CHITTENANGO OVATE AMBER SNAIL
(*Novisuccinea chittenangoensis*)

RECOVERY PLAN
First Revision

Original Approval: March 24, 1983

Prepared by

Alvin Breisch
New York State Department of Environmental Conservation
Albany, New York

and

Robyn Niver
U.S. Fish and Wildlife Service
Cortland, New York

in cooperation with the

Chittenango Ovate Amber Snail Recovery Team

for

Region Five
U.S. Fish and Wildlife Service
Hadley, Massachusetts

Approved: Richard O. Bennett, Ph.D.
Acting Regional Director, Region Five

Date: July 11, 2006

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Recovery plans published by the U.S. Fish and Wildlife Service delineate reasonable actions that are needed to recover and protect listed species. Plans are sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others; however, they do not necessarily represent either the views or the official position of any individuals or agencies involved in the plan formulation other than the U.S. Fish and Wildlife Service, and they represent the official position of the U.S. Fish and Wildlife Service only after they have been formally approved by the Regional Director. Achievement of recovery objectives and availability of necessary funds are contingent upon budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the successful completion of recovery actions.

Literature citations for this document should read as follows:

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Additional copies of this plan can be obtained from:

U.S. Fish and Wildlife Service
New York Field Office
3817 Luker Road
Cortland, New York 13045

The recovery plan also can be downloaded from the U.S. Fish and Wildlife Service's New York Field Office website at http://www.fws.gov/northeast/nyfo/es/recoveryplans.htm and from the U.S. Fish and Wildlife Service's Endangered Species website at http://www.fws.gov/endangered/recovery/index.html .

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EXECUTIVE SUMMARY

Chittenango Ovate Amber Snail Revised Recovery Plan

Current Status: The Chittenango ovate amber snail *(Novisuccinea chittenangoensis)* was listed as threatened in July 1978, and the initial recovery plan for the species was completed in March 1983. *Novisuccinea chittenangoensis* is known from only one site, located in the Chittenango Falls State Park in Madison County, New York. The species was listed due to its rarity and population decline; since listing, habitat protection and captive propagation have been implemented, but the species' status remains exceedingly precarious. The primary threats to the snail in its existing habitat are considered to be the small population size and limited distribution of the species and the negative interaction with an introduced snail, *Succinea* sp. B. Additionally, habitat changes and inadvertent human disturbance present potential threats to *Novisuccinea chittenangoensis.*

Habitat Requirements: The Chittenango ovate amber snail is a terrestrial species that requires the cool, mild-temperature, moist conditions provided by the waterfalls and mist in its environment. Its habitat lies within a ravine at the base of a 167-foot waterfall, and the ledges where it is found comprise an early successional sere that is periodically rejuvenated to a bare substrate by floodwaters. *Novisuccinea chittenangoensis* appears to be an obligate calciphile and seems to prefer green vegetation such as the various mosses, liverworts, and other low herbaceous vegetation found within the spray zone adjacent to the Falls. Clean water may be necessary to maintain essential habitat; however, any effects of water quality on this snail are most likely indirect. Much is still unknown about the species' particular biological and physical needs.

Recovery Strategy: The primary initial strategy for recovery of the Chittenango ovate amber snail is to stabilize the extant population at Chittenango Falls. Two necessary conditions for stabilization are maintaining (or increasing) the baseline population size of the natural colony and maintaining multiple captive populations of *Novisuccinea chittenangoensis*. Achievement of the first condition will entail habitat management planning and research into the species' biological requirements and possible means of controlling the competing *Succinea* sp. B. In addition to securing the *in situ* conditions necessary to stabilize the natural population, captive propagation should be reinitiated in accordance with a newly established propagation protocol to safeguard against extinction of this species.

If and when stabilization of the extant *Novisuccinea chittenangoensis* population at Chittenango Falls has been achieved, progress toward full recovery of the species can commence. This will include augmentation of the population at the Falls, searching for other possible extant populations, long-term maintenance of captive populations, and investigating the feasibility of initiating a population of *Novisuccinea chittenangoensis* at an alternative location.

Recovery Goal: To establish long-term sustainability of the species in the wild.

Recovery Objectives: Given its precarious biological status, the immediate objective of this revised recovery plan is to **stabilize** *Novisuccinea chittenangoensis* in the wild and in captivity. The long-term recovery objective is to delist species.

Recovery Criteria: In order to consider *Novisuccinea chittenangoensis* as **stabilized** the following criteria need to be met:

1. The population at Chittenango Falls is shown to be stable or improving for 10 years. To accomplish this, a baseline population size and distribution must be determined.

2. At least two healthy captive colonies of *Novisuccinea chittenangoensis* are successfully established in order to: (1) provide a source for augmenting the population at Chittenango Falls or introductions to new sites, (2) buffer against extinction in the wild, and (3) provide a source of *Novisuccinea chittenangoensis* for various scientific experiments related to their recovery.

   A healthy captive population is defined as having sufficient genetic diversity and being large enough to meet population goals, which will be specified in a new protocol based in part on the results of genetics research as well as results of research into the optimal conditions for propagation of *Novisuccinea chittenangoensis*.

3. The genetic distinctiveness of *Novisuccinea chittenangoensis* from other snails occupying the site is demonstrated.

4. With respect to the five listing factors, threats to the species are abated as follows:

   a. Factor A. Protection of the snail's Chittenango Falls habitat by the NYSOPRHP is perpetuated.

   b. A sufficient understanding of the relationship between *Novisuccinea chittenangoensis* and *Succinea* sp. B is gained and effective measures to reduce any negative interactions are in place.

   c. A sufficient understanding of any future threat of hybridization is gained to allow an effective response.

5. Monitoring of threats and effects of management practices indicate that recovery actions are contributing to the improved status of the species.

If and when the population is shown to be stable or increasing for at least five generations (10 years), recovery of *Novisuccinea chittenangoensis* can then focus upon meeting conditions for delisting. **Delisting** will be considered when the following criteria (in addition to criteria 1-3) are met.

6. The *Novisuccinea chittenangoensis* population at Chittenango Falls must include at least 1000 snails with occupancy of both the lower and middle ledges. The population must be stable (or improving) for at least 10 years.

7. Threats to the snail are abated as follows:

   a. All sites with *Novisuccinea chittenangoensis* are permanently protected through acquisition, conservation easement, or another form of agreement .

   b. Written management/monitoring plans are in place for each site.

   c. A sufficient understanding of habitat and biological requirements is gained to conduct management efforts.

d. *Novisuccinea chittenangoensis* is ensured continued protection by New York State after ESA protections are removed.

e. Any negative interaction between *Novisuccinea chittenangoensis* and *Succinea* sp. B or other species is controlled with minimal management intervention.

f. Searches for any other potential extant populations have been completed, and the extant population at Chittenango Falls has been successfully augmented.

g. Searches for potential introduction sites have been completed, the potential for introduction has been thoroughly evaluated and, if warranted, one or more additional *Novisuccinea chittenangoensis* populations have been successfully established

8. Monitoring of threats and effects of management practices indicate that recovery actions have led to a secure status for the species.

The stabilization and delisting criteria will be reassessed as additional information on *Novisuccinea chittenangoensis* becomes available.

Actions Needed:

1. Conduct genetics research.
2. Continue to protect the *Novisuccinea chittenangoensis* population and its habitat at Chittenango Falls.
3. Expand data on the biological and environmental requirements of *Novisuccinea chittenangoensis*.
4. Research techniques for removal of *Succinea* sp. B from *Novisuccinea chittenangoensis*' habitat at the Falls.
5. As feasible, increase the population size and broaden the distribution of the Chittenango ovate amber snail.
6. Review and track recovery progress.

Estimated Costs for Stabilization (in thousands)**:**

	Need 1	Need 2	Need 3	Need 4	Need 5*	Need 6	Total
FY1	8	17.5	25	--	5	--	55.5
FY2	9	13.	45	10	22	--	99
FY3	2	4.5	10	10	25	--	80
FY4-10	6	16.5	--	15	123	--	160.5
FY11-20	--	1.5	--	--	150	--	151.5
Total	25	51.5	110	35	325	--	546.5

* additional costs to be determined

Estimated Time Frame for Stabilization:

Stabilization may be achieved by the year 2016, if recovery actions are implemented on schedule. If stabilization occurs and all other necessary activities are accomplished, delisting may be possible in 20 years.

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PART I. BACKGROUND

The Chittenango ovate amber snail (*Novisuccinea chittenangoensis*) is a terrestrial species that comprises one extant population at Chittenango Falls in central New York. The taxon was first discovered at Chittenango Falls in August 1905 by a field party from the Academy of Natural Sciences of Philadelphia (Figure 1). In 1908, H.A. Pilsbry reported the discovery, describing the snail as a subspecies of the widely distributed *Succinea ovalis* Say, 1817, which he placed in the Section *Novisuccinea* (Pilsbry 1948). Hoagland and Davis (1987) subsequently elevated *Novisuccinea* to the genus level.

Figure 1. Type specimens from Philadelphia Academy of Natural Sciences, collected by Hubricht

Novisuccinea chittenangoensis was originally proposed as a Federal endangered species in April 1976 (41 FR 17742-17747), owing to an apparent decline in the species' population coupled with its extremely limited range. Ultimately, however, the species was listed as threatened in July 1978 (43 FR 28932-28935) because of the presumed existence of a second colony in Tennessee and North Carolina. After listing, it was determined that the Tennessee/North Carolina snails were not *Novisuccinea chittenangoensis*, and the Chittenango Falls colony remains the only known population of this species (Figure 2). In 1977, the New York State Department of Environmental Conservation (NYSDEC) amended the State list of endangered species to include *Novisuccinea chittenangoensis* as an endangered species in New York.

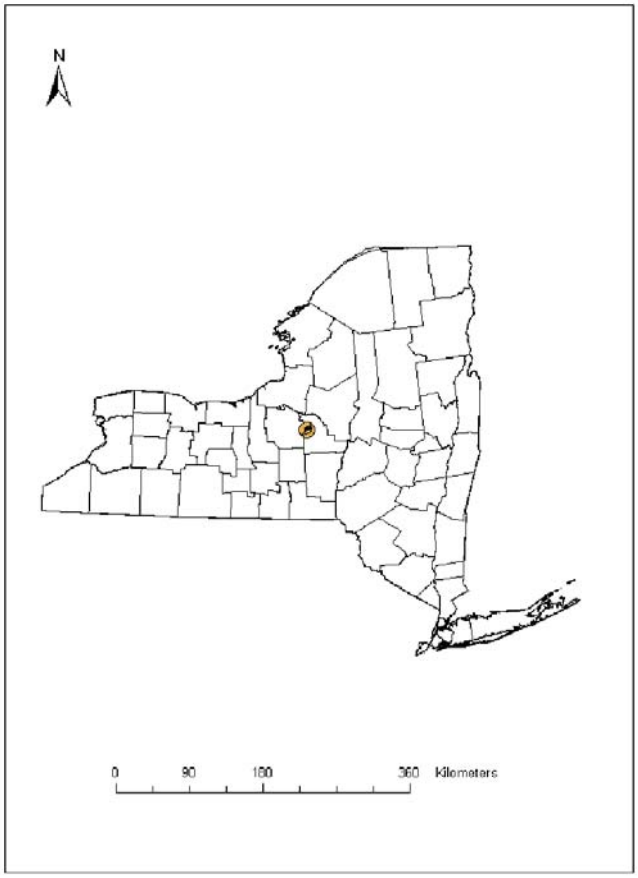


Figure 2. Location of Chittenango Falls colony of *Novisuccinea chittenangoensis*

Based on the single population and existing threats, *Novisuccinea chittenangoensis* may be more accurately classified as an endangered rather than threatened species; however, *Novisuccinea chittenangoensis* will retain its Federal listing as threatened until a status review is completed in accordance with section 4(c)(2) of the Endangered Species Act of 1973, as amended (ESA). Reclassification of *Novisuccinea chittenangoensis* to endangered status would not result in additional protection, as the Chittenango Falls population and its habitat are currently protected. In addition, management efforts are ongoing and would not likely intensify due to a reclassification. Consequently, although *Novisuccinea chittenangoensis* does remain highly vulnerable to extinction due to ongoing threats (see Reasons for Decline and Continuing Threats), retaining the snail's status as threatened unless and until a status review recommends reclassification will neither detract from timely undertaking of recovery activities nor decrease its protections under the ESA.

The initial recovery plan for *Novisuccinea chittenangoensis* was completed in March 1983 (Riexinger *et al*. 1983). Although some progress toward recovery has been made since its listing, the species remains

subject to environmental and stochastic events; of particular concern is another snail, *Succinea* sp. B, which was possibly introduced from Europe and has an undefined negative interaction with *Novisuccinea chittenangoensis*. This revised recovery plan focuses on these issues and recommends strategies for addressing them. The plan also includes a revised recovery objective and a change in priority of required actions. Because there is still relatively little known about this species, the recovery program for *Novisuccinea chittenangoensis* is intended to adapt to new information and issues as they arise.

The recovery priority number[1] for *Novisuccinea chittenangoensis* is 5. This ranking was determined in accordance with the recovery priority criteria in 48 FR 41985. The rank of 5 is based on a high degree of threat, low recovery potential, and taxonomic standing as a species.

DESCRIPTION

Pilsbry (1908) provides a detailed description of the species as *Succinea ovalis chittenangoensis*, which is further refined by Hoagland and Davis (1987) as *Novisuccinea chittenangoensis*.

The shell of *Novisuccinea chittenangoensis* is ovate, slender, acute, and of moderate thickness (Figure 3a). The shell suture is deep. The spire is gently convex, laterally compressed, with 3¼ whorls. The spire is long, slightly less than half the shell length, and the aperture is very oblique. The shell color is subtranslucent, calcareous pale yellow to white. The surface is somewhat glossy and marked with growth wrinkles and lines. The size varies somewhat, but adult specimens of the type lot averaged 20.9 millimeters (mm) in shell length. Various adult specimens measured during the summer of 1981 and 1982 ranged from 19 to 24 mm (Aloi and Ringler 1982). Hatchlings measure 1 to 2 mm in shell length (Molloy and Norton 1993, and Molloy 1995), and yearlings average around 10 mm (Aloi 1985). Measurements of all *Novisuccinea chittenangoensis* in 2002 (Arrigoni 2002) ranged from 7 to 23 mm.

The base color of the living animal is very pale subtranslucent yellow. The mantle, kidney, and hepatopancreas are visible through the shell but are often slightly obscured by the thickness of the shell. The dorsal surface of the mantle is pale yellow, tinted with olive, often marked with black streaks and blotches. Over the hepatopancreas is a golden yellow tessellation that is marked with gray or black spots and streaks. A dark marking on the posterior surface of the foot (Figure 3b) is distinctive (Thomee 1986). However, the mark is not present on the hatchlings making them impossible to identify in the field. The mark is obvious when the snail reaches approximately 6 to 9 mm in length.

[1] Recovery priority numbers from 1C to 18 are determined for all species listed pursuant to the ESA. Species with a recovery priority of 1C ("C" = imminent conflict with development activity) receive the highest priority for preparation and implementation of recovery plans.

Succinea sp. B (Figure 4) is also found at Chittenango Falls State Park and looks quite similar to *Novisuccinea chittenangoensis*. Positive identification of *Novisuccinea chittenangoensis* is based on a combination of morphometric, anatomical, and genetic markers (Hoagland and Davis 1987). At Chittenango Falls State Park, external features alone can be used to differentiate *Novisuccinea chittenangoensis* from other species for individuals with a shell length of 9 mm or greater. The characteristics used to identify *Novisuccinea chittenangoensis* at the Falls are a deep, clearly defined suture on the whorls of the shell and a small dark spot on the dorsal surface of the foot. The DNA of snails with these characteristics at other locations would have to be analyzed in order to determine if they are *Novisuccinea chittenangoensis*. Positive identification is often not possible for empty shells.

Figure 3a and b. Photographs of *Novisuccinea chittenangoensis* (J. Arrigoni, K. Breisch)

Figure 4. Photograph of *Succinea* Sp. B (USFWS)

Other succineid snails (*Oxyloma* spp.) have also been found at Chittenango Falls (Hoagland and Davis 1987). Solem (1976) stated that *Oxyloma* spp. can be easily separated from *Succinea* spp. at the Falls by shell morphology and internal anatomy. Electrophoretic studies by Hoagland and Davis (1987) verified *Oxyloma* as a distinct genus from both *Novisuccinea* and *Succinea*.

TAXONOMY

Mollusca: Gastropoda: Pulmonata: Succineidae: *Novisuccinea chittenangoensis*.

The Chittenango ovate amber snail was originally described as a subspecies or form of the more widespread ovate amber snail *S. (= N.) ovalis*, and is referred to in many publications as *S. ovalis chittenangoensis* (Pilsbry 1908, Solem 1976). Whereas Solem (1976) considered the species as a form of *N. ovalis*, citing similarities in genitalia and radula between the two and attributing shell differences to, possibly, a marked genetic mutation (perhaps with dominance accounting for lack of intergradation between *Novisuccinea chittenangoensis* and *N. ovalis)*. Grimm (1981) considered it a distinct species due to external morphological differences (color and shell shape). By 1981, *N. ovalis* could not be found at the Falls; however, during sampling for Hoagland's electrophoretic analyses, *N. ovalis* was found at two locations within approximately 16 kilometers of Chittenango Falls (Hoagland and Davis 1987).

Individuals assigned to *Novisuccinea chittenangoensis* appeared to be divided into two color morphs, a "gray morph" that was relatively common and widespread at the Falls, and a "red morph" that was restricted to the ledges at the base of the Falls. A preliminary analysis by Hoagland (1984) stated unequivocally that the red and the gray morphs were two distinct species, possibly in separate genera. Solem examined specimens of the gray morph and assigned it to *S. putris*, an introduced snail possibly from Europe which appears to crowd out all other species (Hubricht 1985, Solem pers. comm.). Hoagland and Davis (1987) subsequently completed a thorough analysis, based on electrophoresis, shell morphology, and internal anatomy, of the succineids at Chittenango Falls. They divided *Succinea* into two genera, keeping the Old World *Succinea* in the genus and elevating the New World *Succinea*, of the Section *Novisuccinea* including *ovalis* and *chittenangoensis*, to the genus level. They also determined that the Old World *S. putris* is probably a species complex and that the gray morph, although closely related to *S. putris* sensu lato, is a distinct species, which they designated *Succinea* sp. B (see Appendix A). Based on these factors, the species designation *Novisuccinea chittenangoensis* is considered valid. Both species have been observed with red and gray morphs, bringing into question whether the earlier separation truly represented taxonomic distinctiveness. Currently, *Novisuccinea chittenangoensis*, *Succinea* sp. B, and 3-4 *Oxyloma* spp. (Grimm 1981) are considered to be the only succineid species present at Chittenango Falls.

In 2003, the U.S. Geological Survey (T. King, unpublished data) amplified and sequenced the cytochrome oxidase I region of mitochondrial DNA and the ITS-1 region of nuclear DNA in *Novisuccinea chittenangoensis* and S*uccinea* sp. B. The results (sequence divergence of 10-15 percent) suggest large differences between the two species. No hybridization was observed.

SPECIES BIOLOGY

Until recently, relatively little was known about the biology of the Chittenango ovate amber snail, and it should be emphasized that, due to uncertainty of species identification in earlier work, additional work is crucial to understanding this species and ensuring its survival. Contract studies by investigators at the State University of New York at Syracuse, College of Environmental Science and Forestry (ESF), since 1981 have contributed to the base of knowledge about the biology and life history of *Novisuccinea chittenangoensis*. Aloi (1985) analyzed the population dynamics of the succineid snails at Chittenango Falls (see Appendix B). Thomee (1986) investigated their behavioral ecology (see Appendix C), and Molloy and Norton (1993) developed techniques for captive propagation. Molloy (1995) reported on the captive population of *Novisuccinea chittenangoensis* and associated field studies related to factors influencing the distribution of *Succinea* sp. B (see Appendix D). Confusion on snail identification may have affected the results of Thomee's and Aloi's work, but by the time Molloy's study was initiated, the identification problems had been resolved.

Novisuccinea chittenangoensis survives in and presumably prefers cool, partially sunlit areas of lush herbaceous growth within the spray zone of the Falls. The snails mate from May through July, ovipositing from June through July. They are hermaphroditic; however, it is unclear if selfing is possible. The eggs, numbering 8 to 14 (Molloy and Norton 1993), are approximately 2 mm in diameter, spherical, transparent, and very distinctive within a cluster. Generally, *Novisuccinea chittenangoensis* eggs are not found to have a heavy gelatinous layer surrounding the entire cluster, which is associated with egg masses of *Succinea* sp. B. *Novisuccinea chittenangoensis* egg clusters are deposited at the base of plants, under matted vegetation, or in loose, wet soil. The young snails hatch in 2 to 3 weeks, measuring barely 2 mm. It is still unclear when the snails mature, although Grimm (1981) believes they reach maturity in five to eight months, or the spring following hatching. At the end of their first full year of growth, snails observed by Aloi and Ringler (1982) averaged around 10 mm. By the end of the following year, the adult snails were observed to reach a length of approximately 21 mm; they then die, completing a life span of about 2.5 years. This life span is similar to those in captive populations (Rosamond Gifford Zoo, unpublished data).

A study of the movements of individual snails (Aloi and Ringler 1982), cited in the original recovery plan (Riexinger *et al*. 1983), was conducted on the gray morph in the watercress beds (*Nasturtium officinale*) below Chittenango Falls. Those animals were subsequently identified as *Succinea* sp. B (Hoagland and Davis 1987) rather than *Novisuccinea chittenangoensis*.

Novisuccinea chittenangoensis apparently feed on microflora and must obtain high levels of calcium carbonate from their environment for proper shell formation. Thomee (1986) observed that they were generally found on green vegetation, whereas *Succinea* sp. B was more frequently found on dead vegetation.

Interactions with *Succinea* sp. B may be having a significant impact on *Novisuccinea chittenangoensis*. Hubricht (1985) reported that *S. putris* (*Succinea* sp. B of Hoagland and Davis) is a "very common species within its range. I found no other Succineidae with it. It appears to crowd out all other species." In that the captive colony of *Novisuccinea chittenangoensis* at Rosamond Gifford Zoo did quite well in the first 3 generations in the absence of *Succinea* sp. B, additional studies on the interspecific relationship of these two taxa are needed. It does not appear that the other sympatric snail species (*e.g.*, *Oxyloma* spp.) occurring at the Falls are having a significant impact on *Novisuccinea chittenangoensis*, as they are thought to be native species; *Oxyloma retusa* Lea was described by Pilsbry in 1905 within Madison County (Hoagland and Davis 1987). Nevertheless, further efforts are needed to determine the habitat use of these snails.

Predators may include beetles and sciomyzid fly larvae, many of which specialize in feeding upon snails. Other potential predators may include the Northern Two-lined (*Eurycea bislineata*), Northern Dusky (*Desmognathus fuscus*), and Allegheny Mountain Dusky (*Desmognathus ochrophaeus*) salamanders, which are common in the talus and on the ledges, as well as various small mammals or passerine birds such as robins and pigeons, which are often seen in or near the habitat. Although predation does not appear to be a limiting factor at this time, its potential impact on a low or stressed population is unclear.

HABITAT

Occupied Habitat

The habitat of *Novisuccinea chittenangoensis* lies within the ravine at the base of the 167-foot-tall waterfall formed by Chittenango Creek as it flows north from Cazenovia Lake toward Oneida Lake (Figure 5). This north-south oriented ravine forms a deep gorge that is shaded or partially shaded throughout most of the growing season, resulting in a microclimate that stays relatively cool during the summer, and because of the creek flow and ice formations, is relatively warm in the winter compared to

the surrounding area. Spring thaws and periodic major rainfall events tend to remove vegetation from significant portions of the primary *Novisuccinea chittenangoensis* habitat.

Pilsbry (1948) reported that *Novisuccinea chittenangoensis* was found "on a sloping weedy talus near the foot of the falls." The only sloping weedy talus is on the east side of the Falls. This area is adjacent to and between the vegetated ledge at the base of the Falls where *Novisuccinea chittenangoensis* now occurs and the spring-fed watercress beds previously reported to be *Novisuccinea chittenangoensis* habitat. Presence of *Novisuccinea chittenangoensis* has not been verified on the west side of the Falls.

Work by Grimm (1981), Riexinger (unpublished data 1978-1983), and Aloi (1985) and Thomee (1986), conducted before the 1987 report authored by Hoagland and Davis, did not differentiate between *Novisuccinea chittenangoensis* and *Succinea* sp. B (*S. putris* sensu lato), and their observations that *Novisuccinea chittenangoensis* occurred on both sides of the Falls and in the spring-fed patch of watercress may have been in error. Thomee (1986) mapped the habitat occupied by *Novisuccinea chittenangoensis.* The snails occupied an area of 53.7 m^2 at the base of the Falls, with most snails found in an area of 11.4 m^2. More intense studies (Arrigoni 2002 and Whiteleather 2003, 2004) have further defined the occupied habitat. *Novisuccinea chittenangoensis* is found on a ledge beginning at 4 m from the eastern edge of the Falls and extending to 16 m from the Falls. In addition, *Novisuccinea chittenangoensis* can be found on the middle ledge 4 m above the primary ledge and in the talus as far as 3 m downslope from the primary ledge.

Figure 5. Photograph of habitat at the Falls (K. Breisch).

Habitat Parameters

Five parameters appear to have significance in habitat considerations: humidity, substrate, temperature, vegetation, and water quality.

Humidity: *Novisuccinea chittenangoensis* appears to require sustained, very high humidity. Active snails were found only when relative humidity approached 100 percent (Thomee 1986); during dry periods, Thomee found the snails to be relatively inactive. Portions of the habitat and substrate are consistently at near maximum humidity or saturation in the spray zone of the Falls. However, during 2002, the majority of *Novisuccinea chittenangoensis* were found >5 meters from the edge of the ledge nearest the Falls. Recent monitoring with temperature and humidity data loggers shows that these snails occur in an area where the humidity generally varies from 80 to 100 percent during the active season (Breisch, unpublished data). Further investigation is needed into seasonal and annual hydrological conditions within the Chittenango Creek watershed and at the Falls relative to the high-humidity areas used by *Novisuccinea chittenangoensis*.

Substrate: *Novisuccinea chittenangoensis* appears to be a calciphile, requiring a substrate either derived from limestone dolomite or rich in calcium carbonate from other sources. The dynamic nature of its habitat does not allow for development of soil.

Temperature: The species appears to require the cool, mild temperatures and relatively constant conditions provided by the waterfalls and mist. Water volume and flow rates within the Chittenango Creek watershed influence the size of the waterfall and mist-zone and the temperature at the site. Active *Novisuccinea chittenangoensis* are generally found at temperatures from 12° to 20°C (Thomee 1986). During warmer periods, snails retreat to cool areas provided by the moist rock and moss, or aestivate in the vegetation. During cold winter temperatures, it is believed that the snails at the Falls retreat into the rocks, cracks, or fissures and remain inactive. Various temperature readings were gathered during the summer of 1980-82. In the spray zone, the rock surface temperatures averaged 16°C, the moss averaged 14°C, and the combined temperatures of the substrate, water, and vegetation averaged 16°C. Seasonal and daily temperature variation has been monitored for 2 years using data loggers that record temperature every hour, but this data has not yet been analyzed (Breisch, unpublished data).

Vegetation: Most of the spray zone adjacent to the Falls is covered with patches of various mosses, liverworts, and other low herbaceous vegetation, including *Eupatorium purpureum, Angelica atropurpurea*, and *Aster* spp. (Thomee 1986). In addition, watercress (*Nasturtium officianale*) increased after the 1993 flood event. *Novisuccinea chittenangoensis* were found on vegetation up to 92 cm above the ground and at 1/3 the maximum sunlight intensities of the sympatric *Succinea* sp. B. Vegetation is

quite sparse on the west side of the Falls, and the only snails that have been observed there are *Succinea* sp. B. In drier talus adjacent to the mossy areas are various plant species, such as skunk cabbage (*Symplocarpus foetidus*) and angelica, upon which *Succinea* sp. B has also been found. During periods of heavy water flow, dew, or rain, when the vegetation is saturated, the snails have been observed actively crawling on the vegetation. During drier times, both species of snails attach themselves to the underside of leaves with a mucous epiphragm. In the patch of watercress, the vegetation is dense and lush. Although the watercress is dominant, other species include angelica, jewelweed (*Impatiens capensis* and *I. palida*), forget-me-nots (*Myosotis scorpioides*), various mints, and poison ivy (*Toxicodendron radicans*), which again support *Succinea* sp. B but not *Novisuccinea chittenangoensis*. The ledges where *Novisuccinea chittenangoensis* is found clearly comprise an early successional sere, periodically rejuvenated to a bare rock substrate by flood waters.

Water Quality: It may be fair to presume that clean water is necessary to maintain essential habitat and a healthy population of *Novisuccinea chittenangoensis*, just as it is to the survival of many other invertebrates; however, since *Novisuccinea chittenangoensis* is a terrestrial snail, the effects of water quality are expected to be somewhat indirect. While water quality may play a potential role in the success or decline of *Novisuccinea chittenangoensi*, this relationship has not been clearly defined to date.

RANGE

The only verified extant colony of *Novisuccinea chittenangoensis* is the type-population at Chittenango Falls, in Chittenango Falls State Park, 3.6 miles north of Cazenovia, between the Towns of Cazenovia and Chittenango, in Madison County, New York. At various times in the past, the species has been thought to have a broader range.

During the summer of 1982, "sub-fossil" shells of what appeared to be *Novisuccinea chittenangoensis* were found in the banks on the west side of Chittenango Creek near the Falls. Grimm (1981) postulated that Pleistocene deposits of *N. ovalis pleistocenica* (Baker 1927) are instead *Novisuccinea chittenangoensis*, and that this species was widely distributed during the Pleistocene epoch. Shell specimens have been recorded from Yarmouth, Sangamon, and Peorian deposits (Baker 1927) in the States of Arkansas, Illinois, Iowa, Michigan, Missouri, and Nebraska, and in the Province of Ontario. Alan Solem (pers. comm.), however, questioned assigning fossil succineid shell deposits to any species group. Although Hubricht (1985) mapped the location of extant populations of *Novisuccinea chittenangoensis* to include New York, West Virginia, Virginia, Tennessee, and North Carolina, with fossil records from Iowa, Illinois, Missouri, and Arkansas, Hoagland and Davis (1987) concluded that there is only one verified

extant population of *Novisuccinea chittenangoensis* and that it is impossible to verify fossil records as being *Novisuccinea chittenangoensis* based on shell characteristics alone.

Many field searches have been conducted for additional extant *Novisuccinea chittenangoensis* colonies. Originally, six colonies in North Carolina, Tennessee, Virginia, West Virginia, and Quebec were identified as supporting succineid snail populations; these were investigated further in the early 1980s as potential *Novisuccinea chittenangoensis* colonies, and there was disagreement as to whether *Novisuccinea chittenangoensis* occurred at these other sites. A number of other locations were field-checked by Grimm in 1981 without finding any additional *Novisuccinea chittenangoensis* populations. In October 1981, fourteen waterfalls in central and western New York were visited by representatives of the NYSDEC and Region Five of the U.S. Fish and Wildlife Service (USFWS) to assess their potential as habitat for *Novisuccinea chittenangoensis*. Only two sites yielded succineid shells, none of which were *Novisuccinea chittenangoensis*. Pursuant to the 1983 recovery plan, various waterfalls and other potential *Novisuccinea chittenangoensis* habitat were checked in North Carolina, West Virginia, New York, Minnesota, and Iowa, and succineid snails have been collected and sent to Hoagland and Davis (Academy of Natural Sciences of Philadephia), Solem (Field Museum of Natural History), Dorothea Franzen (Illinois Wesleyan University), and Hubricht for identification. There has been some disagreement of species identification among these malacologists, but *Novisuccinea chittenangoensis* has not been confirmed at any of the sites and the species is considered to be endemic to Chittenango Falls (Breisch 1987).

The process of revising the original recovery plan precipitated further efforts to identify additional extant *Novisuccinea chittenangoensis* colonies. To date, although many potentially suitable colony sites have been searched, no colony has been conclusively identified as *Novisuccinea chittenangoensis* outside of the Chittenango Falls area. Recent efforts to identify additional colony sites by examining shell collections at the National Museum of Canada and the U.S. National Museum and by investigating reports from cooperating malacologists have proved unsuccessful, and findings by Hoagland and Davis (1987), suggest little likelihood of discovering new sites. However, new techniques for identifying genetic relationships should be employed to test further whether *Novisuccinea chittenangoensis* at Chittenango Falls is distinct from specimens at previously reported locations.

POPULATION STATUS

Accurate population trends are not available for this species. In addition to the infrequent surveys and confusion between *Novisuccinea chittenangoensis*, *Succinea* sp. B, and *N. ovalis*, conditions at Chittenango Falls have precluded extensive surveys of the entire spray zone. Climbing the higher, extremely fragile rock ledges may damage these areas and harm any snails inhabiting them.

Prior to 1982, no quantitative estimates were made of the size or status of *Novisuccinea chittenangoensis* population at Chittenango Falls. The species was supposedly "in great abundance" when a field party collected it in 1905 but was not surveyed again until 1954, when Hubricht (Solem 1976) found it in "equal abundance" with *N. ovalis*. Grimm found *N. ovalis* more abundant than *Novisuccinea chittenangoensis* during field surveys in 1964, 1965, and 1973. In 1972, Grimm estimated the total *Novisuccinea chittenangoensis* population at less than 200, but Solem estimated it at about 500 in 1974. Three investigators spent two hours searching the habitat in 1973 and located only 13 specimens; a trip later that summer yielded none. Surveys by the NYSDEC Endangered Species Unit (beginning in 1976) generally uncovered only a few shells or living animals during annual trips, although an intensive search in July of 1981, with Grimm's assistance, yielded 18 live individuals.

Past surveys are suspect, as Grimm (1981) and Hubricht (1985) no longer believe that *N. ovalis* even occurs in *Novisuccinea chittenangoensis* habitat at Chittenango Falls. They surmise, rather, that earlier reported specimens of *N. ovalis* were instead immature *Novisuccinea chittenangoensis*. However, a review of photographic records showed shells of *N. ovalis* that were collected at the Falls when the type specimens of *Novisuccinea chittenangoensis* were collected. Apparently, *N. ovalis* occurred at or near the Falls historically but is no longer encountered there or is only located in adjacent habitats. Therefore, the problem of relative comparisons between the two species' abundance is problematic and confusing (see the Taxonomy section of this plan).

During the summer of 1982, Aloi and Ringler conducted a mark-recapture study in the patch of watercress where the snails appeared most densely. Using two methods (Jolly and Schnabel) and two models, they estimated a population of about 300 snails with a density of four snails per square meter of watercress habitat. These snails have subsequently been identified as *Succinea* sp. B, not *Novisuccinea chittenangoensis*. A 1983 collection of 83 snails for use in electrophoretic studies resulted in removal of 24 *Novisuccinea chittenangoensis* from the population (Hoagland 1984); unfortunately, their identity was not verified at the time of collection, on top of which *Novisuccinea chittenangoensis* was thought to be more abundant than it actually was. The population of *Succinea* sp. B expanded rapidly to an estimate of more than 3,000 snails in 1984 (Aloi 1985), whereas counts of *Novisuccinea chittenangoensis* in 1984 indicated the presence of approximately 100 adults (Thomee 1986). Counts of live *Novisuccinea chittenangoensis* from 1995-2001 yielded an average of five adults per survey with a high of 12 adults in 2001 (A. Breisch pers. comm.), and post-reproductive shell counts made at the end of each activity season from 1987-2001 generally identified 4 to 20 *Novisuccinea chittenangoensis* adults (A. Breisch pers. comm.). Subsequent studies have shown that *Succinea* sp. B outnumbers *Novisuccinea chittenangoensis* by as much as 10 to 1 in the primary habitat areas (Whiteleather 2003, 2004).

In 2002, the NYSDEC, ESF, and the USFWS increased the survey effort and conducted a mark-release-recapture study at the Falls. Sixteen surveys were conducted during the study period between July and October 2002. The final population estimate using the Schumacher-Eschmeyer method was 183 individuals (95 percent C.I.: 145-222 individuals) (Arrigoni 2002). Arrigoni also estimated population size based on capture frequencies, with a final estimate of 206 individuals. Due to differences in survey intensity and questionable species identifications in years past, the validity and comparability of survey data over the 20-year period do *not* provide a sound basis for any accurate status statement. The protocol for the mark-release-recapture study was modified slightly (Appendix E) and continued in 2003, 2004, and 2005 (Whiteleather 2003 and 2004). The *Novisuccinea chittenangoensis* population was estimated to be 178 in 2003 and to be 680 in 2004. Preliminary 2005 survey results show a population slightly larger than the 2004 estimate.

In addition to the wild population at Chittenango Falls State Park, efforts to establish captive populations began in 1990. A single captive *Novisuccinea chittenangoensis* colony was being maintained at the Rosamond Gifford Zoo in Syracuse, New York; however, the last remaining snails died in November of 2002.

REASONS FOR LISTING AND CONTINUING THREATS

The primary reasons *Novisuccinea chittenangoensis* was Federally listed as a threatened species were its extremely limited range and apparent population decline. Since the species was so poorly studied, actual causes of its decline can only be inferred. The 1978 listing rule specified trampling of habitat, water pollution, predation by European snails, and lack of existing regulatory mechanisms as threats to the species. Currently, the most significant threats to *Novisuccinea chittenangoensis* appear to be the species' extremely small population size and limited distribution as well as the potential impacts of the introduced snail, *Succinea* sp. B. Human disturbance also continues to threaten *Novisuccinea chittenangoensis*, although this has been greatly minimized by fencing of its habitat at Chittenango Falls. Other factors may also pose a threat to the species, but further investigations are needed.

Factor A. The present or threatened destruction, modification, or curtailment of its habitat or range:

While destruction of *Novisuccinea chittenangoensis* habitat due to development is not an issue at Chittenango Falls State Park, habitat has been modified due to human disturbance. The 1978 final rule listing *Novisuccinea chittenangoensis* as threatened estimated that 60 percent of the habitat at Chittenango Falls was trampled by humans. Since 1928, Chittenango Falls has been part of Chittenango Falls State Park, one of a series of State Parks in the Central New York Region of the New York State Office of

Parks, Recreation, and Historic Preservation (NYSOPRHP). Approximately 57,000 visitors come to the Park each year to engage in a variety of outdoor recreational activities (D. Wheelock pers. comm.). Fishing and hiking activities have brought a large number of visitors to the Falls area, where potential conflicts may arise. Trampling of the snails and their habitat was identified early on as a major potential threat, and this threat was exacerbated in the early 1980s by flooding, which destroyed a bridge that would have tended to route visitors away from the snail population. Problems with littering in the snail's habitat, e.g., beverage containers and fishing paraphernalia found at various levels of the rock face and around the pool at the base of the Falls, have decreased since the installation in 1984 and 1985 of a fence along the ravine trail and reconstruction of the bridges. Dislodging rocks, talus, or vegetation can cause serious harm to the snails and their eggs and can seriously harm their habitat. Flood events also have the potential to dislodge rocks along the Falls; this is further discussed under Factor E below.

The final rule also reported that pollution in the spray from Chittenango Creek may have caused the population decline, however we have no information at this time to suggest that water quality is or is not impacting *Novisuccinea chittenangoensis*. Changes in water quality may impact the vegetation along the Falls, but no information is available regarding this relationship either. Changes in water quantity throughout the Chittenango watershed may alter the habitat (including parameters such as temperature, humidity, and vegetation) along the Falls and further information is also needed regarding these relationships. Water quantity and quality should be monitored along with any changes in the vegetation and *Novisuccinea chittenangoensis* habitat-use and population status to ensure that they do not surface as threats.

Factor B. Overutilization for commercial, recreational, scientific, or educational purposes:
Collection of *Novisuccinea chittenangoensis* has not been documented as a threat to the species.

Factor C. Disease or predation:
The 1978 listing rule included predation by the introduced European snails, *Discus rotundatus* and *Oxychilus* spp. as serious threats to *Novisuccinea chittenangoensis*. Little is currently known about this relationship. Predation by small mammals, birds, salamanders, beetles, and other invertebrates is also a potential threat, albeit at a low level. There are no reports of disease or parasites threatening *Novisuccinea chittenangoensis*. However, investigation into potential parasites carried by *Succinea* sp. B and potentially transferred to *Novisuccinea chittenangoensis* should be undertaken.

Factor D. Inadequacy of existing regulatory mechanisms:

This is not currently considered to be a direct threat to the species. At the time of the proposed rule, there were no adequate regulatory mechanisms in place to protect *Novisuccinea chittenangoensis*. During the final listing process in 1977, however, the NYSDEC amended the State list of endangered species to include *Novisuccinea chittenangoensis* as an endangered species in New York. New York State (ECL 11-0535) prohibits the "taking, importation, transportation, possession or sale of any endangered or threatened species.... or other parts thereof, or the sale or possession with intent to sell any article.... of any endangered or threatened species .... except under license or permit." The definition of take includes pursuing, shooting, hunting, killing, capturing, trapping, snaring, disturbing, harrying, or worrying (ECL 11-01-03). In addition, through a court decision (Amato and Rosenthal 2001), it was recognized that in New York adverse modification of habitat may jeopardize the continued existence of listed species. This modification was considered a take under New York State law and was therefore prohibited by ECL 11-0535. However, if after the USFWS delisted *Novisuccinea chittenangoensis* the State was to delist it as well, regulatory protection would again be lacking without an adequate management plan in place.

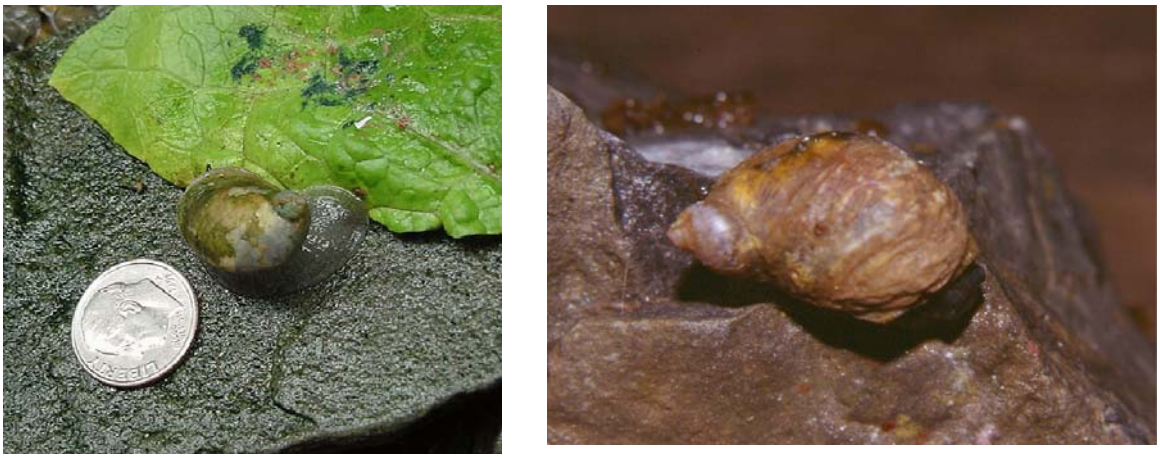
Projects that might adversely affect the general area surrounding Chittenango Falls may be reviewed by either the NYSDEC or the USFWS. The NYSDEC reviews non-Federal projects that may significantly impact the environment through the State Environmental Quality Review Act (SEQR). The SEQR is similar to the National Environmental Policy Act of 1969, which provides a mechanism for public comment on projects that involve Federal agencies. New York State law also requires a permit for the following activities that could impact Chittenango Creek: constructing or using an outlet or discharge pipe (referred to as a "point source") that discharges wastewater into the surface waters or ground waters of the State, constructing or operating a disposal system such as a sewage treatment plant, or discharge of storm water. Depending on the tolerance of *Novisuccinea chittenangoensis* to changes in water quantity or quality, development within the Chittenango Creek watershed (resulting in increased impervious surfaces, potential water withdrawals, and non-point source pollution) may impact the species.

Factor E. Other natural or manmade factors affecting its continued existence:

Species with limited range and narrow ecological niches tend to be more vulnerable and stressed by change than are wider-ranging species. Periodic floods caused by spring thaws (such as occurred in 1980, 1993, and 1995) have resulted in much of the vegetation being washed away from the primary habitat ledge where most *Novisuccinea chittenangoensis* have been found in recent years. Since the species may be intolerant of large fluctuations in light, temperature, and humidity, and this is the only area where the species occurs, impacts to the habitat can certainly be a threat. However, spring thaws generally occur before the snails are active, reducing the potential impact on the population itself by flood events.

In addition to washing away vegetation, flood events also have the potential to dislodge rocks along the Falls. The ledges may break off, destroying the primary habitat and potentially the snails themselves.

A particularly perplexing problem that was first recognized at the Falls in 1985 is the presence of an introduced snail, *Succinea* sp. B, that may be competing with *Novisuccinea chittenangoensis* for food and/or breeding or wintering habitat. *Succinea* sp. B is found throughout *Novisuccinea chittenangoensis*' habitat at Chittenango Falls, and further information is needed about the possible effects of this (e.g., whether *Succinea* sp. B is suppressing the ability of the *Novisuccinea chittenangoensis* colony to sustain itself at viable levels). Investigations into the relationship between *Novisuccinea chittenangoensis* and *Succinea* sp. B were initiated in 2005 by ESF, the NYSDEC, and USFWS. Furthermore, *Succinea* sp. B has become widespread throughout the Chittenango Creek drainage basin both up- and downstream (Molloy 1995), including encroachment onto habitat that might otherwise be suitable for *Novisuccinea chittenangoensis*. In addition to the concerns about competition, there have been questions about whether *Novisuccinea chittenangoensis* and *Succinea* sp. B have the potential for hybridization, but recent analysis (referenced in the Taxonomy section of this plan) indicates that this is not a problem at this time (T. King, unpublished data). Initial concerns regarding *Novisuccinea chittenangoensis*' genetics surfaced when the snails raised in captivity began to change morphologically. These changes, which became noticeable after five generations in captivity, included the shell becoming more rough and opaque and the sutures became less distinct. In addition, the spires were less pronounced and were angled to the side, giving the snails a rounder shape (Figures 6a, 6b). These changes could be due to environmental conditions in a captive setting, diet, gene frequencies, a pathogen, or a combination of these influences.



Figures 6a and 6b. Photographs of captive *Novisuccina chittenangoensis* at the Rosamond Gifford Zoo (USFWS, A Briesch).

CONSERVATION MEASURES

The only known habitat of *Novisuccinea chittenangoensis* is fully protected within the Chittenango Fall State Park, and there is a cooperative program among the NYSDEC, NYSOPRHP, and the USFWS to protect the snail and its habitat there. Post-listing surveys have occurred at the Park almost every year since 1977. These surveys have generally consisted of timed searches within the known habitat area. The second (higher) ledge area has been surveyed a few times, and *Novisuccinea chittenangoensis* have been found in that area, although the loose substrate makes surveys difficult. The current survey protocol consists of 15-minute surveys of 1-meter plots along the primary ledge (Appendix E). As described in the Population Status section of this plan, a mark-release-recapture study was initiated in 2002 and refined in 2003-2005 to better estimate the population size.

During the course of revising the recovery plan, the imperative need to establish a captive colony of *Novisuccinea chittenangoensis* was reinforced. Although past efforts have been unsuccessful, captive propagation continues to be viewed as essential to the conservation of this species for the following purposes: to generate a pool of individuals for further research, to offset imminent threats of extinction at the Chittenango Falls site, and to serve as a source of founders for enhancing the existing population and possibly for establishing new populations at other sites.

The first captive *Novisuccinea chittenangoensis* colony was established in 1990 at ESF at Syracuse (Molloy and Norton 1993, Molloy 1995), starting with six founders from Chittenango Falls. In 1995, F_3 offspring reared at ESF were transported to the Wildlife Conservation Park/Bronx Zoo and the Burnet Park Zoo in Syracuse. Both the Wildlife Conservation Park/Bronx Zoo and Burnet Park Zoo (R. Clawitter pers. comm.) produced a new generation of *Novisuccinea chittenangoensis*. Unfortunately, the population at Burnet Park Zoo was lost to unknown causes in 1996. While reproduction was achieved at the Wildlife Conservation Park/Bronx Zoo, survival of young was very limited. In 1998, the seven remaining *Novisuccinea chittenangoensis* from the Wildlife Conservation Park/Bronx Zoo were transferred to the Rosamond Gifford Zoo (the renamed Burnet Park Zoo). Successful reproduction occurred in 1998 and 1999 with hundreds of eggs produced, although survival of juveniles was low (N. Porter pers. comm). Minimal reproduction occurred in 2000, and five and seven *Novisuccinea chittenangoensis* were given to the Seneca Park Zoo (Rochester, New York) and Buffalo Zoo, respectively. All snails at Seneca Park and Buffalo died within the first year (Murphy pers. comm., Wyatt pers. comm.). In 2001, egg masses proved to be infertile at Rosamond Gifford Zoo; two adults remained through the fall of 2002 but died in November 2002.

Further experiments are necessary to determine ideal conditions for maintaining a healthy captive population of *Novisuccinea chittenangoensis*. In addition to problems with recruitment, growth and shell morphology of the remaining captive adults are different from those in the wild, and the correlation between these differences and either diet or genetic factors is unknown. The Recovery Team held a Chittenango ovate amber snail recovery workshop in March 2005 and discussed future options for reinitiating a captive propagation program. Using information collected at the Falls since 2002, we hope to develop a population model to help determine impacts of adult removal from the population at the Falls. This will help us determine how many founders are both needed and can be collected and used for captive propagation.

Finally, as referenced in the Taxonomy section of this plan, a 2003 genetic analysis conducted by the U.S. Geological Survey (T. King, unpublished data) found amplified and sequenced the cytochrome oxidase I region of mitochondrial DNA and the ITS-1 region of nuclear DNA found a large genetic divergence between *Novisuccinea chittenangoensis* and S*uccinea* sp. B. Consequently, concerns about the threat of hybridization have been allayed.

RECOVERY STRATEGY

The current strategy for recovering *Novisuccinea chittenangoensis* is to buffer the species against extinction by perpetuating the extant population at Chittenango Falls at a baseline size and by maintaining multiple captive populations of the species. Given the apparent threat presented by the introduced competitor *Succinea* sp. B and the previous failure of captive breeding efforts, these are considered to be ambitious but achievable aims. Paired with the *in situ* and *ex situ* management efforts, research is needed to better understand the biological requirements of *Novisuccinea chittenangoensis*, the optimal conditions for captive breeding and rearing, and a feasible means of controlling *Succinea* sp. B (if determined necessary).

Given the grave uncertainty about the *in situ* survival prospects of this snail, captive propagation is viewed as essential for the species' stabilization. Captive propagation should be reinitiated in accordance with a sound propagation protocol in order to ensure success in breeding and rearing *Novisuccinea chittenangoensis*. Surveying other potentially suitable habitat also remains a recovery priority for this species. The primary purpose of conducting surveys will be to determine whether any other populations of *Novisuccinea chittenangoensis* exist.

If the extant *Novisuccinea chittenangoensis* population at Chittenango Falls can be stabilized or increased, progress toward the second phase of the recovery strategy, including augmentation of this population, exhaustively searching for any additional populations that may exist in the wild, and the long-term maintenance of captive populations. Although the draft revised plan (USFWS 2003) called for establishment of three subpopulations at Chittenango Falls (with subpopulations defined as snail colonies separated by physical, temperature, and humidity barriers), we now realize that *Novisuccinea chittenangoensis* regularly uses two ledges at the Falls and there is movement between the ledges. Therefore, it appears that *Novisuccinea chittenangoensis* are functioning as one large population at the Falls, and it is unlikely that we would be able to establish separate subpopulations within currently suitable habitat. In tandem with long-term maintenance of captive populations, augmentation and maintenance of a larger *Novisuccinea chittenangoensis* population at Chittenango Falls should provide adequate assurance that highly localized catastrophic events will not cause the extinction of the species.

This strategy is based on the assumption that the discovery of additional populations of *Novisuccinea chittenangoensis* outside the Chittenango Falls habitat is highly unlikely and on the premise that preservation of the species within its current known range (i.e., Chittenango Falls) and buffered by a captive propagation program will suffice to ensure its long-term viability in the wild. However, we are also reserving the prerogative to establish additional population(s) of *Novisuccinea chittenangoensis* at one or more alternative locations, if and when further investigation shows this to be a feasible and prudent option.

PART II. RECOVERY

RECOVERY GOAL

The overall recovery goal under the ESA is to establish the long-term viability of the Chittenango ovate amber snail (*Novisuccinea chittenangoensis*) population sufficiently to allow delisting of the species.

RECOVERY OBJECTIVES

Given its precarious biological status, the immediate objective of this revised recovery plan is to stabilize *Novisuccinea chittenangoensis* in the wild by investigating its interactions with *Succinea* sp. B and ensuring any negative interactions are controlled, and in captivity by establishing a successful propagation program. The long-term objective is to ensure the continuing survival of *Novisuccinea chittenangoensis* by augmenting the population at Chittenango Falls and, if feasible and prudent, by establishing additional colonies elsewhere.

RECOVERY CRITERIA

In order to consider *Novisuccinea chittenangoensis* as **stabilized,** the following criteria should be met:

1. The population at Chittenango Falls is shown to be stable or improving for 10 years (Actions 2.1.2, 2.1.3, 2.1.4). To accomplish this, a baseline population size and distribution must be determined (Action 2.1.1).

2. At least two healthy captive colonies of *Novisuccinea chittenangoensis* are successfully established in order to: (1) provide a source for augmenting the population at Chittenango Falls or introductions to new sites, (2) buffer against extinction in the wild, and (3) provide a source of *Novisuccinea chittenangoensis* for various scientific experiments related to their recovery (Action 5.2.2). A healthy captive population is defined as having sufficient genetic diversity and being large enough to meet population goals, which will be specified in a new protocol based in part of the results of genetics research as well as results of research into the optimal conditions for propagation of *Novisuccinea chittenangoensis* (Actions 2.1.4, 5.2.1, 5.2.3).

3. The genetic distinctiveness of *Novisuccinea chittenangoensis* from other snails occupying the site is demonstrated (Action 1.1).

4. With respect to the five listing factors, threats to the species are abated as follows (noting that no risks to the snail were identified under Factor B or, for as long as the snail is listed, Factor D):

    a. Factor A. Protection of the snail's Chittenango Falls habitat by the NYSOPRHP is perpetuated (Actions 2.2, 2.3, 2.4).

    b. Factors C and E. A sufficient understanding of the relationship between *Novisuccinea chittenangoensis* and *Succinea* sp. B is gained and effective measures to reduce any negative interactions are in place (Actions 3.1, 4).

    c. Factor E. A sufficient understanding of any future threat of hybridization is gained to allow an effective response (Action 1.1).

5. Monitoring of threats and effects of management practices indicate that recovery actions are contributing to the improved status of the species (Action 6).

If and when the population is shown to be stable or increasing for at least five generations (10 years), recovery of *Novisuccinea chittenangoensis* can then focus on meeting conditions for delisting. **Delisting** will be considered when the following criteria (in addition to criteria 1-3) are met.

6. The *Novisuccinea chittenangoensis* population at Chittenango Falls must include at least 1000 snails with occupancy of both the lower and middle ledges. The population must be stable (or improving) for at least 10 years (Action 2.1.3).

7. Threats to the snail are abated as follows:

    a. Factor A. All sites with *Novisuccinea chittenangoensis* are permanently protected through acquisition, conservation easement, or another form of agreement (Action 2.2.4).

    b. Factor A. Written management/monitoring plans are in place for each site (Actions 2.2.4, 6.4).

    c. Factor A. A sufficient understanding of habitat and biological requirements is gained to conduct management efforts (Actions 3.2, 3.3, 3.4, 3.5).

d. Factor D. *Novisuccinea chittenangoensis* is ensured continued protection by New York State after ESA protections are removed.

e. Factors C and E. Any negative interaction between *Novisuccinea chittenangoensis* and *Succinea* sp. B or other species is controlled with minimal management intervention (Action 4).

f. Factor E. Searches for any other potential extant populations have been completed, and the extant population at Chittenango Falls has been successfully augmented (Actions 1.2, 5.1, 5.3).

g. Factor E. Searches for potential introduction sites have been completed, the potential for introduction has been thoroughly evaluated and, if warranted, one or more additional *Novisuccinea chittenangoensis* populations have been successfully established (Action 5.4).

8. Monitoring of threats and effects of management practices indicate that recovery actions have led to a secure status for the species (Action 6).

The stabilization and delisting criteria will be reassessed as additional information on *Novisuccinea chittenangoensis* becomes available. Meeting the criteria for recovery will rely on implementation of the following recovery actions (outlined in Table 1).

RECOVERY ACTIONS

Note: See Appendix F for a list of recovery tasks included in the original plan.

1. *Conduct genetics research to identify markers to:*

1.1 *Re-evaluate the taxonomic relationship between* Novisuccinea chittenangoensis *and other snails.* Significant progress has been made with regard to the genetic distinctiveness of *Novisuccinea chittenangoensis* , and it has been determined that hybridization is not likely to occur between *Novisuccinea chittenangoensis* and *Succinea* sp. B. However, we do not currently understand the overall relationship among Succinead snails. Additional taxonomic research is needed to evaluate the relationship of *Novisuccinea ovalis*, *Succinea* sp. B, and

Table 1. Recovery Action Outline

1. Conduct genetics research to:

    1.1 Re-evaluate the taxonomic relationship between *Novisuccinea chittenangoensis* and other snails.
    1.2 Identify markers for *Novisuccinea chittenangoensis* to assist with future identification of snails at other sites.

2. Continue to protect the Chittenango ovate amber snail population and its habitat at Chittenango Falls.

    2.1 Determine the size and status of the population at Chittenango Falls.
        2.1.1 Establish a monitoring protocol to determine the baseline population at Chittenango Falls.
        2.1.2 Establish a long-term monitoring protocol for subsequent surveys at Chittenango Falls.
        2.1.3 Conduct surveys based on the monitoring protocols in occupied habitats.
        2.1.4 Develop a model to help understand how *Novisuccinea chittenangoensis'* life history characteristics influence the size and status of the population.

    2.2 Continue to preserve the habitat of this species at Chittenango Falls.
        2.2.1 Ensure consideration of habitat protection in any activities of Park personnel.
        2.2.2 Inhibit or prevent, when possible, human-induced alterations that may adversely affect the snail's habitat at Chittenango Falls.
        2.2.3 Continue to restrict access to the population and habitat at Chittenango Falls.
        2.2.4 Develop a *Novisuccinea chittenangoensis* management/protection agreement for Chittenango Falls.

    2.3 Establish an information and education system conducive to achieving other recovery actions.
        2.3.1 Provide information to both permanent and seasonal NYSOPRHP staff, on an annual basis, as to the presence and uniqueness of the species, and to importance of the protection of its habitat.
        2.3.2 Provide information to Park patrons and the local community as to the presence and uniqueness of the species, and to acquaint them with regulations for its protection.
            2.3.2.1 Improve and maintain the permanent display panel located near the main parking area, keeping it accessible to all patrons, and develop any other necessary signage.
            2.3.2.2 Upon request, provide additional information in the form of brochures or reports on the species.

    2.4 Enforce all laws protecting the species and its habitat.
        2.4.1 Monitor public use and enforce rules to keep visitors off the Falls.
        2.4.2 Enforce water quality regulations along Chittenango Creek upstream of Chittenango Falls.
        2.4.3 Coordinate collecting or other scientific permits that could result in possible take of the species.

3. Expand data on the biological and environmental requirements of *Novisuccinea chittenangoensis*.

    3.1 Determine if *Succinea* sp. B is having a negative impact on *Novisuccinea chittenangoensis*.
    3.2 Further define vegetative composition and structure of habitat used by *Novisuccinea chittenangoensis*.
    3.3 Determine effects of changes in hydrology on *Novisuccinea chittenangoensis* and its habitat.
    3.4 Determine effects of changes in temperature, humidity, substrate, light, and other factors on *Novisuccinea chittenangoensis*.
    3.5 Investigate the effects of environmental contaminants, water quality, and pH on *Novisuccinea chittenangoensis* and its habitat.

4. Research techniques for removal of *Succinea* sp. B from *Novisuccinea chittenangoensis*' habitat at the Falls.

5. As feasible, increase the population size and broaden the distribution of *Novisuccinea chittenangoensis*.

5.1 Expand data on species' Post-Pleistocene range.
- 5.1.1 Check succineid collections at various institutions to determine whether any additional colonies exist.
- 5.1.2 Survey similar appropriate habitats within the eastern U.S. and Canada to locate additional colonies of *Novisuccinea chittenangoensis*, if any, and to identify suitable habitats for establishing new colonies.

5.2 Establish and refine the *Novisuccinea chittenangoensis* captive propagation program.
- 5.2.1 Develop an initial captive propagation protocol.
- 5.2.2 Establish and maintain the captive-propagation program.
- 5.2.3 Conduct research experiments to refine rearing protocols.

5.3 Research potential for augmenting the extant Chittenango Falls population with captive offspring.

5.4 As appropriate, establish additional *Novisuccinea chittenangoensis* populations within the species' likely Post-Pleistocene range.
- 5.4.1 Develop a protocol for evaluating potential release sites.
- 5.4.2 Survey appropriate habitats to identify potentially suitable sites for establishing new subpopulations.
- 5.4.3 Determine methods for establishing additional populations.
- 5.4.4 Establish additional *Novisuccinea chittenangoensis* populations if determined feasible and appropriate.

6. Review and track recovery progress.

6.1 Create a data repository for captive population reports, wild population survey reports, scientific research, etc.
6.2 Conduct recovery team meetings as needed.
6.3 Revise recovery plan as appropriate.
6.4 Develop and implement a monitoring strategy.
- 6.4.1 Monitor the implementation/completion of actions.
- 6.4.2 Monitor the effects of any management actions conducted for *Novisuccinea chittenangoensis*.
- 6.4.3 Monitor current or potential threats to the species.
- 6.4.4 Monitor the biological status of *Novisuccinea chittenangoensis*.

Novisuccinea chittenangoensis at the Falls. In addition, we are interested in determining the origin of *Succinea* sp. B to better understand this species.

1.2 ***Assist with future identification of snails at other sites.*** This action covers the genetics labwork associated with Actions 5.1.2 (to determine if there are other extant *Novisuccinea chittenangoensis* sites beside Chittenango Falls).

2. ***Continue to protect the Chittenango ovate amber snail population and its habitat at Chittenango Falls.***

2.1 ***Determine the size and status of the*** **Novisuccinea chittenangoensis** ***population at Chittenango Falls.***

2.1.1 ***Establish a monitoring protocol to determine the baseline population at Chittenango Falls.*** Multiple years of intensive mark-recapture-release surveys are necessary to determine the baseline population size and distribution of the *Novisuccinea chittenangoensis*. The protocol will identify appropriate marking techniques, frequency of monitoring, and any other information necessary to adequately explain the expected methods for a chosen surveyor to use. A draft protocol that has been used since 2002 is attached (Appendix E).

2.1.2 ***Establish a long-term monitoring protocol for subsequent surveys at Chittenango Falls.*** Data from the initial multi-year monitoring program will help determine the necessary frequency and intensity of subsequent surveys. The goal of long-term monitoring is to assess any change in the species' status, abundance, reproductive success, and/or the level of threats. The protocol should address the number and types (live counts, shell counts) of surveys needed within and among years. The protocol should also include efforts be made to minimize activity in the species' habitat.

2.1.3 ***Conduct surveys based on the monitoring protocols in occupied habitats.*** It is essential that Chittenango Falls be monitored according to established monitoring plans by qualified surveyors.

2.1.4 ***Develop a model to help understand how*** **Novisuccinea chittenangoensis'** ***life history characteristics influence the size and status of the population.*** Population processes are generally too complicated for biologists to understand without the use of population models that synthesize information about all the potential influences acting simultaneously on a small population. For this reason, estimates of vital rates from mark-recapture data collected in the field during the monitoring program will be used to construct a population model to project the fate of the population under various management scenarios. For example, the model can also be useful for informing decision making on the number of individuals that can be safely removed to establish populations elsewhere (including in captivity) without threatening the source population. The model will also aid in understanding what vital rate and associated life stage contributes most to population growth and therefore should be targeted by managers to increase population size. Many other insights are available once such a population has been constructed.

2.2 ***Continue to preserve the habitat of this species at Chittenango Falls.***

2.2.1 ***Ensure consideration of habitat protection in any activities of Park personnel.*** It is imperative that habitat integrity be considered during any Park activities that may affect the species. This could include routine maintenance work or responses to unusual safety hazards. In 1981, a geologist from the NYSOPRHP determined that a fracture exists in the rock beneath the overlook on the west side of the Falls. For human safety reasons, he suggested that about 100 cubic yards of rock be removed by blasting. Regional Park officials, working with the State recovery team, completed the removal in 1983 without adversely affecting the snail's habitat. This type of cooperation should be continued, and since any NYSOPRHP actions affecting, either directly or indirectly, the Falls or *Novisuccinea chittenangoensis* habitat are subject to review under the State Environmental Quality Review Act, this action should be easily attained. Efforts should be made to include recovery plan objectives and actions into any regional planning efforts and documents.

2.2.2 ***Inhibit or prevent, when possible, human-induced alterations that may adversely affect the snail's habitat at Chittenango Falls.*** Human-induced alterations may include erosion, rock falls, and exotic species introductions. While erosional processes are natural, most problems at the Falls can be linked to human causes (*e.g.*, road construction, hiking). If a problem can be anticipated or is detected early, certain amelioratory actions may avert or minimize the impact of those processes on the snail population and habitat. These actions may also be necessary for protection of human safety at the Park (*e.g.*, stabilizing rock ledges). Another action that may minimize human-induced impacts is removal of undesirable invasive vegetation (*e.g.*, black swallow-wort [*Vincetoxicum nigrum*]) that becomes established in the habitat. Unusual weather events or habitat changes should be reported to the recovery team.

2.2.3 ***Continue to restrict access to the population and habitat at Chittenango Falls.*** Erecting endangered species critical areas signs and fencing along the trails into and out of the ravine and reconstruction of the two footbridges has greatly decreased the number of park visitors who unknowingly wandered through the habitat in the past. Annual maintenance of signs and fencing should continue.

In general, a continued low-key approach to limiting access to the habitat is recommended; obtrusive, unaesthetic barriers are not the favored means to keep

people from entering the snail's habitat. However, some steps are necessary to limit access to the Falls. A combined program of limited accessibility, public education, and law enforcement is recommended. This program is consistent with current Park management policy which calls for limitation of access to the Falls for the purpose of patron safety. It is recognized that these efforts will not keep all patrons off the Falls -- some will try to gain access regardless of rules or obstacles -- but decreasing the frequency of intrusion into the snail's habitat will improve conditions significantly.

2.2.4 ***Develop a* Novisuccinea chittenangoensis *management/protection agreement for Chittenango Falls.*** The existing relationship between the NYSOPRHP, NYSDEC, and USFWS is extremely cooperative. Staff at Chittenango Falls have accommodated research and monitoring requests and have assisted with various protection measures at the Falls. However, as staff turnover will affect all three agencies, it is essential to formally document management and protection efforts necessary for the future conservation of *Novisuccinea chittenangoensis*.

2.3 ***Establish an information and education system conducive to achieving other recovery actions.*** The endangered species issue is generally well supported by the public, and when informed and allowed to help, the public will cooperate more readily with necessary, albeit inconvenient, limitations. Considerable concern has been expressed that publicizing the occurrence of this species could result in additional collecting or harassment. Recognizing this, a thoughtfully designed educational approach, with the appropriate amount of detail (or lack thereof), is far superior to suppressing or denying information to the public. When combined with a program to limit access and ensure law enforcement, this approach is expected to be most beneficial to both the species and the public.

2.3.1 ***Provide information to both permanent and seasonal NYSOPRHP staff, on an annual basis, as to the presence and uniqueness of the species, and to the importance of protection of its habitat.*** Regional and Park staff may change over time, making regular contact at these levels important. The NYSOPRHP staff that should be targeted for this effort include Chittenango Falls Park staff, regional office administration, engineers, and landscape architects. Appropriate information and guidance should be provided to all the above-mentioned parties on an annual basis to ensure that any work plans at Chittenango Falls will not impact *Novisuccinea chittenangoensis* or its habitat. For example, one form of guidance/protocol should address appropriate responses by NYSOPRHP to any potential habitat modifications

(e.g., broken ledges due to flood events). Another should assist the staff with appropriate responses to questions from the public and/or media contacts.

2.3.2 ***Provide information to park patrons and the local community as to the presence and uniqueness of the species, and to acquaint them with regulations for its protection.*** Providing information about the presence of the species will probably not increase deleterious activities (*e.g.*, collecting) *if presented properly*. Furthermore, if given a good reason to refrain from harmful activities, visitors may be more likely to oblige. Media interest has been relatively high for this threatened species in the past, and efforts should be made to take positive advantage of this situation. Because of the uniqueness of this localized endemic, the media and the public have been supportive of all recovery actions taken to date. If future recovery activities affect local communities, more support can be anticipated if people have been made aware of the situation and need for action.

2.3.2.1 ***Improve and maintain the permanent display panel near the main parking area, keeping it accessible to all patrons, and develop any other necessary signage.*** The existing educational display presents information about the uniqueness of the environment and ecology within the lower ravine below the Falls and notifies park patrons of the sensitivity of the habitats. *Novisuccinea chittenangoensis* is identified as one of the unique resident species, and basic information is presented on its status and biology without identifying exact habitat locations. Other rare or unique species are also presented. In this manner, the presence of the snail is presented in context and not over-emphasized, and public cooperation in protecting the sensitive habitats is appropriately encouraged. Additional signs could be created which provide more information on rare and listed species and their importance for maintaining biodiversity at the Falls.

2.3.2.2 ***Upon request, provide additional information in the form of brochures or reports on species.*** Interested parties may desire more information on the species, and this should be made available.

2.4 ***Enforce all laws protecting the species and its habitat.***

2.4.1 ***Monitor public use and enforce rules to keep visitors off the Falls.*** Park personnel routinely monitor patron activities as staffing allows. The Park staff has been very effective in restricting patron access to the Falls.

2.4.2 ***Enforce water quality regulations along Chittenango Creek upstream of Chittenango Falls.*** Continued efforts must be made to ensure that water quality regulations are strictly enforced.

2.4.3 ***Coordinate collecting or other scientific permits that could result in possible take of the species.*** NYSDEC scientific collectors licenses are recommended for collecting any fish and wildlife. Further, special permits are required from both the NYSDEC and from the USFWS to collect or affect endangered or threatened species. Any permit applications received for activities that may affect the snail or its habitat must be closely scrutinized and the effects on *Novisuccinea chittenangoensis* of any approved activities minimized.

3. ***Expand data on the biological and environmental requirements of*** **Novisuccinea chittenangoensis.** Relatively little is known about the exact biological requirements of this species, and if full recovery and protection is expected, more must be learned. Studies may further reveal new techniques or actions for recovery. An understanding of what limits *Novisuccinea chittenangoensis* habitat is also essential for making decisions on what other areas may be suitable for the snails. This will become important for determining which sites should be surveyed as potential occupied habitat and which areas may be considered as future introduction areas (see Action 5.4). Studies completed since 1983 have identified preliminary humidity, thermal, and light requirements of *Novisuccinea chittenangoensis*. Unfortunately they included both *Novisuccinea chittenangoensis* and *Succinea* sp. B in their analyses. In addition, these looked at point data, and continuous monitoring of temperature and humidity throughout the year has been initiated.

With establishment of a new captive colony, it will be possible to conduct laboratory studies to further measure the biotic and physical factors that define this species' habitat, predator-prey relationships, and interspecific competition. One note of particular interest is that when five founders were removed from the Falls and placed in captivity, they were able to produce 130+ descendants by the F_2 generation. The question of continued survival is not a result of low reproductive potential, but apparently involves some other factor at the Falls such as predation, competition, disease, or habitat suitability.

3.1 ***Determine if*** **Succinea** ***sp. B is having a negative impact on*** **Novisuccinea chittenangoensis.** Using individuals from the captive colony or from the wild, it should be determined if there are interspecific relationships between these two species (such as competition for resources, aggression, predator-prey interactions, diseases, parasites) that would limit reproductive success of *Novisuccinea chittenangoensis*. Potential relationships

may be studied in the lab or in the field. For example, an exclosure study might determine survival of egg masses with and without the presence of *Succinea* sp. B.

3.2 ***Further define vegetative composition and structure of habitat used by*** **Novisuccinea chittenangoensis.** This is important to maintain and protect essential habitat. Vegetative composition at this site has changed significantly since 1983 due to scouring of the habitat by flood waters followed by revegetation of the bare substrate and due to elimination of the trampling affect of park visitors who are now restricted from the site. It is unknown whether these changes in vegetative composition have affected *Novisuccinea chittenangoensis*. Depending on the outcome of this research and monitoring, the need for vegetative manipulation to improve conditions at Chittenango Falls should be determined.

3.3 ***Determine effects of changes in hydrology on*** **Novisuccinea chittenangoensis** ***and its habitat.*** Water quantity naturally varies tremendously both annually and seasonally at the Falls. However it is important to understand the range of water quantity changes that *Novisuccinea chittenangoensis* can tolerate. Future development within the Chittenango Creek watershed may permanently alter the rate and timing of flows within Chittenango Creek and we are uncertain as to whether that may result in any adverse impacts to *Novisuccinea chittenangoensis*. As mentioned previously, water volume and flow rate likely influences humidity and temperature along the Falls as well as the vegetation that can be sustained at the site. Therefore, potential water quantity changes and *Novisuccinea chittenangoensis* responses should be monitored.

3.4 ***Determine effects of changes in temperature, humidity, substrate, light, and other factors on*** **Novisuccinea chittenangoensis.** Effects on the growth and development of *Novisuccinea chittenangoensis* from these factors should be determined. This may be accomplished through experiments with a captive colony. Environmental factors may also be measured within, and outside of, *Novisuccinea chittenangoensis* habitat at Chittenango Falls.

3.5 ***Investigate the effects of environmental contaminants, water quality, and pH on*** **Novisuccinea chittenangoensis** ***and its habitat.*** Baseline water quality, pH, and contaminant levels at the Falls should be determined. It should then be determined, through laboratory and field studies, what impacts changes in these factors have on the *Novisuccinea chittenangoensis*.

4. ***Research techniques for removal of*** **Succinea** ***sp. B from*** **Novisuccinea chittenangoensis'** ***habitat at the Falls.*** *Succinea* sp. B appears to be an aggressive colonizer that is currently widespread

within the Chittenango Creek drainage basin. Because of its broad habitat tolerance, it is unlikely that it can be removed from *Novisuccinea chittenangoensis* habitat and kept out without applying environmentally unacceptable techniques. However, since *Novisuccinea chittenangoensis* is endemic to this site, and *Succinea* sp. B may impact other rare succineids at other locations in the future, any potential method for removing, eliminating, or controlling *Succinea* sp. B should be investigated. If feasible methods for removal are discovered, an additional task will be added to actually conduct the removals.

5. ***As feasible, increase the population size and broaden the distribution of the Chittenango ovate amber snail.*** Continued protection and efforts to preserve the Chittenango Falls population *may* halt further declines in this species, but enhancement activities will be necessary to promote or accelerate recovery.

5.1 ***Expand data on the species' likely Post-Pleistocene range.*** This species' status and vulnerability appears to be largely a result of its extremely limited range and the presence of *Succinea* sp. B. Identification of additional potential colonies, or suitable sites for introduction, would increase delisting or recovery potential.

5.1.1 ***Check succineid collections at various institutions to determine whether any additional colonies exist.*** Investigation of existing collections of succineid snails might reveal other potential colonies. Identification of other closely related species of *Novisuccinea* might indicate the presence of habitats that could be evaluated for introduction attempts. In addition, the presence of *S.* sp B at a site would preclude that drainage from consideration.

5.1.2 ***Survey similar appropriate habitats within the eastern U.S. and Canada to locate additional colonies of*** **Novisuccinea chittenangoensis*****, if any, or to identify suitable sites for establishing new colonies.*** Using information from Action 3.2, conduct surveys of potential *Novisuccinea chittenangoensis* habitat. Surveys of suitable waterfalls and other similar habitats may reveal undiscovered colonies of this species as well as additional habitats that may be suitable for release of captive-reared snails.

5.2 ***Establish and refine*** **Novisuccinea chittenangoensis** ***captive propagation program.*** There are no existing captive populations at this time. However, recreating and maintaining captive populations are an essential part of the recovery strategy for *Novisuccinea chittenangoensis*. Maintaining the captive colony of this species will involve dividing the

colony between two or more institutions to minimize chances of catastrophic loss of the entire captive population.

5.2.1 ***Develop an initial captive propagation protocol***. A protocol must be developed to determine when and how many founders will be collected to begin a new captive population. The protocol will also address all of the actual rearing methods. A starting point for this protocol should be methods used in the last attempt to maintain a captive colony of *Novisuccinea chitenangoensis*. If known, appropriate changes should be made to previous rearing methods and areas of necessary research should be identified. This protocol should also address addition of new snails to the captive population over time, and when and how many *Novisuccinea chittenangoensis* should be transferred to other facilities. It may be necessary to identify the levels of genetic diversity that need to be maintained over a specified time frame. The protocol will also specify methods for releasing captive animals to the wild.

5.2.2 ***Establish and maintain the captive propagation program***. Based on information gathered from Action 5.2.1, reinitiate the captive breeding programs at the appropriate zoo facilities.

5.2.3 ***Conduct research experiments to refine rearing protocols.*** Further research is necessary to determine optimal conditions for maintaining healthy populations. Conducting an inbreeding study to determine what impact inbreeding actually has on *Novisuccinea chittenangoensis* should also be considered.

5.3 ***Research the potential for augmenting the extant Chittenango Falls population with captive offspring.*** Once healthy, sustained captive populations of *Novisuccinea chittenangoensis* are successfully established, release of snails back to the extant Chittenango Falls site can be considered. Further research is necessary to determine when (which stage), how many, and how *Novisuccinea chittenangoensis* should be released.

5.4 ***As appropriate, establish additional*** **Novisuccinea chittenangoensis** ***populations within the species' likely Post-Pleistocene range.*** As more is learned about the ability of these animals to survive and reproduce within new habitats, a protocol for operational releases or management and monitoring of new populations should be developed in order to gauge progress toward meeting the recovery objective of ensuring self-sustaining populations of *Novisuccinea chittenangoensis* in the wild.

5.4.1 ***Develop a protocol for evaluating potential release sites.*** Based on information learned from habitat monitoring at the extant site at Chittenango Falls, it should be possible to narrow the search image for other potentially suitable areas for *Novisuccinea chittenangoensis*. One factor considered to be essential is the presence of *Succinea sp*. B.

5.4.2 ***Survey appropriate habitats to identify potentially suitable sites for establishing new populations.*** After defining potentially suitable *Novisuccinea chittenangoensis* habitat (Action 3.2), begin conducting surveys and monitoring to find these sites that meet this criteria. At this time, Chittenango Falls appears to be the only potentially suitable site for establishment of new populations. However, once more is learned about the potential historic range of the species (Action 5.1), the need to survey other appropriate habitats to identify potentially suitable release sites may be reconsidered.

5.4.3 ***Determine methods for establishing additional populations.*** It needs to be determined whether captive individuals or individuals from the extant population should be used to establish any additional populations. Information from Action 5.3 can be used to determine appropriate reintroduction/translocation techniques.

5.4.4 ***Establish additional*** **Novisuccinea chittenangoensis** ***populations if determined feasible and appropriate.*** After locating suitable sites (5.4.2) and determining appropriate methods (5.4.3), the process of establishing additional populations should be initiated. Should any additional sites be established away from Chittenango Falls, they will also need management plans (Action 2.2.4).

6. ***Review and track recovery progress.***

6.1 ***Create a data repository for captive population reports, wild population survey reports, scientific research, etc.*** A single collection point for information on *Novisuccinea chittenangoensis* will streamline recovery efforts.

6.2 ***Conduct recovery team meetings as needed.*** Conference calls or meetings should be held to discuss new information, make decisions on field or captive techniques, and exchange information in general.

6.3 ***Revise recovery plan as appropriate.*** At a minimum, the recovery plan should be reviewed every 5 years to ensure it reflects the current needs of the species. If necessary, the plan

should be revised to incorporate research findings and any other changes in the status of the species or threats.

6.4 ***Develop and implement a monitoring strategy.***

6.4.1 ***Monitor the implementation/completion of actions.*** It is necessary to track progress towards completing the various actions deemed necessary for recovery of *Novisuccinea chittenangoensis*.

6.4.2 ***Monitor the effects of any management actions conducted for*** **Novisuccinea chittenangoensis.** In order to determine the effectiveness of the various prescribed management actions, it is essential to monitor the response of the species to various management practices. This would entail monitoring the population before, during, and after management efforts are undertaken.

6.4.3 ***Monitor current or potential threats to the species.*** In addition to monitoring *Novisuccinea chittenangoensis*' response to various management actions, it is essential to monitor the known and potential threats to the species. While monitoring *Novisuccinea chittenangoensis'* population size and distribution, supplemental information on the threats to the species will further increase our understanding of these relationships. Monitoring will also help to identify new threat sources or threats that may have been previously overlooked (e.g., predation).

6.4.4 ***Monitor the biological status of*** **Novisuccinea chittenangoensis.** After taking into account various effects of management actions, implementation of other actions, and the status of various threats to the species, the biological status of *Novisuccinea chittenangoensis* must be monitored. It is essential for the monitoring strategy to lead to a determination as to whether there are stable, increasing, or decreasing populations of *Novisuccinea chittenangoensis* in the wild and in captivity.

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PART III. IMPLEMENTATION

The following Implementation Schedule outlines actions and estimated costs for the Chittenango ovate amber snail recovery program over the next 3 years. It is a guide for meeting recovery objectives discussed in Part II of this plan. This schedule indicates action priorities, action numbers, action descriptions, duration of actions, and estimated costs. In addition, parties with authority, responsibility, or expressed interest to implement a specific recovery action are identified in the schedule. The listing of a party in the Implementation Schedule neither requires nor implies a requirement for the identified party to implement the action(s) or secure funding for implementing the action(s). However, parties willing to participate may benefit by being able to show in their own budgets that their funding request is for a recovery action identified in an approved recovery plan and is, therefore, considered a necessary action for the overall coordinated effort to recover the Chittenango ovate amber snail. Also, section 7(a)(1) of the ESA, as amended, directs all Federal agencies to utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of threatened and endangered species. The schedule will be updated as recovery actions are accomplished.

KEY TO IMPLEMENTATION SCHEDULE PRIORITIES (column 1)

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2: An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

KEY TO RESPONSIBLE AGENCIES (column 5)

FWS	=	Region Five, U.S. Fish and Wildlife Service
NYSDEC	=	New York State Department of Environmental Conservation
OPRHP	=	New York State Office of Parks, Recreation and Historic Preservation
Zoos	=	Zoological institutions such as the Wildlife Conservation Park/Bronx Zoo and Burnet Park Zoo (Rosamond Gifford Zoo)
Acad. Inst.	=	Academic institutions
OSA	=	Natural resource agencies from States or provinces other than New York
Cons	=	The Nature Conservancy and/or other conservation organizations
USGS	=	U.S. Geological Survey
Team	=	Chittenango Ovate Amber Snail Recovery Team

IMPLEMENTATION SCHEDULE

Chittenango Ovate Amber Snail Revised Recovery Plan February 2006

Priority	Action Number	Action Description	Recovery Criterion Number	Action Duration (Years)	Responsibility		Est. Costs ($1000)			Comments
					Parties	Is FWS Lead?	FY1	FY2	FY3	
1	1.1	Re-evaluate the taxonomic relationship between *Novisuccinea chittenangoensis* and other snails	3,4	2	Acad. Inst., USGS, FWS	Y	8	7		Cost includes development of genetic markers.
1	1.2	Assist with future identification of snails at other sites.	7	5	Acad Inst., USGS, FWS	Y	--	1-2	1-2	+ $1-2K for FY4-6. Dependent on number of samples collected under Action 5.1.2.
1	2.1.1	Establish a monitoring protocol to determine the baseline population at Chittenango Falls.	1	3	DEC, OPRHP, FWS	Y	2.5	--	--	Action funded FY02, FY03 and underway; due to be completed FY04.
1	2.1.2	Establish a long-term monitoring protocol for subsequent surveys at Chittenango Falls.	1	1	DEC, Acad. Inst, FWS	Y	--	--	--	Information gathered from Action 2.1.1 will assist with this action.
1	2.1.3	Conduct surveys based on the monitoring protocols in occupied habitats.	1,6	As needed	DEC, OPRHP, FWS	Y	3	3	3	+ $3K/yr for FY4-8 Volunteers and Section 6 funds are used for this action. This may change once the survey protocol is finalized, as monitoring needs may vary among years.
1	2.2.1	Ensure consideration of habitat protection in any activities of Park personnel.	4	Ongoing-Yearly	DEC, OPRHP		--	--	--	Standard operating costs.
1	2.1.4	Develop a model to help understand how *Novisuccinea chittenangoensis'* life history characteristics influence the size and status of the population.	1,2	1-2	Acad. Inst., FWS, DEC	Y	10	10	--	
1	2.2.3	Continue to restrict access to the population and habitat at Chittenango Falls.	4	Ongoing-Yearly	OPRHP		--	--	--	Standard staff costs.
1	2.2.4	Develop a *Novisuccinea chittenangoensis* management/protection agreement for Chittenango Falls.	7	1-2	DEC, OPRHP, FWS		--	--	--	Standard staff costs.

IMPLEMENTATION SCHEDULE

Chittenango Ovate Amber Snail Revised Recovery Plan February 2006

Priority	Action Number	Action Description	Recovery Criterion Number	Action Duration (Years)	Responsibility		Est. Costs ($1000)			Comments
					Parties	Is FWS Lead?	FY1	FY2	FY3	
1	2.3.1	Provide information to both permanent and seasonal NYSOPRHP staff, on an annual basis, as to the presence and uniqueness of the species, and to the importance of protection of its habitat.	4	Yearly	DEC, OPRHP		--	--	--	Standard staff costs.
1	3.1	Determine if *Succinea* sp. B is having a negative impact on *Novisuccinea chittenangoensis*.	4	3	DEC, Zoos, Acad. Inst., FWS	Y	20	20	20	Study design in first year +$20K/yr for two-year study. Research initiated in 2005.
1	3.2	Further define vegetative composition and structure of habitat used by *Novisuccinea chittenangoensis.*	7	1-2 years	DEC, Acad. Inst., FWS	Y	5	5	--	
1	4	Research techniques for removal of *Succinea* sp. B from *Novisuccinea chittenangoensis'* habitat at the Falls.	4,7	2	DEC, OPRHP, FWS	Y	--	10	10	+$5K/yr for FY4, 5, and 6; initial costs high because of intensive monitoring needs; tied closely to Actions 2.1.1 and 3.1.
1	5.2.1	Develop an initial captive propagation protocol.	2	1	DEC, Zoos, Acad. Inst., FWS	Y	5	--	--	
1	5.2.2	Establish and maintain the captive propagation program.	2	20	DEC, Zoos, FWS		--	15	15	+$15K for FY4-20. These are costs per facility and will be refined when the means for establishing a captive population are determined.
1	5.2.3	Conduct research experiments to refine rearing protocols.	2	As needed	DEC, Zoos, Acad. Inst., FWS		--	--	5	+$5K for FY 4-5. Costs in addition to those associated with 5.2.2.
1	5.3	Research the potential for augmenting the extant Chittenango Falls population with captive offspring.	7	As needed	Zoos		--	--	--	To begin after Action 2.2 has been initiated. Possible joint research along with Action 5.4.3. ($15K for 2 years)

IMPLEMENTATION SCHEDULE

Chittenango Ovate Amber Snail Revised Recovery Plan February 2006

Priority	Action Number	Action Description	Recovery Criterion Number	Action Duration (Years)	Responsibility		Est. Costs ($1000)			Comments
					Parties	Is FWS Lead?	FY1	FY2	FY3	
2	2.2.2	Inhibit or prevent, when possible, human-induced alterations that may adversely affect the snail's habitat at Chittenango Falls.	4	As needed	DEC, FWS, OPRHP		--	--	--	Costs contingent on need to offset unpredictable natural hazards, e.g., removing loose boulders above *Novisuccinea chittenangoensis* habitat.
2	2.3.2.1	Improve and maintain the permanent display panel erected near the main parking area, keeping it accessible to all patrons and develop any other necessary signage.	4	Ongoing	DEC, OPRHP		2	--	--	Replacement of the sign, a new smaller sign along the trail. + $500 every 3 years for sign maintenance.
2	2.4.1	Monitor public use and enforce rules to keep visitors off the Falls.	4	Ongoing-Yearly	OPRHP		--	--	--	Enforcement part of standard park operating costs.
2	2.4.2	Enforce water quality regulations along Chittenango Creek upstream of Chittenango Falls.	4	Ongoing	DEC, FWS		--	--	--	Enforcement part of State/Federal standard costs.
2	2.4.3	Coordinate collecting or other scientific permits that could result in possible take of the species.	4	Ongoing	DEC, FWS		--	--	--	No chargeable expenses.
2	3.3	Determine effects of changes in hydrology on *Novisuccinea chittenangoensis* and its habitat.	7	2	Acad. Inst., DEC, FWS	Y	--	20	20	Costs associated with joint research project including Actions 3.4, 3.5
2	3.4	Determine effects of changes in temperature, humidity, substrate, light, and other factors on *Novisuccinea chittenangoensis*.	7	2	DEC, FWS Acad. Inst.,	Y	--	--	--	Costs associated with joint research project along with Actions 3.3, 3.5
2	3.5	Investigate the effects of environmental contaminants, water quality, and pH on *Novisuccinea chittenangoensis* and its habitat.	7	2	DEC, Acad. Inst., Zoos, FWS	Y	--	--	--	Costs associated with joint research project along with Actions 3.3, 3.4
2	5.4.1	Develop a protocol for evaluating potential release sites.	7	1	DEC, Acad. Inst., Zoos, FWS	Y	--	--	--	Standard staff costs.
2	5.4.2	Survey appropriate habitats to identify potentially suitable sites for establishing new populations.	7	1-2	DEC, FWS OPRHP, Acad. Inst.	Y	--	--	--	Coordinated with Action 5.4.3; this action will not begin until Action 2.4.1 is completed.

IMPLEMENTATION SCHEDULE

Chittenango Ovate Amber Snail Revised Recovery Plan February 2006

Priority	Action Number	Action Description	Recovery Criterion Number	Action Duration (Years)	Responsibility		Est. Costs ($1000)			Comments
					Parties	Is FWS Lead?	FY1	FY2	FY3	
2	5.4.3	Determine methods for establishing additional populations.	7	2	DEC OPRHP Acad. Inst., FWS	Y	--	--	--	See Action 5.3
2	5.4.4	Establish additional *Novisuccinea chittenangoensis* populations if determined feasible and appropriate.	7	As needed	DEC, OPRHP, FWS	Y	--	--	--	Standard staff costs. Monitoring costs are included under Action 2.1.3.
3	2.3.2.2	Upon request, provide additional information in the form of brochures or reports on the species.	4	As needed	DEC OPRHP		--	--	--	Fact sheets available; costs include park brochure that highlights, among other things, *Novisuccinea chittenangoensis* protection.
3	5.1.1	Check succineid collections at various institutions to determine whether any additional colonies exist.	7	1	DEC, FWS		--	--	--	
3	5.1.2	Survey similar appropriate habitats within the eastern U.S. and Canada to locate additional colonies of *Novisuccinea chittenangoensis*, if any, and to identify suitable habitats for establishing new colonies.	7	5	DEC, OPRHP, Acad. Inst., OSA, Cons, FWS	Y	--	7	5	Comprehensive survey. +1K FY 4,5,6.
3	6.1	Create a data repository for captive population reports, wild population survey reports, scientific research, etc.	5,7	Ongoing	DEC, FWS	Y	--	--	--	Standard staff costs.
3	6.2	Conduct recovery team meetings, as needed.	5,7	Periodic, FWS	Team	Y	--	--	--	Standard staff costs.
3	6.3	Revise plan as appropriate.	5,7	Review every 5 years	Team, FWS	Y	--	--	--	Standard staff costs.
3	6.4.1	Monitor implementation/completion of actions.	5,7	Yearly	Team, FWS	Y	--	--	--	Standard staff costs.

IMPLEMENTATION SCHEDULE

Chittenango Ovate Amber Snail Revised Recovery Plan February 2006

Priority	Action Number	Action Description	Recovery Criterion Number	Action Duration (Years)	Responsibility		Est. Costs ($1000)			Comments
					Parties	Is FWS Lead?	FY1	FY2	FY3	
3	6.4.2	Monitor the effects of any management actions conducted for *Novisuccinea chittenangoensis*.	5,7	As needed	DEC OPRHP, Acad. Inst. Zoos, FWS	Y	--	--	--	Standard staff costs.
3	6.4.3	Monitor current or potential threats to the species.	5,7	As needed	DEC OPRHP Acad. Inst. Zoos, FWS	Y	--	--	--	Standard staff costs.
3	6.4.4	Monitor the biological status of *Novisuccinea chittenangoensis*.	5,7	Every 5 years	DEC OPRHP Zoos	Y	--	--	--	Standard staff costs.

APPENDIX A.

The Succineid Snail Fauna of Chittenango Falls, New York: Taxonomic Status with Comparisons to Other Relevant Taxa.

Proceedings of The Academy of Natural Sciences of Philadelphia 139:465-526, 1987.

K. Elaine Hoagland and George M. Davis
The Academy of Natural Sciences, 19th and the Parkway, Philadelphia PA 19103

ABSTRACT.--In order to determine the relationships between *Succinea ovalis* Say, *S. ovalis chittenangoensis* Pilsbry of Chittenango Falls, New York, and specimens of uncertain affinity from Minnesota, electrophoretic studies of allozymes were conducted. *Oxyloma retusa* Lea and *O. decampi gouldi* Pilsbry of Chittenango Falls were included in the analysis for comparison. Via electrophoresis and shell morphometrics, we found yet another taxon at Chittenango Falls, *Succinea* sp., with shell shape similar to *Succinea putris* (Linnaeus) of Europe. Subsequent collection yielded two unknown species discovered by noting differences in morality rate in the laboratory, considerable anatomical differences, and later, electrophoretic data. Anatomical studies were done on the above *Succinea*, including *S. putris* of Holland, and a population of *Succinea* from Philadelphia that also has a shell shape similar to *S. putris*. Because we could not find living topotypical *S. ovalis* from Philadelphia, we dissected topotypical material collected in 1923 to confirm the anatomy of *S. ovalis*. *Succinea chittenangoensis* is indistinguishable electrophoretically from *S. ovalis*, but has anatomical and shell-morphological differences worthy of species status. The Minnesota specimens belong to two closely-related taxa, probably subspecies, that in turn are specifically distinct from but in the same species group as *S. ovalis* and *S. chittenangoensis*. These taxa are relegated to the genus *Novisuccinea* Pilsbry. The two *Oxyloma* taxa group as a genus distinct from *Succinea*, as expected. Based on electrophoresis, the *Succinea* spp. of Chittenango Falls and Philadelphia are members of *Succinea* s.s., more closely related to *Oxyloma* than to *Novisuccinea*. Within *Succinea* s.s., one population from New York was referrable to *S. pennsylvanica* Pilsbry; the other, along with the population from Philadelphia, grouped with the *S. putris* species complex. We conclude that *N. chittenangoensis* is a valid species and a member of the *N. ovalis* species complex along with the species from Minnesota. *S. putris* in Europe is probably a species complex, i.e. a superspecies, with some members found in North America. [allozymes, anatomy, endangered species, introduced species, Minnesota, New York, Pennsylvania, Succineidae, *Succinea ovalis chittenangoensis*, *Succinea putris*, systematics]

APPENDIX B.

Aloi, M.A. 1985. Population dynamics of a pulmonate snail adjacent to a central New York stream.

Unpublished MS thesis. State University of New York, College of Environmental Science and Forestry. 116 pp.

Abstract

Population dynamics and life history characteristics were determined for two species of pulmonate snail (Gastropoda; Succineidae) found near the base of Chittenango Falls, Madison Co., New York. The species studied were Succinea ovalis chittenangoensis (Pilsbry), regarded as endangered by the NYSDEC and a "gray morph" population whose species identity appears to be Succinea putris (L.). Mark-recapture data for the gray morph population were collected during the summers of 1982, 1983, and 1984. Mark-recapture data for Succinea chittenangoensis were collected during 1982 and 1983, but remained unchanged between 1983 and 1984. Density of the snails ranged from 1.4 - 11.5 snails/m^2 during 1984. The population size and density of both species populations found on the face of the falls did not change significantly between the sampling years. Several models of population estimation were applied to the data collected during 1984. These were the Schnabel, the Jolly-Seber, the Bailey triple-catch, and a modified Removal model. All gave similar results when the various assumptions were met. The Jolly-Seber method was robust in estimating death rates, whereas the Bailey triple-catch method was not. A life table of the gray morph population was constructed utilizing the data collected. Gray morph individuals had a life span of approximately 1 year, and their fecundity was approximately 160 eggs/snail. Reproduction occurred later in the season than reported for many succineids. The potential for adverse interaction between S. chittenangoensis and the gray morph should be further examined in the event that the gray morph is confirmed as a European introduction.

APPENDIX C.

Thomee, E.T. 1986. Behavioral ecology of the endangered Chittenango ovate amber snail *Succinea chittenangoensis* and a sympatric introduced succineid.

Unpublished MS thesis. State University of New York, College of Environmental Science and Forestry. 227 pp.

Abstract

A 2-year, descriptive field study of *Succinea chittenangoensis* (*Novisuccinea chittenangoensis*), an endangered stylommatophoran gastropod, was conducted in 1983-1984 to determine its life history, behavioral ecology, and requirements for survival. Distribution was limited to a few vertical square meters of saturated, weedy, limestone shelves beside the base of a shaded, 49-meter, north-facing waterfall in Madison County, New York. A European isomorph, *Succinea putris* (never before verified as having migrated to the continental U.S.) was discovered surrounding and sharing the habitat, considered a threat, and studied as well.

Lifespan of *Novisuccinea chittenangoensis* was 2 to 2.5 years, based on shell characters and range of sizes seen. It appeared in May, copulated in June, deposited eggs in July, suffered an abrupt dieoff, became cryptic in August, and overwintered under think ice overhangs. The highest density of *Novisuccinea chittenangoensis* was always near seeps; multiple regression analyses predicted highest densities in plots with blue *Aster, Bidens* sp., exposed wet soil, low light and no Graminae spp. Individual (modal) *Novisuccinea chittenangoensis* were most often seen on green, dry *Eupatorium purpureum*, *Angelica purpurea* and blue *Aster*. Modal microhabitat variable values for individuals were: temperature 16 C, relative humidity 100 percent, 1615 to 7535 lux, and windspeed 0. Field activity correlated positively with wet green vegetation, relative humidity >85 percent, temperature >16 C, light 1615 to 2691 1x, morning hours, and no wind.

S. putris lifespan was 1 to 1.5 years. It reproduced earlier, and for a longer period than *Novisuccinea chittenangoensis*: a seasonal average of 9 masses of 37 eggs or 326 eggs/snail in biweekly peaks (low estimate, determined by culturing). *S. putris* density was lower near seeps, it favored dead vegetation, and its habitat had less stability of temperature and moisture, and more hours of full light, than *Novisuccinea chittenangoensis* habitat. Otherwise, habitats overlapped physically, botanically and microclimatically.

The historical length and nature of the association between the two species remains unresolved; future management decisions would be enhanced by clarification. Further investigation of *Novisuccinea chittenangoensis* requirements is needed prior to attempts to relocate snails, as this study was limited in physical and seasonal scope. Tracking of the *Novisuccinea chittenangoensis* population is important, if it can be done in a non-invasive manner. Factors most adversely affecting survival of the *Novisuccinea chittenangoensis* population are potential competition with *S. putris*, and physical disturbance by man.

APPENDIX D.

MOLLOY, ANDREW. W. Studies on the endangered Chittenango ovate amber snail (*Novisuccinea chittenangoensis*) and related species of the Chittenango Creek watershed.

Typed and bound thesis, 150 pages, 26 tables, 42 figures, 1995.

The Chittenango Ovate Amber Snail (*Novisuccinea chittenangoensis*) is a terrestrial snail known to exist only on ledges adjacent to Chittenango Falls in Madison County, New York. The population has declined to an estimated 25-50 adults. Field and laboratory studies were conducted on the Chittenango Ovate Amber snail and a coexisting succineid snail, *Succinea* sp. B, which may be a competitor. A captive colony of Chittenango Ovate Amber Snail produced an F_2 generation, adults of which are now reproductively active. A survey of area waterfalls to examine sites for introduction of the Chittenango Ovate Amber Snail revealed few suitable sites. A point system to rate waterfalls was developed and applied. *Succinea* sp. B is widespread throughout the Chittenango watershed, from source to outlet. Experiments suggest that *Succinea* sp. B can use the water column and shorelines to spread downstream, complicating control efforts at Chittenango Falls. *Succinea* sp. B was found in higher densities on vegetation and wood substrates over rock and soil/mud.

APPENDIX E.

DRAFT PROTOCOL:
CHITTENANGO OVATE AMBER SNAIL (*NOVISUCCINEA CHITTENANGOENSIS*)
MARK-RELEASE-RECAPTURE SURVEY

Materials:

meter tape and flags	Bee tags and SuperGlue
plastic collecting jars for each survey block	calipers
containers for sorting snails	watch with second hand
field note book	pencils

The east ledge at the base of Chittenango Falls, previously identified as the primary Chittenango ovate amber snail (*N. chittenangoensis*) habitat, will be searched using a time- and area-constrained search. Each block will include 1 meter of ledge frontage and will extend back to bottom of vertical cliff and up 1 to 2 meters from the ledge. For record keeping, blocks will be numbered from "1" to "x" beginning at the block adjacent to the falls, with "x" being one block east of the eastern-most block that contained a *N. chittenangoensis.* Number of blocks can increase during the field season if *N. chittenangoensis* is found in the most eastern block. Limits of one meter wide blocks will be established with a meter tape and marked with temporary flags that will remain in place throughout the field season, beginning at the pre-established point 0.0 next to the falls. Each block will be surveyed for 15 minute intervals with collections placed in separate labeled plastic jars for each block. Record start and stop time and name of surveyor of each block. Searching should be done with minimal disturbance to the vegetation on the ledge and without surveyor standing or kneeling on the ledge except as necessary and only after surveyor has thoroughly searched and removed snails from affected area. All living and dead plant surfaces and substrate should be searched carefully. All live succineid snails and empty shells will be put in container numbered to correspond to block.

On completion of the search, each live snail or empty shell will be examined to determine species identification and checked for previously applied marks. Live *N. chittenangoensis*, live *Succinea* sp. B, unknowns (which may include immature individuals of either species), and empty shells will each be place in separate containers.

Number of snails in each group will be recorded. Snails identified as *S.* sp. B will not be put back in the habitat. They will be removed from the area and humanely euthanized or used for laboratory observations. Empty shells will be taken to the laboratory to be cleaned and sorted. The total shell height of all unidentified and *N. chittenangoensis* individuals will be measured with calipers. A numbered "bee tag" will be superglued to the bottom of the shell whorl of each *N. chittenangoensis* and each unidentified snail with a shell height of 6.0 mm or greater (Figure 1). Live marked snails will be placed back in same block where found. On subsequent searches number on bee tag on any snail found that has been previously marked will be noted. Survey will be repeated every 2 weeks throughout the field season for a minimum of ten replicates.

Figure E-1. Photograph of Chittenango ovate amber snail with bee tag (K. Breisch)

APPENDIX F.

OUTLINE OF RECOVERY TASKS FROM 1983 RECOVERY PLAN

PRIORITY 1 TASKS:

Task I.A.1	Assess Chittenango Ovate Amber Snail population.
Task I.A.2	Monitor Chittenango Ovate Amber Snail population.
Task I.B.1	Determine occupied habitat.
Task I.B.2	Prevent habitat destruction.
Task I.C.1	Determine non-point source pollution.
Task I.C.2	Monitor water quality.
Task I.D.1	Limit access to Chittenango Falls.
Task I.D.2	Evaluate access plan.
Task I.G	Expand biological data.

PRIORITY 2 TASKS:

Task I.C.3	Monitor sewage effluent.
Task I.C.4.a	Sample invertebrates.
Task I.C.4.b	Monitor contaminant levels.
Task I.C.4.c	Determine salinity effects.
Task I.E.1.a	Erect information/education display.
Task I.E.1.b	Provide information.
Task I.E.2	Provide news releases.
Task I.F	Law enforcement.
Task I.H.1	Expand range data.
Task I.H.2	Survey habitats.
Task I.H.3	Determine status of colonies.
Task II.B	Enhance habitat.

PRIORITY 3 TASK:

Task I.A	Enhance population.

APPENDIX G.

LIST OF REVIEWERS

In accordance with USFWS policy (USFWS and the National Oceanic and Atmospheric Administration 1994), requests for peer review of the draft plan were sent to independent scientific experts. These reviewers were asked to pay particular attention to: (1) adequacy of threats assessment in the plan, and (2) appropriateness of recovery strategy for a highly endemic species. Requests for peer review were sent to the following individuals:

Robert H. Cowie
University of Hawaii at Manoa
Honolulu, Hawaii

Dawn Dittman
U.S. Geological Survey
Tunison Laboratory of Aquatic Science
Cortland, New York

Ken Hotopp
Appalachian Conservation Biology
Frostburg, Maryland
Andrew Molloy
Syracuse University
Syracuse, New York

Timothy A. Pearce
Carnegie Museum of Natural History
Pittsburgh, Pennslyvania

Gary Rosenberg
Academy of Natural Sciences
Philadelphia, Pennsylvania

Detailed comments regarding biological information and recovery priorities in the plan were received from Robert Cowie, Ken Hotopp, Timothy Pearce, and Gary Rosenberg, most of whose comments have been incorporated into this final plan. The focus of these comments was on development of a population model, taxonomic clarification, captive propagation, research on the potential historic range, and introduction/reintroduction of *Novisuccinea chittenangoensis* at additional sites.

Comments were also offered by the following individuals and agency representatives (in addition to the Recovery Team) on the technical and/or agency drafts of the recovery plan. These comments have been incorporated as appropriate into the final plan. All comment letters are on file in the New York Field Office of the U.S. Fish and Wildlife Service, 3817 Luker Road, Cortland, New York 13045.

Sandy Bonanno
The Nature Conservancy
Pulaski, New York

Bernadette Castro
New York State Office of Parks, Recreation, and Historic Preservation
Albany, New York

Fran Lawlor
The Nature Conservancy
Pulaski, New York

David Stilwell
U.S. Fish and Wildlife Service
Cortland, New York

Kristian Whiteleather
Geneva, New York

Laury Zicari
U.S. Fish and Wildlife Service
Cortland, New York