledge in Caney Creek (left) and boulders on bedrock in Boyds Creek (right) that represent typical blackfin sucker habitat.

2.7 Feeding Habits

Timmons et al. (1983, pp. 539-540) analyzed gut contents of blackfin suckers and found a variety of aquatic macroinvertebrates, including larval midges (Family Chironomidae), small crustaceans (cladocerans, copepods, ostracods), larval black flies (Family Simuliidae), larval fishflies and hellgrammites (Order Megaloptera) and larval caddisflies (Order Trichoptera). Midges comprised the largest proportion of any food item.

2.8 Movement Patterns and Home Range

We are unaware of any data pertaining to movement patterns or home ranges of the blackfin sucker.

3. Ecological Requisites

In this chapter we assess the ecological requisites at the individual, population, and species level. These requisites inform the analysis of resiliency, representation, and redundancy.

3.1 Individual-level ecology

Occurrence records indicate that the blackfin sucker is restricted to streams in small watersheds (watershed sizes at recent record sites range from 5.7 – 141.2 km^2 (2.2 – 54.5 mi^2)). Qualitative observations from researchers who have surveyed for the species indicate a close association between blackfin sucker occurrence and specific microhabitat features, especially bedrock ledges, slabrock substrates, and boulders, (Stillings and Harrel 2010, pp. 14-15; Stringfield 2013; USFWS 2016, unpublished data). Stringfield (2013, p. 13) speculated that the species may be limited by the availability of microhabitats, which are easily degraded by sedimentation. Bailey (1959, p. 17) observed blackfin suckers mostly in clear water. Stringfield (2013, p. 9) reported a slight negative correlation (20%) between sediment deposition and blackfin sucker catch-per-unit-effort. The species' water chemistry requirements are unknown, but blackfin suckers have been reported from streams with conductivity values ranging from 160 to 587 µS/cm, dissolved oxygen concentrations ranging from 3.07 – 14.3 mg/L, pH values ranging from 7.43 – 9.1, and temperatures ranging from 9.5 – 25.2^{o}C (Stillings and Harrel 2010, p. 29; Stringfield 2013, pp. 30-31; USFWS 2016, unpublished data).

The species has been reported from stream reaches that have been physically altered by channelization and bridge piers (Stringfield 2013, p. 11; USFWS 2016, unpublished data). Stringfield (2013, pp. 9, 14) noted that blackfin suckers were more abundant at sites in Tennessee than sites in Kentucky, and he speculated that this was because of the greater prevalence of agricultural land use (and associated stressors such as sediment) in Kentucky. Conversely, Hurak (2013, p. 16) reported no statistically significant correlation between blackfin sucker abundance and land use/cover (at a watershed level and within a 100m and a 390m buffer).

The species occupies habitats (e.g., bedrock ledges) that are likely susceptible to the effects of sedimentation, but our 2016 field observations (USFWS 2016, unpublished data) demonstrate that these habitats continue to be present in streams across its range, and the species has been able to persist in these streams despite these perceived stressors. No quantitative data is available with respect to the species' vulnerability to sedimentation.

3.2 Population-level ecology

Species viability is influenced by the resiliency of its populations. We do not have the necessary genetic or movement data to determine the number of populations for the blackfin sucker; but we can make some assumptions based on our understanding of the habitat needs of individuals. The streams with blackfin sucker records can be separated into ten sub-basins that drain directly into Barren River Lake (Figure 4). These sub-basins are at least partially isolated from each other by the impounded area of Barren River Lake. Some are separated by areas that are inundated only when the lake is full. Blackfin suckers may be able to travel between these sub-basins during fall or winter months when water levels drop in the reservoir. We expect that permanently inundated areas of the lake would present a more significant barrier between sub-basins. The greater the distance between these sub-basins, the more likely blackfin suckers in these sub-basins are to be isolated from each other. We have no data to support whether or not blackfin suckers within each of these sub-basins are interacting as a single population; they may be further isolated from each other to some degree within these sub-basins.

There have been no population ecology or viability studies to inform our understanding of the resiliency of different populations. The sub-basins referenced in the paragraph above range in size from several first order streams flowing directly into the lake (Boyds Creek, Walnut Creek, and Rhoden Creek) to the 868.7 km^2 (335.4 mi^2) Barren River / East Fork Barren River sub-basin comprising multiple streams (Table 3). It is likely that the larger sub-basins support larger and/or multiple populations of blackfin sucker compared to the smaller sub-basins. The quality and quantity of habitat within these sub-basins would also influence the number of individuals that comprise a population.

3.3 Species-level ecology

In addition to the lack of genetic data on the blackfin sucker, its phenotypic diversity has not been assessed. The species is endemic to the Upper Barren River basin in the Interior Low Plateau in six counties in Kentucky and Tennessee. Based on this naturally-narrow geographical range across latitudinal, longitudinal, climatic, and elevation gradients, the species is expected to have inherently low phenotypic and genetic diversity. Its naturally-narrow geographical range is expected to limit the blackfin sucker's ability to adapt to changing environmental conditions. The number of occupied streams across the species' range is important to its redundancy. This distribution is discussed in the following section.

4. Analysis of Historical and Current Conditions

In this section, we describe the historical and current conditions of the blackfin sucker. For the purposes of our analyses, the historical condition is the reference condition and provides the context for the current and future conditions. The historical condition is the baseline from which the current and future degrees of resiliency, representation, and redundancy are measured.

We reviewed all available occurrence data for the blackfin sucker. The data included peer-reviewed articles, unpublished survey reports, and survey records (1947 to present) contained in agency databases (Kentucky Department of Fish and Wildlife Resources (KDFWR), Kentucky State Nature Preserves Commission (KSNPC), Tennessee Department of Environment and Conservation (TDEC), and Tennessee Wildlife Resources Agency (TWRA)). Additionally, the Service funded two species-specific survey efforts (Stillings and Harrel 2010, Stringfield 2013) that investigated the species' distribution and status. In those studies, surveys were conducted at historical sites and new sites in the Upper Barren River basin. The Service conducted qualitative surveys in 2016 at several sites to further confirm the continued presence of the species in several streams.

We compiled all available species occurrence data from the above sources and created a geographic information system database. Where point data were available, they were included in

the database. Where point data were not available, we estimated the location of survey reaches based on the location description.
We excluded one historical record from our database: a 1982 record of the species from the Cumberland River, credited to Tennessee Valley Authority in the TWRA database. Because the Cumberland River is in a different HUC 4 watershed than the other blackfin sucker records, the species was only recorded there once, and no voucher specimen exists, we are assuming that this record was either a product of an accidental relocation of an individual (e.g., from a bait bucket) or a labelling or identification error. Therefore, we are not including the Cumberland River in the range of the blackfin sucker.

Over 95% of the historical records of the blackfin sucker are from tributaries that lie upstream of and currently flow into Barren River Lake. The following records were obtained from streams that flow into Barren River downstream of the dam:

- Unnamed tributary, West Bays Fork. There are two preserved specimens in the University of Alabama Ichthyology Collection collected by Boschung and Howell in 1963. The physical description of the location, “tributary to Barren River at US Hwy 31E 1 Mile north of Scottsville,” puts this record in the West Bays Fork drainage.
- Trammel Creek. The distributional maps for the blackfin sucker in *A Distributional Atlas of Kentucky Fishes* (Burr and Warren 1986) and *The Fishes of Tennessee* (Etnier and Starnes 1993), include a record (data point on map) of the species from Trammel Creek. The authors substantiated the species occurrence records included in their publications, but neither publication provides the source, year, or specific site for the data points.
- West Fork Drakes Creek. The distributional maps for the blackfin sucker in *A Distributional Atlas of Kentucky Fishes* (Burr and Warren 1986) and *The Fishes of Tennessee* (Etnier and Starnes 1993), include a record (data point on map) of the species from West Fork Drakes Creek. The authors substantiated the species occurrence records included in their publications, but neither publication provides the source, year, or specific site for the data points.
- West Fork Drakes Creek. The Kentucky Department of Fish and Wildlife Resources received documentation of a 1975 record from West Fork Drakes Creek provided to them from Kentucky State Nature Preserves Commission (KSNPC) in 2007; however, this record is no longer included in KSNPC’s database.

We are not aware of surveys designed to locate blackfin suckers in these drainages. The Kentucky Division of Water (KDOW) conducts fish community surveys at certain sites across the state, including several sites in these drainages. These surveys did not result in any incidental blackfin sucker records. Survey efforts by KDOW in the Drakes Creek and Bays Fork drainages are summarized in Table 1.

Table 1. Fish community surveys conducted by KDOW in the Drakes Creek and Bays Fork drainages (KDOW 2017).

	# of sites	# of surveys	Sampling period
Drakes Creek			
West Fork Drakes Creek	8	15	1984-2011
Thompson Branch	1	2	2007-2011
Lick Creek	1	6	1995-2007
Middle Fork Drakes Creek	2	2	2001
Sulphur Fork	1	1	2001
Trammel Fork	7	23	1984-2011
Little Trammel Creek	2	2	2001-2002
Bays Fork			
Bays Fork	1	1	2001
West Bays Fork	2	2	2002-2011

Based on our review of blackfin sucker records from these drainages, the species was present historically in some tributaries to the Barren River downstream of Barren River Lake and the species may still be present in some of those tributaries. We know nothing about the species' abundance in these tributaries, and we have limited information regarding the specific locations and collection years for these records. For these reasons, we are unable to discuss the change in the species' condition downstream of Barren River Lake; the current status of the species in these streams is unknown.

Because of uncertainties related to these records and the relative abundance of species records and recent survey efforts in tributaries upstream of Barren River Lake, the remainder of this SSA will focus on the species' distribution upstream of Barren River Lake. We consider tributaries upstream of the lake to represent the historical condition of the species from which we will evaluate its current condition.

4.1 Historical Condition

We used pre-2008 data to represent the historical condition of the blackfin sucker. Most historical records for the species originated from incidental catches during agency fish community studies. We are not aware of any historical comprehensive surveys that focused on the blackfin sucker. Based on our review of all available pre-2008 data, the species' historical range included 23 streams in the Upper Barren River basin (Figure 4).

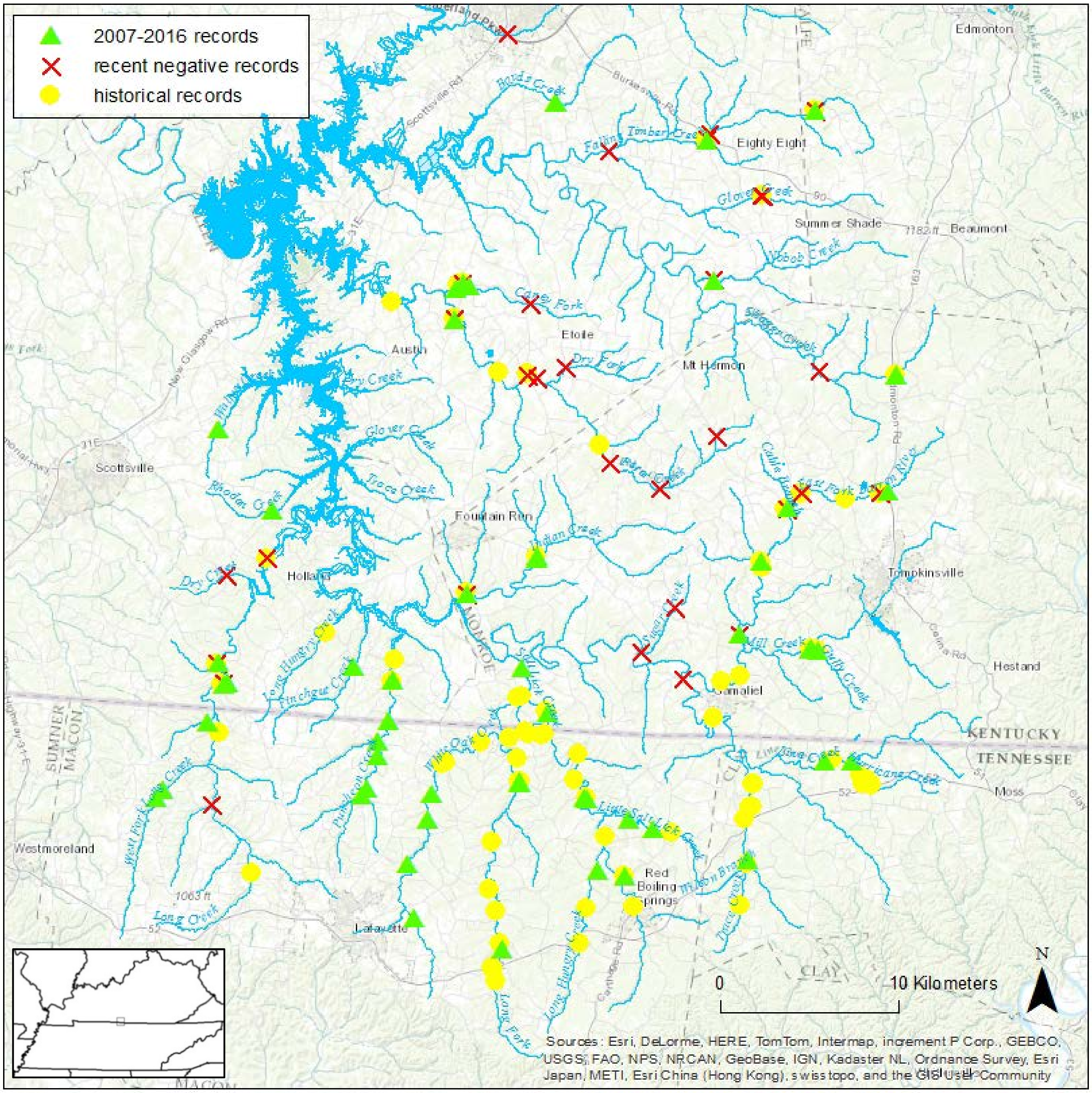

Figure 4. Blackfin sucker records in Kentucky and Tennessee. “Recent negative records” are from sites surveyed in three species-specific survey efforts (Stillings and Harrel 2010; Stringfield 2013; and USFWS 2016, unpublished data).

4.2 Current Condition

To represent the current condition of the blackfin sucker, we classified the species’ occurrence in each stream as “extant,” “likely extant,” or “unknown” (Table 2).

Table 2. Summary of occurrence ranks for the blackfin sucker.

Classification	**Criteria**
Extant	Date of last observation falls within 2008-2016.
Likely Extant	Date of last observation before 2008, but the species has been observed in the receiving stream within close proximity to the historical survey site from 2008-2016.
Unknown	Date of last observation before 2008 and recent surveys have produced negative results.

Streams with positive collection records (species observed) from 2008-2016 were assigned to the "extant" category. Ten years represents two generations of blackfin suckers, a time frame within which the species likely has persisted without significant changes in population. The Upper Barren River basin is rural and not densely populated. We are aware of no major disturbances over the last 10 years that would have significantly altered habitats throughout the watershed or rendered these streams unsuitable for the species.

The species was considered "likely extant" in small streams with historical records if recent records had been obtained from a nearby site in its receiving stream.

We ranked a stream as "unknown" if there were pre-2008 records, but no recent records had been obtained (despite recent surveys) and no information was available that suggested the species likely still occurred there. Because of the qualitative nature and limited scope of our surveys, we could not be certain that the species was extirpated from the stream.

Based upon our review of all historical and recent survey data, there are 29 streams with blackfin sucker records. We consider the species extant in 24 streams, likely extant in 3 streams, and of unknown status in 2 streams (Table 3, Fig. 5).

The 24 streams in which the species is considered "extant" had a positive collection record from at least one survey site in that stream. The recent species-specific surveys (Stillings and Harrel 2010; Stringfield 2013; USFWS 2016, unpublished data) were not designed to determine the extent of the stream that is occupied by the species. There are 37 negative records reported from those surveys; this includes streams or sites surveyed that have no historical records, and sites where the species was later found in a more recent survey. We expect some negative records because detection of the species is not perfect.

Peter Creek is the one stream where the species has not been recently confirmed at multiple historical sites. The only recent record from Peter Creek was from a site approximately 1.6 river km (1.3 river mi.) upstream of the confluence with Caney Fork, a tributary in which the species was also recently found. Despite recent survey effort, the species was not found at four other Peter Creek survey sites scattered across the 27.2 river km (16.9 river mi.) upstream. We do not have historical data indicating that the species was ever found in large numbers in Peter Creek. Stringfield (2013, p. 14) speculated that a scarcity of microhabitat may be limiting the blackfin sucker in Peter Creek.

Table 3. Blackfin sucker status in all streams of historical or recent occurrence in the upper Barren River Basin.

Sub-Basin	**Stream**	**Drainage Area (km^2(mi^2))**	**Status**	**County of Last Observation**
Boyds Creek	Boyds Creek	37.6(14.5)	extant	Barren, KY
Skaggs Creek	Skaggs Creek	380.7(147.0)	extant	Monroe, KY
	Falling Timber	154.6(59.7)	extant	Metcalfe, KY
	Glover Creek	58.8(22.7)	unknown	Barren, KY
	Nobob Creek	45.1(17.4)	extant	Barren, KY
Peter Creek	Peter Creek	178.7(69.0)	extant	Barren, KY
	Caney Fork	30.3(11.7)	extant	Barren, KY
Barren River	Indian Creek	87.8(33.9)	extant	Monroe, KY
	East Fork Barren River	211.3 (81.6)	extant	Monroe, KY
	Mill Creek	85.2(32.9)	extant	Monroe, KY
	Gully Creek	13.5(5.2)	extant	Monroe, KY
	Cable Branch	8.8(3.4)	likely extant	Monroe, KY
	Trace Creek	47.4(18.3)	extant	Clay, TN
	Line Creek	178.5(68.9)	extant	Clay, TN
	Wilson Branch	4.7(1.8)	likely extant	Clay, TN
	Hurricane Creek	20.2(7.8)	likely extant	Clay, TN
	Salt Lick Creek	138.8(52.8)	extant	Macon, TN
	Little Salt Lick Creek	21.8(8.4)	extant	Macon, TN
	Long Hungry Creek	36.3(14.0)	extant	Macon, TN
	Long Fork	85.5(33.0)	extant	Macon, TN
	White Oak Creek	307.0(118.5)	extant	Macon, TN
Puncheon Creek	Puncheon Creek	69.4(26.8)	extant	Allen, KY
Pinchgut Creek	Pinchgut Creek	18.4(7.1)	extant	Allen, KY
Long Hungry Creek	Long Hungry Creek	16.6(6.7)	unknown	Allen, KY
Long Creek	Long Creek	180.0(69.5)	extant	Macon, TN
	West Fork Long Creek	29.3(11.3)	extant	Macon, TN
	Hanging Rock Branch	9.1(3.5)	extant	Macon, TN
Rhoden Creek	Rhoden Creek	12.9(5.0)	extant	Allen, KY
Walnut Creek	Walnut Creek	10.9(4.2)	extant	Allen, KY

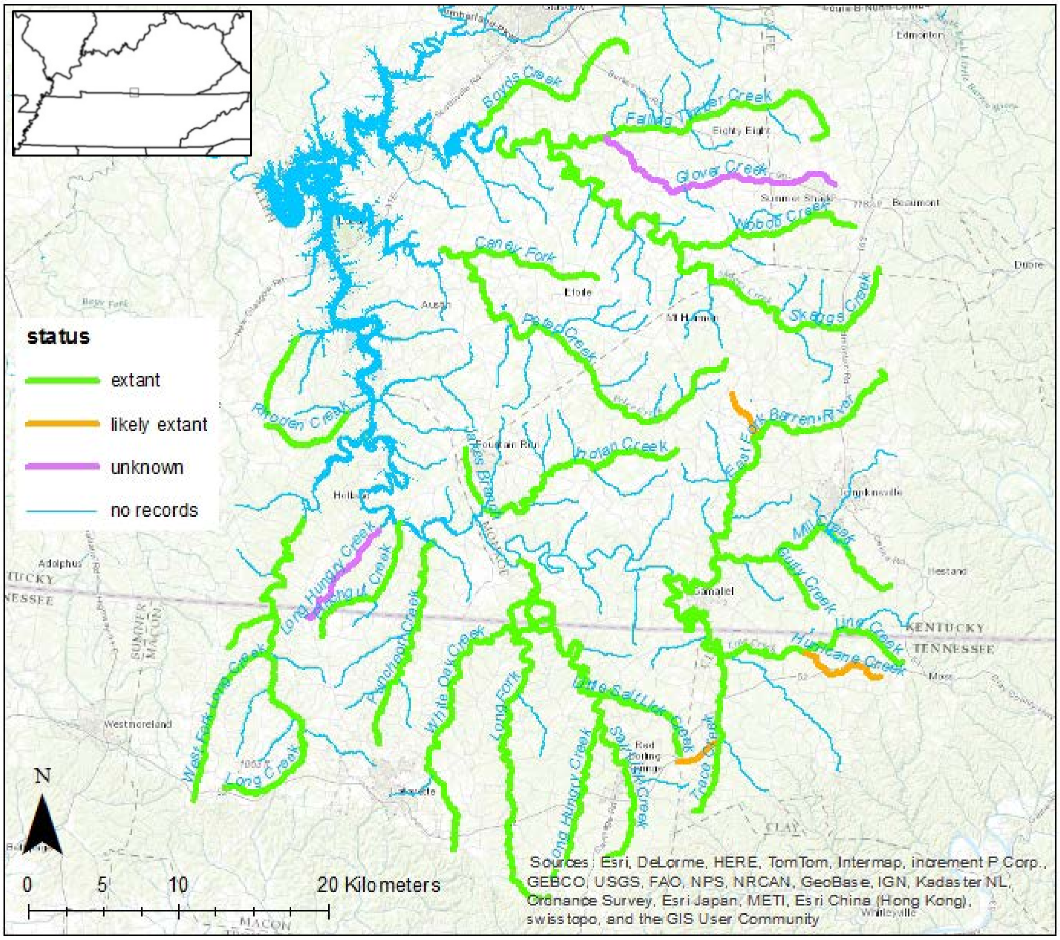

Figure 5. Status of the blackfin sucker in streams in the Upper Barren River basin.

The three streams in which the species is considered “likely extant” (Cable Branch, Wilson Branch, and Hurricane Creek) drain very small watersheds and may have never supported large or reproducing populations of the blackfin sucker. Historical records from these streams were obtained near their mouth, so it is likely that these individuals originated from the larger receiving stream where multiple individuals of the species have been observed. Because the species is considered to be extant in the receiving streams, we would expect the species to occasionally enter these smaller tributaries to feed or seek shelter.

We do not consider the species to be “extant” or “likely extant” in two historical streams: Long Hungry Creek (Allen County, KY) and Glover Creek. The species’ presence in Long Hungry Creek is based on a single 1980 record. We have no additional survey information from this stream, so we are considering its status to be “unknown.” Glover Creek is the only historical stream in which the species has not been observed despite recent surveys. The only historical record from Glover Creek was a single individual reported in 1979 (KSNPC). The species was not observed in Glover Creek during surveys completed between 2007 and 2016 (Stillings and Harrel 2010, p. 28; Stringfield 2013, p. 23; USFWS 2016, unpublished data). We have no information indicating that stressors in this watershed are more severe than in other watersheds where the species has persisted. USFWS (2016, unpublished data) concluded that suitable habitat is present, and chemical water quality parameters measured by Stillings (2010, p. 29), Stringfield (2013, p. 30), and USFWS (2016, unpublished data) were not dissimilar from other streams in which the species is currently present. While we cannot rule out the possibility of extirpation, we do not have sufficient data to support that conclusion. We have no survey data demonstrating that the species was ever present in Glover Creek in high numbers, and our most recent survey efforts were limited in scope. For all these reasons, we are considering the species' status in Glover Creek to be "unknown".

4.2.2 Sub-basin analysis

Table 4 presents a synopsis of recent blackfin sucker surveys (2008-2016) and is organized by stream and sub-basin. The status of the species within these sub-basins contributes to the species' resiliency. These surveys were undertaken to detect species presence, not to estimate population size.

Table 4. Summary of recent Blackfin sucker surveys (2008-2016). Streams are organized by sub-basin (in bold) and stream.

Stream	Location (River km (River mi.))	Watershed size (km^2(mi^2))	Collection Date	# Blackfin Suckers observed
Boyds Creek				
Boyd's Creek	7.6 (4.7)	19.9 (7.7)	2009[1]	10
			2011[2]	22
			2016[3]	15
Skaggs Creek				
Skaggs Creek	13.0 (8.1)	122.2 (47.2)	2009[1]	6
			2016[3]	17
Falling Timber Creek	10.9 (6.8)	58.5 (22.6)	2009[1]	1
Falling Timber Creek	18.0 (11.2)	17.6 (6.8)	2016[3]	3
Nobob Creek	1.3 (0.8)	45.6 (17.6)	2011[2]	1
Peter Creek				
Peter Creek	20.9 (13.0)	128.2 (49.5)	2009[1]	2
Caney Fork	1.3 (0.8)	29.3 (11.3)	2011[2]	18
			2011[2]	19
			2016[3]	12

Stream	Location (River km (River mi.))	Watershed size (km^2(mi^2))	Collection Date	# Blackfin Suckers observed
East Fork Barren River				
Indian Creek	1.1 (0.7)	80.0 (30.9)	2011[2]	1
Indian Creek	8.2 (5.1)	51.0 (19.7)	2011[2]	16
			2016[3]	4
East Fork Barren River	14.0 (8.7)	91.9 (35.5)	2009[1]	2
East Fork Barren River	18.2 (11.3)	65.3 (25.2)	2016[3]	5
East Fork Barren River	7.9 (4.9)	113.7 (43.9)	2011[2]	2
	15.8(25.2)	21.8(8.4)	2013[4]	P[*]
Mill Creek	4.7 (2.9)	54.4 (21.0)	2009[1]	6
			2011[2]	20
			2016[3]	16
Gully Creek	0.5 (0.3)	13.2 (5.1)	2009[4]	P[*]
Line Creek	21.1 (13.1)	54.1 (20.9)	2011[2]	10
			2011[2]	4
Trace Creek	6.0 (3.7)	29.8 (11.5)	2011[2]	27
			2016[3]	29
Salt Lick Creek	1.4 (0.9)	305.6 (118)	2009[1]	1
Salt Lick Creek	5.0 (3.1)	135.5 (52.3)	2009[1]	5
Salt Lick Creek	16.8 (10.3)	107.2 (41.4)	2011[2]	16
			2016[3]	10
Salt Lick Creek	24.0 (14.9)	38.8 (15.0)	2015[5]	8
Little Salt Lick Creek	1.9 (1.2)	16.8 (6.5)	2011[2]	36
Little Salt Lick Creek	3.9 (2.4)	14.5 (5.6)	2011[2]	14
Long Hungry Creek	1.3 (0.8)	33.7 (13.0)	2011[2]	7
Long Fork	8.2 (5.1)	76.7 (29.6)	2011[2]	2
			2016[3]	7
Long Fork	19.6 (12.2)	26.9 (10.4)	2011[2]	3
White Oak Creek	10.1 (6.3)	51.0 (19.7)	2011[2]	24
White Oak Creek	13.8 (8.6)	34.7 (13.4)	2010[6]	6
White Oak Creek	19.2 (11.9)	12.2 (4.7)	2011[2]	25
Puncheon Creek				
Puncheon Creek	3.5 (2.2)	64.0 (24.7)	2009[1]	1
			2016[3]	10
Puncheon Creek	6.1 (3.8)	49.2 (19.0)	2011[2]	3
Puncheon Creek	7.6 (4.7)	33.4 (12.9)	2011[2]	1
Puncheon Creek	8.7 (5.4)	29.3 (11.3)	2012[5]	P[*]
Puncheon Creek	11.3 (7.0)	23.6 (9.1)	2012[5]	P[*]
			2011[2]	8
Pinchgut Creek				
Pinchgut Creek	9.8 (6.1)	5.7 (2.2)	2011[2]	10
			2016[3]	8

Stream	Location (River km (River mi.))	Watershed size (km^2(mi^2))	Collection Date	# Blackfin Suckers observed
Long Creek				
Long Creek	17.9 (11.1)	141.2 (54.5)	2011[2]	1
Long Creek	19.6 (12.2)	130.3 (50.3)	2008[4]	P[*]
			2011[2]	2
Hanging Rock Branch	0.6 (0.4)	8.5 (3.3)	2008[7]	1
West Fork	3.7 (2.3)	20.7 (8.0)	2011[2]	24
			2016[3]	8
Rhoden Creek				
Rhoden Creek	4.7 (2.9)	11.7 (4.5)	2011[2]	9
Walnut Creek				
Walnut Creek	5.8 (3.6)	8.5 (3.3)	2011[2]	3

[1] Stillings and Harrel (2010). Date of record is listed as 2009; actual date may be 2009 or 2010.
[2] Stringfield (2013). Date of record is listed as 2011; actual date may be 2011 or 2012.
[3] USFWS (2016).
[4] KDFWR (2016).
[5] TWRA (2016).
[6] Johansen (2010).
[7] TDEC (2017).
[*] P = Indicates record of presence with no recorded number of individuals.

4.2.3 Population Health

For this assessment, the term “population” is used in a geographical context and is defined as all individuals of the species living in the streams contained in one sub-basin, separated from each other by Barren River Lake. It is reasonable to assume that there may be limited genetic exchange between individuals in these sub-basins, but we do not have behavioral information (movement data) or genetic data to support this assumption. Additionally, we have no data to support that all individuals within a sub-basin comprise a single population.

Available data cannot be used to estimate population size or quantitatively evaluate population viability within streams or sub-basins. Most of the recent distributional data for the species come from Stillings and Harrel (2010) and Stringfield (2013). Both of these studies were designed to determine the species presence (occupancy) at historical streams and to search for new locations. The survey data were also used to estimate the species’ relative abundance in and between sites. The surveys were not designed to estimate the population size in a particular stream. Observations by Stillings and Harrel (2010) and Stringfield (2013) expanded the range of the species to include six additional streams. This range expansion exemplifies the paucity of blackfin sucker historical survey data and demonstrates the limitations of past data in understanding the extent of the species’ historical occurrence.

The methodology used by Stringfield (2013, p. 5), Stillings and Harrel (2010, p. 6), and USFWS (2016, unpublished data) is similar enough to provide a rough comparison of the species' abundance between sites. The number of blackfin suckers observed at sites in those surveys ranged from 1 to 36 individuals with a median of 8 individuals (Table 3). Of the 45 fish species observed by Stringfield (2013, p. 11) across 41 sites, blackfin sucker was the sixth most abundant species. The catch-per-unit effort ranged from 0.025 to 1.080 blackfin suckers per minute in the Stringfield (2013) study (Hurak 2013, p. 29-30) and from 0.21 to 1.76 in USFWS surveys (2016, unpublished data). All three of the recent surveys observed multiple age classes (evidence of recruitment) (Stillings and Harrel 2010, p. 28; Stringfield 2013, p. 23; USFWS 2016, unpublished data). This qualitative analysis of the species' abundance, coupled with the species' extant or likely extant status in 27 of the 29 streams with historical records, indicates populations have persisted in the presence of co-occurring stressors (see Chapter 5 below), including agricultural activities and increased population isolation due to the Barren River Lake impoundment. The continuing persistence of these multiple populations indicates a sufficient level of resiliency to withstand stochastic events.

The blackfin sucker is extant in at least nine of the ten sub-basins from which it has been recorded. Its status is unknown in the remaining sub-basin, a small, 17.4 km^2 (6.7 mi^2) watershed. The blackfin sucker's occurrence in multiple sub-basins and streams indicates a moderately high redundancy.

5. Factors Affecting Individuals and the Species

In this chapter, we review the factors currently affecting the blackfin sucker. These factors can have negative, positive, or no influence on individual fitness, and ultimately, on population resiliency.

5.1 Habitat Loss

When stream reaches are impounded, the resulting lentic condition is unsuitable for species that require free-flowing stream habitats. The most significant impoundment in the upper Barren River basin flooded portions of the Barren River and its tributaries in 1964 to create the 4,087 hectare (10,100 acre) Barren River Lake (Kleber 1992, p. 531). Creation of the lake impounded stream reaches in all ten sub-basins with records of the species. Although we have very few records of the species prior to 1964, it is likely that the lake inundated stream reaches that were once occupied by the blackfin sucker, resulting in permanent habitat loss for the species. Since 1964, there have been no other significant instances of permanent habitat loss. Installation of small road culverts (Stillings and Harrel 2010, p. 14) and the mill dam on Pinchgut Creek (Stringfield 2013, p. 13) may have resulted in the loss of small stream reaches and/or may have resulted in habitat loss by severing connectivity.

5.2 Habitat Degradation

Agriculture is a dominant land use in the upper Barren River watershed. Major stressors associated with agricultural land use include loss or degradation of physical habitat attributes and water quality. Various agricultural activities are sources contributing to these stressors.

Physical manipulation of streams and floodplains occurred historically in the Upper Barren River basin when the land was first converted into agricultural use. Streams were channelized and relocated to one side of stream valleys, and forested valleys were cleared to provide space for livestock, hay production, or row crops. Channelization of streams dramatically alters channel dimensions, gradient, stream flow, and instream habitats, leading to channel instability and increased sedimentation (Allan and Castillo 2007, p. 327). Loss of riparian vegetation and canopy cover result in increased solar radiation, elevation of stream temperatures, loss of allochthonous (organic material originating from outside the channel) food material, and removal of submerged root systems that provide habitat for fish and macroinvertebrates (Allan 2004, p. 262; Hauer and Lamberti 2006, pp. 721–723; Minshall and Rugenski 2006, pp. 721–723).

KDOW (2015, p. 80) identified four pollution sources for the Green River Basin Management Area, which includes the Upper Barren River Basin: loss of riparian habitat, agriculture, channelization, and non-irrigated crop production. These interrelated sources are largely associated with agricultural activities and contribute to sedimentation in streams. Additionally, stormwater runoff from unpaved roads, all-terrain vehicle (ATV) trails, and driveways likely represents a significant but difficult to quantify source of sediment that impacts streams in the Upper Barren River drainage.

KDOW (2015, p. 83) identified sedimentation/siltation as one of the top three pollutants in the Green River Basin Management Area (BMA). The lack of riparian vegetation and increased water velocities resulting from channelized streams promote bank erosion and channel instability that introduces large quantities of sediment into stream channels. The addition of excess sediment can disrupt the dynamic equilibrium of channel width, depth, flow velocity, discharge, channel slope, roughness, sediment load, and sediment size that maintains stable channel morphology (Allan 2004, p. 262). Sedimentation can bury instream habitats (i.e., rock crevices and space under boulders) used by blackfin suckers for foraging, reproduction, and sheltering. Excess sediment has also been shown to damage and suffocate fish gills and eggs, larval fishes, bottom dwelling algae, and other organisms; reduce aquatic insect diversity and abundance; and, ultimately, negatively impact fish growth, survival, and reproduction (Berkman and Rabeni 1987, pp. 285–294; Waters 1995, pp. 5–7; Wood and Armitage 1997, pp. 211–212; Meyer and Sutherland 2005, pp. 2–3).

The other two of the top three pollutants in the Green River BMA are pathogens and nutrients/eutrophication. These two pollutants are commonly associated together and with sedimentation (KDOW 2015, p. 80). Fertilizer and pesticide run-off can contaminate streams near agricultural fields. Cattle in and near streams can add excess nutrients into the water and contribute to bank erosion. Stillings and Harrel (2010, p. 14) and USFWS (2016, unpublished data) noted the presence of cattle at sites.

No blackfin sucker streams have been included on Kentucky's 303(d) list (KDOW 2015). Eaton Branch, a 1.9 mi long tributary to Nobob Creek, a blackfin sucker stream, is on the list for "Nutrient/Eutrophication Biological Indicators" and "Sedimentation/Siltation" as a result of "Agriculture," "Loss of Riparian Habitat," and "Streambank Modifications/destabilization." In Tennessee, White Oak Creek is listed on the 303(d) list for "alteration in stream-side or littoral vegetation," "Nitrate + nitrite," "total phosphorus," and "*E. Coli*" from "municipal point source" and "urbanized high density area" (TDEC 2016a, p.11). KDOW (2015, pp. 36-38) has recognized portions of three blackfin sucker streams (Caney Fork, Falling Timber Creek, and Peter Creek) as Kentucky reference reaches, representing the state's least impacted streams. The headwaters of Long Fork and a few small unnamed tributaries to Long Fork are designated "exceptional Tennessee waters" (TDEC 2016b).

The blackfin sucker's tolerance to habitat degradation is unknown. Stringfield (2013, p. 9) found a slight (20%) negative correlation between blackfin sucker abundance and sediment deposition. Stringfield (2013, p. 14) speculated that the blackfin sucker is limited by available suitable microhabitats (e.g., bedrock ledges) based on comparisons of species occurrence and habitat conditions in Caney Fork versus Peter Creek. The range of values for physicochemical properties in blackfin sucker streams is summarized in section 3.1 (Individual-level Ecology) and indicates that the species is tolerant of a wide range of conditions.

5.3 Collection

There is no evidence that the blackfin sucker is utilized for commercial, recreational, scientific, or educational purposes. Individuals may be collected occasionally in minnow traps and used as live bait, but we have no information indicating that this activity occurs with high frequency.

5.4 Disease

Blackfin suckers are the only identified host species for *Dactylogyrus atripinnei*, a species of gill fluke discovered and described by Timmons and Rogers (1977). The parasite was observed on gills of blackfin suckers in Hurricane Creek. We are unaware of any additional records of this parasite or what effect it has on the blackfin sucker.

5.5 Predation

The blackfin sucker is undoubtedly consumed by predators. Several native predators in the upper Barren River system include fishes such as smallmouth bass (*Micropterus dolomieu*), spotted bass (*Micropterus punctulatus*), and rock bass (*Ambloplites rupestris*), and wading birds such as the great blue heron (*Ardea herodias*). Blackfin suckers have evolved with these native predators, and predation by these species is a natural part of the species' ecology.

Predation pressure could increase with the introduction of new predator species. The KDFWR has historically stocked non-native rainbow trout (*Oncorhynchus mykiss*) in Peter Creek from Barren River Lake upstream to near Dry Fork. While they may prey on blackfin suckers, introduced trout would only be present during the colder months and would not persist in this region without a stocking regime. The KDFWR is not currently stocking rainbow trout within the upper Barren River basin (KDFWR 2017). The KDFWR stocked walleye (*Sander vitreus*) in the Barren River above Barren River Lake from 2007 to 2014 with the intention of establishing self-sustaining population (KDFWR 2014, p. 4). Walleye was historically present in the Barren River; the strain used in the re-introductions is genetically-distinct and native to the Rockcastle River in Kentucky (KDFWR 2014, 2-4).

Because the species is adapted to living with native predators and the influence of introduced predators is minimal, predation does not likely have a significant effect on blackfin sucker populations.

5.6 Genetic Isolation

The blackfin sucker occurs in small populations across a limited geographic range. The creation of Barren River Lake disrupted the connectivity between the ten sub-basins in which the blackfin sucker has been recorded. Smaller barriers, like the mill dam on Pinchgut Creek (Stringfield 2013, p. 13) and road culverts (Stillings and Harrel 2010, p. 14), impede or sever the connectivity of blackfin sucker within these sub-basins. Because of their occurrence in headwater streams (second- to third-order), the blackfin sucker may have been naturally isolated within the upper Barren River basin, occurring in widely scattered upstream reaches or watersheds that were separated from one another by larger stream reaches. However, it is likely that these larger streams served as occasional connecting corridors for the species. Isolation between occupied stream systems would have increased after the creation of Barren River Lake, significantly reducing, or possibly severing, connectivity between the ten sub-basins.

This isolation leaves the species vulnerable to localized extirpations from intentional or accidental toxic chemical spills (e.g., accidents involving vehicles transporting chemicals over road crossings of streams, release of chemicals used in agricultural or residential applications), habitat modification, progressive degradation from runoff (non-point source pollutants), natural catastrophic changes to their habitat (e.g., flood scour, drought), decreased fitness from reduced genetic diversity, and other stochastic disturbances. The level of isolation seen in the blackfin sucker would make natural repopulation following extirpation from a sub-basin extremely unlikely without human intervention.

In addition to specific events, species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression, decreasing their ability to adapt to environmental changes, and reducing the fitness of individuals (Soulé 1980, pp. 157–158; Hunter 2002, pp. 97–101; Allendorf and Luikart 2007, pp. 117–146). The long-term viability of a species is founded on the conservation of numerous local populations throughout its geographic range (Harris 1984, pp. 93–104). These separate populations are essential for the species to recover and adapt to environmental change (Harris 1984, pp. 93–104; Noss and Cooperrider 1994, pp. 264–297). We have no genetic data specific to the blackfin sucker, but studies on other species of fishes have revealed decreased genetic diversity within small, isolated fish populations (Johansen and Cashner 2016). The persistence of the blackfin sucker across its range, following the 1964 construction of Barren River Lake, suggests that the species has the genetic diversity to withstand environmental change.

5.7 Climate Change

The Intergovernmental Panel on Climate Change (IPCC) concluded that warming of the climate system is unequivocal (IPCC 2014, p. 3). Numerous long-term climate changes have been observed including changes in arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves, and the intensity of tropical cyclones (IPCC 2014, p. 4). Climate change has the potential to increase the vulnerability of the blackfin sucker to catastrophic events (McLaughlin et al. 2002, pp. 6060–6074; Thomas et al. 2004, pp. 145–148).
According to Kaushal et al. (2010, p. 465), stream temperatures in the Southeast have increased roughly 0.2–0.4^{o}C (0.4–0.7^{o}F) per decade over the past 30 years, and as air temperature is a strong predictor of water temperature, stream temperatures are expected to continue to rise. Species that are dependent on specialized habitat types, limited in distribution, or at the extreme periphery of their range may be most susceptible to the impacts of climate change (75 FR 48896, August 12, 2010, p. 48911).

5.8 State Status

State status provides some conservation benefits to the species. The blackfin sucker does have state listing status in the two states in which the species occurs: Kentucky and Tennessee.

Kentucky

The blackfin sucker has been identified as a Species of Greatest Conservation Need (SGCN) in the Kentucky State Wildlife Action Plan (KSWAP) (KDFWR 2013) and a species of special concern by KSNPC (2014, p. 43), but these state designations convey no legal protection for the species or its habitat. Kentucky law prohibits the collection of the blackfin sucker (or other fishes) for scientific purposes without a valid state-issued collecting permit (KRS § 150.183). Enforcement of this permit requirement is difficult, but these activities are a minimal threat to the species. Persons who hold a valid Kentucky fishing license (obtained from KDFWR) are allowed to collect up to 500 minnows per day (a minnow is defined as any non-game fish less than 6 inches in length, with the exception of federally listed species) (301 KAR 1:130, § 1(3)). This regulation allows for the capture, holding, and potential use of the blackfin sucker as a bait species; however, these activities are practiced infrequently and are not likely a substantial threat to the species.

The Wildlife Action Plan (KDFWR 2013) identifies conservation issues (threats), conservation actions, and monitoring strategies for 251 animal species belonging to one of 20 terrestrial and aquatic habitat guilds (collection of species that occur in the same habitat). The blackfin sucker belongs to the “upland streams in pools” guild. To fully understand these conservation issues, the KDFWR developed a priority list of research and survey needs for Kentucky’s SGCN. Seven conservation actions were developed for the species’ habitat guild: (1) the creation of financial incentives to protect riparian corridors and watersheds, (2) acquisition and conservation easements of critical aquatic habitat, (3) encouragement and assistance in developing and implementing best management practices, (4) restoration of degraded habitats, (5) coordination and implementation of existing Farm Bill programs or other Federal incentive programs, (6) education of user groups on significance and importance of riparian corridors and watersheds, and (7) development and initiation of local watershed improvement projects.

Tennessee

The blackfin sucker has been identified as a species "Deemed in Need of Management" in the Tennessee State Wildlife Action Plan (TSWAP) (TWRA 2005, p. 48), and the species has been designated as a species "Deemed in Need of Management" (analogous to Special Concern) in Tennessee (TDEC 2016c, p. 78). Under the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 (Tennessee Code Annotated §§ 70-8-101-112): "[I]t is unlawful for any person to take, attempt to take, possess, transport, export, process, sell or offer for sale or ship nongame wildlife, or for any common or contract carrier knowingly to transport or receive for shipment nongame wildlife." Further, regulations included in the Tennessee Wildlife Resources Commission Proclamation 00-14 (Wildlife in Need of Management) (1) prohibit the knowing destruction of habitat of designated species without authorization and (2) provide circumstances for which permits can be given to take, posses, transport, export, ship, remove, capture, or destroy a designated species.

The TSWAP incorporates an integrated geographic information system (GIS) model based on the best available wildlife distribution data and comprehensive habitat classification systems and maps. It identifies sources of stress, conservation priorities, and conservation actions for 664 animal species. Under the TSWAP, the blackfin sucker is placed in the aquatic environment group. For this group, the TSWAP identifies 11 statewide-universal conservation actions (universal = linked to almost every problem), 36 statewide conservation actions, 9 regional-universal conservation actions, and 33 regional conservation actions that are linked to appropriate sources of stress.

5.9 Habitat Protection

The blackfin sucker and its habitats are afforded some protection from water quality and habitat degradation under the Federal Water Pollution Control Act of 1977, commonly referred to as the Clean Water Act (33 U.S.C. 1251 *et seq.*); Kentucky's Forest Conservation Act of 1998 (KRS §§149.330–355); Kentucky's Agriculture Water Quality Act of 1994 (KRS §§ 224.71–140), additional Kentucky statutes and regulations regarding natural resources and environmental protection (KRS §§ 146.200–360; KRS § 224; 401 KAR §§ 5:026, 5:031), and Tennessee's Water Quality Control Act of 1977 (T.C.A. 69–3–101). While it is clear that the protections afforded by these statutes and regulations have not prevented the degradation of some habitats used by the blackfin sucker, the species has undoubtedly benefited from improvements in water quality and habitat conditions stemming from these regulatory mechanisms.

The state statute that is perhaps the most relevant to the sources of stressors in the upper Barren river basin is the Kentucky's Agriculture Water Quality Act of 1994 (KRS §§ 224.71–140). This Act was developed to protect surface water and groundwater resources from agricultural and silvicultural activities. It requires all landowners with 10 or more acres used for agriculture or silviculture operations to develop and implement a water quality plan that incorporates BMPs listed in the Plan from six specified areas: silviculture, pesticides and fertilizers, farmstead, crops, livestock, and streams and other waters.

6. Analysis of Future Conditions

The intent of this analysis is to predict the persistence of blackfin sucker populations in the future to inform us of the viability of the species. Our ability to predict is limited because of the lack of population and genetic data and our uncertainty about how populations respond to stressors. Thus, our analysis will be limited to a discussion of future changes in stressors to the species, both the addition of new stressors and changes in the existing stressors.

6.1 Habitat Loss

As explained in the previous section, creating Barren River Lake in 1964 likely inundated a significant portion of the habitat for the species. This loss is the permanent result of a one-time event. We have no information indicating that such a significant habitat loss is likely to occur in the future.

6.2 Habitat Degradation

Agriculture has been the dominant land use in the counties comprising the upper Barren River basin for over 150 years. Major stressors associated with these activities are largely the ongoing results of the historical land conversion (e.g., increased sedimentation) and are, therefore, not expected to change in nature, intensity, or magnitude in the future. The decrease in the number of acres classified as farms in 2007 compared to 1910 (U.S. Department of Agriculture, 2014) indicates that stressors from ongoing agricultural activities have likely decreased (Table 5).[1] Based on this information, we do not expect the stressors associated with the operation of agricultural activities to significantly increase in magnitude or change in nature in the future. This decrease in land classified as farms appears to be a shift from high-intensity agricultural activities, to lower intensity agricultural activities (*i.e.*, small family farms) and passive land uses (*e.g.*, hunting).

[1] In the 1910 census, land was considered a "farm" if it was greater than three acres or produced at least $250. In 2010, land was considered a "farm" if it produced at least $1,000.

Table 5. Number of acres of land in farms in 1910 (U.S. Department of Commerce and Labor, 1913) compared to 2012 (U.S. Department of Agriculture, 2014) for counties in which the blackfin sucker occurs.

	Land in Farms 1910 (acres)	Land in Farms 2012 (acres)	% change
Allen County, KY	204,681	145,691	-29
Barren County, KY	297,893	248,663	-16
Clay County, TN	155,832	79,745	-49
Macon County, TN	184,963	121,860	-34
Metcalf County, KY	165,833	125,293	-24
Monroe County, KY	204,275	172,276	-16

Development (e.g., construction of new transportation, residential, commercial infrastructure) is a major contributor to habitat degradation in many areas, but does not appear to be a major stressor in the Upper Barren River basin. While much of the country is experiencing population growth that drives these development pressures, the human population change in much of the Upper Barren river basin has been small or negative (Figure 6). A few areas are experiencing positive population growth that exceeds the overall growth rate of the state, 7.3% in Kentucky and 11.5% in Tennessee. These are the areas near Glasgow and Scottsville, Kentucky and Lafayette, Tennessee. Although they have experienced relatively high growth rates recently, the 2010 populations of these small towns remain relatively low: 14,028; 4,474; and 4,226; respectively (U.S. Census Bureau 2010). Based on this information, we do not expect the stressors associated with development activities to significantly increase in magnitude or change in nature in the future.

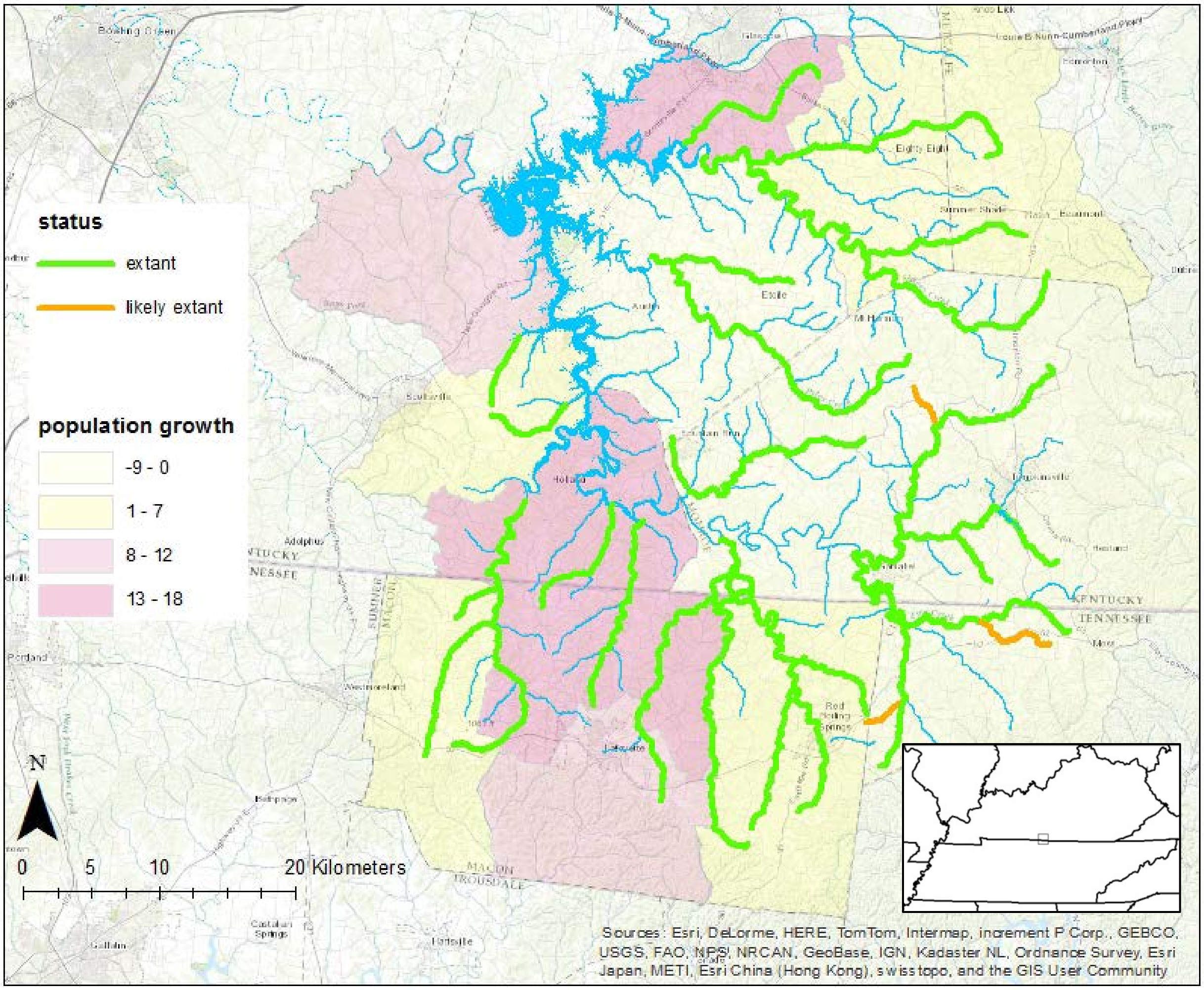

Figure 6. Percent population growth from 2000-2010 in census tracts in the range of the blackfin sucker (U.S. Census 2000; U.S. Census 2010).

6.3 Collection

We have no information that collection of blackfin suckers is currently a significant threat to the species or that it will become a significant threat in the future.

6.4 Disease

The only information that we have about diseases relative to the blackfin sucker is the paper by Timmons and Rogers (1977) about the gill fluke, *Dactylogyrus atripinnis*.We have no information indicating the range of the gill fluke or the past, present, or future severity of this threat to the species.

6.5 Predation

Though blackfin suckers are likely preyed upon by various native and nonnative species, we have no evidence suggesting that this threat is likely to increase in severity in the future.

6.6 Genetic Isolation

We do not expect the physical isolation of blackfin sucker populations to change significantly in the future. While new smaller features, such as culverts, may impede habitat connectivity to some degree, the greatest source of genetic isolation to the blackfin sucker is the habitat fragmentation created by Barren River Lake. The conditions created by the lake have been acting on the species since completion of the dam in 1964. Though the degree of isolation will remain the same in the future, the effects of the resulting genetic isolation have the potential to become more pronounced over time. Specifically, genetic drift and inbreeding depression may cause a loss of heterozygosity and allele diversity, especially in the smaller populations (Allendorf and Luikart 2007, p. 117-142). This loss of representation through decreased genetic diversity can reduce the fecundity of the population and render it less resistant to diseases and less adaptable to changing environmental conditions (Allendorf and Luikart 2007, p. 117-142; Soulé 1980, p. 162). This would decrease the ability of blackfin sucker population to persist over time. A loss of one or more populations would reduce the redundancy, and ultimately, the viability of the species. This stressor would be most severe in sub-basins with fewer blackfin suckers and in the sub-basins that are more isolated from other sub-basins.

It is likely that the creation of the dam has already resulted in some loss of genetic diversity of the species, however, without knowing the current genetic diversity within blackfin sucker populations and the genetic diversity before the creation of the dam, we do not know at what rate this loss is occurring (if any). The continued persistence of the species in nine of the ten sub-basins with historical records (the species' status in one sub-basin is unknown) indicates that genetic diversity has provided sufficient representation to maintain viability of the species. However, we do not have data to inform future projections of the viability of the species based on its genetic diversity.

6.7 Climate Change

An increase in both severity and variation in climate patterns is expected, with extreme floods, strong storms, and droughts becoming more common (Cook et al. 2004, pp. 1015–1018; Ford et al. 2011, p. 2065; IPCC 2014, pp. 58–83). Estimates of the effects of climate change using available climate models typically lack the geographic precision needed to predict the magnitude of effects at a scale small enough to discretely apply to the range of a given species. However, data on recent trends and predicted changes for Kentucky (Girvetz et al. 2009, pp. 1–19) and for specific counties (Adler and Hostetler 2013, entire) provide some insight for evaluating the potential impacts of climate change to the blackfin sucker. These models provide estimates of average annual increases in maximum and minimum temperature, precipitation, snowfall, and other variables. The mean of the various models used predicts an 4.9C (8.8^{o}F) increase in the annual mean maximum temperature for Allen County, Kentucky by the 2075-2099 time period (Girvetz et al. 2009, pp. 1–19; Adler and Hostetler 2013, pp. 1–9). The mean of the precipitation models predicts a 0.51 cm/month (0.2 in/month) increase in precipitation for that same time period (Girvetz et al. 2009, pp. 1–19; Adler and Hostetler 2013, pp. 1–9). Thomas et al. (2004, pp. 145–148) report that frequency, duration, and intensity of droughts are likely to increase in the Southeast as a result of global climate change.

Predicted impacts of climate change on fishes include disruption to their physiology (such as temperature tolerance, dissolved oxygen needs, and metabolic rates), life history (such as timing of reproduction, growth rate), and distribution (range shifts, migration of new predators) (Jackson and Mandrak 2002, pp. 89–98; Heino et al. 2009, pp. 41–51; Strayer and Dudgeon 2010, pp. 350–351; Comte et al. 2013, pp. 627–636). Low species representation due to a decreased genetic diversity (discussed under the previous heading) would inhibit the blackfin sucker's ability to adapt to the effects of climate change. The blackfin sucker has persisted in spite of changing habitat conditions when land in its range was converted for agricultural uses; this demonstrates the species' ability to adapt to some level of change. While continued change is certain, the effect it would have on the blackfin sucker and the ability of the blackfin sucker to adapt to the change is unknown.

7. Synthesis

This chapter is intended to synthesize the results from our historical, current, and future analyses, and discuss the future viability of the blackfin sucker. As discussed in the sections above, the qualitative nature of the available data limits our ability to evaluate changes in blackfin sucker populations over time and to predict the species' response to various stressors. However, species occurrence records over an extended period of time (1947 – 2016) and corresponding estimates of abundance allow us to make some inferences about the species' redundancy, resiliency and representation.

We consider the species to be "extant" or "likely extant" in 27 of 29 streams with previous collection records, and we consider the species to be "extant" in nine of the ten sub-basins with historical records. We consider the species' status to be "unknown" in the remaining two streams and one sub-basin. We cannot conclude that the species is extirpated from any portion of its historical range.

We discussed sources of stressors to the species in the Upper Barren River basin. We considered the most significant of these to be habitat fragmentation from the creation of Barren River Lake in 1964 and agricultural activities that have been occurring in the basin for over 150 years. We have no data indicating that populations of the species have experienced declines in response to stressors from these sources. The persistence of the blackfin sucker across its range demonstrates that these stressors have had no overall negative effect on the species' populations or decreased the species' viability over time.

Climate change and genetic isolation from habitat fragmentation are the two stressors for which we anticipate possible increased responses by the species in the future; however, we cannot predict when or if those responses would result in a change in the species' viability.

Overall, we estimate the blackfin sucker's resiliency and redundancy as moderate to high. Our estimate of resiliency is based on the relatively high abundance of blackfin suckers observed in multiple streams during recent (2007-2016) surveys (observations ranging from 1 to 36, with a median of 8). The species' resiliency was further demonstrated by the presence of multiple age classes (evidence of recruitment) at many collection sites. All of these observations suggest that there are multiple, self-sustaining, moderately large populations across the species range. Our moderate to high estimate of redundancy is based on the species' relatively high number of occupied streams (27) that are distributed across nine separate sub-basins in the upper Barren River watershed. These streams provide a margin of safety for the species to reduce the risk of extirpation from a single catastrophic event. Representation can be measured through genetic diversity within and among populations and the ecological diversity of populations across the species' range. No information is available on genetics of the blackfin sucker; however, the species has demonstrated an ability to persist across its range over time, suggesting it has the necessary genetic and ecological diversity to withstand changing environmental conditions within the upper Barren River basin. Our estimation of the species' moderate to high resiliency, redundancy, and representation suggest that it has the ability to sustain its populations into the future (viability).

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