Flat-spired Three-toothed Land Snail (Cheat Three-tooth Snail) (*Triodopsis platysayoides*)

5-Year Review: Summary and Evaluation

Photo by: C. Stihler

U.S. Fish and Wildlife Service
West Virginia Field Office
Elkins, West Virginia
August 2019

TABLE OF CONTENTS

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Field Office:	West Virginia Field Office, Matthew Cavnar-Johnson, 304-636-6586
Lead Regional Office:	Region 5, Hadley, MA; Anne Hecht, 413-575-4031; Martin Miller, 413-253-8615
Cooperating Offices:	None

1.2 Methodology Used to Complete the Review

This review has been conducted by the West Virginia Field Office (WVFO) of the United States Fish and Wildlife Service (Service). We sought information on the status of the flat-spired three-toothed land snail (*Triodopsis platysayoides*) from individuals familiar with the species, its ecosystem, and/or other land snails. We conducted a visit to Coopers Rock State Forest with Craig Stihler, the species expert for the West Virginia Division of Natural Resources (WVDNR) on July 25, 2019. We also contacted other species experts, and people with experience managing or working with the species and its habitat. This information, combined with relevant scientific information produced since the 2007 review, provides the basis for this review.

1.3 Background

1.3.1 FR Notice announcing this review: 83 FR 39113 (August 08, 2018)

1.3.2 Listing history:

FR notice: 43 FR 28932
Date listed: July 3, 1978
Entity listed: Species
Classification: Threatened

1.3.3 Associated rulemakings: not applicable

1.3.4 Review history:

The flat-spired three-toothed land snail was included in two cursory 5-year reviews initiated in 1983 and 1991:

- December 8, 1983 (48 FR 55100) – all domestic species listed in 1978, resulting in a notice of completion on July 22, 1985 (50 FR 29900).

- November 6, 1991 (56 FR 56882) – all domestic and foreign species listed before 1991.

In these reviews, the status of many species was evaluated concurrently. The Federal Register notices solicited new or additional information on the various species under review to determine if significant data were available warranting any changes in classification. No change in *T. platysayoides* listing classification was recommended from these 5-year reviews.

The first substantive, species-specific 5-year status review of *T. platysayoides* since its listing was completed in 2007. Information available since the 1978 rule was used to evaluate and assess the status of the snail.

In 2011, initiation of a 5-year review was announced in 2011 (76 FR 33334) and a draft document was prepared, but it was never finalized. It has been included in this (2019) 5-year review (as a report) in appendix C.

1.3.5 Species' Recovery Priority Number at start of review: 8c, indicating an overall moderate degree of threat, high recovery potential, and conflict with construction or other development projects.

1.3.6 Recovery Plan:

Plan name: Flat-spired Three-toothed Snail (*Triodopsis platysayoides*) Recovery Plan

Date issued: May 9, 1983

Date(s) of revisions or updates: None

2.0 REVIEW ANALYSIS

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

2.1.1 Is the species under review listed as a DPS? No. This species is an invertebrate and does not qualify for listing as a DPS.

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?

No. The criteria were designed to protect the few known isolated populations from catastrophic loss, and simple assumptions were made about population trends. We now know that the species is more widespread and that it is very difficult to determine presence/absence or detect a population trend. We also know that populations are more genetically interconnected than previously thought with populations spanning multiple sites.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?

No. At the time of listing and development of the recovery plan, the only relevant listing factors were A (habitat impacts) and D (inadequacy of regulatory mechanisms). These factors are addressed by the recovery criteria and are still relevant today, but may merit revision to accommodate new information, including potential threats to habitat from climate change. Predation (factor C) and other natural or man-made factors (factor E) have since been identified as potential threats, but the need for their inclusion in recovery criteria is uncertain. Factor B (overutilization) continues to be irrelevant. The recovery criteria primarily focus on factor A.

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, citing information. For threats-related recovery criteria, note which relevant listing factors are addressed.

The recovery plan states that *T. platysayoides* will no longer need Endangered Species Act (ESA) protection when either of the following sets of criteria is met (Service 1983):

Recovery Option A: *T. platysayoides* is found at less than three additional sites (Service 1983).

1) All known habitat sites supporting *T. platysayoides* are protected from foreseeable human impacts by acquisition, easements or cooperative agreements and management plans. This requires protection of at least 80 percent of the snails' habitat at each of the sites from impacts of recreational usage, adverse management practices, land use changes or other actions that would adversely affect the species.
2) A long-term management and monitoring program is established for the species.
3) The monitoring program shows that there is no downward trend in distribution, number and extent of populations, or habitat quality for a 10-year period (Service 1983).

Recovery Option B:

1) *T. platysayoides* is found at a minimum of three additional sites (i.e., in addition to the known sites in Coopers Rock State Park and at Table Rock), each at least a mile from the other and from the known sites.

2) At least 60 percent of these sites are protected from foreseeable human impacts by acquisition, easement or cooperative agreements and management plans.
3) A long-term management and monitoring program is established for the species.
4) The monitoring program shows that there is no downward trend in distribution, number and extent of populations, or habitat quality for a 10-year period (Service 1983).

Option B applies because there are at least 99 known sites for the species.

Criterion 1 appears to be satisfied. The 99 known sites are distributed across a 14-mile stretch of the Cheat Gorge. At least three sites are $\geq$ 1 mile from known sites in Coopers Rock State Forest and at Snakehill Wildlife Management Area (WMA) and are $\geq$1 mile from other known sites (Stihler, 2006). However, there high uncertainty about how a "site" reflects the status and distribution of the species. The term "site" is used here and in the recovery plan to refer to an observed occurrence of at least one *T. platysayoides* individual or shell. Therefore, each site is not necessarily equivalent in size or condition, and may not represent a separate population. See the 2011 report for a more detailed discussion on the accuracy of the 'sites' terminology (appendix C).

Significant progress towards Criterion 2 has been made, but it still is not completely satisfied. In 2014, the WVDNR purchased 3,681 acres along the Cheat River that constitute a significant portion of the snail's range using funds provided by a Recovery Land acquisition grant by the Service as well as funds provided by The Nature Conservancy. With the subsequent creation of the Cheat Canyon WMA, almost all known snail sites are located on publically owned land. However, there have not been surveys outside the areas that are publically owned, so there may be additional snail populations on private land. Additionally, the populations on publically owned land cannot be accurately described as protected from all foreseeable human threats. Some sites within Coopers Rock have been fenced off from human access, and some snail preserves have been set aside on Cheat Canyon WMA (Service 2007). For the majority of sites, there are no specific plans to protect them. Additionally, despite the land being publically owned, the ownership of mineral rights across the snail's habitat is inconsistent. Mineral rights are mostly privately owned in Cheat Canyon WMA (Cardno MM&A 2013), partially publically owned in Snake Hill WMA (S. Rauch, WVDNR, pers. comm., 2019), and mostly publically owned at Coopers Rock (West Virginia Division of Forestry 2006).

Progress has not been made towards Criterion 3 since completion of the 2011 report (appendix C). Overall, a long-term management and monitoring program has not been established for the species. The Coopers Rock State Forest has a recreation plan that provides a management outline for the species that includes monitoring of the species (Burns and Gaydos 2007). This monitoring has taken place in the form of trail impact assessments (Wallace and Doyle 17) and not detailed surveys that would give insight to population trends. The other goals of the recreation plan have been accomplished including placing an interpretative sign (M. Cavnar-Johnson, Service,

personal observation) and redirecting rock climbers away from snail habitat (C. Stihler, WVDNR, pers. comm., 2019). The recreation plan does not address other sources of recreation threats to the species such as off-trail use and the appropriate placement of new trails (see section 2.3.2.1 Factor A. Habitat Destruction) or other threats to the species. The recreation plan has not been modified since 2006 and is in need of updating with regards to *T. platysayoides*. Coopers Rock State Forest also possesses a wildfire plan (West Virginia Division of Forestry [WVDOF] 2007) which contains guidelines specifically for reducing the threat posed by wildfire to *T. platysayoides*. While management efforts at Snake Hill WMA currently take care to avoid affecting the snail, there is not a long-term management plan in place (Rauch, pers. comm. 2019). Cheat Canyon WMA possesses a management plan that states that there will be no management, and the snail will be left alone (Stihler, pers. comm., 2019). The five-factor analysis in section 2.3 further discusses threats that may require a management strategy for these areas.

Criterion 4 has not been met. No systematic monitoring program for distribution, number, extent of populations, or habitat quality has been established. Trend data are largely unavailable because of the difficulty and impracticality of regular population surveys.

2.3 Updated Information and Current Species Status

2.3.1 Biology and habitat

Our understanding of the basic biology of *T. platysayoides* has not grown since 2011. Information relevant to this review will be summarized, but for a more detailed overview, see the 2011 report (appendix C).

The preferred habitat of *T. platysayoides* consists of cool, moist, deep fissures and rock talus. *T. platysayoides* is primarily active at night. Most snail activity is observed during spring to early summer during cool, moist weather conditions. It is unknown whether the snail hibernates during winter. Its diet consists of a variety of leaves, rat feces, mushrooms, and other plant matter found in the leaf litter. It is believed that the tree cover provides essential cooling that contributes to the preferred microclimate for the snail (Dourson 2007).

2.3.1.1 Abundance, population trends:

There is no new information about population sizes or trends. The snail remains difficult to survey. Pearce (2019) reported searching for snails at known locations and never finding one.

2.3.1.2 Genetics, genetic variation:

When surveyors capture *T. platysayoides*, they are encouraged to take a genetic sample on a Whatman FTA® Classic Card (also known as a slime card) and send it to the WVDNR for analysis. In a study commissioned by the WVDNR, 76 genetic

samples were successfully analyzed for population structure and genetic diversity. Based on the data collected, Garner et al. (2012) concluded that two populations of *T. platysayoides* exist, one on each bank of the Cheat River. This is not surprising as the Cheat River acts as formidable barrier to dispersal and gene flow. A major limitation of this study was that most of the samples on the east bank of the river were taken within Coopers Rock State Forest. If a separate population outside of Coopers Rock on the east bank existed, the study would not have enough data points to detect it. Given that the study did detect evidence of structuring within each of the major populations (albeit weaker), this possibility cannot be ruled out.

Genetic diversity was found to be low or low-to-moderate by Garner et al. (2012). They noted that the allele richness and diversity they found was similar to other both endangered and non-endangered snails. Further research by King et al. (2015) found similar levels of allele diversity in *T. platysayoides*. It is unclear if low genetic diversity poses a threat to the species (e.g., by reducing its adaptive capacity). Further sampling and research would be helpful in understanding more about this aspect of the species' viability.

2.3.1.3 Taxonomic classification:

We have no new information relevant to taxonomic classification. *T. platysayoides*' status as a distinct taxon that is appropriate for listing remains uncontested.

2.3.1.4 Spatial distribution, trends in spatial distribution:

No new localities have been found since the last review. Since the initial listing in 1978, the species' range has expanded to include a 14-mile stretch along the Cheat River Gorge.

Habitat delineation was completed within Coopers Rock State Forest by Adams et al. (2012) based on the criteria established by Pearce et al. (2007). They noted that several known snail sites are located within continuous areas of potential habitat. This is consistent with previous habitat delineation efforts at Snake Hill WMA (Adams et al., 2012). While it was previously believed that each individual site was isolated, the location of many sites within the same area of potential habitat suggests connectivity among sites within continuous habitat. This is consistent with the genetic data. However, the snail distribution is likely fragmented by the noncontiguous areas of suitable habitat. Rather than focusing on sites, it may be more appropriate for management and survey efforts to focus on each area of contiguous potential habitat. Furthermore, habitat delineation outside of Coopers Rock State Forest is lacking and would be helpful in assessing the distribution of the snail across the entirety of its range.

2.3.1.5 Habitat or ecosystem conditions:

Stihler (pers. comm, 2019) estimates that there are about 10,317 acres of potential snail habitat. This is a rough estimate that was not based on a precise habitat delineation. Between Coopers Rock State Forest and Snake Hill and Cheat Canyon WMAs, 7,593 acres are publicly owned. The other 2,742 acres are privately owned.

Rock formations where the snail is found are usually Pottsville Sandstone, a relatively resistant rock which forms steep cliffs (mainly along the canyon rim), boulder fields, and talus slopes. The snail also occurs upon the Greenbrier Limestone formation at cave entrances (exposed in the lower levels of the Gorge). The forest that makes up its habitat is primarily second-growth and oak dominated. It supports a large diversity of plants. A more detailed assessment of the plant community can be found in the 2011 report (appendix C).

2.3.2 Five-factor analysis

The purpose of a 5-Year Review is to recommend whether a listed taxon continues to warrant protection under the ESA and, if so, whether it should be reclassified (from threatened to endangered or from endangered to threatened). This task requires that the analysis of the threats to the species be performed while assuming that the species is not receiving the regulatory protections, funding, recognition, and other benefits of ESA listing. Summaries of ongoing applications of ESA protections may shed light on some future activities that constitute threats to the species. However, the analysis under Factor D focuses on the adequacy of alternative (i.e., non-ESA) mechanisms to address the continuing and foreseeable threats.

To facilitate an analysis of the species' appropriate listing classification under the ESA, the existing threats assessment, last updated in June 2011, was updated in August 2019. Identified threats were analyzed for the spatial magnitude, severity, and immediacy of their effect on the long-term survival of *T. platysayoides.* That assessment, as well as additional information used in the following five-factor analysis, is provided in appendix A.

2.3.2.1 Factor A. Present or threatened destruction, modification or curtailment of habitat or range:

<u>Recreation</u>
At the time of listing, recreational use of Coopers Rock State Forest was identified as the primary threat. Visitors could reduce leaf litter, crush snails, or toss away cigarettes, which could be a serious fire hazard (Service 1978). Of the three publically owned land areas, Coopers Rock continues to be the most highly used for recreational purposes and thus is at highest risk of related effects. In approximately 2014, the Underlook Trail was installed; this trail takes visitors underneath the Overlook and nearer to snail habitat, including the fenced-off snail preserve at the Overlook. While the trail itself does not take visitors into snail habitat, Stihler (pers. comm 2019) expressed concern that visitors going off trail would enter snail habitat, which could reduce leaf litter or result in the crushing of snails. The trail currently has almost no leaf litter, and there has been heavy erosion. Rattlesnake Trail, which is near the Overlook and connected to Underlook Trail, is similarly affected and there is high evidence of off-trail activity (Wallace and Doyle 2017). Rock climbing remains popular at Coopers Rock but has mostly been redirected to areas that are not suitable snail habitat (Stihler, pers. comm., 2019).

There is currently less recreation activity at Snake Hill WMA and Cheat Canyon

WMA (Stihler, pers. comm., 2019). According to J. Daniel (WVDNR, pers. comm, 2019), the manager at Snake Hill WMA, visitors engage in hiking, biking, and rock climbing. Some of this activity occurs within potential snail habitat (Daniel, pers. comm, 2019). Rafting is a popular activity on the Cheat River, but rafters pose little risk of getting near the rock talus and crevices that are usually found along the slopes of the Canyon (Stihler, pers. comm., 2019). While there are less visitors to Snake Hill WMA and Cheat Canyon WMA than to Coopers Rock, there is a concentrated effort by the State of West Virginia to increase tourism (West Virginia Tourism Office 2017), so there may be more visitors in the future.

Fire

As described in the 2007 review, fires pose a potential threat to the species. Fires could kill individuals as well as significantly reduce leaf litter for foraging. The Service is not aware of any fires that have occurred within the snail's range, but fires are not necessarily reported to the Service. Because of the higher volume of visitors, wildfires are primarily a concern in Coopers Rock. Such a fire would be unlikely to threaten the entire species as the Cheat River poses a natural barrier that would protect the west bank population. However, a fire would still negatively affect the genetic diversity of the species since it would severely reduce one of the two genetically distinct populations. The WVDOF (2015) and WVDNR (B. Douglas, Service, pers. comm., 2019) have expressed interest in increasing prescribed burns in general, but they are currently in the exploratory phase and the Service is aware of no imminent plans to conduct prescribed burns within snail habitat.

Timber Harvesting

The purchase of the land that is now Cheat Canyon WMA resulted in almost all snail sites being located on public land; therefore, the threat posed by private logging has been reduced. Because some activities on WMAs use Federal funds to assist in planning or implementing those activities, the WVDNR and the Service developed a programmatic section 7 consultation process for forest management activities that may be conducted on WMAs throughout the state, including within Snake Hill and Cheat Canyon WMAs. The WVDNR committed to conducting site-specific consultations with the Service before harvesting near snail locations (WVDNR 2011). According to Stihler (pers. comm., 2019), it has become standard practice to include a 150-ft buffer around potential snail habitat when conducting timber operations, so under current practices it should be expected that, if there are future timber harvests, buffers will be put in place. However, questions about the width of effective buffers that were identified by Pearce et al. (2007) have not been resolved (see section 2.3.2.1 in appendix C).

Coal Mining

As discussed above, even though the State owns the surface rights to most of the snail's range, they do not own the mineral rights to Cheat Canyon WMA and only partially own the mineral rights to Snake Hill WMA. A 2013 analysis was commissioned by The Nature Conservancy as part of the purchase of land for Cheat Canyon WMA to assess the viability of the development of mineral resources. Within the Cheat Canyon, the primary mineral resources are coal, limestone, and natural gas (Cardno MM&A 2013). Development of these resources could destroy, damage, or disrupt the rock structures that form the snail's habitat. Additionally, associated

personnel and equipment could reduce leaf litter or crush individuals.

The Upper Freeport coal seam runs adjacent to and, in limited areas, through the Cheat Canyon WMA. However, the steep slopes of the canyon make reclamation difficult and expensive. This makes it unlikely for coal mining to be economical within this area (Cardno MM&A 2013).

Limestone Mining

As the snail is known to occur on the Greenbrier limestone formation, limestone mining could pose a serious threat to *T. platysayoides*. However, the exposure that forms the snail's habitat is steep and relatively remote compared to other Greenbrier limestone areas, which makes it an unlikely candidate for future limestone mining (Cardno MM&A 2013).

Natural Gas Drilling

The Marcellus Shale Reserve extends through the Cheat Canyon WMA. There are a few existing wells near the snail's current range, but none are close to encroaching on any known snail sites. However, Cardno MM&A (2013) concluded that it was likely that drilling would occur in the near future. Based on the model developed by Dunscomb et al. (2012) that forecasts the probability of shale gas development across the Appalachian region, the range of *T. platysayoides* was predicted to have around a 60 to 70 percent chance of future shale gas development. A more detailed map produced by overlaying the range of the snail with data developed by Dunscomb et al. (2012) is included in appendix B. In sum, there exists a moderate risk of natural gas drilling that would pose a threat to *T. platysayoides*.

Climate Change

Climate change poses a threat of significant magnitude to *T. platysayoides*. Overall, West Virginia is expected to have an increase of 2 to 8 degrees Fahrenheit and a 5 to 10 percent increase in annual precipitation by 2050 (Runkle et al. 2017). *T. platysayoides'* preference for rock talus and crevices that provide shade, as well as its activity in the night, suggests that cooler temperatures are an important factor for the continued suitability of its habitat. Pearce (2019) noted that because there are many gaps between suitable habitats that are inhospitable, the slow moving *T. platysayoides* has very limited dispersal capability. As a result, the species has been ranked as 'extremely vulnerable' to climate change (Byers and Norris 2011). This is consistent with research that has identified snails as a taxon of high concern for effects from climate change (Nicolai and Ansart 2017). Climate change is also expected to have negative effects on the forest ecosystem that the snail inhabits. Warmer winters are expected to increase populations of pest including the hemlock wooly adelgid as well as populations of white-tailed deer, which contribute to defoliation (Dupigny-Giroux et al. 2018). Climate change could also expand the range of new invasive species (see factor C: Disease and Predation). It is important to note that while climate change is expected to increase the risk of wildfires across the United States, especially in the west, that is not as much of a concern for *T. platysayoides*. This is because West Virginia is expected to have increases in moisture and precipitation as opposed to many other parts of the United States that are expected to become dryer.

The best available scientific data indicate that climate change is highly likely.

Because of the snail's limited geographic range, development of finely tuned climate models specific to its habitat are currently impractical. But the best available data on West Virginia in general produced by NOAA indicate temperature changes within the next 30 years (Runkle et al. 2017) that could negatively affect the species. This is consistent with the National Climate Assessment (Dupigny-Giroux et al. 2018) that makes very clear projections about the future effects that climate change will have in the Northeast region. Therefore, even though there may be some variance, there is little reason to doubt that climate change will have an effect on the habitat of *T. platysayoides*. Our understanding of the species' response is less certain, but still indicates that climate change is a threat. Other snail species have changed their distributions in response to changes in climate (Baur and Baur 2013). Nicolai and Ansart note that there have been models produced in the past that predict shifts in the range of snail species, but those models have limited utility for threatened or endangered snails that also face anthropogenic threats other than climate change. Additionally, Nicolai and Ansart (2017) note that extrapolating physiological responses from other, more easily studied snail species is not scientifically sound for understanding at-risk species. However, these uncertainties point to the need for further research specific to *T. platysayoides* and do not discount the effects of climate change on the species. Our understanding of the life history of the species indicates that it should be comparatively more vulnerable to climate change than other snail species because of the reasons outlined above.

Defoliation

Decline in tree cover poses a moderate threat to *T. platysayoides*. Tree cover provides shade that can influence the microclimate of the snail's habitat which is important given the specie' preference for cooler areas especially during the summer. Eastern hemlock trees that form a major component of the tree cover in Coopers Rock State Forest are suffering high mortality from hemlock wooly adelgid (Wallace and Doyle 2017). Currently, efforts are underway to treat trees in the forest (Wallace and Doyle 2017), but the effectiveness of these treatments is unknown.

The gypsy moth has historically been a threat in Coopers Rock State Forest and throughout West Virginia. The last major defoliation event from the gypsy moth was in 2002 (West Virginia Department of Agriculture, 2005). Stihler (pers. comm., 2019) reports that there has not been significant gypsy moth activity since then. Gypsy moth invasions are highly cyclical, occurring once every 5 to 10 years (WVDOF 2010), so there is still a moderate risk of future gypsy moth activity that could pose a threat to *T. platysayoides.*

The decline of yellow birch was identified in the 2011 report as a potential threat. Yellow birch leaves are likely one of the best sources of calcium (Gosz et al. 1973; Dourson 2007), which is an essential nutrient for the formation of snails' shells (Fournie and Chetail 1984). The degree to which the generally reported decline affects the Cheat Gorge and thus *T. platysayoides* was unknown at the time. There is no new information about yellow birch decline that clarifies the extent that it will affect the species.

Residential Development

Residential development no longer poses a threat to most known sites because they

are on public land. Because the remaining private land has not been delineated for snail habitat, we do not know whether there are snail occurrences on private land that are threatened by residential development.

Invasive Plants

The threat posed by invasive plants in currently unknown. There have been previous reports of tree-of-heaven (Dourson 2007) and garlic mustard within snail habitat (Stihler, pers. Comm., 2007). We have no new information on the extent to which these or other invasive plants may affect the species, but there has been statewide work by WVDOF, WVDNR, and others to combat the spread of invasive plants.

2.3.2.2 Factor B. Overutilization for commercial, recreational, scientific, or educational purposes:

This factor was not applicable at the time of listing and is not a threat today. The species is extremely difficult to find, and there is no known market for collection of *T. platysayoides* for commercial or educational purposes. The extremely limited amount of collecting for scientific purposes is regulated by the WVDNR, and primarily consists of collecting dead shells.

2.3.2.3 Factor C. Disease or predation:

We have no new information about disease or natural predation. There are still no known diseases of *T. platysayoides*. Dourson (2007) found evidence of predation, but while the last review identified potential predators, it is still unknown whether natural predation threatens the species.

Predation by invasive animal species poses a new threat to *T. platysayoides*. *Platydemus manokwari*, commonly known as the New Guinea Flatworm, was recorded in Florida, the first time it had been spotted in the continental United States (Justine et al. 2015). Previously, it had been confined to tropical islands, mostly in the Pacific. The New Guinea Flatworm preys on snails and other mollusks and has pushed many endemic snail species in the Pacific to extinction or near extinction (Sugiura 2009). If the flatworm reached the range of *T. platysayoides*, it would likely pose a significant threat to the species. However it is not known how quickly it can spread across land as it had been mostly introduced by boats in the past. It is also unclear if the Cheat Canyon would be suitable habitat for the flatworm as it has previously been documented only in tropical environments. A combination of lab and field experiments by Sugiura (2009) demonstrated that the worm struggles around 10 degrees C (about 50 degrees F), and winter temperatures within the range of the snail go well below that (Stihler, pers. comm., 2019). However, climate change is expected to bring warmer temperatures in West Virginia (WVDNR 2014) that could result in the expansion of the range of the New Guinea flatworm. In sum, the degree and immediacy of the threat posed by the New Guinea flatworm are unclear. Further research on New Guinea flatworm's dispersal capabilities in the context of climate change would be useful in determining the degree of the threat posed.

2.3.2.4 Factor D. Inadequacy of existing regulatory mechanisms:

There are currently no regulatory mechanisms that would protect the species in the absence of the ESA. While mandatory soil erosion prevention practices offer a moderate degree of protection to a small portion of the species (Service 2007), West Virginia lacks any state laws that would protect the species in the absence of Federal listing. *T. platysayoides* has been designated as a Species of Greatest Conservation Need (SGCN) in West Virginia's most recent State Wildlife Action Plan (WVDNR 2015), but that designation only represents a nonbinding commitment to prioritizing the conservation of the species without any specific regulatory requirements.

As described above, although much of the snail habitat is currently on publically owned lands, these lands do not have long-term management plans in place that would ensure the protection of the species in the absence of ESA listing, or that provide specific guidance on activities that should or should not occur to conserve the species. Furthermore, the section 7 consultation processes that are in place for activities on WMAs would only be in place while the species is listed. Development of private mineral rights, or leasing or development of State-owned mineral or timber rights, could occur without coordination with the Service, and in the absence of ESA listing, there would be no legal prohibitions or restrictions on activities that could adversely affect the species. The snail's vulnerability to human recreation and industry require some level of regulatory protection to address activities that may occur in the immediate vicinity of its habitat.

2.3.2.5 Factor E. Other natural or man-made factors affecting the continued existence of the species:

The decline in the Allegheny woodrat population has previously been identified as a potential threat to *T. platysayoides* (Service 2007). Allegheny woodrats supply a potentially important source of food because they carry known snail food items including vegetation, fungi, and their own excrement into snail habitat (Dourson 2007). There has been no new information about the extent to which this affects the Cheat Gorge.

The 2007 review identified cannibalism, intraspecies competition, and toxins from treated lumber near the overlook at Cooper's Rock as potential threats of unknown significance. We have no new information about these threats.

2.4 Synthesis

Up to this point, this review has discussed the information (and its implications) that has become available since the time of listing of *T. platysayoides* as threatened in 1978. The Synthesis section brings this information together to draw an overall picture of the species' biological and conservation status. The fundamental question is whether *T. platysayoides* is in danger of extinction throughout all or a significant portion of its range (the ESA definition of endangered) or is likely to become endangered in the foreseeable future (the ESA definition of threatened). The information pertinent to addressing this question includes: (1) the population status of *T. platysayoides*, (2) implementation and success of recovery actions, and (3) threats to the long-term survival of the species.

The population status of the species in regard to the biological principles of representation, redundancy, and resilience has not changed significantly since the species was reviewed in 2007. We now know that the *T. platysayoides* likely forms two genetically distinct populations, but has low overall diversity, occupies a very specific ecological niche, and has limited dispersal potential to occupy new habitat. Therefore, we can conclude that *T. platysayoides* likely has limited ability to adapt to changes in habitat conditions. Our understanding of the species redundancy has improved since the 2011 report. The genetic data and habitat delineation suggest a higher degree of connectivity than previously believed, but that still may be insufficient to allow for adaptation to threats. The presence of populations on each side of the river insulates the species from fires, the most likely catastrophic event that threatens it. With the lack of knowledge regarding population size, it is difficult to evaluate the species' resiliency. However, given the rarity of the species, it is reasonable to conclude that the species lacks resilience to the threats that have been identified.

Since the last review, the primary focus of recovery actions has been the acquisition of land for the Cheat Canyon WMA. This has been a major success for the long-term recovery of the species. In addition, since the 2011 report, habitat within Coopers Rock was delineated, and recreational effects within Coopers Rock continue to be monitored intermittently. Although the recovery plan is out of date, a large majority of the actions outlined by that plan have been completed.

Despite this progress, several essential recovery actions have not been completed. We still do not have a long-term monitoring plan that would allow us to evaluate trends in the population status, which is an essential metric to determine the recovery status of the species. While almost all known occurrences are now on public land, this is in part due to the lack of presence/absence surveys of the remaining private land that is potential habitat for *T. platysayoides*. There are not long-term management plans for the occurrences on public land that would assure the protection of the species absent Federal listing.

Even though almost all known sites occur on public land, human recreational effects still pose a significant threat to the species. The installation of a new trail has increased the risk of direct human effects and signals the need for increased communication regarding the snail in the absence of a management plan. While the threat of logging by private landowners has been reduced, there is still potential for future logging activity on State lands. Natural gas extraction poses a new threat to the species within a portion of its range. The growing threat of climate change poses a threat to the snail and its habitat and increases the magnitude of other threats like defoliation. All of the threats that have been identified in this review, when combined with our understanding of the biology of the species and the lack of knowledge on population data, indicate that there continues to be a likelihood that the species will become endangered in the foreseeable future throughout all or a significant portion of its range.

3.0 RESULTS

3.1 Recommended Classification: Threatened. No change is needed.

Rationale: Population trend is unknown, and threats continue to pose the likelihood that the species will become endangered in the foreseeable future throughout all or a significant portion of its range.

3.2 Recommended Recovery Priority Number: Retain the current recovery priority number of 8c, indicating an overall moderate degree of threat, high recovery potential, and conflict with construction or other development projects.

Rationale: While some threats to the species have abated, the primary threats identified at the time of listing as well as new threats could result in long-term population decline. With most of the species occurring on land owned by conservation-oriented state agencies, further recovery actions are highly feasible and well understood. Potential logging and mineral development pose potential conflicts with the recovery of the species.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Based on the outcome of this 5-year review, we recommend:

Priority 1

- Development of long-term management plans with the WVDNR and WVDOF.

- Development of a metric to determine population trends and status that takes into account difficulties in surveying the species, and the implementation of a long-term monitoring plan to measure that metric.

- Surveying of private lands for potential *T. platysayoides* habitat, and the purchase, acquisition, or establishment of conservation agreements for any additional *T. platysayoides* habitat.

Priority 2

- Research on the physiological effects of climate change on *T. platysayoides* as well as on the effects of climate change within the Cheat Gorge.

- Completion of habitat delineation in Snake Hill and Cheat Canyon WMAs.

- Determination of the effectiveness of buffers for timber management practices, including how edge effects and selective harvesting affect *T. platysayoides* habitat.

Priority 3

- Transition from using "sites" to using contiguous patches of occupied or suitable habitat to evaluate the distribution.

- Revision of the recovery plan to account for revised distribution, population genetics, connectivity, and new threats discovered since the plan was written, and update objective, measurable recovery criteria.

5.0 LITERATURE CITED

Adams, J., M. Gumbert, and P. Roby. 2012. Habitat delineation for *Triodopsis platysayoides* on Coopers Rock State Forest, West Virginia. Prepared by Copperhead Consulting, Paint Lick, KY. Prepared for West Virginia Division of Natural Resources, Elkins, WV.

Baur, B., and A. Baur. 2013. Snails keep the pace: shift in upper elevation limit on mountain slopes as a response to climate warming. Canadian Journal of Zoology 91:596-597.

Burns, R. C. and K. R. Gaydos. 2007. Recreationists at the Coopers Rock State Forest: A Survey of User Characteristics, Behaviors, and Attitudes. Report submitted to the West Virginia Division of Forestry. 61 pp.

Byers, E. and S. Norris. 2011. Climate change vulnerability assessment of species of concern in West Virginia. West Virginia Division of Natural Resources, Elkins, WV 26241.

Cardno MM&A. 2013. Mineral Resource Reconnaissance Cheat Canyon Tract Preston County, West Virginia. Unpublished report prepared for The Nature Conservancy of West Virginia; Elkin, WV.

Dourson, 2007. Revised survey protocol for Cheat Threetooth (*Triodopsis platysayoides)*. Report submitted to U.S. Fish and Wildlife and West Virginia Division of Natural Resources, Elkins, WV. 37 pp.

Dunscomb, J. K., J S. Evans, J. M. Strager, M. P. Strager, and J. M. Kiesecker. 2012. Assessing Future Energy Development across the Appalachian Landscape Conservation Cooperative. Report submitted to the Appalachian Landscape Conservation Cooperative. 55 pp.

Dupigny-Giroux, L.A., E.L. Mecray, M.D. Lemcke-Stampone, G.A. Hodgkins, E.E. Lentz, K.E. Mills, E.D. Lane, R. Miller, D.Y. Hollinger, W.D. Solecki, G.A. Wellenius, P.E. Sheffield, A.B. MacDonald, and C. Caldwell. 2018. Northeast. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 669–742.

Fournie, J. and M. Chetail. 1984. Calcium dynamics in land gastropods. American Zoologist, 24:857-870.

Garner, B. A., M. van Tuinen, and B. S. Arbogast. 2012. Conservation Genetics of and endemic and threatened species of West Virginia snail: the flat-spired three-toothed land snail, *Triodopsis platysayoides*. Unpublished report prepared for the West Virginia Division of Natural Resources. 23 pp.

Gosz, James R., G. E. Likens, and F. H. Bormann. 1973. Nutrient release from decomposing leaf and branch litter in the Hubbard Brook Forest, New Hampshire. Ecol. Mono. 43:173-191.

Justine, J. L., L. Winsor, P. Barriere, C. Fanai, D. Gey, A. W. K. Han, G. La Quay-Velazquez, B. P. Y. H. Lee, J. M. Lefevre, J. Y. Meyer, D. Philippart, D. G. Robinson, J. Thevenot, and F. Tsatsia. 2015. The invasive land planarian Platydemus manokwari (Platyhelminthes,

Geoplanidae): records from six new localities, including the first in the USA. Peerj 3:1-20.

King, T. L., M. S. Eackles, B. A. Garner, M. van Tuinen, and B. S. Arbogast. 2015. Isolation and characterization of microsatellite DNA loci in the threatened flat-spired three-toothed land snail Triodopsis platysayoides. Conservation Genetics Resources 7(3):767-769.

Nicolai, A. and A. Arnsat. 2017. Conservation at a slow pace: terrestrial gastropods facing fast-changing climate. Conservation Physiology 5: 1-17.

Pearce, T., R. Caldwell, D. Dourson, and G. Watters. 2007. Criteria for recognizing potential habitat of *Triodopsis platysayoides*, the Cheat Threetooth Snail. Report submitted to Allegheny Wood Products, Inc., Petersburg WV. September 3, 2007. 90 pp.

Pearce, T. 2019. Flat-spired Three-toothed Land Sanil Status Review Questionnaire. Unpublished correspondence prepared for the U.S. Fish and Wildlife Service. 1 pp.

Runkle, J., K. Kunkel, R. Frankson, and B. Stewart. 2017. West Virginia State Climate Summary. NOAA Technical Report NESDIS 149-WV, 4 pp.

Sugiura, S. 2009. Seasonal fluctuation of invasive flatworm predation pressure on land snails: Implications for the range expansion and impacts of invasive species. Biological Conservation 142:3013-3019.

U.S. Fish and Wildlife Service. 2007. Flat-Spired Three-toothed Land Snail 5-Year Review: Summary and Evaluation. West Virginia Field Office, Elkins, WV. 24 pp.

U.S. Fish and Wildlife Service. 1983. Flat-spired three-toothed snail *(Tridopsis platysayoides)* recovery plan. Prepared by Region 5 of the U.S. Fish and Wildlife Service. 22 pp. plus appendix.

U.S. Fish and Wildlife Service. 1978. Determination that seven eastern U.S. land snails are endangered or threatened species. 43 Federal Register: 28932-28935.

Wallace, J and R. Doyle. 2017. Notes on trail impact assessment in FSTTLS habitat within the Coopers Rock State Forest. Prepared as part of the Federal Assistance Performance Report to the U.S. Fish and Wildlife Service by the West Virginia Division of Natural Resources.

West Virginia Department of Agriculture. 2005. Gypsy moth damage assessment report 2005. West Virginia Division of Forestry, Charleston, WV. 10 pp.

West Virginia Division of Forestry. 2005. West Virginia silvicultural best management practices for controlling soil erosion and sedimentation from logging operations. Charleston, WV. 18 pp.

West Virginia Division of Forestry. 2006. Coopers Rock State Forest, Forest Resources Management Plan. pp. 1-59.

West Virginia Division of Forestry. 2007. Public-owned facility wildfire plan Coopers Rock State Forest. pp. 1-9.

West Virginia Division of Forestry. 2010. Issue 7: Forest Health in West Virginia Statewide Forest Resource Assessment 2010. pp. 269-298.

West Virginia Department of Forestry. 2015. West Virginia 2015 Forest Action Plan National Priorities Section Addendum. pp. 43.

West Virginia Division of Natural Resources, Wildlife Resources Section. 2011. Programmatic forest management plan for potential Indiana bat habitat on wildlife management areas for which the West Virginia Division of Natural Resources Wildlife Resource Section has forest management authority. Unpublished report prepared by West Virginia Division of Natural Resources, Wildlife Resources Section; Elkins, West Virginia.

West Virginia Division of Natural Resources. 2014. West Virginia Invasive Species Strategic Plan and Voluntary Guidelines 2014. pp 1-71.

West Virginia Division of Natural Resources. 2015. 2015 West Virginia State Wildlife Action Plan. pp. 1-1106.

West Virginia Tourism Office. 2017. West Virginia Tourism Office Annual Report 2017. pp. 1-11.

6.0 EXPERTS CONSULTED

During this review, information was requested from the following species, taxa, or ecosystem experts, or interested parties:

Craig Stihler, West Virginia Division of Natural Resources*

Dr. Dan Dourson, Biological Consulting

Dr. Tim Pearce, Carnegie Museum of Natural History*

Mark Gumbert, Copperhead Consulting

Jim Vanderhorst, West Virginia Division of Natural Resources

Dr. Ron Caldwell, Cumberland Mountain Research Center

John MacGregor, U.S. Forest Service

Joshua Daniel, West Virginia Division of Natural Resource*

Steven Rauch, West Virginia Division of Natural Resources*

Judy Rodd, Friends of Blackwater Canyon

The following experts provided relevant information for previous reviews, prior to this document:

Dr. Ken Hotopp, Appalachian Conservation Biology

Andy Dick, West Virginia Division of Forestry

Dr. Tom Watters, Ohio State University

Shane Jones, U.S. Forest Service

* Indicates this person responded to our request or provided information.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW: FLAT-SPIRED THREE-TOOTHED LAND SNAIL

Current classification: Threatened

Recommendation Resulting from the 5-Year Review: No change in status

Listing/reclassification priority number: Not applicable

Review conducted by: Matthew Cavnar-Johnson, West Virginia Field Office

REGIONAL OFFICE APPROVAL:

Approved Paul R. Phy Date 8/23/19
Assistant Regional Director

APPENDIX A. FLAT-SPIRED THREE-TOOTHED LAND SNAIL THREATS ASSESSMENT					
Listing Factor	Stressor	Spatial Magnitude	Immediacy	Severity	Overall Threat Level
A. Destruction, modification, or curtailment of habitat or range	Recreational uses: trampling of individuals and foraging habitat.	Localized (multiple locations within range)	Imminent or probable (historic threats being managed, but future threats continue).	Medium	Moderate
	Fire: burning of individual snails and overstory and/or understory vegetation and leaf litter (cover, foraging, and potential nesting habitat).	Potentially significant portion of range	Low probability (has not happened in 30 years since listing); but potentially increasing due to increased recreation.	Unknown but potentially significant (unknown effect to individuals in deep crevices; depending on the geographic scope of the fire, could significantly reduce foraging habitat in the area burned and possibly result in loss of 1 or more years of reproduction).	Unknown
	Logging	Significant portion of range	Existing	With buffers, low risk of crushing individual snails and/or habitat; unknown effect on shade within habitat.	Moderate
	Road building (to facilitate logging)	Localized	Existing	High risk of crushing individual snails and loss of habitat unless potential habitat is avoided; low to high risk of siltation downslope if erosion is not controlled on slopes.	Moderate
	Warming climate	Rangewide	Existing	High (the rate of climate change could surpass snails' ability to acclimate or adapt, affecting the entire species).	Moderate and increasing

Listing Factor	Stressor	Spatial Magnitude	Immediacy	Severity	Overall Threat Level
A. Destruction, modification, or curtailment of habitat or range, cont'd.	Siltation	Localized	Existing	Moderate in the event of logging activities or heavy rains; high in the combination of both.	Moderate
	Yellow birch dieback	Potentially rangewide	Low probability (has not yet occurred in West Virginia)	Low (snails may have other sources of calcium).	Low
	Residential development	Localized (primarily at the rim of the gorge in lower quality habitat)	Existing	Low (impacts to suboptimal habitat).	Low
	Gypsy moth (defoliation)	Localized (but potential to spread rangewide)	Existing	Low	Low
	Hemlock wooly adelgid	Localized (primarily on north and northeast aspects)	Existing	Low (hemlocks are a small component of the forest in the Cheat Gorge)	Low but increasing
	Deer browsing of understory vegetation.	Localized (Snakehill WMA)	Existing	Unknown	Unknown
	Invasive plants	Localized	Existing	Unknown	Unknown but increasing

Listing Factor	Stressor	Spatial Magnitude	Immediacy	Severity	Overall Threat Level
A. Destruction, modification, or curtailment of habitat or range, cont'd.	Natural gas drilling	Localized (Snake Hill and Cheat Canyon WMAs	Imminent	Moderate	Low but increasing
	Coal mining	Localized (Snake Hill and Cheat Canyon WMAs	Unknown	Low (locations may not be near snail habitat)	Low
	Limestone mining	Localized (Snake Hill and Cheat Canyon WMAs	Unknown	Moderate	Low
B. Overutilization for commercial, recreational, scientific, or educational purposes	Scientific collecting	Extremely localized	Existing	Negligible	Extremely low
	Collecting for commercial or educational purposes.	NA	NA	NA	NA
C. Disease or Predation	Natural predation by small mammals, amphibians, and birds.	Rangewide	Existing	Unknown	Unknown
	Disease	NA	NA	NA	NA

Listing Factor	Stressor	Spatial Magnitude	Immediacy	Severity	Overall Threat Level
C. Disease or Predation, cont'd.	Invasive predation by the New Guinea flatworm	Unknown (flatworm's ability to survive within the snail's range is unknown)	Unknown	High	Low
D. Inadequacy of regulatory mechanisms	No state Endangered Species Act	Rangewide	Existing	Medium	High
	Enforcement of erosion control requirements.	Localized (portion of range that overlaps with riparian areas).	Existing	Moderate to High	Moderate
E. Other natural or man-made factors	Competition, cannibalism	Potentially rangewide	Unknown	Low (known to occur in captivity but not in the wild).	Unknown
	Toxins from treated lumber used in boardwalk and railing at Cooper's Rock overlook.	Extremely localized, but present at type locality (i.e., the location where the snail was first discovered).	Existing	Low	Low
E. Other natural or man-made factors, cont'd.	Decline of Allegheny woodrats (which supply provisional but reliable sources of food to *T. platysayoides*).	Potentially rangewide for *T. platysayoides*; some evidence of woodrat decline at Coopers Rock but woodrats still present.	Existing	Low to medium	Potentially high (if provisional food sources are relatively important compared to other food sources).

Key:

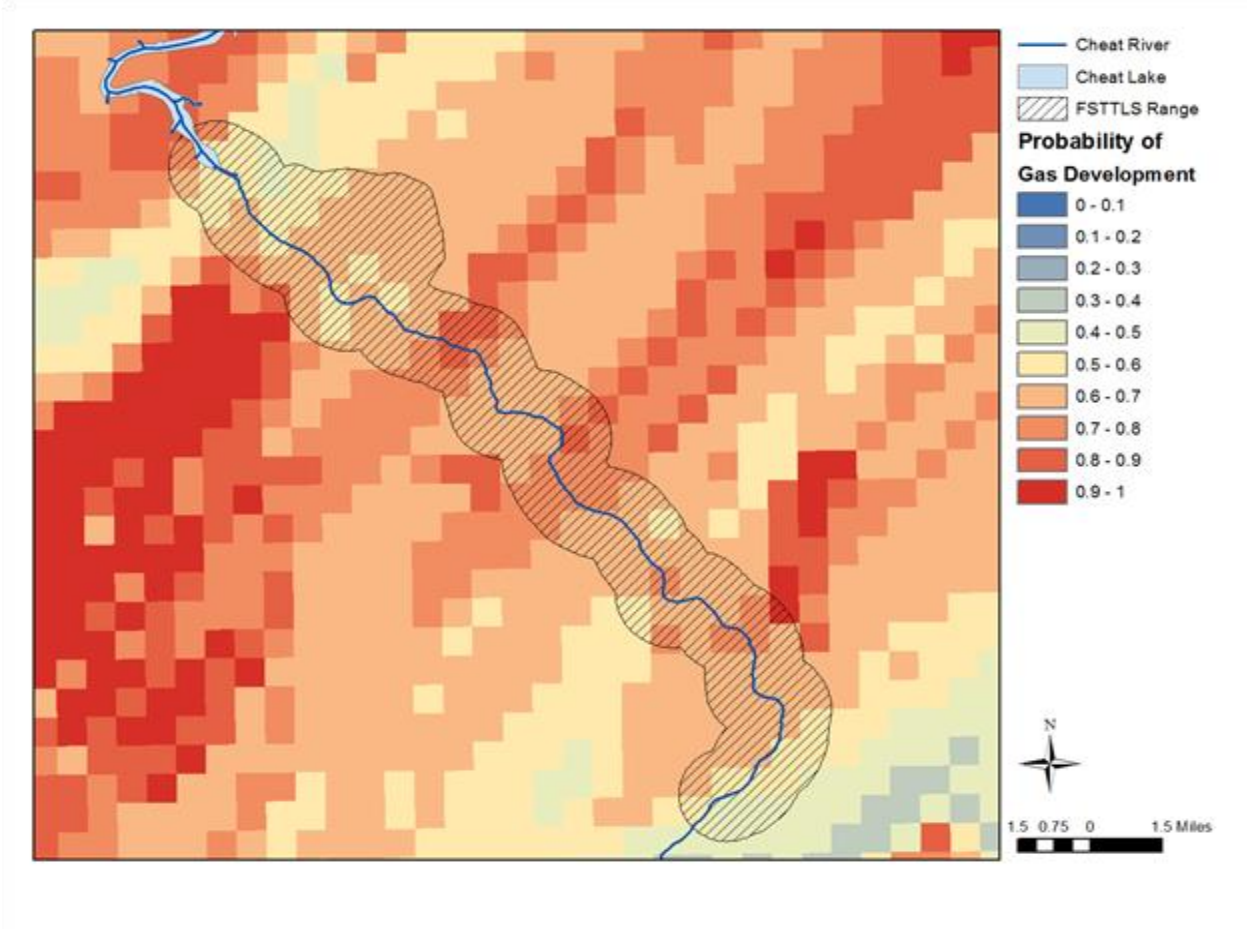
Spatial magnitude (the geographic scope of impact on the species and habitat that currently exists and can reasonably be expected within 10 years under current circumstances and the continuation of existing management situations): rangewide; significant portion of the range; localized; extremely localized.

Immediacy (the temporal nature of the threat): existing; imminent or probable; unknown.

Severity (the level of damage to the species that occurs or can be expected to occur when and where the species and/or its habitat is exposed to the threat): high; medium; low; negligible; unknown.

Overall Threat Level: high; moderate; low; unknown

Appendix B: Map of the Probability of Natural Gas Development



This map was developed by overlaying the range of the snail with the GIS model of the probability of natural gas development in the Appalachian Region from Dunscomb et al. 2012.

Appendix C: 2011 Report

Flat-spired Three-toothed Land Snail (Cheat Three-tooth Snail)
(*Triodopsis platysayoides***)**
Status Report

U.S. Fish and Wildlife Service
West Virginia Field Office
Elkins, West Virginia
July 2011

TABLE OF CONTENTS

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Field Office: West Virginia Field Office, Whitney Kroschel, 304-636-6586

Lead Regional Office: Region Five, Hadley, MA; Mary Parkin, 617-876-6173

Cooperating Offices: None

1.2 Methodology Used to Complete the Review

This review has been conducted by the U.S. Fish and Wildlife Service's West Virginia Field Office (WVFO). We sought information on the status of the flat-spired three-toothed land snail (*Triodopsis platysayoides*) from individuals familiar with the species, its ecosystem, and/or other land snails. We also reviewed the status of, and threats to, the species in consultation with Craig Stihler, the species expert for the West Virginia Division of Natural Resources (WVDNR), during a meeting on May 26, 2011. The new information that has been compiled since listing and the previous 5-year reviews, in combination with coordination with the WVDNR species expert, provide the basis for this 5-year review.

1.3 Background

1.3.1 FR Notice announcing this review: 76 FR 33334 (June 08, 2011)

1.3.2 Listing history:

FR notice: 43 FR 28932
Date listed: July 3, 1978
Entity listed: Species
Classification: Threatened

1.3.3 Associated rulemakings: not applicable

1.3.4 Review history:

The flat-spired three-toothed land snail was included in the following 5-year reviews conducted in 1983, 1991, and 2007:

- December 8, 1983 (48 FR 55100) – all domestic species listed in 1978, resulting in a notice of completion on July 22, 1985 (50 FR 29900)
- November 6, 1991 (56 FR 56882) – all domestic and foreign species listed before 1991

In these cursory reviews, the status of many species was evaluated concurrently. The Federal Register notices solicited new or additional information on the various

species under review to determine if significant data were available warranting any changes in classification. No change in *Tridopsis platysayoides* listing classification was recommended from these 5-year reviews.

The assessment in 2007 constituted the first substantive, individual 5-year status review of *T. platysayoides* since its listing. Information available since the 1978 rule was used to evaluate and assess the status of the snail.

1.3.5 Species' Recovery Priority Number at start of review: 8c, indicating an overall moderate degree of threat, high recovery potential, and conflict with construction or other development projects.

1.3.6 Recovery Plan:

Plan name: Flat-spired Three-toothed Snail (*Triodopsis platysayoides*) Recovery Plan

Date issued: May 9, 1983

Date(s) of revisions or updates: None

2.0 REVIEW ANALYSIS

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

2.1.1 Is the species under review listed as a DPS? No. This species is an invertebrate and does not qualify for listing as a DPS.

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?

No. The criteria were designed to protect a few isolated populations from catastrophic loss, and simple assumptions were made about population trends. We now know that the species is more widespread than previously thought and that it is very difficult to determine presence/absence or detect a population trend. Although we know of more occupied sites, we do not know the number of populations or if there is genetic interchange among population sites. We need to rethink the concept of isolated populations and address connectivity issues.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?

No. At the time of listing and development of the recovery plan, the only relevant listing factors were A (habitat impacts) and D (inadequacy of regulatory mechanisms). These factors are still relevant today. Predation (factor C) and other natural or man-made factors (factor E) have since been identified as potential threats; however, there is uncertainty about their significance. Factor B (overutilization) continues to be irrelevant. The recovery criteria focus exclusively on factor A.

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, citing information. For threats-related recovery criteria, note which relevant listing factors are addressed.

The recovery plan states that *T. platysayoides* will no longer need Endangered Species Act protection when either of the following sets of criteria is met (USFWS, 1983):

Recovery Option A: *T. platysayoides* is found at less than three additional sites (USFWS, 1983).

4) All known habitat sites supporting *T. platysayoides* are protected from foreseeable human impacts by acquisition, easements or cooperative agreements and management plans. This requires protection of at least 80 percent of the snails' habitat at each of the sites from impacts of recreational usage, adverse management practices, land use changes or other actions that would adversely affect the species.
5) A long-term management and monitoring program is established for the species.
6) The monitoring program shows that there is no downward trend in distribution, number and extent of populations, or habitat quality for a 10-year period (USFWS, 1983).

Recovery Option B:

5) *T. platysayoides* is found at a minimum of three additional sites (i.e., in addition to the known sites in Coopers Rock State Park and at Table Rock), each at least a mile from the other and from the known sites.
6) At least 60 percent of these sites are protected from foreseeable human impacts by acquisition, easement or cooperative agreements and management plans.
7) A long-term management and monitoring program is established for the species.
8) The monitoring program shows that there is no downward trend in distribution, number and extent of populations, or habitat quality for a 10-year period (USFWS, 1983).

Option B applies because there are at least 99 known sites for the species.

Criterion 1 appears to be satisfied. The 99 known sites are distributed across a 14-mile stretch of the Cheat Gorge. At least 3 sites are $\geq$ 1 mile from known sites in Coopers Rock State Forest[1] and at Snakehill Wildlife Management Area[2] and are $\geq$1 mile from other known sites (Stihler, 2006). It is important to note that the term "site", as used here, simply refers to an observed occurrence of at least one *T. platysayoides* individual or shell, and not a population. It is likely we have far fewer populations compared to "sites". Furthermore, many of these "sites" were established based on the discovery of a *T. platysayoides* shell, not a live individual. Moreover, shells within rock crevices are more protected from weathering from external elements; they may persist much longer than the live individuals' occupation of the site. This creates a high degree of uncertainty in regards to what is known about the distribution of *T. platysayoides* throughout its range. It also creates high uncertainty regarding how a "site" reflects the species' actual distribution and status. Thus, although the recovery plan and this review use the term "site", the recovery potential of *T. platysayoides* may be more accurately viewed in terms of suitable habitat.

Progress toward Criterion 2 has been made, but the criterion has not been satisfied. Roughly two-thirds of the 99 known occupied sites (element occurrences) are on public lands (Coopers Rock State Forest and Snakehill Wildlife Management Area) (Stihler, 2006), and thus are protected to some degree from foreseeable human impacts. These sites, however, face continuing threats from human impacts, including increasing recreation (Stihler, pers. comm., 2011) and timbering operations (Hotopp, pers. comm., 2011). Timber management is also a threat on roughly one-third of the occupied sites that are on private lands (Stihler, pers. comm., 2011). Property owned by The Forestland Group amounts to approximately 3,410 acres of potential snail habitat (WVDNR, 2010a) on which six snail preserves and two adjunct preserve areas, ranging from 6 to 50 acres, were established to protect the snails from future timber harvests (Stihler, pers. comm., 2011). Known occupied and potential snail habitats were delineated in 2008 by Copperhead Consulting at Coopers Rock State Forest using criteria from Pearce et al. (2007). Buffers were subsequently established around the delineated habitat for protection from future human impacts in the State Forest, especially impacts from timbering operations. However, the effectiveness of recently established habitat buffers and snail preserves on private timber lands (Quarles et al., 2007) for protecting the snail are currently unknown.

---

[1] The area known as Coopers Rock is technically a state forest, though previously published documents (e.g., the recovery plan; the 2007 5-year review) may refer to it as a state park.

[2] Snakehill Wildlife Management Area (WMA) includes the area known as Table Rock.

Progress toward Criterion 3 has been made, but this criterion also has not been met.

A long-term management and monitoring program has not been established for the species. Coopers Rock State Forest (WVDOF, 2007) completed a fire plan and recently produced a recreation plan which addressed threats to the snail. The recreation plan lists goals that intend to spread public awareness about the snails' presence and protection needs within Coopers Rock State Forest (Burns and Gaydos, 2007). In 2007, presence/absence survey protocols and protocols to delineate potential habitat for the species were completed (Dourson, 2007b; Pearce et al., 2007). The overlook site in Coopers Rock State Forest is monitored annually by the WVDNR with the exception of the last two years due to time and staff constraints (WVDNR, 2009, 2010b). Other sites have been monitored once or intermittently, as needed for assessment of impacts from proposed land use changes (WVDNR, 2008).

Criterion 4 has not been met. While the known distribution of the species has increased, trend data on the number and extent of populations are largely unavailable (Stihler, pers. comm., 2011). Although current management efforts seek to avoid damage to snail habitat, such as the establishment of buffers, the effectiveness of these efforts is unknown. This is because in areas where large human-caused disturbances occurred (e.g., timber harvests), only post-disturbance data was collected. There was no baseline data with which to compare the end effects. Therefore, downward trends in distribution, population statuses, and habitat quality effects have not been confirmed.

2.3 Updated Information and Current Species Status

2.3.1 Biology and habitat

Overview

T. platysayoides is endemic to the Cheat River Gorge of northern West Virginia. Little is known of the life history of this secretive animal. *T. platysayoides* typically are observed within 1 meter of a rock feature. They can be found in cool, moist, deep fissures in shale, sandstone and limestone outcrops and in talus. This snail occurs in outcrops from the river bottoms to the ridgetops. Rock outcrops one meter or more in height are considered potential habitat if there are cracks and crevices at least one meter deep. The snail appears to prefer rock talus but also is found in cliffline areas that contain deep, dark crevices. When the two habitats coincide (rock talus and cliffline), *T. platysayoides* is more often found in the talus. Dourson (2007a) designated rock talus to fall into several categories. Type 1 rock or boulder talus is optimal (boulders stacked). Type 2 rock or boulder talus is potential, although not optimal, habitat (boulders touching). Type 3 habitat is not suitable for *T. platysayoides* (scattered rocks or boulders not touching).

While plant associations and ages of trees occurring at known sites vary greatly, several plant species are commonly found at *T. platysayoides* sites: sweet birch, rhododendron, and red maple (Caldwell et al., 2006; Hotopp, 2000). Some sites are covered in old growth while others are occupied by saplings, and in some cases, open grape arbors growing over talus (Dourson, 2007a). Dourson (2007a) concluded that

rock structure is more important than age of trees or vegetative composition growing on rocks. Slope aspect also is a factor. North and northeast slopes in the Cheat Gorge provide naturally cooler and moister habitats than south and southwest facing slope aspects. Thus, heavy canopy cover may be more important on south and southwest facing slopes.

T. platysayoides is primarily active at night. Optimum snail activity occurs during spring and early summer, especially during cool, moist weather conditions when air temperatures are between 60-65 degrees Fahrenheit with relative humidity greater than 85 percent (Dourson, 2007a).

During daytime, the species primarily has been found on the ceiling, wall, or floor of rock structures. During the night, snails have been found equally on both rock and the leaf litter near rock features. The species has been observed foraging and resting under wet leaves (next to rock structure) and moving across the litter to a rock feature (Dourson, 2007a). It may also lay its eggs in soil or leaf litter but this has not been verified. A captive colony of *T. platysayoides* laid small clusters of 3-5 eggs in the soil under the leaf litter in the spring and summer (USFWS, 1985).

T. platysayoides is thought to be a relatively long-lived land snail. Based upon shell growth rings, *T. platysayoides* in the wild reach maturity at 3 years, or at 2 years in captivity (Hotopp, 2003). Hotopp (2000) reported that approximately 33 to 67 percent of the individuals located in the field were adults.

T. platysayoides has a varied diet of at least 27 documented foods, including a variety of aged leaves and flower blossoms, fresh catkins, fresh and aged wood rat feces, lichens, mushrooms, and crickets (Dourson, 2007a, 2008; Hotopp, 2000). Calcium may be a limiting factor, especially for snails living among sandstone habitats which are predominantly acidic. Dead birch leaves provide a considerable amount of calcium (Gosz et al., 1973) and *T. platysayoides* has been observed feeding on aged beech leaves and catkins (good sources of calcium), as well on the shells of *Tridopsis denotata*, *Mesomphix cupreus*, and its own kind (Dourson, 2007a).

It is unknown whether *T. platysayoides* hibernates during the winter months. These snails share a habitat with the Allegheny woodrat (*Neotoma magister*) (which do not hibernate); they provide the snails with a constant supply of feeding material by carrying vegetation and fungi deep into the rock crevices where snails retreat during dry periods (Dourson, 2007b). It is during these periods that *T. platysayoides* is believed to have an advantage over other land gastropods because they can avoid extreme weather conditions. Furthermore, the snails are known to feed on woodrat scat and the mold that grows on woodrat scat (Dourson, 2008). Thus, it is possible *T. platysayoides* remains actively feeding throughout the entire year.

2.3.1.1 Abundance, population trends:

Little is known about population sizes or trends because the snail is so difficult to survey. Presence/absence surveys have been conducted at spotty locations throughout the Cheat Gorge. The failure to detect a snail during a presence/absence

survey does not prove absence, especially if surveys are conducted during suboptimal conditions (e.g., dry and hot). The most successful detection of presence has been at night during rain events (Stihler, pers. comm., 2011). Regular surveys under such conditions are thus difficult and could be dangerous.

Before 1981, only one very restricted population of *T. platysayoides* was known. Grimm (1972) observed 50 individuals on one occasion and estimated a population of "several hundred," whereas Solem (1974) estimated the population to be 300-500. Field surveys in 1984 at this same location located only 35 individuals. In 1984, 12 *T. platysayoides* were marked but no recaptures were obtained (USFWS, 1985). Stihler observed increasing numbers of *T. platysayoides* at Coopers Rock State Forest after the site was fenced to control human access (Dourson, 2007a; Stihler, pers. comm., 2007); however, Solem (1982) cautioned that observations of snail numbers cannot be used to deduce trends, as other snails show short-term fluctuations of 10-15 times a low number.

Dourson (2007a) notes that *T. platysayoides* appears to be a relatively common snail species where it is found. Although many other species of snails have been documented coexisting with *T. platysayoides*, they generally do not exceed *T. platysayoides* numbers (Dourson, 2007a). In many cases, *T. platysayoides* was the most common snail, sometimes exceeding all other snail species combined.

In general, most population information regarding *T. platysayoides* remains uncertain or unknown. This includes the size of populations, the viable population size, the amount of isolation for each population, and whether or not populations are functionally connected or fragmented. Therefore, population trends are difficult to evaluate before understanding how to measure a population.

2.3.1.2 Genetics, genetic variation:

When surveyors capture *T. platysayoides*, they are encouraged to take a genetic sample on a Whatman FTA® Classic Card (also known as a slime card) and send it to the WVDNR for analysis. Genetic data have been collected from approximately 40 individuals for the purpose of analyzing levels of gene flow and migration among *T. platysayoides* populations in the Cheat Gorge. This will aid in discerning how populations of *T. platysayoides* are defined. Specifically, the genetic data will help determine gene flow and migration across the Gorge, and among disjunct populations on the same side of the Gorge. It would help determine the degree to which these populations are isolated. Due to their limited mobility and small size, it is entirely possible that dispersal is quite rare (Arbogast and Van Tuinen, 2010). Genetic analysis is currently ongoing. Adding genetic samples from more individuals would strengthen the results.

2.3.1.3 Taxonomic classification:

T. platysayoides is a formally recognized species. It was first collected by Graham Netting at Coopers Rock and later described by Stanley Brooks (1933) as *Polygyra platysayoides* from the area of Coopers Rock State Forest (USFWS,1983; Watters,

2006). Although the taxonomic status of the species was questioned, in 1940 Pilsbry considered it to be a distinct species and transferred it to the genus *Tridopsis* (Stihler, 1994). Based on rather limited information, Vagvolgyi (1968) classified *T. platysayoides* as a subspecies of *T. complanata*. This reclassification was not widely accepted and in 1974 Solem concluded that available evidence supported full species status (USFWS, 1985).

In 1988, Emberton confirmed that *T. platysayoides* was a valid species with a unique penal morphology. Emberton (1988) also used starch-gel electrophoresis of foot tissue to examine evolutionary relationships among 40 species of tridopsine snails in eastern North America. He divided populations into family trees showing the phylogentic relationships among 18 groups of species. Nine of these groups consisted of a single species, of which *T. platysayoides* was one group. Today *T. platysayoides* is commonly referred to as the Cheat threetooth snail (Turgeon et al., 1998).

2.3.1.4 Spatial distribution, trends in spatial distribution:

At the time of listing in 1978, *T. platysayoides* was thought to be restricted to an area of less than 160 acres on the summit of Cooper's Rock, at the downstream end of Cheat Gorge, in Monongalia County, West Virginia. In 1981, the known range of the species was extended approximately 0.9 miles upstream (east) of Cooper's Rock. The first population on the south side of the Gorge was discovered in 1982. When the recovery plan was written in 1983, the known range included 7 locations, all in close proximity to Cooper's Rock. During surveys conducted from 1981-1991, eleven new localities were found, located south of Interstate-68 in Monongalia and Preston counties, West Virginia, encompassing an area of roughly 2.1 miles by 8.7 miles (Stihler, 1994). Additional survey work through 2007 has resulted in many new localities.

Like most of West Virginia, the Cheat Gorge was logged extensively in the late 1800s and early 1900s, followed by widespread forest fires (Pauley, 2008), then an era of fire suppression and forest diseases (Vanderhorst, pers. comm., 2007). It is quite possible the original spatial distribution of *T. platysayoides,* before the timber harvests and forest fires, was not restricted to merely rock crevices within forested areas, but rather was continuous throughout its range. At least one documented locality of *T. platysayoides* is outside of forest canopy (Dourson, 2007b). Given the small size of the species and its limited mobility, it is reasonable to believe catastrophic events, such as forest fires, allowed little opportunity for individuals to survive, unless they happened to be near refugia. The outcome after such an event would be islands of surviving populations associated with rock outcrops. Pauley (2008) noted Cheat Mountain Salamander (*Plethodon nettingi)* populations to be associated with large, emergent rocks. Cheat Mountain Salamanders, endemic to the West Virginia Allegheny Mountains, also have a discontinuous distribution consisting of multiple disjunct populations. Pauley (2008) suspects Cheat Mountain Salamanders survived the early 1900s logging and forest fire events by taking refuge in the deep crevices of emergent rock structures. Thus, it is possible *T. platysayoides* also experienced a similar history of disturbance and recovery.

A fragmented distribution of a species throughout its range is often evidence of a past population collapse (Hotopp, pers. comm., 2011). If such were the case with *T. platysayoides*, this also opens the possibility that their distribution was once contiguous throughout its range. For instance, *Patera panselenus*, the Virginia bladetooth snail, is also generally restricted to scattered rock outcrops and talus within the Cheat Gorge (Hotopp, 2006a). But its range is not limited to the Gorge. Further south, within the heart of its range, *P. panselenus* occurs much more contiguously; it may be on leaf litter, logs, rocks, and is not merely found within talus and deep rock micro-habitats (Hotopp, pers. comm., 2011). This also suggests the possibility *T. platysayoides*, at one point in time, potentially occupied its range more continually than what is observed today.

Although examples with surrogate species and other reasonable hypotheses present evidence for the original distribution of *T. platysayoides*, there is still a great amount of uncertainty regarding this topic. It is equally possibly that *T. platysayoides* has always been closely associated with rock features and never occupied other types of habitat. Hence, understanding more about the species' present occupation of habitat may help in ascertaining its original distribution. The present known range of *T. platysayoides* includes 99 element occurrences, including a site at Cornwell Cave, approximately 6 miles south of Cooper's Rock. The snail occurs on both sides of the Gorge within an approximately 14-mile stretch, including portions of the major tributary ravines. The range of the species begins near the mouth of Muddy Run near Ruthbelle in Preston County, and extends to the lower reaches of Cheat Lake near Tyrone in Monongalia County (WVDNR, 2006). Although the range of the species has expanded since listing, it is still considered to be a narrowly ranging species endemic to scattered rock features within the Cheat Gorge.

2.3.1.5 Habitat or ecosystem conditions:

Based primarily upon a gross-scale analysis of underlying geologic formations, Jones and Stihler estimated a total of approximately 10,582 acres of potential habitat for *T. platysayoides* within and on the rim of the Cheat River Gorge (USFWS, 2003). Rock formations where the snail is found are usually Pottsville Sandstone, a relatively resistant rock which forms steep cliffs (mainly along the canyon rim), boulder fields, and talus slopes. The snail also occurs upon the Greenbrier Limestone formation at cave entrances (exposed in the lower levels of the Gorge). Of the 10,582 acres of potential habitat, roughly 27 percent (2,861 acres) is currently in public ownership (Coopers Rock State Forest and Snakehill Wildlife Management Area), 43 percent (4,600 acres) is owned by The Forestland Group, and 30 percent (3,121 acres) belongs to other private landowners (USFWS, 2003). Of this acreage, approximately 3 percent (311 acres) of the forested acreage will be affected by the Scott Run II Project designed and approved by the West Virginia Division of Forestry (WVDOF) and Coopers Rock State Forest. This project is a selective timber harvest designed to promote oak regeneration in a forest where red maple is overtaking mature oak and yellow poplar stands. It also aims to improve wildlife habitat by increasing forest heterogeneity in terms of species and structure (WVDOF, 2009).

Currently the WVDNR is seeking to purchase a total of approximately 4,000 acres of

land owned by The Forestland Group. This land is located in the Cheat River Gorge and includes approximately 3,410 acres of potential habitat for *T. platysayoides*. The WVDNR received a Recovery Land Acquisition (RLAG) grant from the U.S. Fish and Wildlife Service that covers about 27 percent of the anticipated acquisition. Additional funding was requested in a second proposal dated 2010. If sufficient funding to purchase these lands is acquired, and the transfer is successfully negotiated, the WVDNR's acquisition of this land would provide additional protection to 33 percent of the known habitat of *T. platysayoides* (WVDNR, 2010a).

A forest inventory and deed records show that the Gorge was extensively logged, including clearcutting, several times in the 20th century (Riddle, 2006). Several logging companies operated in the Cheat Gorge between 1900 and 1945. The dominant cutting practice at that time was harvest of all merchantable trees. Selection harvests were done in portions of the Gorge in the 1960s and 1970s, again in 1993-1994, and will continue for the foreseeable future.

Today the Cheat Gorge is forested primarily by mature second-growth forest. It contains large blocks of relatively unfragmented forest habitat, notable for relict old growth patches, functioning natural disturbance regimes, and high biodiversity (USFWS, 2003). However, areas of the forest lack structural diversity due to the historic timber harvests, which have promoted stands of similar age. Furthermore, the forest species composition has been shifting over the past 50-60 years, primarily due to the expansion of the red maple range (WVDOF, 2009).

The sandstone/limestone forested ecosystem in the Cheat Gorge has unique plant communities associated with acidic soils (Vanderhorst, pers. comm., 2007). The lands are forested primarily with dry, oak-dominated forest communities, sometimes underlain by dense stands of mountain laurel and rhododendron (USFWS, 2003; Caldwell, 2006). A great variety of plant associations are found in the Gorge, too numerous to mention here, including oak-hickory and maple-beech-birch forest associations (Hotopp, 2000).

Oak-dominated communities, such as those in the Cheat Gorge, are thought to be in general decline today due to high mortality from gypsy moth invasions, selective harvesting of oak over other species, and deer herbivory (Widmann, 2004). In addition, oaks are fire-adapted and in some areas are being replaced by more shade-tolerant trees, such as red maple, through fire suppression (USFS, 2006; Vanderhorst, pers. comm., 2007). The introduction of exotic pests and diseases could potentially affect forest composition in the Gorge.

2.3.2 Five-factor analysis

To facilitate an analysis of the snails' appropriate listing classification under the Endangered Species Act, a threats assessment that conforms to the five listing factors was conducted in March 2007 and updated in June 2011. Identified threats were analyzed for the spatial magnitude, severity, and immediacy of their effect on the

long-term survival of *T. platysayoides.* That assessment, as well as additional

information used in the following five-factor analysis, is provided in the appendix to this review**.**

2.3.2.1 Factor A. Present or threatened destruction, modification or curtailment of habitat or range:

At the time of listing, the species was thought to be restricted to isolated patches of deep undisturbed litter and sheltered retreats among rocks in a small area less than 0.25 square miles near Cooper's Rock, a popular spot for sightseeing and rock climbing in West Virginia. Recreational impacts at Coopers Rock State Forest were believed to be a primary threat. High visitor use was thought to be resulting in crushing of snails and habitat degradation from the loss of leaf litter on the forest floor (USFWS, 1978). Smoking by persons standing on the caprock, or the boardwalk (which passes over the location where the snail was first discovered), and throwing cigarettes into the leaf litter, was thought to be a serious fire hazard.

Since then, *T. platysayoides* has been found at 99 locations throughout its historic range. Rock climbing at Cooper's Rock has been banned on rock formations at or near known snail sites, and in 1997 sections of chain-link fence were erected on either side of a large crevice beneath the overlook walkway. Since the fence installation, leaf litter has increased substantially and Stihler has observed increasing numbers of *T. platysayoides* (Dourson, 2007a).

Most of the known and potential snail habitat (about 80 percent) at Coopers Rock State Forest was mapped with GIS software (Gumbert and Roby, 2008). This data can facilitate land managers' efforts to avoid impacting snail habitat from future human-induced threats. Recreation continues to be a threat, especially from off-trail foot traffic and rock climbing activities. In 2007 a group requested permission to host a rock "bouldering" event at the park. The request was denied because this event could have caused trampling of individual snails (with up to 400 people climbing over boulder fields) and, possibly, disturbance of snail foraging and breeding habitat (participants also could have raked leaves away from the base of boulders) (Stihler, pers. comm., 2007). The recreation plan produced by Coopers Rock State Forest presented goals to use signage to educate climbers about species unique to the State Forest, including the snail. These goals included placing interpretive signs around climbing areas about protecting endangered species; regular monitoring of threatened and endangered species; and developing strategies to allow bouldering and climbing activities to take place, while still adequately protecting the snail from related threats (Burns and Gaydos, 2007). However, presently there is only a small poster about the snail at the Climber's Kiosk in the upper parking area. The status of placing signage in the near future is unknown at this time.

While fires have not occurred in known occupied snail habitat in the 30 years since listing, state land managers recently prepared a fire management plan, as they are concerned about the threat of fire from increasing human use of Coopers Rock State Forest (WVDOF, 2007). The effect of fire on *T. platysayoides* is unknown but potentially significant. As such, it could possibly have the most damaging impacts on the snail (Stihler, pers. comm., 2011). Campfires, cigarettes, or other sources of fire could easily initiate large scale destruction. Depending on the scope and intensity of

the fire, snails occupying deep, cool, moist rock crevices at the time of fire likely stand a better chance of surviving than those foraging, laying eggs, or seeking cover in leaf litter. Fire could kill individual snails and significantly reduce foraging habitat in the area burned and possibly result in the loss of one or more years of reproduction. However, fires at certain times of the year when snails are inactive may not pose a significant threat and may help maintain the oak-hickory forest community (Stihler, pers. comm., 2007). Studies elsewhere have shown that land snail communities have survived fires when there was adequate habitat structure to provide for deep vertical movement and shielding from heat during wildfires (e.g., coarse rock substrate with deep fissures and access to underground moisture) (Kiss and Magnin, 2003; Duncan, 2007). Additionally, the distribution of the snails on both sides of the Cheat Gorge increases their likelihood of surviving a large fire because such an event would likely be restricted to one side of the Gorge.

New threats to habitat have arisen since the time of listing. Collectively, road-building and logging pose ongoing threats (e.g., crushing of individuals and loss or degradation of habitat) within a substantial portion (50 percent) of the range of the species. Allegheny Wood Products (AWP) retained timber rights when the WVDNR purchased land for what became Snakehill Wildlife Management Area (WMA). In March and April 2007, AWP initiated a one-time harvest of trees on this WMA, which comprised roughly 30 percent of the known occupied snail site locations. On this WMA, known occupied and potential *T. platysayoides* habitat was buffered to avoid and minimize impacts to snails. Based upon a survey of rock structure, a 150-foot-wide "no touch" buffer was placed around occupied and optimal habitat; limited harvesting was allowed within an additional 50-foot buffer, extending from the outer edge of the "no touch" buffer. A 100-foot "no touch" buffer was placed around potential habitat, with limited harvesting within an additional 50-foot buffer. While these buffers likely avoided crushing *T. platsayoides* from road construction and timber harvest, their effectiveness in providing adequate shade and foraging habitat is unknown. No pre-harvest habitat data was collected with which to compare the effects. Furthermore, because the process of "selective harvesting" allows flexibility in the definition, it is possible the more heavily harvested areas still impacted the health of the snail habitat. In 2009 AWP's timber rights expired on that property, and The Forestland Group acquired approximately 4,600 acres of former AWP property. The six snail preserves established by AWP are maintained on The Forestland Group property, and potential snail habitat is mapped with included buffers to aid in protection from any future harvesting. At present there is no immediate intent to harvest land on The Forestland Group property. The WVDNR is currently attempting to purchase a portion of these lands from The Forestland Group.

A timber harvest around snail habitat in Coopers Rock State Forest is currently being planned. The proposed Scott Run II Project area is approximately 311 acres, of which 53 acres (17 percent) is a no-cut primary (known) and potential snail habitat buffer (WVDOF, 2009). In the summer of 2008 this area was delineated and mapped for potential snail habitat by Copperhead Consulting using the criteria by Pearce et al. (2007). A 150-ft buffer was placed around potential snail habitat and a 200-ft buffer was placed around primary snail habitat (WVDOF, 2009). Although there is some uncertainty about the effectiveness of these buffers (Pearce et al., 2007), the Scott Run II Project has presented an opportunity to study them. From spring through

autumn 2010 and 2011, data loggers were placed in and around snail habitat within the project area. The data loggers collected temperature and humidity data at regular intervals on a daily basis. They were placed at 10 sites; each site had three loggers: one within rock fissures, one adjacent to rock structures, and one in the open near the snail habitat. Preliminary data showed high temperature and moisture fluctuations in the adjacent and open locations, but relatively steady readings in the fissure locations (WVDNR, unpublished data). These results confirm that deeper rock crevices often maintain cooler, moister conditions and suggest that the establishment of buffers, in addition to the protection of the rock crevices, will likely protect the snails from micro-habitat alterations due to timber harvesting. The WVDOF is proposing to use these data loggers to evaluate the micro-habitat conditions after the Scott Run II Project is completed. Pre- and post-project conditions will be compared, which will provide further insight into the most appropriate buffer size to avoid impacts to the snail and its habitat. These findings will likely help refine future recommendations regarding timber operations around snail habitat in Coopers Rock State Forest and other areas.

Siltation remains a significant threat to *T. platysayoides*, especially because of its association with logging activities and the likelihood of these activities to continue around snail habitat. Poorly managed logging roads have contributed to increased soil erosion in the past. Timbering that occurred between 2006 and 2009 on what is now The Forestland Group property possibly increased siltation in *T. platysayoides* habitat. Soil erosion problems associated with old logging roads on Snakehill WMA became evident during the heavy rains of summer 2007. Heavy rain events wash loads of exposed or loose soil into interstitial rock spaces; they may also wash *T. platysayoides* individuals into inappropriate environments where they do not survive (Dourson, pers. comm., 2011). Although erosion is a natural phenomenon, human disturbance of habitat tends to accelerate this process. The threat of adverse effects from siltation can be reduced through the appropriate management and use of logging roads in and around snail habitat.

Change in climate is a present and future threat to *T. platysayoides*. Within the next 50 to 60 years northern West Virginia is predicted to experience a 5.0-5.6 °F increase in temperature (Gervitz et al., 2009). In terms of moisture over the same year period, West Virginia is expected to experience an overall increase. But coupled with temperature rises, the overall moisture status is unlikely to be maintained. Furthermore, net moisture status across the contiguous United States is predicted to decrease (Gervitz et al., 2009); though, the moisture models are not as consistent as the temperature models. In general, land snails are extremely vulnerable to temperature and moisture changes due largely to their inability to disperse far distances. This is heightened by strong natural and anthropogenic barriers, a small physiological thermal habitat niche, specific physical habitat characteristics, and possible genetic bottlenecks (Byers and Norris, 2011). A temperature change of a few degrees within talus habitat could have large impacts on *T. platysayoides*, especially during extreme seasonal highs and lows when the snails depend on deep rock crevices for consistent conditions (Dourson, pers.comm., 2011). Due to *T. platysayoides'* dependence on cooler temperatures and high relative humidity during the growing season, it is reasonable to anticipate it will respond to future climatic

changes within the Cheat Gorge. However, it is important to note that deep rock crevices may ameliorate potentially harmful climate change effects on the snails; temperature and moisture may not experience as dramatic shifts compared to outside the rock crevices. Until research is conducted regarding their potential response, it is unknown the extent to which *T. platysayoides* would be affected by warming temperatures and moisture changes within the foreseeable future.

The overall decline of yellow birch in the eastern United States (Bourque et al., 2005) presents a potential threat to *T. platysayoides*. Calcium concentrations generally increase in decaying leaf litter and snails need this element to develop and strengthen their shells (Fournie and Chetail, 1984). Yellow birch is likely one of the best sources of calcium within *T. platysayoides* habitat (Gosz et al., 1973; Dourson, 2007b). Die off of yellow birch has been a recognized problem since the 1930s, but the most severe instances have so far been concentrated in eastern Canada and northeastern United States. Various causes have been investigated (e.g., pests, fungi, bacteria, viruses), but the most likely reason is from extended winter thaws followed by abrupt refreezes. These events cause shoot dieback in northern hardwood species, but the shallow root systems of yellow birch make them especially more susceptible (Bourque et al., 2005). Increasing warming trends due to climate change could easily expand the range of yellow birch dieback. A decrease of yellow birch in the Cheat Gorge could potentially affect *T. platysayoides* and its habitat, but the extent to which is unknown.

Residential development at the rim of the Gorge adjacent to Snakehill Wildlife Management Area poses a localized and minor threat to *T. platysayoides*. These are tracts of land owned by other private landowners, and at this time, the Service does not know how these land owners intend to manage their lands. Habitat in this area is marginal. But until these areas are adequately delineated for snail habitat using appropriate criteria (e.g., Pearce et al., 2007), the potential threat of development on these properties remains unknown.

Forest insect infestations pose an ongoing threat to the habitat of *T. platysayoides.* Gypsy moths and hemlock wooly adelgids attack trees and result in defoliation that could affect shading of snail habitat. Whereas the bulk of recorded gypsy moth defoliation occurred in the eastern panhandle of West Virginia in 2000-2002, some defoliation occurred in Preston and Monongalia counties (West Virginia Department of Agriculture, 2005), and defoliation continues to spread eastward, peaking on a roughly 10-year population cycle, despite control efforts in place since 1983. Gypsy moths feed on more than 500 species of trees and shrubs, and repeated heavy defoliation by gypsy moths leads to death of trees, e.g., hardwood tree mortality after 2 successive years of defoliation can reach 80 percent. Because of their high reproduction rates and potential to develop resistance to pesticides, gypsy moths pose a pervasive threat to *T. platysayoides* habitat in the Gorge, especially due to potential loss of shading.

Hemlock wooly adelgids likely pose less of a threat to *T. platysayoides* habitat than gypsy moths. It is possible that, within a decade, eastern hemlock will be reduced to a minor component of forest in West Virginia. However, eastern hemlock occurs primarily in isolated patches on moist north and northeasterly aspects soils in the

Gorge (Kish, 2007), and the position and orientation of *T. platysayoides* sites are important factors in assessing possible impacts to habitat. The loss of eastern hemlock trees on predominantly northerly slopes may not have as abrupt an impact as loss of other trees on hotter and drier slopes.

Deer herbivory in the Cheat Gorge also may be a factor today in reducing oak regeneration in portions of the Gorge, possibly leading to replacement by shade-tolerant maples (Vanderhorst, pers. comm., 2007). Whereas tree species composition may be less important than rock structure in *T. platysayoides* habitat (Dourson, 2007a), lack of understory vegetation may adversely affect snails. Hotopp (2005) reported that deer over-browsing was widespread at Snakehill WMA. On many forested slopes, herbaceous understory vegetation was reduced, possibly affecting cover and food supply of *T. platysayoides*. However, the extent to which over-browsing limits *T. platysayoides* is unknown. Leaving slash and tree tops when timber harvests are conducted in areas surrounding *T. platysayoides* habitat might help to provide cover and limit the effects of deer browsing.

There is some evidence that invasive plants may be increasing in the Cheat Gorge, especially following recent disturbances from road-building and timber harvesting. Dourson (2007a) reported the beginning of Tree-of-Heaven (*Ailanthus altissima*) encroachment, and Stihler (pers. comm., 2007) reported the incursion of garlic mustard in the Gorge. The impact of invasive plants to snail food supply is presently considered to be localized and of unknown severity but increasing in magnitude.

In summary, while *T. platysayoides* is now known to be distributed at 99 scattered locations throughout its historic range, it continues to be threatened by recreational impacts at local sites and by threats to its habitat rangewide that pose an overall moderate or unknown degree of risk to the species. The efficacy of attempts to manage these threats is largely unknown.

2.3.2.2 Factor B. Overutilization for commercial, recreational, scientific, or educational purposes:

This factor was not applicable at the time of listing and is not a threat today. The species is extremely difficult to find and there is no known market for collection of *T. platysayoides* for commercial or educational purposes. An extremely limited amount of collecting for scientific purposes is regulated by the WVDNR, and primarily consists of collecting dead shells.

2.3.2.3 Factor C. Disease or predation:

This factor was not identified as a threat at the time of listing. There are no known diseases of *T. platysayoides.* On several occasions, Dourson (2007a) observed recently attacked but still alive and or fresh dead *T. platysayoides* among rock talus or as much as 10 feet from a rock feature (i.e., beyond the normal commuting distance of the species). The freshly bitten snails were not consumed, and Dourson speculated that *T. platysayoides* may exude distasteful mucus. Dourson named several potential predators of *T. platysayoides*; however, it is unknown to what extent predation limits snail population size. Potential predators include a variety of small mammals (e.g.,

short-tailed shrew, white-footed mouse, pine vole, eastern chipmunk), salamanders (e.g., red eft, green salamander, slimy salamander, mountain dusky salamander, seal salamander, and redback salamander), *Cychrine* beetles (Carabidae), and birds. Dourson (2007a) noted that wild turkey and grouse, as well as a variety of song birds, regularly eat snails, and female birds that are laying eggs will consume snails and feed them to their young. Thus natural predation poses an unknown degree of threat to *T. platysayoides* rangewide. (Also see factor E below with regard to competition and cannibalism.)

2.3.2.4 Factor D. Inadequacy of existing regulatory mechanisms:

At the time of listing, no specific regulatory mechanisms other than the federal Endangered Species Act were adequate to protect the species from human pressures. This is still largely the case today. West Virginia does not have any state laws protecting federally-listed threatened or endangered species, and there are no local or state land use regulations that would restrict activities within snail habitat, except for controlling erosion and soil movement into streams. West Virginia Code 19-1B-7(g) requires implementation of the West Virginia Division of Forestry's "Silvicultural Best Management Practices for Controlling Soil, Erosion, and Sedimentation from Logging Operations" (BMPs). The BMPs specify that streamside management zones be at least 100 feet wide on each side of perennial or intermittent streams and 25 feet wide on each side of ephemeral streams. Custom alternative practices can also be used to minimize soil erosion hazards as mandated by the Logging Sediment Control Act (WVDOF, 2005). Implementation of these practices provides a moderate degree of protection to *T. platysayoides* in a small portion of its range where it overlaps with riparian areas.

2.3.2.5 Factor E. Other natural or man-made factors affecting the continued existence of the species:

Declines in Allegheny woodrat populations throughout the Appalachian Mountains during the past 20-30 years (Castleberry, 2000) may potentially pose a low to moderate degree of threat to the food supply of *T. platysayoides* rangewide. Allegheny woodrats are still present at Coopers Rock State Forest but there is some evidence of decline (Stihler, pers. comm., 2007). Dourson (2007a) noted that the Allegheny woodrat supplies a provisional, yet often reliable, source of food to *T. platysayoides*. Woodrats carry into the talus and rock shelters a plethora of known and potential *T. platysayoides* food items, including fungi, freshly cut herbaceous vegetation, and deposits of their own excrement. Dourson (2007a) observed *T. platysayoides* feeding on woodrat scat, especially during August when the snail remains deep in crevices. He speculated that woodrat scat may be a more reliable source of food than other sources at this time of year, but this is uncertain.

In addition, the effects of competition in the wild for resources among individuals of *T. platysayoides* and with other snail species are unknown. Grimm maintained a breeding colony of *T. platysayoides* in captivity for 4 years and found that a

population density of 3-4 individuals per square foot induced cannibalism (Moser, 1985). In contrast, the WVDNR had a captive colony of *T. platysayoides* for several years, and even at high densities, there was no sign of cannibalism; however, the snails were provided chalk as a source of calcium and this may not have been done by Grimm (Stihler, pers. comm., 2007). Dourson (2007a) noted *T. platysayoides* grazing on the shells of other snails species as well as its own kind, presumably for the calcium carbonate content; however, it is unknown if, or to what degree, *T. playtsayoides* cannibalizes live snails in the wild. *T. platysayoides* is often the most abundant snail at sites where it is found (Dourson, 2007a), suggesting that it may be more successful than other snails in the area competing for resources in calcium poor environments.

Another concern may be the unknown effect of toxins from treated lumber used for the boardwalk and railings near the overlook at Cooper's Rock. This effect is extremely localized but present at the location where the snail was first discovered.

2.4 Synthesis

This review has discussed the information that has become available since the time of listing of *T. platysayoides* as threatened in 1978. The Synthesis section brings this information together to draw an overall picture of the snails' biological status.

The biological principles that allow us evaluate the rangewide population status of the snail relative to its long-term conservation are representation, redundancy, and resiliency. At the time of listing, *T. platysayoides* was thought to be an extremely rare and declining taxon that occurred within a very small range. We now know that occupancy of available habitat is much more widespread than formerly thought, and that the geographic extent of the snails' range approximates the Cheat Gorge. Although the sandstone/limestone oak-dominated ecosystem upon which the snail depends has not rebounded to pre-logging conditions, we have learned that *T. platysayoides* individuals have persisted in at least 99 locations in the largely contiguous second-growth forest that has come back since the widespread logging and fires that occurred at the turn of the 20th century. From this, we can infer that there is more representation (i.e., occupancy of representative habitats formerly occupied by the snail across its range) and redundancy (i.e., distribution of individuals in a pattern that offsets unforeseen losses across a portion of the snails' range) of *T. platysayoides* than was known at the time of listing. The extent of resilience maintained by the snail is unknown. Thus, protection from any potential detrimental effects to the snails' habitat is crucial. The snail is still considered a rare, narrowly ranging species that is endemic to the Cheat Gorge. We lack sufficient information to detect population trends because the species is extremely difficult to survey and site locations have not been grouped into populations. Until genetic information is analyzed, we will not know if populations are isolated or connected.

Although the recovery plan is in need of updating, about half of the actions in the plan have been or are being implemented. These include: protecting locations outside Coopers Rock State Forest which support *T. platysayoides*, determining and managing impacts of recreational activities in Coopers Rock State Forest, conducting surveys at locations throughout the Cheat Gorge, developing standardized presence/absence protocols and habitat delineation protocols, determining periods of snail activity and microhabitat use, analyzing

population statuses and connectivity, and collecting data concerning threats from forest management practices, land use changes, and predation.

Rarity, potential isolation, and the threats of habitat degradation are key factors continuing to support its classification as threatened today. Whereas nearly two-thirds of the known snail sites occur on public land, human recreation impacts are increasing and a standardized monitoring program and long-term management plans or agreements that adequately secure the snails' habitat rangewide are lacking. Potential forest fires remain a threat to *T. platysayoides* habitat, especially as recreation levels increase at Coopers Rock. Nearly half of the forest within the species' range has been affected by logging activities, and potential remains for future logging operations. The adequacy of current timber management prescriptions and habitat buffers for protecting the snail has yet to be determined. Thus, the species continues to face an overall moderate degree of threat within a large portion of its range from ongoing or imminent logging and human recreation impacts, and from forest defoliation. The species' forested ecosystem also faces a low or unknown but increasing degree of risk from deer herbivory and invasive plants. Natural predation, cannibalism, and competition with other snail species are suspected threats, but the magnitude of their impact is largely unknown.

In sum, currently available information shows that the species is persisting throughout its historic range, with a relatively more widespread distribution than was known at the time of listing. However, this snail is not distributed widely enough to preclude serious losses from catastrophic events, and a substantial amount of habitat is either at risk from localized high-impact human recreation or declining in quality from ongoing timber management practices.

3.0 LITERATURE CITED

Bourque, P.A., R.M. Cox, D.J. Allen, P.A. Arp and F. Meng. 2005. Spatial extent of winter thaw events in eastern North America: historical weather records in relation to yellow birch decline. Global Change Biology, 11: 1477-1492.

Brooks, S.T. *Polygra platysayoides*, a new species from West Virginia. Nautilus 46:54.

Byers, E. and S. Norris. 2011. Climate change vulnerability assessment of species of concern in West Virginia. West Virginia Division of Natural Resources, Elkins, WV 26241.

Caldwell, R.S., J. E. Copeland, and G.L. Mears. 2006. Findings for habitat analysis of *Tridopsis platysayoides* (Brooks 1933), Cheat threetooth. Cumberland Mountain research Center of Lincoln Memorial Univ., Kentucky. 35 pp. + attachments.

Castleberry, S.R. 2000. Conservation and management of the Allegheny woodrat in the central Appalachians. PhD Dissertation, West Virginia University, Morgantown, WV. <https://eidr.wvu.edu/documentsdata.eTD?documentid=1503>.

Dourson, D. 2008. The feeding behavior and diet of an endemic West Virginia land snail, *Triodopsis platysayoides*. American Malacological Bulletin, 26: 153-159.

Dourson, D. 2007(a). Survey protocol for Cheat threetooth (*Tridopsis platysayoides)*. Report submitted to West Virginia Division of Natural Resources, Elkins, WV. 28 pp.

Dourson, 2007(b). Revised survey protocol for Cheat Threetooth (*Triodopsis platysayoides)*. Report submitted to U.S. Fish and Wildlife Service and West Virginia Division of Natural Resources, Elkins, WV. 37 pp.

Duncan, N. 2007. Monitoring of sensitive mollusk populations following low-intensity wildfire in old growth coniferous forest. U.S. Department of the Interior, Bureau of Land Management, Roseburg, OR. Summary posted to Land Snail Webpage, bibliography on land snail community response to fire. <http://www.unc.edu/~keperez/land%20snail%20webpage.html>.

Emberton, K.C. 1988. The genitalic, allozymic, and conchological evolution of the eastern North American tridopsinae (Gastropoda; Pulmonata: Polygyridae). Malacologia 28:159-273.

Fournie, J. and M. Chetail. 1984. Calcium dynamics in land gastropods. American Zoologist, 24:857-870.

Girvetz, E. H., C. Zganjar, G. T. Raber, E. P. Maurer, P. Kareiva, and J. J. Lawler. 2009. Applied climate change analysis: the climate wizard tool. PLoS ONE 4: e8320. <doi:10.1371/journal.pone.0008320>.

Gosz, James R., Gene E. Likens, and F. Herbert Bormann. 1973. Nutrient release from decomposing leaf and branch litter in the Hubbard Brook Forest, New Hampshire. Ecol. Mono. 43:173-191.

Grimm, F.W. 1972. Office of Endangered Species Information Form.

Gumbert, M. and P. Roby. 2008. Habitat delineation for *Triodopsis platysayoides* on Coopers Rock State Forest, West Virginia. Prepared by Copperhead Consulting, Paint Lick, KY. Prepared for West Virginia Division of Natural Resources, Elkins, WV.

Hotopp, K. 2006(a). *Patera panselenus* (Hubricht) on the lower Cheat River, West Virginia (Gastropoda: Pulmonata: Polygyridae). Banisteria, 27:40-44.

Hotopp, K. 2006(b). Expert report: opinion for conservation of the Cheat threetooth (*Tridopsis platysayoides* Brooks). Prepared for DiTrapano, Barrett & DiPiero, PPLC, Charleston, WV. 26 pp.

Hotopp, K. 2005. Cheat threetooth habitat mapping at Snake Hill 2003. Report prepared for West Virginia DNR, Elkins, WV. 10 pp.

Hotopp. K. 2003. Land snails of selected Pennsylvania natural areas. Unpublished report to the Pennsylvania Dept. of Conservation and Natural Resources, Harrisburg, PA. 44 pp.

Hotopp, K. 2000. Cheat threetooth (*Tridopsis platysayoides* Brooks) inventory 2000. Unpub. Rep. to U.S. Fish and Wildlife Service and West Virginia Division of Natural Resources, Elkins, WV. 38 pp.

Kish, K. 2007. Hemlock wooly adelgid management plan. West Virginia Department of Agriculture, Cooperative Forest Health Protection Program. Charleston, WV. 11 pp.

Kiss, L. and F. Magnin. 2003. The impact of fire on some Mediterranean land snail communities and patterns of post-fire recolonization. Journal of Molluscan Studies:69;43-53. Abstract only.

Pauley, T.K. 2008. The Appalachian inferno: historical causes for the disjunct distribution of *Plethodon nettingi* (Cheat Mountain salamander). Northeaster Naturalist 15(4):595-606.

Pearce, T., R. Caldwell, D. Dourson, and G. Watters. 2007. Criteria for recognizing potential habitat of *Triodopsis platysayoides,* the Cheat Threetooth Snail. Report submitted to Allegheny Wood Products, Inc., Petersburg WV. September 3, 2007. 90 pp.

Quarles, S.P., D. A. McDaniel, J.I. Barrett, and E.R. Glitzenstein. 2007. Settlement Agreement (case no. 1:05-CV-61 in the Northern Dist. of West Virginia. The Cheat Lake Environment and Recreation Association; Friends of Blackwater; and the West Virginia Chapter of the Sierra Club (plaintiffs) vs. Allegheny Wood products, Inc. (defendant).

Riddle, K. 2006. Declaration of Kelly S. Riddle (case no. 1:05-CV-61-WCB in the Northern Dist. of West Virginia. The Cheat Lake Environment and Recreation Association; Friends of Blackwater; and the West Virginia Chapter of the Sierra Club (plaintiffs) vs. Allegheny Wood products, Inc. (defendant).

Solem, A. 1982. Letter to William Ashe, U.S Fish and Wildlife Service. Newton Corner, MA. 1 p.

Solem, A. 1974. Office of Endangered Species Information Form.

Stihler, C. 2006. Revised *Tridopsis platysayoides* maps. December 2006. Note and maps provided to U.S. Fish and Wildlife Service, Elkins, WV. 88 pp.

Stihler, C.W. 1994. New records for the land snail *Tridopsis platysayoides*, a West Virginia endemic. West Virginia Acad. Sci. 66 (No's 2-4): 2-6.

Turgeon, D.D., J.F. Quinn, Jr., A.E. Bogan, E.V. Coan, F.G. Hochberg, W.G. Lyons, P. Mikkelson, R.J. Neves, C.F.E. Roper, G. Rosenberg, B. Roth, A, Scheltema, F.G. Thompson, M. Vecchione, and J.D. Williams. 1998. Common and Scientific Names of Aquatic Invertebrates from the United States and Canada: Mollusks, Second Edition. American Fisheries Society Special Publication 26. Bethesda, Maryland. 509 pp.

U.S. Fish and Wildlife Service. 2003. Funding proposal for land acquisition for *Tridopsis platysayoides* for the President's 2004 Budget initiative. West Virginia Field Office, Elkins, WV. 5 pp.

U.S. Fish and Wildlife Service. 1985. Endangered species information system record. 13 pp.

U.S. Fish and Wildlife Service. 1983. Flat-spired three-toothed snail *(Tridopsis platysayoides)* recovery plan. Prepared by Region 5 of the U.S. Fish and Wildlife Service. 22 pp. plus appendix.

U.S. Fish and Wildlife Service. 1978. Determination that seven eastern U.S. land snails are endangered or threatened species. 43 Federal Register: 28932-28935.

U.S. Forest Service. 2006. Monongahela National Forest Land and Resource Management Plan.

Vagvolgy1, J. 1968. Systematics and evolution of the genus Tridopsis (Mollusca: Pulmonatya: Polygridae). Bull. Mus. Comp. Zool. 136:145-254.

Watters, G.T. 2006. Expert report of Dr. G. Thomas Watters regarding flat-spired three-toothed snail survey. Ohio State Univ., Columbus, OH. 16 pp + appendices.

West Virginia Department of Agriculture. 2005. Gypsy moth damage assessment report 2005. West Virginia Division of Forestry, Charleston, WV. 10 pp.

West Virginia Division of Forestry. 2009. Coopers Rock State Forest *Scott Run II Project* silvicultural prescription & overview for multiple use management. Coopers Rock State Forest, Fairmont, WV. 9 pp.

West Virginia Division of Forestry. 2007. Public-owned facility wildfire plan for Coopers Rock State Forest. Coopers Rock State Forest, Fairmont, WV. 9 pp.

West Virginia Division of Forestry. 2005. West Virginia silvicultural best management practices for controlling soil erosion and sedimentation from logging operations. Charleston, WV. 18 pp.

West Virginia Division of Natural Resources. 2010(a). Recovery land acquisition grant proposal. Acquisition of land in Cheat River Gorge, WV to benefit: flat-spired three-toothed land snail (*Triodopsis platysayoides*) (Federally threatened) and Indiana bat (*Myotis sodalis*) (Federally endangered). 9 pp.

West Virginia Division of Natural Resources. 2010(b). Federal Assistance Performance Report, Endangered Species (animals), October 2009-September 2010. p. 53.

West Virginia Division of Natural Resources. 2009. Federal Assistance Performance Report, Endangered Species (animals), October 2008-September 2009. p. 43.

West Virginia Division of Natural Resources. 2008. Federal Assistance Performance Report, Endangered Species (animals), October 2007-September 2008. p. 31.

West Virginia Division of Natural Resources. 2006. Pages 41-43 and appendices in Federal Assistance Performance Report, Endangered Species (animals). October 2005 – September 2006.

Widmann, R. H. 2006. The Mountain State's forests—trends in the resource. NE-INF-152-04. U.S. Department of Agriculture, Forest Service, Northeastern Research Station. Newton, Square, PA. 9 pp.

4.0 EXPERTS CONSULTED

During this review, information was requested from the following species, taxa, or ecosystem experts:

Craig Stihler, West Virginia Division of Natural Resources

Dr. Dan Dourson, Biological Consulting

Dr. Ken Hotopp, Appalachian Conservation Biology

Dr. Tim Pearce, Carnegie Museum of Natural History

Andy Dick, West Virginia Division of Forestry

Mark Gumbert, Copperhead Consulting

The following experts provided relevant information for previous reviews, prior to this document:

Dr. Ron Caldwell, Cumberland Mountain Research Center

Dr. Tom Watters, Ohio State University

John MacGregor, U.S. Forest Service

Shane Jones, U.S. Forest Service

Jim Vanderhorst, West Virginia Division of Natural Resources

APPENDIX. FLAT-SPIRED THREE-TOOTHED LAND SNAIL THREATS ASSESSMENT					
Listing Factor	Stressor	Spatial Magnitude	Immediacy	Severity	Overall Threat Level
A. Destruction, modification, or curtailment of habitat or range	Recreational uses: trampling of individuals and foraging habitat.	Localized (multiple locations within range)	Imminent or probable (historic threats being managed, but future threats continue).	Medium	Moderate
	Fire: burning of individual snails and overstory and/or understory vegetation and leaf litter (cover, foraging, and potential nesting habitat).	Potentially significant portion of range	Low probability (has not happened in 30 years since listing); but potentially increasing due to increased recreation.	Unknown but potentially significant (unknown effect to individuals in deep crevices; depending on the geographic scope of the fire, could significantly reduce foraging habitat in the area burned and possibly result in loss of 1 or more years of reproduction).	Unknown
	Logging	Significant portion of range	Existing	With buffers, low risk of crushing individual snails and/or habitat; unknown effect on shade within habitat.	Moderate
	Road building (to facilitate logging)	Localized	Existing	High risk of crushing individual snails and loss of habitat unless potential habitat is avoided; low to high risk of siltation downslope if erosion is not controlled on slopes.	Moderate
	Warming climate	Rangewide	Existing	High (the rate of climate change could surpass snails' ability to acclimate or adapt, affecting the entire species).	Low but increasing

Listing Factor	Stressor	Spatial Magnitude	Immediacy	Severity	Overall Threat Level
A. Destruction, modification, or curtailment of habitat or range, cont'd.	Siltation	Localized	Existing	Moderate in the event of logging activities or heavy rains; high in the combination of both.	Moderate
	Yellow birch dieback	Potentially rangewide	Low probability (has not yet occurred in West Virginia)	Low (snails may have other sources of calcium).	Low
	Residential development	Localized (primarily at the rim of the gorge in lower quality habitat)	Existing	Low (impacts to suboptimal habitat).	Low
	Gypsy moth (defoliation)	Localized (but potential to spread rangewide)	Existing	Low	Low
	Hemlock wooly adelgid	Localized (primarily on north and northeast aspects)	Existing	Low (hemlocks are a small component of the forest in the Cheat Gorge)	Low but increasing
	Deer browsing of understory vegetation.	Localized (Snakehill WMA)	Existing	Unknown	Unknown
	Invasive plants	Localized	Existing	Unknown	Unknown but increasing

Listing Factor	Stressor	Spatial Magnitude	Immediacy	Severity	Overall Threat Level
B. Overutilization for commercial, recreational, scientific, or educational purposes	Scientific collecting	Extremely localized	Existing	Negligible	Extremely low
	Collecting for commercial or educational purposes.	NA	NA	NA	NA
C. Disease or Predation	Natural predation by small mammals, amphibians, and birds.	Rangewide	Existing	Unknown	Unknown
	Disease	NA	NA	NA	NA
D. Inadequacy of regulatory mechanisms	No state Endangered Species Act	Rangewide	Existing	Medium	High
	Enforcement of erosion control requirements.	Localized (portion of range that overlaps with riparian areas).	Existing	Moderate to High	Moderate
E. Other natural or man-made factors	Competition, cannibalism	Potentially rangewide	Unknown	Low (known to occur in captivity but not in the wild).	Unknown
	Toxins from treated lumber used in boardwalk and railing at Cooper's Rock overlook.	Extremely localized, but present at type locality (i.e., the location where the snail was first discovered).	Existing	Low	Low

Listing Factor	Stressor	Spatial Magnitude	Immediacy	Severity	Overall Threat Level
E. Other natural or man-made factors, cont'd.	Decline of Allegheny woodrats (which supply provisional but reliable sources of food to *T. platysayoides*).	Potentially rangewide for *T. platysayoides*; some evidence of woodrat decline at Coopers Rock but woodrats still present.	Existing	Low to medium	Potentially high (if provisional food sources are relatively important compared to other food sources).

Key:

Spatial magnitude (the geographic scope of impact on the species and habitat that currently exists and can reasonably be expected within 10 years under current circumstances and the continuation of existing management situations): rangewide; significant portion of the range; localized; extremely localized.

Immediacy (the temporal nature of the threat): existing; imminent or probable; unknown.

Severity (the level of damage to the species that occurs or can be expected to occur when and where the species and/or its habitat is exposed to the threat): high; medium; low; negligible; unknown.

Overall Threat Level: high; moderate; low; unknown.