

# FEASIBILITY STATEMENTS FOR FRESHWATER MUSSELS MANAGEMENT OBJECTIVES

Prepared by: Beth Swartz  
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The desirability, feasibility, habitat capability, and possible consequences of the recommended freshwater mussel objectives are presented below. To achieve the stated objectives, survey and monitoring programs, habitat management activities, research, and outreach will all have to be increased significantly. The necessary financial and staff resources to meet all of these objectives are currently unavailable to the Maine Department of Inland Fisheries and Wildlife (MDIFW). Significant new funding will have to be generated, and outside expertise and contract personnel will need to be hired.

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## GOAL

**Ensure the long-term viability of native freshwater mussels, their habitats, and their hosts in Maine.**

**Funding Objective: By 2010, develop and implement a plan to secure funding to accomplish the following conservation and management objectives.**

Desirability: Adequate funding is essential to accomplishing the objectives outlined below for freshwater mussels.

Feasibility: State Wildlife Grants and monies acquired through the Endangered and Nongame Wildlife Fund (primarily Chickadee Checkoff and Loon Plate revenues) are not adequate to accomplish all of the proposed objectives. Additional funding opportunities are possible, but securing funds in the amount needed may be beyond MDIFW's capabilities.

Capability of Habitat: N/A

Possible Consequences: The level of funding will directly influence which objectives are addressed and whether they are accomplished by their target dates.

**Population Objective 1: Through 2023, at a minimum, maintain current distributions and population levels of all native freshwater mussel species in Maine. Where feasible, restore historical distributions of native species and increase current population levels of Endangered, Threatened, or Special Concern species where numbers are documented to be low or declining.**

Desirability: Freshwater mussels play a vital role in Maine's aquatic ecosystems. Because they often make up the largest proportion of the total biomass of aquatic animals in a lake or river, they can have significant influence on water quality, nutrient cycling, aquatic food webs, and benthic structure. Freshwater mussels are also one of the most imperiled groups of animals in North America. Of the nearly 300 species found in the United States, more than a third is currently listed as federally Endangered, Threatened, or are already extinct – primarily as a result of habitat degradation and loss. Maintaining at least the current distributions and population levels of our ten native species is fundamental to supporting healthy aquatic

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ecosystems in Maine, as well as conserving both state and range wide status of even our most common species.

Historical information about the distributions and population levels of Maine's freshwater mussels is very limited, but there are indications that species may have been extirpated from some rivers (e.g., alewife floater from southern coastal watersheds). Data on current population levels are also limited and based largely on qualitative assessments made during recent statewide surveys by MDIFW. Most species appear to be common or abundant and doing well throughout all or most of their range in Maine, but several have restricted distributions and/or are often documented in low numbers, with little evidence of recruitment. Population trends are completely unknown, and there is currently no system in place to indicate declines or monitor changes over time. When documentation supports it, however, restoration of extirpated or declining populations -- especially of state-listed mussels -- should be a priority consideration for returning species to their historical distributions and preventing further declines in Maine.

Feasibility: As a result of MDIFW's statewide atlasing project and ecoregional surveys over the past 15 years, very good information exists on the current distributions and relative abundances of Maine's ten native freshwater mussel species. General statewide and watershed distributions are well documented, and the number of modern records far exceeds those recorded historically. These surveys are by no means complete, however, and there are many water bodies with significant survey gaps or no survey data at all. Consequently, without more exhaustive and costly survey work, it is impossible to know the entire current distribution of a species. Likewise, abundance has only been recorded qualitatively in comparison to other mussel species present at a site. Quantitative data on current population sizes do not exist except at a very few sites where listed species have recently been studied in depth. Other than in general terms of relative abundance and status (e.g., "common", "abundant", "rare"), the current population levels of Maine's native freshwater mussels are unknown. Determining baseline population levels from which to monitor trends and demographics over time would require development of an effective population survey and monitoring scheme that could be applied at a local, watershed, and/or statewide scale.

Maintaining current distributions and population levels of native freshwater mussels is most feasible through efforts to maintain and improve habitat integrity and quality for both mussels and their larval hosts. Current regulations for land and water use, endangered species and other resource protection, and municipal zoning all contribute towards conserving aquatic habitats and mussels in Maine. Conservation actions such as river restoration, fish passage facilitation, mussel relocation, and cooperative management agreements (e.g., with hydroelectric companies) can help maintain or improve habitat or protect existing populations. Expanding outreach (e.g., developing management guidelines for riparian habitat buffers or flow regimes; notifying landowners of rare species occurrences) and research (e.g., identifying fish hosts; determining threats and limiting factors) efforts is also important to conserving Maine's mussel populations.

The feasibility of restoring extirpated or declining populations will be limited largely by a lack of historic information or quantitative data on population sizes and trends in Maine. Restoration actions should not be initiated without first determining the true status of a species in a water body or confirming extirpation, and this would require costly, exhaustive survey work. Determining the capability of a habitat to support a population prior to restoration also needs to be considered, since past, current and future threats or limiting factors may be unknown or impossible for MDIFW to resolve (e.g., global warming). In many cases, however, restoring or preventing further degradation of habitat may facilitate natural restoration of a mussel species over time (e.g., dam removal or fish passage installation allowing recolonization of alewife floaters). Effective restoration techniques and protocols would have to be developed. Possible conflicts with the timing, funding needs, and research

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priorities of other freshwater mussel objectives may also impede MDIFW's progress on accomplishing this objective.

Capability of Habitat: The amount of freshwater habitat available in Maine is likely not limiting to maintaining, increasing, or restoring native mussel populations. The suitability of certain habitats for specific mussels, however, has been altered (both positively and negatively) from historical conditions by modifications to flows, channel integrity, water quality, and the distribution and abundance of host fish. While the quality of Maine's freshwater habitats has improved greatly over the last several decades, contamination from point and non-point source pollution likely will continue to affect habitat quality for mussels. As more dams are removed from Maine's rivers and streams, the amount and quality of riverine habitat for species that require clean, free-flowing water and/or access to anadromous fish hosts should increase. Conversely, habitat would be reduced for species that prefer standing or slow water environments and softer substrates. One environmental trend that may significantly affect future habitat quality and availability for some freshwater mussel species is global warming. This has important negative implications for freshwater mussels that rely on cold and coolwater fish as hosts, but may increase habitat availability for warm water species and habitat generalists.

Possible Consequences: Intensive surveys to investigate species distributions, population levels and trends may confirm or contradict current statuses, or identify additional issues needing conservation action. Monitoring population levels on a watershed or statewide basis may prove to be an unfeasible task. Habitat improvement efforts could conflict with other resource management objectives or may not be realistically feasible. Restoration costs may be prohibitive or compete with limited resources needed to accomplish other priority objectives for freshwater mussels. If successful, maintaining and restoring Maine's native freshwater mussel populations should ensure their long-term viability and enhance the quality of our freshwater ecosystems.

### **Population Objective 2: By 2013, determine need for and feasibility of reintroducing Endangered or Threatened freshwater mussel species into their historical waters in Maine.**

Desirability: Restoration of state-Endangered and Threatened mussel species to former habitats has already been acknowledged as integral to accomplishing Population Objective #1. Where feasible, initial efforts to restore historical distributions of native freshwater mussels should be targeted at state-listed species. Prior to undertaking reintroduction steps, however, it should be confirmed that a species is in fact extirpated from a reported historical site, and that the habitat can still support a re-introduced population. Although all known historical sites for state-listed species have been surveyed in recent years, these surveys have been neither comprehensive nor intensive. It is possible that individuals may still persist at these sites, either in areas not surveyed or at such low densities that they have gone undetected. It is also possible that natural re-colonization could ultimately take place without intervention if reproducing populations are present in nearby connected water bodies. Habitat changes may also have occurred at historical sites and either increased or decreased suitability for the target species or its host fish. Factors that contributed to extirpation may still be present and potentially difficult or impossible to identify or resolve. New threats may have emerged. In these cases, reintroduction would likely prove to be an unnecessary or unwise expense of limited resources and potentially an inappropriate risk to native or relocated mussel populations (e.g., introduction of diseases and/or parasites, modification of locally-adapted gene complexes; exposure to unsuitable habitat conditions).

Feasibility: Very few historical records are known for Maine's three state-listed freshwater mussels (brook floater, yellow lampmussel, tidewater mucket), and the species are still extant at most of these sites. Failure to reconfirm previously documented occurrences has

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happened in only three water bodies: Cold Stream Pond in Enfield (tidewater mucket), Presumpscot River in Cumberland County (brook floater), and Dennys River in Washington County (brook floater). Comprehensive survey and assessment of these three sites are feasible by 2013, although complete confidence in the results will likely never be achievable. Confirming species presence or absence would require exhaustive surveys (including excavation and SCUBA) over multiple visits in water bodies whose sheer size would preclude complete coverage. If necessary, nearby connected waters should also be surveyed for the presence of local source populations (both Cold Stream Pond and the Presumpscot River have adjoining tributaries with good populations of the target species). These surveys would require MDIFW contract experienced teams of mussel surveyors, including divers. Assessment of habitat suitability and threats would also require comprehensive surveys at each of the three sites, and likely entail the assistance of additional expertise (e.g., fisheries biologists to assess host fish populations, Department of Environmental Protection staff to assess water quality issues). Current MDIFW funding is not likely sufficient to meet these survey needs. It is also possible some landowners may deny access, making it impossible to survey some areas.

Determining the feasibility of restoring historical populations should also include a thorough investigation of effective reintroduction techniques and protocols (e.g., via infected fish hosts vs. juvenile or adult mussels; holding, quarantine, and transport methods). MDIFW's capability (e.g., funding, staff) to monitor the success of a restoration effort should be considered. Assessing landowner and public support for the reintroduction of a state-listed species that might trigger regulatory concerns needs to be an integral part of determining feasibility and measuring probability of success. Possible conflicts with the timing, funding needs, and research priorities of other freshwater mussel objectives may impede MDIFW's progress on accomplishing this objective.

Capability of Habitat: N/A

Possible Consequences: Intensive surveys to confirm presence/absence of a state-listed mussel at sites where extirpation may have occurred would enhance MDIFW's understanding of the species' status and distribution. Rediscovery of one or more individuals should halt any further actions towards reintroduction, and require additional monitoring to determine current status of the population. Reasonably confident confirmation of extirpation may trigger development of a reintroduction plan, including allowing or facilitating natural re-colonization from local sources. The Maine Legislature must first approve all reintroductions of listed species, and it is possible the public will not always be supportive.

If reintroduction is necessary, habitat restoration (e.g., fish host reintroduction, water quality improvements, dam removal) could conflict with other resource management objectives, or it may not be realistically feasible. Restoration costs may be determined to be prohibitive or compete with limited resources needed to accomplish other priority objectives for freshwater mussels.

### **Population Objective 3: Through 2023, investigate and monitor the need to regulate the commercial harvest of native freshwater mussels in Maine and, if needed, implement necessary actions.**

Desirability: As is the case for all freshwater invertebrates in Maine, the only mussel species currently protected from any form of take are those listed under the Maine Endangered Species Act. Consequently, seven of Maine's ten native mussel species are potentially vulnerable to unregulated harvest. While Maine's freshwater mussels are not as commercially valuable as those in other regions of the country are, they do have some limited consumptive use potential. Although the full magnitude is undocumented, several credible reports are known of large numbers (thousands) being harvested from Maine rivers for sale to

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the biological laboratory supply industry. Over the past several years, MDIFW has also received increasing numbers of inquiries about restrictions on the consumptive use and commercial harvest of freshwater mussels, with interests ranging from freshwater pearl culture to human food production, to bait supply. Given the freshwater mussel's unique life history traits (e.g., long life span, long age to sexual maturity, low recruitment, immobility), unregulated harvest and over collection – particularly for species that are already rare or populations that are already stressed – could result in severe declines or local extirpations. In addition, allowing harvest in the absence of baseline population data or any kind of long-term monitoring program – especially for a faunal group experiencing significant range wide declines and extirpations – would contradict sound resource management practices.

Feasibility: Some ongoing level of investigating and monitoring the need to regulate commercial harvest of Maine's freshwater mussels is feasible through 2023. Without collection permit or reporting requirements, however, it may be very difficult to track the incidence and magnitude of this activity. Mussel harvests, even large scale, are likely to go unnoticed and thus unreported to MDIFW or other resource agencies. Preliminary investigations should follow up on previous leads and inquiries when possible. Potential distributors or buyers could also be contacted to inquire about the frequency and size of commercially sold mussel harvests from Maine. Increased reporting of harvest activity could also be facilitated by outreach efforts to both resource agency staff (e.g., game wardens, fisheries biologists) and the general public. If it is determined that harvest regulation is needed, the Commissioner of MDIFW has regulatory authority to develop and propose rules that address conservation concerns for non-listed native freshwater mussels in Maine.

Capability of Habitat: N/A

Possible Consequences: Regulating commercial harvest could enhance MDIFW's ability to ensure the long-term viability of all native freshwater mussel species in Maine. Public awareness of and support for freshwater mussel conservation could also be increased. Developing harvest regulations for a group of freshwater invertebrates with no prior protection in Maine might open MDIFW's proposal to adverse modifications or result in unwanted repercussions on the use of regulatory protection in future conservation and management of other freshwater invertebrate taxa. Not having any form of commercial harvest regulations in Maine could create a loophole for collectors in other states with stricter regulations to take advantage of (i.e., listing Maine as the source of illegally harvested mussels).

### **Habitat Objective 1: Through 2023, where feasible, improve or restore degraded, altered, or lost freshwater mussel habitats in Maine, especially at sites with Endangered, Threatened, or Special Concern species.**

Desirability: Freshwater mussels play an important role in keeping Maine's aquatic ecosystems clean and healthy, yet they are sensitive to habitat changes and degradations. The severe declines experienced by many native mussel populations throughout the U.S. have been largely due to loss of, or alteration to, habitat. Improving or restoring habitat for freshwater mussels in Maine is fundamental to accomplishing Population Objective #1, especially for rare species that may benefit from habitat restoration at some sites in order to maintain or improve existing populations.

Feasibility: Observations of possible threats to freshwater mussel habitat were sometimes recorded during MDIFW's statewide surveys, and this information could be assessed to identify specific sites where management actions or monitoring might be needed. However, evidence of habitat degradation, alteration or loss may not always be apparent (e.g., contaminants or other water quality issues, loss of unknown fish host), making it difficult to identify some sites in need of restoration – particularly without intensive research and monitoring. Likewise, resolution of some changes or degradations to habitat may be beyond MDIFW's capability and/or jurisdiction (e.g., global warming, contaminants).

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Improving or restoring habitat for native freshwater mussels is most feasible by adhering to and, where necessary, strengthening regulations for land and water use, endangered species and other resource protection, municipal zoning, and riparian habitat preservation. Conservation actions such as river restoration through dam removal and/or fish passage facilitation, or cooperative management agreements can also help improve or restore habitat. Expanding outreach (e.g., developing management guidelines for riparian habitat buffers or flow regimes; notifying landowners of rare species occurrences) and research (e.g., investigating habitat-related threats and limiting factors) efforts are also important to habitat conservation. It is possible that conflicts with the timing, funding needs, and research priorities of other freshwater mussel objectives may impede MDIFW's progress on accomplishing this objective.

**Capability of Habitat:** The advent of habitat protection and restoration measures, such as land and water use regulations, pollution control programs, fish passage facilities, dam removals, riparian habitat acquisition, and other conservation efforts, has greatly improved the quality of Maine's freshwater habitats over the last several decades. While contaminants and other habitat integrity issues are ongoing conservation concerns for aquatic ecosystems, these improvements likely are positively affecting freshwater mussel populations in some of Maine's once heavily degraded water bodies.

**Possible Consequences:** Habitat improvement and restoration efforts (e.g., fish passage facility, water quality improvements, dam removal) could conflict with other water uses or resource management objectives, and may not be realistically feasible. Restoration costs may be determined to be prohibitive or compete with limited resources needed to accomplish other priority objectives for freshwater mussels. Where feasible, however, the accomplishment of key habitat improvements or restorations could significantly contribute to ensuring the long-term viability of all native freshwater mussel species in Maine. As a result of habitat improvement activities, public awareness of, and support for, freshwater mussel conservation could also be increased.

### **Habitat Objective 2: Through 2023, identify and initiate conservation measures for all known sites supporting listed species or exemplary native freshwater mussel communities (e.g., sites with high mussel diversity or abundance) in Maine.**

**Desirability:** Native mussel communities are an important component of Maine's rivers, streams, lakes and ponds, and play a vital role in keeping freshwater ecosystems clean and healthy. Currently, the State hosts some of the best remaining populations of several species experiencing severe declines and extirpations range wide (e.g., brook floater, tidewater mucket, yellow lampmussel, triangle floater). Consequently, Maine may ultimately serve as an important last refugium for some Atlantic Slope mussel species. Conserving sites supporting rare species, and/or high value mussel beds of even common species, is integral to accomplishing the overall goal of ensuring the long-term viability of native mussels in Maine.

**Feasibility:** Many sites supporting state-listed mussel species or exemplary native mussel communities have already been identified during MDIFW's statewide atlas and ecoregional survey efforts. Because the total number of sites supporting listed species or exemplary communities is high (>100), prioritization is essential to guide effective conservation efforts – especially where funding, jurisdiction, or probability of success may be limited. A number of sites support more than one rare species and often overlap with high species diversity and/or abundance – these should be given highest priority for site-specific conservation initiatives (e.g., habitat restoration, fee acquisition or easement in riparian zones). Far-reaching conservation tools such as land and water use regulations or classifications (e.g., MDEP Water Classification system, Natural Resources Protection Act, Maine Endangered Species Act), outreach (e.g., “Beginning With Habitat”), and industry implementation of management

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guidelines (e.g., riparian buffers for forest industry, flow and water level regimes for hydro-electric industry) are the most feasible methods available for general conservation of high value freshwater mussel habitats. Determining the success of conservation initiatives would require extensive monitoring, for which funding is currently unavailable to MDIFW.

Capability of Habitat: N/A

Possible Consequences: Conservation initiatives at high value mussel habitats could be critical to successfully maintaining or restoring populations of rare or declining species, and to ensuring the long-term viability of all native freshwater mussel species in Maine. Other aquatic organisms would likely also benefit from conservation actions focused on mussels and their freshwater habitats. Some conservation activities could potentially conflict with existing management priorities for other resources, or with current or future use and demand of private or public lands. Current factors of rarity or population decline are not well documented for Maine's mussels, and it is possible that conservation initiatives limited solely to general habitat protection may not significantly influence recovery at some sites. Well-publicized efforts to conserve rare species habitat or exemplary mussel beds could increase public awareness of and support for freshwater mussel conservation.

### **Habitat Objective 3: Through 2023, maintain and/or restore viable populations of native host fish for freshwater mussel species native to Maine that have restricted or specialized host requirements, or are listed as Endangered, Threatened, or Special Concern.**

Desirability: The larvae of nearly all freshwater mussels require a vertebrate host to complete development and reach the juvenile stage. Most species use fish and are host-specific – requiring one or more particular fish species in order to successfully transform. As adult mussels are virtually sedentary, this parasitic phase also is the only time that significant dispersal and exchange of genetic material between populations can take place. Where host fish species have declined or become unavailable, corresponding changes in the population size or distribution of native mussels have also occurred (e.g., the loss of alewife floaters from rivers where passage of their anadromous hosts has been blocked by dam construction). Consequently, conservation of freshwater mussels is directly tied to the conservation and management of their host fish species.

Feasibility: One primary obstacle to managing fish populations on behalf of mussel conservation is that, for many species, the host fish have not been identified. For Maine's rarest mussels (brook floater, yellow lampmussel, tidewater mucket, creeper), several species have been confirmed and others have been identified as potentially suitable. More research is needed to completely understand their host fish requirements. Most of Maine's mussel species appear to be host generalists – successfully using a broad range of several fish species. A few mussel species, however, such as the alewife floater and eastern pearlshell, are more host-specific and utilize fish species that are vulnerable to habitat changes (e.g., anadromous species blocked by dams, coldwater salmonids or fluvial species sensitive to increased temperatures or flow modifications).

Managing viable populations of native host fish for freshwater mussels is most feasible through efforts to preserve or restore the natural composition and dynamics of native fish communities. Maintaining and improving habitat integrity and water quality by adhering to or, where necessary, strengthening land and water use regulations as a broad-scale management tool that can be applied to fisheries management. Implementing conservation actions such as river restoration through dam removal, construction of fish passage facilities, fish stocking, or modification of culvert crossings can have significant affects on fish species distribution and movements on a site-specific basis. Preventing the introduction or expansion of non-native, invasive fish species that could prey on or compete with native host fish species for resources is also an important management consideration.

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**Capability of Habitat:** The amount of freshwater habitat available in Maine is likely not limiting to maintaining or restoring viable populations of native fish species. The suitability of certain habitats for specific fish, however, has been altered (both positively and negatively) from historical conditions by modifications to access, flows, water quality, and fish community composition. While the quality of Maine's freshwater habitats has improved greatly over the last several decades, contamination from point and non-point source pollution likely will continue to affect habitat quality for aquatic species. As more dams are removed from Maine's rivers and streams, the extent and quality of riverine habitat available should increase, and anadromous fish species would be able to recolonize previously inaccessible areas – taking freshwater mussel larvae with them. Conversely, habitat would be reduced for species that prefer warmer, standing, or slow water environments. One environmental trend that may significantly affect future habitat quality and availability for some native freshwater fish species is global warming. This has important negative implications for freshwater mussels that rely on cold and coolwater fish as hosts, but may increase habitat availability for warm water species and habitat generalists.

**Possible Consequences:** Maintaining or restoring viable populations of native host fish could result in the successful restoration of restricted, declining, or extirpated populations of native mussels at some sites. Fisheries management and restoration efforts (e.g., fish passage construction, dam removal, stocking) on behalf of mussel conservation could conflict with existing management priorities for other resources, including sport or bait fish. Restoration of host populations through stocking from other water bodies could result in the introduction of diseases or parasites, as well as new species or unrelated mussel genetic material through translocation of encysted larvae. Current factors of rarity or population decline are not well documented for Maine's mussels, and it is possible that conservation initiatives limited solely to managing fish host populations may not significantly influence population levels at some sites. Restoration costs may be prohibitive or compete with limited resources needed to accomplish other priority objectives for freshwater mussels.

**Outreach Objective:** **By 2010, develop and implement an outreach plan to increase awareness and understanding of freshwater mussels and their conservation needs in Maine.** [*Examples of high priority outreach needs include: habitat management guidelines; protocols for the recovery, relocation and post-monitoring of listed species; notifications of listed species occurrences targeted at landowners and water managers; and proactive measures to prevent introduction of invasive species.*]

**Desirability:** Outreach is a significant, ongoing need for freshwater mussel conservation. While efforts have improved in recent years as a result of MDIFW's listing process and survey efforts, the general public still has a limited understanding of, and appreciation for, freshwater mussels and other aquatic invertebrates. Outreach to landowners, industries, and municipalities having the potential to affect (e.g., alter water quality, riparian habitat, or flow regimes) sites with listed mussels is especially important. Involvement of local watershed groups could enhance outreach and improve MDIFW's ability to develop a statewide conservation and monitoring program for mussels. Outreach efforts to help prevent the introduction of exotic competitors (e.g., zebra mussel) or invasive plants (e.g., Eurasian milfoil) that degrade freshwater habitats, also need to be increased and likely would require collaboration with partners such as the Maine Dept. of Environmental Protection.

**Feasibility:** Some outreach materials have already been developed by MDIFW, most notably the book "*The Freshwater Mussels of Maine*" published in 2000 and fact sheets for two of the State's threatened species. Additional products (e.g., poster, video, news articles, school curricula, kiosks, field guide) would greatly enhance outreach efforts for both general mussel conservation and rare species protection, as well as for invasive species prevention. In particular, specific outreach materials for landowners, municipalities, water managers, and

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others having potential influence over aquatic habitat quality and mussel communities need to be developed (e.g., habitat management guidelines for riparian buffers and flow regimes, protocols for relocation efforts). With adequate funding, it would be feasible to develop an outreach plan and produce some of these materials by 2010. Partnerships (e.g., with industrial landowners, local watershed associations) could be developed, where appropriate, to assist with outreach efforts and funding.

Capability of Habitat: N/A

Possible Consequences: Continuing outreach to promote awareness and appreciation of freshwater mussels could result in an increased use and demand (e.g., shell and freshwater pearl collection, photography, wildlife watching), which in turn could increase threats to their conservation. More likely, a successful outreach program would have many positive consequences – particularly an increased public appreciation for freshwater mussels and the valuable role they play in aquatic ecosystems, which could in turn lead to increased support and funding for their conservation.

**Research Objective: Through 2023, identify and implement strategies to increase our knowledge and understanding of the life histories, habitat requirements, and conservation needs of native freshwater mussels in Maine.** *[Examples of high priority research needs include: effective population monitoring techniques; population dynamics and demographics of listed species; micro habitat requirements; fish hosts; conservation genetics; effects of contaminants; effects of dam removal and significance of impoundments to listed species; and effective recovery, relocation, and post-monitoring protocols.]*

Desirability: Range wide, there are significant gaps in knowledge about the general life history, biology, and conservation needs of freshwater mussels. In Maine, recent cooperative projects with the University of Maine have led to advances in our understanding of important ecological and conservation issues such as fish host identification, conservation genetics, and relocation strategies. Additional research is needed, however, to further investigate life histories, habitat requirements, influences of contaminants, significance of impoundments, and the effects of dam removal, as well as to develop effective population monitoring techniques and relocation protocols. Research to identify key threats and limiting factors, especially for listed species, is also needed. Increasing our knowledge of these and other critical issues is essential to making sound conservation and management decisions that ensure the long term viability of Maine's native freshwater mussels, their habitats and hosts.

Feasibility: Identifying and implementing strategies to increase our knowledge of freshwater mussels is feasible through 2023, but the level of accomplishment will be greatly determined by available funding and the successful continuation of partnerships with outside expertise. A series of graduate studies at the University of Maine would be the most effective method of investigating the majority of research and management questions. Funding to help support these types of research projects would require MDIFW to secure significant grant monies.

Capability of Habitat: N/A

Possible Consequences: It may be determined that implementing these strategies would require funds beyond the capability of MDIFW. Results of investigations may identify additional critical conservation, management, and research needs.