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All about amphibians : an environmental education curriculum for western Montana high schools

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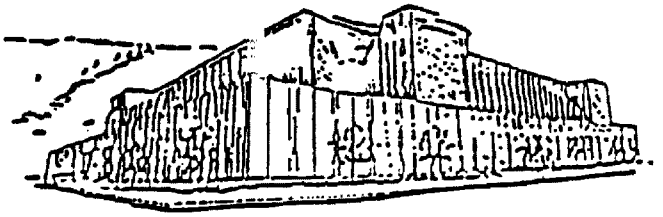

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ALL ABOUT AMPHIBIANS: AN ENVIRONMENTAL EDUCATION CURRICULUM FOR WESTERN MONTANA HIGH SCHOOLS

by

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We grieve only what we know.

-Aldo Leopold

We cannot win this battle to save species and environments

without forging an emotional bond

between ourselves and nature as well -

for we will not fight to save what we do not love.

- Stephen Jay Gould

INTRODUCTION

This body of work is a response to a global environmental dilemma, amphibian decline. In recent decades the scientific community has become alarmed and concerned about the rapid disappearance of amphibians from locations around the world. Amphibian decline is a component of the larger biodiversity crisis, which threatens the health and prosperity of numerous organisms on the planet.

This project was initiated at the Montana Environmental Education Association conference in Missoula, Montana in the spring of 1999. At the conference Catherine Lynch presented information on ZooMontana's "Frog Frenzy and Toad Tally" programs, which seek to involve volunteers and students in local amphibian monitoring efforts. At this time, Lisa Mills of the Montana Natural History Center (MNHC) expressed an interest in the development of materials on amphibians in western Montana, and asked me if I would be interested in working on such a project.

The product of my work with MNHC is a curriculum focused on amphibians and amphibian decline entitled "All About Amphibians." This curriculum is designed for high school science students in western Montana. The curriculum themes include biology, ecology, and environmental education (EE). The educational trunks that MNHC has developed and currently distributes to public schools served as a model for the final curriculum product.

This professional paper provides an overview of the curriculum development project. Chapter One provides information on amphibian decline and relates this issue to the larger crisis in biodiversity. Chapter Two documents the history of environmental

education, discusses the implementation of EE into the public school system, and comments on the overall effectiveness of EE. A description of the lesson plans and components of the curriculum are described in detail in Chapter Three. Chapter Four includes the text of the curriculum that will be distributed to high school science educators. To complete this paper, the final chapter discusses the process of the project development and provides recommendations for similar efforts in the future.

CHAPTER ONE

Amphibian Decline and the Biodiversity Crisis

According to evolutionary theory, approximately 350 million years ago the first fish-like creatures left the fresh waters and moved onto the landscape, which was uninhabited by vertebrate animals. "Our brave and ancient forefathers," (Argo, 1995) the amphibians, diversified and eventually gave rise to all other terrestrial vertebrates. Relatives of today's amphibians survived at least two major extinction events that greatly reduced the diversity of life on the planet. Today, there are almost five thousand species of frogs, toads, salamanders, and caecillians known to science and amphibians populate every continent except Antarctica. Wherever they are found, amphibians play a vital and important role in the ecosystem.

During the early 1980s scientists began to report widespread decline and extinction of amphibian populations (Griffiths and Beebee, 1992). The topic of amphibian decline received a great deal of attention when scientists convened at the First World Congress of Herpetology in 1989, and the global nature of the dilemma became evident (Griffiths and Beebee, 1992, Stebbins and Cohen, 1995). "Herpetologists from several continents were telling the same story: on returning to their old frog-haunts, they were finding that the local amphibian populations were either much smaller than they had been a few years before, or had disappeared entirely" (Griffiths and Beebee, 1992). This frightening phenomena is referred to as Global Amphibian Decline or GAD.

Recent studies have shown evidence of amphibian decline both nationally and regionally. "Up to one-third of 230 native species in the United States are declining in

numbers" (Baker, 1999), with fifteen North American species currently on the federal endangered species list (Eaton, 1999). "The North American evidence mainly concerns species living in the higher mountainous districts of the western United States" (Beebee, 1996). In this region, the leopard frog (*Rana pipiens*) as well as the boreal toad (*Bufo boreas*) are currently listed by the United States Forest Service as sensitive species. There is also evidence that another Montana native, the tiger salamander (*Ambystoma tigrinum*), may be in decline as well (Beebee, 1996).

At the global level, researchers have been unable to determine any single direct cause for amphibian decline. In fact, the search for causation has been compounded by the decline and disappearance of amphibians in seemingly pristine habitats. Studies have revealed that populations are threatened even in undeveloped, legally protected areas like Costa Rica's Monteverde Cloud Forest Reserve (Griffiths and Beebee, 1992), Yellowstone National Park (Stebbins and Cohen, 1995), Sequoia National Park, and Yosemite National Park (Polson, 1997). Possible causes currently being investigated include: ultraviolet radiation, acid rain, habitat loss, introduced predators, disease, toxic contaminants, global warming, and trade in amphibians for use as pets, food, and dissection subjects (Baker, 1999, Eaton, 1999).

Amphibian decline alarms many scientists who believe that amphibians serve as an early warning mechanism for environmental degradation. Ron Heyer of the Smithsonian says "the amphibians are telling us something has happened to the habitat we share with the frogs. We need to act on the warning the frogs are giving us" (Eaton,1999). Amphibian decline is a significant contemporary problem whose "ecological message

should be of concern to all of us" (Stebbins and Cohen, 1995). The issue is receiving increased attention from scientists, federal land managers, and legislators.

Unfortunately, amphibians are not the only organisms in peril during present times. Extinction has always occurred and is believed to be part of the evolutionary process, making way for the arrival of new species. However, there is growing concern over the present rate of extinction events. Many scientists believe that the planet is in the midst of a biodiversity crisis.

> Examinations of the fossil record of marine invertebrates suggest that the natural or 'background' rate of extinctions - the rate that has prevailed over millions of years of evolutionary time - claims approximately one to three species per year. In stark contrast, most estimates of the current situation are that at least 1,000 species are lost a year - an extinction rate 1,000 times the natural rate even with the most conservative assumptions." (Tuxill and Bright, 1998)

At least five major extinction events have occurred that have drastically changed life on earth. The most recent took place 65 million years ago and is credited with wiping out the dinosaurs. Concern over the present situation has to do with causation.

> Scientists warn that the sixth mass extinction of animals could occur within 100 years, wiping out 50% of the worlds animal population. Unlike the past five mass extinctions, the sixth is due to human activities. Among those that will be greatly hit are beetles, birds, amphibians and large mammals. (Morell, 1999)

The situation for amphibians is not an isolated series of events, but rather part of a larger trend. Amphibian researcher Andrew Blaustein notes that amphibian decline and

extinction "is obviously one part of the overall biodiversity crisis. Rates of extinction have accelerated in recent times, in many cases because of human interference that has damaged suitable habitat" (Blaustein, 1994). Conservation efforts to preserve biodiversity have called for the creation of more and larger parks, reserves and wilderness areas. Unfortunately, the information on amphibians disappearing from these areas demonstrates that this approach alone is not the solution. "Ultimately, it means replacing our consumer culture with a less materialist and far more environmentally literate way of life" (Tuxill and Bright, 1998). The biodiversity crisis and amphibian decline have become such significant problems that they can no longer be ignored by education or our society in general.

CHAPTER TWO

History and Definition of Environmental Education

The history of environmental education (EE) can be traced back nearly 100 years. EE has as its roots the fields of nature study, outdoor education, and conservation education. As an early teacher of conservation, Aldo Leopold recognized a lack of and necessity for ecological understanding. In his collection of writings, *A Sand County Almanac*, he states that:

> The question is, does the educated citizen know he is only a cog in an ecological mechanism? That if he will work with the mechanism his mental wealth and his material wealth can expand infinitely? But that if he refuses to work with it, it will ultimately grind him to dust? If education does not teach us these things, then what is education for? (Leopold, 1966)

Leopold understood that the laws of ecology apply to humans and that a deepened appreciation of ecology would ultimately improve the human situation. He also realized that education was the tool for bringing about this understanding.

> Ecology is now teaching us to search in animal populations for analogies to our own problems. By learning how some small part of the biota ticks, we can guess how the whole mechanism ticks. The ability to perceive these deeper meanings, and to appraise them critically, is the woodcraft of the future. (Leopold, 1966)

A Sand County Almanac was first published in 1949. The environmental movement in the United States accelerated during the 1960s and environmental education began to receive increased attention as a means of addressing the situation. In 1969 the

Journal of Environmental Education was established as a forum for ideas and research in the field. The first issue of this journal contained a broad definition of environmental education by William Stapp.

> Environmental education is aimed at producing a citizenry that is knowledgeable concerning the bio-physical environment and its associated problems, aware of how to help solve those problems, and motivated to work toward their solution. (Stapp, 1969)

Stapp's definition of EE includes knowledge and awareness as well as a behavioral component.

In the United States, federal policies on the environment were also developed during this time period. The National Environmental Policy Act of 1969 and the National Environmental Education Act of 1970 both identified education as a mechanism for improving the quality of the human environment (NEEAC, 1996).

In 1977 the first Intergovernmental Conference on Environmental Education was held in Tbilisi, USSR. The result was the Tbilisi Declaration, which defined the primary goal of EE as the creation of environmentally responsible behavior (NEEAC, 1996). In order to achieve this goal, the document outlined five categories of objectives for environmental education.

> 1) Awareness and sensitivity to the environment and environmental challenges
> 2) Knowledge and understanding of the environment and environmental challenges
> 3) Attitudes of concern for the environment and a motivation to improve or maintain environmental quality
> 4) Skills to identify and help resolve environmental challenges
> 5) Participation in activities that lead to the resolution of environmental challenges (NEEAC, 1996)

The inclusion of skills and participation in the objectives differentiates environmental education from other fields such as natural history, interpretation and outdoor education. EE seeks not only to inform, but also to encourage students to take action on behalf of the environment. This document further established the role of EE in the affective domain. From 1977 to the present a great deal of time and effort has been applied to further define environmental education, but these five objectives still serve as the foundation for effective environmental education.

In 1980 Harold Hungerford, R. Ben Peyton and Richard J. Wilke published "Goals for Curriculum Development in Environmental Education," in order to translate the general recommendations from Tbilisi into more specific instructional goals. In order to achieve this and guide curriculum design four goal levels were established.

> Level I. Ecological Foundations Level
> Level II. Conceptual Awareness Level - Issues and Values
> Level III. Investigation and Evaluation Level
> Level IV. Environmental Action Skills Level - Training and Application
> (Hungerford, Peyton, and Wilke, 1980)

These goal levels complement the objectives from the Tbilisi Declaration and form a hierarchical approach to EE. In order for EE to achieve its purpose learners must be exposed to all four goal levels. In addition to the goals, the authors developed twenty-eight sub-goals to further assist efforts in the development of curriculum. Again, the emphasis of EE goes beyond knowledge and awareness to include issue investigation and

action skills. In other words, environmental education should "engage young people and faculty in the effort to solve real problems" (Orr, 1994).

In an effort to promote and improve EE, the North American Association for Environmental Education has published *Excellence in Environmental Education: Guidelines for Learning (K-12)*. These voluntary guidelines are patterned after the educational standards that have been developed for many of the educational disciplines. Environmental education is embedded within the standards that guide other disciplines. Elements of EE are found in the National Science Education Standards (NRC, 1996) as well as the Montana Standards for Science (OPI, 1999). The standards for several other disciplines also contain guidelines that are pertinent to EE.

Implementation of Environmental Education

With the objectives and goals well defined and generally agreed upon, environmental education was and still is faced with the challenge of changing human behavior. It was originally assumed that behavioral change occurs in a linear fashion, "that, if we make human beings more knowledgeable, they will, in turn, become more aware of the environment and its problems and, thus be more motivated to act towards the environment in responsible ways" (Hungerford and Volk, 1990). Unfortunately, this model for behavioral change was incomplete (Hines, Hungerford, and Tomera, 1986, Hungerford and Volk, 1990). Research on responsible environmental behavior found additional variables: knowledge of issues, knowledge of action strategies, locus of control,

attitudes, verbal commitment, an individual's sense of responsibility, and situational factors (Hines, Hungerford , and Tomera, 1986.) These variables interact in complex ways. In order to address these variables and maximize the effectiveness of EE, efforts should begin with knowledge and skills and issues should be the primary focus of instruction (Hines, Hungerford, and Tomera, 1986, Hungerford and Volk, 1990). "The research is very clear on the matter. Citizenship behavior can be developed through environmental education" (Hungerford and Volk, 1990).

Environmental education is a broad field that seeks to influence the behavior of a wide variety of audiences from preschool students to adults. "It has generally been accepted that public schools should be instrumental in accomplishing the goals of environmental education" (Ham and Sewing, 1988). However, progress has been slow in the effort to implement EE into the public school curriculum. "EE has not found an established niche in the U. S. schooling process" (Ramsey, Hungerford, and Volk, 1992). Researchers have studied, categorized, and defined the barriers that exist in the implementation of EE into the public school system.

1. *Conceptual* - barriers stemming from lack of consensus about the scope and content of EE
2. *Logistical* - barriers stemming from a perceived lack of time, funding, instructional resources, suitable class sizes, and so forth
3. *Educational* - barriers stemming from teachers' misgivings about their own competence to conduct EE programs
4. *Attitudinal* - barriers stemming from teachers; attitudes about science and EE instruction (Ham, Rellergert-Taylor, Krumpe, 1988)

More emphasis has been placed on the cognitive elements of EE than on the affective

aspects (Ham and Sewing, 1988).

Three different approaches have been utilized to incorporate environmental education into public schools (Heimlich, 1992, Trisler, 1993). First, inclusion, also known as imposition or insertion, is the creation of new courses of study that deal specifically with the environment. Many high schools have inserted courses into the curriculum in environmental science, environmental studies, and environmental issues. The second method involves an interdisciplinary approach to environmental education in which an environmental issue is explored across the curriculum in several classes. This method has been used predominantly in primary schools.

The third way in which EE reaches public school audiences is infusion or integration. "Simply stated, infusion refers to the integration of content and skills into existing courses in a manner as to focus on that content (and/or skills) without jeopardizing the integrity of the courses themselves" (Ramsey, Hungerford, and Volk, 1992). Most states rely on infusion as the main approach for integrating environmental education into the curriculum (NEEAC, 1996). Prior to infusion, environmental education must be related conceptually to a given subject matter so that it makes sense pedagogically (Samuel, 1993). The interdisciplinary nature of environmental education allows for infusion into almost any subject, but the sciences are usually perceived as having the strongest conceptual links.

Has Environmental Education Made a Difference?

Environmental education has been successful at increasing awareness. The public is concerned about environmental quality and the environment is consistently ranked by young people as one of the most important issues facing the planet (NEEAC, 1996). The awareness level has been achieved, but environmental education still has yet to reach its' primary goal. Two recent articles indicate that many students have several fundamental misconceptions about ecology and lack basic environmental knowledge (Munson, 1994, Gambro and Switzky, 1996). The objectives and goals of environmental education to create an informed and active citizenry have not yet been met.

Munson's article "Ecological Misconceptions" is the result of student responses from fourth grade to upper-division college students. The research shows that some students do not understand the basic concept of a species, many understand a food chain, but few comprehend the complexities of a food web, students believe some species are important to an ecosystem while others species are not, and they do not understand the scientific conception of a niche (Munson, 1994). Gambro and Switzky assessed tenth to twelfth grade students and concluded that:

> Most high school seniors possess an extremely elementary comprehension of environmental problems and lack the necessary understanding to go beyond the common recognition of an issue and use their knowledge to grasp the consequences of environmental problems or offer solutions for those problems (Gambro and Switzky, 1996).

Gambro and Switzky also report that only about one quarter of Americans have a minimal understanding of acid rain and the hole in the ozone layer (Gambro and Switzky, 1996). In order for the public to make informed and accurate environmental decisions the upper levels of environmental education must be reached. These studies indicate weaknesses in environmental education that must be addressed. "We seem to have produced a citizenry that is emotionally charged but woefully lacking in basic ecological knowledge" (Gigliotti, 1990).

In his book, *Earth in Mind*, David Orr claims that "all education is environmental education. By what is included or excluded, students are taught that they are part of or apart from the natural world" (Orr, 1994). Education can no longer encourage or allow people to view themselves separately from the environment.

The objectives and goals of EE are well defined and ultimately focus on environmentally responsible behavior. The environmental movement and EE have successfully increased awareness of environmental problems, yet numerous problems still exist. Future efforts in the field must increase knowledge and overcome misconceptions as well as motivate the citizenry to take action on behalf of the environment.

> Were we to confront our creaturehood squarely, how would we propose to educate? The answer, I think, is implied in the root of the word *education*, *educe*, which means 'to draw out.' What needs to be drawn out is our affinity for life. That affinity needs to be instructed and disciplined, and it needs to be harnessed to the goal of building humane and sustainable societies. (Orr, 1994)

People make decisions every day that have consequences for the environment and EE can and must influence those decisions.

CHAPTER THREE

Project Description

As stated earlier, environmental education seeks to foster environmentally responsible behavior. One indication that this has not been achieved is the contemporary problem of amphibian decline. There are many theories that attempt to explain the loss of amphibians, and central to all of these theories is human caused environmental change. Human actions and decisions are having negative consequences for amphibians. The protection and safety of amphibians requires awareness, knowledge, investigation, and action. The ultimate goal of this project is to promote environmentally responsible behavior through EE in order to reverse amphibian decline.

In order to reach this goal, this project focused on the development and distribution of an amphibian curriculum to secondary science educators in western Montana. The curriculum supplies teachers with an exciting, relevant, and useful tool modeled under the guidelines of EE. The final product is a multi-media, traveling amphibian curriculum (trunk) that will be advertised and distributed by the Montana Natural History Center (MNHC). The materials are designed for high school biology classes, and general interest adult groups. The primary objective is to provide the audience with the information and skills necessary to understand amphibian biology, ecology, and decline as well as illuminate the involved environmental issues.

MNHC delivers a wide variety of educational programs and materials to the public in western Montana. The topics include interpretation, natural history, conservation, and

environmental education. They also provide interested public school educators with supplementary curricula.

One popular approach that has been utilized by MNHC in the delivery of educational materials to public schools is the use of educational trunks or traveling boxes. Trunks provide a mechanism to distribute curricula developed outside the public school system to educators within this system. "Boxes typically contain objects and materials on an environmental topic or issue of local or regional concern and can help educators to incorporate the topic into a variety of subjects and teach to a variety of learning styles" (Roy, p. 10). Trunks cover a wide variety of topics that includes wildlife, natural history, and endangered species. They are useful tools for EE.

> "Although not a panacea for EE curriculum integration, this methodology can eliminate some of the barriers to EE in the public schools. Given that most boxes are accompanied by interdisciplinary curriculum guides, they provide teachers not trained in EE or those who do not have time to design a comprehensive unit a means to present a focused EE experience with relatively little preparation" (Roy, p. 15).

MNHC sends these curricula to educators in the region for a minimal fee. The traveling curriculum format is an effective, inexpensive method for providing teachers with a mechanism to teach environmental issues in the classroom (Roy, 1997). The Songbird Blues box was created and is distributed by MNHC as an educational response to the decline in North American migratory songbird populations.

A nationwide survey of educators who utilized traveling boxes listed amphibians as a frequently recommended subject for future box programs (Roy, 1997). MNHC has

recognized the need for the development of an amphibian curriculum for educators in western Montana to address this topic. The complex nature of amphibian decline makes it most appropriate for high school audiences. "Complexities of the biodiversity crisis and roles for science in conservation are appropriate topics for discussion in every high school and undergraduate biology course" (Greene, 1994). MNHC currently does not have any curricula designed for secondary students and educators. This audience is important because "high school is a time to reach all students" (BSCS, 1993). The "All About Amphibians" materials are also appropriate in the context of educational reform. "The consistent exploration of bio-societal problems, ethical dilemmas and interactive environmental consequences is critical if educational systems are going to influence the survival of global society" (Wright and Govindarajan, 1992).

There is an established need for the development of a curriculum that addresses the biology, ecology and environmental issues associated with amphibians, and a traveling box is an effective and efficient method to achieve this goal (Roy, 1997). "We can hope that the publicity generated on behalf of amphibians will lead to a heightened awareness of the crisis facing this group and other organisms, and to effective responses" (Pechman and Wilbur, 1994). Amphibian decline and biodiversity must be explained to and explored by the public. "Amphibians are ideal subjects for many kinds of ecological studies that can throw new light on fundamental questions in the natural sciences, and at the same time they exemplify the plight of wild creatures suffering declines all over the planet at human hands" (Beebee, 1996). Education about amphibians and the issues surrounding their decline is necessary to foster their protection and has inherent educational value:

> The declining amphibian story is open-ended and represents a frame in an ongoing process, the outcome of which is uncertain. Some parts of it are speculative. However, it exposes the reader to the scientific process - the gathering of data, development of hypotheses, the importance of basic knowledge concerning the subject under study, and it's ultimate integration with other fields of knowledge (Stebbins, 1995).

Taking into account the high school classroom learning environment, the infusion approach to implementation was chosen. Infusion is appropriate at the secondary level because of the disciplinary organization of high school education. "The infusion of environmental concepts in biology education can help students understand the need for working toward a balance between human activities and environmental quality" (Chipman and Brody, 1993). One method of infusion is to use supplementary curricular guides, like educational trunks, to transform the learning process into an environmental focus and these "short-term programs usually evoke very positive responses from both teachers and learners" (Heimlich, 1992).

The "All About Amphibians" curriculum was developed using the following components or themes: ecological foundations, conceptual awareness, investigation and evaluation, and environmental action skills. Given this framework, the curriculum meets all four goal levels for EE established by Hungerford, Peyton and Wilke (1980). In addition, the curriculum was developed to be consistent with the National Science Standards (NRC, 1996) and the Montana Standards for Science (OPI, 1999). The curriculum provides three discrete and detailed lesson plans. Each lesson is approximately one hour in length. The lessons are sequenced, but can also be used individually if time is

limited.

Each lesson plan incorporates the learning cycle, inquiry, and cooperative learning strategies. The learning cycle is a constructivist model (BSCS, 1993) that utilizes a framework consisting of five basic phases:

> The first phase is to *engage* the students in the learning task. Once the students are engaged, they need time to *explore* the ideas through common, concrete experiences on which they can build concepts, processes, and skills. Next, the students must *explain* - develop common explanations for their explorations. They then should *elaborate* the concepts, processes, or skills that have been explained. Finally, the students need *evaluation* - feedback about the adequacy of their explanations (BSCS, 1993).

This adaptation of the learning cycle is used in attempt to accommodate the educational needs of all students. The phases of this learning cycle are not labeled within the curriculum, but each phase is embedded within the lessons. "Inquiry is based on methods of scientific investigation that may include some or all of the following components: observing, questioning, forming hypotheses, predicting, experimenting, analyzing data, and relating concepts and ideas to each other" (BSCS, 1993). Inquiry is utilized in the lessons by the replacement of conventional texts and lectures with activities that incorporate these components. Inquiry is important in both biology and EE because it provides students with the ability "to analyze scientific information from the media and make informed, ethical decisions about social issues that affect them and society at large" (BSCS, 1993). There are activities within each lesson that divide the class into small learning groups that work cooperatively on tasks. This strategy places the teacher in the role of facilitator and

has the advantage of improving students positive interdependence, individual accountability, face-to-face interactions, social skills, and processing (Bennett, Rolheiser-Bennet, and Stevahn, 1991). The curriculum uses these mechanisms to create a positive learning experience and enhance student learning and retention.

The following information is provided for the teacher with each lesson: time, central focus question, concepts, background, objectives, materials, procedure, evaluation, extensions, references and resources, education standards. The "All About Amphibians" curriculum is organized so that teachers can quickly determine the merits of each lesson.

Lesson Number One provides a review of amphibian biology and focuses on the biological concepts that are necessary to understand amphibian decline.

> The central hypothesis of GAD is that amphibians are especially susceptible to environmental change and should therefore receive particular attention with respect to both study and conservation. Two features of amphibian biology have been widely cited as underpinning this hypothesis: firstly, their typically naked and permeable skin make them highly vulnerable to chemical pollutants and radiation; and secondly, the life style of many species, requiring both aquatic and terrestrial habitats to be maintained in suitable conditions, is more at risk of disruption than that of taxa with inherently simpler needs. (Beebee, 1996)

This biological information is presented to the students in a slide show on the natural history of amphibians. The slide show also introduces the students to the six most commonly occurring amphibians in western Montana. Information on habitat, species interactions, and vocalizations are included in the presentation. Two of these species, the northern leopard frog (*Rana pipiens*) and the boreal toad (*Bufo boreas*), are currently listed as sensitive species in Montana. After viewing the slide show, a jigsaw cooperative

learning strategy is used to develop a visual identification key for the six species. Upon completion of the lesson students should be able to identify each of the six species by their unique physical characteristics. The knowledge provided in Lesson One is essential because,

> Systematics and natural history define the boundaries and contours of biodiversity; they elucidate the fundamental kinds of organisms (species and higher taxa) as well as their interactions with each other and their environments. (Greene, 1994)

The first two lessons provide the ecological foundations for goal Level I recommended by Hungerford, Peyton, and Wilke (1980).

Lesson Number Two deals expands the students ecological knowledge by dealing with the complexities of species interactions. Students are provided with a reading on "Extinction and Trophic Cascades" adapted from David Quammen's book *Song of the Dodo*. The species interactions described in this reading are complex and go way beyond the simplified concept of a food chain. Students are required to diagram the interactions and discuss the symbiotic relationships between ten organisms. The reading and exercises also illuminate the impacts of a single extinction event upon the entire community. All of the ecological misconceptions of students, found by Munson (1994), are addressed to some degree in this activity including food webs, ecological adaptations, carrying capacity, ecosystems and niches.

Amphibian decline is the central topic of Lesson Number Three. This lesson incorporates the curriculum design goals of Conceptual Awareness (Level II) and

Investigation (Level III) of the Hungerford, Peyton, and Wilke (1980) model. The National Geographic video "The Last Frog" serves as a stimulating engagement piece and an introduction to amphibian decline. A viewing guide for the video is provided. Working in cooperative groups the students investigate eight categories of scientific research on amphibian decline: pollution, predator/prey relationships, global climate changes, habitat, pathogens and disease, human consumption, deformities, and ultraviolet radiation. Students develop a hypothesis on amphibian decline in Montana through the use of books, websites, and numerous magazine and journal articles on the topics. "Resource conservation articles can help teachers facilitate a direct link between in-school information and the world outside of school" (Chipman and Brody, 1993). Teachers have also found that wildlife conservation publications are valuable tools for teaching ethics and values to students (Chipman and Brody, 1993).

At this point, the curriculum requires students to apply their comprehension of amphibian biology and ecology to the analysis of amphibian decline. Teaching students to effectively analyze environmental issues is the third goal level of EE (Hungerford, Peyton, and Wilke, 1980). "Few environmental educators would argue the importance of dealing with critical issues as a major component of instruction" (Ramsey, Hungerford, and Volk, 1989). "Unfortunately, the majority of instructional materials in EE fail to develop skills associated with investigating and evaluating issues" (Hungerford and Volk, 1990). Each group presents the results of their investigation and defends or refutes their original hypothesis. Presentations are evaluated by the class and the teacher.

In addition to the lesson plans, the "All About Amphibians" curriculum also

contains a section on "Getting Involved." This section highlights opportunities for students to actively participate in the effort to improve the amphibian decline situation. By participating, the students develop the environmental action skills of Level IV (Hungerford, Peyton, and Wilke, 1980). When used in its entirety the curriculum addresses all four goal levels recommended by Hungerford, Peyton, and Wilke (1980). Students should become aware of amphibians in the local environment, understand the ecological importance of these organisms, investigate amphibian decline, and take action on this issue.

The list of potential causes for amphibian decline contains many topics relevant to environmental education. Extension activities can pursue any of the following contemporary environmental issues: extinction and endangered species, habitat loss, ultraviolet radiation, air and water pollution (acid rain), introduced species, biodiversity, and indicator species. These concepts will all be investigated by the students when they study how these concepts relate to amphibian decline. There is also the potential for students to become locally involved in citizen amphibian monitoring efforts. The development of educational materials relative to the study of amphibians provides a resource for educators to approach these topics in the classroom.

The final product is scientifically accurate, complete, and easy to use. The traveling curriculum format has proven successful at infusing EE into primary and middle schools, and should be effective at the secondary level as well. The role of MNHC as an established distributor of educational resources in western Montana is vital to the success of the project. The materials are appropriate for general interest adult audiences and may

also be beneficial as an educational tool for MNHC's future goal of implementing a program of community amphibian monitoring.

CHAPTER FOUR

The "All About Amphibians" Curriculum

ALL

ABOUT

AMPHIBIANS

Eric A. Leach

ALL ABOUT AMPHIBIANS

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INTRODUCTION

Welcome to All About Amphibians, a curriculum on amphibians for use in western Montana. This curriculum is designed for use by high school biology or environmental studies students. It can be used any time of the year. All of the lessons are designed for use in the classroom, although field trips to investigate amphibians are recommended. The materials were developed to increase student understanding of amphibian biology, introduce students to the amphibians of western Montana, expand student knowledge of ecology, and investigate amphibian decline. While the materials provided focus on amphibians, the concepts that are covered are fundamental to biology, ecology, and environmental education.

Amphibian decline is a complex topic that is related to the larger biodiversity crisis. The theories on decline are associated with many contemporary environmental issues. Numerous opportunities exist for students to explore these issues further.

The lessons incorporate inquiry and the learning cycle into their design and also utilize cooperative learning strategies. The lessons are sequenced and should be used in order if time permits. Each lesson can also stand alone and be used separately if necessary. The following information is provided with each lesson for the teacher's convenience: time, central focus question, concepts, background, objectives, materials, procedure, evaluation, extensions, references and resources, and national and state science standards.

The curriculum also contains a slide show on the amphibians of western Montana including vocalizations, a National Geographic video on amphibian decline, several reference books, numerous journal articles and an annotated list of websites on amphibians. Ideas for students involvement are also provided.

Please take the time to fill out the Curriculum Evaluation Form before returning the materials to the Montana Natural History Center. This information will be used to evaluate and improve the curriculum.

LESSON NUMBER ONE

Amphibians of Western Montana

TIME

1-2 hours

CENTRAL FOCUS QUESTION

What are the most common amphibian species in western Montana and how can they most easily be identified?

CONCEPTS

amphibian biology, identification of western Montana's most common amphibian species, sensitive species, dichotomous keys, taxonomy and classification, binomial nomenclature

BACKGROUND

The class Amphibia is fascinating and diverse. Amphibians play a significant role in evolutionary theory since they are considered to be the first terrestrial vertebrates. Today there are nearly 5,000 species of frogs, toads, salamanders, and ceacillians, inhabiting almost every ecosystem on the planet.

The slide show serves as the engagement piece for this lesson. The slide show begins as a review of the characteristics that all amphibians share, the characteristics that differentiate this class of organisms from all others. The slide show also introduces the students to the most commonly occurring amphibian species in western Montana. Students will learn to visually identify the adult forms of western Montana's resident amphibians, and be introduced to the vocalizations of several local frogs and toads. There are only six species that are common in this part of the state, two of which are currently listed as sensitive

species. Each species has several unique characteristics that make identification easy.

OBJECTIVES

At the completion of this activity, students should be able to:

1. describe the shared characteristics of the class Amphibia

2. recognize that Montana's frog and toad species can be identified by their vocalizations

3. identify six western Montana species of amphibians by their unique physical characteristics

MATERIALS

slide projector, audio cassette player, identification resources (provided), preserved specimens of local amphibians (if available)

PROCEDURE

1. Assign information on amphibians in biology textbooks as a review. Ask students to list the biological characteristics that all amphibians share. See if students can name any of the species of amphibians that occur in this area or relate information about where they have encountered amphibians. The slide show references frogs in popular culture. Have students brainstorm about where amphibians appear in fairy tales, advertisements, movies, television, etc. How are amphibians generally represented in our culture?

2. Present the slide show to the class. The accompanying audio tape provides information on amphibian biology, local species and their vocalizations. The tape can be stopped at any point to allow time to discuss the information or the slides.

3. Refer to **Slides and Text of Slide Show** (Page 30).

4. Divide the class into cooperative groups containing six students. Each student within the cooperative group will become an expert on one of the six species.

long-toed salamander (*Ambystoma macrodactylum*)
western toad (*Bufo boreas*)
pacific chorus frog (*Hyla regilla* also known as *Pseudacris regilla*)
northern leopard frog (*Rana pipiens*)
Columbia spotted frog (*Rana luteiventris* formerly *Rana pretiosa*)
bullfrog (*Rana catesbeiana*)

5. Representatives from each cooperative group now join expert groups. There will be six expert groups, each one investigating a single amphibian species.

6. Using the photographs in the slide show and the additional resources on Montana's amphibians allow the expert groups to research their species. If computers are available the Online Field Guide for North Americans is located at:

http://www.npwrc.usgs.gov/narcam/idguide/specieid.htm

Emphasis should be placed on visual identification of the adult form of the amphibian. The challenge is for students to move beyond descriptions that apply generally to amphibians to descriptions that help distinguish one species from another. Allow the expert groups to list the visual characteristics of their species on the board. Discuss the characteristics and work at eliminating those that are shared by more than one of the species.

7. Once the characteristics have been narrowed done for each species the experts should return to their original cooperative groups. Utilizing the knowledge of the individual experts within the cooperative group, have each cooperative group work at developing a series of contrasting questions that can be used to identify all six amphibians. (The

Modern Biology textbook has a similar exercise on leaf identification on pages 354-355 if students need practice with this concept). Tell the students to think about describing the differences to someone younger than themselves.

8. Each cooperative group should develop a simple dichotomous key to identify the adult forms of the six most common amphibians in western Montana. Use pairs of contrasting, descriptive statements to differentiate between the visual characteristics of each species. This can be demonstrated in the form of a flow chart or by using simple yes/no questions.

9. Each cooperative group should present their key on the board. Discuss the strengths and weaknesses of each key and allow the whole class to decide which key is the most straightforward and easy to use. It may be necessary to combine the strengths of several cooperative group efforts to make the best possible key. Return to the slides and use the class key to identify each slide. If possible, present the students with unlabeled specimens of these species and allow them to identify the species.

10. Refer to **Identification Key** (Page 43).

11. Review taxonomy and use the binomial nomenclature to show students how their key fits into this larger classification system. The *Modern Biology* text provides information on the three Orders belonging to Class amphibia on pages 821-823.

12. Refer to **Taxonomic Classification of Amphibians**(Page 44).

13. Make certain that students realize that the criteria they use to visually differentiate these six species may not be exactly the same criteria that a herpetologist would use.

Slides and Text of Slide Show

The slides:

1) Far Side I
2) Far Side II
3) Bullfrog (*Rana catesbeiana*) eggs
4) Northern leopard frog (*Rana pipiens*) tadpole
5) Pacific chorus frog (*Hyla regilla* also known as *Pseudacris regilla*) metamorph
6) Far Side III
7) Far Side IV
8) Long-toed salamander (*Ambystoma macrodactylum*)
9) Boreal toad (*Bufo boreas*)
10) Pacific chorus frog (*Hyla regilla* also known as *Pseudacris regilla*)
11) Northern leopard frog (*Rana pipiens*)
12) Columbia spotted frog (*Rana luteiventris* formerly knows as spotted frog *Rana pretiosa*)
13) Bullfrog (*Rana catesbeiana*)

All amphibian slides were courteously donated by Bryce Maxell.

The following is the text of the slide show:

EVOLUTION (Slides 1 and 2)

What are these creatures that cartoonist Gary Larson has drawn? What is he trying to tell us? These cartoons are essentially a natural history lesson about a specific class of animals. So, let's see if we can use the information in the cartoons to classify these animals. Their habitat appears to be the edge of the water. They have fins like a fish. They have bulging eyes and wide mouths with big lips. One of them can run on land. So, they must have a backbone, but they can't be fish. Some reptiles can run across the ground. Are they reptiles? Nope, reptiles do not live under water. What animals can live

in the water like fish and can move across land like reptiles?

There are more hints in the cartoons. Whenever you see the word "evolution" you need to think about huge lengths of time. You cannot think about weeks or years or even millennia. You need to measure time in millions of years. The fossil record shows that up until about 350 million years ago (350 MYA) there were no animals with backbones living on land. Life on the surface of the earth was very different than it is today. No lizards. No snakes. No dinosaurs. No birds. No mammals. Mostly there were just plants and insects and bacteria. In scientific terms, there were no terrestrial vertebrates. There was lots of swimming going on though, because the oceans and freshwater contained aquatic vertebrates. Fish. According to evolutionary theory, around 350 million years ago, something fishy ventured onto the landscape to avoid predators and find new food sources.

In cartoon form, Gary Larson is showing us this exciting moment of exploration. The class of organisms known as Amphibians were the animals that first performed this feat.. The word amphibian is a combination of "amphi" meaning two and "bios" meaning life. Salamanders, frogs, and toads essentially have two lives. During their life cycle most amphibians inhabit both the water and the land. For millions of years amphibians born in freshwater, live on the land when they mature. They are both aquatic and terrestrial. They live in almost every ecosystem on the planet and there are about 5000 species of amphibians known. The most familiar are the frogs.

METAMORPHOSIS (Slides 3,4, and 5)

Since they have been around for 350 million years and they have two distinct lives, it's not surprising that people have told some stories about frogs. Here's one. Kiss a frog. Get a prince. Move to the castle and live happily ever after. The frog in the story of "The Frog Prince" undergoes a miraculous transformation. A kiss initiates this change from lowly frog to elegant prince. This storybook frog undergoes a metamorphosis. His form

becomes human. His habitat becomes a castle. Appropriately, this fairy tale amphibian has two lives, but not the two that we expect.

Real frogs also undergo metamorphosis. Their form changes from tadpole or pollywog to frog, and their habitat shifts from water to land. The change from aquatic tadpole to terrestrial adult frog is hard to imagine. Frogs lay large quantities of eggs in freshwater that hatch into tadpoles. Tadpoles have large heads, small round mouths, and tapered tails that help them swim. As metamorphosis occurs, four legs sprout from the tadpole's body. Eventually Gary Larson's "great moment" occurs. The frog uses its' legs to pull itself through the film that separates the water and the air, and moves onto dry land. The now useless tadpole tail drags behind the frog. As metamorphosis completes the alteration of form, the tail is slowly absorbed into the frog's body and the eyes migrate to opposite sides of the head. The amphibian now has nearly 360 degree vision and the appearance of a mature frog. This metamorphosis changes nearly every aspect of the frog's life. Much like the frog in the fairy tale, everything changes. Body shape, locomotion, habitat, vision, diet, all become radically different when an amphibian begins its second life.

GLANDS AND POROUS SKIN

What about the other amphibian stories? There are stories about newts and toads in witchcraft and tales about frogs that cause warts. These stories are skin deep. Amphibian skin has many fascinating and unique properties. Glands in the skin of frogs and toads manufacture everything from adhesives to antibiotics, to hallucinogens and dangerous toxins. This ability to create such strange and useful products makes these little animals very interesting to both folklore and science. However, Montana's amphibians are harmless to humans. They don't even cause warts.

Their two-lived existence requires their skin to be unique. Although metamorphosis turns amphibians into terrestrial, land-dwelling animals they still require water in their environment to keep them moist. Their skin is porous. It is water permeable. Moisture

and gases easily pass in and out of their bodies through their skin. Human skin on the other hand perspires, but does not allow moisture to pass back into the body. We obtain water by drinking it, not absorbing it through our skin. Mammal skin is like a leather football and amphibian skin is like a Nerf football. Throughout their entire lives amphibians require contact with fresh water to replenish the moisture in their bodies. This amazing skin can have drawbacks however; it literally absorbs the contents of the environment even if those contents are harmful to the organism.

ECOLOGY (Slides 6 and 7)

Again the bulging eyes and the wide mouths, but now what's up with the enormous tongues? Gary Larson is helping us learn more about amphibians. This time he is supplying a humorous and important ecology lesson. Now we know not only what frogs eat, but how they catch their food as well. Many amphibians are tongue zapping insectivores. They eat insects and they are very well adapted for catching them. Their long tongues and keen eyesight equip them to snare all kinds of bugs. This makes amphibians very important as food for other animals as well.. Reptiles, especially snakes, birds and mammals that are unable to obtain nutrition directly by eating insects feed on amphibians. Lots of fish and some people eat amphibians too. These silly cartoons capture the frogs attempting to perform their essential role in the complex food web that supports all life.

DECLINE

Have you ever seen the video game called "Frogger?" You know, the one where you get to control the frog as it hops across the busy highway. Remember what happens when you can't dodge the cars and trucks on the video screen? You get three chances, but then it is game over. Amphibians today are threatened by many things besides cars and trucks. The current situation for amphibians is very serious. Herpetologists, the scientists who study amphibians and reptiles, from all over the world are investigating what they call Global Amphibian Decline (GAD). Numerous species of salamanders, frogs, and toads

have shrinking populations, and some have gone completely extinct in recent years. Game over. No replay.

There are many theories that attempt to explain why this is happening. Because amphibians have been so successful for the last 400 million years, most of these theories link human caused environmental change to amphibian decline. Two of Montana's amphibians, the leopard frog (*Rana pipiens*) and the boreal toad *(Bufo boreas*), are classified as sensitive species because they have disappeared from many locations where they once thrived. There is also concern about the tiger salamander (*Ambystoma tigrinum*) in this area. The global and local environments have changed and these alterations, like the vehicles in the video game, have a deadly effect on amphibians. Frogger the video game is exciting. The real frog situation is scary.

There are two things that were already mentioned that make amphibians more sensitive to environmental change than many other animals, two of the adaptations that set this class apart from all the others are probably linked to their decline. First, their two lives require both healthy freshwater and terrestrial habitat and any alteration of either habitat can have damaging impacts. In both environments the porous skin of amphibians, that is useful in so many ways, allows pollutants to easily enter the body. Amphibians have been called "environmental sponges" because of the way their skin absorbs water, air, and any pollutants. If you touch an amphibian you must be sure that you have clean hands. The amphibian will absorb any noxious chemicals that are on your hands like sun screen or bug repellent. The biology that makes these animals so fascinating and unique also makes them very sensitive.

VOCALIZATION

It is not always easy to see amphibians in the environment. They are often camouflaged and inconspicuous, but there is one way that frogs and toads let everyone know where they are. Either by watching the Superbowl or by placing yourself within hearing of a

body of water, you can become familiar with frog vocalizations. A series of well known beer advertisements contain the distinct vocalizations of several frogs. As you will learn, Montana's frogs and toads can be easily identified by their calls. With a little training the human ear can be taught to differentiate between these calls as easily as one can distinguish between "ER," "WEIS," and "BUD!" One easy and fun way to help protect amphibians is to become involved with frog call surveys. By following a simple procedure, surveyors identify frog species and populations in local waters, and report this information to amphibian scientists. The uniqueness of each species' vocalizations and the fact that there only a few species in Montana makes listening for frogs quite simple.

CONCLUSION

There is an episode of The Simpsons where Bart and the whole family travel to Australia. As usual, Bart skillfully assumes his role as the prankster. As the family approaches customs in Australia, Bart draws his seemingly harmless travel companion from his pocket, a cute green toad. The critter is deliberately placed in the airport's water fountain for safekeeping until the prankster's return. The plot that unfolds from Bart's actions contains lessons in amphibian ecology and biology.

In real life, Bart's actions could be described as ecological terrorism! Of course the toad is not content to remain in the unexciting water fountain, but compelled to explore her new environment. The toad must be female, because it doesn't take long for a population explosion of little green toads to appear across Australia. As ecologists we realize that this cute green species must not ordinarily be found in the homeland of the kangaroo. Modern day technology, the airplane, has transported and introduced the species to a new ecosystem. As often occurs, the visitor finds itself able to out compete the native species and thrive. In this case the toad is the introduced species. In other situations amphibians are threatened when fish are introduced into new freshwater habitats. The results might have been similar if Bart had brought a pocket full of beetles or even weeds into a new territory. Cane toads have been introduced to the continent of Australia with effects very

similar to those on the Simpsons. Another common conception about amphibians also makes them appropriate to this story's plot.

Amphibians have the ability to reproduce in enormous numbers when conditions are right. Casual observers around the world have been startled by the sounds of jumpy frogs at the waters edge. At certain times of the year, especially during wet seasons, frogs can become so abundant that people have been led to believe that it has rained frogs! The comic story line of The Simpsons shows us the catastrophic results of introducing species to new environments as well as the ability of amphibians to proliferate under the right conditions. This capacity to reproduce in large numbers may be the salvation of the amphibians.

Perhaps the most well known frog of all goes by the name Kermit. He is the green star of Sesame Street, the Muppet Show and the muppet movies. With skinny legs and a big mouth he looks like a frog, but acts a lot like a human. This isn't too hard to believe, because amphibians and humans actually have much in common. We share our environment with the amphibians. We live on the same land. We drink the same water. We breathe the same air. We need to do whatever we can to keep all these things clean and healthy. Kermit the frog said it the best. "It's not easy being green."

Now that we have discussed what amphibians all around the world have in common, it's time to take a look at those that live right here in western Montana. Unlike regions with wetter climates, this area is the home to relatively few amphibian species. In fact, there are only about half a dozen species of salamanders, toads, and frogs that you are likely to encounter here. The adult form of each species has very unique characteristics that make identification easy. Have you ever seen or heard an amphibian and wondered exactly what it was?

Slide 8 - Long-toed salamander (*Ambystoma macrodactylum*)

Look at the slender body and long tail on this amphibian. It is obviously not a frog or a

toad. This is the long-toed salamander *Ambystoma macrodactylum* western Montana's most common salamander. Adults of this species are between two and three and a quarter inches in length, about as long as your index finger. They can be found in all types of habitat from lower elevation sagebrush to high alpine and everywhere in between. Like many salamanders, they hide in forest litter, under leaves and in rotten logs, where they feed on terrestrial insects. In early spring, as soon as the snow melts, long-toed salamanders breed and lay their eggs in ponds or lakes, preferring those without fish. They do have long toes on the hind feet, but the easiest way to identify the long-toed salamander is by the yellow or greenish stripe running down the back of the dark body.

Slide 9 - Western toad (*Bufo boreas*)

Toads do not give people warts, but they do have dry, bumpy, skin like we see here. This is the western toad (*Bufo boreas*), the only toad found in western Montana. They are gray, brown, or olive colored with a distinct yellow line running down the length of the back. You can see this stripe in the photograph, starting at the toad's nose. Western toads can be fairly large, sometimes reaching five inches in length. They can be found from valley bottoms to high elevations and they are usually near water, but almost never in it. The eggs are laid in the shallow waters of lakes, ponds and streams with a preference for areas with muddy bottoms. Observers have reported that gray jays feast on western toad tadpoles and the toads themselves sit at the entrances to beehives and use their long tongues to zap bees out of the air. *Bufo boreas* was once common throughout the northern Rockies, but is now in decline throughout its' range. The western toad is listed by the Forest Service as a sensitive species in this area. The call is a high-pitched plinking sound similar to the peeping of chicks. First is a lone male toad with other frogs in the background, followed by a small group of western toads. (Vocalization)

If you ever see western toads please record the number you saw as well as the time and location. This information is very helpful to scientists who are studying amphibians.

Slide 10 - Pacific chorus frog (*Hyla regilla*)

Cute, huh? This is the Pacific chorus frog (*Hyla regilla*). Some sources use the genus *Pseudacris* instead of *Hyla*, so don't let this confuse you. *Pseudacris regilla* refers to the same species. This is the smallest frog you can find in western Montana. Adults are less than two inches in length. The frog in the photograph is a vivid green, but the Pacific chorus frog is the chameleon of the forest. These frogs can rapidly change color from light to dark. This is done not only for camouflage, but also to adjust the amount of heat the organism absorbs. This would seem to make identification difficult, but that is not the case because all Pacific chorus frogs have a conspicuous eye line from the nostril to the shoulder. This marking is always darker than the rest of the frog. Another easy way to identify chorus frogs is by the distinct, bulbous toe pad. This is only the frog in Montana with toe pads.

Pacific chorus frogs eagerly eat small earthworms and grubs. These frogs breed shortly after snowmelt in temporary ponds with vegetation. After the breeding season is over the adult frogs move upland and are rarely seen. Many frogs occupy the same pools and the volume can be very loud at night. The attraction calls of the males form duets, trios, and quartets giving the effect of a chorus. In order to make this music, these tiny frogs expand their throat pouches until they are three times larger than the head. The sound is a two-part "ribbit" or "kreck-ek." Here are several males calling, followed by a full chorus. (Vocalization)

Slide 11 - Northern leopard frog (*Rana pipiens*)

Can you picture the spots on a leopard? Well, this is a northern leopard frog (*Rana pipiens*). These frogs are greenish brown with large dark spots on the legs, head, sides, and back. Each spot is outlined by a light colored halo. The belly, which you can't see here, is a light cream color. Adult frogs are two to five inches long. Leopard frogs are adapted to cold climates and they are found in or near water. They do not dwell in forested habitats, but prefer the heavy vegetation of wet sage meadows and cat-tail

marshes just like you see in the photograph. Northern leopard frogs feed on worms and all types of insects.

In March or April, they breed in the slow waters of lakes, beaver ponds, and freshwater springs. The male call is a low-pitched chuckling sound almost like rubbing an inflated balloon. Here are several males calling. (Vocalization)

Like the western toad, the northern leopard frog is a sensitive species. This species may be extinct in western Montana. If you find leopard frogs, please record the number, time and location and make sure that they are not spotted frogs.

Slide 12 - Columbia spotted frog (*Rana luteiventris*)

This is a Columbia spotted frog (*Rana luteiventris*). It is the most common frog in western Montana. The spots are noticeably smaller than those of the leopard frog and are not surrounded by light colored halos. The skin on the back is not smooth, but has small bumps. You cannot see it when the frog is sitting, but the underside of the hind legs is orange or red. The large webbed feet make this frog an agile swimmer and they are rarely found far from a body of water. They feed greatly on small fish. Spotted frogs prefer forested habitat not large, open valleys.

In March or April you may hear the call of the spotted frog if you are in the right place and you listen carefully. The sound does not carry very far and consists of a series of five to fifty clicks. You can imitate this call by clicking your tongue against the roof of your mouth. (Vocalization)

Significant decline in spotted frog populations has been reported in nearby states. One reason is that spotted frogs do not survive in areas where bullfrogs have been introduced.

Slide 13 - Bullfrog (*Rana catesbeiana*)

Wow, look at the size of this frog! This is a photograph of a bullfrog (*Rana catesbeiana*) taken near the Bitterroot River at the Teller Wildlife Refuge. Bullfrogs are native to the eastern United States and have been introduced to many western states. They were most likely brought west because people like to eat the large back legs of these frogs. Supposedly they taste like chicken! The large back legs result in powerful swimming and on land the average jump is three feet! In this area bullfrogs can now be found in the Bitterroot, Clark Fork, and Flathead Rivers. They cannot survive in colder mountain waters. One obvious characteristic is the large ear, or tympanum, which in the bullfrog is much larger than the eye. Another characteristic is their large size. Bullfrogs can grow to eight inches! They grow this large because they are voracious eaters. They will eat anything that is smaller than themselves including: fish, mice, ducklings, small turtles and other frogs. They may be partially responsible for declining populations of native amphibians, turtles and waterfowl.

Bullfrogs hibernate until late May or early June and then their deep, powerful calls can be heard over long distances. "Bar-room!" (Vocalization)

If you lived in Florida it would be different, but here there are only a few species of amphibians. Each one is very easy to distinguish from the others. Thank you to Bryce Maxell for contributing all these wonderful amphibian photographs.

Identification Key

A) Does the adult amphibian have a long, slender body and a tail? No. The amphibian is an Anuran (frog or toad). Go to B.

Yes. Does the Urodelan (salamander) have a yellow stripe?

Yes. This is a long-toed salamander (*Ambystoma macrodactylum*).

No. This is one of the less common salamanders in western Montana.

B) Does the Anuran (frog/toad) have dry skin with numerous warts and glands? No. Go to C.

Yes. This is a western toad (*Bufo boreas*), a sensitive species in this area.

C) Are there distinct toe pads on the end of each digit? No. Go to D.

Yes. This is a pacific chorus frog (*Hyla regilla*).

D) Are there dark spots with light halos on the legs, sides, head, and back? No. Go to E.

Yes. This is a northern leopard frog (*Rana pipiens*), a sensitive species in this area.

E) Does the frog have rough bumpy skin? (Or is the frog less than 4 inches?) No. Go to F.

Yes. This is a Columbia spotted frog (*Rana luteiventris*) Formerly known as spotted frog (*Rana pretiosa*).

F) This is the non-native bullfrog (*Rana catesbeiana*).

Taxonomic Classification of Amphibians

Kingdom: Animalia

Phylum: Chordata

Class: Amphibia

Order: Urodela (salamanders)

Family: Ambystomatidae

Genus: *Ambystoma*

Species: *macrodactylum*

Order: Anura (frogs and toads)

Family: Bufonidae (toads)

Genus: *Bufo*

Species: *boreas*

Family: Hylidae (tree frogs)

Genus: *Hyla*

Species: *regilla*

Family: Ranidae (frogs)

Genus: *Rana*

Species: *pipiens*

Genus: *Rana*

Species *luteiventrens*

Genus: *Rana*

Species: *catesbeiana*

EVALUATION

1. Have students individually list as many shared characteristics of amphibians as possible.

2. Have students individually list the six most common species in western Montana and provide at least one unique visual characteristic for each.

3. Ask students what other criteria scientists might use to classify species.

EXTENSIONS

1. Use the vocalizations provided with the slide show to develop an identification key that uses amphibian vocalizations instead of visual characteristics to differentiate between species.

2. Allow the expert groups to further investigate each of the six species they were originally assigned. Some possible topics include: geographic distributions, habitat requirements, feeding, identification of egg and tadpole forms, and interspecies relationships.

3. Show students how field guides utilize classification schemes to identify organisms.

4. Compile a small field guide with information on western Montana's amphibians.

5. Introduce students to the amphibian surveys from the Lolo National Forest. Explain that students can use their ability to differentiate between amphibians to help scientist in their studies.

6. Use the Lolo National Forest Survey forms and the two articles on amphibians distribution by Jeffrey Black to predict what species you would expect to find in local habitats.

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EDUCATION STANDARDS

National Science Education Standards

Grades 9-12:

Content Standard A: Science as Inquiry

-abilities necessary to do scientific inquiry

-understandings about scientific inquiry

Content Standard C: Life Science

-biological evolution

-interdependence of organisms

-behavior of organisms

Montana Standards for Science

Science Content Standard 3

Students demonstrate knowledge of characteristics, structures and function of living things, the process and diversity of life, and how organisms interact with each other and their environment.

Upon Graduation - End of Grade 12

Students will:

4. predict and model the interactions of biotic and abiotic factors which limit populations (natural selection), and contribute to the

change of a species over time (evolution).

5. apply a biological classification scheme to infer and discuss the degree of species divergence using local ecosystems.

LESSON NUMBER TWO

Extinction and Trophic Cascades

TIME

one hour

CENTRAL FOCUS QUESTION

What are the ecological implications of the extinction of a single species?

CONCEPTS

trophic levels, species interactions, symbiosis, parasitism, commensalism, mutualism, competition, energy webs, extinction

BACKGROUND

Community ecology deals with the interactions between species inhabiting an ecosystem. The ways in which species interact are complex and fundamental to ecological understanding.

This lesson displays to students the intricacies of symbiotic relationships and demonstrates the effects of a single species extinction on the community.

OBJECTIVES

At the completion of this activity, students should be able to:

1. Describe the ways in which populations within a community interact.

2. Compare parasitism, commensalism, and mutualism and give examples of each.

3. Recognize the diverse relationships that exist between organisms in a community.

4. Understand the ecological effects of the extinction of a single species upon other species in a community.

MATERIALS

photocopies of "Extinction and Trophic Cascades"

PROCEDURE

1. Photocopy the reading on "Extinction and Trophic Cascades" and distribute to class. Discuss any definitions and concepts that may make the reading difficult for students. An understanding of the concept of trophic levels is essential. Chapter 21 in the *Modern Biology* textbook and Chapter 48 in the *Biology* textbook contain information on community ecology and species interactions. Assign the reading on "Extinction and Trophic Cascades" as homework. Students should focus on the complex relationships between the organisms when reading the assignment.

2. Refer to **Extinction and Trophic Cascades** (page 55).

3. List the three organisms in SCENARIO ONE and the nature of their relationships.

HONEYCREEPER (bird)

-obtains nectar from *Hibiscadelphus*

-pollinates *Hibiscadelphus*

-killed by malaria

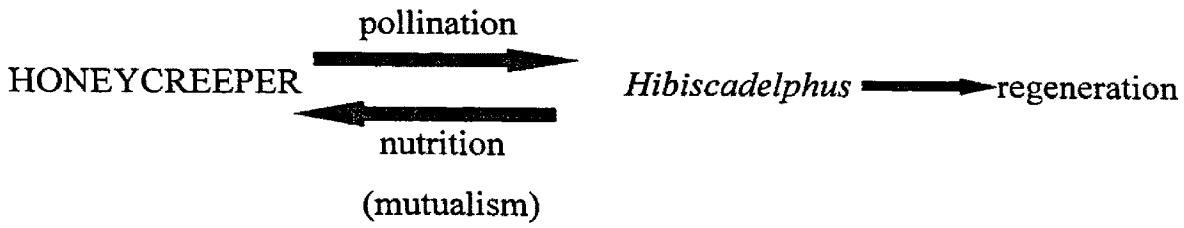
Hibiscadelphus (flowering plant)

-pollinated exclusively by honeycreeper

MALARIA (protozoan)

-kills honeycreeper

4. Using a simple flow chart to diagram the relationship between the honeycreeper and *Hibiscadelphus*.



5. Ask the class if the symbiosis is parasitic, mutualistic, or commensalistic. Now diagram the relationship between malaria, the honey creeper and *Hibiscadelphus*.

MALARIA infection -> HONEYCREEPER -> extinction -> *Hibiscadelphus* -> extinction

Both the honeycreeper and *Hibiscadelphus* become extinct as the result of this trophic cascade.

6. As a class, list all the organisms from SCENARIO TWO. There are 10. Write them across the board in this order: PECCARY, FROG, MOSQUITO, MICROBIAL PARASITE, MONKEY, MANGO TREE, LEAFCUTTER ANT, LIZARD, WASP, OWL

7. Divide the class into 10 groups and assign an organism to each group. Allow the

students in each group to review SCENARIO TWO and determine what other organisms they have direct relationships with and the nature of the relationship.

8. Allow each group to describe what other organisms they are directly linked to and describe the relationship. Place this information on the board under the appropriate organism.

9. Diagram the relationships described in SCENARIO TWO. Discuss each symbiotic relationship in terms of benefits and detriments to each organism.

PECCARY
creates habitat for frog eggs
creates habitat for mosquito eggs

FROG
egg habitat created by peccary
tadpoles eat mosquito larvae

MOSQUITO
egg habitat created by peccary
larvae eaten by frog tadpoles
transmits microbial parasite
blood from monkey

MICROBIAL PARASITE
transmitted by mosquito
infects monkey

MONKEY

donates blood to mosquito

infected by microbial parasite

eats mango fruit and disperses mango seeds

MANGO TREE

seeds dispersed by monkey

eaten by leafcutter ant

LEAFCUTTER ANT

eats mango tree

eaten by lizard

LIZARD

eats leafcutter ant

eats wasps

WASP

eaten by lizard

competes with owl for habitat

OWL

competes with wasp for habitat

10. Have each of the 10 groups study the relationships that their organism is involved with in SCENARIO THREE. Add these interactions to the list on the board from SCENARIO TWO.

11. Alter the diagram of SCENARIO TWO to depict the events described in SCENARIO THREE. Allow each group to describe the causes and results of the trophic cascade for their organism.

EXTINCTION AND TROPHIC CASCADES

adapted from *The Song of the Dodo* (pages 342-344), by David Quammen

We haven't begun to comprehend extinction until we comprehend trophic cascades.

The term refers to cascading disruptions that can pass between trophic levels–that is, between different categories of interrelated organisms in the hierarchy of energy transfer within an ecosystem. The ecosystem itself is not just a landscape full of plant and animal species: it's an intricate network of relationships, including those between predators and their prey, between flowering plants and their pollinators, between fruiting plants and the animals that disperse their seeds. Each such relationship constitutes a link between trophic levels. Trophic cascades, as defined by Jared Diamond in his "Rosetta Stone" paper, are secondary effects that can ramify from level to level in consequence of a single extinction.

His words: "Since species abundances depend on each other in numerous ways, disappearance of one species is likely to produce cascading effects on abundances of species that use it as prey, pollinator, or fruit disperser." At the low extreme of abundance, of course, a species faces rarity unto extinction.

SCENARIO ONE

As an example, Diamond cited a plant group that seems to have suffered--secondarily--from malaria. "All five species of the endemic Hawiian plant genus *Hibiscadelphus* are extinct or nearly extinct due to the disappearance of their pollinators, Hawaiian honeycreepers, whose long curved bills match the plants' narrow tubular curved flowers." The extreme shape of the flowers implies an exclusive relationship between plant and pollinator. A lengthy history of mutual adaptation seems to have fitted the bills of certain honeycreeper species to the flowers of certain honeycreeper to the flowers of certain *Hibiscadelphus* species, leaving other nectar-gathering animals (such as bees,

moths, bats) excluded. If this is so, then with those honeycreepers eliminated by malaria, the *Hibiscadelphus* species can't be pollinated. As older plants die, no new plants germinate to replace them. The eventual result is extinction. The plants disappear as a secondary result of the birds' disappearance. The mechanism is trophic cascade.

SCENARIO TWO

Imagine another set of species relationships in another tropical forest. This forest is hypothetical, but the particulars are all plausible. The full set includes a species of peccary, a species of frog, a species of mosquito, a microbial parasite, a species of monkey, a species of mango tree, a species of leafcutter ant, a species of lizard, a species of wasp, and a species of owl--which in this case is a pigmy, adapted to nesting in cavities. These species interact with each other in diverse and incalculable ways, but a few of the interactions can be noted. The peccary roots for food along the soft banks of forest creeks, and its rooting creates muddy puddles. The frog and the mosquito both lay eggs in those puddles. As the tadpoles hatch and grow, they feed on the larvae of the mosquito. The mosquito, as an adult, carries the microbial parasite in its saliva and that parasite causes disease in the monkey. Fortunately for the monkey, the mosquito population is small--and so the incidence of the disease remains low. The monkey eats a wide variety of plant material, but it prefers items that are juicy and sweet. Whenever the mango tree comes into fruit, the monkey gorges on that. The mangos are small enough that sometimes the monkey swallows them whole, and the woody mango seeds pass through the monkey's gut. The leafcutter ant depends on the same tree for its forage. The ant is so specialized, in fact, that it relies on that tree and no other. The lizard is slightly less specialized, feeding on ants, flies, and an occasional wasp. The wasp builds its nest in the small tree holes originally excavated by woodpeckers. The pygmy owl, like the wasp, nests in abandoned woodpecker holes.

Now let's disturb the ecosystem with a single extinction and postulate what might happen. The peccary population is killed off, say, by hunters.

With the peccary gone, the creeks flow clear, the soft banks remain undisturbed, and after a period of time there are no muddy puddles. So the frog, deprived of egg-laying sites, follows the peccary to extinction. But the mosquito, less specialized than the frog, survives. It adjusts to the absence of peccary walllows by laying its eggs in the tiny pools of rainwater that accumulate on fallen leaves. In fact, the mosquito does better than simply survive; relieved of predation by tadpoles, its population soars. Hungry mosquitos swarm thickly through the forest, with the microbial disease. This disease outbreak comes as a final blow to the monkey, which (like the peccary) has already been reduced by hunting. So the monkey goes extinct. The mosquito scarcely misses the monkey, shifting its bloodsucking attacks to a variety of small mammals and birds. But the mango tree does suffer from loss of the monkey, which is an irreplaceable partner. Without monkeys to swallow its fruits, to process its seeds by digestion, to excrete those seeds onto the ground along with little legacies of fertilizer, the tree can't reproduce. So in the years following the monkey's extinction, the tree sets no saplings. After two centuries of helpless sterility, two centuries without offspring, the last old mango tree dies.

Our tally so far: peccary extinct, frog extinct, monkey extinct, tree extinct. The mosquito is thriving. The microbial parasite, like the tree, has followed the monkey to extinction--it was insufficiently versatile to establish new reservoirs of infection in other mammals preyed on by the mosquito.

The cascading effects continue. The leafcutter ant, bereft of its favored tree, goes extinct. In the absence of the ant, the lizard population declines sharply. The lizard's decline is a boon to the wasp population, which finds itself no longer harried by lizards. Some few lizards do continue to prey on some unwary wasps, but far fewer than ever, and wasps become vastly more numerous. They seize every abandoned woodpecker hole, building their nests, raising their offspring, producing ever more wasps, claiming ever

more holes. The pygmy owl is the loser in that competition. Faced with a wasp's territorial fervor, the owl is meek. It does not inherit the Earth. Denied access to breeding holes, it goes extinct.

The ecosystem has been transformed by trophic cascades.

Another definition of trophic cascades: Falling ecological dominoes, with each domino a species and each fall an extinction.

EVALUATION

1. As a class, develop a scenario on extinction and trophic cascades using common Montana species including amphibians. Classify the symbiotic relationships. Speculate on the community effects of an extinction event in this scenario. Here are some sample animals: mosquito, wasp, beaver, bat, bullfrog, spotted frog, trout

2. Develop posters on ecological interactions that take place between animals in Montana.

EXTENSIONS

1. Use the articles "Protecting Nature's Diversity" by John Tuxill and Chris Bright and "The Sixth Extinction" by Virginia Morell to begin an investigation of the larger issue of mass extinction and biodiversity currently effecting many animal populations including amphibians.

2. Have each student find an article on extinction and present the information to the class.

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EDUCATION STANDARDS

National Science Education Standards

Grades 9-12:

Content Standard A: Science as Inquiry

-abilities necessary to do scientific inquiry

-understandings about scientific inquiry

Content Standard C: Life Science

-interdependence of organisms

-matter, energy, and organization in living systems

-behavior of organisms

Content Standard F: Science in Personal and Social Perspectives

-population growth

-natural resources

-environmental quality

-natural and human-induced hazards

-science and technology in local, national, and global challenges

Montana Standards for Science

Science Content Standard 3

Students demonstrate knowledge of characteristics, structures and function of living things, the process and diversity of life, and how organisms interact with each other and their environment.

Upon Graduation - End of Grade 12

Students will:

4. predict and model the interactions of biotic and abiotic factors which limit populations (natural selection), and contribute to the

change of a species over time (evolution).

5. apply a biological classification scheme to infer and discuss the degree of species divergence using local ecosystems.

LESSON NUMBER THREE

The Mystery of the Vanishing Amphibians...What's Up in Montana

TIME

one hour (minimum)

CENTRAL FOCUS QUESTION

What are the contemporary theories on amphibian decline and which theories are most applicable to amphibians in Montana?

CONCEPTS

scientific method, amphibian decline, acid precipitation, pollution, predators and prey, global climate change, habitat, pathogens and disease, human consumption, amphibian deformities, ultraviolet radiation

BACKGROUND

The National Geographic video, "The Last Frog," serves as the engagement piece for this lesson on amphibian decline. Scientists around the world believe that many populations of frogs and toads have declined significantly in number and that several species have become extinct in the last 50 years. There are numerous theories that attempt to explain this global phenomenon and there is a great deal of controversy on the matter. There are strong indications that several of Montana's amphibian species are in decline, but information on the status of amphibians in Montana is limited.

After watching the video, the lesson utilizes a cooperative learning strategy in which the class is subdivided into small groups. Each group will explore one area of contemporary research on amphibian decline, and formulate a working hypothesis on Montana's amphibians. Readings are provided to begin the investigation and further research will

involve outside resources including the Internet. Each group will deliver a final presentation on their topic to the whole class and either confirm or reject their original hypothesis. Presentations will be evaluated by the teacher and the class. The class will apply the information contained in the presentations to speculate on amphibian decline in Montana.

OBJECTIVES

At the completion of this activity, students should be able to:

1. name and recognize several amphibians that are extinct or endangered

2. list the main issues that are involved in amphibian decline

3. give details and analyze one theory on amphibian decline in depth

4. apply knowledge of amphibian biology and ecology to an investigation of amphibian decline

5. communicate the findings of scientific research to other students

6. apply broad information on amphibian decline to the situation in Montana

MATERIALS

Photocopies of the Viewing Guide for "The Last Frog" for the entire class, National Geographic video "The Last Frog;" VCR; television, clue sheets, articles on amphibian decline (provided)

PROCEDURE

1. Generate a class discussion to determine what students already know about amphibian decline. Brainstorm as a class to form a list of possible causes or theories that may explain

the extinction or endangerment of amphibians.

2. Distribute the **Viewing Guide for "The Last Frog"** (Page 67) to the class. While watching the video have students answer the questions on the viewing guide. The video is 26 minutes in length.

At the completion of the video discuss the answers to each question from the Viewing Guide. Discuss the possible causes of amphibian decline last. Explain to students that there are many theories and that in order to investigate further it will be necessary to categorize those theories. For example, roads are dangerous for amphibians and should be placed in the more general category of habitat considerations.
In the investigation that follows in the lesson the theories are organized into eight general categories.

pollution (acid precipitation, pesticides)
predators and prey (introduced species)
global climate changes
habitat fragmentation, elimination, and alteration
pathogens and disease
human consumption
deformities
ultraviolet radiation (UV-B)

With the exception of deformities, all of these issues are covered to some degree in the video. Make sure students understand these categories and where any of their recorded answers should be placed.

3. Divide the class into eight study groups. Assign each group one of the topics to investigate, allowing anyone who expresses an interest in a specific topic to pursue this

research if possible. Provide each group with photocopies of the introduction clues and the appropriate readings for their topic. The provided readings vary from easy to read news articles to technical scientific research. The more technical pieces contain valuable information in the abstracts and discussion sections and also provide examples of the scientific method.

4. From this information, students will develop a hypothesis for their work. For example, the hypothesis could be "that _____ is the cause of declining amphibian populations in Montana."

5. Distribute "**Peer Evaluation of Group Presentations** " forms (Page 68) to each group. This form outlines the criteria that students and the teacher will use to evaluate the final presentations. Provide class time for the groups to begin their research. Each group will need to divide responsibilities and develop an action plan for further investigation.

6. After studying the provided resources, students should go beyond this information by using additional resources in the curriculum, library research and Internet resources. Several books containing pertinent information are provided with the curriculum and should be shared among the groups. A list of Internet resources is provided in the "Amphibian Websites" section of the curriculum. Many of the resources contain information pertaining to more than one category. Students should be encouraged to cooperate and share appropriate resources that may benefit other groups. Emphasis should be placed on the aspects of amphibian biology and ecology addressed in the research (the life cycle, permeable skin, habitat, predation, etc.). Emphasis should also be placed on whether or not the group findings are likely to apply to Montana's amphibian populations.

7. From the information found students defend or refute their original hypothesis. In other words, students must communicate whether they agree or disagree with the

proposed hypothesis on amphibian decline in Montana and why they agree or disagree with this.

8. Each group should present a final product in the form of a report presented to the class. The report should contain the chosen hypothesis plus research, and the conclusion. Students should also indicate what information is controversial, what information is unknown or missing, and what research they would recommend. A written outline of the presentation should be delivered to the class.

9. Discuss as a class what theories most likely apply to amphibians in Montana. Discuss how these theories might combine and further complicate the situation for amphibian populations.

Viewing Guide for "The Last Frog"

Record answers to the following questions while watching the video.

How long have amphibians been around?

Why does the narrator refer to the frog as "our brave and ancient ancestor"?

What other animals feed on frogs or tadpoles?

What is unique about the frog life cycle shown in the video? Can you think of any advantages to this adaptation? Any disadvantages?

In what ways are frogs beneficial to humans?

What are people doing to try to help frogs?

In what countries and states are people concerned about frogs?

The video mentions several possible causes for declining amphibian populations. What are they?

Peer Evaluation of Group Presentations

	Low				High
Outline / overview of presentation	1	2	3	4	5
Quality of information	1	2	3	4	5
Delivery of material	1	2	3	4	5
Quality of visuals	1	2	3	4	5
Creativity	1	2	3	4	5
Understanding of amphibian biology / ecology	1	2	3	4	5
Information applied to Montana	1	2	3	4	5
Equal participation by group members	1	2	3	4	5

Strength(s) of the presentation:

_____

_____

_____

_____

_____

_____

_____

Suggestion(s) for improvement:

_____

_____

_____

_____

_____

What was the most interesting thing you learned from this presentation?

EVALUATION

The presentation should meet the following criteria:

1. Clearly state the hypothesis researched by the group

2. Clearly state the conclusion of the group and show this by referring to the information found - written sources or Internet sources. Information from the Internet should be confirmed by multiple Internet sources or other written or expert sources. Sources used should be cited by the author or the URL listing.

3. Each report should be neat and organized and show the level of effort put into the project.

4. The reports should convey an understanding of amphibian biology and ecology and how this relates to the theories.

5. Use the "Peer Evaluation of Group Presentations" form to evaluate each presentation.

EXTENSIONS

1. Additional research can be performed on Montana's sensitive species, the western toad (*Bufo boreas*) and the northern leopard frog (*Rana pipiens*). Both of these species have been studied and found to be in decline in Montana and surrounding states and provinces.

2. Students can further investigate any or all of the environmental issues presented in the reports. Students can determine what other plants and animals are affected and how these issues affect humans.

3. Students can take action on behalf of amphibians in a number of ways, by working to improve the quality of the environment or becoming involved with scientific research to

provide better information on amphibians. Some of these opportunities are outlined in the "Getting Involved" section of this curriculum.

4. Apply the approach detailed in "A Technique for Analyzing Environmental Issues" by Ramsey, Hungerford, and Volk to an analysis of one of the amphibian decline articles.

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EDUCATION STANDARDS

National Science Education Standards

Grades 9-12:

Content Standard A: Science as Inquiry

- -abilities necessary to do scientific inquiry
- -understandings about scientific inquiry

Content Standard C: Life Science

- -interdependence of organisms
- -matter, energy, and organization in living systems
- -behavior of organisms

Content Standard E: Science and Technology

- -abilities of technological design
- -understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

- -population growth
- -natural resources
- -environmental quality
- -natural and human-induced hazards
- -science and technology in local, national, and global challenges

Montana Standards for Science

Science Content Standard 1

Students design, conduct, evaluate and communicate scientific investigations.

Upon Graduation - End of Grade 12

Students will:

2. select appropriate means for representing, communicating, and defending results of investigations and scientific and technological arguments using appropriate mathematical analysis and graphical representation.

6. investigate and evaluate science studies and identify strengths and weaknesses in experimental design.

Science Content Standard 5

Students understand how scientific knowledge and technological developments impact society.

Upon Graduation - End of Grade 12

Students will:

2. model the ongoing, collaborative scientific process of gathering and evaluating information.

GETTING INVOLVED

There are numerous ways for students to get involved on behalf of the amphibians of Montana. Information on amphibian populations in Montana is limited, so any observations made by students are very valuable to the scientific community. Students can participate in call surveys, atlassing projects, egg and tadpole surveys and terrestrial salamander monitoring. Protocols will be provided and the projects are fun and educational.

Miscellaneous Observation Form
Montana Natural Heritage Program

These forms are provided with the curriculum. Please feel free to photocopy and distribute forms to the class. These forms should be used to report the location of any uncommon amphibians and reptiles. Location is reported by township, range, and section. This information can be obtained from Forest Service maps. It may be necessary for students to practice obtaining this information from maps. You can visit the Montana Natural Heritage Program's website at:

http://imnh.isu.edu/digitalatlas

ZooMontana's Frog Frenzy and Toad Tally

ZooMontana is encouraging, individuals, families, and groups (classes) to adopt a local wetland and periodically monitor its' inhabitants. Any information on amphibians given to ZooMontana will be passed along to the North American Amphibian Monitoring Program (NAAMP), the North American Center for Reporting Amphibian Malformations, and Montana Fish, Wildlife & Parks.

For more information please contact the regional coordinator.

Catherine Lynch, Education Specialist
ZooMontana
PO Box 80905
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Fax: (406) 652-9281
E-mail: zoomont@wtp.net

Information on NAAMP is available on the Internet at
http://www.im.nbs.gov/amphib.html

Build a Breeding Pond for Frogs and Toads

See the article from *Organic Gardening* to learn how to add an amphibian breeding pond to your garden.

Organize a 'Frog Day in Your Community

See the article on 'Frog Day' in Condon, Montana from the *Seeley Swan Pathfinder.*

Annotated List of Amphibian Websites

There is abundant information on amphibians on the Internet. Most of these sites are linked to each other and to other websites. This list is provided as a starting point for Internet research.

A Thousand Friends of Frogs Project
http://cgee.hamline.edu/frogs

Hamline University's Center for Global Environmental Education, teacher/student resources, numerous categorized links

Montana Natural Heritage Program
http://nris.state.mt.us/mtnhp/

MNHP information on threatened and endangered spesies of Montana

Amphibian malformation reporting center
http://www.npsc.nbs.gov/narcam/index.htm

Comprehensive government site on amphibian deformities includes research, reporting and species identification, numerous links

USGS Amphibian Information Website
http://monitoring2.pwrc.nbs.gov/amphibs

Searchable database on amphibians

Canadian Amphibian and Reptile Conservation Network
http://www.cciw.ca/ecowatch/dapcan/intro.html

Information on amphibian decline and a key to identify amphibians

Declining Amphibian Populations Task Force (DAPTF)

http://www.open.ac.uk/OU/Academic/Biology/J_Baker/JBtxt.htm

Information on amphibian decline from the task force organized to research the issue

Froglog

http://acs-info.open.ac.uk/info/newsletters/FROGLOG.html

On-line newsletter on amphibian decline, current and back issues available

Herpetolgy Organizations on the web

http://home.ptd.net/~herplink/org.html

Links to organizations specializing in reptiles and amphibians

Herpetology Societies on the web

http://gto.ncsa.uiuc.edu/pingleto/herps/herpsoc.html

Links to reptile and amphibian societies listed by country and state

Herp Toxicology website

http://www.cciw.ca/green-lane/herptox/

Site dealing with the effects of environmental contaminants on reptiles and amphibians

Online Field Guide for North American Amphibians

http://www.npwrc.usgs.gov/narcam/idguide/specieid.htm

Photos and descriptions for identifying amphibians of North America

North American Amphibian Monitoring Program (NAAMP)

http://www.im.nbs.gov/amphibs.html

Homepage for government organization that coordinates amphibian monitoring

Frogwatch USA

http://www.mp2-pwrc.usgs.gov/frogwatch/

Site for contributing data from amphibian monitoring efforts

Amphibia Web

http://elib.cs.berkeley.edu/aw/history.html

University site on amphibians with numerous links

Frog Web

http://www.frogweb.gov

National Biological Information Infrastructure contains information on declining and malformed amphibians

Amphibian Disease Homepage

http://www.jcu.edu.au/school/phtm/PHTM/frogs/ampdis.html

Numerous articles and links related to amphibian disease

Partners in Amphibian and Reptile Conservation

http://www.parcplace.org/

Educational materials and student partners program in conservation

MONTANA NATURAL HISTORY CENTER
The Nature Center at Fort Missoula
Post Headquarters Bldg. T-2
Fort Missoula Rd.
Missoula, MT 59804

NATURE DISCOVERY KIT EVALUATION FORM

Please complete this evaluation and return it to MNHC. Your comments are greatly appreciated.

Kit: Date:

Name: Number of students who used kit:

Grade: Number of estimated hours the kit was used:

Rate the following: (Check appropriate box)

	Excellent	Good	Average	Poor
Overall				
Curriculum				
Hands-on Materials				
Relevance to your classroom study				
Ease of kit rental				
Communication with MNHC staff				

Comments:

What part of the kit benefited you the most?

Which of the lessons provided in the curriculum did you use?

Within each lesson, which components were the most useful?

Which items were not useful and why?

What additional materials or background information does the kit need?

Would you recommend this kit to other teachers? Definitely Maybe No

Why or why not?

Thanks for your feedback! Your input helps us continue to improve our kits!

CHAPTER FIVE

Discussion

There is a great deal of work to be done in environmental education in order for EE to achieve its goals and objectives. This project was selected for numerous reasons. Designing an educational trunk provided an opportunity for graduate work to have an immediate use in regional schools. The materials will be available for use by regional educators in the 2000-2001 school year. The traveling curriculum format is a unique approach which provides educators with the curricular materials to cover EE topics in the classroom. I feel that this is an effective strategy to encourage and implement quality EE programs in the public schools. Knowing that the final product will be distributed to and used by educators was rewarding and helped to focus my efforts.

The traveling curriculum format is cost effective. The entire curriculum was designed with free labor, and the cost of the materials was less than $100. The following suggestions have been given to MNHC in order to improve the "All About Amphibians" curriculum:

*In order to protect the curriculum and the included articles, all the materials need to be laminated.

*"Identification of Montana's Amphibians an Reptiles" supplement to *Montana Outdoors* by Jim Reichel and Dennis Flath is the most useful guide to species in Montana. I recommend that MNHC obtain as many copies of this resource as possible, ideally one per student.

*The inclusion of preserved specimens of local amphibians in the trunk would also be very useful.

*The slide show could be improved upon by adding additional slides of each of the local species.

*It would also be very beneficial if new articles on amphibian decline are included in the curriculum as these become available.

Amphibians are a fascinating and diverse group of organisms. I chose the topic of amphibians because I feel that students have an innate attraction to and curiosity about these animals, what some call biophilia. "The ability of living things to hold children's attention should help them learn how to understand the living environment, respect the appearance of the world, and take responsibility for its care" (Katcher and Wilkins, 1993). Amphibians, unlike wolves and grizzly bears, have the advantage of being an uncontroversial topic. Theories on amphibian decline investigate some of the biggest issues facing the environment, issues that are crucial to EE. It is my hope that a connection to amphibians will make topics like habitat loss, endangered species, pollution, ultraviolet radiation, extinction, and global climate change more relevant and accessible to students. The immediate urgency of these broad environmental issues may become more obvious when they are viewed in terms of their effect on a specific group of local animals.

Environmental education is interdisciplinary by nature. The topics and issues that are explored in EE have many components beyond biology and ecology. It would be beneficial to examine amphibian decline through a broader lens that would also encompass English and the social sciences. Unfortunately, this is difficult to accomplish within the

disciplinary boundaries that are typical of high schools. David Orr addresses this in an essay titled "The Problem of Disciplines and the Discipline of Problems" and concludes that:

> We are not likely anytime soon to dispense with disciplinary knowledge, nor do I propose to do so. What I do propose is that we seek out ways to situate disciplinary knowledge within a more profound experience of the natural world while making it more relevant to the great quandaries of our age (Orr, 1994).

The scope of this project was not to reform high school education, but rather to work within the established system to infuse EE on an urgent topic. "All About Amphibians" targets the discipline of the life sciences. Having a very specific discipline and age group in mind influenced the lessons in the curriculum. Unlike the trunks developed for younger students, the amphibian trunk contains only three lesson plans. However, the lessons are detailed and the content is scientifically based. All of the concepts are critical to a scientific understanding of amphibian decline. The lessons and extension activities prepare high school students to act knowledgeably and positively to protect amphibians.

When developing curriculum the role of the teachers who will eventually use the materials is critical. Several high school science teachers were consulted and provided valuable input that helped to shape the final product. They were helpful and genuinely interested in the success of the project, and they informed me that students are aware of and concerned about amphibian decline. I learned that this issue currently receives very little coverage in the classroom. Through their input I was able to determine to what

degree amphibian biology is covered in middle school and high school. This information helped me to avoid duplicating what is already covered in science classes. They described to me the systems approach to biology that is currently in use and made suggestions as to how to design the curriculum so that it would complement this approach. They emphasized the necessity for a curriculum that could be used in small segments to fit into their busy schedule. I was provided with high school biology textbooks which proved to be a valuable resource during this project. In retrospect, I should have involved teachers much earlier in the process. This input saves time and insures the usefulness and effectiveness of the final product.

Darcy Hover, a biology teacher at Hellgate High School, helped throughout the process and made many insightful suggestions that helped to shape the final product. She also reviewed the completed "All About Amphibians" curriculum. She felt that the lessons were well sequenced, but that each could be used independently as time permits. She commented that the curriculum promotes a wide variety of teaching and learning styles and fits well with the science standards. She pointed out that the lessons may take longer than the indicated one hour, but that the entire curriculum would make an excellent week-long learning unit. She stated that the curriculum was well organized and would be very easy to use. She plans to use "All About Amphibians" in her biology classes next school year.

Piloting or workshopping with teachers and students can help to modify and improve curricular materials. Unfortunately, time constraints prohibited this from occurring during the development of the "All About Amphibians" curriculum. The

curriculum contains an evaluation form for teachers to complete after using the materials. The evaluation form is presented in this paper at the end of Chapter Four. The purpose of the survey is to determine which materials were used, which were the most useful, how the lessons could be improved, and what the students liked most about the curriculum. This information should help MNHC improve the overall effectiveness of "All About Amphibians" as well as help to guide future efforts at developing educational trunks. I plan to give MNHC a computer disk containing the entire curriculum so that they can revise and edit the materials.

The process of designing the "All About Amphibians" materials was a valuable educational experience. By gathering and analyzing articles and books on amphibian decline I developed a deep understanding and appreciation of this complex issue. The damaging effects that humans have had on the environment and its components, like amphibians, is frightening. The numerous environmental threats to the health and existence of this group of organisms illuminates the many ways that humans have altered the planet. We are just beginning to see the long term consequences of our behavior toward the land. When amphibian decline is viewed in the larger context of the biodiversity crisis the necessity to educate for environmentally responsible behavior becomes even more compelling.

Deciding how to organize and present the materials allowed me to apply educational theory to a real project. It was challenging to incorporate inquiry, the learning cycle, science standards, and cooperative learning into each lesson. It was also challenging to meet all the objectives and goals of EE. This project forced me to think

about how to best reach its intended audience. The success of "All About Amphibians" ultimately rests with the educators who use the curriculum, however, it was designed to insure success as much as possible. Having taken all this into consideration, the final product should be an effective tool for bringing amphibian decline and EE into high school biology classes.

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