U.S. Fish & Wildlife Service

Candy Darter Recovery Outline

Photo by Corey Dunn, University of Missouri

Species Name: Candy Darter (*Etheostoma osburni)*
Species Range: Upper Kanawha River Basin including the Gauley, Greenbrier, and New River Watersheds including portions of Greenbrier, Pocahontas, Nicholas, and Webster counties in West Virginia; and Bland, Giles, and Wythe counties, Virginia. The range of the species is shown in figure 1 below.
Recovery Priority Number: 5*;* explanation provided below
Listing Status: Endangered; November 21, 2018; 83 FR 58747
Lead Regional Office/Cooperating RO(s): Northeast Region, Hadley MA
Lead Field Office/Cooperating FO(s): West Virginia Field Office, Elkins WV; Southwestern Virginia Field Office, Abingdon, VA; White Sulphur Springs National Fish Hatchery, White Sulphur Springs, WV
Lead Contact: Barbara Douglas, 304-636-6586 ext 19. barbara_douglas@fws.gov

1) Background

This section provides a brief overview of the ecology and conservation of the candy darter. This information is more fully described in the Species Status Assessment (SSA), the final listing rule, and the proposed critical habitat rule. These documents are available at:
https://www.fws.gov/northeast/candydarter/

Type and Quality of Available Information to Date:

Important Information Gaps and Treatment of Uncertainties
One of the primary threats that resulted in the listing of the candy darter under the Endangered Species Act (ESA) is the spread of the introduced variegate darter (*Etheostoma variatum*). This species hybridizes with the candy darter. Key information gaps and areas of uncertainty for the recovery and management of the candy darter include whether there are any habitat or other natural factors that could limit the spread of variegate darter. We assume that the rate of spread of the variegate darter in other watersheds would be similar to that observed in the Greenbrier, and that the variegate darter would continue to spread throughout the upper Greenbrier at the same rate as observed within the lower Greenbrier. The viability of the Greenbrier population is uncertain. In addition, techniques to establish new populations of the candy darter are unknown and have an uncertain probability of success.

Brief Life History: The candy darter is a small, freshwater fish endemic to 2nd order and larger streams and rivers within portions of the upper Kanawha River basin, which is synonymous with the Gauley and greater New River watersheds in Virginia (VA) and West Virginia (WV). The species is described as a habitat specialist, being most often associated with faster flowing stream segments with coarse bottom substrate (e.g., gravel, cobble, rocks, and boulders), that provides shelter for individual darters. Candy darters are intolerant of excessive sedimentation and stream bottom embeddedness (the degree to which gravel, cobble, rocks, and boulders are surrounded by, or covered with, fine sediment particles). The available candy darter occurrence data, all of which were collected after the aquatic habitat in the region was degraded by widespread forest clearing in the late 1800s, indicate the species prefers cool or cold water temperatures, but that warm water conditions may also be tolerated. The fish are opportunistic feeders, eating mostly benthic macroinvertebrates such as mayflies and caddisflies. In streams maintaining favorable habitat conditions, through natural or managed condition, candy darters can be abundant throughout the stream continuum.

Candy darters are sexually mature at 2 years of age and live to a maximum age of 3 years. They are classified as brood-hiding, benthic spawners. In this reproductive strategy, the female deposits her eggs in the pebble and gravel substrate between larger cobbles and boulders and an attendant male simultaneously fertilizes the eggs as they are released. It is uncertain whether individual candy darters complete their life cycle within single riffles or riffle complexes spanning just a few hundred meters or are capable of longer, seasonally mediated movements within suitable habitat. Although data are sparse regarding the minimum habitat size and degree of genetic connectivity required for candy darter population viability, the historical distribution of the species and the fundamentals of conservation biology suggest these factors are important to the species. Additional information regarding the life history, habitat needs, and distribution (historical and current) of the candy darter are available in chapter 2 of the Candy Darter SSA.

Limiting Life History Characteristics: Based on the life history characteristics described above, primary factors needed to support the candy darter include: 1) an absence of nonnative species; 2) unembedded gravel and cobble substrates with minimal sedimentation, 3) adequate water quality (temperatures, physical and chemical parameters), 4) an abundant, diverse benthic macroinvertebrate community; and 5) sufficient water quantity and velocities. Absence or degradation of these features could limit populations of the candy darter.

Primary Threats: Chapter 3 of the SSA identifies the factors (i.e., stressors and ongoing conservation measures to address stressors) most likely affecting the candy darter. Hybridization with the closely related introduced variegate darter is the most significant threat to the candy darter. Other ongoing contributing threats include excessive sedimentation, warming water temperatures, habitat fragmentation, changes in water quality and flow, catastrophic events, and competition or predation associated with other introduced species.

The variegate darter is native to the upper and middle Ohio River drainage including the lower Kanawha River basin below Kanawha Falls in Fayette County, West Virginia. Kanawha Falls serve as a natural barrier to fish dispersal from the lower Kanawha River basin (and greater Ohio River basin) upstream into the range of the candy darter in the upper Kanawha River basin. However, in the late 20th century, the variegate darter was introduced into the upper Kanawha basin, likely by "bait bucket transfer." Since their introduction, variegate darters have expanded within the range of the candy darter and genetic studies have demonstrated that where variegate and candy darter ranges now overlap, the two species will hybridize, quickly resulting in "genetic swamping" (the homogenization or replacement of native genotypes) of the endemic candy darter population and eventually its complete replacement by variegate darters or hybrids.

Current Biological Status of the Species: Historically, the candy darter occurred in 35 populations distributed across 7 metapopulations located in the Bluestone, Lower New River, Upper Gauley, Lower Gauley, Greenbrier, Upper New, and Middle New watersheds. However, the candy darter has been extirpated from almost half of its historical range; 17 of 35 known populations and 2 of 7 known metapopulations have been extirpated. The species is no longer known to occur in the Bluestone and Lower New River watersheds.

> **Resiliency**: Of the 18 extant populations, only 5 currently have high or moderate to high resiliency. These populations are located in the Upper Gauley, the Greenbrier, and Middle New metapopulations. The remaining two extant metapopulations (the Lower Gauley and the Upper New River) maintain populations with moderate and low resiliency. Therefore, the candy darter currently maintains moderate resiliency.
>
> **Redundancy**: The loss of candy darter populations and the areas they represented within the species' historical range, as well as the fragmentation of extant populations, has compromised the species' ability to repatriate those areas or avoid species level effects from a catastrophic event. Therefore, the candy darter's current redundancy is moderate to low.
>
> **Representation**: The best available data for the candy darter indicate that there is a high level of genetic differentiation between the Greenbrier River and Upper and Lower Gauley River metapopulations. These metapopulations currently have moderate resiliency, however the loss of either would represent a substantial reduction in the species' genetic representation. Although the candy darter retains representation in both of the Appalachian Plateaus and Valley and Ridge physiographic provinces, the species has a different distribution than it had historically, and likely a different ability to respond to stochastic and catastrophic events, thereby putting the species at increased risk of extinction from any such events. Therefore, we conclude that the species' representation is currently moderate to low.

Conservation Actions to Date: In addition to the conservation measures identified in the final listing or proposed critical habitat rules, the following candy darter conservation measures are being initiated by State or Federal partners:

- White Sulphur Springs National Fish Hatchery has begun working with candy darters to develop propagation techniques. Initial results indicate that captive propagation is feasible.
- West Virginia Division of Natural Resources (WVDNR) has begun evaluating sites within the historical range for potential reintroduction.
- The U.S. Geological Survey (USGS), West Virginia Cooperative Fish and Wildlife Research Unit, WVDNR, and their cooperators have initiated a study that will complement the best available information summarized in the 2018 candy darter SSA. The study will (1) conduct genetic analyses on introgressive hybridization between the candy darter and introduced variegate darter, including comparison with existing genetic data, (2) levels of genetic differentiation among populations and genetic diversity within populations, (3) provide a review and compilation of published and unpublished literature on the ecology of the species, and on range reduction based on historical and recent data, and (4) produce a landscape level threat assessment for the historical and current range of the candy darter using GIS-based methods. In addition to the other objectives, this study will be an expansion of previous genetic research that suggested high levels of genetic distinction between candy darters in the Gauley and Greenbrier systems. Results are expected in 2020.
- The WVDNR, the Service, and the Monongahela National Forest have initiated outreach efforts to increase the public's understanding of existing fishing regulations and to reduce additional introductions of variegate darters into candy darter watersheds.
- The Monongahela National Forest has implemented watershed-scale restoration in the Upper Greenbrier watershed (East and West Forks of the Greenbrier) to reduce sedimentation, maintain stream thermal regimes, provide habitat connectivity, and improve habitat complexity. These actions include road decommissioning, in-stream habitat improvements, riparian restoration and planting, and road-stream crossing replacements. Planned projects include the aforementioned restoration elements within North Fork Anthony Creek, Slabcamp Run of the Greenbrier, and the Upper Gauley watersheds.
- Although the candy darter is not State listed as endangered in Virginia, the Virginia Department of Game and Inland Fisheries (VDGIF) does prohibits the possession of the species.
- A new VDGIF regulation proposed for 2018 will prohibit the use of fish as bait in waters containing candy darter. The goal of this regulation will be to reduce the likelihood of introduction of non-native species in candy darter waters.
- The VDGIF ceased the stocking of brown trout in waters containing candy darter in 1994.

- The Jefferson National Forest recognized Stony Creek as the stronghold for candy darter in Virginia, and designated most of this stream and adjacent areas to Forest Plan prescription 9A4 (Aquatic Habitat areas), specifically for the protection of the candy darter.
- The USGS, Virginia Cooperative Fish and Wildlife Research Unit, VDGIF, and cooperators have initiated three interrelated studies that will complement the best available information summarized in the 2018 candy darter SSA. The first study is examining effects of environmental factors (e.g., habitat type, season, population density) and sampling effort on the detectability of candy darter. The second study is examining how the size and spatial distribution of habitat patches influence candy darter movement. The third study is describing population genetic structure, as well as estimating effective population sizes and life-history traits (e.g., fecundity, recruitment, age distribution) of candy darter. Results are expected in 2020.
- The USGS, Virginia Cooperative Fish and Wildlife Research Unit, VDGIF, and cooperators have initiated a study that will complement the best available information summarized in the 2018 candy darter SSA. The study focuses on the three species of saddle darters (*Etheostoma variatum* group) found in Virginia – candy darter, variegate darter, and Kanawha darter (*E. kanawhae*). The study will (1) develop a set of eDNA markers and protocols that selectively amplify DNA of the *Etheostoma variatum* group within ambient water samples, (2) use field studies to develop a preliminary estimate of the detectability of *Etheostoma* eDNA in streams where they occur, and (3), make recommendations on the use of eDNA techniques in subsequent studies of *Etheostoma* species in Virginia. Results are expected in 2019.

Recovery Priority Number: The candy darter is assigned a recovery priority number of 5 on a scale of 1C (highest) to 18 (lowest; the "C" indicates the potential for conflict with human economic activities). This ranking is based on the high degree of threat, a low potential for recovery, and its status as a species (November 21, 2018; 83 FR 58747). The high degree of threat is based on the severity and immediacy of threats currently affecting the species throughout its range. The overall range has been significantly reduced, and the remaining populations are threatened by hybridization and, to a lesser extent, a combination of other threats, reducing the overall viability of the species. The risk of extinction is high because the remaining populations are isolated and the threat of hybridization is ongoing and increasing. Recovery potential is considered low because while threats to the species are relatively well understood (i.e., spread of the nonnative variegate darter and sedimentation), it will be relatively difficult to alleviate the continued introduction and spread of the variegate darter. Techniques needed to control the variegate darter and/or establish new populations of the candy darter are unknown and have an uncertain probability of success. There is the potential for a low degree of conflict because the range of the species is largely rural with limited human development.

2) Interim Recovery Program

Interim Recovery Strategy: To ensure long term viability of the candy darter, we need to increase the redundancy, resiliency, and representation of the species. In order to achieve this, an Interim Recovery Strategy has been developed that has five approaches:

1. Maintain extant populations by conserving the genetic diversity and physical and biological features on the landscape that are essential for the species' conservation.
2. Minimize the risk of variegate darter introductions or spread in areas with little evidence of introgression.
3. Investigate factors that would minimize and control hybridization, and implement those measures in currently occupied areas that are affected by ongoing hybridization.
4. Repatriate candy darters to historically occupied areas where variegate darters are not present.
5. Investigate feasible methods to remove variegate darters and repatriate candy darters.

The first three approaches should be implemented in currently occupied habitat. However, based on the loss of redundancy and representation due to extirpation from approximately 50 percent of its historical range, recovery of the species cannot be achieved solely through the use of those three components. Therefore, the final two approaches should be used in areas where the species has been extirpated but where habitat is or can become suitable.

Action Plan: The Service has identified the following actions that are needed to implement each of the components of the interim recovery strategy. Further research and monitoring and conservation planning will be needed to effectively implement any comprehensive recovery strategy and additional activities of this nature have been identified that are relevant to all five approaches. Additional actions in any of these categories may be identified as recovery planning progresses.

1. Maintain extant populations by conserving the genetic diversity and physical and biological features on the landscape that are essential for the species' conservation.
Inherent in this strategy is the need to sustain widely distributed populations that maintain any unique genetic lineages. Existing populations should be maintained and enhanced by protecting habitat integrity and quality of streams within watersheds that currently support the species: This should be accomplished by avoiding and minimizing threats to the species including: 1) sedimentation; 2) increases in water temperatures; 3) spills and discharges; and 4) other non-native species (i.e., besides variegate darters). Measures to protect other physical and biological features should also be implemented.

Activities to reduce sedimentation include:

- protecting existing forested riparian areas and reforesting degraded areas;
- fencing livestock out of streams;
- decommissioning underutilized or unneeded forest roads;
- utilizing enhanced best management practices (BMPs) designed to reduce sedimentation, erosion, and bankside destruction when implementing construction and forestry projects; and
- avoiding or reducing other watershed activities that release sediments, pollutants, or nutrients into the water or that result in instream disturbances.

Activities to protect water temperatures include:

- ensuring protected areas in both surface fed and spring fed streams/watersheds;

- developing and implementing BMPs to better address warming waters (nutrient and sedimentation sources);
- protecting riparian corridors and retaining sufficient canopy cover along banks; and
- maintaining or restoring forest cover within candy darter watersheds to protect water temperatures and warmwater runoff.

Activities to reduce potential spills and discharges include:

- rerouting roads away from riparian corridors;
- constructing or reconstructing guard rails in areas adjacent to streams;
- modifying drainage systems at stream crossings or impervious cover so that discharges or spills are directed away from streams;
- locating or relocating facilities that could result in spills away from candy darter streams; and
- developing spill prevention and response plans.

Activities to reduce effects from other non-native species (i.e., other than variegate darters) include:

- not stocking brown trout or other potentially detrimental non-natives into candy darter streams.

Activities to protect other physical and biological features include:

- avoiding instream activities during candy darter spawning and larval development periods;
- avoiding and minimizing instream disturbances;
- maintaining instream flows and appropriate water quantity and quality;
- conducting stream liming to maintain appropriate pHs in streams that have been affected by acid mine drainage, acid precipitation, or other factors;
- conducting instream habitat restoration and enhancement to improve habitat within stream reaches that support existing populations while also ensuring appropriate measures to minimize any short-term adverse effects to candy darters are employed;
- conducting habitat restoration in stream reaches adjacent to existing candy darter populations so that these populations can expand; and
- implementing long-term habitat protections through voluntary easements/purchase, or long-term management agreements.

2. ***Minimize the risk of variegate darter introductions or spread in areas with little evidence of introgression.*** This strategy is particularly important for the Upper Gauley and Middle New River watersheds. However, this strategy is also applicable to other areas where variegate darters may be present and could be a source for introductions into candy darter watersheds. Actions to implement this strategy include:
   - revising fishing regulations publications and websites to highlight existing prohibitions against using and/or releasing live bait;
   - increasing enforcement or outreach or both regarding existing regulations prohibiting the movement of bait fish;
   - restricting the use of live fish as bait in candy darter watersheds; and

- conducting outreach and education campaigns to increase the public's awareness of the candy darter and the importance of stopping the introduction and movement of nonnative aquatic species.

3. ***Investigate factors that would minimize and control hybridization, and implement those measures in currently occupied areas that are affected by ongoing hybridization.*** It is currently not known whether there are any factors that could be used to accomplish this strategy. However, there is some indication that cooler water temperatures could benefit candy darters over variegate darters. Other natural or man-made features could also reduce the potential for variegate darter movement and spread. Actions that could be used to implement this strategy include:
   - conducting research to determine whether there are any environmental factors that might allow candy darters to persist despite variegate darter introductions;
   - conducting research into the competitive behavior that allows for variegate darters to outcompete candy darters, which leads to hybridization; and
   - developing tools and techniques and implementing any measures identified by research to help control variegate darter spread;
   - evaluating barriers to fish passage to determine their effect on candy darter population viability and variegate darter spread, and take action accordingly;
   - monitor candy darter streams at risk of variegate darter invasion so that new invasions are detected early.

4. ***Repatriate candy darters to historically occupied areas where variegate darters are not present but where habitat is or could become suitable.*** It is critical to the recovery of the candy darter that we reestablish the species in areas outside of its currently occupied range. The current distribution of the candy darter is reduced from its historical distribution. We anticipate that recovery will require continued protection of existing populations and habitat. This action is in addition to establishing populations in additional streams that more closely approximate its historical distribution to ensure there are adequate numbers of fish in stable populations and that these populations occur over a wide geographic area. Areas considered for repatriation should have the following characteristics: 1) candy darters are no longer present; 2) do not currently contain the variegate darter; 3) land use-based threats previously responsible for the candy darter's extirpation have been ameliorated; and 4) repopulation of the candy darter in these areas would not be possible without human assistance because they are isolated from other currently occupied candy darter streams. Based on preliminary assessments conducted to date, areas within the historical range that may be considered for repatriation include sections of Reed Creek, Pine Run, and Sinking Creek in VA; and sections of Indian Creek, Bluestone River, and Camp Creek in WV. These areas may be modified and other areas may be identified or prioritized as a result of additional review or research. Actions that could be used to implement this strategy include:
   - characterizing habitat conditions in historically extirpated candy darter sites to facilitate successful reintroduction efforts;
   - develop a multiscale habitat suitability model to determine the distribution of suitable habitat within the historical range of the species;
   - identifying and prioritizing areas for reintroductions based on the assessments described above;

- identifying appropriate source populations;
- developing propagation and reintroduction techniques;
- evaluating and developing appropriate ESA conservation tools, which may include but not be limited to 10(j) populations, safe harbor agreements, etc.;
- conducting re-introductions of candy darters to historically extirpated areas;
- monitoring any re-introduced populations; and
- protecting and restoring habitats targeted for reintroductions using actions identified for Strategies 1 and 2 above.

5. ***Investigate feasible methods to remove variegate darters and repatriate candy darters.*** There is currently no known means of accomplishing this strategy. However, research should be conducted to determine whether there any feasible tools or techniques to remove or reduce populations of variegate darters that would allow candy darter populations to be maintained or enhanced. This could include population augmentation of candy darters in sufficient numbers to outcompete variegate darters.

Additional landscape level conservation planning will help refine and effectively implement the overall recovery strategy. Activities include:

- conducting refined threats assessments on all current and historical candy darter watersheds to inform a watershed prioritization strategy;
- working with landowners and other partners to help support candy darter conservation actions including by leveraging financial and staffing resources;
- reconvening and expanding the Candy Darter Conservation Team and holding at least annual meetings;
- encouraging voluntary stewardship such as through watershed group, stream monitoring, etc.; and
- working with project proponents through ESA section 7 or section 10 consultations, to avoid, minimize, and mitigate for potential adverse effects to the candy darter and its habitat.

Research and monitoring should be conducted to address any information gaps and uncertainties associated with the approaches and activities identified above, and to track the status of candy darters within each watershed. Activities include:

- conducting research to clarify genetic structure of populations;
- developing and implementing a long-term monitoring strategy for candy darters that is consistent between states and land managers;
- surveying and monitoring to further characterize the extent and spread of hybridization with variegate darters in affected watersheds;
- developing and implementing monitoring strategies to detect variegate darter presence in currently unaffected watersheds (e.g., eDNA);
- conducting research into the life history and population dynamics of the species and on the water quality and habitat requirements (e.g., upper and lower limits) needed to support healthy populations of candy darters.

- conducting research into the life history and population dynamics of the species and on the water quality and habitat requirements (e.g., upper and lower limits) needed to support healthy populations of candy darters.

3) Preliminary Steps for Recovery Planning

A single-species recovery plan will be prepared for the candy darter. Recovery planning will follow the Service's Recovery Planning and Implementation Approach with the development of a Recovery Plan, and a Recovery Implementation Strategy (RIS) based on the information developed in the SSA. The Recovery Plan will include objective and measurable criteria which, when met, will ensure the conservation of the species without the need for Federal listing. The Recovery plan will address all meaningful threats to the species, and will estimate the time and the cost to achieve recovery. The RIS is a short-term, more flexible operational document focused on how, when, and with whom the recovery actions will be implemented.

The Recovery Plan and RIS will be prepared by the West Virginia and Southwestern Virginia Ecological Services Field Offices, the Northeast Regional Office, and the cooperating Fish and Aquatic Conservation offices. We plan to use working groups or expert elicitation to help determine the recovery vision and criteria and then develop future conservation scenarios that will most effectively achieve those criteria. Groups or experts consulted may include academics or managers who are authorities on the species, aquatic ecology and management, watershed health and restoration, and population/conservation biology. Primary authorship of the recovery plan will be the responsibility of Service staff, but state wildlife management agencies will be heavily involved in all phases of the planning and implementation process.

Input and review will be sought from multiple stakeholders within the states of WV and VA when developing the RIS. This will include state and Federal agencies, local communities, industry, and conservation organizations. This stakeholder input will be focused on developing a suite of recovery actions that could be most effectively implemented to achieve the criteria and vision developed above.

Recovery Planning Milestones: A draft recovery plan will be completed within 18 months of initiation and a final recovery plan should be completed 1 year after release of the public review draft. These timelines may be affected by available resources and regional priorities. Timelines for completing the draft and final recovery plan may be affected by available resources and regional priorities.

Signed: _____ Date OCT - 1 2018

Regional Director, Northeast Region
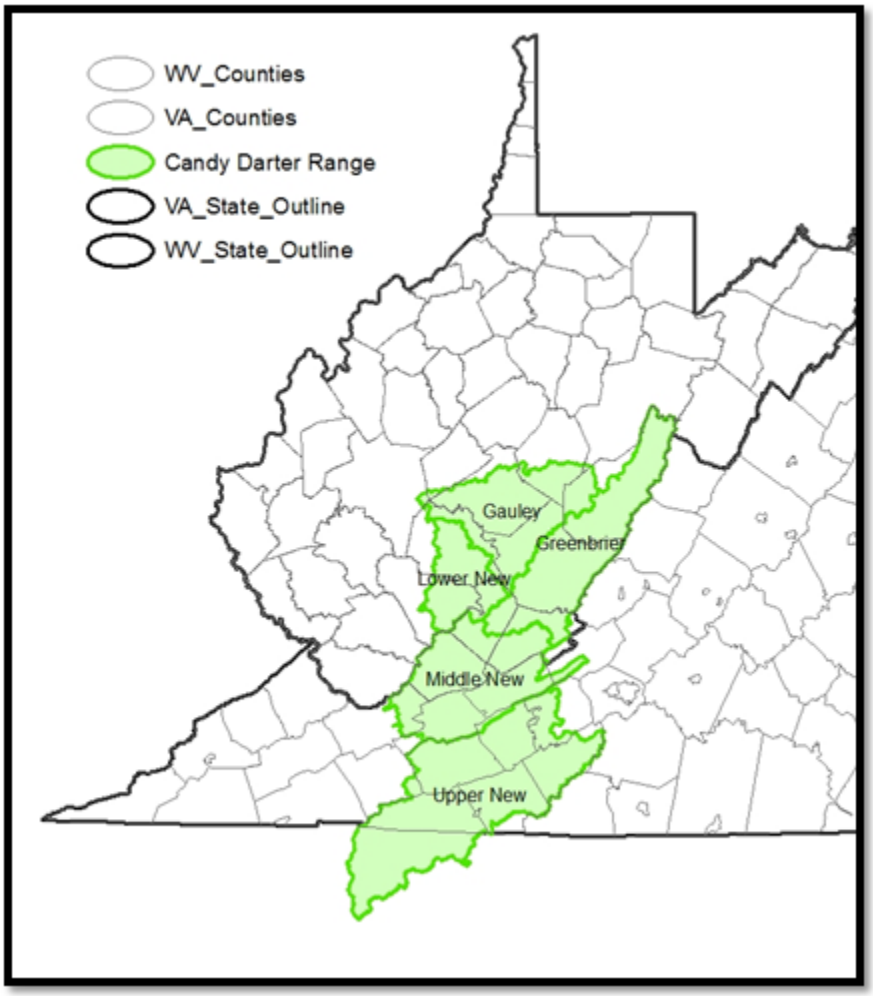
Figure 1: Range of the Candy Darter