Iowa Pleistocene Snail
(Discus macclintocki)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service, Midwest Region
Rock Island Ecological Services Field Office
Moline, Illinois
Driftless Area National Wildlife Refuge
McGregor, Iowa

5-YEAR REVIEW
Iowa Pleistocene snail (*Discus macclintocki*)

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional Office:
Carlita Payne, Recovery Coordinator, Midwest Region (612-713-5339)

Lead Field Office:
Kristen Lundh, Rock Island Ecological Services Field Office, Rock Island, IL (309-757-5800)
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1.2. Methodology used to complete the review

The Service solicited information from the public through a Federal Register notice (71 FR 16177) requesting new information on Iowa Pleistocene snail (*Discus macclintocki*) that may have a bearing on its classification as endangered. This review was completed by Cathy Henry at the Driftless Area National Wildlife Refuge (NWR) in McGregor, Iowa and Kristen Lundh, Rock Island, Illinois Field Office, Ecological Services. The Driftless Area NWR was established to meet recovery goals of the Iowa Pleistocene snail. Therefore, the majority of information related to this species was available at the Refuge or developed by Refuge staff through literature review, annual monitoring and site visits. The new information used to compile this review (Clark et al 2008) has undergone peer review during the publishing process.

1.3 Background

1.3.1 FR Notice citation announcing initiation of this review:

Federal Register vol. 71, No. 61, Thursday March 30, 2006, pp 16176-16177

1.3.2 Listing history

Original Listing
FR notice: Final Determination that Seven Eastern U.S. Land Snails are Endangered or Threatened Species July 3, 1978; 43 FR 28932

Entity listed: Species
Classification: Endangered

1.3.3 Associated rulemakings

NA

1.3.4 Review History

The Iowa Pleistocene snail was included in a cursory five-year review of all species listed in 1978 (December 8, 1983; 48 FR 55100) and a cursory review of all species listed before January 1, 1991 (56 FR 56882; November 6, 1991). These 5-year reviews resulted in no change to the listing classification of endangered.

1.3.5 Species' Recovery Priority Number at start of review

Recovery Priority number 14: Degree of threat considered low at the species level with high potential for recovery.

1.3.6 Recovery Plan

Name of plan: National Recovery Plan for Iowa Pleistocene snail (*Discus macclintocki*)

Date issued: March 22, 1984
Dates of previous revisions: NA

2.0 REVIEW ANALYSIS

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

2.1.1 Is the species under review a vertebrate?

No. The species is an invertebrate that is listed in its entire range; therefore, the DPS policy is not applicable to this listing.

2.2 Recovery Criteria

2.2.1. Does the species have a final, approved recovery plan containing objective, measurable criteria?

Yes.

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?

No. The number of known colonies has increased from 19 to 37 since issuance of the recovery plan in 1984. Based on this new information, a review of the recovery criteria is advised. New information on population demographics and monitoring methods that will help with achieving the recovery criteria over the long-term is now available, in addition to more information on buffer areas that are needed to protect the snail's habitat. There is new genetic information that should be considered when establishing the recovery criteria.

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

Recovery criteria:

> The Iowa Pleistocene snail can be considered for reclassification from endangered to threatened status if permanent protection of 16 of the existing colonies can be achieved and documentation of stable or increasing populations at these sites can be provided by a monitoring program.
>
> Delisting of the species can be considered if documentation of stringent protection of at least 24 or more sufficiently dispersed viable breeding colonies is obtainable (USFWS 1984).

Neither the criteria for reclassification from endangered to threatened nor the delisting criteria have been met. The recovery plan cites a total of 19 snail colonies as of 1984. Subsequent surveys in the 1980s located additional colonies so that there are now a total of 36 in Iowa and one in Illinois. At the time of the recovery plan, only 6 sites were in public ownership and these sites were not completely protected. As of 2007, there are 24 colonies in some form of protected ownership (Table 1). This includes Federal, state, and county fee title ownership as well as preserves owned by the Nature Conservancy and conservation easements held by the state of Iowa on private lands. However, 13 of these sites need additional protection to consider them permanently protected. Although these colonies are in protected ownership, additional buffer areas are needed adjacent to the algific slope habitat to eliminate threats (USFWS 1984). This buffer would primarily protect sinkholes important to cold air flow and also protect them from adjacent land uses such as row crop production. Twelve sites have no protection at all beyond landowner education.

The recovery plan states "The most important feature of the plan is the protection of existing *D. macclintocki* colonies by: 1) gaining control of relevant algific talus slopes; 2) protecting them from human disturbance." The number of existing colonies has increased to 37. A review of this new information should occur to determine if the initial reclassification criteria of protecting 16 colonies should be revised in order to adequately protect and recover the species.

The delisting criteria of stringent protection of at least 24 populations that are sufficiently dispersed was also based on the number of known populations at the time. As stated above, a review of the new population information should occur to determine if the number of protected, sufficiently dispersed viable breeding colonies should be increased to reflect the current information.

A population monitoring method was established in 2001 by the U.S. Fish and Wildlife Service (USFWS), Driftless Area NWR (Clark et al. 2003) with the objective to begin long-term monitoring that would allow the documentation of population trends as required by recovery criteria. Monitoring on select sites has taken place from 2001 through 2006 (Clark et al 2008). In the case of the Iowa Pleistocene snail, the monitoring of population trend that is required under the recovery plan is complicated because of its small size and habit of moving vertically through the litter layer. In addition, algific talus slope habitat is fragile because of steepness and loose rock covering. Activity on a site can dislodge rocks and soil, compact surface vents, and crush snails. Therefore, monitoring methods need to be minimally intrusive and yet be able to reliably detect snails. Although a double-sampling approach (Phillipi et al. 2001, Clark et al. 2003) helps to account for some of the biases, results suggest that the spatial-temporal variation will make it difficult to derive precise estimates using such procedures. However, population growth rates can be estimated. Analyses of six years of monitoring data showed that the estimation procedures based on the robust design used produced repeatable and precise estimates of population size at mark-recapture locations (Clark et al. 2008). Population demographic results from monitoring are described in Section 2.3.1.2.

Thus far, monitoring indicates that recruitment will be more responsible than survival for fluctuations in growth rate (Henry 2008). Fluctuations in recruitment might be a function of immediate threats to local habitat conditions, such as grazing or trampling on the sites, that would reduce plant cover and litter that is important as both food and cover. In contrast, factors such as global warming that could influence the subterranean ice, cold air drainage, and the unique microclimate of the sites might have long-term effects on adult survival and population persistence. Obviously damage from flooding that can remove much of the talus layer, leaving sites that are steep and unstable is a catastrophic loss of habitat and snails from which populations cannot demographically recover (Clark et al. 2003). Therefore, monitoring will be an important component in determining recovery, but may not indicate what is causing observed population growth rates, whether positive or negative. Monitoring needs to be done with consistent methods over a long term and will only indicate trends for populations at each site sampled.

Although a monitoring program has been developed, data to this point does not indicate whether populations are stable and so this portion of the reclassification criteria has also not been met. It will be difficult to extrapolate population trends from one site to the entire snail population because of the extreme variation between sites and the highly divided nature of snail populations within sites. However, information from multiple sites may allow some determination of the overall trend of snail populations.

The reclassification criteria and the delisting criteria both address listing factors A (the present or threatened destruction, modification, or curtailment of the species' habitat or range), B (overutilization for commercial, recreational, scientific, or educational purposes), D (the inadequacy of existing regulatory mechanisms), and E (other natural or manmade factors affecting the species survival). Listing factor C, (disease and predation) is not addressed by either of the recovery criteria. The recovery plan indicates that predation by shrews is a major cause of adult mortality, although it is a factor found in all land snails and can not be avoided. The recovery plan also cites Hubricht's 1972 finding of predation by cychrine beetles as a cause of mortality at one colony, although it states this threat had not been assessed. Still, at this time little is known about the affects of disease or predation on Iowa Pleistocene snails.

Although the above are the only recovery criteria given, there is a list of recovery actions that are divided into habitat protection, population management and protection, information and education. Eleven of the 16 recovery actions have been completed or are ongoing (USFWS 2008). Reintroduction of snails has had the least amount of attention.

Table 1. Summary of Iowa Pleistocene snail site protection.

Site (number or name if not numbered)	County/State	Ownership	Conservation easements on privately held land	Additional Protection Needed
206	Dubuque/IA	County		Yes
207	Dubuque/IA	Federal		No
279	Fayette/IA	Private	No	Yes
280	Fayette/IA	Private	No	Yes
281	Fayette/IA	Private	Yes	Yes
61	Clayton/IA	State		Yes
115	Clayton/IA	State		Yes
062	Clayton/IA	State		Yes
Bluebell Hollow 2	Dubuque/IA	Private	No	Yes
Bluebell Hollow 4	Dubuque/IA	Private	No	Yes
291	Fayette/IA	Private	Yes	Yes
98	Clayton/IA	The Nature Conservancy		Yes
99	Clayton/IA	The Nature Conservancy		Yes
103	Clayton/IA	Private	Partial	Yes
120	Clayton/IA	The Nature Conservancy		Yes
121	Clayton/IA	The Nature Conservancy		Yes
119	Clayton/IA	The Nature Conservancy		Yes
137	Clayton/IA	Private	No	Yes
138	Clayton/IA	Federal		No
29	Clayton/IA	Federal		No
76	Clayton/IA	Federal		No
302	Clinton/IA	Private	No	Yes
167	Clayton/IA	Private	No	Yes
246	Clayton/IA	Federal		No
247	Clayton/IA	Federal		No
249	Clayton/IA	Private	No	Yes
297	Jackson/IA	State		No
232	Jackson/IA	County		No
South Cedar Creek	Clayton/IA	Private	No	Yes
241	Delaware/IA	Private	No	Yes
33	Dubuque/IA	State		No
211	Dubuque/IA	State		No
83	Dubuque/IA	State		No
229	Clayton/IA	Federal		Yes
LM1	Dubuque/IA	Private	No	Yes
LM2	Dubuque/IA	Private	No	Yes
213	Jo Davies/IL	Private	No	Yes

2.3 Updated Information and Current Species Status

2.3.1. Biology and Habitat

2.3.1.1 New Information on the species' biology and life history:

No changes

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

Original population estimates are given by Frest (1981, 1982, 1983, 1985, 1986a-c, 1987, USFWS 1984) and range from 50 to 10,000 snails for individual sites. Frest conducted surveys to locate algific talus slope habitat in the 1980s and then sampled most of these for land snail species by obtaining litter grab samples. Many algific slopes were sampled only once and additional surveys may be needed to ensure that all Iowa Pleistocene snail locations are known. Since Frest's work, there have been three studies related to estimating and monitoring populations which are summarized below. Overall, the most complete and recent monitoring shows that recruitment is largely responsible for fluctuations in population growth and that snails are highly subdivided within sites (Clark et al. 2008). Comparing density estimates among studies or extrapolating total numbers within a site is problematic because of this (Clark et al. 2008). Overall, monitoring indicates that populations at each site have widely varying abundance and population growth rates.

Summary: A monitoring methodology for the Iowa Pleistocene snail (*Discus macclintocki*). W.R. Ostlie. 1992

Ostlie (1991) first experimented with methods for monitoring the Iowa Pleistocene snail in 1991 and 1992 using sampling boards at site 99. Population information from his work is summarized in Wallendorf and Clark (1992) below. Ostlie discussed the monitoring needs for this species and expressed the need to weigh the usefulness of the information gained against the potential impacts of disturbance caused by human monitoring on fragile algific slopes and subsequent damage to snails. In addition, at most sites there would be little management action that could occur to improve a population showing decline. He suggested some monitoring is needed, but should be restricted spatially and temporally.

Summary: Evaluation of a population monitoring methodology for *Discus macclintocki*. Wallendorf, M.J. and W.R. Clark. 1992.

Wallendorf and Clark used mark recapture data from Ostlie's (1992) sampling boards at four sites on one algific slope. They estimated survival rates and average population size during the sampling season. They determined a population estimate of 205,000 for the entire slope, but assumed uniform density of 86 snails/m^2 over the entire slope. Subsequent studies indicate this assumption is not realistic (Anderson 2000, Clark et al 2008). However, the mark recapture method with sampling boards did appear to be a good method for detecting and sampling Iowa Pleistocene snails and laid the groundwork for future monitoring and population demographics work.

Summary: Population size estimates for the endangered Iowa Pleistocene snail, *Discus macclintocki* Baker. T. K. Anderson. 2000.

Anderson estimated populations by quadrat litter searches and by using sampling cover boards placed on 12 algific slopes with mark recapture methods. Size estimates for Iowa Pleistocene snail populations in Iowa and Illinois ranged from 182 to 22,125 individuals. Two techniques, the program CAPTURE and Bayesian estimation, gave similar size results. The population estimates from this study showed large confidence intervals and are likely biased low and provide good minimum estimates to serve as baseline data. Using cover boards resulted in much higher probabilities of capture and more recaptures versus visual estimation in the leaf litter. Spatial heterogeneity in microhabitat conditions can have a large effect on snail presence or absence, even within an algific slope. This likely explains why snails are not uniformly distributed across algific talus slopes. There was little overall snail movement in this study, with an average movement of 0.7 m per day. It is uncertain how snail populations fluctuate and which habitat, seasonal, daily, and yearly qualities contribute to that fluctuation.

Anderson (2000) compared her estimates to Frest (Table 3) and found large confidence intervals. Anderson attempted to extrapolate estimates to suitable habitat although it was unclear how she quantitatively defined suitable habitat. Eight of 12 of Anderson's estimates were much higher than Frest's. Some of this difference is likely due to assumptions about suitable habitat area.

Table 3. Comparison of total population estimates from this study and those previously reported by Frest (1982, 1985, 1986). The estimates in the first two columns are calculated by extrapolating estimates (Tables 1 and 2) for the sampled area over the total potential habitat area. Confidence intervals (CI) are also extrapolated from the confidence intervals in tables 1 and 2. Slope numbers refer to numbers assigned in original reports by Frest (1981–1987). Slope 99 is divided into three distinct areas B, C, and X which were studied separately. Slopes marked with — could not be estimated under Chao's M(th) model.

Population	Chao M(th) (95% CI)	Bayesian (95% CI)	Frest's estimates	Area Sampled (m^2)	Potential Snail Habitat (m^2)
297	810 (234–3,334)	270 (156–364)	4,000—6,000	150	300
207	22,125 (9,000–92,625)	28,500 (10,500–51,750)	2,000	80	30,000[a]
103	298 (142–786)	200 (106–342)	2,000	69	138
247	182 (54–929)	193 (58–416)	500	70	126
120	740 (300–2,215)	540 (330–703)	4,000	186	465
99total	—	18,667	2,000	—	—
99B	941 (455–2,196)	1,680 (719–2,636)	—	157	342
99C	—	4,262 (556–16,308)	—	77	1,427
99X	—	19,690 (4,125–33,458)	—	36	660
62	981 (228–5,150)	1,282 (350–2,352)	400–600	78	142
98	1,629 (731–4,051)	2,114 (991–3,474)	1,000	84	240
121	11,946 (6,986–21,864)	19,809 (10,063–35,938)	2,000	72	1,035
33	20,698 (13,828–32,041)	20,234 (14,579–27,612)	600–1,000	67	740
119	21,602 (10,287–47,704)	25,806 (12,269–47,222)	2,000	108	1,000
246	—	297,300 (81,500–485,000)	1,000	150	15,000[b]

[a] Slope size estimate from Frest (1983)
[b] Slope size estimate from Frest (1985)

Summary: Demographic processes influencing population viability of the Iowa Pleistocene snail (*Discus macclintocki*). Clark et al. 2008.

A population monitoring protocol for the Iowa Pleistocene snail was initiated by the Driftless Area NWR in 2001 with the assistance of Dr. William Clark at Iowa State University (Clark et al. 2003). Monitoring continued through 2006. Monitoring occurred on the Driftless Area NWR, state lands, TNC preserves, and private sites. Sampling occurred on 12 total sites. Eight of these sites were sampled every year. The objective of Iowa Pleistocene snail monitoring was to establish population estimates for individual colonies and to determine population growth rates. Monitoring needed to be minimally intrusive because of the fragile algific slope habitat. A double-sampling monitoring scheme was designed based on sampling 5 boards (0.124 m^2, ~20 x 61 cm) placed at random locations across the site combined with intensive mark-recapture sampling at a cluster of 8 adjacent boards (0.991 m^2). Snails attach to the underside of the boards are more easily sampled. Snails were tagged and shell measurements taken. Environmental variables of soil temperature, air temperature and humidity were also recorded at each sampling location. Humidity at the time of sampling influenced captures, but soil and air temperature did not. Empirically, moisture under the boards seems to influence whether snails are at the surface and more easily sampled.

The mark-recapture sampling was designed to take advantage of the robust design (Pollock 1982, Kendall et al. 1997) that uses a combination of closed and open population models to estimate demographic parameters. Effectively, the design estimates abundance (N_i) for each year of the study (i = 1,6), assuming population closure during 5-day sampling periods (Williams et al. 2002) as implemented in program MARK (Cooch and White 2006). A major advantage of the robust design is that data from the 5-day sampling periods is used to assess variation in capture probability, enabling robust estimation of N_i and the vital rates of change between years. Analyses of six years of monitoring data showed that the estimation procedures based on the robust design produced repeatable and precise estimates of population size at the mark-recapture locations.

Results showed high variability in number of captures between years as expected (Tables 2 and 4). Most sites had less than 50 captures. Most sites had within-year and between-year recaptures with some snails captured multiple years. Site 281 however, ranged from 120 to 243 captures during mark-recapture sampling (Table 4). Sufficient recaptures occurred at sites 98, 207, and 281 to select appropriate models. The demographic analyses showed that finite population growth rate was constant at site 281. In contrast, at sites 98 and 207, where the population density was an order of magnitude lower, finite population growth fluctuated substantially among years. At site 98 the population initially increased and then declined steadily. Site 207, where average density was lowest, fluctuated around a constant mean population size rather than exhibiting decline (Table 4). Sampling showed a predominance of mature individuals (greater than or equal to 5 mm shell diameter) (Table 5). Overall, recruitment was shown to be a more important factor than survival in population growth.

Densities for three sites ranged from 26 to 583 snails/m^2. Sites 207 and 98 were also sampled by Anderson and so density estimates between the two studies were conservatively estimated as follows. At site 207 Anderson estimated 11.8 snails/m^2 and Clark et al. estimated 26 snails/m^2, and at site 98 Anderson estimated 114 snails/m^2 and Clark et al. estimated 51 snails/m^2. However, comparing density estimates among studies or extrapolating total numbers within a site is problematic because snail populations are highly subdivided within a site because of their sedentary nature and association with patches of suitable habitat. Although in the short-term, fluctuations in recruitment may influence local dynamics most substantially, long-term threats of habitat loss or climatic change will ultimately affect survival of adults and persistence of the populations.

Table 2. Number of snails captured on random boards located on algific slopes, summer 2001-2006.

Slope name	Slope number	2001	2002	2003	2004	2005	2006
Buck Creek 2	81-99	17	18	1	17	1	9
Buck Creek 1	81-98	12	15	4	3	0	1
Bear Creek 5	86-281	56	6	31	40	20	21
Bixby	80-62	13	0	3	4	0	1
Bankston West	83-207	2	0	0	1	0	5
Howard Creek 3	85-247	2	0	0	[a]	0	[a]
White Pine 2	80-33	16	3	14	0	4	[a]
Cow Branch West	85-229	1	0	0	0	0	0
Dry Mill East	81-137	[a]	26	14	10	7	21
Brush Creek	86-291	0	0	[a]	0	[a]	[a]
Lytle Creek 6	86-297	16	16	[a]	22	17	37
Dry Mill North	81-76	[a]	[a]	[a]	1	5	2

[a] site not sampled in this year.

Table 4. Snails captured (M_{t+1}), capture probability (p_i), estimated population (N_i), finite population growth rate (λ_i), apparent survival (Φ_i), per capita recruitment (f_i), and seniority (γ_i) of Iowa Pleistocene snail populations recaptured on 0.991 m^2 sample locations on 3 algific sites in northeastern Iowa, 2001-2006.

Site and Parameter	2001		2002		2003		2004		2005		2006	
Site 281												
M_{t+1}	142		172		180		172		88		91	
p_i [a]	0.30	(0.10)[b]	0.19	(0.05)	0.21	(0.08)	0.07	(0.01)	0.30	(0.09)	0.32	(0.08)
N_i	579	(162)	576	123	578	97	581	84	577	132	575	162
$\lambda_.$	1.00	(0.08)										
$\Phi_.$	0.38	(0.04)										
$f_.$	0.62											
$\gamma_.$			0.38									
Site 98												
M_{t+1}	28		86		8		20		1		5	
p_i	0.16	(0.04)	0.13	(0.02)	0.04	(0.02)	0.19	(0.05)	0.19	(0.12)	0.29	(0.12)
N_i	48	(11)	173	(26)	44	(25)	30	(6)	1	(0.02)	6	(2)
λ_i	3.78	(1.16)	0.37	(0.15)	0.51	(0.20)	0.00	(0.00)	ne[c]	ne	ne	
Φ_i	0.06	(0.06)	0.10	(0.04)	0.82	(0.28)	1.00	(0.00)	0.05	(0.05)	ne	
f_i	3.37	(1.05)	0.07	(0.06)	0.42	(0.47)	0.00	(0.00)	0.13	(0.09)	ne	
γ_{i+1}			0.02	(0.02)	0.60	(0.27)	0.65	(0.26)	1.00	(0.00)	0.26	(0.23)
Site 207												
M_{t+1}	16		4		11		29		17		26	
p_i	0.21	(0.06)	0.05	(0.06)	0.33	(0.08)	(0.29)	(0.05)	0.25	(0.06)	0.15	(0.04)
N_i	22	(5)	18	(23)	12	(2)	35	(4)	22	(4)	45	(11)
λ_i	0.96	(1.16)	0.58	(0.72)	2.79	(1.00)	0.67	(0.20)	1.90	(0.64)	ne	
Φ_i	0.19	(0.25)	0.16	(0.17)	0.21	(0.14)	0.20	(0.08)	0.62	(0.23)	ne	
f_i	0.76	(1.03)	0.43	(0.67)	2.58	(0.98)	0.48	(0.18)	1.28	(0.55)	ne	
γ_{i+1}			0.20	(0.22)	0.27	(0.35)	0.08	(0.05)	0.30	(0.12)	0.33	(0.11)

Table 5. Mean number of snails and percentage immature snails captured under 0.124 m^2 boards placed at random locations on algific slopes in northeastern Iowa, 2001-2006.

Site	Mean number captured	SE	Random locations	Percent immature	SE
281	5.92	(0.77)[a]	1,2,4	7.73	(3.35)
98	1.06	(0.73)	none	4.62	(3.17)
207	0.27	(0.84)	none	0.00	
33	1.48	(0.76)	1	4.32	(3.31)
62	0.32	(0.92)	none	2.00	(3.98)
99	2.13	(0.74)	4	8.50	(3.19)
137	3.29	(0.78)	2,4	13.88	(3.38)
297	5.04	(1.05)	3	14.44	(4.57)

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

One study (Ross 1999) was completed by Iowa State University on the genetics of the Iowa Pleistocene snail which is summarized below. In addition, Clark et al. (2008) state that the demographic analyses completed in their report support Ross' (1999) view that genetic diversity remains relatively high in these snail populations because they exist in numerous local demes with relatively low migration rates, even within sites and especially among sites. Like other studies of snails, self fertilization and reduction in population size may be major forces that reinforce local genetic drift helping to maintain the observed genetic structure (Viard et al. 1997, Backeljau et al. 2001). Differences in the demographic rates may provide the basis for substantially different rates of evolutionary change within and among sites.

Summary: Phylogeography and conservation genetics of the Iowa Pleistocene snail. T. K. Ross. 1999

Genetic diversity was extremely high within the 10 Iowa Pleistocene snail populations (33, 62, 99, 103, 119, 120, 121, 213, 232, and 297) sampled. Forty different haplotypes occurred within a 4000 km^2 region. Haplotypes formed monophyletic groups by the watershed on which they were found, suggesting that watersheds were important historical avenues of gene flow. This also suggests that flooding is the main method of dispersal for these snails. Genetic distances were strongly related to the geographical distance among all populations, but this relationship was dependent on the scale being considered. The data was suggestive that at least on small watersheds, gene flow might be in more than just the downstream direction. Habitat variation across high quality and less suitable habitat could influence genetic diversity if there is reduced movement across these patches on any particular slope. However, common haplotypes for a particular slope were distributed across the entire slope. Neither population size nor habitat area was related to haplotype diversity or nucleotide diversity, which suggests current population and slope size have little relationship to the amount of genetic variation within the population. Management should focus on maintaining the processes that allow for high genetic diversity and many different populations should be conserved if possible.

2.3.1.4 Taxonomic classification or changes in nomenclature:

No changes.

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

It is known from fossil records that the Iowa Pleistocene snail was distributed throughout the Midwest during the Pleistocene era (400,000 year ago). As the glaciers receded, the snail survived in small pockets of suitable habitat now known as algific talus slopes. In modern times, the snail populations have always been fragmented. Destruction of some algific slopes has reduced the range to its present distribution (USFWS 1984).

This species currently occurs in a small, discrete, specialized habitat type scattered throughout the range shown below (Figure 2). Since the time of surveys conducted in the early 1980's, the completion of the recovery plan, and the 1991 5-year review, more populations have been discovered, but the range has not changed. The habitat, or the Iowa Pleistocene snail, is not likely to occur outside this range (USFWS 1984). As stated above, additional surveys should be completed to ensure that all locations for this species within the known range (Clayton, Clinton, Delaware, Dubuque, Fayette, and Jackson counties, Iowa; Jo Davies County Illinois) are located. Recent monitoring indicates that populations are highly subdivided within sites due to patchiness of suitable habitat (Clark et al. 2008).

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

Since the Iowa Pleistocene snail occurs on a specific and unique habitat type, a brief explanation of the habitat is given here. The Iowa Pleistocene snail only occurs on high quality algific slopes with temperature ranges from about 35 to 45^{o}F. Air flows through fractured bedrock, over frozen groundwater, and out-vents on steep slopes to create a cold microclimate (Figure 1). These are talus covered slopes with thin soil that makes them extremely fragile and sensitive to disturbance, and irreplaceable. This habitat is known only to occur in the driftless area that overlaps the states of Illinois, Iowa, Minnesota, and Wisconsin (Figure 1) (USFWS 1984).

There are about 300 algific slopes in the driftless area, many of which are not suitable for the Iowa Pleistocene snail. The habitat available in the last 50 years has been disturbed and degraded due to human activities such as grazing, logging, sinkhole filling, and development (USFWS 1984). Some sites have also improved due to landowner education and assistance with fencing through Federal or state programs. Many of the sinkholes associated with algific slopes have been mapped (Henry 2008). Therefore, there is better information on what areas should be acquired to adequately protect the slopes. Some sites contain invasive plant species, most notably garlic mustard (*Alliaria petiolata*) (USFWS 2006). There is no defined baseline data, or complete animal or plant inventories on these sites, other than qualitative information to compare site conditions. Data loggers to record surface temperature were placed on sites 98, 22, 246, 75, 95, 295, 401 and 207 in the Driftless Area NWR in 2002 to begin gathering long-term temperature trends (Henry 2008).

Figure 1. Diagram of an Algific Talus Slope.

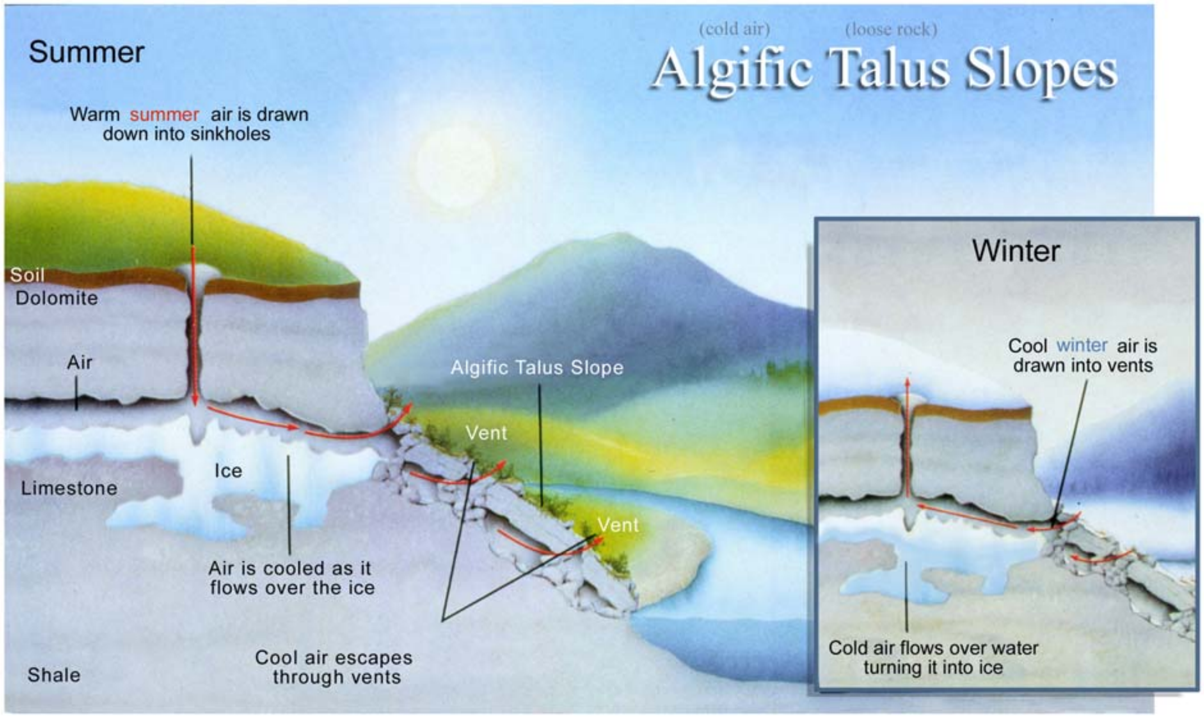
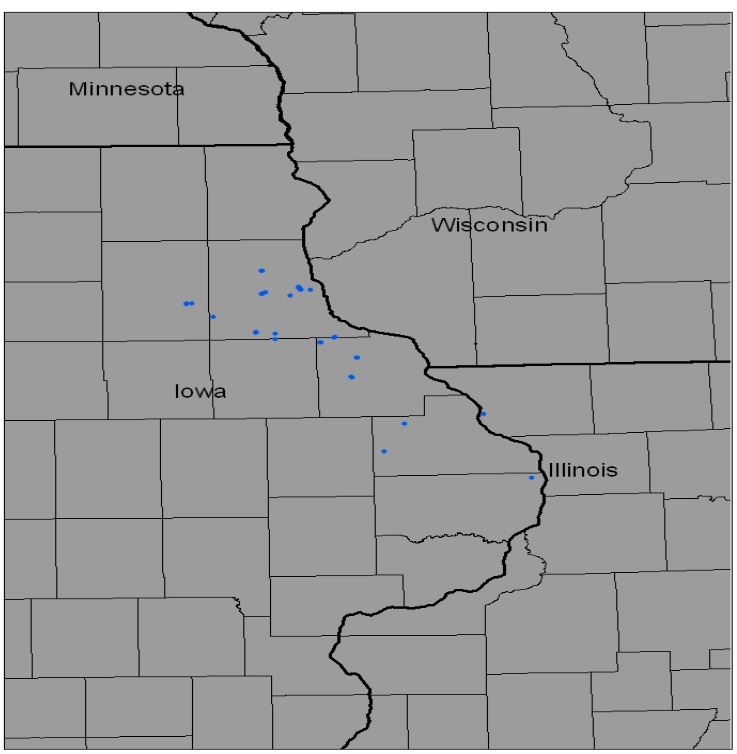


Figure 2. Locations of Iowa Pleistocene snail in northeast Iowa and northwest Illinois.



2.3.1.7 Other:

None

2.3.2 Five-Factor Analysis

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

The threats outlined in the recovery plan still apply (USFWS 1984). Those related to destruction or modifications of habitat are algific slope clearing, pasturing, human traffic, road building, subsurface modifications, other human related factors, natural calamities.

Increased development (primarily rural house building) in northeast Iowa since the issuance of the 1984 recovery plan and 1991 5-year review could threaten some sites as there tend to be scenic ridges above the algific slopes (Henry 2008). Most grazing threats have been alleviated by working with landowners to fence their sites. Landowner contacts occur regularly through the Driftless Area NWR to ensure landowners maintain fences and to monitor land use changes at all sites. Deer populations have greatly increased since the recovery plan was written and may impact some algific slopes with increased trails and trampling (Henry 2008). Sinkhole filling is still a concern when they occur in crop fields or pastures. Some are not intentionally filled, but are impacted by runoff from crop fields causing soil and probably agricultural chemicals to enter. Sinkhole searches and mapping have been completed for all snail locations and several of the sinkhole sites occur in forested areas where they likely will not be disturbed (Henry 2008). Landowners have been educated about the need to leave the sinkholes open.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

Overutilization is not a concern at this time.

2.3.2.3 Disease or predation:

There is little data since the issuance of the 1984 recovery plan and the 1991 5-year review to indicate the extent of the effects that disease and predation have.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

The Iowa Pleistocene snail is protected through the Endangered Species Act on public and private land. The algific slopes within the Refuge are closed to the public but there is no regular law enforcement patrolling which may affect the ability to detect impacts to the snails. There is little regulation in Iowa regarding sinkholes. There are USDA programs such as the Conservation Reserve Program (CRP) or the Wildlife Habitat Incentives Program (WHIP) available for buffering sinkholes, but the landowner has to be willing to enroll in the program.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

Climate change including warming trends is a potential threat to the habitat of the Iowa Pleistocene snail. Warming of the climate and the effects, or potential effects on wildlife has been, and continues to be, well documented (Hansen et al. 2006, Inkley et al. 2004). The Iowa Pleistocene snail is a glacial relict that lived in a cold climate historically. This snail has a narrow temperature tolerance of 35º-45ºF which is provided on algific talus slopes. Underground ice is critical to maintaining this habitat. Algific slope systems are relatively shallow systems with an annual freeze/thaw cycle (Figure 1). Presumably, if the freezing cycle is shorter and the thaw cycle is longer because of global warming, the system will be unable to perpetuate ice throughout the entire summer and the snail loss could be catastrophic. The slope needs to be cooled all summer long until winter temperatures arrive for the snail to survive.

The snail is not a mobile species and likely would not survive in other cold microclimates because of specific diet or other life history requirements. Inkley et al. (2004) state that species with small and/or isolated populations and low genetic variability will be least likely to withstand impacts of climate change. Other cold microclimates will also likely be affected by climate change making transplant only a temporary option. There is no data on how large the ice mass is and how much variation it can withstand before disappearing. Daily temperatures are being collected by refuge staff to begin a long-term dataset for algific slopes (Henry 2008).

Increased rain events could also impact the habitat. Sinkholes are a direct conduit for runoff and increased water may increase melting, or conversely may provide water for more ice formation. In addition, most snail sites are located directly above streams that are subject to flash flooding causing erosion of the algific slopes (Henry 2008).

Invasive species, primarily garlic mustard are overtaking some algific slopes (Henry 2008). It is not known whether the dominance of this species would affect the snail's food resources or other habitat characteristics in any way.

2.4 Synthesis

The Iowa Pleistocene snail has a very specific habitat tolerance and currently only occurs on 37 sites. Since the issuance of the 1984 recovery plan and the 1991 5-year review, there is additional information on genetics and population demographics. Buffer area needs have been more precisely identified to protect and preserve the algific slopes and their associated sinkholes from disturbance, runoff and other adverse adjacent land uses. Eighteen additional colonies have been located since completion of the recovery plan in 1984. Eighteen more colonies have also been protected through conservation easements or fee title acquisition, since the recovery plan, but the surrounding habitat remains vulnerable on many of these sites (USFWS 2006). Global warming and invasive species are emerging as new threats to the habitat of the Iowa Pleistocene snail. There is little new information on the life history of the snail.

The recovery criteria for downlisting are protection of 16 colonies and documentation of population status of stable or increasing via a monitoring program. The recovery criteria for delisting is protection of at least 24 sufficiently dispersed viable breeding colonies. Twenty-four colonies have been protected to date (USFWS 2006). However, 13 of the protected colonies need additional buffer protection to their habitat to ensure they are permanently protected (USFWS 2006). In addition, sites at the south end of the range in Iowa and in Illinois remain unprotected (USFWS 2006). These sites should be considered part of the 'sufficiently dispersed' protection criteria. More information is needed to better define a viable breeding colony from a genetics and population sustainability standpoint. The recovery plan states that 500 snails would be an effective breeding population -- this should be confirmed in future life history studies.

Algific slopes that do not contain Iowa Pleistocene snails should be evaluated for reintroduction suitability. A monitoring method has been developed and evaluated as suitable for monitoring recovery goals (Clark et al 2003). Monitoring will continue by the Driftless Area National Wildlife Refuge.

The recovery criteria numbers were based on the known populations at the time of recovery plan development and the potential for finding more. Protection of the majority of the sites was essentially advocated. Since there are now 37 known sites, the recovery criteria should be reviewed to consider the new sites. Criteria should also be more specific regarding what constitutes protection because of the need for buffer around the snail's habitat. Protection might be defined as "encompassing the entire algific slope and associated snail colonies and the sinkholes presumed to be associated with the site and buffer of at least *x number* of feet above the slope and at least *x number* of feet below the slope".

Global warming is perhaps the largest looming threat to the Iowa Pleistocene snail. More information on ice formation and melting in algific slopes is needed to understand how global warming or other effects of climate change will potentially affect this species. Modeling under different climate scenarios may help with predictions. Perhaps the climate scenarios can be achieved by obtaining estimates of the underground ice masses, air flow, and modeling under various climate scenarios. Presumably, with gradually warmer seasons, insufficient ice may reform in the winter to last through the summer, or the ice mass may disappear too fast in the summer. Eventually some threshold may be reached where cold air flow will cease. Temperatures on the algific slopes would then increase and snail colonies could conceivably be lost in one season. Climate change is happening gradually and any effects on the ice will likely take many years, but once that potential threshold is reached, the snails could be quickly impacted. Establishment of a laboratory colony for preservation, for additional life history study, and for study of how this glacial relict survives its cold environment may be justified.

The reclassification criteria outlined in the recovery plan has been partially met as 11 of the 16 colonies are protected, and according to the FY 2008 recovery data call, the overall status is "stable". The endangered status of the Iowa Pleistocene snail should remain because the original threats outlined in the final listing rule, recovery plan, and the additional threat of global warming, are present. The snail still meets the definition of endangered throughout all of its range and therefore, no change in the classification is recommended.

3.0 RESULTS

3.1 Recommended Classification:

__x_ No change is needed

3.2 New Recovery Priority Number _NA____

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4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

The recovery plan should be revised to include all currently known sites, monitoring and genetics information, global warming threat, and subsequent revised and more specific recovery criteria. More specific determination of the potential impacts of global warming should be done. Temperature monitoring should continue. If sufficient understanding of potential negative impacts is reached, a captive snail colony should be considered to propagate the species. Protection of sites through land acquisition and conservation easements should continue as well as landowner contact and education. The Driftless Area NWR expanded its acquisition boundary and acreage so that acquisition for this and other species can continue (USFWS 2006). The Iowa DNR has a USFWS Landowner Incentive Program grant in which additional conservation easements may be funded. Additional funding is needed to continue acquisition.

All potential sites where conditions are suitable for the Iowa Pleistocene snail should be thoroughly surveyed to determine their presence or absence so that all sites are known. The surveys should probably be done prior to revision of the recovery plan so that recovery criteria can reflect the total known sites. Information needs include viable breeding colony size, temperature tolerances, food requirements, and methods for potential reintroductions.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Iowa Pleistocene snail

Current Classification: Endangered____

Recommendation resulting from the 5-Year Review

____ **Downlist to Threatened**
____ **Uplist to Endangered**
____ **Delist**
__x_ **No change is needed**

Appropriate Listing/Reclassification Priority Number, if applicable __NA__

Review Conducted By: Cathy Henry and Kristen Lundh

FIELD OFFICE APPROVAL:
Lead Field Supervisor, Fish and Wildlife Service

Approve J. E. Miller acting Date 8/25/2009

REGIONAL OFFICE APPROVAL:
Lead Assistant Regional Director, Ecological Services, Fish and Wildlife Service, Midwest Region

Approve Lynn M. Lewis Date 8/31/09