

## Supplementary File Southeastern Naturalist

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## **Appendix 1**

### **Blackside Dace *Phoxinus cumberlandensis***

#### **Species Account and Cumberland Habitat Conservation Plan (HCP) Survey Results**

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*This document was created during the development phase of the Cumberland HCP. Specific species surveys were sent electronically and manually to experts on blackside dace. Fifteen experts completed the surveys and are referenced in this document by BD1-BD15. Results of the surveys are discussed in both sections of this document.*

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## SECTION I: SPECIES ACCOUNT

### ***Taxonomic Status***

The blackside dace, *Phoxinus cumberlandensis*, is a small member of the minnow family (Cyprinidae), reaching a maximum total length of approximately 85 mm (Etnier and Starnes 1993; H.T. Mattingly, personal observation, Tennessee Technological University 2007). The species was probably first observed in 1883 by D. S. Jordan and J. Swain in Clear Fork tributaries, Whitley County, Kentucky (based on the color description), but they regarded it as a color variation of the southern redbelly dace, *P. erythrogaster* (Starnes and Starnes 1978). Not until 1978 was the species recognized as a distinct species and scientifically described (Starnes and Starnes 1978). The blackside dace is one of seven North American species in *Phoxinus*, the only cyprinid genus shared with Eurasia, including *P. eos*, *P. erythrogaster*, *P. neogaeus*, *P. oreas*, *P. saylori*, and *P. tennesseensis*, (Etnier and Starnes 1993, Skelton 2001). Based on morphology and osteology, the mountain redbelly dace (*P. oreas*), found on the Atlantic slope of Virginia and North Carolina as well as in the upper Tennessee drainage, is the closest relative of *P. cumberlandensis* (Starnes and Starnes 1978).

### ***Conservation Status***

The blackside dace was listed as “threatened” by the U.S. Fish and Wildlife Service on June 12, 1987 (52 FR 22580-22585; USFWS 1988). Critical habitat was not designated for blackside dace at the time of listing in 1987 because USFWS determined that designation of critical habitat was not prudent for the species at that time. The Service believed that the designation and publication of critical habitat areas would increase the species’ vulnerability to illegal taking and/or vandalism, further threaten the species, and increase law enforcement problems. Protection of the species’ habitat could be accomplished without a critical habitat designation by notifying all appropriate local, state, and federal agencies and governmental officials about specific habitat locations. Additional protection of the species’ habitat would be addressed through the recovery process and the Endangered Species Act (Section 7) consultation process. There are no experimental populations designated for this species. The blackside dace is ranked as “vulnerable” on the most recent IUCN Red List 2007 (<http://www.iucnredlist.org/>).

This species is globally ranked as G2, which means that it is very rare and imperiled within the world, six to twenty occurrences, or few remaining individuals, or because of some factor(s) making it vulnerable to extinction. It is ranked in the state of Tennessee and Kentucky as S2, indicating it is very rare and imperiled within the state, six to twenty occurrences, or few remaining individuals, or because of some factor(s) making it vulnerable to extinction. Both of these rankings are based on a scale of G1-G5 or S1-S5, with the lowest number representing the most imperiled rank (NatureServe 2007).

### ***Identification***

The blackside dace has a moderately deep and slightly compressed body, a life span of about 3 years in the wild (females generally live longer than males) and an average adult total length (TL) of 2-2.6 inches (50-65 mm) (maximum 3.3 in [85 mm] TL) (Starnes and Starnes 1978, Etnier and Starnes 2001). This species differs from other *Phoxinus* by exhibiting several distinct coloration patterns and a unique opercular bone (Starnes and Starnes 1978). These color patterns include an olivaceous dorsolateral background with black speckling and a large single black lateral stripe or two stripes converging on the caudal peduncle (Starnes and Starnes 1978, Eisenhour and Strange 1998, Etnier and Starnes 2001). During spawning season (April to July), the lateral stripe becomes an intense black, the belly, ventral portion of head, lips, nape, and base of dorsal fin develop a scarlet coloration, and fins turn bright yellow

(Etnier and Starnes 2001). Their scales are small and embedded, and lateral scale counts average 75. The lateral line is incomplete, and the anal fin ray count is 8. Etnier and Starnes (1993) and Eisenhour and Strange (1998) provided concise descriptions of the species, and Starnes and Starnes (1978) thoroughly characterized the species in their scientific description published in *Copeia*.

## **Distribution**

The blackside dace was not recognized as a distinct species until the 1970s, so the extent of the species' historic range is unknown. Most blackside dace populations occur in tributaries above Cumberland Falls where the species is assumed to have originated (Starnes and Starnes 1978, Starnes 1981, Starnes and Starnes 1981, O'Bara 1990). A small number of populations occur in tributaries that enter the Cumberland River below the falls. These populations may have circumvented this barrier via lateral tributary capture or the falls may have receded upstream past the tributaries during relatively recent geologic times (Starnes and Starnes 1978).

1. The blackside dace is thought to have been widely distributed in headwater stream systems throughout the upper Cumberland River drainage in Kentucky and Tennessee.
2. The first range-wide survey conducted by Starnes (1981) reported that the species was present in only 27 of 168 surveyed streams (16.1 %).
3. Based on an evaluation of physical habitat compared to the species' preferences, Starnes (1981) speculated that the species had been eliminated from at least 52 streams before its existence was known, approximately 60 to 70 % or more of its historic range. A later survey by O'Bara (1985) observed the species in only 30 of 193 surveyed streams (15.5 percent), despite the fact that at least 151 of the surveyed streams contained adequate habitat to sustain the species. Furthermore, O'Bara discovered that the species was absent from 10 streams in which Starnes (1981) had reported it.

The most complete and intensive ichthyofaunal investigation of the upper Cumberland River basin to date was completed from 1982 to 1994 by the Kentucky State Nature Preserves Commission (Laudermilk and Cicerello 1998). This study reported blackside dace at 88 of 454 collection sites (72 streams) in Kentucky. Fifty (50) of these streams contained previously unknown populations of the species; approximately half of the newly discovered populations were located in two basins, Stinking Creek in Knox County (12 streams) and Jellico Creek in McCreary and Whitley counties (12 streams).

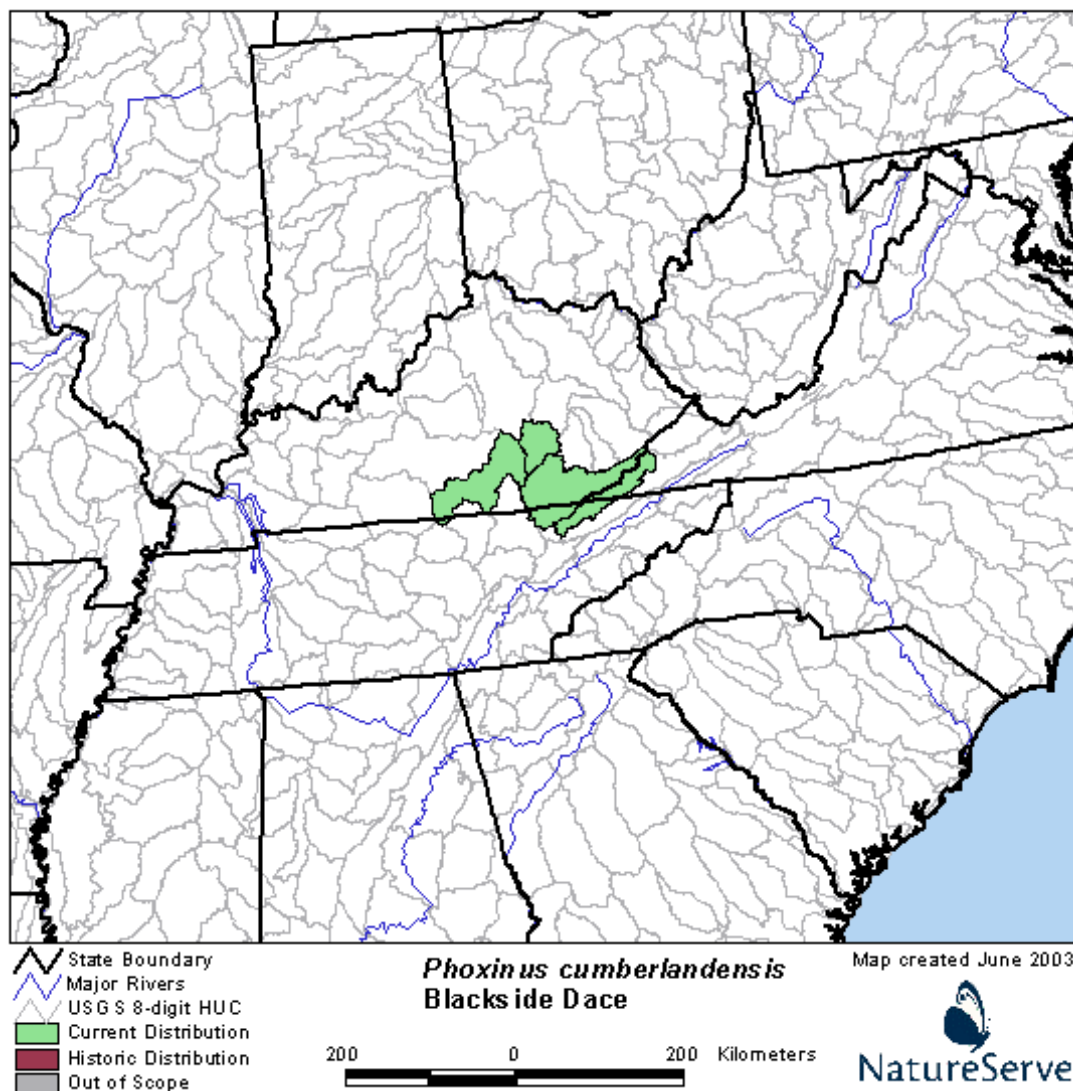
Since 1998, blackside dace have been documented from approximately 30 additional streams as part of inventories or surveys by state/federal agencies, biological assessments for road and other construction projects, and baseline surveys for mining permits (Underwood *et al.* 1999; Roghair *et al.* 2001; M. Floyd, personal communication, USFWS, 2007). The most recent intensive survey efforts were completed in the summers of 2003, 2005, and 2006 by Mattingly *et al.* (2005), Black and Mattingly (2007), and Black (2007), who surveyed a total of 63 streams (127 sites) in Kentucky and Tennessee that historically harbored dace populations or contained potential dace habitat. Blackside dace were present in 45 out of 63 streams and 80 of 127 sampling sites.

Currently, blackside dace populations are believed to persist in about 105 streams across eight Kentucky counties (Bell, Harlan, Knox, Laurel, Letcher, McCreary, Pulaski, and Whitley) and three Tennessee counties (Campbell, Claiborne, and Scott) (M. Floyd, personal communication, USFWS, 2007). Unfortunately, many of these populations are considered to be small and remnant in nature (*i.e.*,  $\leq 10$  individuals observed during 200-m surveys). This was clearly demonstrated by Mattingly *et al.* (2005) and Black and Mattingly (2007), who documented low abundances at the majority of sites visited and

declines in some populations. Starnes (1981) described Buffalo Creek in Claiborne County, Tennessee and Gum Fork in Scott County, Tennessee as the healthiest blackside dace populations in Tennessee. Black and Mattingly (2007) recorded only a single specimen from each of these streams. Based on our review of all available survey data gathered since 1960, the species appears to have been extirpated from at least 24 streams in which it was previously documented.

There have been small populations of blackside dace discovered in western Virginia outside of their known historic range in Kentucky and Tennessee. However, the Virginia fish are closely related to blackside dace populations in the center rather than eastern margin of their range in Kentucky, suggesting an anthropogenic introduction (R.M. Strange, personal communication, University of Southern Indiana).

### U.S. historic and current distribution of blackside dace (NatureServe 2007)



## **Abundance**

Research by Mattingly *et al.* (2005) and Detar (2004) investigated population densities within the species' current range. Blackside dace were captured at 52 of 72 sites (25 of 28 streams) in the upper Cumberland basin using single-pass electrofishing in the summer of 2003 (June to August). The majority of sites (58 percent) had catch rates of 10 or fewer dace per 200-m site, and 70 or more dace were captured in only 7 of the 72 sites. Single pass catch rates averaged  $29 \pm 37$  (mean  $\pm$  SD;  $n = 52$ ) dace per 200 m in occupied sites, while the median number of captured dace was only 14 per 200 m. Petersen mark-recapture population estimates also were conducted on nine sites within five different streams. Population estimates averaged  $176 \pm 133$  dace per 200 m (range: 33 - 429), corresponding to density estimates of  $27.7 \pm 19.7$  dace per  $100 \text{ m}^2$  (range: 2.7 - 55.3). Based on these data, a regression model was constructed to obtain population estimates for the other 43 sites in which dace were captured during single-pass electrofishing. Population estimates for these sites averaged  $65 \pm 82$  dace per 200 m (range: 4 - 321), corresponding to density estimates of  $8.8 \pm 13.6$  dace per  $100 \text{ m}^2$  (range: 0.3 - 73.9). Overall, population estimates for the 52 sites in which dace were present averaged  $84 \pm 101$  dace per 200 m, corresponding to density estimates of  $12.1 \pm 16.3$  dace per  $100 \text{ m}^2$ .

Density estimates (56.8 - 73.1 dace per  $100 \text{ m}^2$ ) reported by Starnes and Starnes (1981) for three sites in Youngs Creek (Whitley County, Kentucky), one of the healthiest known populations at the time, were consistent with the two highest densities identified by Mattingly *et al.* (2005) and Detar (2004). Population estimates for Big Lick Branch by Leftwich *et al.* (1997) and Middle Fork Beaver Creek by Leftwich *et al.* (1995) were 10 - 350 dace per  $100 \text{ m}^2$  and 130 dace per  $100 \text{ m}^2$  (one pool), respectively. These results were considerably higher than those calculated by Mattingly *et al.* (2005) and Detar (2004), but both studies conducted by Leftwich *et al.* were based on habitat units (pools and riffles), rather than specific stream lengths. Consequently, they may have encountered elevated densities of blackside dace in certain pools.

Black and Mattingly (2007) conducted additional presence-absence surveys and performed population estimates on an additional 27 streams (47 200-m reaches) in Kentucky and Tennessee via single-pass backpack electrofishing. Seven sites were double-sampled to allow estimates of population size (Peterson mark-recapture). Blackside dace were found in 18 of 27 streams and 27 of 47 reaches, but most reaches (72 %) had catch rates of  $\leq 10$  dace per 200 m. Occupied reaches had single pass catch rates of 1 to 96 ( $21 \pm 25$ ). Petersen mark-recapture population estimates at 7 chosen reaches ranged from 54 to 613 dace per 200-m reach and densities averaged  $37.5 \pm 27.2$  dace per  $100 \text{ m}^2$ . These results were used to calibrate the single-pass electrofishing results and provide population estimates at the remaining 19 reaches. The mean population estimate was  $46 \pm 84$  (range: 2 to 360) dace per 200 m, and associated mean density was  $9.3 \pm 17.6$  (range: 0.3 to 73.5) dace per  $100 \text{ m}^2$ . Population estimates for the 26 reaches harboring dace averaged  $92 \pm 150$  dace per 200 m, and associated densities averaged  $16.9 \pm 24.2$  dace per  $100 \text{ m}^2$ .

## **Habitat Requirements**

In general, habitat for the blackside dace consists of small, cool, upland streams with moderate stream flows and generally silt-free substrates (Starnes and Starnes 1978; Starnes 1981; O'Bara 1985; USFWS 1988; O'Bara 1990; Mattingly *et al.* 2005). When not spawning, blackside dace prefer to inhabit shallow pools with ample refugia such as undercut banks, rootwads, sunken logs and boulders in cool streams (rarely exceeding 20 C). These 6.6-to-16.4-ft (2-to-5-m) wide stream habitats include intact riparian zones to maintain water temperatures and filter runoff, often composed primarily of Eastern hemlock

(*Tsuga canadensis*) and *Rhododendron* spp., with a percent riffle:pool ratio not exceeding 60:40 (Starnes and Starnes 1981, Biggens 1987, USFWS 1988, O'Bara 1990). Juveniles and females seem to prefer shallower water with less cover than males, a preference which becomes more pronounced during summer (O'Bara 1988). Streams inhabited by the species are generally those with good riparian vegetation that provide at least 70% canopy cover and numerous submerged root wads, undercut banks, and large rocks (USFWS 1988). Blackside dace rarely have been found in low-gradient streams or high-gradient tributaries (O'Bara 1985; USFWS 1988). Elevations ranging from approximately 305 to 500 m (1,000 to 1,640 ft) above sea level appear to be preferred by the species (Starnes and Starnes 1981; O'Bara 1990). Streams with higher riffle to pool ratios (exceeding 60% riffle) harbor fewer populations of blackside dace and tend to be dominated by blacknose dace (*Rhinichthys atratulus*) and creek chubs (*Semotilus atromaculatus*).

Research by Jones (2005) and Mattingly *et al.* (2005) identified environmental attributes correlated with the distribution of blackside dace. Map-produced and field-collected habitat variables (*e.g.*, turbidity, stream temperature, conductivity) were gathered for 91 streams at a headwaters-to-mouth stream scale and at 72 stream sites at a 200-meter-long reach scale. Logistic regression analyses at the stream spatial scale showed that dace presence was significantly predictable from only one environmental variable, the crude stream gradient. The model predicted that dace were about four times more likely to occur in a stream with a crude gradient between 1 and 6 % than in a stream with a lower or steeper gradient. At the 200-m reach spatial scale, they determined that blackside dace were likely to be present in stream reaches with low turbidity (at or below 10 NTU), high dissolved oxygen (greater than 8.5 mg/L), low summer temperatures (between 58.3 and 65.3 °F [14.6 and 18.5°C]), low to moderate stream conductivity (at or below 240µS), percent riffle habitat between 35 and 50 %, and a link magnitude (measure of stream size) between three and six. Blackside dace presence was also positively associated with southern redbelly dace (*Phoxinus erythrogaster*) and arrow darter (*Etheostoma sagitta sagittal*) but negatively associated with two potential predators, largemouth bass (*Micropterus salmoides*) and redbreast sunfish (*Lepomis auritus*).

Black (2007) and Black and Mattingly (2007) measured environmental variables at 47 additional stream reaches to validate the logistic regression habitat models developed by Mattingly *et al.* (2005) and Jones (2005). Model performance was assessed quantitatively with the Cohen's kappa statistic (Cohen's kappa is a statistic that calculates the proportion of all presence/absence cases that are correctly predicted by a model after taking random chance into consideration [Manel *et al.* 2001]). Kappa values range from -1 to 1, with higher values representing stronger model performance and values below zero indicating poor performance. The stream scale model (crude gradient) and several reach scale models (utilizing turbidity, percent riffle, and link magnitude) performed poorly when tested with the new independent data. All of the strongest (best performing) models included conductivity as a predictor variable, with the combination of conductivity and temperature producing the strongest performance (kappa = 0.41). These results confirm earlier conclusions by Jones (2005) that blackside dace presence and persistence at a site are encouraged by, and best predicted by, a combination of lower summer water temperatures and lower water conductivities (*i.e.*, less than 240 µS).

## **Ecological Interactions**

O'Bara (1990) published an article on blackside dace ecology and Jones (2005) further expanded our understanding of the species' relationship with environmental (biotic and abiotic) at two spatial scales. Fish species commonly found in association with blackside dace include the creek chub (*Semolitus atromaculatus*), central stoneroller (*Campostoma anomalum*), white sucker (*Catostomus commersoni*), northern hogsucker (*Hypentelium nigricans*), green sunfish (*Lepomis cyanellus*), striptail darter

(*Etheostoma kennicotti*), arrow darter (*E. sagitta sagitta*), and rainbow darter (*E. caeruleum*) (Starnes and Starnes 1978; O'Bara 1990; Mattingly *et al.* 2005). Additional species that may occur along with blackside dace include the bluntnose minnow (*Pimephales notatus*), silverjaw minnow (*Notropis buccatus*), striped shiner (*Luxilus chrysocephalus*), longear sunfish (*Lepomis megalotis*), redbreast sunfish (*Lepomis auritus*), and Cumberland darter (*Etheostoma susanae*). Based on research by Eisenhour and Piller (1997), blackside dace are known to occasionally hybridize with creek chubs.

Blackside dace can often be observed grazing on rock and other substrates, at times drifting downstream in small groups of two or three fish, searching for food items along the stream bottom (Starnes and Starnes 1981). They feed predominantly on algae and organic and diatomaceous material with seasonal inclusion of small invertebrates; also, they prefer gravel or cobble substrate free of sediment, particularly for spawning activity (Starnes and Starnes 1981, O'Bara 1990, Underwood *et al.* 1999, Mattingly and Black 2007). Streams that fit these conditions may dictate the diet of *P. cumberlandensis*, which includes a mix of diatoms, algal cells, organic detritus, root hairs, and benthic macroinvertebrates (Starnes and Starnes 1981, Etnier and Starnes 2001). Also, Starnes and Starnes (1981) noticed large volumes of sand in the digestive tract, but it is unclear whether sand is accidentally or intentionally ingested.

The blackside dace faces a potential competitive invader in the southern redbelly dace (*Phoxinus erythrogaster*). In a geological timeframe, the redbelly dace is a relative newcomer to this river basin (Starnes and Starnes 1978, USFWS 1991). It appears that the blackside dace is able to hold its own in clear, relatively unaltered streams with healthy riparian zones, but the redbelly dace is speculated to competitively displace its congener in lower gradient streams in more open terrain with heavier silt loads and warmer water (Starnes and Starnes 1978, USFWS 1988). Mattingly and Black (2007) found that blackside dace constancy was highest for creek chub (*Semotilus atromaculatus*), while fidelity values were highest with southern redbelly dace (*Phoxinus erythrogaster*). The high constancy with creek chub suggested that blackside dace could depend heavily on creek chub as a nest-building spawning associate, perhaps in an obligatory fashion. The high fidelity with southern redbelly dace indicates a common preference for similar habitat conditions, but also highlights the potential for competition between the two *Phoxinus* species.

Jones (2005) found that blackside dace were negatively correlated with the presence of redbreast sunfish (*Lepomis auritus*), a non-native fish stocked by state agencies in past years. Redbreast sunfish are a potential predator of blackside dace individuals.

Most of the survey participants rated ecological interactions as a life history aspect that may require more research (61% rated this aspect as poorly known; 39% rated it as moderately known). One survey participant noted, "We need to know more about the interactions with southern redbelly dace (competitor?) and creek chubs and other potential nest associates and potential predators such as redbreast sunfish" (BD9).

## **Behavioral Patterns**

Strange and Burr (1995) provided genetic information that indicated that migration is important in maintaining blackside dace populations. Mattingly *et al.* (2005) and Detar (2004) studied movement patterns of the species by tagging 653 dace from Big Lick Branch (Pulaski County, Kentucky) and Rock Creek (McCreary County, Kentucky) with visible implant elastomer injections. Movement was monitored in Big Lick Branch from November 2002 to August 2005 (post-March 2004 data have not yet been analyzed; data reported below are for an approximate one-year cycle, November 2002 to March 2004) and in Rock Creek from March 2003 to March 2004 using baited minnow traps. The majority of

tagged dace (81 % in Big Lick Branch and 58 percent in Rock Creek) were recaptured within their original tagging site. Other individuals moved considerable distances from their original tagging site, including the first documented intertributary movement for the species (the tagged individual moved from an unnamed tributary of Big Lick Branch downstream through impounded backwaters of Lake Cumberland and into Big Lick Branch). Distances moved upstream in Big Lick Branch ( $149 \pm 139$  meters;  $490 \pm 457$  feet) and Rock Creek ( $739 \pm 12,695$  meters;  $2,425 \pm 41,652$  feet) were not statistically different from distances moved downstream ( $78 \pm 29$  meters;  $255 \pm 96$  feet and  $317 \pm 622$  meters;  $1,039 \pm 2,041$  feet, respectively). However, the mean overall distance moved was statistically greater in Rock Creek than in Big Lick Branch; maximum distances moved in Big Lick Branch and Rock Creek were 1 km and 4 km (0.62 mi and 2.5 mi), respectively (Jones 2004, Mattingly *et al.* 2005; H.T. Mattingly, personal communication, Tennessee Technological University 2006). These results were similar to other movement studies that showed that stream fish populations are comprised of a relatively large sedentary group and a small mobile group (Freeman 1995, Smithson and Johnston 1999, Rodriguez 2002).

## **Reproduction**

The spawning period for the species extends from April until July (Starnes and Starnes 1981), and eggs are typically deposited in fine gravel nests constructed by other species such as creek chubs *Semotilus atromaculatus* (Cicerello and Lauder milk 1996) and central stonerollers *Campostoma anomalum* (Starnes and Starnes 1981). This spawning strategy may offer some protection for eggs against predators such as *S. atromaculatus*, as observed by Starnes and Starnes (1981) when *C. anomalum* aggressively protected its nest site from a large nuptial male creek chub. It has also been documented that spawning over *Semotilus* nests can produce *Phoxinus X Semotilus* hybrid individuals that lack defined gonads (Eisenhour and Piller 1997). Eisenhour and Piller (1997) suggest that hybrids are probably the result of breeding behaviors and habitat alterations.

Creek chub nests appear to be used more often than stoneroller nests, as suggested by Cicerello and Lauder milk (1996). In a study of blackside dace reproductive behavior, Mattingly and Black (2007) provided evidence that blackside dace rely heavily on creek chubs as a nest-building spawning associate, perhaps in an obligatory fashion. Mattingly and Black (2007) observed 25 spawning events, and all of these events were made over creek chub nests; there was no evidence that blackside dace spawned independently. It is suspected that the species takes advantage of other species' nests because these habitats provide the most abundant silt-free substrates in much of the species' current range. It is possible that blackside dace may spawn independent of other species if suitable substrates are available, although this behavior has not been observed. Starnes (1981) observed spawning in May at water temperatures of approximately 18°C (64°F). Females deposited eggs on fine gravel at the lip of an existing stoneroller nest located in a run area. Adults are capable of spawning at age 1 and have a lifespan of 3 to 4 years (USFWS 1988; H.T. Mattingly, personal communication, Tennessee Technological University, 2007); females appear to have greater survivorship (Starnes and Starnes 1981).

Mattingly and Black (2007) observed that differences between blackside dace spawning and non-spawning microhabitats were related to channel width, silt depth and substrate embeddedness levels. Spawning areas were located at mean channel widths of 9.8-13.1 ft (3-4 m), whereas non-spawning areas had narrower channel widths averaging near 6.6 ft (2 m). Silt depths and substrate embeddedness at spawning areas were always at zero, whereas non-spawning areas in sites with no logging disturbance averaged about 0.04 inch (1 mm) silt depth and negligible-to-low embeddedness, and non-spawning areas in sites with moderate logging disturbance averaged 0.08 inch (2 mm) silt depth and moderate substrate embeddedness. Among logging disturbance categories, habitat variables only differed for embeddedness index and dominant substrate. Embeddedness values were similar for no and light disturbances and

similar for light and moderate disturbances, but moderate disturbances had higher substrate embeddedness than no disturbance sites. Dominant substrate did not differ significantly for no and light disturbances, but moderate disturbance differed significantly from no and light disturbance levels, with dominant substrate particle size being smaller in the sites with moderate logging disturbance.

### ***Early Life History***

Rakes et al. (1999) reported rearing the first blackside dace in captivity. These juveniles reached adult size by one year and exhibited secondary sexual characteristics. Observations during captive reproduction by Rakes et al. showed that eggs produced by blackside dace in nature probably sink into gravel crevices and remain for up to two days. They concluded that eggs, embryos, and larvae could be susceptible to smothering by sediment, which may have led to the decline of blackside dace.

Most of the survey participants rated early life history as a life history aspect that merits more research (80% poorly known; 20% moderately known).

### ***Adult Life History***

Starnes (1981) reported the sex ratio in September as 21 males: 29 females and in April as 11 males: 11 females. Based on length/frequency and scale data, growth rates were similar for males and females (age 0, 0.8-0.9 in [20 to 24 mm] standard length [SL]; age I, 1.5-2.2 in [39 to 57 mm] SL; and age III, 2.4-2.5 in [62 to 64 mm] SL). The fastest growth occurs during the first year and then gradually declines during the second and third year (Starnes and Starnes 1981). Etnier and Starnes (1993) stated that mature females expend an average of 1540 eggs per spawning season. Other life history information was provided by Starnes and Starnes (1981) in their summary of blackside dace biology.

### ***Threats and Reasons for Decline***

The decline of the blackside dace can be attributed to a variety of human-related activities in the upper Cumberland River basin. Coal mining, silviculture, agriculture, gas/oil well exploration, road construction, and inadequate sewage treatment are the primary activities that have contributed to the degradation of streams within the range of the species and the decline of their associated aquatic communities, including the blackside dace (USFWS 1988; O'Bara 1990; Wood and Armitage 1997; Mattingly and Black 2007). Adverse impacts result primarily from the removal of riparian vegetation, sedimentation of streams, inputs of untreated sewage, acidification of streams, and elevation of stream conductivity. The removal or reduction of riparian vegetation during mine preparation, road construction, and clear-cut logging causes increased siltation, thereby degrading instream substrates used by blackside for feeding and reproduction (O'Bara 1990). The reduction or loss of riparian vegetation results in the elevation of stream temperatures, destabilization of stream banks and siltation, and removal of submerged root systems that provide habitat for fish and macroinvertebrates. Silt settling on the stream bottom can smother eggs and larval fish, as well as benthic macroinvertebrates upon which adult fish feed (especially in winter as documented by Starnes and Starnes [1981]). Furthermore, silt can clog gills of adult fishes, impeding respiration and feeding. Inputs of untreated sewage can degrade stream water quality by introducing excessive nutrients that cause algal blooms and by increasing the stream's biological oxygen demand that results in lower dissolved oxygen concentrations.

Coal-mining-related activities can introduce acid mine runoff to blackside streams. Acid mine drainage is created through the oxidation of sulfide ions that are exposed to the atmosphere through erosion of coal mine spoils. Typically, acid mine streams have low pH, high conductivity, and high metal and sulfate

concentrations (Herlihy *et al.* 1990) that are highly detrimental to fish populations (Henry *et al.* 1999). Based on research conducted by Mattingly *et al.* (2005), most blackside dace appear intolerant of elevated stream conductivities (*i.e.*, > 240 $\mu$ S) associated with coal mining and other resource extraction activities. With few exceptions (*e.g.*, Blacksnake Branch, Bell County, Kentucky; Smith Creek, Letcher County, Kentucky; and Patterson Creek, Whitley County, Kentucky), individuals of the species were absent when conductivity levels rose above 240 $\mu$ S.

The Tennessee's State Wildlife Action Plan (TN SWAP) listed four threat sources and corresponding threat stresses for the blackside dace:

1. Incompatible mining practices - Altered chemical environmental regime
2. Incompatible mining practices - Altered physical environmental regime
3. Incompatible forestry practices - Altered physical environmental regime
4. Incompatible species management practices - Altered biological component or integrity

Survey participants listed other sources of stress not covered by the TN SWAP. Many indicated that urbanization currently and in the future is a source of stress for the blackside dace. Comments by survey participants were, "Occurs spottily throughout range, sometimes without BMPs; certain culverts impede natural fish movements" (BD9); and "This could become a factor in the future" (BD8). Oil and gas drilling was added by survey participants. One participant indicated, "Could be a future problem" (BD5). Other added stresses include inadequate sewage treatment, agriculture and fish passage issues.

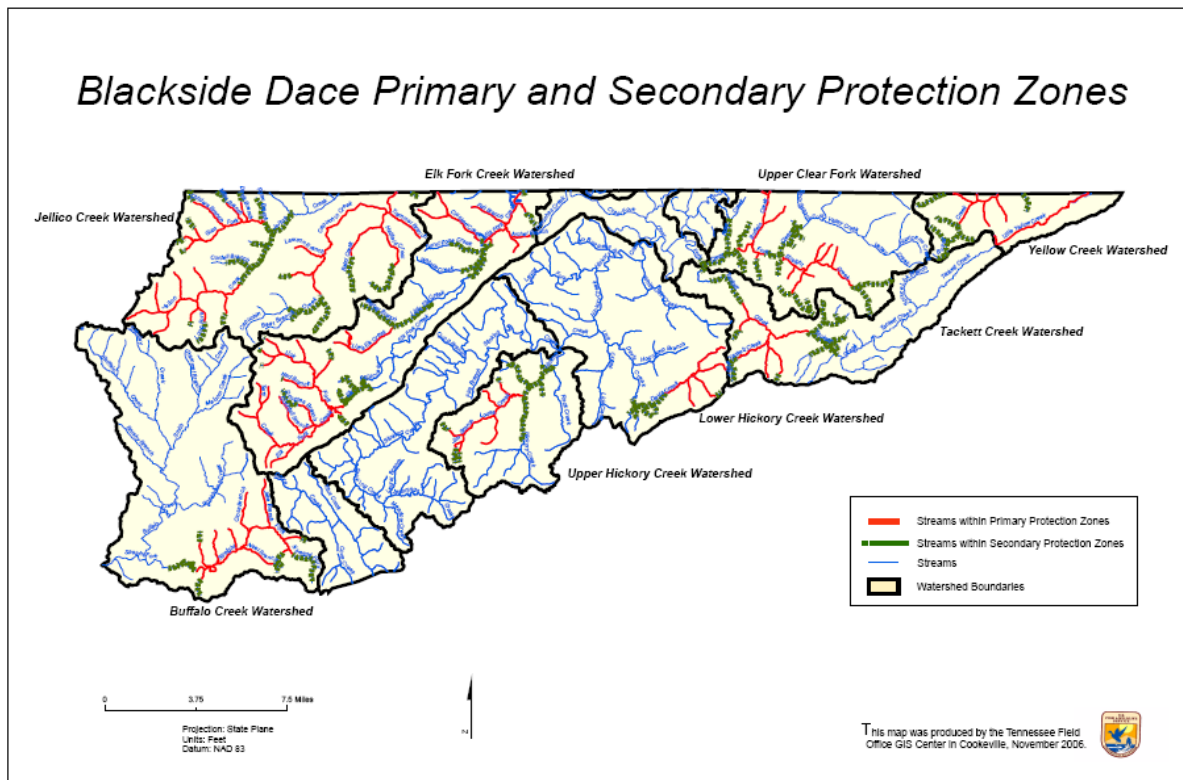
### **Conservation Actions**

A recovery plan for the blackside dace was completed in 1988 (USFWS 1988). To complement this and other conservation efforts to protect this species, Strange and Burr (1995) investigated the blackside dace's genetic variation and metapopulation structure. Their research revealed the presence of three or four metapopulation units: one centered in the upper Poor Fork through Straight Creek stream systems (Group A), another unit comprising the stream systems from Stinking Creek to Youngs Creek (Group B), a third centered around Marsh and Jellico Creeks (Group C), and a potential fourth comprised of streams below Cumberland Falls. A cladistic analysis of gene flow indicated that Group B was the center of dispersal for blackside dace mitochondrial DNA haplotypes.

In order to preserve genetic diversity, Strange and Burr (1995) recommended that recovery plans treat the metapopulations as management units, employing carefully planned reintroductions and habitat protection. Translocation of the species between metapopulations was discouraged; rather, they recommended that translocations be made from sites geographically proximate to the site of the reintroduction and preferably within the same stream system. Their data further indicated considerable gene flow within metapopulations, suggesting that the protection of dispersal corridors may allow the species to reinvade formerly occupied habitats on its own.

Coal mining guidelines for the development of protection and enhancement plans (PEPs) for blackside dace in Tennessee have been developed by the U.S. Fish and Wildlife Service and U.S. Office of Surface Mining in cooperation with the U.S. Army Corps of Engineers, Tennessee Department of Environment and Conservation, and Tennessee Wildlife Resources Agency. These guidelines provide a consistent framework for mining applicants around which PEP's will be developed. Within these guidelines, streams (intermittent and perennial) have been divided into primary and secondary protection zones based on relative location to known blackside dace populations. See the PEP report (USFWS *et al.* 2008, *in press*) for the protection and enhancement measures, which includes a monitoring protocol for primary

protection zones. The following is a map of the primary and secondary protection zones produced by the Cookeville Field Office, USFWS.



### **Likelihood of Take**

Survey participants were asked which landuse is the most threatening for causing take now and in the future. Participants were given the choice of forestry, mining, water development, all of the above, none of the above, or unable to answer. Although there are other possible causes of take of the blackside dace such as residential/urban sprawl and agriculture related issues, we focused on these three because they are being proposed for inclusion in the Cumberland HCP; however, only forestry harvests, road construction, and prescribed burning are covered under the Northern Cumberland Forest Resources HCP. Based upon survey results, 87% of the 15 survey participants agreed that mining is **currently** the most threatening landuse practice and is causing take of the blackside dace. Thirteen percent of participants agreed that forestry is the most threatening. One survey participant who voted for mining commented, “Forestry is a close second but streams can recover; water quality alteration by mining creates a long-term problem” (BD1).

Survey participants were also asked which landuse practice is the most threatening and has the greatest potential to cause take **over the next 10 years**. Mining remained at the top of the list of activities considered by survey participants as the highest threat in the future (73%). Forestry was rated behind mining with 13%. Two of the survey participants were split with one agreeing that all of the above (forestry, mining, and water development) were the most threatening and the other participant was unable to answer. A survey participant commented, “With concerns over gas prices, there is talk of expanding coal extraction. Impacts will probably increase” (BD7). Another participant stated, “As human populations grow and expand into previously undeveloped areas in the region, the need for land clearing and water utilization will increase. As long as mining is profitable, mineral extraction will continue” (BD8).

Nineteen people from the Science Advisory Committee (SAC) met at Cumberland Mountain State Park near Crossville, Tennessee on September 14, 2006. The committee, comprised of scientists, agency personnel, graduate students, and other technical experts, divided into three groups (one for terrestrial plants and animals, a second for mussels, and a third for fishes and crayfishes) to assess the likelihood of take of imperiled species as a result of forestry, mining, or water development activities within the HCP project area. For blackside dace, their confidence in the likelihood of take was “very high” for forestry and mining and “high” for water development.

The following table is based upon the SAC meeting (September 2006) and received surveys. Options for likelihood of take were: very high, high, moderate, low, none, or unknown.

**X indicates high or very high likelihood of take.**

<i>Species</i>	<i>Common name</i>	<i>Forestry</i>	<i>Mining</i>	<i>Water Development</i>
<i>Phoxinus cumberlandensis</i>	Blackside dace	X	X	X <sup>a,b</sup>

<sup>a</sup> – Practice rated in surveys by two survey participants, however not a SWAP threat.

<sup>b</sup> – Rated as high at meeting, but moderate (not significant because N=2) in surveys.

### **Strategies for Minimizing Take**

Suggested strategies from surveys range from public awareness and education and changing governmental leadership to making sure existing regulations and BMPs are being enforced in all landuse practices including forestry mining and water development. Specific suggestions for land use practices are:

#### **Forestry**

- Implementation of forestry BMPs (specified by KDOF) would prevent most sedimentation problems on logging sites (BD1).
- Enforcement of known methods to keep mud out of streams is probably the single most important strategy to improve the management of ongoing activities (logging and mining).
- Eliminating mining and logging in the watersheds (BD6).
- Stricter BMPs on mineral and forestry resource utilization. Stricter enforcement and penalties for permit violations and non-permitted activities (BD8).
- Specifically, better targeting and enforcing sediment management associated with logging practices, as well as perhaps incentivizing the leaving of forested buffers around streams while logging an area (BD11).

#### **Mining**

- Protection and Enhancement Plans (mining) for KY and TN; TN’s plan is in draft form, KY will prepare a PEP in 2007/2008.
- Stricter BMPs on mineral resource utilization. Stricter enforcement and penalties for permit violations and non-permitted activities (BD8).
- Mining laws and regulations need to be updated and enforced regularly (BD12).

Refer to Section II for a detailed list of all of the suggestions from survey participants.

### **Strategies for Mitigating Take**

Suggested strategies from surveys range from preserving current habitat through an easement or purchase, restricting access to lands, creating buffers around existing habitat, restoring degraded areas to provide suitable habitat, creating new suitable habitats, and modifying landuse practices to reclamation of abandoned mine areas and re-stocking of the species to restored streams. Specific suggestions by survey participants are:

- Require buffer zones that shade and protect rivers/creeks. That is, timber harvest should not come within 100 ft. of the stream (BD7).
- Funding for sewage treatment systems or septic system improvements or wetlands construction to filter water and trap sediments (BD4).

Refer to Section II for a detailed list of all of the suggestions from survey participants.

### **Coexisting Imperiled Species**

Based upon survey results, the following were considered imperiled species that are immediately syntopic or sympatric with the blackside dace on the Cumberland Plateau.

1. Cumberland darter *Etheostoma susanae* (formerly known as Cumberland johnny darter *Etheostoma nigrum susanae*; see Strange 1998) (BD1, BD2, BD3, BD4, BD6, BD8, BD9, BD10, BD13)
2. Arrow darter *Etheostoma sagitta sagitta* (BD2, BD4, BD5, BD8, BD9, BD12, BD14)
3. Cumberland elktoe *Alasmidonta atropurpurea* (BD1, BD9, BD13)
4. Emerald darter *Etheostoma baileyi* (BD5, BD8)
5. Big South Fork crayfish *Cambarus bouchardi* (BD9)
6. Indiana bat *Myotis sodalis* (BD9)

<b>Common Name</b>	<b>Scientific Name</b>	<b>Global Status, TN Status, Federal Status</b>	<b>% Survey Participants (n=12)</b>
Cumberland darter	<i>Etheostoma susanae</i>	G1G2, S1, C	75
Arrow darter	<i>Etheostoma sagitta sagitta</i>	G3G4T3T4, -- <sup>a</sup> , NL <sup>b</sup>	58
Cumberland elktoe	<i>Alasmidonta atropurpurea</i>	G1G2, S1S2, LE	25
Emerald darter	<i>Etheostoma baileyi</i>	G4G5, S2, NL <sup>b</sup>	17
Big South Fork crayfish	<i>Cambarus bouchardi</i>	G2G3, S1, NL <sup>b</sup>	8
Indiana bat	<i>Myotis sodalis</i>	G2, S1, LE	8

<sup>a</sup>- Does not occur in state

<sup>b</sup>- Species is not federally listed

Global and state statuses are from NatureServe (2007) <http://www.natureserve.org/explorer/>

Ranking definitions and information found at <http://www.natureserve.org/explorer/ranking.htm>

Federal status from USFWS endangered species site <http://www.fws.gov/endangered/wildlife.html>

### **Survey Methods**

Seining, backpack electrofishing, snorkeling, minnow traps, and tagging were all mentioned as survey methods. A few participants mentioned concerns of mortality due to electrofishing; however, one survey participant noted the following:

We have used backpack electrofishing with good success and minimal injuries/mortalities to blackside dace. Most mortalities have occurred in August when water temperatures are near their highest, and mortalities were less common with pulsed DC units than with AC units. Through mark-recapture experiments we have developed regression models to predict population size from single-pass electrofishing catch rates. The efficiency (number of dace collected divided by number of dace present at the site) of the backpack units using a 3-person crew is in the neighborhood of 25-35%. An alternative approach to survey or monitor populations is by using baited minnow traps. We have had excellent success with this method with very few blackside dace injuries or mortalities after trapping and handling thousands of individuals. If individuals need to be anesthetized for marking or collection of tissue for genetic analyses, then we recommend a 40 mg/L dose of clove oil for this species. (BD9)

Please refer to section II for more specific recommendations by survey participants.

### ***Monitoring Recommendations***

A monitoring protocol is described in the coal mining PEPs document (USFWS et al. 2007). Survey participants also had recommendations:

- Water chemistry surveys, visual habitat surveys, and benthic surveys (BD5).
- Monitor stream substrate as well as aquatic insect population trends over long-term (BD7).
- A method that was originally developed for salmonid populations, the Basinwide Visual Estimation Technique (BVET) would be a good choice for monitoring physical habitat changes and conditions within a reach of stream. This technique has seen broader applications in recent years to include many other fish species (blackside dace <http://www.sdafs.org/meetings/98sdafs/techn/leftwich.htm>) and to evaluate freshwater mussel habitat. It is a thorough technique to characterize species habitat utilization and requirements through the combination of physical habitat inventory and biological surveys (BD8).
- Stream-scale habitat conditions might be best monitored from the air (or space?) via planes or satellites. Local-scale conditions such as a small-scale forestry operation or an ATV rodeo might be best detected by personnel on the ground. Key instream variables to be monitored would be water conductivity and temperature (BD9).
- Develop reference sites that contain the best conditions possible – (e.g., Big Lick Branch) to compare habitat scores with at other locations (BD12).
- To effectively monitor habitat it is important to know which environmental attributes have the greatest influence on the distribution of Blackside Dace. Environmental variables identified through predictive models in a recent study by Jones in Mattingly et al. (2005) is the most significant step I have seen thus far in being able to use a model based approach to managing the species and its habitat (BD13).

Please refer to section II for more specific recommendations by survey participants.

### ***Recovery***

A recovery plan for the blackside dace was completed in 1988 (USFWS 1988). The ultimate goal of the recovery plan is to restore viable populations of the species in a significant portion of its historic range

and then remove the species from the Federal List of Endangered and Threatened Wildlife and Plants. The species will be considered for delisting upon achievement of the following criteria:

1. Each of the eight subbasins identified in the recovery plan has a viable population comprised of at least three protected, inhabited stream reaches per subbasin.
2. Each of the 24 stream reaches is protected in some manner, either through public agency or private conservation organization ownership or some form of permanent easement, and a management plan has been implemented for each stream that provides for the species' long-term protection.
3. No foreseeable threats exist that would threaten survival of the species in any of the subbasins.
4. Noticeable improvements in coal-related problems and substrate quality have occurred to the species' habitat throughout the upper Cumberland River basin, and the species has responded through natural means or with human assistance to successfully recolonize other streams and stream reaches within the upper Cumberland River basin.

The following table is directly from the Recovery Plan (1988):

Table 3. Distribution and number of stream reaches per subbasin presently known to be inhabited by the blackside dace (*Phoxinus cumberlandensis*) and the distribution and number of inhabited stream reaches by subbasin that must be present before this fish can be considered for removal from the Federal list of endangered and threatened species.

Subbasin	Number of Inhabited Streams At Present	Number of Protected Inhabited Streams Required Per Subbasin to Reach Recovery
Poor Fork Drainage	1	3
Cumberland River Tributaries from Clover Fork to Clear Creek	3	3
Straight Creek Drainage	6	3
Clear Fork Drainage	5	3
Jellico Creek Drainage	7	3
Marsh Creek Drainage	1	3
Cumberland River Tributaries above Cumberland Falls from Youngs Creek to Bunches Creek except Jellico Creek and Marsh Creek	3	3
Cumberland River Tributaries below Cumberland Falls	9	3
<b>Total</b>	<b>35</b>	<b>24<sup>1</sup></b>

<sup>1</sup>The number of population segments needed for recovery is less than the number presently known to exist. Therefore, some presently known marginal populations may be lost. Measures should be taken to protect all presently known populations, but some of them are so small and tenuous that it is unlikely they can survive.

### **Uncertainty Regarding Species Ecology**

According to survey participants, most of our uncertainty lies in the early life history of blackside dace. Eighty percent of survey participants agreed that this ecological aspect is poorly known. This species has spawned and been reared in captivity only once, otherwise little information exists. Over 50% of survey participants agreed that ecological interactions and behavioral patterns are other aspects of blackside

dace's ecology that is poorly known. One survey participant commented, "We need to know more about the interactions with southern redbelly dace (competitor?) and creek chubs and other potential nest associates and potential predators such as redbreast sunfish" (BD9). Another comment by that survey participant was, "We are working on reproductive behavior, movement patterns, and habitat selection, but many other facets of behavior are poorly known" (BD9).

One hundred percent of participants agreed that identification and distribution are life history aspects that are well known or moderately known; however regarding the distribution of this species, one survey participant commented, "because the fish moves around easily and their small stream habitat changes relatively quickly, present distribution knowledge isn't always what's most recently reported" (BD10).

Survey participants also identified research needs for the blackside dace. The most common suggestion focused on tolerance levels of the species to habitat disturbance, such as sedimentation, conductivity, dissolved solids, and water quality. Other suggested research needs were related to early life history such as habitat, diet, and embryology and reproduction. Adult life history research needs include habitat, behavioral, and ecological interactions such as predation, competition with exotics, and hybridization.

See Section II for all categories regarding uncertainty about blackside dace species ecology rated by survey participants.

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## SECITON II: SURVEY RESULTS

### 1. Threat rating of each of Tennessee's State Wildlife Action Plan (SWAP) threat sources by survey participants.

severe=3, moderate=2, mild=1, unsure=U

<i>Threat Source</i>	<i>Threat Stress</i>	<i>Threat Rating</i>	<i>Mean</i>
Incompatible mining practices	Altered chemical environmental regime	3,2,2,3,3,2,3,3,3,U,n/a,3,3,3,3	2.8 (N=13)
Incompatible mining practices	Altered physical environmental regime	3,2,3,3,3,2,3,2,3,3,n/a,3,3,3,3	2.8 (N=14)
Incompatible forestry practices	Altered physical environmental regime	3,2.5,3,3,3,2,2,2,2,3,2.5,3,3,2,3	2.6 (N=15)
Incompatible species management practices	Altered biological component or integrity	U,2.5,2,1,2,2,1,1,U,U,1,2,U,2,2	1.7 (N=11)
Urban sprawl (BD3) <sup>a</sup> / Residential development (BD5) <sup>a</sup> / Residential/Commercial Development (BD8) <sup>a</sup> / Incompatible residential development (BD9) <sup>a</sup> / Urbanization (BD12) <sup>a</sup>	Altered physical environment (BD3) <sup>a</sup> / Altered physical environmental regime (BD5, BD8, BD12) <sup>a</sup> / Altered physical and chemical stream environment (BD9) <sup>a</sup>	3 (BD3), 2 (BD5, BD12), 1 (BD8, BD9)	1.8 (N=5)
Oil and gas drilling <sup>a</sup> /Oil or natural gas drilling <sup>a</sup>	Altered chemical/physical environmental regime <sup>a</sup> / Altered chemical environmental regime <sup>a</sup>	2 (BD1, BD5)	
Straight pipes – poor or inadequate sewage treatment <sup>a</sup> / Untreated or improperly treated sewage and septic outfalls <sup>a</sup>	Altered chemical environmental regime <sup>a</sup> / Altered water chemistry; poor water quality <sup>a</sup>	2 (BD1, BD9)	
Agriculture – livestock (horses, cattle) <sup>a</sup>	Stormwater runoff – altered chemical environmental regime (from animal waste) <sup>a</sup>	2 (BD1)	
Agriculture – livestock (horses, cattle) <sup>a</sup> /Agriculture <sup>a</sup>	Stormwater runoff – altered physical environmental regime <sup>a</sup> / Altered physical environmental regime <sup>a</sup>	2 (BD1, BD12)	

<i>Threat Source</i>	<i>Threat Stress</i>	<i>Threat Rating</i>	<i>Mean</i>
Road Construction and Maintenance <sup>a</sup>	Altered Physical environment (BD7) <sup>a</sup> / Altered physical environment; potential changes in water chemistry; improperly installed culverts (BD9) <sup>a</sup>	1-3 Mild to severe (BD7), 1 (BD9)	
Off-road development <sup>a</sup>	Chronic erosion of stream banks and adjacent areas; reduction in water quality <sup>a</sup>	1 (BD9)	
Periods of drought <sup>a</sup>	Reduced surface flow in streams; increased temperatures in remaining surface water <sup>a</sup>	U (BD9)	
Global warming <sup>a</sup>	Increased stream temperatures <sup>a</sup>	U (BD9)	
Incompatible grazing or pasture management practices <sup>a</sup>	Altered physical and chemical stream environment <sup>a</sup>	1 (BD9)	
Dam construction by humans and beavers <sup>a</sup> / Incompatible species invasions (beavers) <sup>a</sup>	Altered flow regime; increased sediment accumulation and alteration of local fish community; standing waters represent potential barriers to natural movements and gene flow among disjunct populations <sup>a</sup> / Altered habitat conditions <sup>a</sup>	1 (BD9), 3 (BD15)	
Culverts <sup>a</sup>	Altered physical environmental regime <sup>a</sup>	2 (BD12)	

<sup>a</sup>–additional threats added by survey participant

**Comments by survey participants:**

**Incompatible mining practices - Altered chemical environmental regime**

- Agree (BD1, BD5, BD6, BD13, BD14)
- There is a long history of negative impacts of mining on this species (BD9).
- AMD, heavy metals (BD12)
- Responsible for elimination of many populations (BD15)

**Incompatible mining practices - Altered physical environmental regime**

- Agree (BD1, BD5, BD6, BD13, BD14)

- There is a long history of negative impacts of mining on this species (BD9).
- Sedimentation (BD12)
- Siltation resulting from mining (BD15)

**Incompatible forestry practices - Altered physical environmental regime**

- Agree (BD1, BD5, BD6, BD13, BD14)
- In certain places, especially on private lands, poor forestry practices (little to no BMPs) have been and continue to be a problem (BD9).
- Sedimentation, increased water temperature (BD12)
- Need more laws and enforcement in known dace stream watershed (BD15).

**Incompatible species management practices – Altered biological component or integrity**

- Agree (BD5, BD6, BD14)
- Unsure (BD1)/ Not sure what this means (BD9). / Unsure, but probably agree (BD13)
- Beavers are a major problem in some areas (BD2).
- Not sure what is meant by “Incompatible species management practices.” Is there potential for conflicts with game species management? (BD10)
- Somewhat uncertain – did not see high prevalence of introduced species (BD11).
- Potential interspecific competition and predation (BD12)
- All stocking of “game fish” should have to evaluate potential effects on dace (BD15).

**Oil or natural gas drilling - Altered chemical environmental regime**

- Could be a future problem (BD5)

**Residential/ commercial development - Altered physical environmental regime**

- Could be a future problem (BD5)
- This could become a factor in the future (BD8).
- Occurs spottily throughout range, sometimes without BMPs; certain culverts impede natural fish movements (BD9).
- Sedimentation (BD12)

**Untreated or improperly treated sewage and septic outfalls - Altered water chemistry; poor water quality**

- In many places, straight pipe sewage outfalls and failing septic systems are a problem (BD9).

**Off-road development - Chronic erosion of stream banks and adjacent areas; reduction in water quality**

- ATVs have increased access to streams; ATV use of these areas has increased in some locales (BD9).

**Periods of drought - Reduced surface flow in streams; increased temperatures in remaining surface water**

- Blackside dace should be able to migrate downstream to maintain favorable flows, but deteriorated conditions downstream may deter such movements (BD9).

**Global Warming - Increased stream temperatures**

- Blackside dace tend to favor streams with summer temperatures <20 C (BD9).

**Incompatible residential development - Altered physical and chemical stream environment**

- In some places, houses or trailer parks are positioned alongside streams with little to no riparian buffer; some do not adequately treat human wastes (see sewage/septic comments above) (BD9).

**Incompatible grazing or pasture management practices - Altered physical and chemical stream environment**

- Cattle have access to streams in some places; also, riparian buffers are inadequate in some places (BD9).

**Dam construction by humans and beavers - Altered flow regime; increased sediment accumulation and alteration of local fish community; standing waters represent potential barriers to natural movements and gene flow among disjunct populations**

- Beavers apparently have been associated with the decline and near demise of at least one population of this species; human-made reservoirs occur spottily throughout the species' range (BD9).

**Incompatible species invasions (beavers) – Altered habitat conditions**

- Though often not considered, this can eliminate populations of dace in small streams by changing habitat conditions and favoring incompatible predatory fish species (BD15).

**Culverts - Altered physical environmental regime**

- Restricted movement (BD12)

**Agriculture - Altered physical environmental regime**

- Sedimentation, increased water temperature (BD12)

**Additional Comments**

- Not sure about the last source – would it be fish management activities – stocking of exotics like trout and redbreast sunfish? (BD1)
- Based on the Buck Creek (Whitley Co., KY) mining debacle, I'd guess that immediate stress of individual adult dace is generally not as much of a problem regarding mining in terms of the physical environmental regime as it is a problem in terms of recruitment of young fish to streams (BD2).
- Abandoned mine probably provide more threat to chemical and physical environmental regimes. Although we're unsure of the level of threat caused by active mine projects to chemical and physical environmental regimes, some impairment of blackside dace habitat may be occurring as a result of construction and use of haul roads/lack of enforcement of BMPs, loss of sediment from coal extraction sites, and chemical transport from processing plants to streams (BD2).
- Urban sprawl involves construction of poorly planned housing developments adjacent to blackside dace streams. Generally all trees are cut down, there is no riparian zone, the stream is ditched/channelized, and used as a receptacle for untreated sewage ("straight-pipes"). This is the most important cause of loss of blackside dace populations in the Middlesboro, Kentucky area (BD3).
- In a few instances watersheds were impacted by residential development, and/ or road construction practices (BD6).
- My severity (third column) rankings of threat source/stress are based on a rangewide evaluation for blackside dace. For example, in certain streams off-road development or sewage outfalls pose a severe local-scale threat although these are rated as only "mild" or "moderate" for the species' whole range. In other words, a threat could be locally severe but only moderate or mild on a regional scale (BD9).
- While I would postulate that removal of riparian buffers resulting in increased sedimentation and temperature fluctuation would result in take of blackside dace, I have not witnessed this enough times to assert this as incontrovertible fact. However, while surveying in SE KY in 2003 and 2004, it was certainly the case that forestry was having a higher impact on streams – at least according to parameters we were measuring. We observed little to no change in water acidity as would be associated with mine drainage. It is of note, though, that it was unclear what factors were causing changes in water conductivity. If this is associated with mining, these practices would be cause for greater concern (BD11).
- While a more minor component, infrastructure and residential development (urbanization) is another source of stress to blackside dace populations. In many cases, much of the

sediment load during storm events appeared to be coming from dirt county and forest roads (BD12).

- Reduced fish passage is also a source of stress. Many of the old culverts that I observed had steep drop offs and were not conducive to fish passage (BD12).
- Agriculture and associated reduction/loss of riparian buffers. Ryans Creek is a good example. Blackside dace were collected in good numbers in the forested upper reaches of the watershed. The lower reaches of the watershed were dominated by agriculture (mostly hay fields) with little or no riparian buffer and no blackside dace were captured in these areas. Increased sedimentation and water temperature (BD12).
- \*Overall, heavy sedimentation stemming from logging, mining, dirt roads, development, and agriculture was the most severe alteration to the physical habitat that I observed on a range-wide basis (BD12).
- The first three Threat Sources cover those activities/disturbances having the greatest impacts to Blackside Dace. With respect to the fourth “Incompatible species management practices”, I immediately thought of trout stocking activities in certain streams where dace are known or could potentially occur. Although we don’t know to what extent these introduced predators are impacting Blackside Dace populations, piscivory of small native fishes by stocked trout has been documented, particularly in streams of western North America. Furthermore, Mattingly et al. (2005) found a negative correlation between the presence of dace with Largemouth Bass and Redbreast Sunfish, two large predators. While this Threat Source as well as activities involved in biological studies may cause some impact, I doubt that is of the same magnitude of that resulting from poor mining and forestry practices and other forms of development (e.g., urbanization) (BD13).
- My experience with blackside dace and beavers at Cumberland Gap National Historic Park shows that beavers drastically change habitat conditions (including substrate composition, turbidity, temperature, and flow) by removing tree canopy, damming the stream, and increasing erosion and subsequent siltation into the stream habitat. Secondly, the creation of pool habitat (large ponds) in former headwater stream habitat creates conditions favorable for expansion of fish species (redbreast sunfish, *Micropterus* sp., etc) that prey on blackside dace and may drastically reduce or eliminate dace populations.] Prior to the decline of the fur trade, trapping kept beaver populations under control – before that, large predators were also present in the ecosystem that prevented unrestricted expansion of beavers (BD15).

**2. SWAP threat course scale stresses rated by survey participants at the fine scale threat stress level.**

<i>Threat Source</i>	<i>Coarse Scale Threat Stress</i>	<i>Fine Scale Threat Stress</i>
Incompatible mining practices	Altered chemical environmental regime	1. Conductivity – metals, sulfates (BD1)/ Increased conductivity/dissolved solids associated with coal recovery sites, chemicals associated with processing plants (BD2)/ Conductivity (BD4, BD6, BD14)/ Increased conductivity (BD5, BD13)/ Increased water conductivity from turbidity and metal ions (BD9)/ Increased conductivity? (BD11) 2. pH (BD3, BD4) / Decrease in pH (BD5)/ Low pH (BD6)/ Lowered pH (BD7)/ pH decreases (BD8)/ Reduced pH (BD12)/ Lower pH (BD15)

<i>Threat Source</i>	<i>Coarse Scale Threat Stress</i>	<i>Fine Scale Threat Stress</i>
		<ul style="list-style-type: none"> <li>3. Heavy metal precipitation (BD7)/ Increased heavy metals (BD12)</li> <li>4. Lower iron, aluminum input into system (BD15).</li> </ul>
Incompatible mining practices	Altered physical environmental regime	<ul style="list-style-type: none"> <li>1. Sediment (BD1, BD4, BD14)/ Siltation/sedimentation (BD6)/ Sedimentation (BD7, BD8, BD10, BD12, BD13)/ Removal of riparian vegetation causes increased sedimentation (BD9)/ Increased sediment load (BD11)</li> <li>2. Water temperature (BD6)/ Removal of riparian vegetation causes increased water temperatures (BD9)/ Increased temperature (BD3, BD11, BD14)/ Increased water temperature if riparian buffer is removed (BD12)</li> <li>3. Turbidity (BD3, BD4)</li> <li>4. Haul roads and other sediment control problems (BD2)</li> <li>5. Impacted environment (BD3)</li> <li>6. Increased siltation and physical loss of habitat (BD5)</li> <li>7. Erosion (BD13)</li> <li>8. Silt ponds within streams (BD15)</li> </ul>
Incompatible forestry practices	Altered physical environmental regime	<ul style="list-style-type: none"> <li>1. Sediment (BD1, BD4, BD14)/ Mostly sediment loss (BD2)/ Siltation/sedimentation (BD6)/ Sedimentation (BD7, BD8, BD10, BD12, BD13)/ Removal of riparian vegetation causes increased sedimentation (BD9)/ Increased siltation (BD15)</li> <li>2. Increased temperature (BD3, BD14)/ water temperature (BD6)/ Removal of riparian vegetation causes increased water temperatures (BD9)/ Increased temperature? (BD11)/ Increased water temperature if riparian buffer is removed (BD12)/ Increased temperature due to canopy removal (BD15).</li> <li>3. Loss of shade / , poor crossings – fish barriers (BD1)</li> <li>4. Turbidity (BD3, BD4)</li> <li>5. Impacted environment (BD3)</li> <li>6. Increased siltation and physical loss of habitat (BD5)</li> <li>7. Loss of canopy cover (BD8)</li> <li>8. Increased conductivity? (BD11)</li> <li>9. Erosion (BD13)</li> </ul>
Incompatible species management practices	Altered biological component or integrity	<ul style="list-style-type: none"> <li>1. Exotic predators? (BD1)/ Predation (BD6, BD7, BD13)/ Predation by nonnative gamefish (BD12)</li> <li>2. Increase species competition (BD5)/ Potential interspecific competition for food and habitat (BD12)</li> <li>3. Stocking of trout in BSD streams (BD14)/ Introduction of species, such as trout in dace habitat (BD15)</li> <li>4. Beaver ponds resulting in sedimentation and pooling of streams, also blocking fish passage (BD2).</li> </ul>

<i>Threat Source</i>	<i>Coarse Scale Threat Stress</i>	<i>Fine Scale Threat Stress</i>
		5. Hybridization and competition with <i>Phoxinus erythrogaster</i> (upper Elk Fork Creek watershed) (BD8) 6. Unsure what this means (BD9)
Oil and gas drilling <sup>a</sup>	Altered chemical/physical environmental regime <sup>a</sup>	1. Conductivity (BD1)
Straight pipes – poor or inadequate sewage treatment <sup>a</sup>	Altered chemical environmental regime <sup>a</sup>	1. Organic enrichment – bacteria (BD1)
Agriculture – livestock (horses, cattle) <sup>a</sup>	Stormwater runoff – altered chemical environmental regime (from animal waste) <sup>a</sup>	1. Organic enrichment – bacteria (BD1)
Agriculture – livestock (horses, cattle) <sup>a</sup> (BD1)/Agriculture <sup>a</sup> (BD12)	Stormwater runoff – altered physical environmental regime <sup>a</sup> (BD1)/Altered physical environmental regime <sup>a</sup> (BD12)	1. Sediment (BD1, BD12) 2. Loss of shade (BD1) 3. Increased water temperature (BD12)
Urban sprawl <sup>a</sup> / Urbanization <sup>a</sup>	Altered physical environment <sup>a</sup> / Altered physical environmental regime <sup>a</sup>	1. Turbidity, increased temp (BD3) 2. Sedimentation (BD12)
Construction of dams or impoundments <sup>a</sup>	Altered physical habitat structure <sup>a</sup>	1. Inundation/habitat destruction (BD4)
Residential development <sup>a</sup>	Altered physical environmental regime <sup>a</sup>	1. Increased siltation and physical loss of habitat (BD5)
Residential development <sup>a</sup>	Altered chemical environmental regime <sup>a</sup>	1. Increased use of pesticides and herbicides (BD5)
Oil or natural gas drilling <sup>a</sup>	Altered chemical environmental regime <sup>a</sup>	1. Increase chance of environmental spills (BD5)
Highway/Road construction and maintenance <sup>a</sup>	Altered physical regime (BD7) <sup>a</sup> / Altered physical environment; potential changes in water chemistry; improperly installed culverts (BD9) <sup>a</sup>	1. Sedimentation (BD7) 2. Removal of riparian vegetation causes increased sedimentation and increased water temperatures; lack of BMPs or improper site design can lead to chronic sediment input problems; poor culvert design can pose a barrier to natural movement patterns (BD9)
Residential/ Commercial development (BD8) <sup>a</sup> / Incompatible residential development	Altered physical environmental regime (BD8) <sup>a</sup> / Altered physical and chemical stream environment (BD9) <sup>a</sup>	1. Sedimentation and loss of canopy cover (BD8) 2. Removal of riparian vegetation causes increased sedimentation and increased water temperatures; sewage or septic problems are also possible, with associated changes in BOD and COD (BD9)

<i>Threat Source</i>	<i>Coarse Scale Threat Stress</i>	<i>Fine Scale Threat Stress</i>
(BD9) <sup>a</sup>		
Untreated or improperly treated sewage and septic outfalls <sup>a</sup>	Altered water chemistry; poor water quality <sup>a</sup>	1. Increased BOD and COD; zones of biotic community alteration below outfalls; alteration of blackside dace predator and prey species (BD9)
Off-road development <sup>a</sup>	Chronic erosion of stream banks and adjacent areas; reduction in water quality <sup>a</sup>	1. Increased sedimentation; pollution of stream with organic contaminants (BD9)
Periods of drought <sup>a</sup>	Reduced surface flow in streams; increased temperatures in remaining surface water <sup>a</sup>	1. Lack of surface water for basic survival; increased predation risk; increased water temperatures; recolonization of locally extinct populations thwarted by poor conditions in surrounding waters (BD9)
Global warming <sup>a</sup>	Increased stream temperatures <sup>a</sup>	1. Direct temperature increases; indirect temperature increases due to possible changes in riparian vegetation community (BD9)
Incompatible grazing or pasture management practices <sup>a</sup>	Altered physical and chemical stream environment <sup>a</sup>	1. Removal of riparian vegetation causes increased sedimentation and increased water temperatures; trampling of soils by livestock increases runoff and can decrease infiltration; waste material from livestock can cause nutrient enrichment, increased BOD/COD and associated biotic community changes (BD9).
Dam construction by humans and beavers <sup>a</sup> / Incompatible species invasion (beavers, etc) <sup>a</sup>	Altered flow regime; increased sediment accumulation and alteration of local fish community; standing waters represent potential barriers to natural movements and gene flow among disjunct populations <sup>a</sup> / Altered habitat conditions <sup>a</sup>	1. Standing waters tend to be warmer and more likely to accumulate undesirable level of sediment (which can deter blackside dace reproduction) (BD9). 2. Increased siltation, temperature, changes from lotic to lentic conditions (BD15).
Culverts <sup>a</sup>	Altered physical environmental regime <sup>a</sup>	1. Restricted movement; potential loss of spawning habitat in tributaries that cannot be accessed (BD12)

<sup>a</sup>—additional threats added by survey participant

**Comments by survey participants regarding their answers:**

**Threat Source-Coarse Scale Threat Stress-Fine Scale Threat Stress-Comments (BD3)**

1. Additional comments regarding fine-scale threat table- *My experience is that massive swings in conductivity are almost unrelated to blackside dace (or other fish) abundance.*

**(BD5)**

1. Incompatible mining practices-Altered chemical environmental regime- ***Increased conductivity and decrease in pH - Will also cause decrease in fish food organisms.***
2. Incompatible mining practices-Altered physical environmental regime- ***Increased siltation and physical loss of habitat - Will also cause decrease in fish food organisms.***
3. Incompatible forestry practices- Altered physical environmental regime- ***Increased siltation and physical loss of habitat - Will also cause decrease in fish food organisms.***
4. Incompatible species management practices - Altered biological component or integrity- ***Increase species competition - Could also result in hybridization with southern redbelly dace.***
5. Residential development – Altered physical environmental regime- ***Increased siltation and physical loss of habitat - Will also cause decrease in fish food organisms.***
6. Residential development – Altered chemical environmental regime- ***Increased use of pesticides and herbicides - Will also cause decrease in fish food organisms.***
7. Oil or natural gas drilling – Altered chemical environmental regime – ***Increase chance of environmental spills - Will also cause decrease in fish food organisms.***

**(BD9)**

1. Incompatible mining practices-Altered chemical environmental regime- ***Increased water conductivity from turbidity and metal ions - Blackside dace tend to be absent in stream reaches where conductivity exceeds 240 uS.***
2. Incompatible mining practices-Altered physical environmental regime- ***Removal of riparian vegetation causes increased sedimentation and increased water temperatures - Blackside dace tend to be absent in stream reaches where summer water temperatures exceed 20-24 C; also, the species requires clean substrate for spawning with its nest associate species.***
3. Incompatible forestry practices- Altered physical environmental regime- ***Removal of riparian vegetation causes increased sedimentation and increased water temperatures - Blackside dace tend to be absent in stream reaches where summer water temperatures exceed 20-24 C; also, the species requires clean substrate for spawning with its nest associate species.***
4. Road construction and maintenance - Altered physical environment; potential changes in water chemistry; improperly installed culverts - ***Removal of riparian vegetation causes increased sedimentation and increased water temperatures; lack of BMPs or improper site design can lead to chronic sediment input problems; poor culvert design can pose a barrier to natural movement patterns - Removal of riparian vegetation causes increased sedimentation and increased water temperatures; lack of BMPs or improper site design can lead to chronic sediment input problems; poor culvert design can pose a barrier to natural movement patterns.***
5. Untreated or improperly treated sewage and septic outfalls - Altered water chemistry; poor water quality - ***Increased BOD and COD; zones of biotic community alteration below outfalls; alteration of blackside dace predator and prey species - We noticed a pattern with oxygen levels, but it was correlated with temperature, which seemed to wield the stronger effect.***
6. Off-road development - Chronic erosion of stream banks and adjacent areas; reduction in water quality - ***Increased sedimentation; pollution of stream with organic contaminants - We have observed gasoline sloshing out of a “monster truck” driving inside of a blackside dace stream; smaller ATVs are also a problem.***
7. Periods of drought - Reduced surface flow in streams; increased temperatures in remaining surface water - ***Lack of surface water for basic survival; increased predation risk; increased water temperatures; recolonization of locally extinct populations thwarted by***

*poor conditions in surrounding waters - Periods of natural drought can be exacerbated by reduction in water table if local runoff or infiltration rates have been altered by development or resource extraction activities.*

8. Global warming - Increased stream temperatures - *Direct temperature increases; indirect temperature increases due to possible changes in riparian vegetation community - Southern redbelly dace seem to be slightly more tolerant of warmer temperatures than blackside dace and could possibly replace the latter in the face of global warming.*
9. Incompatible residential development - Altered physical and chemical stream environment - *Removal of riparian vegetation causes increased sedimentation and increased water temperatures; sewage or septic problems are also possible, with associated changes in BOD and COD - Blackside dace tend to be absent in stream reaches where summer water temperatures exceed 20-24 C; also, the species requires clean substrate for spawning with its nest associate species.*
10. Incompatible grazing or pasture management practices - Altered physical and chemical stream environment - *Removal of riparian vegetation causes increased sedimentation and increased water temperatures; trampling of soils by livestock increases runoff and can decrease infiltration; waste material from livestock can cause nutrient enrichment, increased BOD/COD and associated biotic community changes - Blackside dace tend to be absent in stream reaches where summer water temperatures exceed 20-24 C; also, the species requires clean substrate for spawning with its nest associate species; not sure how tolerant this species is to livestock presence.*
11. Dam construction by humans and beavers - Altered flow regime; increased sediment accumulation and alteration of local fish community; standing waters represent potential barriers to natural movements and gene flow among disjunct populations - *Standing waters tend to be warmer and more likely to accumulate undesirable level of sediment (which can deter blackside dace reproduction) - Davis Branch in Cumberland Gap Historic Park is a good example of a stream where beavers moved in and blackside dace went downhill over about a 10 or 12 year period; Doug Stephens has a good annual dataset of monitoring this stream to document the decline (blackside dace numbers have plummeted).*
12. Additional comments regarding fine-scale threat table- *BOD and COD refer to biological oxygen demand and chemical oxygen demand.*

**(BD11)**

1. Additional comments regarding fine-scale threat table- *Difficult to say at a fine scale – I am not comfortable saying I am sure what exactly is exacerbating dace rarity or on the other hand, allowing them to persist.*

**(BD13)**

1. Incompatible species management practices - Altered biological component or integrity- *Predation - Small potential probably exists for some predation by native species (e.g., Creek Chub, Largemouth Bass, Green Sunfish) that has likely increased through the introduction of non-native predators (e.g., trout, Redbreast Sunfish, Bluegill, Largemouth Bass, etc.).*

**(BD15)**

1. Incompatible mining practices-Altered chemical environmental regime- *Lower pH, iron, aluminum input into system- Severe*
2. Incompatible mining practices-Altered physical environmental regime- *Silt ponds within streams - Severe*
3. Incompatible forestry practices- Altered physical environmental regime- *Increased siltation, increased temperature due to canopy removal - Severe*

4. Incompatible species management practices - Altered biological component or integrity- ***Introduction of species, such as trout in dace habitat - Moderate***
5. Incompatible species invasion (beavers, etc) - Altered habitat conditions - ***Increased siltation, temperature, change from lotic to lentic conditions – Severe***

### **3. Confidence values based on SWAP threats and threats added by survey participants.**

very high=4, high=3, moderate=2, low=1, none=0, U=unknown

<i>Threat Source</i>	<i>Threat Stress</i>	<i>Confidence Values (Regarding Take)</i>	<i>Mean</i>	<i>Mode</i>
Incompatible mining practices	Altered chemical environmental regime	4,2 <sup>a</sup> ,2,3,4,3,3,3,3,4,U,U,3 <sup>b</sup> ,4,4,3	3.2 (N=13)	3.0
Incompatible mining practices	Altered physical environmental regime	4,2,3,3,4,3,3,2,4,3,3,3 <sup>b</sup> ,4,4,2	3.1 (N=15)	3.0
Incompatible forestry practices	Altered physical environmental regime	4,3,3,3,3,3,2,3,4,3,4,3,4,3,3	3.2 (N=15)	3.0
Incompatible species management practices	Altered biological component or integrity	U,3,U,1,2,U,1,1,U,0,U,3,U,2,2	1.7 (N=9)	1.0-2.0 tie
Urban Sprawl/ Residential Development <sup>c</sup> / Residential/Commercial development <sup>c</sup> / Incompatible residential development <sup>c</sup>	Altered physical environment <sup>c</sup> (BD3)/ Altered physical environmental regime <sup>c</sup> (BD5, BD8)/ Altered physical and chemical stream environment <sup>c</sup> (BD9)	2 (BD3, BD5, BD8), 1 (BD9)	1.8 (N=4)	2.0
Oil and Gas Drilling <sup>c</sup>	Altered chemical environmental regime <sup>c</sup>	2 (BD1, BD5)	2.0 <sup>d</sup>	
Straight pipes-poor or inadequate sewage treatment <sup>c</sup> / Untreated or improperly treated sewage and septic	Altered chemical environmental regime <sup>c</sup> / Altered water	2 (BD1), 3(BD9)	2.5 <sup>d</sup>	

<i>Threat Source</i>	<i>Threat Stress</i>	<i>Confidence Values (Regarding Take)</i>	<i>Mean</i>	<i>Mode</i>
outfalls <sup>c</sup>	chemistry; poor water quality <sup>c</sup>			
Highway construction and maintenance <sup>c</sup> / Road construction and maintenance <sup>c</sup>	Altered physical regime <sup>c</sup> / Altered physical environment; potential changes in water chemistry; improperly installed culverts <sup>c</sup>	2 (BD7, BD9 <sup>e</sup> )		
Dam construction by humans and beavers <sup>c</sup> / Incompatible species invasions (beavers) <sup>c</sup>	Altered flow regime; increased sediment accumulation and alteration of local fish community; standing waters represent potential barriers to natural movements and gene flow among disjunct populations <sup>c</sup> / Altered habitat conditions <sup>c</sup>	2 (BD9), 3 (BD15)	2.5 <sup>d</sup>	
Oil and Gas Drilling <sup>c</sup>	Altered physical environmental regime <sup>c</sup>	2 (BD1)		
Agriculture-livestock (horses, cattle) <sup>c</sup>	Stormwater runoff – altered chemical environmental regime <sup>c</sup>	2 (BD1)		
Agriculture-livestock (horses, cattle) <sup>c</sup>	Stormwater runoff – altered	2 (BD1)		

<i>Threat Source</i>	<i>Threat Stress</i>	<i>Confidence Values (Regarding Take)</i>	<i>Mean</i>	<i>Mode</i>
	physical environmental regime <sup>c</sup>			
Off-road development <sup>c</sup>	Chronic erosion of stream banks and adjacent areas; reduction in water quality <sup>c</sup>	2 (BD9)		
Periods of drought <sup>c</sup>	Reduced surface flow in streams; increased temperatures in remaining surface water <sup>c</sup>	2 (BD9)		
Global warming <sup>c</sup>	Increased stream temperatures <sup>c</sup>	1 (BD9)		
Incompatible grazing or pasture management practices <sup>c</sup>	Altered physical and chemical stream environment <sup>c</sup>	1 (BD9)		
Urbanization <sup>c</sup>	Altered physical environmental regime <sup>c</sup>	2 (BD12)		
Culverts <sup>c</sup>	Altered physical environmental regime <sup>c</sup>	2 (BD12)		
Agriculture <sup>c</sup>	Altered physical environmental regime <sup>c</sup>	2 (BD12)		

<sup>a</sup> - Active mine sites may contribute much less to this problem than abandoned sites.

<sup>b</sup> - Two streams that we sampled in which blackside dace were historically collected had coal mining occur within their watersheds between the historic sample and my sample. Blackside dace were not captured in either of the streams during my sampling. Both streams appeared to be impacted by the mining operations and had heavy sedimentation and increased conductivity (BD12).

<sup>c</sup> - Additional threats added by survey participant.

<sup>d</sup> - Not enough values to be considered a significant mean alone.

<sup>e</sup> - Depends on how well the work is done (BD9).

**Additional comments regarding this table:**

- Direct harvest of blackside dace by recreational fishermen who use dace for bait occurs spottily throughout the species' range. We have encountered deployed minnow traps and individuals harvesting blackside dace on a number of occasions. This form of take has the potential to locally deplete a population if the harvest is regular enough. Some form of education campaign should be initiated to discourage or prevent such practices (BD9).

**4. Which landuse currently is most threatening and is causing take of the focal species?**

Numbers are percents of the total survey participants.

<i>Species</i>	<i>Forestry</i>	<i>Mining</i>	<i>Water Development</i>	<i>All of above</i>	<i>None of above</i>	<i>Unable to answer</i>
Blackside Dace (N=15)	13	87				

**Comments by survey participants regarding their answers:**

**Forestry**

- I believe forestry and mining have the greatest potential to contribute to stress of the species. Forestry is the least noticed of these in terms of ensuring that protective measures are implemented for blackside dace (BD2).
- Inasmuch as it leads to sedimentation coating stream substrates and removal of riparian zones controlling water temperatures and energy/pollutant input into streams (BD11).

**Mining**

- Forestry is a close second but streams can recover; water quality alteration by mining creates a long-term problem (BD1).
- Some of the forestry aspects and urban sprawl are most intense, but usually affect only small areas. The widespread and expanding coal mining can affect large areas. In addition, the sheer maliciousness of many coal mining operators is relevant (BD3).
- While all three are concerns, mining is currently in process and has probably impacted at least one population in Tennessee (Elk Fork Creek tributary) (BD5).
- I have witnessed the cumulative impacts from surface mining over the last 30 years (BD7).
- Past mining influences are still regulating this species' return to historical localities (BD8).
- Surface/ridgeline/deep coal mining has my vote because of the sheer scale and potential widespread destruction it can cause if poorly practiced. The landscape could take centuries to recover, and residual acid mine drainage and high water conductivity can present a chronic threat for many years and can be extremely difficult to remediate. Forestry would be my runner-up vote, but the forestry-damaged landscape has the potential to heal itself over a shorter period of time and there probably are fewer chronic problems. For example, if either mining or forestry caused a local blackside dace population to be extirpated, then subsequent natural recolonization or human re-establishment of the dace population would be inherently easier, in my opinion, in a forestry-impacted scenario than in a mining-impacted scenario. We have all encountered streams in what seem to be restored/revegetated post-mining habitats but the streams are largely devoid of any meaningful aquatic life due to chronic post-mining water quality problems (BD9).
- Coal mining is the most threatening activity due to the altered physical and chemical environments that often take place. Additionally, the increased demand for coal will result in increased extraction and continue to threaten blackside dace into the future. Logging ranks a close second to mining. When done in a sustainable manner, logging operations

would likely have a much-reduced impact on blackside dace as compared to the current methods that I observed (e.g., clear cutting riparian zones, constructing haul roads directly up mountainsides, operating equipment through streams, etc.). Regulations appear to be minimally enforced by the states of Kentucky and Tennessee (BD12).

- There is little doubt that coal surface-mining activities have had and continue to have the most devastating impacts on stream habitats in the upper Cumberland River drainage. Because of the relatively recent increase in mining activity that likely will not diminish anytime soon, I see this as the most significant threat to Blackside Dace populations (BD13).
- My observation is that any level of mining activity in the watershed of a stream containing blackside dace results in a declining dace population (BD15).

**5. Which landuse practice is most threatening and has the greatest potential to cause take over the next 10 years?**

Numbers are percents of the total survey participants and are rounded to the nearest whole numbers.

<i>Species</i>	<i>Forestry</i>	<i>Mining</i>	<i>Water Development</i>	<i>All of above</i>	<i>None of above</i>	<i>Unable to answer</i>
Blackside Dace (N=15)	13	73		7		7

**Comments by survey participants regarding their answers:**

**Forestry**

- Although an adequate level of enforcement of mining activities may be difficult in some cases, the enforcement of BMPs relative to logging appears to have more potential for widespread problems. I base this statement on the current limitation of enforcement and on the obvious increase in logging and potential for logging. Housing developments (in association with the water development issue) may also provide some site-specific challenges in the future (BD2).
- Unregulated logging on private lands is increasing due to a decline of logging on national forest lands in the upper Cumberland basin (BD15).

**Mining**

- Forestry is a close second but streams can recover; water quality alteration by mining creates a long-term problem (BD1).
- But all three are concerns, especially when two or more are going on simultaneously (BD5).
- With concerns over gas prices, there is talk of expanding coal extraction. Impacts will probably increase (BD7).
- Surface/ridgeline/deep coal mining has my vote because of the sheer scale and potential widespread destruction it can cause if poorly practiced. The landscape could take centuries to recover, and residual acid mine drainage and high water conductivity can present a chronic threat for many years and can be extremely difficult to remediate. Forestry would be my runner-up vote, but the forestry-damaged landscape has the potential to heal itself over a shorter period of time and there probably are fewer chronic problems. For example, if either mining or forestry caused a local blackside dace population to be extirpated, then subsequent natural recolonization or human re-establishment of the dace population would be inherently easier, in my opinion, in a forestry-impacted scenario than in a mining-impacted scenario. We have all encountered streams in what seem to be

restored/revegetated post-mining habitats but the streams are largely devoid of any meaningful aquatic life due to chronic post-mining water quality problems (BD9).

- Potential impacts related to mining include, but are not limited to the following (BD10):
  - Failure of settling ponds release toxic chemicals into fish habitat.
  - Building settling ponds in locations where they act as barriers that prevent fish from accessing spawning habitat.
- Coal mining is the most threatening activity due to the altered physical and chemical environments that often take place. Additionally, the increased demand for coal will result in increased extraction and continue to threaten blackside dace into the future. Logging ranks a close second to mining. When done in a sustainable manner, logging operations would likely have a much-reduced impact on blackside dace as compared to the current methods that I observed (e.g., clear cutting riparian zones, constructing haul roads directly up mountainsides, operating equipment through streams, etc.). Regulations appear to be minimally enforced by the states of Kentucky and Tennessee (BD12).
- I think that current levels of enforcement are not really eliminating or even reducing the impacts; it seems that violations still occur and permits are still issued, regardless of whether Blackside Dace are present within the area impacted (BD13).

**All of the above**

- As human populations grow and expand into previously undeveloped areas in the region, the need for land clearing and water utilization will increase. As long as mining is profitable, mineral extraction will continue (BD8).

**Unable to answer**

- I would say it depends on the direction in which the upper Cumberland region goes in the next ten years. If mining activity increases to meet increased energy demands, and as a result, becomes even more invasive and destructive, then I would highlight that. If however, development in the area increases (less likely unless new economic opportunities spring up), the demand for water and infrastructure is very real, as is the creation of massive volumes of stormwater and its associated impacts (BD11).

**6. If not answered in the tables in questions 1-3, specifically how is take of the Blackside Dace linked to the landuse practices that you selected in questions 4-6?**

**[A hypothetical (fabricated) example of the detail needed for this question follows: poor road construction in steep terrain can result in erosion, increased turbidity and sedimentation of aquatic habitats, which clogs adult Blackside Dace gills and prevents adequate respiratory function.]**

- Destruction of natural vegetation probably has several effects. Obviously these are most pronounced with loss of riparian zone, but likely removal of vegetation anywhere in the watershed will cause some of these. First, lack of shade is going to result in increased water temperature, apparently above that tolerable for *P. Cumberlandensis*. Second, removal of vegetation will affect flow regimes – more prone to drought and flood. Fishes may directly be killed by drying in pools or be forced downstream where they can't compete with other fishes or they are preyed upon by other fishes. Third, the siltation produced by land disturbance is likely to radically affect the substrate, shifting or eliminating invertebrate communities that can serve as food sources (BD3).
- Destruction of natural vegetation can occur by logging, surface mining, or urban sprawl, but the result on the fishes is probably similar (BD3).

- As noted hypothetically, sediment can affect prey base as well as visual feeding and spawning behavior, egg survivorship in gravel interstitial spaces, and direct stress on gills. Eutrophication and resulting excessive algal growth can have similar results (BD4).
- All (mining, forestry, water development, and residential development) directly or indirectly increase runoff, erosion, siltation, and water temperatures; which will physically alter fish habitat, spawning habitat, and also fish food organism habitat. Chemical alterations (e.g. lower pH) directly impact the survival of all life stages, especially reproductive potential. It also directly impacts fish food organisms (BD5).
- Mining, logging, agricultural practices, road construction, etc., all have the potential to increase erosion and sedimentation/siltation in the stream, increase water temperatures, or negatively alter the chemical/physical (decreased pH, increased conductivity, etc.) regime of the stream (BD6).
- Within the range of the Blackside Dace, there are a number of low water crossings that produce sedimentation every time a car utilizes the crossing. Also the counties have a number of roads through the floodplain. These roads frequently flood. Ditch cleaning, grading, and new road construction all cause significant erosion at times (BD7).
- Sediment deposition and altered water quality from mining and associated activities (land clearing) could increase the take of blackside dace by reducing suitable habitat (both physical and chemical). Residential development could lead to the increase in sedimentation and the reduction of riparian canopy in certain situations (BD8).
- Largely covered in questions 1-3 (BD9)
- See answer to question 5. Blackside dace are capable of moving around and can colonize and recolonize areas according to habitat suitability and water quality, as long as there are no physical barriers to this dispersal. Alternatively, ecological barriers (inappropriate habitat or water quality) could inhibit dispersal into areas that may have more appropriate habitat or water quality in other parts of the system (BD10).
- Poor road construction techniques in steep terrain can result in erosion and increased sedimentation and turbidity, which may limit spawning habitat and/or primary production. A decrease in primary production such as diatoms may limit availability food resources. (BD12).
- Siltation introduced into streams through runoff resulting from coal surface-mining, logging, road construction, and other land use activities is the most frequently cited cause for blackside dace population declines. Siltation likely affects Blackside Dace by filling in and covering shelter and foraging spaces and surfaces as well as spawning sites. Dace have also been shown to be intolerant of unusually high conductivity that results from mining activity. Although many of the streams currently supporting blackside dace have experienced some degree of impact from siltation and other physical and chemical changes to instream habitat, the extent to which dace can withstand these impacts is not entirely known (BD13).
- Sediment may also be impacting early life history stages of blackside dace through suffocation (BD14).
- Unregulated logging in the watershed increases erosion and subsequent siltation into the stream. Also, removal of riparian trees increases solar radiation and thereby increasing stream temperatures beyond the optimum for this species (BD15).

**7. Are you aware of any landuse activities other than logging, mining, or water development that are causing take of the Blackside Dace now, or are likely to cause take in the next 10 years?**

- Various county governments (highway depts.) frequently do bridge replacements/repairs, simply “clean out the creek” to remove obstructions, or clean out ditches – these activities can be a significant problem, cause significant sedimentation. I have seen it (BD1).
- Not necessarily, but activities that may be contributing to take include oil/gas, highway/bridge maintenance, housing development, and un-reclaimed mine sites (BD2).
- Urban sprawl above. As far as I can tell, these expansions (often trailer parks) are popping up without any regulation (BD3).
- Agricultural practices & ORV use, introducing sediment, direct sewer outfalls (BD4).
- Residential development is probably not a current problem in this area, as compared to other places; but the future potential is there, at some unforeseen level (BD5).
- Residential and/or industrial development within a few watersheds. Also have witnessed gravel mining and other physical changes (channelization, stream re-location, etc.) to streams using bulldozers (BD6).
- Within the range of the Blackside Dace, there are a number of low water crossings that produce sedimentation every time a car utilizes the crossing. Also the counties have a number of roads through the floodplain. These roads frequently flood. Ditch cleaning, grading, and new road construction all cause significant erosion at times (BD7).
- Residential development could potentially impact localized populations in desirable localities (BD8).
- See tables in questions 1 through 3 (BD9).
- Cattle and other livestock in streams. The associated bacteria loads and destruction of riparian zone would lead me to hold this practice highly suspect in take of blackside dace (BD11).
- Infrastructure development (e.g., road construction that could cause heavy sedimentation) (BD12).
- To a lesser extent, poor agricultural practices, urbanization and increased residential development, and industrial wastes have contributed to the degradation of some Blackside Dace streams. I think that these disturbances will only increase with human population growth and expansion into more rural areas (BD13).
- ATVs? There have been problems with people driving ATVs (includes jeeps, etc.) up and down streams and disturbing soil that could cause sedimentation (BD14).
- Not at the present time (BD15).

**8. Is take of the Blackside Dace occurring in ways not related to any particular landuse activity?**

**[For example, low levels of take occasionally occur when fishermen unwittingly collect Blackside Dace in minnow traps while collecting minnows as fishing bait. This type of take would not be related necessarily to a particular landuse (unless road/trail development afforded greater access to Blackside Dace streams).]**

- Your example is correct – there is some collection (take) by minnow traps (BD1).
- No other threats come to mind, especially in terms of ways that we can affect management tools for the species (BD2).
- I really doubt this is important (BD3).
- Not sure (BD4).

- There is evidence that bait collection does go on in streams where blackside dace occur and we have observed this on at least two occasions. In one minnow trap we observed that about 70 blackside dace had been trapped. In the Elk Fork Creek drainage in Tennessee, the southern redbelly dace (*Phoxinus erythrogaster*) has become well established within the last ten years and in at least one tributary has replaced most of the blackside dace. The possibility of exclusion by competition or hybridization by this closely related species might be a real concern in this area (BD5).
- Yes, I have seen a few individuals in minnow traps in the past (BD6).
- I have not witnessed this activity (BD7).
- Yes- We have encountered the take of dace by fishermen who unknowingly use them as bait fish. This is also a vector for establishing populations in new localities. Additionally there is some concern that the recolonization of beavers into blackside dace streams be detrimental (BD8).
- Yes, see my comments after the table in question 3 (BD9).
- I suppose the example given above could be pretty realistic, given that the species may be pretty abundant (and likely to enter minnow traps) where they occur, and they presumably would make good bait for fishing (BD10).
- Besides incidental take as bait, I cannot think of anything (BD11).
- A number of anglers that I spoke with preferred using “redbelly minners” blackside dace and southern redbelly dace for fishing. Additionally, I observed minnow traps that contained many blackside dace that I presume were being collected for bait. The locations in which I observed minnow traps containing blackside dace were very close to roadways (BD12).
- I have received occasional reports of fishermen unknowingly collecting blackside dace in minnow traps for use as bait. I do not know how often or extensively this occurs, but it is unlikely to be a significant factor in population declines or extirpations, unless it involves a population barely hanging on in small numbers (BD13).
- Yes, bait bucket is a problem; I saved about a dozen dace from a fisherman this spring (2006) (BD14).
- I think that collecting minnows for bait has a minimal impact on the dace population. It has occurred at higher level in the past. Posting the streams for the purpose of prohibiting bait collection would only draw attention to the population of the species and may create a situation where the population would be more likely to be harmed (because of curiosity, malicious intent, etc. (BD15).

**9. Are you aware of any strategies that could be used to either (a) minimize take or (b) completely avoid take of individuals or habitat?**

**[For example, which best management practices could be modified, implemented, and enforced to achieve better conservation of this species and its habitat?]**

- Protection and Enhancement Plans (mining) for KY and TN; TN’s plan is in draft form, KY will prepare a PEP in 2007/2008.
- Implementation of forestry BMPs (specified by KDOF) would prevent most sedimentation problems on logging sites (BD1).
- Enforcement of known methods to keep mud out of streams is probably the single most important strategy to improve the management of ongoing activities (logging and mining).
- Reforestation of riparian corridors would improve the long-term health of streams (BD2).
- I have to make this comment. Two of the biggest threats to saving this fish concerns our government. The process of getting permits to do scientific research on blackside dace is

almost unworkable. I find it amazing, that large trailer parks can be erected on blackside dace streams and the stream treated so badly that not only did a healthy population of blackside dace disappear, but all other fishes disappeared and the stream is almost completely devoid of macroinvertebrate life. Yet, an ichthyologist with past record of working with the conservation biology of this and other federally protected species can't get a permit to study them that requires no death of blackside dace! (The stream I am talking about above is Stephenson's Branch, near Middlesboro, KY).

- The second problem is our present government leadership. Until we get government leadership that values conservation biology, not much is going to happen. Case in point – recently did a survey for blackside dace in a stream that had never been surveyed before, but was nearby a blackside dace stream. Two days before we did the survey, the coal company “nuked” the stream we were to survey. They got in the creek, bulldozing it out, changing a hemlock, rhododendron, rocky stream into a mud ditch. We found zero fishes and only a handful of insects in an entire day's survey. As far as I know, no penalty was ever assessed.
- The problem is not education. When I talk to people like this, they know about endangered species and can list off the values of biodiversity and such. They are just making an economic decision. They will only act if rules are enforced (BD3).
- Maintain strict minimum undisturbed riparian zones throughout watersheds (BD4).
- Implement and enforce BMPs, especially for roads and road construction and buffer zones on streams.
- Avoid any activity that will alter the natural course on any stream (BD5).
- Eliminating mining and logging in the watersheds.
- Establish buffer zones that prevent or reduce physical impairment of the stream.
- Sample streams with the best blackside dace populations to establish baseline chemical parameters and then establish and enforce strict water quality standards for the remaining dace streams (BD6).
- Stricter BMPs on mineral and forestry resource utilization. Stricter enforcement and penalties for permit violations and non-permitted activities (BD8).
- For mining, I am not convinced that coal mining in or near blackside dace watersheds is really compatible with blackside dace persistence. I am basing this on data that show, with few exceptions, that blackside dace do not occur or do not persist in places where water conductivities exceed 220-240 uS. There are a few exceptions (near White Oak Junction in McCreary County, KY, for example) where blackside dace somehow persist in spite of high conductivity. This raises the question of whether high conductivity is simply an indicator of past mining activities which themselves (i.e., the past mining impacts) destroyed the dace population, or whether high conductivity itself currently affects dace and a few populations are able to withstand it by some mechanism (maybe all other factors such as temperature and stream size have to be “right” for the dace and only conductivity can be “wrong” for dace to persist). This conductivity question warrants further research, and it is an important question. Water conductivity was one of several significant environmental predictor variables in 2003-2004 *and* water conductivity was the single best predictor variable when the models were validated (tested) the models in new streams in 2005-2006. I would recommend keeping blackside dace watersheds off-limits to mining activities until the issues with conductivity can be resolved. Perhaps there is room for environmental engineering or mining research to ultimately prevent chronic high conductivity in pre-, during-, and post-mining stream habitats. This would be even more important if conductivity in and of itself were to be the key direct stressor on blackside dace populations (rather than simply a post-mining indicator of presence/absence).

- For many other stressors (such as pre-mining clearing, forestry, residential development, and so forth) proper BMPs should be implemented and perhaps made more stringent in certain areas. For example, given blackside dace preference for cooler habitats, it might be reasonable to increase the width of riparian buffer from current BMP recommendations. Increasing buffer width would also provide an extra measure of erosion control and reduction of in-stream sedimentation rates, which would provide a better habitat to allow blackside dace reproduction to occur. It also might be reasonable to prohibit certain activities during the spawning season (March through June). Forestry trails, skidding areas, yards, haul roads, and stream crossings should be designed and constructed to prevent as much erosion as possible. Forestry BMPs should be mandatory, monitored, and enforced in both states (KY and TN). Tennessee should consider implementing a Master Logger program with endangered species training sessions like is being implemented in Kentucky.
- Current and future residential developments should have mandatory and inspected modern sewage and septic systems with minimal impact to stream water quality.
- ATVs in National Forest lands should be better monitored and enforced, and their use in reclaimed mine sites is questionable if erosion cannot be better managed. If not already in effect, a purchase tax could be implemented on ATVs (similar to that levied against hunting and fishing gear) that could create a fund for monitoring and improving erosion control in areas in which ATV use is commonplace.
- In general, monitoring and enforcement of environmental laws such as ESA and CWA should be prioritized. Too many instances of take go either unnoticed or are ignored due to lack of manpower or willpower to tackle cases of noncompliance.
- Agencies should be given the resources and support to conduct proper enforcement activities and incidences of take would likely decline (BD9).
- To conserve/manage this species, my opinion is that diligence is needed to maintain the most up-to-date information on population status in the various watersheds inhabited by the species. The small streams/watersheds it inhabits are likely to be adversely affected more quickly and easily than larger streams/watersheds, and consequently population status can change quickly. We don't seem to be monitoring these changes frequently enough. This includes the positive changes as well as the negative (BD10)!
- Conservation of intact riparian zones, incentive-based restoration of already denuded areas, positive education of local governments and citizens to build stewardship of native stream resources.
- Specifically, better targeting and enforcing sediment management associated with logging practices, as well as perhaps incentivizing the leaving of forested buffers around streams while logging an area (BD11)?
- Logging BMP's should:
  - Require use of approved stream crossings (e.g., portable bridges) to keep equipment out of creeks.
  - Require that a minimum of 100' buffers (50' on each side of stream) be maintained with no operation of equipment in these areas. A few high-dollar trees may be cut in the zone, but must be winched out using cables, and no trees on stream banks should be harvested.
  - Require that skid roads run perpendicular with the slope, using switchbacks to climb hillsides with water bars installed to reduce erosion (no roads cut straight up mountainsides).
- Log landings and skid roads should be mulched and seeded with seasonal grasses when operation is complete.
- More strict enforcement of regulations by states of Kentucky and Tennessee.

- Mining laws and regulations need to be updated and enforced regularly.
- BMPs for dirt roads could be implemented to reduce erosion and sedimentation (BD12).
- Existing legislation and regulations such as the Federal Endangered Species Act, Clean Water Act, Federal and State surface mining laws would minimize take of Blackside Dace and habitat if these laws and regulations were strictly enforced. Timber harvesting BMPs also exist that are very useful for protecting Blackside Dace and its habitat. It appears that much of the problem with population declines and extirpation has resulted from activities that violate these laws. With mining and timber harvest activity on the rise (which likely will not diminish anytime soon), I think that additional measures such as those proposed in early 2006 by the USFWS, USOSM, TDEC, USACOE, and TWRA to provide mining applicants with guidelines for the development of protection and enhancement plans for Blackside Dace is a step in the right direction.
- Above all, I think that an increased effort towards public awareness and education is crucial to gain the necessary support for protection and conservation of this and other imperiled species and their habitats (BD13).
- BMPs enforced on logging/mining activities.
- Have KY and TN state agencies actually list approved baitfish and/or create a section in the regulations book that shows pictures of state and federally listed fish species (BD14).
- Restriction of logging in riparian zone along streams known to contain a population of blackside dace. Better logging regulations (on the books and enforced) on private lands would increase chances of survival for this species (BD15).

***10. What mitigation strategies might be appropriate to offset take, if an incidental take permit were to be issued for some particular landuse activity?***

**[Examples of mitigating take include (but are not limited to) preserving current habitat through an easement or purchase, restricting access to lands, creating buffers around existing habitats, restoring degraded areas to provide suitable habitat, creating new suitable habitats, and modifying landuse practices.]**

- All of these examples (preserving current habitat through an easement or purchase, restricting access to lands, creating buffers around existing habitats, restoring degraded areas to provide suitable habitat, creating new suitable habitats, and modifying landuse practices) would apply (BD1).
- Reclamation of abandoned mine areas to improve water quality (e.g., stabilization of spoil piles and stabilization of the abandoned sediment pond at the upper end of Lick Fork).
- Re-stocking of the species to streams that have been restored.
- Reforestation of riparian corridors.
- Beaver control.
- Removal of impediments to movement (such as dams) (BD2).
- Don't even remotely suggest new suitable habitats or restoring – as finicky as the blackside dace is, these will not work. It has to be protecting present habitat (BD3).
- Minimum width riparian buffer creation, catch basins or run-off control structures.
- Funding for sewage treatment systems or septic system improvements or wetlands construction to filter water and trap sediments (BD4).
- In an extreme situation that may result in extirpation of the existing population, temporarily captive holding of the existing population for re-introduction or for captive breeding to re-stock with progeny from that population when the activity is concluded and habitat is restored could be considered (BD5).

- All of the strategies given in the example (Preserving current habitat through an easement or purchase, restricting access to lands, creating buffers around existing habitats, restoring degraded areas to provide suitable habitat, creating new suitable habitats, and modifying landuse practices.) should be employed with a high priority given to preserving the best dace streams through a purchase or conservation easement (BD5, BD6).
- Require buffer zones that shade and protect rivers/creeks. That is, timber harvest, agricultural clearing, etc., should not come within 100' of the stream (BD7).
- Have landuse entities pay into a mitigation bank that would be used to address alterations (either on site or off site) incurred during development.
- Establish new populations of blackside dace in suitable streams within the watershed when permitted activities will lead to the degradation or destruction of an existing population (BD8).
- All the listed examples should be considered, as well as mitigation banks and a fund to re-establish dace populations in watersheds where they have been extirpated, provided the stream habitat has been sufficiently restored to actually support the population (BD9).
- The preservation or restoration of continuous riparian buffers around currently healthy populations, which are perpetually protected, would be a first priority (BD11).
- Once habitat and/or water quality is lost or degraded, it can be very difficult to restore. Thus, any mitigation that is directed at preserving watersheds that contain blackside dace in perpetuity may be the best use of mitigation funds.
- Conservation easements on other streams that contain blackside dace.
- Purchase of mineral rights in watersheds on Daniel Boone National Forest that contain blackside dace populations (e.g., Big Lick Branch) (BD12).
- Should an incidental take permit be issued for a particular land use activity, I would recommend mitigation strategies to protect the healthiest known populations remaining. Such strategies may include preserving these populations and their habitat through easement or purchase, or creating appropriate sized buffer zones around habitat known to support significant populations.
- Reintroduction of individuals into areas within the species' historic range where optimal habitat conditions [as detailed by Jones in Mattingly et al. (2005)] exist may also be effective strategy. However, such efforts should proceed in a way that would protect the genetic integrity of the species. Reintroductions should involve individuals taken from within each metapopulation as identified by Strange and Burr (1995) in order to maintain natural genetic diversity.
- Consideration should also be given to protecting natural dispersal corridors between metapopulations as well as habitat protection (BD13).
- Use easements and create buffers (BD14).
- I'm not sure if allowing incidental take in some streams would be a good precedent to consider. Although, I do believe if a sound system was in place prior to any consideration of this, that some marginal population could be eliminated only if another damaged stream with a marginal or good population within the same watershed were improved with good stream restoration techniques to improve habitat conditions. This should be done only on an experimental basis at first to determine success before ANY population of dace is eliminated. Adequate improvements in population levels should be agreed upon at the onset of such an experiment and the program only be able to continue if agreement by all agencies involved that the program is accomplishing its goals.
- An easement or purchase of watersheds that contain good populations of dace should be a high priority. Again, if this occurs, periodic monitoring of the dace population should be done to ensure that the dace population remains stable or improves (BD15).

## **11. What are the major natural/ecological sources of stress or mortality for the Blackside Dace that may only be indirectly related to human activities?**

**[For example, altered physicochemical conditions might favor a predator or competitor (either native or nonindigenous) that displaces the Blackside Dace.]**

- Drought and low flow conditions create stress on populations – low DO, greater predation pressures (BD1)
- Beavers alter high quality blackside dace habitat in some areas (BD2).
- Back to my comments above, I suspect altered landuse, especially removal of riparian vegetation and large woody debris will eliminate cover places. I strongly suspect this makes the blackside dace vulnerable to predation by syntopic critters like large *Semotilus*. Given the blackside dace's extremely strong association with heavy cover (large root masses, undercut banks, large woody debris piles), I suspect this is an adaptation to reduce predation (BD3).
- Habitat and population fragmentation reducing ability of populations to recolonize habitats from which they've been extirpated (BD4)
- Floods and droughts are natural ecological stressors that act on blackside dace populations. The impact of floods may be increased due to human activities that alter natural stream courses. Depending on timing of the event, a flood can wipe out an entire year-class if it occurs when eggs or fry are most susceptible. Prolonged droughts may impact overall abundance of blackside dace populations and result in lowering reproductive success over time (e.g., droughts lasting more than three years will exceed their normal life span). Also, droughts reduce stream habitat to isolated pools that may make them more vulnerable to predators. Floods and droughts are natural occurrences that seldom result in population extinctions, but do lower abundances, and must be taken into account for observed population declines (BD5).
- Exactly. Stocking of predator fishes in or near streams with blackside dace, and altering the physiochemical conditions to favor predators has happened in the past and probably resulted in a higher than normal rate of predation. Redbreast sunfish (*Lepomis auritus*) appeared to be a problem in some streams, especially some of the Jellico Creek (Whitley Co., KY) tributaries (BD6).
- Climatic variability associated with warmer or drier summers could cause significant problems. Global warming? Storms tend to be more severe and more frequent than in past decades (BD7).
- Competition and hybridization with southern redbelly dace in the Elk Fork Creek watershed, recolonization of beavers into blackside dace streams, potential hemlock woolly adelgid infestations within riparian zones (BD8)
- Drought periods would be a major natural stressor, but drought effects can be exaggerated due to human activities. On a different but perhaps related note, one of the two fish species that had a negative correlation with blackside dace (from field studies in 2002-2004) was the redbreast sunfish (*Lepomis auritus*), a non-native fish historically introduced by Ky. Dept. Fish and Wildlife Resources into streams within the dace's range. Redbreast sunfish would be a potential predator of blackside dace. Also along these lines, southern redbelly dace are a potential competitor species whose populations might be more tolerant to warmer waters and degraded water quality than blackside dace would be. This last statement is speculation based on anecdotal observations that remain untested (BD9).
- The spread of stocking trout or centrarchid species could lead to increased predation upon dace (BD11).

- Non-native gamefish. Southern redbelly dace may outcompete blackside dace when water temperatures rise and sediment increases (BD12).
- It has been suggested (e.g., Starnes and Starnes, 1981) that Blackside Dace may have been displaced to some degree by other species that have become established in areas where water and habitat quality have been altered by human activity to create warmer and more turbid conditions. Examples include Southern Redbelly Dace (*Phoxinus erythrogaster*), Green Sunfish (*Lepomis cyanellus*), and Largemouth Bass (*Micropterus salmoides*). Expansion or introduction of these species could adversely affect Blackside Dace through increased predation (e.g., centrarchids), competition for food and space, or loss of genetic purity or extirpation by hybridization (e.g., Southern Redbelly Dace) (BD13).
- Increased water temperatures allow predators such as bass and sunfish species to inhabit areas that may also contain dace. Also, the interaction between blackside and southern redbelly dace is unknown (BD14).
- Increase in siltation and/or temperature may favor southern redbelly dace, which may out compete blackside dace. Also, impounding of streams by beavers favor a population increase of the introduced redbreast sunfish (widespread occurrence in the upper Cumberland River drainage), a predator on dace and other minnow species (BD15).

<i>Natural/ecological source of stress or mortality</i>	<i>Stocking of Predator Fishes</i>	<i>Interactions with Southern redbelly dace</i>	<i>Climactic Variability (global warming, drought, floods)</i>	<i>Beavers impounding water</i>
Percent of survey participants (N=14)	50	43	29	21

\*Other sources that were mentioned by one survey participant (7%) were: Population fragmentation, Increase in predators because of loss of cover in habitat, and hemlock woolly adelgid.

## **12. For the Blackside Dace, what is the best way to survey individuals or populations of this species?**

- Seining, backpack electrofishing (BD1)
- Electroshocking generally appears to be the most efficient as long as the surveyors use caution in shocking the fish. Seining can also be effective when used properly (BD2).
- Probably need to use shocking. It has the potential to kill a few individuals, but one can cover a lot more stream area with shocking and you will see many, many more fish. The few individuals that are inadvertently killed while shocking are not likely to represent a population decline. If loss of only one or two individuals harms a population, the population has not a chance anyway (BD3).
- Seining, backpack electrofishing, minnow traps (BD4).
- Population monitoring of known populations on some type of rotation scheme (possibly every 3 or 5 years) by electrofishing or seining. Catch per unit effort (CPUE) is a relatively simple method for this type of monitoring (BD5).
- I recommend using seines or snorkeling and avoiding the use of electrofishers. The potential mortality of electrofishing is unknown, so it is best to err on the side of caution. Seining or snorkeling defined stream segments and counting all individuals encountered allows for low-impact sampling, but can give an estimate of the number of individuals/stream length (BD6).

- Seining. It is easiest to collect this species in the spring. The same technique and the same level of effort should be utilized for a long-term quantified effort (BD7).
- The least disruptive technique that results in good catch rates is seining. This method can be used to gather qualitative or quantitative survey data depending on project goals. Electrofishing is also effective but has the associated risk of fish mortality (BD8).
- Backpack electrofishing has been used with good success and minimal injuries/mortalities to blackside dace. Most mortalities have occurred in August when water temperatures are near their highest, and mortalities were less common with pulsed DC units than with AC units. Mark-recapture experiments were used to develop regression models to predict population size from single-pass electrofishing catch rates. The efficiency (number of dace collected divided by number of dace present at the site) of the backpack units using a 3-person crew is in the neighborhood of 25-35%. An alternative approach to survey or monitor populations is by using baited minnow traps. This method produces with very few blackside dace injuries or mortalities after trapping and handling thousands of individuals. If individuals need to be anesthetized for marking or collection of tissue for genetic analyses, a 40 mg/L dose of clove oil is recommended by Detar and Mattingly (2005) for this species (BD9).
- Seems like backpack electroshocking seining/dipnet surveys are the most efficient way to survey for this species. May want to do some tagging to follow dispersal (BD10).
- I have not compared methods – used both electrofishing and minnow trapping. I would like to know more about the effects of electrofishing on this species though (BD11).
- Pulsed-DC backpack electrofishing; baited minnow traps. Could try to develop a CPUE index by setting minnow traps in pools, processing and releasing the dace, then electrofishing the pools to determine if there is a consistent relationship between catches in minnow traps vs. electrofishing catch. Minnow traps are the quickest and least invasive technique, but may not detect the presence of a sparse population. I rarely captured dace in riffles; thus, it would be most time efficient to target pool habitat. During summer low flow conditions, visual observation can be used to determine presence/absence, but may not detect the presence of a low-density population (BD12).
- For periods excluding spawning months (April – May/early June), electrofishing using a voltage output that minimizes fish injury appears to be the best method for determining dace presence/absence. Additional methods detailed by Detar in Mattingly et al. (2005) serve as a good example of how to properly estimate presence/absence and population densities. During the spawning period, non-invasive methods such as snorkeling or binocular observations should be used to avoid nest destruction and interruption of the spawning process (BD13).
- Backpack electrofishing or possible use of minnow traps for long-term monitoring (BD14)
- Snorkeling would be the best, although most people surveying the species are not very knowledgeable about how to do this surveying technique. The second best would be electrofishing (at appropriate electrical output). I believe seining in streams that contain blackside dace may result in injury of many individuals because of crushing by rocks and debris in the net. Trapping with minnow traps may be very effective if guidance were given to those sampling pertaining to type of bait, traps, etc. (to standardize the technique so data would be comparable among surveyors (BD15).

### **13. What is the best way to monitor its habitat and habitat conditions?**

- RBPs for habitat developed by EPA, KDOW, TDEC (BD1).

- Examination of sediment deposits may be the most important in terms of determining potential management tools. The best tool for measuring this probably still needs to be developed/determined. A variety of potential tools have been used or recently considered: pool-filling (USFS in North Carolina – in association with the off-road vehicle area of the upper Tellico River drainage), EPA’s 10-metric habitat assessment technique, pebble counts (although their application in describing sediment deposition is considered by some to be limited), photographic documentation of pools, etc. Canopy coverage, riffle/pool ratio, structure/habitat complexity (e.g., root wads, undercut banks), and other important habitat metrics come into play too. Conductivity and/or dissolved solids. Invertebrate monitoring? (BD2)
- Not sure – probably a set of water quality tests and habitat assessments (maybe similar to the EPA habitat assessment sheets) (BD3).
- Not sure (BD4).
- Water chemistry surveys, visual habitat surveys, and benthic surveys (BD5).
- Difficult to say what is “best”, but one way to do it is to follow the same protocols used to monitor the physical/chemical/biological components of any stream on a regular basis (BD6).
- Monitor stream substrate as well as aquatic inset population trends over long-term (BD7).
- A method that was originally developed for salmonid populations, the Basinwide Visual Estimation Technique (BVET), would be a good choice for monitoring physical habitat changes and conditions within a reach of stream. This technique has seen broader applications in recent years to include many other fish species (blackside dace <http://www.sdafs.org/meetings/98sdafs/techn/leftwich.htm>) and to evaluate freshwater mussel habitat. It is a thorough technique to characterize species habitat utilization and requirements through the combination of physical habitat inventory and biological surveys (BD8).
- Stream-scale habitat conditions might be best monitored from the air (or space?) via planes or satellites. Local-scale conditions such as a small-scale forestry operation or an ATV rodeo might be best detected by personnel on the ground. Key instream variables to be monitored would be water conductivity and temperature (BD9).
- Qualitative visual assessments by someone who understands the habitat needs are probably also most efficient (rather than taking quantitative measurements that are time-consuming and expensive) (BD10).
- Visual assessment (BD11).
- Develop reference sites that contain the best conditions possible – (e.g., Big lick Branch) to compare habitat scores with at other locations (BD12).
- To effectively monitor habitat it is important to know which environmental attributes have the greatest influence on the distribution of Blackside Dace. Environmental variables identified through predictive models in a recent study by Jones in Mattingly et al. (2005) is the most significant step I have seen thus far in being able to use a model based approach to managing the species and its habitat (BD13).
- It appears that conductivity may be a major concern for the survival of blackside dace, so monitoring conductivity levels may be more important than overall habitat (BD14).
- Not sure (BD15).

**14. Are you aware of other imperiled species that are immediately syntopic or sympatric with the Blackside Dace on the Cumberland Plateau? Would these co-occurring species also be at risk of take if the Blackside Dace were**

**to be covered by an incidental take permit for logging, mining, water development, or some other landuse practice? Please explain how the other species would likely be affected.**

- **Cumberland darter, Cumberland elktoe** – same threats as blackside dace – sediment, conductivity, poor habitat, etc. (BD1)
- Sorry, I don't have a good species for you here. Creek chubs might be the most highly correlated with dace habitats. **Cumberland johnny darters** and **arrow darters** come to mind relative to species that may benefit from blackside dace conservation measures (BD2).
- ***Etheostoma susanae*** is in some areas of blackside dace. It would likely be protected by same measures as those for blackside dace (BD3).
- **Arrow darter, Cumberland Johnny darter**; affected in much the same manner (BD4).
- ***Etheostoma baileyi* (Emerald darter)** and ***E. sagitta* (Arrow darter)** both occur in this area and would probably be at a similar risk as blackside dace (BD5).
- Yes, the **Cumberland darter (*Etheostoma susanae*)** occurs in some of the same streams and is very rare (BD6).
- **Arrow Darter (*Etheostoma sagitta*), Emerald Darter (*Etheostoma baileyi*), Cumberland Darter (*Etheostoma susanae*)** (BD8)
- Other imperiled fishes include the **Cumberland darter, *Etheostoma susanae***, and perhaps the **arrow darter, *Etheostoma sagitta sagitta***. I would be particularly concerned about the Cumberland darter. It seems to be quite rare. I know less about the mussels and crayfishes, but **Cumberland elktoe, *Alasmidonta atropurpurea***, would be found in this general area. **Big South Fork crayfish, *Cambarus bouchardi***, is in the Roaring Paunch drainage. There are terrestrials that should be covered by an IT permit for logging or mining, such as **Indiana bat, *Myotis sodalis***, and perhaps others (BD9).
- **Cumberland Johnny darter (*Etheostoma nigrum susanae*, or *E. susanae* maybe now?)** is probably even in more trouble than the blackside dace because it isn't likely to be able to disperse, recolonize like blackside dace. Its distribution is more limited also, but it isn't presently on the federal list (BD10).
- I am unsure (BD11).
- **Arrow darter *E. sagitta sagitta*** is a species of special interest endemic to the upper Cumberland River drainage and often occurs sympatrically with blackside dace. They would likely be negatively impacted by similar threats/stressors as blackside dace (BD12).
- Other imperiled aquatic species I am most familiar with that are sympatric and sometimes syntopic with Blackside dace are the **Cumberland Darter (*Etheostoma susanae*)** and **Cumberland Elktoe (*Alasmidonta atropurpurea*)**. These species are being impacted in much the same way (by similar means) as Blackside Dace. Therefore, efforts to protect Blackside Dace habitat would likely also benefit these other jeopardized species (BD13).
- **Arrow darter (*E. sagitta*)** would have the same problems as the blackside dace: sediment, chemical changes, etc. (BD14).
- Not sure (BD15).

**15. Uncertainty Regarding Species Ecology. Our current state of blackside dace knowledge rated by survey participants.**

Values are percentages that are rounded to the nearest whole numbers. Highest percentages are in blue-shaded boxes.

	Well Known	Moderately Known	Poorly Known	Completely Unknown
Identification N=15	100			
Distribution N=15	40	60		
Abundance N=15	13	77	10	
Habitat requirements N=15	7	90	3	
Ecological interactions N=14		39	61	
Behavioral patterns N=14		43	57	
Reproduction N=15	7	73	20	
Early life history N=15		20	80	
Adult life history N=14		86	14	
Movement patterns N=1 (BD9)		100		

**Comments from survey participants based upon levels of uncertainty:**

**Identification**

- Small individuals can be a little difficult to distinguish from southern redbelly dace (BD9).
- Sometimes hybrids and minor variation in pigmentation can make identification difficult (BD13).

**Distribution**

- Need to conduct more surveys (BD5).
- Previously unknown populations occasionally are discovered (BD9).
- But as mentioned above, because the fish moves around easily and their small stream habitat changes relatively quickly, present distribution knowledge isn't always what's most recently reported (BD10).
- Overall, but some new populations are still encountered (BD13).

**Abundance**

- More surveys (BD5).
- We don't have a good handle on abundance in some streams (BD9).
- See above (BD10).
- For some streams more than others (BD13).

**Habitat requirements**

- Habitat requirements for spawning are under investigation now (BD9).
- Are there substantial seasonal differences? (BD13).

**Ecological interactions**

- We need to know more about the interactions with southern redbelly dace (competitor?) and creek chubs and other potential nest associates and potential predators such as redbreast sunfish (BD9).
- Ecological associations are known, but not interactions (BD13).

- Blackside dace and southern redbelly dace interactions (BD14).

**Behavioral patterns**

- Reproductive behavior, movement patterns, and habitat selection have been studied, but many other facets of behavior are poorly known (BD9).
- But mostly associated with feeding and reproduction (BD13).

**Reproduction**

- Work is currently underway to expand on what was initially reported by Starnes and Starnes, and what has been learned by Rakes et al. in propagation efforts (BD9).
- Period, temperature, nest association (BD13).
- More spawning surveys (BD14).

**Early life history**

- We spawned and reared, but only once (BD4).
- Very little is known here (BD9).
- Sediment impacts (BD14).

**Adult life history**

- Starnes and Starnes did a fairly comprehensive study here (BD9).
- But better known than early life history (BD13)

**Movement patterns**

- We have a fairly good idea now (BD9).

**16. For the Blackside Dace, would it be better (or more practical) to set biological goals and objectives and design monitoring protocols that are individual-based or habitat-based, or both?**

	<i>Individual-based</i>	<i>Habitat-based</i>	<i>Both</i>
Percent of survey participants (N=15)	7	13	80

- **Both** – biological and habitat data can be easily collected (BD1).
- Because blackside dace densities can be very dynamic and seem to respond quickly to natural factors such as year-to-year rainfall, **habitat-based** monitoring may be the most practical. However, monitoring of the **presence of blackside dace** may be important in substantiating this information (BD2).
- **Habitat based.** See all comments above (BD3).
- **Both**, especially to permit restoration possibilities for lost populations (BD4).
- It would be more practical to design protocols on **individual-based** monitoring. **Habitat-based** surveys could then be used after fish monitoring surveys indicate a decline in a population or an observed problem (BD5).
- **Both.** Establishing baseline physiochemical protocols coupled with population estimates in the best blackside dace streams will provide a benchmark that can be used to set goals and objectives in other streams. It will also help identify potential problems or limiting factors in streams with no or only small populations (BD6).
- These headwater-type streams are variable in flow and flushing from year-to-year. That is, there are times when the streams have natural sediments and biological deposits that are flushed with heavy rains. This, there is some variability in stream conditions seasonally. A long-term database that shows **both** population and habitat trends is best. This does not have to be intensive (weekly surveys); rather, quarterly or even annual surveys can be indicative of trends (BD7).

- Given blackside dace occurs in a wide variety of sub-watershed dynamics and has a fairly limited distribution, it would be important to look at *individual* populations and evaluate status based on current and perceived risks within a particular stream or sub-watershed (broader scale) (BD8).
- **Both.** Biological goals would need to cover reproduction, recruitment, sufficient age-class representation in a population, and sufficient densities (number of individuals per habitat unit) to maintain population viability. Habitat goals should cover riparian buffer widths, instream water quality parameters, and fish community composition, particularly if blackside dace are an obligate nest associate with creek chubs (*Semotilus atromaculatus*) or other minnow species as recent studies on blackside dace reproductive behavior seem to indicate (BD9).
- I would think *population*-based goals (i.e., follow changes in size and distribution of a population within a watershed/subwatershed) coupled with qualitative notes on *habitat* quality (BD10).
- **Habitat based.** Managing a habitat for a single species has been historically problematic. At the same token, it can be difficult to monitor a system in which we are unsure of all vital components required for the sustenance of any species. However, by focusing on an entire habitat, instead of a single species, there seems to be a far greater chance of preserving the system of which the species is a part and within which may lie components it relies on of which we are not currently aware. Additionally, conserving any habitat benefits all of the native species which make their home there; as a result, species which are now common are able to remain so, meaning we are not then required to list them as threatened or endangered five or ten years from now (BD11).
- Monitoring protocols should be representative of the various *habitat* types through the dace's range. Additionally, it would be beneficial to monitor *populations* of various densities to potentially help determine what factors are responsible for high and low density populations (BD12).
- **Both** species and habitat characteristics should be taken into consideration when designing monitoring protocols. I believe that the most effective monitoring plans should incorporate knowledge of the species' habitat requirements and ecological associations, as well as its life history parameters such as reproduction, food habits, age and growth, mortality factors, etc (BD13).
- **Both** should be set up. You need to link habitat to populations; any data are good data (BD14).
- Obviously, a *habitat* based protocol would be the best focus but any goals and objectives should also include *individual* based objectives. Since we may not know or be able to practically measure all critical habitat parameters, we need to also be able to monitor population parameters to ensure that we are monitoring sufficiently (BD15).

**17. In your estimation, what aspects of Blackside Dace biology / ecology / status are we most uncertain about? What would be the best way to obtain such knowledge?**

- What are impacts from sedimentation – on reproduction, ecology, etc.? How does conductivity affect the species? What constituents cause the increased levels of conductivity? (BD1).
- We need to determine the level of sediment deposited on stream substrate at which blackside dace begin to exhibit a negative reaction. In-stream development/use of a method to measure sediment deposits in conjunction with its actual application is needed.

This may be helpful in documenting cumulative impacts in addition to direct effects of specific pollution episodes. Further examination of the conductivity/dissolved solids issue may be helpful. In addition, when money is available, a study of stream canopy coverage and benefits to blackside dace would be interesting (BD2).

- Not sure here. Probably more about early life history and reproduction. Where are the young at? I almost never see them collecting, but I do see young of other syntopic cyprinids. What are the young eating? Embryology? Probably need a classic life-history study. Trick will be to collect eggs (BD3).
- Population abundance and annual variation with putative causative factors; effects of sedimentation and other habitat alterations on survivorship and reproduction. Long term repetitive standardized-protocol monitoring; thesis and/or dissertation studies, respectively (BD4).
- Habitat, behavioral, and ecological interactions. Through university research (BD5).
- Probably the effects of disturbance in the watershed, specifically water quality changes/requirements, including the effects of silt/sediment loads on reproduction. Also, the effects of predators, both native and exotic, on eggs, juveniles and adults are the least understood. Long-term water quality monitoring of the best dace streams would probably provide the best available data on water quality. It would be difficult to design a study to measure *in situ* reproduction and mortality, but a study like that could be very informative (BD6).
- This species seems to exist throughout its range in low numbers. Are their populations limited? What are this species' interactions with other species? What physical/chemical factors affect breeding and other key life history aspects? (BD7).
- Early life history, key limiting factors (BD8).
- Effects of water conductivity on individual physiology and population viability (conduct field and laboratory studies focused on this factor). The role of southern redbelly dace as a potential competitor or "hybridizer" with blackside dace (field and lab studies to determine spatial/temporal factors contributing to reproductive isolating mechanisms and degree of general niche overlap regarding other resources). We also know very little about how susceptible early life history stages (embryos, larvae, juveniles) are to various pollutants such as silt, sediments, high conductivity, and so forth (BD9).
- Probably we know least about early life history - what happens after hatching, how mobile are juveniles, are they more susceptible to water quality impacts, etc. (BD10).
- Early life history and accurate habitat requirements. Unsure of best way to acquire such knowledge except through further study (BD11).
- It would be valuable to develop a monitoring program to obtain population dynamics data through time at a subset of sites that could be used to represent the status of the species as a whole.
- Additionally, it would be valuable to reinventory all streams with known populations on a periodic basis (BD12).
- Further research on tolerance levels of Blackside Dace to habitat disturbance is needed. For example, we know that the species appears to be able to withstand some disturbance and which variables seem to be most limiting, but what are its tolerance limits? Although Starnes and Starnes (1981) and O'Bara (1990) provided some basic information on life history, additional research is needed, especially the species' early life history as well as ecological interactions with other species (BD13).
- The impacts of sedimentation on all life history stages. Graduate student projects (BD14).
- Competition with other species. We need to better understand species interactions between dace and exotic species, especially those that are stocked (such as trout) and established exotics (BD15).

## ***Acronyms used in this document***

ATV - All-Terrain Vehicle  
AMD - Acid Mine Drainage  
BMP- Best Management Practice  
BOD - Biological Oxygen Demand  
BSD - Biological Science Division  
COD- Chemical Oxygen Demand  
CPUE- Catch Per Unit Effort  
CWA- Clean Water Act  
DO- Dissolved Oxygen  
EPA - Environmental Protection Agency  
ESA- Endangered Species Act  
IT- Incidental Take  
KDOF- Kentucky Division of Forestry  
KDOW- Kentucky Division of Water  
ORV - Off-Road Vehicle  
RBPs - Rapid Bioassessment Protocols  
TDEC - Tennessee Division of Environment and Conservation  
TWRA- Tennessee Wildlife Resources Agency  
USACOE- United States Army Corps of Engineers  
USFWS - United States Fish and Wildlife Service  
USOSM- United States Office of Surface Mining