Report of Kanab Ambersnail Review Panel on Taxonomic, Ecological, and Translocation Issues Concerning the Conservation of *Oxyloma* Snails in Arizona and Utah

Reed Noss (chair), Mark Gordon, Elaine Hoagland,
Charles Lydeard, Patricia Mehlhop, and Barry Roth

Introduction

Our panel was assembled to review the research and conservation efforts made in behalf of the Kanab ambersnail (*Oxyloma haydeni kanabensis*) and related taxa of succineid snails in the Colorado River drainage of Arizona and Utah, with emphasis on the population at Vasey's Paradise in Grand Canyon National Park. A long-standing issue is how water releases from Glen Canyon dam might be modified to match more closely the natural flow regime and provide ecosystem-level benefits, such as building beach habitat along the Colorado River downstream from the dam, and how these flows may affect endangered species such as the Kanab ambersnail (KAS). This issue has been cited as a classic case of conflict between ecosystem-based management and management for the benefit of individual, imperiled species. The issue is made more poignant by the fact that the Vasey's Paradise population is within a national park, where the prevailing management paradigm is natural regulation. Complicating the issue further, the taxonomic identity of succineid snails at Vasey's Paradise and elsewhere in the region has been called into question with recent molecular genetic studies suggesting that the Vasey's Paradise population is distinct from all others and probably is not KAS.

This report addresses eight issues, each of which carries a set of specific questions that were presented to our panel for consideration. Our responses to the questions carry the assumption that the population at Vasey's Paradise, although probably not KAS, is an unique taxon that deserves protection. Moreover, given the taxonomic uncertainties and indications that multiple *Oxyloma* taxa may be present and potentially imperiled in the Colorado River drainage, we suggest that an appropriate conservation target, or unit of management, is the entire suite of succineid snail populations and their highly variable habitats. This "ecosystem" approach is more consistent with the first stated goal of the Endangered Species Act of 1973, which is to conserve the ecosystems upon which threatened and endangered species depend, than is the current management approach, which emphasizes intensive species-by-species and site-by-site efforts.

Among the general conclusions of our review, reported in more detail in our responses to specific questions, are the following recommendations:

- Additional analyses of shell morphology, anatomy, and molecular genetics (e.g., mitochondrial DNA), using state-of-the-art methods, are urgently needed to resolve taxonomic, phylogenetic, and, in part, distributional questions.

- Also urgently needed are additional field surveys of potential succineid habitats both

upstream of Glen Canyon dam and downstream within the Colorado River drainage, as well as in regions outside the Colorado River basin that provide potential habitat.

- In contrast, additional efforts at translocation and establishment of captive populations are not warranted.

- Population viability analysis of the Vasey's Paradise population, and probably other *Oxyloma* populations, is not likely to be informative or helpful for conservation of these populations; preferable alternatives to population viability analysis exist.

- Flooding from dam releases within the historic (pre-dam) seasons and levels is justified ecologically and is unlikely to pose a significant threat to the Vasey's Paradise snail population, which appears to have evolved under an intense flooding regime.

- No scientific basis exists for heroic efforts to maintain or create artificially large or multiple populations of the Vasey's Paradise snail; instead, available information on historical ecology supports a minimally invasive approach to management of Vasey's Paradise and other populations of *Oxyloma*.

- The Recovery Plan for the *Oxyloma* populations in this region should be re-written as soon as the major taxonomic issues are resolved. The Vasey's Paradise population may warrant listing and conservation as a distinct, imperiled taxon, perhaps a single-site endemic.

- The administrative and management implications of new taxonomic findings should be discussed and disseminated widely and promptly to all parties. Any subsequent management or recovery plan should be subjected to a review process similar to that of this panel prior to implementation.

- Our conclusions suggest a reconsideration of current management direction for these snails and their ecosystems.

It is noteworthy that our team reached consensus on every major issue, with no dissenting opinions. This is a remarkable achievement, and rare for such panels, especially considering that our team represented diverse areas of expertise, including molluscan anatomy, morphology, taxonomy, and systematics; molecular genetics; evolutionary ecology; landscape ecology; conservation biology; and environmental policy.

Issue 1

This issue involves the molecular genetics, shell morphology, internal anatomy, and taxonomy of *Oxyloma* snails in the Colorado River drainage. We find that neither of the current statements, morphological/anatomical or DNA-based, on ambersnail taxonomy is adequate to describe the

taxonomic status of the populations in question. Although the morphological/anatomical and molecular genetic assessments appear to conflict, both studies are so preliminary that the apparent conflict may not mean much. The available information indicates an urgent need for revision of the specific and subspecific taxonomy of *Oxyloma* after further study.

The morphological/anatomical study by Shi-Kuei Wu was not presented with enough rigor for us to evaluate its conclusions. Clear, replicable character state definitions and a data matrix of characteristics versus taxa are needed to resolve problematic systematic relationships. More specimens and populations also need to be examined. The DNA-based study by Mark Miller resolved well at the level of the traditional genus (i.e., *Succinea*, *Catinella*, *Oxyloma*), although one of the two "*Succinea*" clades may represent *Novisuccinea*, which the best modern taxonomy recognizes as a full genus. Nevertheless, the DNA-based analysis provided only minimal resolution within the *Oxyloma* clade. We were not given complete information on the genus-wide study, and several minor errors (e.g., incorrect localities) were apparent in these results.

We also note that the DNA results were based on only a portion of a single gene, cytochrome B, and no non-succineid out-groups were employed in the statistical analyses. Additionally, the partial use of the cytochrome B gene, and the related relatively low number of base pairs, in the analyses suggests potential degradation of some tissue samples. The entire cytochrome B and other genes, for example more rapidly evolving ones, should be studied and might provide better resolution of taxa. Any subsequent molecular genetic investigations should be conducted, at least in part, by a professional with expertise in molluscan systematics. We recommend a genus-wide study of *Oxyloma*, including Old World specimens. In fact, a thorough systematic treatment of Succineidae is in order.

(1A) *Is it appropriate to identify ambersnails exclusively, or primarily, based on morphological characteristics?* It is not yet clear that ambersnails can be identified reliably at the species level or below based on reproductive anatomy or shell morphology, alone or in combination. Resolution might be possible with more rigorous qualitative and quantitative criteria in place.

(1B) *What is the current understanding of KAS distribution in northern Arizona and southern Utah based on genetic analyses?* The current understanding of KAS distribution in the region based on molecular genetic analysis is unclear. The DNA-based study was unable to resolve taxa within the *Oxyloma* clade, with the possible exception of the Vasey's Paradise population. We make two observations in this regard: 1) The only samples that might be topotypic KAS (*Oxyloma haydeni kanabensis*) are 40.304 and 40.305, which cluster as zero-length branches in the middle of the *Oxyloma* clade. These specimens, however, were not identified as *kanabensis* by Wu on the basis of shell morphology or reproductive anatomy. Thus, it is not clear that any true KAS have been analyzed yet or that its differentiation from *O. haydeni sensu stricto* is warranted. Further morphological or anatomical study may alter this conclusion. 2) Other purported KAS from areas that have been studied ecologically (e.g., Vasey's Paradise, Three Lakes, -9 Mile, Indian Garden) are "all over the map" genetically according to Miller's analysis. Miller's preliminary study, which addressed only the above four congregations, demonstrated that

they are distinct from one another. The scale or significance of these distinctions is not clear, however. Furthermore, the four congregations nest differently in the large study than in the preliminary study.

(1C) *Is the Vasey's Paradise (VP) population unique?* The Vasey's Paradise population is genetically unique (distinct), i.e., it has three gene changes that the rest of *Oxyloma* do not have and lacks seven that the rest have, based on Miller's Figure 2 (tree #1 of 32 equally parsimonious phylogenies). We conclude that it is likely that the Vasey's Paradise population is a distinct, presumably undescribed species, but a rigorous phylogenetic framework to demonstrate this distinctness is not yet in place.

(1D) *How do recent discoveries, experimental results, and observed findings alter the current understanding of ambersnail taxonomy for populations in the Grand Canyon region?* Recent discoveries, results, and findings highlight the need for improved morphological, anatomical, and genetic study on which to base taxonomic, policy, and management decisions. The decision-making process can be no better than the underlying taxonomy.

(1E) *In seeking to establish additional populations of KAS at new sites in Grand Canyon, would it contribute to genetic exchange and population viability to translocate snails from more than just the VP site?* No. As discussed later in this report, we recommend against translocation.

(1F) *Is inbreeding a significant risk factor for the translocated VP KAS?* From what is known, no.

Issue 2

This issue concerns the observed wide seasonal and annual fluctuations of the Vasey's Paradise population in relation to the 1994 biological opinion of the U.S. Fish and Wildlife Service that "incidental take will assume to be exceeded if more than 10% of the occupied habitat in Grand Canyon will be inundated by high flows or a controlled flood." To put this issue into perspective, we note that *Oxyloma* snails in the Southwest inhabit highly variable environments, subject to extreme flooding, drought, and associated fluctuations in water table and outflow from springs and seeps. Suitable habitats for these snails, although probably more widespread during full glacial periods of the Pleistocene as well as wet periods of the Holocene, were probably always isolated and were regularly decimated by natural events. Hence, populations of these snails can be assumed to have winked on and off over time. This is the ecological milieu in which these populations evolved and continue to evolve. Populations that persist a long time in isolation have a high probability of becoming genetically distinct, which may be what has happened in the case of the Vasey's Paradise population (see Issue 1), although we cannot be sure that differentiation took place at the Vasey's Paradise site.

Our team was presented information (primarily from Larry Stevens) showing that habitat for the Vasey's Paradise snail population increased by at least 40% after construction of Glen Canyon

Dam and cessation of natural flooding. The population undoubtedly increased earlier, but by an indefinite amount, in response to the invasion of the site by the non-native watercress (*Nasturtium officinale*), now a preferred food. The post-dam increase in habitat and population for the snails is an artificial phenomenon. There is no ecological basis for the 10% take limit set by the U.S. Fish and Wildlife Service, which corresponds to regulated floods (dam releases) of approximately 25,000 cfs (higher by some accounts). The 1996 experimental beach habitat-building flow of 45,000 cfs took about 15% of currently occupied habitat, whereas an unplanned flood of ca. 100,000 cfs in 1983 took approximately 33%. The snail population at Vasey's Paradise recovered to its unnaturally high level within three years of the 1996 flood (recovery after the 1983 flood was not monitored). In contrast, average *annual* flooding before the dam was at a level of 90,000-125,000 cfs, which would correspond to a take of 30-40% of currently occupied habitat.

The floods that will result from proposed releases from the dam (i.e., beach habitat-building floods of 45,000-90,000 cfs) will be well within the natural (pre-dam) range of variability. In fact, a strong case can be made that releases should be increased to more closely match the natural hydrologic regime, including inter-annual variability. That the habitat at Vasey's Paradise has recovered and persisted despite such floods is indicated by the similarity of the present scene to John Wesley Powell's description of the site more than a century ago (in Stegner, 1992, *Beyond the Hundredth Meridian*, Penguin Books edition). The Vasey's Paradise snail population presumably persisted for a long period of time with annual floods of around 125,000 cfs, and with occasional floods (i.e., 100-year events) of twice this level or more. There is no reason to believe that the population cannot survive floods of these magnitudes in the future.

(2A) *What is the natural mechanism of dispersal for KAS or similar snail species to expand their range?* Passive dispersal though rafting (e.g., in clumps of dislodged vegetation) and carriage on birds are the primary means by which *Oxyloma* snails colonize new habitats and re-colonize habitats from which they have been extirpated. Populations in meadows versus seep habitats probably relied on different mechanisms. For example, carriage on birds is probably more common for meadow populations, whereas rafting can be assumed to be more important for populations inhabiting riverside seeps. Within Vasey's Paradise, dispersal downslope to colonize new habitat exposed with lower, post-dam water levels has been documented. Hence, snails are able to colonize nearby habitat actively, presumably by crawling, whereas long-distance dispersal is passive.

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(2B) *Is this dispersal enhanced or depressed by dam operations?* Dispersal of land snails has always been haphazard. Successful colonization is a rare event. There is no evidence that the dam has depressed the dispersal of snails. Surveys below the dam have failed to turn up any additional populations. Again, we emphasize the need for new field surveys in the Colorado drainage above the dam, including potential shoreline habitats along Lake Powell and in the tributaries currently draining into it, further surveys downstream from known populations (including tributaries of the Colorado, e.g., the Virgin River below Zion National Park, where potentially suitable wetland habitats are available according to Vicky Meretsky), and in regions adjacent to the Colorado

River basin that support similar habitats.

(2C) *How was the VP population able to recover and reinhabit VP after extreme high flow events before the dam was built?* Ambersnails follow post-flood revegetation, recolonizing substrates exposed after floods. The species at VP appears to have evolved in this kind of habitat and flow regime for a geologically long period. They are adapted to this variability through high fecundity and other mechanisms. Dispersal is not necessarily limited; rather, suitable habitats for colonization are limited, so successful colonization is a rare event. The question of precisely how the snails recovered and reinhabited habitats after pre-dam floods is not particularly relevant. The important fact is that they did and can be assumed to do so again, albeit infrequently.

Issue 3

This issue is focused on the Vasey's Paradise (VP) site and raises questions about the vegetative habitat of the snail population there.

(3A) *Is it appropriate to distinguish primary and secondary habitats, and extent of use, or is it enough to know that the snails use it, therefore it's of critical value?* What is defined as secondary habitat is the lower zone habitat, below the 45,000 cfs line. To assume that all vegetation currently occupied by the snails is of critical value to the persistence of the snail population is fallacious. We believe it is generally appropriate to distinguish secondary from primary habitat at VP; the secondary habitat would not have been there consistently in any abundance under the pre-dam flow regime. Therefore, it is presumably not critical to the persistence of the snail.

(3B) *What are the critical biotic and abiotic characteristics of the VP site that create unique habitat for KAS only at this location in the Canyon?* The VP population exists at VP probably as a consequence of a chance historical event. The question assumes that the site is unique. It may not be. The equilibrium theory of ecology would support the assumption that all favorable habitat will be occupied, whereas unfavorable habitat will be unoccupied. The alternative non-equilibrium view, which has more scientific support, suggests a large role of chance colonization and extinction events in shaping distributional patterns. At a given point in time, many areas of favorable habitat may be unoccupied, whereas marginal habitat may be occupied (at least temporarily). Over time, populations at individual sites often wink on and off. Nevertheless, we note that the VP site appears at this time to be quite different from other habitats in the region that contain populations of *Oxyloma* snails. The significance of this difference is unclear, given the lack of thorough knowledge of *Oxyloma* taxonomy and distribution.

Issue 4

This issue, which states that, within Grand Canyon National Park, KAS is restricted to VP and that no other populations have been detected at more than 100 other springs and seeps in the Canyon, is based on the assumption that the VP population is *O. h. kanabensis*. The conclusion

that the VP population is KAS has been thrown in doubt by recent molecular studies (Miller). Although no populations have been detected downstream, intensive surveys have not been conducted in many suitable habitats. This issue also suggests that the VP snail is a Pleistocene relict which was formerly more widespread. Although this may be true, it is equally plausible that this particular taxon has always been restricted to this site or a small collection of sites, whether narrowly or widely distributed, with other occurrences yet to be discovered. What is known, so far, of its genetics (see Issue 1) suggests that it is a long-branch taxon that diverged from a more basal portion of the phylogenetic tree; hence, its separation from other *Oxyloma* populations, whether by dispersal or vicariance, probably took place a long time ago, perhaps much earlier than the Pleistocene. The questions below, and our responses, are partially redundant with Issue 2, addressed earlier.

(4A) *What percentage of snails can be lost in one year, or consecutive years, without adverse long-term consequences to the population (given the high inter-annual variability in population size)*? No definitive answer exists to the question of what proportion of the population can be lost in a given year without adverse long-term consequences. Nevertheless, this question should be interpreted in light of the historic flow regime. Under natural conditions, the VP snail population would have fluctuated from year to year depending on the severity of flooding, drought, temperature, and other factors. It seems to be a "r-selected" species, with a short life-span, high reproductive potential, and a population regulated largely by density-independent, physical factors. In order to monitor the status of the population, we suggest a minimally invasive approach using photographic series combined with annual observations of egg masses and young of the year (i.e., if egg masses and young can be found with relative ease, then the population can be assumed to be of viable density) until a reasonably predictive model of population responses to flooding can be developed. The model can then be validated periodically with new surveys. We caution against frequent, intensive population surveys, because they are expensive and destructive of vegetation and snails.

(4B) *Given the recent information on KAS population status and ecology, should the 10% take limit of VP habitat still apply to current management of Glen Canyon Dam operations?* No. The 10% take limit has no basis in science. Suitable habitat for the snail population at VP has increased by more than 40% since building of the dam and, before that, by colonization of the site by *Nasturtium*. Variable flood events up to 125,000 cfs annually—with occasional, much higher flows (e.g., 200,000 - 300,000)—are part of the natural disturbance regime and can be assumed to pose no long-term threat to the snail. An initial flood event of 125,000 cfs would "take" approximately 40% of currently occupied VP snail habitat. Thereafter, annual flows of approximately this magnitude would take a very small percent (if any) of the habitat, because the snails would be restricted to a smaller area more similar to their pre-dam distribution at the site.

(4C) *What percentage of habitat protection is appropriate to ensure long-term survival of the VP KAS population?* As explained above, initial take of 40% would almost certainly not threaten the persistence of the snail population. The question of the percentage of habitat protection needed appears misguided. A more important consideration is the perpetuation of the natural processes

that create and renew a variety of natural habitats within the broader ecosystem.

Issue 5

This issue, which again concerns managed flood regimes and their impact on the VP snail population, is largely a restatement of Issue 4 and also overlaps with Issue 2. We addressed this issue for VP in Issue 4; available data do not allow us to address the issue for the other *Oxyloma* populations. This difficulty underscores the need for further field studies and taxonomic work before establishing a long-term conservation strategy for these populations.

5A) *Can we establish or predict what level of habitat destruction would most likely have long-term adverse consequences to a local KAS population or to the species throughout its range?* As suggested by our response to questions #4A-C, no. Moreover, it is important to recognize that flooding is not "habitat destruction;" rather, it is a natural process that creates a variable patch dynamic characteristic of these riverine environments.

(5B) *What information is necessary to establish a population viability index for KAS, with a reasonable degree of confidence?* We seriously doubt that population viability analysis (PVA) or development of a population viability index (whatever that is) will produce information of much use for the conservation or management of *Oxyloma* snails and their habitats. We suggest that PVA is generally not appropriate for annual species, nor is it suitable for a species whose population size and demographic parameters are so difficult to estimate, as suggested by past sampling problems and data sets limited by the sampling methodology employed.

Several alternatives to PVA may be more appropriate for *Oxyloma* populations. Elasticity analysis can be used to estimate the proportional change in population growth rate for a proportional change in vital rates (i.e., survival, growth, reproduction), using a projection matrix based on life-history stages (for an overview, see Benton and Grant, 1999. *Trends in Ecology and Evolution* 14:467-471). Elasticity analysis has been applied successfully to many species with a wide variety of life histories. Such analysis can help managers determine the life-history stage that, when varied, has the greatest impact on overall population size or persistence. In conjunction with elasticity analysis, a detailed habitat dynamics model could be used to predict the impacts of floods and other disturbances of different levels on vegetation and population dynamics. This general kind of approach has been called "species-centered environmental analysis," which begins by organizing prior knowledge about the factors that limit the population of interest, then considers results from new studies to evaluate alternative explanations for how environmental factors and various management actions might affect populations (see James et al. 1997, *Ecological Applications* 7:118-129). These approaches generally do not provide the "hard numbers" of PVA (persistence times, probabilities of extinction, etc.), but it has become increasingly apparent that such numbers are usually wrong and almost always misleading. In any case, we suspect that viability of the VP snail population is linked most strongly to the probability of a major catastrophe (i.e., a Noah-sized flood), which could be an entirely natural event.

(5C) *Is the time it takes for habitat to recover critical to the viability of the KAS population?* This question is irrelevant if we assume (as we recommend) that a natural, annual flooding regime will be mimicked by dam releases.

(5D) *If the VP habitat (KAS host plants) are somehow protected from flood scour, can KAS in the affected habitat withstand 2-4 days of inundation and displacement from river currents?* Experimental evidence is that the snails cannot withstand this level of inundation and displacement, as snails died after 17 hours of immersion. We do not recommend protecting KAS host plants from flood scour, nor do we recommend moving snails within the lower-zone habitat out of the way of flood waters. This expendable portion of the population, however, could serve as the source of individuals for taxonomic, physiological, and other studies.

Issue 6

This issue involves the requirement of the Endangered Species Act that actions funded, authorized by or carried out by a federal agency should not jeopardize a listed species. Management actions taken so far at Vasey's Paradise to avoid jeopardy have included moving snails to higher ground before floods and translocating snails to new locations within Grand Canyon National Park and to captive refugia in zoos and elsewhere. As explained in our responses to the questions below, our panel believes that such actions are misguided and unnecessary to conserve this taxon.

(6A) *Is moving an endangered species an appropriate, ongoing method to protect the species?* As we stated in our response to question #5D, we do not think moving snails to higher ground is worthwhile. Nor do we think translocation, in this instance, is a wise practice. In some cases translocation of an endangered species has been shown to further the conservation and recovery of the species. This intensive effort, however, should be seen as a last resort. Although there is precedent for translocations of endangered species in the region, the record of success is generally poor. Historical distributions, present distribution, and taxonomy should be thoroughly resolved before considering translocation in any case. Our panel believes that translocations into sites where no previous records exist is not advisable except under emergency circumstances. Translocation commits agencies to perpetual active intervention (e.g., population augmentation, monitoring, and associated surveys) which is expensive, destructive of the habitat and individuals of the natural population, and not justified by the available scientific information and reasoning.

(6B) *Are there other options?* Management of the *Oxyloma* populations at their present locations in a minimally invasive way is our preferred alternative. Reintroduction to sites where a species is verified to have occurred in the past, and where suitable conditions for persistence remain or can be restored, is an important adjunct to protection and management of currently occupied habitat. This style of reintroduction is consistent with the strategy of restoring natural processes, such as floods.

(6C) *Does the historic distribution of an imperiled species (wide-ranging or narrow endemic)*

suggest different conservation strategies? Yes, it can. Hundreds, perhaps thousands, of species in North America have their known, current ranges restricted to single sites. An unknown proportion of these narrow endemic species, but undoubtedly many, have always been restricted to single sites or small constellations of sites. Restoring any species, whether formerly wide-ranging or endemic, to areas it previously occupied is a legitimate conservation action whenever the circumstances for such restoration are favorable. In contrast, artificial expansion of the range of a narrow endemic is not justifiable biologically or in terms of conservation strategy.

(6D) *Should an endemic mollusk be considered secure if its habitat appears stable and its population is considered both viable and defensible?* The idea of stability is problematic for habitats that are naturally dynamic, which all habitats are to one degree or another. Resilience—the ability to recover from periodic disturbance—is a more appropriate concept. Examples exist of populations going extinct due to disease and other factors, while their habitat remained intact. Distinguishing between background rates of extinction versus human-caused extinctions is often difficult, although it is well accepted that humans have recently increased overall extinction rates well over background levels. Over long periods of time, the natural fate of most small populations (e.g., narrow endemics), with or without human influence, is extinction. Indeed, the natural fate of any species is extinction. Meanwhile, other isolated populations slowly differentiate into new species, some of which expand their ranges. Outside of the mass extinction events recorded in the fossil record, and that occurring now as a consequence of human activity, the rate of speciation slightly outpaced the rate of extinction. *Oxyloma* populations should be considered reasonably secure if they are fluctuating, along with their habitats, within a historic range of variation. Then, they have a good chance of persisting and evolving for a long time.

(6E) *Does the risk of translocation outweigh the reward of reduced likelihood of extinction?* Intensive intervention always carries risks. If a historic flow regime is restored, there will be fewer expendable individuals available for translocation. Moving individuals to higher ground within the VP site is not a defensible strategy. We do not recommend further translocations or further augmentation of the populations already established within Grand Canyon National Park. On the other hand, we do not recommend extermination of translocated populations within the Park at this time. We do not see a useful conservation-oriented purpose for the captive populations (refugia). These populations exist in an artificial selective regime and may harbor diseases that potentially could be disastrous if introduced to the wild. We recommend that the captive populations not be the source of individuals to return to the wild. On the other hand, they may be useful for controlled laboratory research. The dam population, because it could result in unintentional releases of snails to the wild and artificial gene flow, should be exterminated or transferred to the populations at Northern Arizona University or the Phoenix Zoo.

Issue 7

The Vasey's Paradise snail population and the population at Three Lakes are known to be infected by a parasitic trematode, *Leucochloridium cyanocittae*. This symbiotic association of

Oxyloma and *Leucochloridium* is probably ancient and close, although the worm has been found in other succineid taxa (e.g., *Catinella*). No evidence suggests that the parasite has a significant, negative effect on the snail population. Infected snails, which make up a small proportion of the population, have been observed to reproduce normally, although possibly with depressed fecundity. The conservation of the worm is ultimately as worthwhile as the conservation of the snail. The issue of how the worm should be treated in snail translocations is not particularly relevant because we do not believe that translocations are warranted.

(7A) *What measures should be undertaken when introducing KAS to new locations to reduce parasite infection?* This question assumes that further translocations will take place, which we recommend against. Nevertheless, if translocation were to take place, we do not believe that measures to reduce parasite infection are warranted. This is a non-issue.

(7B) *Should the parasite also be intentionally (or incidentally) moved, or should efforts be taken to use only parasite-free specimens?* Again, we do not recommend translocation, but if it were to take place, moving the natural parasites and other symbionts of the snails would be proper.

(7C) *Are there risks of adverse effects on other snail species already inhabiting sites for KAS introduction?* No. If the parasite could potentially infect these other populations, it probably would have done so already.

Issue 8

This issue cites the U.S. Fish and Wildlife Service's biological opinion for the 1996 beach habitat-building flow, which required formal consultation if incidental take from flows will exceed the 10% limit established in a 1995 biological opinion. Our panel concludes that the biological opinions were not reasonable, neither at the time they were established nor especially today, given the increased information available. The 10% take limit and similar opinions are not justified by available knowledge of the biology of these species. It appears that the U.S. Fish and Wildlife Service has been preoccupied with setting and enforcing arbitrary and biologically naïve statutory requirements, rather than promoting broader conservation goals. We note that a broader strategy (i.e., one that takes into consideration evolutionary and ecological processes, as well as a greater variety of taxa and habitats) may better achieve the goals of the Endangered Species Act and other conservation legislation in the long term. Hence, it is important not just to follow the letter of the law, but also the spirit of the law to sustain, within natural bounds, these continually evolving lineages within the context of their dynamic ecosystems.

As discussed earlier, we do not believe that the establishment of new populations through translocation is a sound policy. Although the Vasey's Paradise population and taxon may have been more widespread in the past—and may be more widespread now than we know—no evidence exists to support such speculation. Given available information, it is just as reasonable to assume that the taxon evolved at its present site, or nearby, and has always been approximately as rare as it is now. The 10% take limit does not correspond to the distribution of habitats and

operation of natural processes under a pre-dam flow regime. Furthermore, the criteria for success by the establishment of new wild populations are not reasonable, nor is the idea of establishing new populations outside the known, natural range of each taxon reasonable.

Recent surveys have found new *Oxyloma* populations in Utah. Until the taxonomy of these populations is resolved, we have no idea how many populations of each taxon are extant. In any case, the requirement to establish 10 populations of KAS before downlisting can occur has no basis in science. It seems unreasonable to require any populations to be translocated until taxonomic and survey work has been completed. The three populations of KAS that exist under current taxonomic assumptions provide sufficient replication of populations, especially considering the size of the Greens population. The Alberta population, tentatively identified as *kanabensis* by Wu, is questionable due to the immaturity of the specimens.

(8A) *In attempting to establish new populations, what period of time (persistence) or number of successful generations is reasonable to consider the population a success?* We do not recommend establishment of new populations. Nevertheless, if the currently translocated populations are to be monitored, 10-30 years (generations) may be required to judge the translocation a success. As before, we recommend against intensive, frequent population surveys, as they are destructive of habitat and snails.

(8B) *How close geographically can ambersnail populations be to each other and still be considered distinct?* The geographic distance separating populations is relevant only to the extent that relative distance determines the probability of a single, catastrophic disturbance affecting both populations. Populations can be considered distinct if they are unlikely to be extirpated by the same catastrophic event, such as a flood or landslide. Virtually the only conceivable major catastrophe, in the near term, that would extirpate populations in the Grand Canyon is dam failure, which would probably eliminate populations and suitable habitat up to 500' above current water level.

(8C) *Could genetic variances in newly discovered KAS congregations be considered significant enough to change our assessment of the number of known KAS "populations"?* We cannot answer this question until further molecular genetic studies have been conducted and the taxonomy of these populations is resolved. The targets for conservation should be whatever taxa are distinguished by this work.

(8D) *What should be the boundaries for establishment efforts--historic ranges versus state/political boundaries?* We favor basing boundaries for reestablishment on documented historic ranges only.

(8E) *Should establishment efforts concentrate within the known geographic range or extend outside this range?* We suggest that all efforts be conducted within the known range. Protection of extant populations (within historic, pre-dam ranges of variation) is the highest priority.

Conclusion

We conclude that the recovery plan and biological opinions regarding the Vasey's Paradise and other *Oxyloma* populations should be revised as soon as the major taxonomic and distributional issues are resolved by further morphological, anatomical, and molecular genetic studies and new field surveys. Current, intensive actions (protection from flow-induced take, intensive population surveys, translocations, management of captive populations) taken on behalf of the Vasey's Paradise population cannot be justified by available scientific information or reasoning. We note that funds for the conservation of this and other endangered species are limited and are likely to remain so; hence, they must be spent on actions that will best meet conservation goals in the long term, including the primary goal of the Endangered Species Act to conserve the ecosystems upon which threatened and endangered species depend. With regard to the Vasey's Paradise population, assuming no increased anthropogenic threats, historical (pre-dam) patterns of vegetation inundation and loss and associated fluctuations in the snail population do not pose a significant threat to population persistence.

Acknowledgments

The panel unanimously agrees that this was one of the best organized, most efficient, and most productive panels on which we have participated. The organizers of the workshop, especially Jeff Sorensen of the Arizona Game & Fish Department, deserve the highest praise for making this event so worthwhile. They presented us with essentially all the information that is currently available and relevant to the issues discussed here. That our panel's recommendations are somewhat at odds with current policy and management direction on the part of state and federal agencies is no reflection on the competence of the staff, which we found to be of the highest caliber. To other participants in the workshop, especially the researchers, we express our gratitude and thanks for sharing their data and opinions in such a selfless and congenial manner.