Recovery Plan for the Newcomb's Snail

(Erinna newcombi)

Photo courtesy Susan Middleton and David Liittschwager, used by permission.

RECOVERY PLAN

for the

NEWCOMB'S SNAIL

(*Erinna newcombi*)

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: _____
Regional Director, Region 1, U.S. Fish and Wildlife Service
Acting

Date: MAY 4 2006

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Electronic copies may be found at:

- http://pacific.fws.gov/ecoservices/endangered/recovery/default.htm
- http://endangered.fws.gov/recovery/index.html

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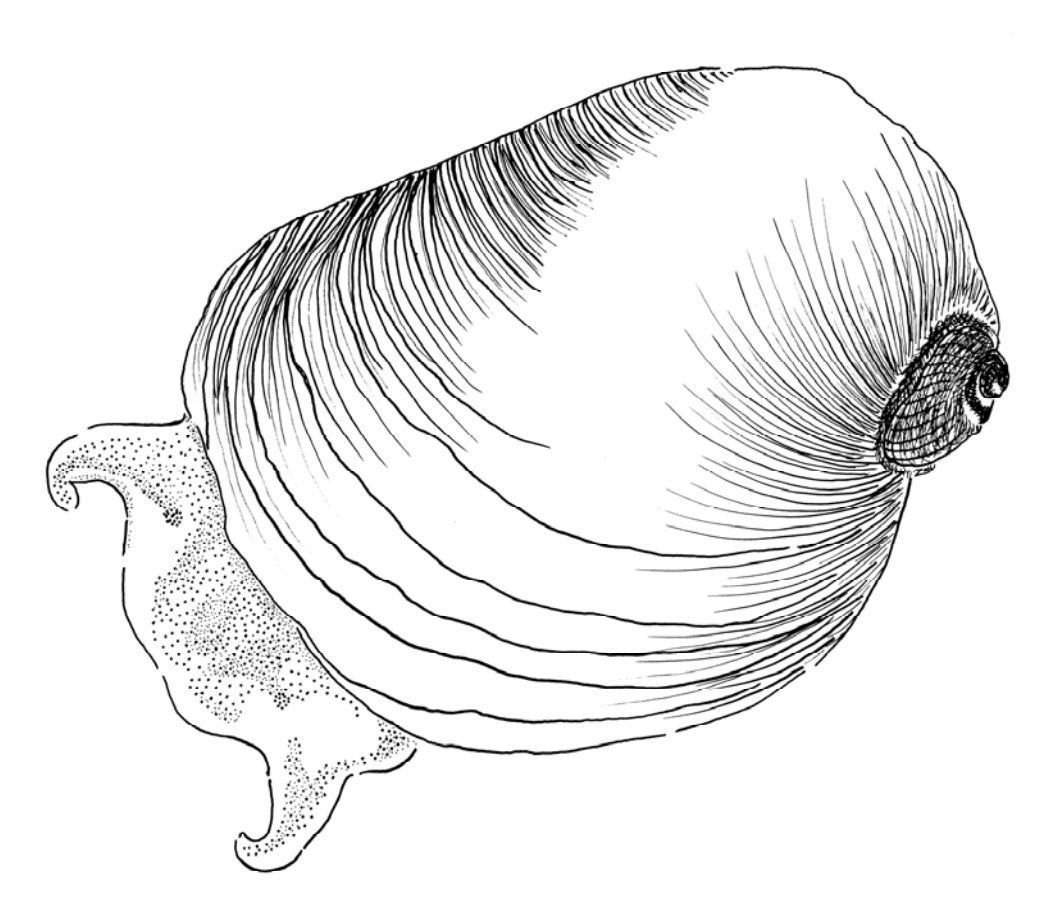

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EXECUTIVE SUMMARY

Current Species Status: Newcomb's snail (*Erinna newcombi*) is listed as a threatened species (U.S. Fish and Wildlife Service 2000). The range of this small freshwater aquatic snail is limited to 10 small stream and spring sites (subpopulations) located in 6 watersheds (populations) in the mountainous interior of the Hawaiian island of Kaua`i. The historical range of the Newcomb's snail includes at least four additional watersheds where the snail is thought to have become extirpated. Based on known data, we estimate that the 6 known populations of Newcomb's snails contain approximately 6,000 to 7,000 individuals, with the majority of individuals restricted to 2 of the 10 subpopulations (Kalalau and Lumaha`i).

Habitat Requirements and Limiting Factors: Newcomb's snail is restricted to cool, clean, moderate-to fast-flowing water in streams and springs located at mid-elevations in valleys on the island of Kaua`i. Currently, the known distribution is limited to 10 small sites (subpopulations) of approximately 2 to 30 square meters each (21.5 to 323 square feet). Suitable habitat appears to be limited primarily to spring-fed tributaries of streams and main channel areas that are protected from channel scour. The island-wide distribution of Newcomb's snail prior to human-caused alteration of surface and groundwater systems was probably limited by long-term water supply: these snails are only found in locations that appear to have hydrologic regimes supporting perennial water flow throughout even the most severe drought conditions. Introduced predators (found throughout their range) may be limiting factors that currently affect snail populations. These include the non-native predatory snail *Euglandina rosea*, two species of non-native marsh flies (*Sepedomerus macropus* and *Sepedon aenescens*) that prey on aquatic snails, and possibly other species.

Critical Habitat: On August 20, 2002, we designated critical habitat for the Newcomb's snail (U.S. Fish and Wildlife Service 2002). The designation includes eight stream segments and associated tributaries, springs, seeps, and adjacent riparian areas (populations) totaling 1,812 hectares (4,479 acres), and including 19.76 kilometers (12.28 miles) of stream channel. Critical habitat for the Newcomb's snail includes the six streams (populations) thought to be

occupied, and two streams where snails were observed historically but are now thought to be extirpated.

Recovery Objective: The objective of the actions proposed by this recovery plan is to recover the Newcomb's snail to the point where delisting is appropriate.

Recovery Priority Number: The recovery priority number for the Newcomb's snail is 7 on a scale of 1 to 18 (1 equals the highest priority), indicating that the snail faces a moderate degree of threat, has a high recovery potential, is a monotypic genus (not a species or subspecies), and does not currently involve a significant degree of resource management conflict, although recovery may, in the future, require resolution of conflicting priorities for consumptive use of groundwater and surface water flows on the island of Kaua`i.

Recovery Criteria: The criteria outlined in this recovery plan provide for maintenance of the majority of the genetic diversity of Newcomb's snail and provides assurance that a catastrophic event will not reduce population viability of Newcomb's snail.

The species can be considered for delisting when:

1. Abundance and population variability have been quantified and Newcomb's snail populations stabilize or increase in size due to natural reproduction for a minimum of 5 consecutive years (population goals can not be quantified here, because little fieldwork has been completed on this species in the past 10 years, and original data on sites and densities were rough estimates based on casual observance and not surveys conducted according to a protocol);

2. Populations are identified in a minimum of eight watersheds with a wide geographical distribution throughout the range of the Newcomb's snail;

3. Minimum in-stream flows protective of aquatic life are established and implemented for stream reaches containing Newcomb's snail populations;

4. Non-native predators and competitors have been studied, their effects on the snail quantified, and the appropriate control measures have been established and implemented in order to support the population goal researched under criterion 1 above; and

5. A post-delisting monitoring plan has been completed.

Actions Needed:

1. Confirm populations are extant, determine baseline snail population numbers;
2. Research the Newcomb's snail population biology and life history;
3. Analyze and prevent predation and other forms of negative interspecific interactions that may limit or reduce Newcomb's snail populations;
4. Protect spring and instream flows that provide Newcomb's snail habitat;
5. Incorporate recovery of Newcomb's snail into other landscape conservation efforts such as preservation of upland forests that maintain and regulate surface run-off to streams and act as areas of infiltration for groundwater;
6. Use initial recovery efforts and research to periodically validate recovery objectives; and
7. Develop and implement a public outreach program for Newcomb's snail conservation.

Date of Recovery: Delisting could be initiated by 2019, if conservation measures produce positive responses at each population site.

Estimated Cost of Recovery Actions: The estimated cost of recovering the Newcomb's snail is $2,530,000 through 2019 (see Implementation Schedule).

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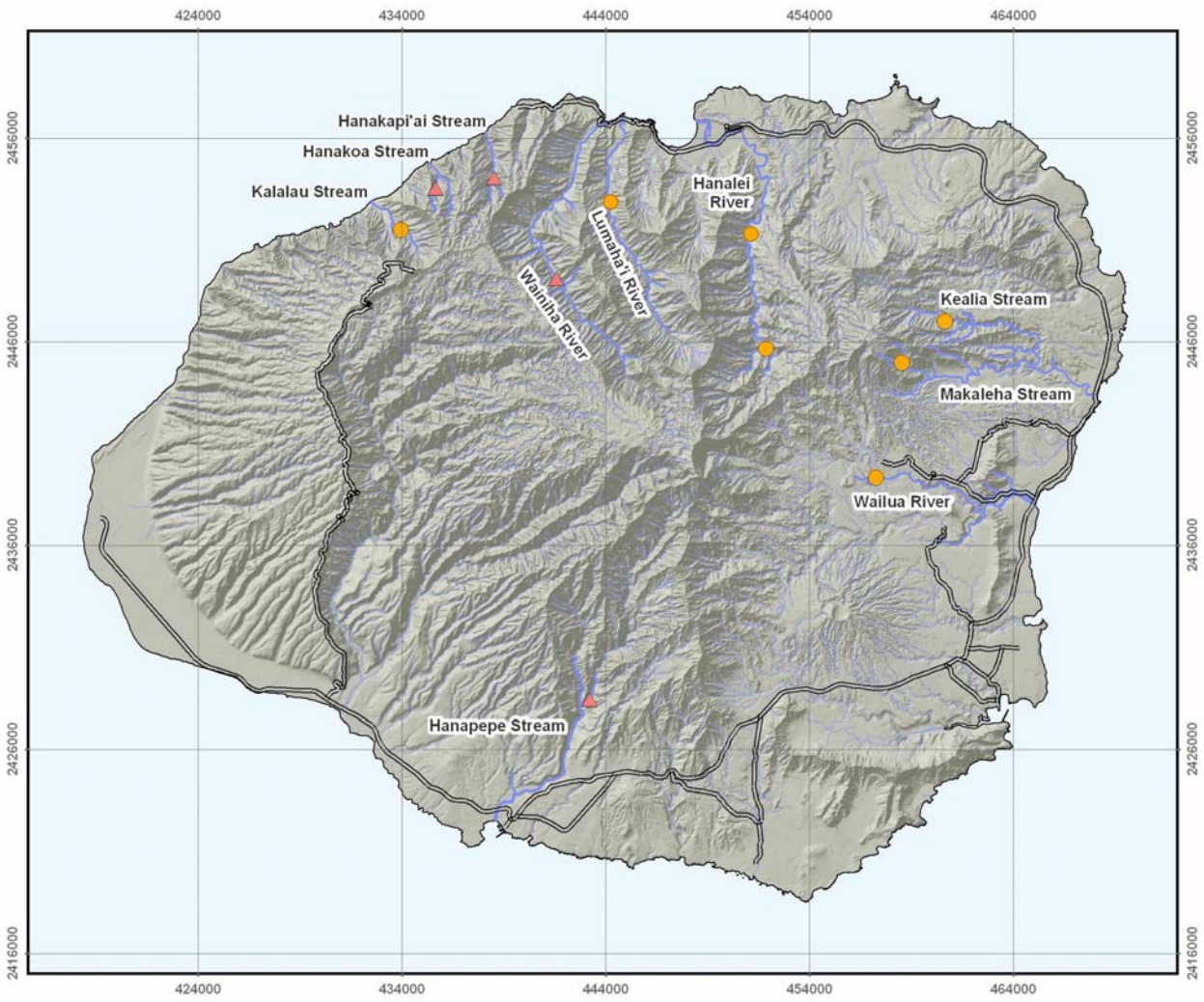
I. INTRODUCTION

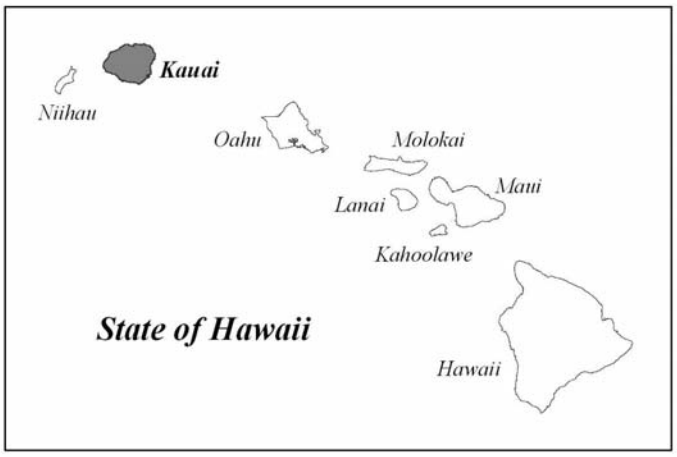
A. The Hawaiian Islands and Kaua`i

The Hawaiian archipelago consists of eight main islands and the numerous shoals and atolls of the northwestern Hawaiian Islands. Ongoing erosion has formed steep-walled valleys with well-developed soils and stream systems throughout the chain. Hawai`i Island, geologically the youngest of the islands, is characterized by gently sloping shield volcanoes and frequent, long-lasting eruptions. Volcanoes on the other islands are dormant or extinct. Kaua`i is characterized by deep valleys, high rainfall, abundant vegetation, and numerous streams and springs.

The island of Kaua`i (Figure 1) is 1,430 square kilometers (552 square miles) in size, the fourth largest of the Hawaiian Islands. Due to the geologic age and climate of the island, Kaua`i is heavily eroded with numerous steep, water-carved valleys and gulches. The prevailing northeasterly trade winds are typically laden with moisture in the subtropical central Pacific latitudes where Kaua`i is located. Substantial precipitation is brought to the windward and interior portions of the island as a result of uplift and cooling of the warm, moist surface airmass as it flows up and over the steep topography of the island. The high-elevation areas in the vicinity of the Alaka`i Plateau, such as Mt. Wai`ale`ale (1,569 meters, 5,248 feet), are among the rainiest places on earth, receiving an average of 11.3 meters (444 inches) of precipitation annually (Juvik and Juvik 1998). This large volume of rainwater flows to perennial and intermittent streams and wetlands, and infiltrates into the island's aquifers. The west and southwest coastal areas of the island lie in the rain shadow of the Alaka`i Plateau and interior uplands, and these areas receive considerably less rain.

Figure 1
Island of Kauai - Newcomb's Snail Recovery Habitat





Current Newcomb's Snail populations
Observed 1994-2003

Extirpated Newcomb's Snail populations
Observed c.1840-1925

Streams

Major Roads

N

0 2.5 5 Kilometers

0 2.5 5 Miles

Scale = 1:320,000

UTM Zone 4, Old Hawaiian

Prepared by U.S. Fish & Wildlife Service, October 2004

At least 61 streams on Kaua`i are considered perennial; a similarly large number of intermittent streams also exist (Hawai`i Stream Assessment 1990). The largest stream system in the State by volume is the Hanalei River, which is 27 kilometers (17 miles) in length and has a long-term mean discharge of 6.5 cubic meters per second (216 cubic feet per second; 34-year average from 1964 to 1997)(U.S. Geological Survey 2004). The headwaters of the Hanalei River are located near the summit of Mt. Wai`ale`ale and the river flows towards Hanalei Bay located on the island's north shore.

The porous and permeable basalts that form the bulk of the main Hawaiian Islands facilitate infiltration and storage of groundwater. A large body of groundwater exists within these porous basalts at lower elevations throughout the interiors of the larger islands. In addition to this basal groundwater layer, smaller, perched groundwater systems form at higher elevations, contained by dense geologic features of low permeability. Many physical and biological characteristics of Hawaiian streams, such as channel form and function, are maintained through the action of relatively frequent high-flow events. However, equally important low flows maintain and distribute aquatic life during periods of drought. Because extensive groundwater reserves are found in some parts of the interior of Kaua`i, streams, springs, and rock seeps (rheocrenes) fed by basal groundwater exhibit permanent, stable flows (Izuka and Gingerich 1998). As a result, the aquatic communities supported by these water sources persisted over long periods, despite occasional episodes of severe drought.

Human-caused modifications to surface and groundwater systems have profoundly altered natural hydrologic regimes on Kaua`i. Extensive irrigation systems, built over a century ago to support the intensive cultivation of sugarcane, transfer large volumes of water out of natural watercourses and into complex systems of ditches, tunnels, flumes, and reservoirs to supply cane fields.

Historically, streamwater diversion structures were built to efficiently capture water. In many locations, these dams and other diversion structures entrain all of the flowing stream water at moderate to low flow levels, leaving the stream channel below the dam completely dry. At least one-third of all of Kaua`i's streams are significantly dewatered for agricultural and industrial water supplies (Hawai`i Stream Assessment 1990). In 1994, a total of 849.60 million liters (224.17 million gallons) per day were used island-wide for irrigation. In addition, 355.20 million liters (93.72 million gallons) of water per day was diverted from streams for the generation of hydroelectric power, further decreasing instream flows in many watersheds (Wilcox 1996).

B. Species Description and Taxonomy

Four species of Lymnaeidae snails are native to Hawai`i (Hubendick 1952; Morrison 1968). Three of these species inhabit two or more of the eight main islands. The fourth species, Newcomb's snail, is restricted to the island of Kaua`i. Newcomb's snail is unique among the Hawaiian lymnaeids in that the shell spire typically associated with lymnaeids is substantially reduced. The result is a nearly smooth, brown to black shell formed by a single, oval whorl, six millimeters (0.25 inch) long and three millimeters (0.12 inch) wide. A Japanese lymnaeid exhibits a very similar shell shape (Burch 1968), but a study of chromosome numbers suggests that Newcomb's snail's evolutionary ties lie with the rest of the Hawaiian lymnaeids, all of which are derived from North American ancestors (Patterson and Burch 1978). Therefore, it appears that parallel evolution of similar shell morphology occurred between these two distinct lineages of lymnaeid snails.

At the present time, no completely accepted nomenclature exists for the genera of Hawaiian lymnaeids, although each of these snail species, including Newcomb's snail, is recognized as a valid species. Hubendick (1952) did not

believe the distinctive shell form (described above) and reduced structures of the nervous system of Newcomb's snail warranted a monotypic genus. In fact, Hubendick included all Hawaiian lymnaeids in the genus *Lymnaea*. Morrison (1968) contradicted Hubendick and argued the distinctive shell characters of Newcomb's snail supported the generic name *Erinna*. Burch (1968), Patterson and Burch (1978), Taylor (1988), and Cowie *et al*. (1995) all followed Morrison and referred to Newcomb's snail as *Erinna newcombi*, which is the currently accepted scientific name.

C. Life History and Ecology

Newcomb's snail is an obligate freshwater species. The details of its ecology, such as life span, reproductive cycle, and number of eggs/young, are unknown. Newcomb's snail probably shares life history similarities with other members of its family. Lymnaeid snails generally feed on algae and vegetation growing on submerged rocks. Snails attach eggs to submerged rocks or vegetation and larval stages do not disperse widely; the entire life cycle is tied to the stream system in which the adults live (Baker 1911). Little is known about the biological or environmental factors affecting Newcomb's snail population size, however, important factors may include: annual, multi-year, or decadal changes in stream flows; severe weather, high flow, or channel-scouring events; and periods of prolonged drought. Snail dispersal both upstream and downstream within a stream system probably plays an important function in colonizing or recolonizing suitable habitat, particularly microhabitat protected from channel scour. Dispersal of Newcomb's snail between stream systems is likely infrequent due to their obligate freshwater habitat requirements; historic dispersal probably relied on long-term erosional events that captured adjacent stream systems. This life history differs greatly from the freshwater Hawaiian neritid snails (*Neritina granosa*, *Neritina vespertina*) that have marine larvae that migrate into and up streams following a period of oceanic dispersal (Kinzie 1990). Most likely, the

planktonic larvae of the neritid snails disperse across the oceanic expanses that separate the main Hawaiian Islands and can colonize streams on any or all of these islands. Newcomb's snail lacks this dispersal capacity.

Based on past and recent field observations, the specific habitat requirements of Newcomb's snail include fast-flowing perennial streams and associated springs, seeps, and vertical or overhanging waterfalls (Hubendick 1952; Burch 1968; Polhemus *et al*. 1992; Stephen Miller *in litt*. 1994a). Surveys of main stream channels of many of the perennial streams of Kaua`i indicate Newcomb's snail is only found in areas protected from high scouring flows within main stream channels (Michael Kido *in litt*. 1994). The limited occurrence of this snail in main stream channels is likely due to periodic channel scouring by sediment, rocks, and boulders that are moved downstream during high flow runoff events. Consequently, suitable habitat is generally restricted to protected, small, spring-fed tributaries, or to stream segments with overhanging waterfalls that have perennial flows supported by stable groundwater input. The common element among sites harboring snail populations is that the water source appears to be consistent and permanent, even during severe drought.

Limited to a relatively narrow zone of mid-elevation sites, populations of Newcomb's snail are found at an average elevation of 306 meters (1,005 feet), and range between 196 meters and 396 meters (643 feet to 1,299 feet).

D. Distribution and Population Status

The scientific collection efforts of the U.S. Exploring Expedition of 1838 to 1842 obtained the first known specimens of Newcomb's snails (Morrison 1968). Historical documents indicate that the specimens were collected sometime between October 25, and November 6, 1840, at "Hanapēpē Falls," presumably what is now called Manuwaiopuna Falls, or possibly one of several other waterfalls located in the middle Hanapēpē watershed of southeast Kaua'i (see Figure 1). Individuals from this early collection made their way to the British Museum of Natural History and were used as the type specimens from which the species was later described in 1855. A number of very large watersheds traverse the southeast quadrant of the island, including Olokele Stream, Hanapēpē Stream and Waimea River, all of which have numerous tributaries. No recent surveys for Newcomb's snails have been undertaken in the Hanapēpē watershed, or in any of the large neighboring stream systems, because they are located on privately owned lands and are difficult to reach due to the rough terrain. It is possible that Newcomb's snail populations remain in that region of Kaua`i.

Until about 1925, snails were collected from small sites located in Kalalau Stream, Hanakoa Stream, Hanakāpī`ai Stream, Wainiha River, and Keālia Stream. Three of these populations (Hanakoa Stream, Hanakāpī`ai Stream, Wainiha River) are now thought to be extirpated (see Table 1). Since about 1993, Federal and State agencies, academic researchers, and other interested parties have conducted opportunistic surveys at approximately 50 sites along numerous streams and their associated tributaries and springs on Kaua'i, and have located four previously unknown populations of Newcomb's snail (M. Kido *in litt*. 1994). These recently discovered populations are located in Lumaha`i River, the Hanalei River, Makaleha Stream (a tributary to Kapa`a Stream), and the North Fork Wailua River. With the exception of the snails at Makaleha Springs, most of these populations have only been observed once or twice. Recently, two

individual snails were reported from a single site in Limahuli Stream in the Hanalei District of Kaua`i's north shore (M. Kido *in litt*. 2001). However, if a viable population of Newcomb's snail exists in the Limahuli watershed, its location remains unknown, therefore Limahuli Stream is not considered to have a "population" of Newcomb's snails.

Table 1. Extirpated Populations of Newcomb's Snail

Hanakoa Stream	Located in the northwest part of the island. Included with 6 streams in Table 3 as critical habitat.
Hanakāpī`ai Stream	Located in the northwest part of the island. Included with 6 streams in Table 3 as critical habitat.
Wainiha River	Located in the northwest part of the island, and very inaccessible.
Hanapēpē Stream	Only stream in southern part of Kaua`i with historical record of Newcomb's snail occurrence.

Recent survey work conducted from 1994 to 2003, limits the known range of Newcomb's snail to small sites located in a total of six watersheds in north- and east-facing drainages on Kaua`i (see Figure 1 and Table 2). They are: Kalalau Stream, Lumaha`i River, Hanalei River (four subpopulations), Keālia Stream, Makaleha Stream (two subpopulations), and the North Fork Wailua River. The term "subpopulation" refers to a discreet group of individuals, separated from other discrete groups within a single watershed. Due to low mobility, no interaction between subpopulations exists. No historical information is available on the population sizes of Newcomb's snail. However, anecdotal reports indicate the Kalalau Stream and Lumaha`i River populations of Newcomb's snails are larger in comparison to the other four.

Table 2. Existing Populations of Newcomb's Snail

Watershed/ Population (6)	Site/ Subpopulation (10)	Area (m^2)	Density (snails/m^2)	Notes*
Kalalau Stream	Kalalau Stream	8-10m by 15m	857 (+/-302 standard deviation)	Possible 'large' population found 2005.
Lumaha`i River	Lumaha`i River	No estimate	No estimate	No field notes; verbal report – 'large'.
Hanalei River	Diversion Kaapoko Tributary Tributary Lower site	10-20 No estimate No estimate No estimate	2-3 No estimate No estimate No estimate	None seen recently Few Few ~25 individuals
Keālia Stream	Keālia Stream	8-10	50-80	
Makaleha Stream	Falls Spring	2-3 20	30 20-30	
NF Wailua River	NF Wailua River	No estimate	No estimate	Kido 1995 – 'large'; recent visit - none found.

*Population estimates are not provided for each subpopulation, because little fieldwork has been completed on this species in the past 10 years, and original data on sites and densities were rough estimates based on casual observance and not surveys conducted according to a protocol.

Kalalau Stream

The Kalalau Stream population is found in the northeastern fork of Kalalau Stream on two permanent waterfalls and in the stream reach between the waterfalls. The high density of individuals in this population may result from its minimally disturbed natural condition. The estimated maximum density at the base of the upper waterfall, including the area behind the falling water, was approximately 800 snails/square meter (75 snails/square foot) (S. Miller *in litt*. 1994b). The total area occupied by these snails could not be accurately evaluated due to the extreme vertical orientation of the waterfall. Habitat used by these snails may be limited to the protected lower section of the waterfall that is not actually submerged but is inundated by spray from the falling water.

Lumaha`i River

No information on the specific size or area inhabited is available for the Newcomb's snail population in the Lumaha`i River, although this population was reported as "large" (M. Kido *in litt*. 1995). This population was observed only once, on the occasion of its discovery. The Hawai`i Department of Land and Natural Resources Division of Aquatic Resources biologist who found the

population did not undertake a quantitative survey of snail numbers at this location. In addition, the precise location of this population is not well documented.

Hanalei River

The population of Newcomb's snail in the Hanalei River is divided into four subpopulations in the upper reach (M. Kido *in litt*. 1994, 1995). One subpopulation has approximately 10 to 20 snails/square meter (1 to 2 snails/square foot) and occupies 2 to 3 square meters (21 to 32 square feet) (M. Kido *in litt*. 1994). A second subpopulation supports only 25 snails. The two remaining subpopulations in the Hanalei River were reported to be "small" with very few snails (M. Kido *in litt*. 1995). No snails were found at the upper Hanalei locations when last visited by biologists on May 26, 2005.

Keālia Stream

In 1994, the population in Keālia Stream was estimated to cover 5 to 10 square meters (53 to 106 square feet) with a density of approximately 50 to 80 snails/square meter (4 to 8 snails/square foot; A. Asquith *in litt*. 1994). In 2003, the same area revealed an estimated density of approximately 37 snails/square meter (1 to 3 snails/square foot) (G. Smith pers. obs. 2003). This is the only population to have been relocated and resurveyed in the last several years.

Makaleha Stream

The population in Makaleha Stream is divided into two subpopulations. The subpopulation at the waterfall forming the head of the main channel of Makaleha Stream was estimated at 30 snails/square meter (2 to 3 snails/square foot) distributed over 2 to 3 square meters (21 to 32 square feet) (M. Kido *in litt*. 1994), a considerably smaller number than the population in Kalalau Stream described above. The reasons for the small subpopulation at Makaleha Stream is not known with certainty, but may result from the presence of non-native

predators, and "biological control" species introduced to feed on non-native species (e.g., rosy glandina snails), which may prey on Newcomb's snails. The subpopulation found at Makaleha Springs (which forms a series of very small, short tributaries to Makaleha Stream) covered approximately 20 to 30 square meters (212 to 318 square feet) (S. Miller *in litt*. 1994b). Snail densities at this site were difficult to estimate, but may be as high as 20 to 30 snails/square meter (1 to 3 snails/square foot) (S. Miller *in litt*. 1994a). This population was relocated in 2000, 2002, and 2003, however no quantitative estimates of snail density were obtained.

North Fork Wailua River

The population found in the upper and middle reaches of the North Fork of the Wailua River, just upstream of a concrete agricultural water diversion intake, was made up of a few scattered individuals during surveys in 1996 and 1997 (M. Kido and Don Heacock pers. comm. 2001). Visits to this site in 2001 and again in 2003 revealed no snails.

Based on these data we estimate the 6 existing populations of Newcomb's snails contained a total of approximately 6,000 to 7,000 individuals. The great majority of these snails, perhaps over 90 percent, were located in the two populations at Kalalau and Lumaha`i. Terrain occupied by Newcomb's snail populations is remote and extremely rugged. Three of the six populations can only be visited using helicopter transport, although the Kalalau Stream population potentially could be accessed in summer months with boat support and strenuous hiking. Due to the difficulty in accessing the sites, no comprehensive Newcomb's snail population census has been undertaken since 1995, and changes to the population since that time remain undocumented.

The total area inhabited by Newcomb's snails at any one location is remarkably small, from just 2 square meters (22 square feet; Makaleha waterfall,

Hanalei subpopulations) to a maximum of 30 square meters (323 square feet; Makaleha Springs subpopulation). Microhabitat characteristics limiting suitable habitat remain unknown. Because known populations are confined to such small areas, they are highly vulnerable to eradication by unpredictable catastrophic events. Flooding due to hurricanes and tropical storms, catastrophic landslides, drought, infestation by introduced invasive species, and other localized phenomena that occur unpredictably could eradicate Newcomb's snail habitat across significant portions of the island. Recent examples of such recurring natural events include Hurricane `Iniki (a Category IV hurricane that devastated Kaua`i on September 11, 1992), Hurricane `Iwa (November 23, 1982), and the large upper Olokele Valley landslide of October 31, 1981. Each of these events greatly impacted and may have eliminated large areas of unsurveyed potential Newcomb's snail habitat. Any recovery planning effort must take the island-wide distribution of Newcomb's snails into account to ensure maintenance of separate populations in watersheds geographically distributed throughout the island.

E. Reason for Decline and Current Threats

Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

Newcomb's snails face a continued threat from human-caused changes to the hydrologic landscape of Kaua`i. The first collection and description of the species by western naturalists occurred in 1840, prior to the severe degradation of natural aquatic environments. For example, the collection of the U.S. Exploring Expedition contains Newcomb's snails collected at "Hanapēpē Falls," apparently one of the waterfalls located in the middle or lower Hanapēpē watershed (Morrison 1968). A large irrigation diversion structure is now built into the base of the falls. Because of irrigation water withdrawals, this stream has reaches that are entirely dewatered and dry much of the time. The Hanapēpē watershed is located in the southwest quadrant of the island where extensive plantation style

agriculture continues to divert and pump significant volumes of water out of both surface waterbodies and groundwater sources. The watersheds in this part of the island are widely separated geographically from currently known Newcomb's snail populations in drainages located in the north and northeast part of the island. It is unknown if any Newcomb's snails exist in Hanapēpē or other southwest Kaua`i watersheds because they remain unsurveyed. Much of the land in this part of the island is privately owned. Planning and management strategies for both State and private lands currently emphasize continued or expanded large-scale agricultural operations that divert stream water.

The specific effects of surface water diversion or groundwater withdrawal on the Newcomb's snail are unknown. However, none of the six known snail populations are found below points of significant water diversion. Three of four Hanalei subpopulations are found in close proximity to, or below, sites once part of a major stream diversion complex now abandoned and nonfunctional. These subpopulations were not reported prior to this diversion complex falling into disuse, so effects on snails, other than possibly reducing snail abundance below the level of detection, are not known.

A recent water development plan stands as an example of water withdrawal as a threat to Newcomb's snail. In 1995, prior to Newcomb's snail being listed as threatened, the County of Kaua`i planned a major water diversion project to capture flow from Makaleha Springs for domestic use. The project construction and operation was expected to eliminate the entire subpopulation of Newcomb's snail at Makaleha Springs. The application process was continued by the Kaua`i Board of Water Supply and cleared a number of State and local regulatory reviews. Ultimately, the State Commission on Water Resource Management denied the applicable permits on the basis of numerous unresolved environmental issues, including impacts to aquatic life (M. Wilson *in litt*. 1995).

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

No collecting or harvesting of Newcomb's snail is known to occur for commercial or recreational purposes. There have been no permit requests to collect Newcomb's snails for scientific or educational purposes.

Disease and Predation

Predation by the non-native rosy glandina snail (*Euglandina rosea*) remains a serious threat to the survival of Newcomb's snail (U.S. Fish and Wildlife Service 2000). This predatory snail, introduced into Hawai`i in 1955 (Funasaki *et al*. 1988), has established populations throughout the main islands. The rosy glandina feeds on snails and slugs, and field studies document that it readily feeds on native snails found in Hawai`i (Hadfield *et al*. 1993). Furthermore, Kinzie (1992) demonstrated that the rosy glandina snail exhibits remarkable hunting behaviors leading to capture and predation of submerged prey. Although terrestrial, the rosy glandina will fully immerse itself in water to locate and feed on aquatic molluscs such as Newcomb's snail. The rosy glandina has been observed on the wet, algae-covered rocks of the Makaleha Stream in close proximity to individual Newcomb's snails (S. Miller *in litt*. 1994a), and is believed to prey on them. The rosy glandina snail is responsible for the extirpation of many populations and even the extinction of numerous species of native snails throughout the Pacific Islands (Tillier and Clarke 1983; Murray *et al*. 1988; Hopper and Smith 1992; Hadfield *et al*. 1993; Miller 1993), and represents a significant threat to the survival of Newcomb's snail.

Predation on the eggs and adults of native Hawaiian lymnaeid snails by two non-native species of sciomyzid flies represents a significant threat to the survival of Newcomb's snail. Two species of marsh flies (*Sepedomerus macropus* and *Sepedon aenescens*) that feed on lymnaeid snails (Davis 1960) were

introduced into Hawai`i in 1958 and 1966, respectively. These predatory flies were intended to act as biological control agents for the non-native lymnaeid snail, *Fossaria viridis* (Funasaki *et al*. 1988). As discussed in Morrison (1968), another non-native lymnaeid snail, *Galba viridis*, was misidentified as *Fossaria ollula* by earlier workers (Alicata and Swanson 1937; Alicata 1938). This species was also targeted for biological control because it is an intermediate host of the cattle liver fluke (*Fasciola gigantica*). The non-native lymnaeid snails and the two biological control flies occur on Kaua'i as well as on other islands in Hawai`i (Hubendick 1952; Davis 1960; Davis and Chong 1969; Funasaki *et al*. 1988). One of the marsh fly species was observed at Hanakoa Stream where Newcomb's snail was historically recorded but is no longer present (S. Miller *in litt*. 1994b). A marsh fly was observed near the waterfall of Mānoa Stream on the island of O`ahu containing many dead lymnaeids in the waterfall plunge pool (S. Miller *in litt*. 1994b). Another marsh fly was observed along a small unnamed tributary on the middle reach of the Lumaha'i River, located near to the Newcomb's snail population in that watershed (G. Smith pers. obs. 2000). These biological control species may represent a significant threat to Newcomb's snail and other native lymnaeid snails.

Another widespread non-native aquatic insect group, the Trichoptera, (caddisflies), appears to be expanding its range throughout the Hawaiian Islands. In 2001, a fourth species was documented to occur in the islands (Flint *et al*. 2003). It is suspected that the introduced caddisflies are adversely impacting native aquatic invertebrate populations either through competition for space and resources, or due to the its large body size and sheer abundance in Hawaiian streams (Flint *et al.* 2003). In recent surveys of upper elevation Kaua`i streams, for example, a single caddisfly species accounted for 57 percent of all biota collected in the streams (Englund *et al.* 2000). Caddisflies now inhabit all of the 57 perennial streams on the island of O`ahu (Flint *et al.* 2003).

Several introduced, predatory aquatic species, including the green swordtail fish (*Xyphophorus helleri*), the American bullfrog (*Rana catesbiana*), the wrinkled frog (*Rana rugosa*), and the cane toad (*Bufo marinus*) potentially threaten populations of Newcomb's snail. Over 50 species of non-native aquatic organisms are naturalized in Hawaiian freshwater habitats (Yamamoto and Tagawa 2000). Some of the earliest introductions are the most widespread. In 1867, the American bullfrog was introduced, and in 1896, the wrinkled frog was first recorded (State of Hawai`i, Job Progress Report, 1995). In 1905, two fish species, the mosquito fish (*Gambusia affinis*) and the sailfin molly (*Poecilia latipinna*), were widely introduced for biological control of mosquitoes (Van Dine 1907). In 1922, three additional fish species were established for mosquito control: the green swordtail (*Xiphophorus helleri*), the moonfish (*Xiphophorus maculatus*), and the guppy (*Poecilia reticulata*). In 1932, the cane toad (*Bufo marinus*) was introduced to Hawai`i (Pemberton 1934). All potentially prey on the Newcomb's snail. Because of a pervasive toxin released by cane toad skin, this species is implicated in creating conditions of aquatic toxicity where eggs, tadpoles, and adult cane toads exist in aquatic environments (Crossland and Azevedo-Ramos 1999; Punzo and Lindstrom 2001).

Inadequacy of Existing Regulatory Mechanisms

In the State of Hawai`i all natural flowing surface water (streams, springs and seeps) are considered public trust resources and managed according to the State Water Code (Hawai`i Revised Statutes Chapter 174C-71, 174C-81-87, and 174C-9195 and Administrative Rules of the State Water Code, Title 13, Chapters 168 and 169). The Hawai`i Department of Land and Natural Resources retains management responsibility for aquatic organisms in these waters. Newcomb's snail populations associated with streams, seeps and springs are, directly and indirectly, under the jurisdiction of the State of Hawai`i, regardless of the ownership of the property across which the stream flows.

State regulatory mechanisms do not provide adequate protection for the Newcomb's snail's habitat. Due to historical water allocation patterns in place prior to statehood, the State Water Code does not afford adequate protection from the adverse effects of water diversion and withdrawal for out-of-stream uses. The State of Hawai`i manages the withdrawal of surface and ground water resources through the Commission on Water Resource Management (State Water Commission), as mandated by the State Water Code. Recent judicial decisions have reaffirmed the public trust doctrine as the underlying principle upon which water allocation decisions should be based. The State's role under the public trust doctrine is to protect natural resources for the benefit of citizens of the State. Unfortunately, maintenance of instream flow, which is required to protect the habitat of the Newcomb's snail and other aquatic wildlife, is regulated by the establishment of standards on a very cumbersome stream-by-stream basis. Currently, "interim" instream flow standards simply represent the existing flow conditions in streams in the State, including many situations in which streams are entirely dewatered on an almost permanent basis. The State Water Code does not require permanent or minimum instream flow standards solely for the protection of aquatic wildlife.

Modification of instream flow conditions can be undertaken at any time by the Water Commission or via public petitions to revise inflow standards in a specified stream. In accordance with the State Water Code, the Water Commission must consider economic benefits gained from out-of-stream water uses. Consequently, existing conditions or future minimum stream flows set for the protection of Newcomb's snail habitat are subject to modification at a future date.

The natural values of Hawai`i's stream systems are recognized under the State of Hawai`i Instream Use Protection Program. In the Hawai`i Stream

Assessment Report, prepared in coordination with the National Park Service, the State Water Commission identified high quality rivers or streams, or portions of rivers or streams that could be placed within a wild and scenic river system (Hawai`i Stream Assessment 1990). This report recommended that streams meeting certain criteria be protected from further alteration or water withdrawals. However, there is no formal or institutional mechanism within the Water Code to designate and provide additional protections to these streams, or to identify and protect stream habitat for the Newcomb's snail.

Existing Federal regulatory mechanisms that may protect the Newcomb's snail and its habitat are also inadequate. The few hydroelectric power projects located in Hawai`i are not located on navigable waters, public lands, or United States reservations. These facilities do not use surplus water or water power from a Federal Government Dam and do not affect the interests of interstate or foreign commerce. As a result, the Federal Energy Regulatory Commission has very limited jurisdiction in Hawai`i. Licensing of existing hydroelectric projects does not come under the purview of the Federal Energy Regulatory Commission. However, future hydropower developers in Hawai`i may voluntarily seek licensing under the Federal Energy Regulatory Commission.

Other Natural or Manmade Factors

Even if the threats responsible for the decline of this species were controlled, the persistence of existing populations is complicated by the small number of extant populations and the small geographic range of the known populations. This circumstance makes the species more vulnerable to extinction due to stochastic natural processes. Small populations are particularly vulnerable to reduced reproductive vigor caused by inbreeding depression, and they may suffer a loss of genetic variability over time due to random genetic drift, resulting in decreased evolutionary potential and ability to cope with environmental change (Lande 1988; Center for Conservation Biology 1994). Small populations are also demographically vulnerable to extinction caused by random fluctuations in population size and sex ratio, and to catastrophes such as hurricanes (Lande 1988).

F. Conservation Measures

Newcomb's snail was listed under the Endangered Species Act as threatened on January 26, 2000 (U.S. Fish and Wildlife Service 2000). An endangered species is defined in section 3 of the Endangered Species Act as any species that is in danger of extinction throughout all or a significant portion of its range. A threatened species is defined as any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

The Endangered Species Act provides several opportunities for the conservation of threatened and endangered wildlife and plants and the ecosystems upon which they depend. Listed animals receive recognition and protection against take. The term "take" is defined as to harass, harm, shoot, wound, kill, trap, capture, or attempt to engage in any such conduct. "Harm" is further defined

to include significant habitat modification or degradation resulting in mortality or injury of wildlife by significantly impairing essential behavioral patterns such as breeding, feeding, or sheltering (50 CFR 17.3). Federal agencies must ensure their actions do not jeopardize the continued existence of a listed species or adversely modify its designated critical habitat. The Endangered Species Act also prohibits possessing, selling, delivering, carrying, transporting, or shipping through interstate or foreign commerce any listed fish or wildlife species, except as permitted under provisions of section 10.

Section 4(b) of the Endangered Species Act requires that we designate critical habitat for species listed as threatened or endangered. Critical habitat is a specific geographic area essential for the conservation of a threatened or endangered species and that may require special management and protection. Critical habitat may include an area not currently occupied by the species but is needed for its recovery. On August 20, 2002, we designated critical habitat for the Newcomb's snail (U.S. Fish and Wildlife Service 2002). The designation includes eight stream segments and associated tributaries, springs, seeps, and adjacent riparian areas totaling 1,812 hectares (4,479 acres), and including 19.76 kilometers (12.28 miles) of stream channel. Critical habitat for the Newcomb's snail includes the six stream locations known to be occupied and two sites where snails were observed historically but are now thought to be extirpated (Hanakoa Stream and Hanakāpī`ai Stream).

When a species is listed as threatened or endangered under the Endangered Species Act, it is automatically added to the State of Hawai`i's list of protected species (Hawai`i Revised Statutes Chapter 195D). Hawai`i State law prohibits take of threatened fauna and encourages conservation by State government agencies ("take" as defined by Hawai`i State law means to "harass, harm, pursue, wound, kill, trap, capture, collect... or attempt to engage in any such conduct"). Furthermore, the State may enter into agreements with Federal

agencies to administer and manage any area required for the conservation, management, enhancement, or protection of threatened or endangered species.

Newcomb's snail is the first and only freshwater organism found in Hawai`i listed under Federal and State law as threatened. The Hawai`i Department of Land and Natural Resources, Division of Aquatic Resources is building its capacity to undertake research and implement management directed towards conservation of rare and vulnerable aquatic species such as the Newcomb's snail. Interaction between the State Division of Aquatic Resources management and staff and our endangered species biologists will assist development of an institutional framework to accomplish effective conservation for the Newcomb's snail. To date, no conservation measures have been implemented.

II. RECOVERY

The ultimate goal of the actions proposed in this recovery plan is to recover the Newcomb's snail to the point where delisting is appropriate.

We establish recovery criteria to serve as objective, measurable guidelines to assist us in determining when a species has recovered to the point that the protections under the Endangered Species Act are no longer necessary. Delisting is warranted when a species no longer meets the definition of threatened or endangered under section 3 of the Endangered Species Act. The change in listing status requires a formal rulemaking process based on an analysis of the same five factors considered in the original listing of the species. The recovery criteria presented in this recovery plan represent our best assessment of the conditions that would result in a determination that delisting of the Newcomb's snail is warranted.

A. Recovery Strategy

1. Establish baseline population numbers and geographic distribution;
2. Research the population biology and life history of the Newcomb's snail;
3. Analyze and prevent predation and other forms of negative interspecific interactions limiting or reducing Newcomb's snail populations;
4. Assure adequate stream and spring flows to protect known and potential Newcomb's snail habitat;
5. Incorporate recovery of Newcomb's snail into other landscape conservation efforts, such as preservation of the structure and function

of upland forests that maintain and regulate surface run-off to streams and act as areas of infiltration for groundwater;

6. Use initial recovery efforts and research to periodically validate recovery objectives; and
7. Develop and implement a public outreach program for Newcomb's snail conservation.

B. Recovery Objectives

1. Stabilize and increase populations of the Newcomb's snail throughout its range;
2. Ensure adequate water quantity for the conservation of the snail; and
3. Reduce impacts from introduced species.

C. Recovery Criteria

The Newcomb's snail can be considered for delisting when:

1. Abundance and population variability are quantified, and populations (an unspecified number of individuals that allows for environmental, climatic, and genetic variations) are stable or increasing in size due to natural reproduction for a minimum of 5 consecutive years (population goals can not be quantified here, because little fieldwork has been completed on this species in the past 10 years, and original data on sites and densities were rough estimates based on casual observance and not surveys conducted according to a protocol);
2. Populations are identified in a minimum of eight watersheds with a wide geographical distribution throughout the range of the Newcomb's snail;

3. Minimum in-stream flows protective of aquatic life are established and implemented for stream reaches containing Newcomb's snail populations;
4. Non-native predators and competitors have been studied, their effects on the snail quantified, and the appropriate control measures have been established and implemented in order to support the population goal researched under criterion 1 above; and
5. A post-delisting monitoring plan has been developed.

These criteria should maintain the genetic diversity of the Newcomb's snail, and ensure that a catastrophic event does not reduce population numbers below the minimum needed for the species to remain viable.

Recovery actions should focus on protecting the most significant Newcomb's snail populations first (Table 3). We assigned each population to one of three tiers to designate their status. "Tier 1" populations are designated based primarily on total number of snails and likelihood of successful habitat protection efforts. "Tier 2" populations are designated based on wide geographic distribution and existence of extant populations. "Tier 3" populations are based on historical records documenting the existence of suitable habitat, but lacking information concerning extant snail populations.

Table 3. Newcomb's Snail Populations and Priority Actions

Populations	Required Research	Recovery Actions
Tier 1 Populations:		
Kalalau Stream	1) Population census 2) Characterize interactions with introduced species 3) Map location	1) Introduced species control
Lumaha`i River	1) Population census 2) Characterize interactions with introduced species 3) Map location	1) Instream flow protection 2) Introduced species control
Tier 2 Populations:		
Hanalei River (Four subpopulations)	1) Population census 2) Characterize interactions with introduced species 3) Map location	1) Instream flow protection 2) Introduced species control
Makaleha Stream (two subpopulations)	1) Population census 2) Characterize interactions with introduced species	1) Introduced species control
Keālia Stream	1) Population census 2) Characterize interactions with introduced species	1) Instream flow protection 2) Introduced species control
North Fork Wailua River	1) Population census 2) Characterize interactions with introduced species	1) Instream flow protection 2) Introduced species control
Tier 3 Populations:		
Hanakoa Stream	1) Confirm if snails extirpated 2) Assess threats at potential translocation sites	1) Translocation experiments
Wainiha River*	1) Confirm if snails extirpated 2) Assess threats at potential translocation sites	1) Instream flow protection 2) Translocation experiments
Hanakāpī`ai Stream	1) Confirm if snails extirpated 2) Assess threats at potential translocation sites	1) Translocation experiments

*Population, if present, is not within Newcomb's snail critical habitat.

Research and Monitoring

Research on population characteristics and optimal habitat conditions for the Newcomb's snail will assist development of appropriate recovery actions, and will allow verification or refinement of recovery criteria. Recovery actions will guide monitoring protocols and habitat restoration goals and techniques.

Key activities expected to help reach the ultimate goal of delisting the Newcomb's snail include research and monitoring. Because current information is so limited, even the most basic management actions cannot be undertaken with reasonable certainty that the proposed actions will benefit the species. The initial focus includes development and application of survey and monitoring techniques, and collecting basic life history information. In particular, accurate population estimates throughout the known range of the snail are needed. The earliest stages of recovery implementation should undertake this work, so that all currently known snail populations are surveyed within a relatively short period of time to provide a synoptic estimate of the existing snail numbers and actual geographic distribution. Life history information, such as fecundity, should be investigated by documenting egg mass deposition. Microhabitat requirements should be documented by measuring substrate, flow velocity, and other fine-scale characteristics in stream and spring areas inhabited by Newcomb's snail. The resulting information on life history and habitat characteristics is needed to plan and implement snail translocation activities and other recovery efforts.

Evaluation of translocation need and likelihood of success to establish (or re-establish) Newcomb's snail populations is necessary. The first sites assessed should be those at Hanakoa Stream, Hankapi`ai Stream, and the Wainiha River where Newcomb's snails were found, but now appear to be extirpated. Microhabitat requirements appear to severely limit snail distribution, and

considerable research is needed to develop the expertise to undertake experimental translocations of this species. In addition to careful investigation into habitat suitability in watersheds considered for translocation experiments, an assessment of threats due to a variety of factors such as predation and severe weather events is needed at each site.

Predation

Threats should be assessed through research and monitoring. In particular, populations of the carnivorous snail *Euglandina rosea* should be surveyed in areas adjacent to known populations of Newcomb's snail, and the potential threat posed by these introduced predators should be assessed. If we find predation by *Euglandina rosea* is a significant factor inhibiting the recovery of Newcomb's snail, appropriate control measures should be implemented in concert with *Euglandina* control efforts elsewhere.

Stream and Spring Flows

Maintainance and protection of adequate water flows at the stream and spring sites containing Newcomb's snail populations must be accomplished through coordination and cooperation with the Hawai`i Department of Land and Natural Resources, Commission on Water Resource Management (State Water Commission) - the agency responsible for regulating surface water and groundwater allocation. The State Water Commission was created through the Hawaii State Constitution, and authorized by the State Water Code (Hawaii State Division of Forestry and Wildlife 1995). A variety of administrative rules and related policy and planning documents guide the Commission's mission as trustee of the State's surface and groundwater for the benefit of the people of the State of Hawai`i.

The Water Commission regulates the withdrawal of groundwater through a permit program for well construction and pump installation, and a water use permit program. Alteration of instream flows is regulated through a permitting and water use allocation system including a variety of permits for diversion work and stream channel alteration, and petitions to amend existing interim instream flow standards. Diversion of surface water for use in agriculture, resort, and golf course development, and for domestic purposes, is often a contentious public policy issue, resulting in lengthy State Water Commission decision-making deliberations. When the State Water Commission is called upon to act in its capacity as a quasi-judicial body, such as in a contested case hearing, water use allocation decisions may take years to conclude. Decision-making regarding water licenses that are brought to the courts for resolution may take even longer. For example, the landmark *McBryde Sugar Co. vs. Robinson* case, which grew out of a dispute over diversion of irrigation water from the Hanapepe River on Kaua`i, involved water rights and the public trust, and was adjudicated by the Hawai`i State Supreme Court for over 20 years, from the early 1950's until 1973 (Wilcox 1996).

State policies establishing management goals for water resources are sometimes contradictory within the various departments having mandates to promote both out-of-stream water use and aquatic resource conservation. The State Water Commission itself has conflicts between its directives to fully utilize water resources for agricultural and domestic uses, and simultaneous public trust requirements to conserve natural resources. Coordination with the State Water Commission and other stakeholders regarding instream flow protection for conservation of Newcomb's snail habitat is critical to recovery of the species.

Cooperative Planning and Public Outreach

Restored habitat and populations require long-term protection from threats. Involvement of the public (especially major landowners) in recovery efforts, increased public awareness of the Newcomb's snail and its habitat, our participation in State and County watershed planning and conservation programs, and enforcement of applicable laws and regulations better ensure the long-term protection of populations and habitats.

III. RECOVERY ACTION NARRATIVE

1. Conduct research and monitoring essential to the conservation of the species. Basic information about Newcomb's snail population sizes, distribution, and variability is required for effective conservation of Newcomb's snail. Information gathered from population monitoring, surveys to locate possible undiscovered populations, and life history studies (Table 3) will aid the formulation and refinement of recovery goals and management activities.

1.1 Surveys and monitoring. Develop standardized survey and monitoring protocols to determine current Newcomb's snail distribution and abundance. Significant areas of potential habitat lack adequate surveys to locate undiscovered populations of Newcomb's snail, and at least one location of historically occupied habitat has not been resurveyed for Newcomb's snail within the last 150 years. The recently reported observation of two individual Newcomb's snails in Limahuli River should be investigated.

1.2 Implementation of monitoring program. Implement a population monitoring program to determine Newcomb's snail abundance and population variability. Survey all Newcomb's snail populations synoptically on a 3- to 4-year cycle to assess trends in population status.

1.3 Obtain basic life history data. Coincident with initiation of regular monitoring, basic life history characteristics need describing. These characteristics should include fecundity, egg loss/mortality, growth rates, and incidence, prevalence, and effect of disease or parasitism.

1.4 Initiate translocation program. Reintroduction of Newcomb's snails to historically occupied locations where they are now extirpated should be attempted once we obtain sufficient knowledge regarding habitat needs and reduction of threats, especially predation. Historically occupied sites at Hanakoa Stream, Hanakāpī`ai Stream, and the Wainiha River should be assessed for suitability of reintroduction first.

1.5 Validate recovery objectives.

1.5.1 Determine the number of populations and individuals needed for long-term recovery and survival. Evaluation of recovery actions and results using population viability analysis techniques or other methodology should be undertaken approximately 5 years after implementing this plan. An analysis of population viability should be undertaken utilizing population data obtained from monitoring.

1.5.2 Revise delisting criteria as necessary. New information may be obtained that would require changes to recovery planning objectives defined in this recovery plan.

2. Manage predation and interspecific interaction. Assess the threat of predation by introduced species and develop appropriate conservation measures to protect Newcomb's snail from excessive predation.

2.1 Predation by *Euglandina rosea*. Conduct surveys to estimate the threat of predation by *Euglandina rosea*. Surveys should focus

on numbers and densities of *Euglandina* in habitat adjacent to Newcomb's snail sites.

2.2 Predation by *Sepedomerus macropus* and *Sepedon aenescens*. Conduct surveys to estimate the threat of predation by the marsh flies, *Sepedomerus macropus* and *Sepedon aenescens*. Surveys should establish whether marsh fly predation occurs, and if so, determine numbers and densities of marsh flies in habitat adjacent to Newcomb's snail sites.

2.3 Predation by other introduced species. Conduct surveys to estimate the threat of predation by introduced, nonnative species. A variety of introduced vertebrate predators may reduce Newcomb's snail populations, however the level of threat posed by these species remains unclear. Investigations should be directed toward threat assessments of the green swordtail (*Xyphophorus helleri*), the mosquito fish (*Gambusia affinis*), livebearing guppies (*Poecilia* spp.), the marine toad (*Bufo marinus*), the American bullfrog (*Rana catesbiana*), and the wrinkled frog (*Rana rugosa*).

2.4 Interaction with other introduced species.

2.4.1. Competition with introduced lymnaeid and physid snails. Competition with introduced lymnaeid and physid snails for space, food and other resources may detrimentally affect Newcomb's snail populations. The potential for negative interspecific interaction should be evaluated by surveying the occurrence, population distribution, and overlapping habitat requirements of

introduced aquatic snails that co-occur with Newcomb's snail.

2.4.2 Evaluate *Bufo marinus* aquatic toxicity. The introduced toad *Bufo marinus* is found throughout lowland and mid-elevation areas of the Hawaiian Islands, including Kaua`i. These toads breed by congregating and laying large masses consisting of hundreds of eggs in slow, deep pools such as the pools below terminal waterfalls containing Newcomb's snails (for example, the waterfall/pool complex in Kalalau Stream). This toad excretes highly toxic compounds from glands located in its skin. *Bufo marinus* is implicated in creating conditions of acute and chronic aquatic toxicity due to its breeding activities in aquatic environments. The potential for *Bufo marinus* to create toxic conditions in areas where it co-occurs with Newcomb's snail needs investigation.

2.5 Predator and introduced species control. If predation or other interactions with introduced species is found to limit or reduce Newcomb's snail populations, develop and implement appropriate predator control measures in coordination with other efforts to control introduced species in terrestrial and aquatic environments on Kaua`i and other parts of the State.

3. Maintain stream and spring flows to protect Newcomb's snail habitat.

3.1 Inventory of water diversion and water extraction activities. Inventory all existing and planned water diversion activities including operation of wells and hydropower development proposals that may impact known and potential Newcomb's snail habitat.

3.2 Instream flow standards development. Cooperate in the Water Commission's ongoing Stream Protection Program by providing technical assistance and review of the Commission's efforts to set quantifiable interim and permanent instream flow standards in watersheds providing or potentially providing habitat for Newcomb's snail.

3.3 State Water Plan participation and coordination. Provide input into revision of the State Water Plan under preparation by the Water Commission with regard to water resource protection in watersheds providing or potentially providing habitat for Newcomb's snail. As specified in the State Water Code, this comprehensive planning effort is coordinated by the Water Commission with involvement from several State and county agencies, and is reviewed every 5 years.

3.3.1 State Water Projects Plan. Provide input into revision of the State Water Projects Plan being prepared by the Water Commission with regard to water resource protection in watersheds providing or potentially providing habitat for Newcomb's snail.

3.3.2 Agricultural Water Use and Development Plan. Provide input into revision of the Agricultural Water Use and Development Plan being preparated by the Hawai`i State Department of Agriculture with regard to water resource extraction in watersheds that provide or potentially provide habitat for Newcomb's snail.

3.3.3 State Water Quality Plan. Provide input into revision of the State Water Quality Plan under preparation by the Hawai`i State Department of Health with regard to water resource protection in watersheds that provide or potentially provide habitat for Newcomb's snail.

**3.3.4 County of Kaua`i Water Use and Development Plan.** Provide input into revision of the County of Kaua`i Water Use and Development Plan with regard to water resource protection in watersheds that provide or potentially provide habitat for Newcomb's snail.

**3.4 County of Kaua`i General Plan.** Provide input into revision of the County of Kaua`i General Plan for agricultural and domestic purposes, with regard to water resource protection in watersheds that provide or potentially provide habitat for Newcomb's snail. This input is required approximately every 5 years when the General Plan undergoes revision.

4. Conduct landscape planning and conservation efforts. A variety of landscape planning and conservation efforts are underway and may affect long-term management of land and water resources in watersheds that provide habitat for the Newcomb's snail.

4.1 Proposed Makaleha Natural Area Reserve. The State of Hawai`i Department of Land and Natural Resources is considering a proposal to include a portion of the Makaleha Stream Watershed within the Natural Area Reserve System. The proposed area contains two known subpopulations of Newcomb's snail found in the vicinity of Makaleha springs and waterfall. This proposal to include an area containing Newcomb's snails in the Reserve System deserves support through cooperative efforts by groups such as the Kaua`i Watershed Partnership.

4.2 Hanalei American Heritage River Program. The American Heritage River Program facilitates cooperative participation by Federal, State, local, and non-government organizations in watershed planning, conservation, and development. In 1998, the Hanalei River was selected for participation as 1 of 14 U.S. rivers in the American Heritage River Program. Because the Hanalei River and its tributaries harbor four known subpopulations of Newcomb's snails, the Heritage River Program should, with support and cooperation from us, take into account watershed preservation and water resource protection for recovery efforts benefiting the Newcomb's snail.

4.3 Partners for Fish and Wildlife Programs (private lands). Two populations of Newcomb's snail are located on private lands. A variety of cooperative projects under our Partners for Fish and

Wildlife Program should be considered between us and the landowners to aid in recovery of the Newcomb's snail.

**4.3.1 Kamehameha Schools - Lumaha`i Watershed.** The Lumaha`i River population of Newcomb's snail is located on lands owned by Kamehameha Schools, previously known as the Bishop Estate. This very large private trust, along with its for-profit subsidiaries, owns approximately 10 percent of the entire land area of the State of Hawai`i. Much of the trust's lands, including the entire Lumaha`i watershed, is managed to provide income to operate a private school for children of Hawaiian descent. A significant portion of the trust's lands lie within the State Conservation District, and trust staff are developing proficiency in managing lands and water resources for the purpose of achieving a variety of conservation goals. Because Kamehameha Schools owns the entire Lumaha`i watershed, a unique opportunity exists to initiate comprehensive planning of land and water resources for conservation purposes. In the years 1999 and 2000, the Partners for Fish and Wildlife Program cooperatively developed a management framework for conservation activities in the Lumaha`i watershed. In cooperation with Kamehameha Schools, we should expand support of watershed conservation actions, including recovery activities for Newcomb's snail.

**4.3.2 Cornerstone Hawai`i Holdings LCC - Keālia Stream.** Keālia Stream is located on land owned by Cornerstone Hawai`i Holdings, LCC. This land ownership

and management company is currently involved in a variety of activities including residential development, a variety of agriculture enterprises including agro-forestry and ranching, resort development, and tourism. A resource conservation plan for agricultural uses of the land was prepared by the Natural Resources Conservation Service for the landowner. The landowner solicited input from a variety of State and Federal agencies on management activities on their lands. We should ensure comprehensive planning of land and water resources for the conservation of Newcomb's snail is considered in the plan prepared by the Natural Resources Conservation Service. Development of a Partners for Fish and Wildlife project, or similar conservation project, to assist with protection of stream or watershed resources should be developed with the landowner.

5. Develop and implement a public outreach program for Newcomb's snail. Public outreach on the preservation of inland surface water and groundwater resources and the habitat these waters support is important as Kaua`i undergoes changes in its agricultural economy and growth in urban land use. As residents of Kaua`i and the rest of the State become more aware of these issues, their receptiveness to conservation of the Newcomb's snail may increase. Visitor centers at State Parks, U.S. Fish and Wildlife Service refuges, and other State, Federal, and non-governmental facilities can be contacted to provide exhibit space, and to develop printed and multi-media material to enhance understanding this unique organism and its habitat.

6. Develop a post-delisting monitoring plan. Prior to delisting Newcomb's snail, a post-delisting monitoring plan and agreements to continue post-delisting

monitoring should be in place and ready for implementation. Monitoring populations following delisting will verify the ongoing recovery of the species and provide a means of assessing the continuing effectiveness of management actions.

Table 4. Cross-reference of recovery actions and listing factors for the Newcomb's snail.

Listing Factor	Threat	Still a Threat?	Recovery Actions	Recovery Criteria
A - Present or threatened destruction, modification, or curtailment of habitat or range.	Modification of stream and spring flows.	Yes	1.1, 1.2, 1.3, 1.4, 1.5.1, 3.1, 3.2, 3.3.1, 3.3.2, 3.3.3, 3.3.4, 3.4, 4.1, 4.2, 4.3.1, 4.3.2, 5, 6	1, 2, 3, 5
B - Overutilization for commercial, recreational, scientific, or educational purposes.	Not Applicable.			
C - Disease or predation.	Predation from non-native species.	Yes	1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 2.4.1, 2.4.2, 2.5, 4.1, 4.2, 4.3.1, 4.3.2, 5, 6	1, 2, 4, 5
D - Inadequacy of existing regulatory mechanisms.	Water resource protection.	Yes	3.1, 3.2, 3.3.1, 3.3.2, 3.3.3, 3.3.4, 3.4, 4.1, 6	3, 5
E - Other natural or manmade factors.	Interspecific competition.	Yes	1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 2.4.1, 2.4.2, 2.5, 6	1, 2, 4, 5

IV. IMPLEMENTATION SCHEDULE

The following Implementation Schedule outlines actions and estimated costs for the recovery of Newcomb's snail, and is a guide for meeting the objectives discussed in Chapter II of this plan. This schedule describes action priorities, action numbers, action descriptions, duration of actions, the organizations involved, and estimated costs. When multiple organizations are listed as the responsible party, an asterisk is used to identify the lead entity.

The actions identified in the implementation schedule, when accomplished, should aid understanding of the current distribution and status of Newcomb's snail, protect habitat for the species, stabilize the existing populations, and allow for an increase in population sizes and numbers so that the species can be considered for delisting.

A. Recovery Action Priorities

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

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

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

B. Acronym Definitions

C	Actions that will be implemented on a continual basis once begun.
CoK	County of Kaua`i
COWRM	Commission on Water Resources Management, Hawai`i Department of Land and Natural Resources
DAR	Division of Aquatic Resources, Hawai`i Department of Land and Natural Resources

DOFAW	Division of Forestry and Wildlife, Hawai`i Department of Land and Natural Resources
HHR	Hanalei American Heritage River Program
HIDOA	Hawai`i Department of Agriculture
HIDOH	Hawai`i Department of Health
NRCS	Natural Resources Conservation Service
UH	University of Hawai`i
USFWS	U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai`i
WRD	Geological Survey, Water Resources Division

Implementation Schedule for the Newcomb's snail Recovery Plan.

Priority #	Action #	Action Description	Action Duration	Responsible Party (*lead agency)	Total Cost - FY 2019	Costs Estimates ($1,000's)													
						FY 06	FY 07	FY 08	FY 09	FY 10	FY0 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19
Conduct research and monitoring essential to the conservation of the species.																			
1	1.1	Survey and monitoring.	2	USFWS* DAR	**30** **20**	15 10	15 10												
1	1.2	Implementation of monitoring program.	C	USFWS* DAR	**40** **40**		5 5	5 5	5 5	2.5 2.5	2.5 2.5	2.5 2.5	2.5 2.5	2.5 2.5	2.5 2.5	2.5 2.5	2.5 2.5	2.5 2.5	2.5 2.5
1	1.3	Obtain basic life history data.	14	USFWS* DAR	**34** **16**	5 2	5 2	2 1	2 1	2 1	2 1	2 1	2 1	2 1	2 1	2 1	2 1	2 1	2 1
1	1.4	Initiate translocation program.	C	USFWS* DAR UH	**128** **31** **90**			50 10 40	50 10 40	10 2 10	2 1	2 1	2 1	2 1	2 1	2 1	2 1	2 1	2 1
1	1.5	Validate recovery objectives.	14	USFWS* DAR	**14** **3**	1 1	1 1	1 1	1	1	1	1	1	1	1	1	1	1	1
Subtotal					**446**	**34**	**44**	**115**	**114**	**31**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**
Manage predation and interspecific interaction.																			
1	2.1	Predation by *Euglandina rosea*.	3	USFWS* DAR UH	**15** **15** **25**	5 5 15	5 5 5	5 5 5											
1	2.2	Predation by *Sepedomerus macropus* and *Sepedon aenescens*.	3	USFWS* DAR UH	**15** **15** **25**	5 5 15	5 5 5	5 5 5											
1	2.3	Predation by other introduced species.	3	USFWS* DAR UH	**15** **15** **25**	5 5 15	5 5 5	5 5 5											

Priority #	Action #	Action Description	Action Duration	Responsible Party (*lead agency)	Total Cost - FY 2019	Costs Estimates ($1,000's)													
						FY 06	FY 07	FY 08	FY 09	FY 10	FY0 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19
1	2.4.1	Competition with introduced lymneid and physid snails.	3	USFWS DAR UH*	**15** **15** **25**	5 5 15	5 5 5	5 5 5											
1	2.4.2	Evaluate *Bufo marinus* aquatic toxicity.	3	USFWS DAR UH*	**15** **15** **25**	5 5 15	5 5 5	5 5 5											
1	2.5	Predator and introduced species control.	C	USFWS* DAR	**400** **200**			100 50	100 50	20 10	20 10	20 10	20 10	20 10	20 10	20 10	20 10	20 10	20 10
Subtotal					**875**	**125**	**75**	**225**	**150**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**
Maintain stream and spring flows to protect Newcomb's snail habitat.																			
2	3.1	Inventory of water diversion and water extraction activities.	3	USFWS* COWRM	**15** **15**	5 5	5 5	5 5											
2	3.2	Provide input into Instream Flow Standards development.	C	COWRM* USFWS	**340** **75**	20	50 10	50 10	20 5	20 5	20 5	20 5	20 5	20 5	20 5	20 5	20 5	20 5	20 5
2	3.3.1	Provide input into State Water Projects Plan.	C	COWRM* USFWS	**70** **5**		10 1	20 1					10 1	20 1					10 1
2	3.3.2	Provide input into Agricultural Water Use and Development Plan.	C	HIDOA* USFWS	**70** **5**		10 1	20 1					10 1	20 1					10 1
3	3.3.3	Provide input into State Water Quality Plan.	C	HIDOH* USFWS	**70** **5**		10 1	20 1					10 1	20 1					10 1

Priority #	Action #	Action Description	Action Duration	Responsible Party (*lead agency)	Total Cost - FY 2019	Costs Estimates ($1,000's)													
						FY 06	FY 07	FY 08	FY 09	FY 10	FY0 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19
3	3.3.4	Provide input into County of Kaua`i Water Use and Development Plan.	C	CoK* USFWS	**70** **5**		10 1	20 1					10 1	20 1					10 1
3	3.4	Provide input into County of Kaua`i General Plan.	C	CoK* USFWS	**40** **4**			10 1	10 1					10 1	10 1				
Subtotal					**789**	**30**	**114**	**165**	**36**	**25**	**25**	**25**	**69**	**120**	**36**	**25**	**25**	**25**	**69**
Conduct landscape planning and conservation efforts.																			
3	4.1	Proposed Makaleha Natural Area Reserve.	C	DOFAW* USFWS	**110** **7**	20 2	30 5	5	5	5	5	5	5	5	5	5	5	5	5
3	4.2	Hanalei American Heritage River Program.	C	HHR* USFWS	**50** **20**	5 5	5 5	5 5	5 5	3	3	3	3	3	3	3	3	3	3
3	4.3.1	Kamehameha Schools Lumaha`i Watershed.	C	KS* USFWS	**85** **30**	10 10	10 10	10 10	5	5	5	5	5	5	5	5	5	5	5
3	4.3.2	Cornerstone Hawai`i Holdings LCC - Keālia Stream.	3	CHH* USFW NRCS	**15** **15** **15**	5 5 5	5 5 5	5 5 5											
Subtotal					**347**	**67**	**80**	**50**	**20**	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**
Develop and initiate a public outreach program for Newcomb's snail.																			
3	5	Develop a public outreach program for Newcomb's snail.	C	USFWS	**33**	15	5	2	1	1	1	1	1	1	1	1	1	1	1
Subtotal					**33**	**15**	**5**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

Develop a post-delisting monitoring plan.																			
3	1.5.1	Determine number of populations and individuals needed for long-term recovery and survival.	5	USFWS	**25**	5	5	5	5	5									
3	1.5.2	Revise delisting criteria as necessary.	3	USFWS	**15**												5	5	5
Subtotal					**40**	**5**	**5**	**5**	**5**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**5**	**5**
TOTAL COST					**2,530**	**276**	**323**	**562**	**326**	**105**	**81**	**81**	**125**	**176**	**92**	**81**	**86**	**86**	**130**

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APPENDIX A
Newcomb's Snail Recovery Planning
Stakeholder Involvement, Comments on the Draft, and Peer Review

The Newcomb's Snail Draft Recovery planning process was initiated with preparation of the Recovery Outline in March 2000. Since that time we have consulted with a variety of stakeholders through various formal and informal mechanisms associated with public information meetings, solicitation of scientific expertise, designation of critical habitat, and field surveys to relocate Newcomb's snail populations.

Stakeholder Involvement

- Public information meeting to solicit informal input into critical habitat designation (Hanalei Courthouse, March 2001).
- Meeting with Alexander and Baldwin (A&B) representatives regarding implications of critical habitat (A&B Honolulu Office, March 25, 2002). A&B owns a large parcel of land that encompasses the Wainiha River watershed, a historical Newcomb's snail location.
- Public hearing to formally solicit input form the public regarding critical habitat designation (this hearing was preceded by lengthy discussion period covering Newcomb's snail conservation topics such as listing and recovery) (Radisson Hotel, Hanamā`ulu, April 2002).
- Meeting and discussion with Keālia Ranch managers prior to walking to Newcomb's snail population at Keālia Stream (Keālia Ranch/Spaulding Monument, May 2003).
- Discussion with the staff of the Hanalei American Heritage River Program (Hui) and cooperation with access for a snail survey at the Hanalei Diversion site (May 2005).

Comments on the Draft Recovery Plan

The Notice of Availability for the Draft Recovery Plan was published March 24, 2004. Letters were received from the office of Senator Akaka and the Hawai`i Department of Land and Natural Resources expressing thanks for sending the Draft. The Office of Hawaiian Affairs had 2 comments: 1) critical habitat must take into account Native Hawaiian traditional and cultural gathering and access rights, and 2) Hawai`i's Public Trust Doctrine requires that the needs of stream ecosystem and habitat protection must be accounted for prior to any diversion of water. Both of these comments are consistent with approach of our recovery planning process.

Peer Review

Scientific experts in the field were consulted for both the designation of critical habitat and for recovery planning:

- Michael Kido, Director, Hawai`i Stream Research Center, University of Hawai`i.
- Adam Asquith, Sea Grant Extension Service, University of Hawai`i.
- Donald Heacock, Kaua`i District Aquatic Resources, Hawai`i Department Land and Natural Resources.

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