Puritan Tiger Beetle
(*Cicindela puritana*)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Chesapeake Bay Field Office
Annapolis, Maryland

2019
5-YEAR REVIEW

Species reviewed: Puritan tiger beetle (*Cicindela puritana*); recent change to *Ellipsoptera puritana* (Bousquet 2012; p.296).

Note: a new study of taxonomy has indicated the genus *Cicindela* should be changed to *Ellipsoptera* (Bousquet 2012; p.296) and the new name for the Puritan tiger beetle should be *Ellipsoptera puritana*. However, the current regulation for this species uses the older name. Until the name change is published in the *Federal Register* we will continue to use the older name of *Cicindela puritana* throughout this document to be consistent with current regulations.
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5-YEAR REVIEW
Puritan tiger beetle (*Cicindela puritana*)

1.0 GENERAL INFORMATION

1.1 Reviewers:
U.S. Fish and Wildlife Service: Susi von Oettingen,
Others: Dr. Barry Knisley, Randolph-Macon College
Jim McCann, Maryland Department of Natural Resources
Laura Saucier, Connecticut Department of Energy and Environmental Protection
Dr. Rodger Gwiazdowski, Advanced BioConsulting, LLC

Lead Regional Office: Northeast Regional Office, Martin Miller, 413-253-8615

Lead Field Office: Chesapeake Bay Field Office, Cherry Keller, 410-829-3963


1.2 Methodology used to complete the review: This 5-year review was developed by Andy Moser, Cherry Keller, and Julie Slacum of the Chesapeake Bay Field Office (CBFO) with additional input from Susi von Oettingen of the New England Field Office, who summarized the Connecticut River data. Data for the review were solicited from interested parties through a June 8, 2018, Federal Register notice and by sending a Dear Interested Party e-mail on May 10, 2019, to request new information from the states, academic experts, Federal agencies, and other U.S. Fish and Wildlife Service (Service) Ecological Service offices and programs located within the range of the species that conduct research, surveys, and recovery activities for the species. A meeting attended by rangewide partners was also held at the Service’s Northeast Regional Office on October 12, 2018, to discuss the status of the species and recovery efforts including propagation and translocation efforts in the Connecticut River populations. The Service used data from annual monitoring conducted by Dr. Barry Knisley (Randolph Macon University) and James McCann (Maryland Department of Natural Resources) to evaluate the status and population trends of the Chesapeake Bay population, while data from Laura Saucier, Connecticut Department of Energy and Environmental Protection Wildlife Division, and Chris Davis was used to evaluate the New England population. On May 30, 2019, a preliminary draft of the scientific assessment portion of the review was sent to state wildlife agencies, appropriate Service offices, and other interested parties for technical input, which was used in developing the final version of this 5-year review.

1.3 Background: This 5-year review summarizes the biological status of Puritan tiger beetle (*Cicindela puritana*) and provides an analysis of the threats to the species based principally on information collected since the last 5-year review completed in 2007 and a technical draft review developed in 2014, which was not finalized. Since 2014, annual reports have documented survey results of adult beetle numbers as well as information on
habitat conditions. In addition, a population viability analysis (PVA) for the Chesapeake Bay population of the beetle (Gowan and Knisley 2005) was updated in 2010 and 2015 (Gowan and Knisley 2010, Gowan and Knisley 2016), superceding the PVA previously developed (Gowan and Knisley 2005).

1.3.1 FR Notice citation announcing initiation of this review: 83 FR 39,113 (June 8, 2018): Notice of Endangered and Threatened Wildlife and Plants; Initiation of a 5-Year Reviews of Nine Species

1.3.2 Listing history:

FR notice: Determination of Threatened Status for the Puritan Tiger Beetle and the Northeastern Beach Tiger Beetle (55 FR 32088-32094)
Date listed: August 7, 1990
Entity listed: Species
Classification: Threatened

1.3.3 Associated rulemakings: Not applicable

1.3.4 Review History: The last 5-year review was completed in May 2007. Previous to that, the Puritan tiger beetle was included in a cursory 5-year review conducted for all species listed before 1991 (56 FR 56882, November 6, 1991). Prior to listing, Dr. C. Barry Knisley conducted a status survey (dated February 10, 1987) of the species.

1.3.5 Species’ Recovery Priority Number at start of 5-year review: 5C

This ranking is indicative of a species facing a high degree of threat and with a low recovery potential.

1.3.6 Recovery Plan

Name of plan: Puritan Tiger Beetle (*Cicindela puritana*) Recovery Plan
Date issued: September 29, 1993

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate? No. The DPS policy is therefore not applicable.

2.2 Recovery Criteria
2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes

2.2.2 Adequacy of recovery criteria:

2.2.2.1 Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat? Yes. There is new information on population viability, population trends, and threats, which was not considered during development of the existing recovery criteria, but this new information may not necessarily require the modification of recovery criteria.

2.2.2.2 Are all of the five listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)? No. The listing factors addressed in the recovery criteria include Factor A (habitat loss and degradation) and Factor D (inadequacy of regulatory mechanisms). Factors B (overutilization) and C (disease or predation) are not considered relevant to this species’ status. Factor E (other) includes threats to the Puritan tiger beetle’s status (i.e., climate change/sea level rise and invasive species) that have been identified since the 1993 recovery plan was approved.

2.2.3 List the recovery criteria as they appear in the recovery plan and discuss how each criterion has or has not been met:

Criterion 1: A minimum of six large (500-1000 or more adults) populations and their habitat are protected in perpetuity at current sites along both shores of the Chesapeake Bay.

Criterion 1 has not yet been met, but progress has been made since the last 5-year review. Two large populations along the western shore (Warriors Rest and Calvert Cliffs State Park) and three large populations (Grove Point, West Turner, and West Betterton) on the eastern shore of the Chesapeake Bay have been protected. Conservation easements protecting the majority of the Grove Point subpopulation and nearly all of the West Betterton subpopulation were completed in 2014. Note that increases in the West Betterton population have changed it from a small protected population to a large protected population. Thus, we have five large populations protected from development.
Criterion 2: Sufficient habitat between these populations is protected to support smaller populations, thereby providing an avenue for genetic interchange among large populations and ensuring a stable metapopulation.

*Criterion 2 has not yet been fully met, but progress has been made.* One small subpopulation serving this purpose has been protected on the eastern shore of the Chesapeake Bay—Ordinary Point. In addition, several small parcels in Chesapeake Ranch Estates and Scientists Cliffs have been protected by a Federal Emergency Management Agency (FEMA) Hazard Mitigation Grant approved in 2012. This resulted in 10 buy-outs which protected 9 percent of the carrying capacity in Little Cove Point and 2.9 percent of the carrying capacity in Scientists Cliffs.

Criterion 3: A minimum of three metapopulations, at least two of which are large (500-1000+ adults), are maintained (at extant sites) or established (= self-maintained for at least 10 years) within the species’ historical range along the Connecticut River, and the habitat they occupy is permanently protected.

*Criterion 3 has not been met.* Only one metapopulation exists along the Connecticut River— it is a large population (500+ beetles as defined by the recovery plan) and comprises four sites near Cromwell, Connecticut (CT) (figure 1). The beetles have been documented moving among the different sites; thus, it is functioning as a metapopulation. There have been sporadic observations at two additional sites.

The single site for this species in Massachusetts (MA) (not considered part of a metapopulation) is owned jointly by the City of Northampton and the Massachusetts Division of Fisheries and Wildlife. The unregulated recreational use and extended periods of inundation limit the population, and it is very unlikely that the recovery goal of 500-1,000 adults can be met here. As noted in Section 2.3.1.2 below, numbers have declined precipitously there since 2008, with only two adults detected in 2014 and six adults detected in 2017.

In an effort to meet this Recovery Criterion, the Service funded a project to propagate Puritan tiger beetles for reintroductions at the Aquatic Resource Center and Silvio O. Conte National Wildlife Refuge in Sunderland, MA. During 2016, 2017, and 2018, a rearing facility was constructed, upgraded, and used to captive rear and then reintroduce more than 1,400 Puritan tiger beetles to sites in CT and MA. Techniques for lab rearing of Puritan tiger beetles have been successfully developed. Reintroductions have been attempted at two State-owned sites in CT (Windsor Islands and Higganum Meadows), and augmentations of the MA site (Rainbow Beach) have been conducted (Gwiazdowski 2018). In October 2016, 90 lab-reared larvae were released at Rainbow Beach; in October 2017, 726 lab-
reared larvae were released; and in 2018 approximately 23 captive-reared larvae were released.

Adult beetles in numbers greater than would have occurred based on the existing, unaugmented annual populations were documented at Rainbow Beach indicating that the reintroduction effort using larval beetles was successful (Gwiazdowski 2018). However, adults from larval introductions at the Connecticut sites were not observed in 2018 (Gwiazdowski 2018). New surveys in 2019 may yet identify whether the introduction efforts were successful.

Additional potential sites for future translocations have been identified along the Connecticut River in Vermont. Surveys were conducted in 2015 and 2016. Six sites were identified as having potential for translocation, although no adult Puritan tiger beetles were observed (Gwiadowski 2018; p.29).

**Criterion 4: There exists an effective long-term program for site-specific management that is based on an adequate understanding of life history parameters, human impacts, factors causing decline, population genetics, and taxonomy.**

*Criterion 4 has not been met at all sites since most of them are privately owned.* An experimental vegetation management program began in 2006 at the State-owned Sassafras Natural Resource Management Area in Maryland (MD), and appears to have been effective in increasing Puritan tiger beetle populations. Additional vegetation management is likely to be funded on selected sites in MD protected by conservation easements.

An experimental vegetation management program was also conducted at the Rainbow Beach site along the Connecticut River in MA, but it was not effective (Davis 2004). The removal of certain species during early vegetation management efforts (2001-2004) provided open areas of sand for potential egg-laying; however, disturbance of the substrate appeared to increase plant growth. Additional efforts (2005-2008) were also inadequate to maintain the suitable larval habitat (Davis 2008).

Habitat at the Cromwell, CT population site was improved in July 2016 with the assistance of the Silvio O. Conte National Fish and Wildlife Refuges’ Youth Conservation Corps, who cleared vegetation and removed debris. Monitoring over time will inform whether these activities result in increased numbers of beetles at that site.

### 2.3 Updated Information and Current Species Status
2.3.1 Biology and habitat:

The Puritan tiger beetle is a 0.5-inch-long brown beetle with narrow white lines on each wing. It occurs in only two regions: along the Chesapeake Bay in MD and along the Connecticut River in New England. Puritan tiger beetle populations in these two regions have probably been separated for thousands of years and have developed significant genetic and ecological differences.

The Chesapeake Bay contains two metapopulations along its shorelines, one in Calvert County on the western shore of the Bay, the other along the Sassafras River of the eastern shore of the Bay (figures 1 and 2). Each metapopulation consists of subpopulations that are spatially separated from each other but likely have some level of dispersal among them. There is likely no dispersal between the eastern and western shore metapopulations. In MD, the Puritan tiger beetle larvae occupy only naturally eroding cliffs, where they develop in deep horizontal burrows in sandy deposits of nonvegetated portions of the bluff face or at the base of the cliffs. They are most abundant at sites where the bluffs are long and high with little or no vegetation and composed in part of sandy soil. Erosion results in the loss of some larval beetles, but is necessary to maintain the bare bluff faces they require.

In New England, only a few small populations remain; these include one metapopulation consisting of four sites near Cromwell, CT and one single site in MA (figure 3). In New England, Puritan tiger beetles occur in the sand and gravel islands of the river where beetle larvae develop in vertical burrows in suitable substrate.

2.3.1.1 New information on the species’ biology and life history: Knisley and Fenster (2009) provided evidence that increased vegetation has a negative effect on larval habitat and may explain the decline of populations at some sites, and that soil compaction and grain size were important determinants of larval habitat. Successful propagation of Puritan tiger beetle larvae occurred in 2016 and an Animal Care Manual with methods for propagation was developed (Gwiazdowski 2017, 2019).

Taxonomic classification or changes in nomenclature: As previously stated, a new taxonomic study has indicated that the genus Cicindela should be changed to Ellipsoptera (Bousquet 2012) and the new name for the Puritan tiger beetle should be Ellipsoptera puritana. However, the current regulation for this species uses the older name, and until that is formally changed in the Federal Register we will continue to use the older name to be consistent with current regulations.

It has been suggested by Dr. Dan Duran of Drexel University that the 1993 paper by Vogler et al. provides sufficient evidence, based on genetics and habitat differences, that the New England and MD populations are distinct subspecies (Knisley 2014). The work completed by Dr. Tim King of the U.S. Geological
Survey (USGS) developed microsatellite markers that work well for differentiating populations of *Cicindela dorsalis*, but not for *C. puritana*. Species-specific markers for *C. puritana* are currently being developed by USGS using microsatellite genotyping and mtDNA sequence data. Results from USGS should be available in fall/winter 2019.

**Genetics, genetic variation, or trends in genetic variation:** Preliminary data indicating the genetic distinctness of the Chesapeake Bay and New England Puritan tiger beetles were already available at the time the Recovery Plan was completed (Vogler et al. 1993). Additional information demonstrating the distinctness of these two geographic populations was provided in Vogler and Desalle (1994) and Knisley and Hill (1994). A more detailed genetic study mapping the genomes of several *Cicindela* species including *Cicindela dorsalis*, *C. puritana*, and *C. marginata* was nearly completed by Dr. Tim King of USGS with Service funding, but no report was provided. Other USGS researchers have been funded to augment this study and complete a final report. As described in the following section, current results of this work are of limited value in differentiation of populations of *C. puritana*.

**Population Viability Analyses:** Three population viability analyses (PVAs) for the Puritan tiger beetle in the Chesapeake Bay region have been completed (Gowan and Knisley 2005, Gowan and Knisley 2010, and Gowan and Knisley 2016), the latter two since the last 5-year review. These PVAs compare different management scenarios to the baseline condition of all subpopulations continuing at the current population level. They all conclude that maintaining as many subpopulations as possible is important and that we cannot rely on the protected subpopulations alone to maintain the species.

The 2010 PVA indicates that the risk of the Calvert County population reaching the low threshold of 100 individuals in 100 years is 0.08 (8 percent) if all subpopulations continue with current abundance. The risk is essentially the same if each of the subpopulations is reduced to 85 percent of the current carrying capacity. But if each of the subpopulations is reduced to 50 percent of the carrying capacity, the risk of reaching this low threshold goes up to 0.14 (14 percent). For the Sassafras River metapopulation these risks were much higher at that time. The risk of the Sassafras River metapopulation reaching the 100 individual threshold is 0.36 (36 percent) if all populations continue at that level but 0.6 (60 percent) if the carrying capacity of each of the subpopulations is reduced by 50 percent.

The 2016 PVA results were consistent with the previous PVA results, but also showed that increases in the Sassafras River metapopulation had reduced the extinction risk to some extent for that population even though it was still smaller than the Calvert County metapopulation. Similarly, the decrease in the Calvert County metapopulation had increased the extinction risk for that metapopulation (Gowan and Knisley 2016). Knisley (2011) states that his studies of tiger beetles
have found that many populations have existed at low numbers (less than 100, for example) for a long period of time and that many of these populations have recovered from bottlenecks.

2.3.1.2 Abundance, population trends, demographic features, or demographic trends: New information on population trends has been gathered since the completion of the 2007 5-year review and the 2014 draft technical review from long-term monitoring (Knisley 2018, Saucier 2018, Davis 2018).

Spatial distribution, trends in spatial distribution, or historic range

Two new subpopulations have been discovered since the 2007 5-year review in the Chesapeake Bay area (figure 1). One new population site was discovered in 2014 by Benedict Pagac of the Entomological Branch of the U.S. Army Public Health Command. The new site was found on the shore of the Severn River in Anne Arundel County, Maryland, approximately 24 miles north of the nearest known site in Calvert County. Mr. Pagac reported observing two to three dozen Puritan tiger beetles at this site on July 11, 2014. On July 16, 2014, the occurrence of Puritan tiger beetles at this site was confirmed by Andy Moser of the Service. Habitat for the species at this site is limited to several hundred feet of shoreline by riprap to the southeast and lack of cliffs to the northwest. Additional beetles were discovered at a second site on the Severn River 2 miles upstream from the first discovery in 2015. The number of beetles counted at these sites has always been small with 23 and 12 counted at Sites 1 and 2 respectively in 2015, but 54 beetles were recorded in 2018 at Site 2 (Knisley 2018). However, they are likely too far away from other sites to be contributing to the Calvert metapopulation.

In 2010 there was an additional discovery of beetles at a new location (Rocky Point) located between the Calvert Cliffs Nuclear Power Plant and Calvert Cliffs State Park by Service biologists visiting the shoreline. Counts of this approximately 1-km length of shoreline have continued since that 2010 discovery with a high of 195 beetles counted in 2017 (Knisley 2018). While this location is nearly continuous with subpopulations to the north and south, it adds additional areas of occupied habitat that we did not realize were there previously.

Population Trends

Calvert County Metapopulation: Surveys for Puritan tiger beetles have been conducted since 1989 in Calvert County and this has always been the largest metapopulation (Knisley 2018). The highest count was in 1998 with 9,801 beetles, but in most years the total counts ranged between 2,000 and 4,000 (figure 4). The total population of beetles is estimated to be twice the number of beetles that are counted (Knisley and Fenster 2009; Part 2), thus most years the
population is between 4,000 and 8,000 beetles. It is unclear why the 1998 beetle count was so high.

Since 2004, survey data have been standardized to reflect specific portions of the shoreline and annual reports indicate beetles counted in various survey segments of shoreline. Looking at the last 14 years, overall population counts do not show strong trends with most years counts between 2,000 and 4,000 (figure 5). It is worth noting that in this dataset, the lowest value counted was in 2005 and the highest value only 4 years later in 2008. Dramatic changes in numbers of beetles counted can occur over relatively short time periods.

This species has a 2-year life cycle, and thus there are even-year and odd-year cohorts (beetles that emerge in even years such as 2014 and those emerging in odd years such as 2015). Another way to look at this is to consider these as two populations that co-exist in the same habitat. If we consider each of these two cohorts separately, the odd-year cohort has increased in number from 2004 to 2018; the even-year cohort is declining (figures 6 and 7).

The two largest subpopulations in Calvert County are Warriors Rest and Calvert Cliffs State Park, and both are largely undeveloped and protected from future development. Warriors Rest and several of the small subpopulations are increasing with higher numbers in the most recent 6 years than the previous 6 years (figure 8). Most of the other subpopulations are showing small declines. Overall, the Calvert County metapopulation in the last 6 years averages about 5,575 total beetles, down slightly from 6,650 in the previous 6 years (table 2).

There is considerable synchrony in the trends among the subpopulations in Calvert County, meaning subpopulations tend to have high or low numbers in the same year (figure 9). This suggests that the populations are primarily influenced by large-scale weather patterns that produce similar effects on the habitat or the beetle populations across large areas.

**Sassafras River Metapopulation:** Surveys for Puritan tiger beetles have been conducted in the Sassafras River metapopulation since 1992 (Knisley 2018), and numbers have ranged dramatically, from lows of less than 1,000 beetles counted to the highest value of 3,479 in 2018 (figure 10). Most years the counts range from 1,000 to 3,000. The population of beetles is estimated to be twice the number counted (Knisley and Fenster 2009; Part 2), thus most years the population is between 2,000 and 6,000 beetles.

Since 2004, survey data have been standardized to reflect specific portions of the shoreline and annual reports indicate beetles counted in various survey segments of shoreline. Over the last 14 years, population counts show highs and lows, but most years the total population is estimated between 2,000 and 6,000 and the overall trend is increasing, though with large fluctuations (figure 11). Both the
odd-year and the even-year cohort has increased in number from 2004 to 2018 (figures 12 and 13).

Among the eight main subpopulations in the Sassafras River, the Grove Point subpopulation is by far the largest, is increasing in size, and has recently been protected from development (table 3 and figure 14). Smaller populations, such as West Turner and West Betterton, are also increasing or stable and protected.

Similar to the Calvert County metapopulation, there is great similarity in the trends among the subpopulations within the Sassafras River metapopulation, suggesting that the annual abundance is primarily influenced by large-scale weather patterns that may affect the habitat and beetle abundance over large areas (figure 15).

If we compare the overall pattern of beetle counts over time in both the Calvert County and Sassafras River metapopulations we see very similar patterns up to 2012. Then the Sassafras population pattern appears to lag behind the Calvert County population by 1 year (figure 16). In 2012 and 2014, the Calvert County even-year cohort declined and stayed low and the odd-year cohort became the larger cohort. Overall, since 2004, the Sassafras River metapopulation has increased in size and the Calvert County metapopulation has had small declines.

**New England Region:** Since the 2007 review, the CT metapopulation had generally been increasing in numbers with total beetle counts reaching 1,631 beetles in 2012 (Saucier 2018). Then numbers decreased, and the most recent 4 years averaged about 500 beetles (figure 17). Poor weather in 2013 precluded most of the surveys that year.

The Rainbow Beach, Massachusetts population was augmented with 3rd instar larvae translocated from the Connecticut sites between 2000 and 2006 to stabilize the declining population. Initially, the population responded with increasing adult numbers until 2009. For unknown reasons, possibly prolonged inundation caused by summer flood events affecting the 2012 and 2013 breeding season, the population began to decline (figure 18). Augmentation using lab-reared larvae initiated in 2016 may reverse the downward trend. After larval augmentation in 2016, the even-year cohort population almost doubled from a peak of 38 adults in 2016 to 62 adults in 2018. The effects of the 2017 augmentation effort should be ascertained by adult surveys conducted in 2019. Preliminary evidence of the large numbers of 2nd and 3rd instar burrows indicates that the augmentation may be successful (R. Gwiazdowski 2019).

**2.3.1.3 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):** Knisley and Fenster have documented habitat characteristics at Puritan tiger beetle subpopulation sites on both shores of the Chesapeake Bay (Knisley and Fenster 2009). In MD, the Puritan tiger beetle larvae occupy only naturally eroding cliffs, where they develop in deep horizontal
burrows in sandy deposits of nonvegetated portions of the bluff face or at the base of the cliffs. They are most abundant at sites where the bluffs are long and high with little or no vegetation and composed in part of sandy soil. Erosion of the cliff face is necessary to maintain the bare bluff faces they require even though it may result in the loss of some larval beetles.

The precise time and place of cliff erosion is difficult to predict. Recent studies of the Calvert County cliff faces have documented that the freeze/thaw cycles are the predominant forces causing cliff collapse and erosion in this area and are more significant than wave action at the toe of the slope in many areas (Wilcock et al. 1998; Zissler et al. 2014). Variables such as soil type, soil moisture, number of freeze/thaw cycles, slope, and exposure influence the likelihood of cliff collapse (Zissler et al. 2014).

There has been a continuing gradual decrease in suitable habitat along the shores of the Chesapeake Bay for the Puritan tiger beetle since 2007, as revetments and groins are constructed along eroding shorelines (USFWS 2012) and cliff faces have been invaded by vegetation in several locations (Knisley 2017). There also seems to be progressive narrowing of beaches at many Chesapeake Bay sites that may be reducing adult habitat and could impact populations (Knisley 2014, 2018). The amount of remaining habitat that is protected from development by acquisition or easement has significantly increased by a conservation easement protecting the majority of the Grove Point subpopulation site (largest subpopulation in the Sassafras River metapopulation). In addition, there are also several properties within the Little Cove Point and Scientists Cliffs subpopulation that will now be owned and managed by Calvert County as a result of FEMA buyouts.

A model of habitat suitability has been under development to enable better identification of potential reintroduction sites along the Connecticut River (Gwiadowski 2017, 2018). Variables for habitat suitability include sediment type, prey abundance, and flow regimes of the river. There is concern that degradation of suitable habitat is continuing to occur in MA and CT as a result of water releases from dams that cause long periods of inundation in the summer, vegetation encroachment, intensive recreational use of the Connecticut River shoreline, and development (docks, shoreline hardening, dredging, and boat launches) (Gwiadowski 2017, 2018). A GIS analysis of historic sites and potential new sites for reintroduction concluded that there were very few (less than five) potential sites for reintroduction that could be identified in the river (Gwiadowski 2018).

2.3.2 Five-factor analysis (threats, conservation measures, and regulatory mechanisms):

2.3.2.1 Present or threatened destruction, modification, or curtailment of its habitat or range: Destruction or degradation of habitat remains the primary
threat to the species, especially for the MD population. Since 1997, Calvert County has required a 100- to 300-foot set-back from the cliffs for new home construction; setbacks of 200 feet are used where housing development is already present (https://ecode360.com/29294889Z). However, the demand for shoreline erosion control measures to protect existing homes has greatly increased. Since 2006, six shoreline revetment projects have been built in Calvert County (primarily in the Chesapeake Ranch Estates (Little Cove Point subpopulation) and Scientists Cliffs communities. Two projects have been built on the eastern shore in the Chesapeake Haven Estates community (Grove Point subpopulation) (USFWS 2019, appendix B). Increasing hardening of shorelines that reduce habitat supporting the Puritan tiger beetle has also been documented by the Virginia Institute of Marine Science (VIMS 2006). In addition, some Puritan tiger beetle habitats along the Chesapeake Bay have been reduced in value, by increased vegetation growing on habitat cliffs and on the shoreline (Knisley 2005a, 2005b, 2017). Increased degradation of suitable habitat is also occurring in MA and CT, primarily as a result of changes in flow regimes, vegetation encroachment, intensive recreational use, and development of the Connecticut River shoreline in these areas.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes: Although there is a single instance where overcollecting was a potential problem for the New England population, overall, it is not a significant threat to the species (and was not considered to be a factor at the time of listing).

2.3.2.3 Disease or predation: Observations of high densities of a co-occurring tiger beetle, Cicindela repanda, at several sites suggest that these may have a negative effect on the Puritan tiger beetle due to predation or competition (Knisley 2011). Disease was not mentioned as a threat at the time of listing, and no new information has become available concerning this factor.

2.3.2.4 Inadequacy of existing regulatory mechanisms: The Rainbow Beach population in Massachusetts is subject to unregulated recreational use, primarily in the summer. Access to the beach is almost completely by boat. State regulations for Wildlife Management Areas, including but not limited to prohibitions on camping and fires, are not enforced. The species is protected under the Massachusetts Endangered Species Act (MESA); however, measures to protect the habitat and individual beetles have not been implemented. In Calvert County, MD, county regulations prevent new construction within 200 feet of the cliff edge on the top of the cliff in most areas where housing already occurs and 300 feet in undeveloped areas (https://ecode360.com/29294889Z), but this does not prevent homeowners from constructing shoreline erosion control structures near the toe of the cliff which results in loss of beach and cliff habitat. A 404 permit is required from the U.S. Army Corps of Engineers to construct shoreline erosion control structures within mean high tide; a permit is not required above mean high tide.
2.3.2.5 Other natural or manmade factors affecting its continued existence:
Changing climate may have an effect on habitat in the Chesapeake Bay area. Studies of Calvert County cliff erosion suggest that slides and sloughing of the cliff face can happen through freeze/thaw cycles that increase with high amounts of rain and soil moisture (Wilcock et al. 1998; Zeissler et al. 2014). If the mid-Atlantic climate becomes wetter, with more precipitation in winter, as suggested by the 2014 National Climate Assessment (https://nca2014.globalchange.gov/report/our-changing-climate/precipitation-change), it is possible that new exposure of suitable habitat will happen more often, regardless of erosion control structures at the base of the cliff. Hurricanes and winter storms can also cause erosion and provide newly exposed cliff faces in either Chesapeake Bay metapopulation. While storms may cause significant temporary reductions in population size, they help maintain beetle habitat over the long term through shoreline and cliff erosional processes. The species’ ability to recover from storm events and recolonize newly created habitat requires the continuation of all the subpopulations and maintaining the distribution across the metapopulation. Sea level rise is an emerging threat with the potential to reduce the requisite beach shoreline habitat for this species in the foreseeable future. Sea level is rising 3 to 4 millimeters per year (12 to 16 inches per century) along the MD coast (Nuckols et al. 2010).

Along the Connecticut River there is evidence that prolonged periods of high water during flood events and the resulting prolonged inundation of larval habitat may result in reduced beetle populations (Davis 2006, Davis 2013). Similar to the Chesapeake Bay area, the Northeast is predicted to have higher precipitation in the winter, though there is uncertainty how this may influence summer inundation. (https://nca2014.globalchange.gov/report/our-changing-climate/precipitation-change, figure 2.14). Changes in duration and frequency of summer precipitation could affect the number of flood events and the need for dams to release water.

2.4 Synthesis
The information discussed in this review indicates we have two strong metapopulations in the Chesapeake Bay with the highest number ever counted in the Sassafras River metapopulation in 2018. The Calvert County metapopulation is not increasing in the same way but is not in a sharp decline either. This species has been at very low and very high numbers in the past and we cannot fully explain the causes of these patterns. Our understanding is that weather patterns are causing habitat to be created and reduced depending on whether the appropriate sandy soil layers needed for larval habitat are exposed or covered by vegetation (Knisley and Fenster 2009). This understanding is further supported by the synchrony in the population highs and lows among the subpopulations (figures 9 and 15). Thus, habitat availability for Chesapeake Bay area Puritan tiger beetles is very dynamic, and the metapopulation models used in the PVAs
correctly echo the need for multiple subpopulations that can recolonize sites where and when new habitat becomes available.

The Connecticut River populations include one fairly strong metapopulation in CT and one site in MA that declines to perilously low numbers without periodic augmentation could become extirpated. Although there has been great progress in our ability to raise Puritan tiger beetle larvae in the lab and transfer them to the wild to augment existing populations or establish new populations, managing existing habitat has not been demonstrated to have long-term success. Encroaching native and nonnative vegetation limits larval habitat, and efforts to reduce or eliminate vegetation in larval habitat have not been successful. Moreover, suitable habitat to establish new sites appears to be very limited within the Connecticut River watershed and almost nonexistent within the historical range.

It is also useful to consider the viability of this species in terms of its resiliency, redundancy, and representation (Smith et al. 2018). For the purpose of this assessment, we generally define viability as the ability of the species to sustain populations in natural ecosystems within a biologically meaningful timeframe. We have three metapopulations for this species, one in the Northeast and two in the Chesapeake Bay. In the Chesapeake Bay, the redundancy in the metapopulations has been retained as the subpopulations identified in 2007 are still present and a few new small areas containing beetles have been discovered. The geographic distribution is similar to that in 2007, with the exception that the Severn River discovery is much farther north than any other location, perhaps too far north to provide the potential for dispersal to other sites. Over the approximately 30 years that this species has been surveyed, most subpopulations have persisted. Whether this is long enough to demonstrate their viability is not clear. Certainly they have survived a wide range of weather conditions. Future sea level rise may destroy the beach habitat that they need, but may actually increase the amount of cliff erosion that they also need. Whether they will adapt to new conditions and use the lower portions of cliff faces as they do at high tide remains to be seen.

Persistence in the CT metapopulation has continued, but there is concern whether the MA site can persist without augmentation. Better understanding of river flows and its effects on this beetle is needed, as is the ability to identify and manage larval and egg-laying habitat

We have made some progress toward the recovery criteria for this species, though we have not yet fully met any of the recovery criteria. In Maryland, three large subpopulations are currently protected from development by State ownership, and a fourth and fifth are now protected by conservation easements. Thus, we will have achieved protection of five of the six large populations for Criterion 1. Protection of undeveloped sites is important as these areas will be allowed to erode and provide new habitat as natural forces occur. Protection of both large and small subpopulations helps to ensure there will be some habitat available and distributed around the metapopulation.
In 2016, a project was funded through the Service’s Cooperative Recovery Initiative which resulted in the establishment of a lab for captive propagation of Puritan tiger beetle with the purpose of establishing additional metapopulations in New England through translocation to two additional CT sites. Currently, there is no evidence of adult survival at the Connecticut sites, although adult emergence from lab-reared larvae most likely has occurred at the Rainbow Beach population. Thus, no additional metapopulations have been yet established in New England. Although some site-specific habitat management has been conducted at the New England sites, it is absent at most of the Chesapeake Bay Puritan tiger beetle sites, and only a few small subpopulations have been protected there to provide dispersal corridors. In addition, shoreline erosion control measures and recreational use activities continue to threaten the species’ habitat rangewide, as do storm and flooding events that could increase in frequency and/or intensity due to changing climate conditions.

The PVAs for the Chesapeake Bay Puritan tiger beetle populations (Gowan and Knisley 2005, 2010, and 2016) provide evidence that both Chesapeake Bay metapopulations are vulnerable to extinction; this is particularly true for the Sassafras River metapopulation. The PVAs also show that, between 2005 and 2015, the probability of extinction has increased for the Calvert County population, but decreased for the Sassafras River population because of recent population increases in the Sassafras population. The 2016 PVA results, indicate that the loss of habitat due to shoreline erosion control projects does increase the probability of extinction but while there has been a decrease in numbers, most years the population has consistently ranged between 2,000 and 4,000 beetles in the Calvert County metapopulation which has experienced the largest number of shoreline erosion control projects occurring in different subpopulations.

In New England, the CT metapopulation appears to be stable, since the last 5-year review although populations have been fluctuating, the overall trend does not demonstrate a decline. Some of the discrepancy in population counts may be attributed to limited survey efforts and unusual flood events during the summer breeding season. There is also limited shoreline development and recreation that may affect the future of the metapopulation. The Massachusetts populations is limited by habitat degradation resulting from intensive recreational usage, vegetation encroachment of larval habitat, and daily fluctuating water levels from an upriver peaking hydropower facility.

In summary, recovery progress has been made but significant threats remain and habitat loss is continuing. Progress in habitat protection, with five large subpopulations along the Chesapeake Bay either acquired or under protection by conservation easement, the improved status of the Sassafras metapopulation, and the information provided in the 2010 and 2016 PVAs lead us to conclude that the species’ designation as threatened is still appropriate at this time.
3.0 RESULTS

3.1 Recommended Classification: Threatened

3.2 Recommended Recovery Priority Number: 5C (no change)

Rationale: The recovery priority number is unchanged because the species continues to be subject to a high degree of threat with a low potential for complete recovery.

3.3 Listing and Reclassification Priority Number: Not applicable.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

It is recommended that:

1. A high priority be given to identifying additional private landowners who are willing to enter into conservation easements for the protection and management of their Chesapeake Bay or Connecticut River shoreline habitats supporting Puritan tiger beetles.

2. The Service and its partners continue to implement management strategies (vegetation management in New England and the Chesapeake Bay and propagation/translocations in New England) using the principles of adaptive management through monitoring and research to improve population levels and habitat quality and quantity for this species at as many locations as feasible.

3. The species recovery group review the recovery criteria in the 1993 recovery plan in light of progress on habitat protection, results of the 2016 PVA, and new information on threats, population numbers, and genetics.

4. The annual counts of Puritan tiger beetle populations be continued to allow further analysis of population trends.

5. The results of the soon to be completed genetic analysis of Puritan tiger beetle populations be used to determine how they may direct recovery in the future.

6. The potential effects of sea level rise on habitat suitability and the long-term viability of each metapopulation be evaluated.
5.0 REFERENCES


U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of the Puritan tiger beetle

Current Classification:  Threatened

Recommendation resulting from the 5-Year Review:  Maintain as Threatened

Review Conducted By:  Cherry Keller and Julie Slacum, Chesapeake Bay Field Office

APPROVAL:
FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve ___________________________ Date: 24 July 2019

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

Approve ___________________________ Date: 24 July 2019

Assistant Regional Director, Ecological Services
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Figure 18. Puritan tiger beetle counts at Rainbow Beach, Massachusetts, including the years where lab-reared larvae were introduced to the site to augment the population.
Table 1. Population estimate (average 2013 to 2018) for subpopulations of the Calvert County and Sassafras River metapopulations. Bold indicates large (>500) populations; * indicates populations that are protected from development.

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<th>Subpopulations</th>
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### Table 2. Counts of Puritan tiger beetles in the Calvert County subpopulations over time.

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**Total counts** 2627 5720 2118 3041 2763 1927 3663 1660 2733 2460 4281 2179

**Population size** 5254 11440 4236 6082 5526 3854 7326 3320 5466 4920 8562 4358 6650 5575

### Table 3. Counts of Puritan tiger beetles in the Sassafras River subpopulations over time (*indicated protected subpopulations*).

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**Sassafras total counts**: 1566 1810 837 2726 1530 1478 1864 3395 1132 1911 1956 3479 1658 2290

**Total Population**: 3132 3620 1674 5452 3060 2956 3728 6790 2264 3822 3912 6958 3316 4579
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Figure 7. Calvert County Puritan tiger beetle counts from 2004 to 2017; odd-year cohort.
Figure 8. Subpopulations of the Calvert County metapopulation from north to south (left to right). Average number of beetles counted in the most recent 6 years (2013 to 2018) shown in red and the previous 6 years (2007 to 2012) shown in blue (* indicated protected subpopulations).
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