Environmental Education Module

Biological Diversity for Secondary Education

Dr. Ben Peyton
Dr. Henry Campa, III
Dr. Scott R. Winterstein
Michigan State University
East Lansing, Michigan

Michael D. Peyton
Judith V. Peyton
Environmental Education Consultants
Carlock, Illinois

UNESCO-UNEP
International Environmental Education Programme (IEEP)

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Table of Contents

List of Figures

List of Tables

SECTION 1: INTRODUCTION TO ENVIRONMENTAL EDUCATION AND BIODIVERSITY

CHAPTER 1:

Introduction to Environmental Education and Biodiversity

What is the Biodiversity Problem?

During the next 20 to 30 years, the world could lose more than a million species of plants and animals--primarily due to environmental changes induced by humans. At 100 species per day, this extinction rate will be more than 1,000 times the estimated "normal" rate of extinction. The list of lost, endangered and threatened species includes both plants and animals. About 10% of temperate region plant species and 11% of the world's 9000 bird species are at some risk of extinction. In the tropics, the destruction of forests threatens 130,000 species which live nowhere else.

This alarming rate of extinction is the global problem which has kindled interest in **"biological diversity"** or **"biodiversity"**. Biodiversity implies more than simply the number of species that inhabit our planet. The ecological interactions among these diverse species create the existence, complexity, health and functions of ecosystems upon which the human species depends for survival. Biodiversity implies as well, the genetic variability of life on the planet. Without genetic variability, life loses its ability to survive change--a quality known as adaptation.

As the concern for biodiversity has grown, scientists of many disciplines have reorganized to form the science of conservation biology. ***Loss of biodiversity*** is the problem; ***conservation biology*** is the attempt of science to understand the problem and discover solutions. ***Environmental education*** is the means of getting solutions implemented.

Who The Module is For

The ultimate targets of this module are the youth in the world's secondary classrooms who

must eventually cope with the causes, solutions and consequences of biodiversity problems. (At least some of the content and principles outlined in this module are appropriate for grades 7 and 8, although the primary focus is on grade levels 9 to 12.) However, the immediate target audiences for the module are curriculum developers, teacher trainers, or teachers of many disciplines (e.g., biology, earth science, social science, history, political science) who wish to teach biodiversity/environmental education to secondary level students.

The module is prepared for professional educators who already have a background in various aspects of the educational process. Therefore, while educational principles with application to biodiversity education are recommended in the module, extensive background discussion is not provided on teaching and training methods, evaluation, curriculum design, and infusion processes.

The Objectives of the Module

Teachers, curriculum designers and teacher trainers striving to provide effective educational experiences regarding worldwide biodiversity issues and problems face a difficult and critical challenge. This module presents a framework of information and models to guide these educators as they prepare educational experiences and materials. The module is designed to provide:

...background information on both the social dimensions and the ecological dimensions of the biodiversity problem;

...a curriculum framework to guide development of educational materials and experiences;

...the application of environmental education principles to biodiversity education;

...guidelines for teaching and evaluating biodiversity education; and

...recommendations for implementing this training module on biodiversity and environmental education.

Further, the module is intended to assist users of this module to become:

...knowledgeable about factors influencing human behavior regarding biodiversity issues and problems.

...knowledgeable about the range of values held by people which influence the creation and resolution of biodiversity problems.

...skilled at recognizing the structure of biodiversity issues, identifying specific needs for resolution and prescribing the appropriate roles for environmental education.

...better able to apply recommended principles of teaching and evaluation to the selection, design and/or adaptation of effective biodiversity education teaching materials.

...sufficiently knowledgeable to identify opportunities for infusion of biodiversity education into diverse education subjects.

...capable of effectively designing, adapting and/or implementing biodiversity activities into their own educational programmes.

How the Module is Organized

This module is organized into three major sections. Section 1 introduces biodiversity and relates biodiversity education to environmental education. Chapter 2 provides the groundwork on environmental education development, goals and strategies.

Section 2 presents an academic framework for understanding biodiversity problems and issues. Chapter 3 focuses on the ecology and science of biodiversity problems, while Chapter 4 presents a broader scientific, technological and sociological view of what can be done to preserve and manage biodiversity locally, regionally and globally. The nature of biodiversity issues and integration of the sociological and ecological dimensions of the issues are also discussed in Chapter 5.

Section 3 applies the above information to the task of infusing biodiversity/environmental education into our world's secondary education programmes. In Chapter 6, a framework is presented for identifying opportunities to infuse biodiversity/environmental education into various subject areas. Guidelines are discussed for evaluating environmental education efforts to infuse biodiversity into educational programmes. Chapter 7 presents specific examples of activities to illustrate how the infusion of the topic might be achieved. The activities have been selected to reflect a broad cross section of the framework presented in Chapter 6, but are not intended to be exhaustive. Chapter 8 recommends some uses of this module to develop curriculum materials and to train educators.

Limitations of the Module

This module is not intended to be an exhaustive text book on either biodiversity or environmental education. However, the authors have attempted to identify essential elements of both environmental education and biodiversity which are needed to guide curriculum developers and teacher trainers as they implement biodiversity/environmental education in their own situations. It is intended that each user of the module will continue to add to the basic information provided here. For example, curriculum developers, teacher trainers and teachers must become familiar with the political, social and ecological dimensions of biodiversity issues in their own country or region. The material provided in this module such as the activities presented in Chapter 7, serves as a model which must be adapted for use in various educational systems in the world. Case studies more familiar to the teachers (and/or students) being trained, should be substituted for those included in the module.

Nor have the authors presumed to provide the "correct" perspective regarding global biodiversity issues. The problems our world society faces regarding biodiversity are complex and value laden. Each decision to manage biodiversity involves difficult "tradeoffs". The goal of the authors is not to select and advocate certain tradeoffs for the world society, but rather to illustrate the difficult choices and processes to be faced. Certainly, our society must not ignore the long term costs to our global environment--and progeny--associated with the loss of biodiversity. However, it is also imperative that the economic and social costs of preserving--rather than developing--natural resources not be taken lightly.

Since the economic costs and benefits associated with our diminishing global biodiversity are traditionally recognized by society, the authors have placed more emphasis on the ecological consequences of the issues. To the casual reader, this may make the module appear to advocate protection of biodiversity at any cost. However, that is not the intent of the authors. The module is not a blueprint for preserving biodiversity, but is an educational process to prepare citizens to confront the difficult social and environmental questions surrounding biodiversity issues. The responsibility to make these tradeoff decisions faces every nation. It is the purpose of this module to help prepare future citizens for that responsibility.

CHAPTER 2:

Biodiversity as a Goal of Environmental Education

The Need for Environmental Education

Acid Rain
Ozone Depletion
Greenhouse Warming
Desertification
Deforestation
Toxic Contamination
Air Pollution
Ground Water Contamination
Industrial Accidents

In the early 1960's, few of the world's inhabitants had heard of any of the above terms, much less worried about their meaning and implications. By the early 1970's all of those terms were familiar features in the world's news media. By the year 2000, these terms will become household conversation in many parts of the world. And the list of terms continues to grow.

The environmental movement began in the late 1960's with the growing awareness that serious environmental problems such as these were developing on the planet. Many of the problems listed above were already manifest in parts of the world; others, such as the ozone depletion in the atmosphere or greenhouse warming, were predicted, but not yet documented. For a period during the late 70's and early 80's, most of the world appeared to be distracted from the environmental situation--perhaps in the hope that these serious problems would disappear or that they really didn't exist anyway. However, in the decade of the 90's, the environment can no longer be ignored. It has become clear that environmental problems are not just threats for some future generation to worry over, but have, in fact, arrived--some in crisis proportions.

The environmental concern of the 70's, and the renewed movement of the '90's, differed from earlier "conservation" concerns in several ways. For example, both movements advocate wise use of individual component parts of the environment such as soil or water, but the environmental movement includes a greater focus on the holistic nature of ecosystems. The environmental movement has historically been spurred by a greater sense of urgency. Environmental problems could not be viewed as just local or regional problems, but were likely to become (if not already) global conditions.

Environmental concerns have escalated over the past three decades as environmental threats and risks increased in number and intensity; eventually materializing into existing environmental crises. It has become clear that humans--like other species--must adapt to our environment or perish. As is natural, society turned to education to prepare world citizens to cope with the continuing environmental deterioration. While other species adapt to environmental changes primarily by slow genetic changes in physiological, structural or instinctive characteristics, humans prevail as the species which adapts by learning. We are capable--at least by design, if not in

practice--of tremendous adaptive changes in our behavior in the short time span of one generation. The process by which this adaptive behavior spreads among human populations is education. The educational message of the 1970's was urgent: the quality of human life--if not the existence of human life--on the planet, depended on changing human behavior through environmental education.

The Development of Environmental Education

The early roots of environmental education were in conservation education, but differed from its precursor much in the same manner that the environmental movement differed from earlier conservation activities. Environmental education focused on the protection and improvement of our total environment--biosphere, biomes, ecosystems, etc.--in addition to developing and conserving those components traditionally recognized as natural resources--soil, water, forest products, etc. Ecology became an important foundation of environmental education because ecology helped us to understand how these important ecosystems functioned and how they could be maintained. Eventually, environmental education also placed a stronger emphasis on not just making world citizens aware of problems, but of making them skilled and willing participants in environmental management. The notion that simply making citizens aware of problems is not an effective means of producing positive environmental behavior has become a key principle of environmental education.

By the early 70's, political, educational and scientific leaders of the world had begun to recognize the increasing implications of environmental problems. The concept of "environmental education" became accepted in a few countries of the world and environmental education programmes were developed. What began as a local and national movement took its first steps toward an international, global effort in environmental education when the United Nations Conference on the Human Environment was held in Stockholm in 1972. Recommendations at that conference led to the creation of the International Environmental Education Programme (IEEP) as a project of the Unesco United Nations Environmental Programme (UNEP) in 1975. Under the auspices of IEEP, global environmental education adopted a disciplinary structure and direction at the 1977 Intergovernmental Conference on Environmental Education in Tbilisi, Georgia (USSR). The Declaration and Recommendations of the Tbilisi Conference created a landmark beginning for international environmental education. The event established the nature, objectives and pedagogical principles of environmental education as well as broad guidelines for developing environmental education nationally and internationally (UNESCO-UNEP 1987). The goals, objectives and guiding principles of the Tbilisi Conference are presented here (UNESCO-UNEP 1978).

Figure 1. Goals, objectives and guiding principles of environmental education (UNESCO-UNEP 1978. p3.)

The *goals* of environmental education are:

* to foster clear awareness of, and concern about, economic, social, political and ecological interdependence in urban and rural areas;

* to provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment;

* to create new patterns of behavior of individuals, groups and society as a whole towards the environment.

The categories of environmental education *objectives* are:

Awareness: to help social groups and individuals acquire an awareness and sensitivity to the total environment and its allied problems.

Knowledge: to help social groups and individuals gain a variety of experience in, and acquire a basic understanding of, the environment and its associated problems.

Attitudes: to help social groups and individuals acquire a set of values and feelings of concern for the environment and the motivation for actively participating in environmental improvement and protection.

Skills: to help social groups and individuals acquire the skills for identifying and solving environmental problems.

Participation: to provide social groups and individuals with an opportunity to be actively involved at all levels in working toward resolution of environmental problems.

***Guiding Principles* - environmental education should:**

* consider the environment in its totality - natural and built, technological and social (economic, political, cultural-historical, moral, aesthetic);

* be a continuous lifelong process, beginning at the pre-school level and continuing through all formal and nonformal stages;

* be interdisciplinary in its approach, drawing on the specific content of each discipline in making possible a holistic and balanced perspective;

* examine major environmental issues from local, national, regional and international points of view so that students receive insights into environmental conditions in other geographical areas;

* focus on current and potential environmental situations while taking into account the historical perspective;

* promote the value and necessity of local, national and international cooperation in the prevention and solution of environmental problems;

* explicitly consider environmental aspects in plans for development and growth;

* enable learners to have a role in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences;

* relate environmental sensitivity, knowledge, problem-solving skills and values clarification to every age, but with special emphasis on environmental sensitivity to the learner's own community in early years;

* help learners discover the symptoms and fear causes of environmental problems;

* emphasize the complexity of environmental problems and thus the need to develop critical thinking and problem-solving skills;

* utilize diverse learning environments and a broad array of educational approaches to teaching/learning about and from the environment with due stress on practical activities and first-hand experience.

Formal environmental education has continued to develop since 1977. Environmental education goals have become more operational. Additional research has accumulated to suggest more effective means of achieving the desired behavioral changes through environmental education. The IEEP has continued to support environmental education programmes in curriculum development and teacher training. It provides an international communication network through the publication of "Connect", and worldwide seminars on environmental education. Over 30 publications on environmental education methods, curriculum development and teacher training (published in four languages) have been produced and distributed by IEEP. International leadership in environmental education continues to be provided by IEEP at all levels including: a programme of research, curriculum development, information dissemination, teacher training and production of audio-visual aids for environmental education (UNESCO-UNEP 1987).

Hungerford et al (1980) expanded the goals of environmental education expressed in the Tbilisi Declaration to provide an operational set of guidelines for curriculum development. These are used as a basis for a biodiversity curriculum framework in Chapter 2. The four goal levels specify that not only information about ecology and environmental issues be provided, but that environmental education prepare learners with skills to investigate, evaluate and take action on environmental problems and issues. A primary contribution of these goals is the identification of environmental action as an explicit step in the environmental problem solving process. Goal Level III describes the need to prepare students to develop effective ***solutions*** to environmental problems. Goal Level IV identifies the need for learners to become skilled at selecting and taking the ***actions*** necessary to implement these ***solutions***.

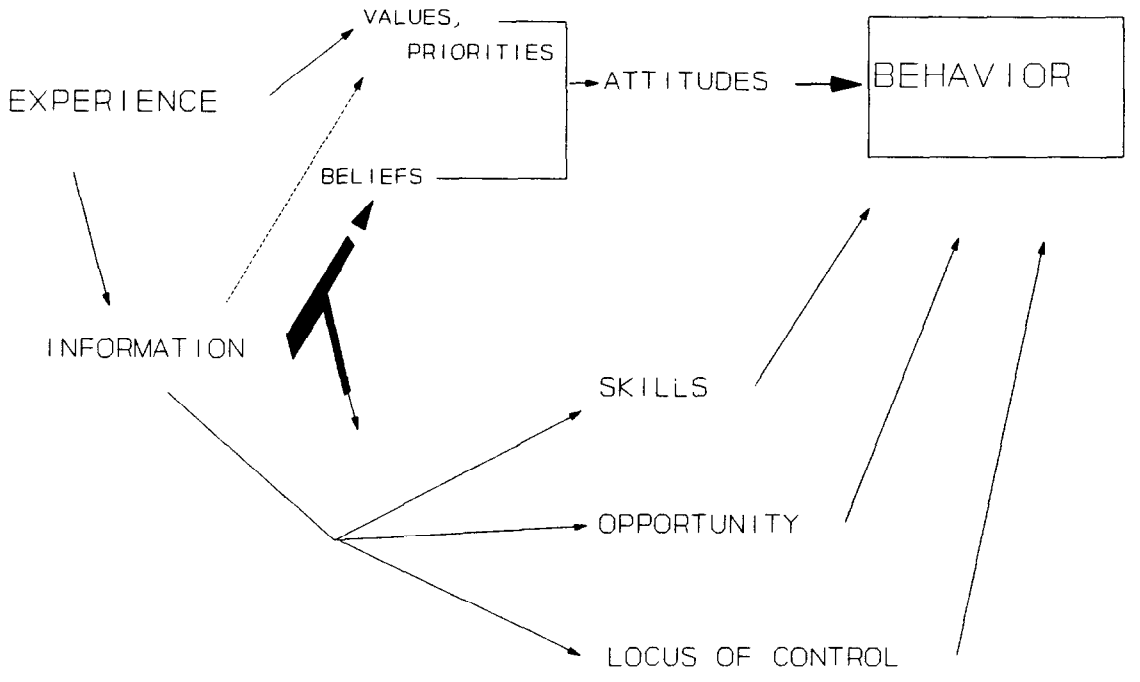
Achieving the Goal of Positive Environmental Behavior Changes

Can Environmental Education Influence Citizen Behaviors?

Regardless of how the goals are stated, the major goal of environmental education is to effectively prepare the world's citizens to be capable and willing to implement behaviors which improve and/or maintain environmental health and quality. Our understanding of the factors which support environmentally positive behaviors has grown considerably since the 1970's. For example, we understand that while information *may* influence attitudes, and attitudes are usually *precursors* of the desired behavior, behavior is influenced by many factors and may be expressed through many pathways (fig. 2). Providing information about the environment and environmental choices remains an important role of environmental education, but it is not the *only* role (Hungerford and Volk 1990).

Figure 2 illustrates the complexity of factors which may influence citizen behavior regarding environmental matters. While even more factors have and will be shown to be important influences on behavior, these serve to illustrate some major implications for environmental educators. Attitudes are really valuative *processes* which depend upon an individual identifying some affected values as well as some pertinent beliefs regarding the subject of the attitude. As indicated in the figure, information *can* influence attitudes and thus behavior, but information actually works by impacting on beliefs, and this may or may not result in attitude shifts. In this discussion, belief is being defined

Figure 2. A model of factors which influence environmental behaviors of people.



simply as what an individual perceives to be *true* about a situation[1]. A lesson learned long ago, is that new information may not even produce the desired changes in learner beliefs. The learner may reject all or some of the new information, or may distort the information to more closely fit into what is already believed, a phenomenon known as cognitive consistency. However, even if new or more accurate beliefs are created, substantial attitude shifts may not occur.

Values are standards of importance which are held by an individual. Since values can be assigned some *relative* strengths, we can speak of value priorities. For example, an individual may value both a comfortable, materialistic lifestyle and an attractive, natural environment, but place a higher priority on the former. Unfortunately, it is often difficult to place such clear priorities on our values, even when we are well informed and objective. To further complicate matters, citizens often enter into environmental issues lacking a full awareness of all their own values being affected by the issue, a clear definition of their own priorities, and/or a good information basis for predicting consequences to those values. Indeed, preparing learners to objectively and carefully undergo these difficult processes of values clarification and information gathering is a major task of environmental education. However, regardless of how thoroughly we might have explored our values and assigned priorities, humans form attitudes when they evaluate an issue and take a position using held values

[1]It is recognized that the definition used here is more narrow than that commonly found in the literature by social psychologists. However, it is useful in this discussion to define beliefs as perception of reality and therefore influenced by information and to define values as standards of importance held by an individual. Thus, values and beliefs are different constructs and may be targeted differently and separately by educators. Readers are directed to Rokeach (1968) for a more technical definition of values, beliefs and attitudes.

and salient beliefs.

For example, when confronted with the question of whether to lobby for a law to protect forests from agricultural development, an individual might identify both ecological and economic values, an array of beliefs regarding economic alternatives, the effectiveness of the proposed law, and the probable impact of the prohibited agricultural practices. Whether they formed an attitude favorable to lobbying for the law will be influenced by which value is given highest priority and an evaluation of consequences based on the salient beliefs. Even though ecological values were given highest priority, if the law was viewed as ineffective, the attitude might be negative regarding the lobbying behavior. If economic values were held more strongly than ecological values, a belief that there are existing effective economic alternatives to forest development may result in a pro-lobbying attitude anyway. Obviously, predicting attitudes based only on information provided to a learner is a risky venture.

Predicting behaviors is even more risky. Even if favorable attitudes are developed, these may not lead to the desired behavior. An individual may support the law and wish to lobby, but not know how to do so (lacks the skills), or may in fact, not be given--or recognize--the opportunity. Or the individual may lack an internal "locus of control" regarding lobbying for environmental laws. Locus of control is someone's perception of their own ability to influence the outcome of a situation. It may be that an individual who favors the environmental law, and who knows what opportunities are available and how to use them, still would not take action if he or she perceived that the outcome was not influenced by their own behavior, but was determined by some other force (chance, powerful others, God, etc.).

These and many other factors influence behaviors. Fortunately, many of these factors can be influenced by environmental education if the educational programmes are designed to do so. Based on extensive research by themselves and others, Hungerford and Volk (1990) have proposed that the following components of an educational programme are critical to influencing the many variables involved and thus effecting changes in learner behavior:

...teach environmentally-significant ecological concepts and the environmental interrelationships that exist within and between these concepts.

...provide carefully designed and indepth opportunities for learners to achieve some level of environmental sensitivity which will promote a desire to behave in appropriate ways.

...provide a curriculum that will result in an indepth knowledge of issues.

...provide a curriculum that will teach learners the skills of issue analysis and investigation as well as provide the time needed for the application of these skills.

...provide a curriculum that will teach learners the citizenship skills needed for issue resolution as well as provide the opportunity to practice the application of these skills.

...provide an instructional setting which increases learners' expectancy of reinforcement for acting

in responsible ways, i.e. attempt to develop an internal locus of control in learners. (Hungerford and Volk 1990, p.10)

Many questions remain regarding the best ways to provide the types of experiences called for by Hungerford and Volk. Even though some of these are still unanswered, we have many more effective educational tools at our disposal than we are currently using to produce active, environmentally literate citizens of the world.

Effective Strategies for Environmental Education

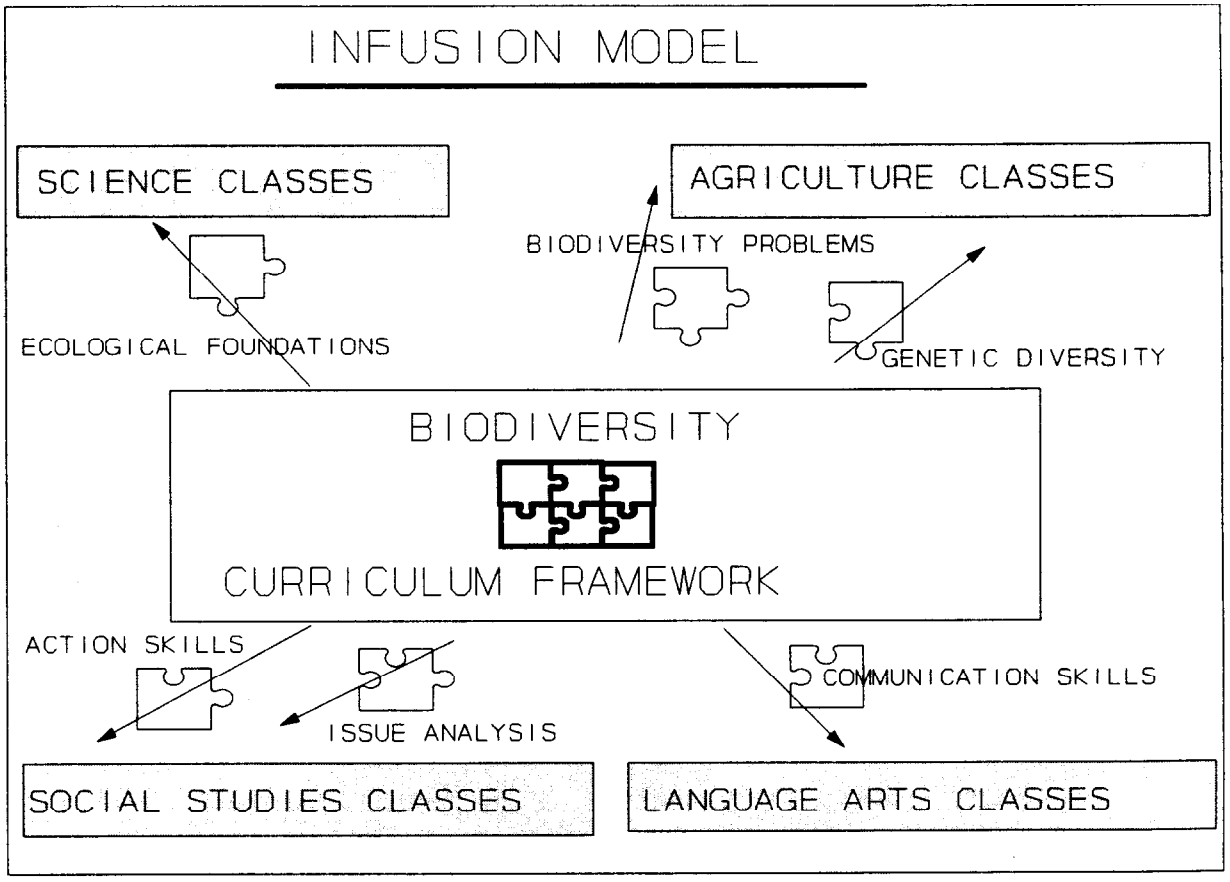
Any good educational practices will certainly enhance the outcome of environmental education efforts. However, the complex nature and challenge of achieving environmental education goals calls for some special attention to selecting effective educational strategies. The following recommendations are offered to guide teachers and curriculum developers in designing approaches to environmental education. The first recommendation is discussed in detail here. The rest are presented in more detail in Chapter 6 where they are applied directly to the development of biodiversity education programmes.

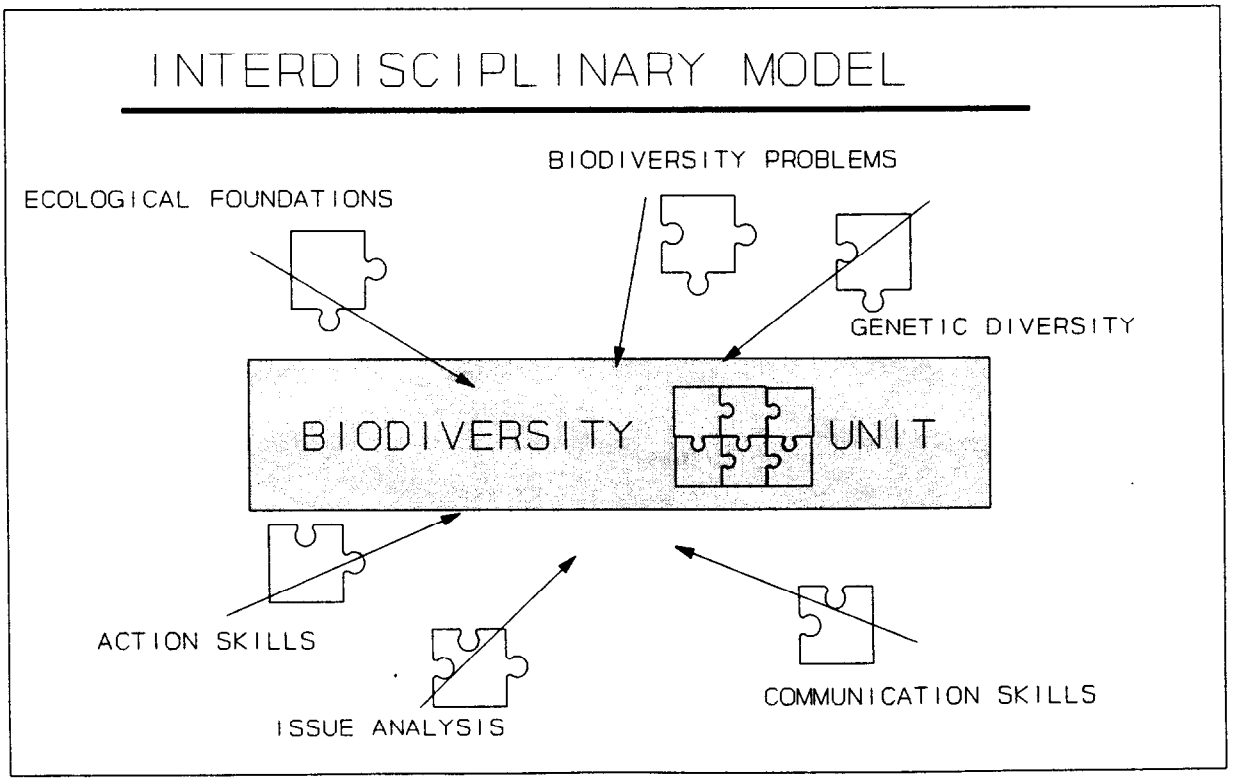
Recommendation 1: Environmental education is most effectively implemented in an infusion model.

Infusion describes a process of integrating environmental education concepts, skills and strategies throughout an existing general education curriculum. (fig. 3) This contrasts with a monodisciplinary model in which environmental education is treated in a separate course or as a comprehensive unit within a course. There are several reasons to support the infusion model. First, classroom teachers are already coping with a full curriculum with little opportunity to add new disciplines to the limited time and resources available. Infusion of environmental education would enhance existing programmes without competing for limited curriculum time and resources.

Second, as an interdiscipline, environmental education shares subject content and intellectual processes with many other disciplines. Solving environmental problems in the world will require the *integration* and *application* of science, sociology, communications, mathematics and other academic endeavors. This is effectively achieved by infusion, since it reinforces the principle that environmental criteria must apply to *all* of our decision making. We do not knowingly make decisions which would threaten our economic, health or cultural well being and we take great care to avoid such consequences of our actions. Similarly, we must carefully consider environmental consequences in all personal and social decisions. A coordinated infusion model has the potential to integrate these environmental criteria into problem solving education in other disciplines. For example, students who are studying the influences of history on their current and future world, could be exposed to the intricate relationship between culture and environment, and the role that each has in shaping the other. Infusing these ideas into the history unit strengthens the material taught and contributes to the goals of both history and environmental education.

Figure 3. A comparison of the infusion and interdisciplinary models.





The difficulty and complexity of achieving all four goal levels with learners also make the infusion model a more effective teaching strategy. By integrating environmental topics and skills throughout a curriculum, ideas and skills are reinforced, understanding and retention are enhanced, and environmental challenges can be presented to learners in less formidable, overwhelming packages. Students build towards environmental literacy as they expand their knowledge and skills throughout the secondary education programme. This develops a stronger and more stable basis for achieving all four goal levels.

While there are clear advantages to the infusion model, there are some disadvantages which must be dealt with. Perhaps the most important of these is the requirement that a larger number of classroom teachers must be trained to infuse environmental education into their own discipline, compared to the smaller number required to teach environmental education in a monodisciplinary fashion. It is not likely that environmental education components would be properly integrated and reinforced by a teacher who had not been trained.

The difficulty of teacher training may be partially related to a tendency for environmental education to be primarily infused into the science areas and not into all appropriate disciplines as is necessary for truly effective infusion (Simmons 1989). This may be due to the greater skills and affinity of science teachers for the technical aspects of environmental problems. Nonscience educators may be reluctant to deal with these technical scientific aspects for which they do not feel adequately trained, and thus, avoid potential environmental education opportunities. There may also be a shortage of curricular materials which *adequately* infuse environmental education into these nonscience disciplines. *In short, while the infusion model may be more effective when used appropriately, it may be the most difficult to accomplish.*

It must also be recognized that in a curriculum which has environmental education effectively infused throughout, the interdiscipline itself will have lost its identity. This need not pose a problem to educators or the environmental education community as long as environmental education remains identified at the curriculum level--locally, nationally and internationally. However, it is important to realize that students may need to have the environmental topics identified as a cohesive set of concerns. If environmental education goals are so subtly infused into a curriculum that learners are not aware that the various educational experiences share a common environmental problem solving theme, they may not readily transfer this learning to actual environmental problem solving. For example, an analysis of an educational programme might reveal that all components of the environmental education goal levels are being covered in various disciplines, but not in an environmental problem context. Students may be learning about values and valuing processes, issue investigation and evaluation, and issue action, but not applied to *environmental* issues. Educational psychology suggests these students may not be as capable in effectively *synthesizing* these skills and *applying* them to the resolution of environmental problems. Therefore, it is essential that an environmental context be clearly developed either by using environmental examples throughout the infusion process and/or by providing a "capstone" (i.e., culminating) experience which allows students to apply knowledge and skills specifically to *environmental* problem solving.

The following additional recommendations for environmental education strategies are applied to biodiversity and discussed in more detail in Chapter 6:

Recommendation 2: Strategies that teach the inquiry skills needed for Goal Levels III and IV, should be considered as the core of the environmental education curriculum.

Recommendation 3: Strategies which explicitly teach about the role of values and valuing processes in environmental issues must be included.

Recommendation 4: Environmental education must utilize strategies which put students into groups for problem solving.

Biodiversity as an Environmental Education Topic

There is a growing trend to break environmental education into smaller, more specific issue-oriented topics such as energy education, solid waste education, wildlife education, or, in the current situation, biodiversity education. Certainly, there would be great disadvantages in proliferating a group of separate disciplines if each discipline then created its own substantive structure and goals and competed for curriculum space and teacher use. Incorporating these as topics of environmental education, provides more efficiency and greater consistency in achieving meaningful educational goals. Environmental education provides an excellent interdisciplinary format for preparing world citizens to cope with biodiversity problems and issues.

Among the reasons for this trend is a psychological one. The task of correcting our complex and massive environmental problems can be intellectually overpowering. Simply considering the long list of critical issues and problems at the beginning of this chapter can make one feel powerless and ineffective. When confronted with such massive problems, a frequent response is to feel ineffective and fail to take action. Social psychologists recommend that large, complex social or environmental problems be broken into smaller, more solvable problems; a strategy termed "small wins". It may well be a useful strategy for environmental education to approach environmental problem solving in a similar fashion so that students can develop an internal locus of control with respect to their own participation. However, the smaller pieces of the problem should be related to one another and to the "big picture" for students.

Whatever the term used to describe educational process designed to deal with biodiversity problems, approaches to this educational effort should be guided by the comprehensive construct and the recent--but rich--pedagogy provided by environmental education. Figure 4 illustrates how environmental education goal levels can be adapted to outline a topical curriculum framework for biodiversity education. The curriculum framework in Figure 4 should be referenced frequently by users of this module since it can provide the basis for selecting content and processes for biodiversity education curriculum design and teacher training. The content of this framework is further expanded in the detailed chapters which follow.

Figure 4. An application of environmental education goals for biodiversity (based on Hungerford et al 1980). The content of this framework is expanded in later chapters of the module.

A Biodiversity Curriculum Framework of Goals, Concepts and Skills

THE SUPERORDINATE GOAL: ...to aid citizens in becoming environmentally knowledgeable and, above all, skilled and dedicated citizens who are willing to work, individually and collectively towards maintaining or enhancing biodiversity at local, regional or global levels.

GOAL LEVEL I: THE ECOLOGICAL FOUNDATIONS LEVEL

Learners should be provided with sufficient knowledge about biodiversity to make ecologically sound decisions with respect to biodiversity issues. Minimally, learners should be able to do the following...

A...define biodiversity.

Biodiversity refers to diversity of life in at least three levels:

1. **species diversity** - describes the numbers and kinds of different plants and animals locally, regionally or globally.

2. **genetic diversity** - refers to the diversity in genetic makeup that exists *within* populations or species of plants and animals.

3. **ecosystem diversity** - implies the variety of habitats, biological communities and ecosystems that make up the biosphere.

B...describe where biodiversity exists in the world.

1. Species diversity tends to decrease from the equator to the poles

2. Historically biodiversity varied widely, but it has been modified throughout history by human activity.

C...describe the status of biodiversity in their own local and regional area.

D...describe the ecological importance of biodiversity.

1. Genetic diversity within species allows species to adapt to change over time.

2. Species diversity provides the array of interactions that contribute to

ecosystem stability and complete the complex energy flow and nutrient cycles of ecosystems.

3. Ecosystem diversity governed by climates, soils, nutrient availability and land use history provides the series of ecosystem services (cleansing water, air, regulating rainfall, etc.) which maintain the biosphere.

E...describe the factors which can reduce biodiversity.

1. Biodiversity is reduced by changes in the (local/global) environment that exceed the ability of species and/or ecosystems to adapt and result in extinction of life forms locally and/or globally. Characteristics of change which cause extinction include:

a. extreme rate of change

b. critical nature of the change

c. total degree or extent of change

2. Factors which bring about rapid and/or intense changes in environmental conditions include both natural catastrophe's and human induced shifts in environmental conditions

GOAL LEVEL II: THE CONCEPTUAL AWARENESS LEVEL - BIODIVERSITY ISSUES AND VALUES

Learners should be made conceptually aware of the nature and important components of the issues associated with biodiversity management, the role of individual and collective actions in creating--and resolving--biodiversity issues, and the variety of social, economic, political and institutional factors which influence the resolution of biodiversity issues. Learners should be made aware of at least the following...

A...the current and future biodiversity issues that may exist locally, regionally, or globally.

B...the nature of biodiversity issues.

1. Stakeholders are those with an interest in the outcome of an issue. In the biodiversity issues, stakeholders actually include every citizen, but not all are participants in the issue.

2. Biodiversity issues are often associated with conflicts in values and/or beliefs held by stakeholders in the issue.

3. The adequacy of our science to provide us with understanding and technical solutions to biodiversity issues varies, but is usually inadequate to totally eliminate risk associated with alternative solutions.

4. Issues tend to develop in intensity and nature over time. For many reasons, biodiversity issues could be more effectively dealt with at earlier

rather than later stages if stakeholders would participate.

C...the nature of human responses to stressful issues

D...the range of values which impinge on biodiversity issues.

1. Important values associated with biodiversity range from "use-oriented" values to "moralistic" or ethical values.

E...the values/benefits which can be derived from protecting our (local...global) biodiversity.

F...the relationship between human cultural mores and activities (e.g. religious, economic, political, social, etc.) and biodiversity problems and issues.

G...the important role of individual behaviors in creating or resolving biodiversity problems/issues.

H...the scientific and technological means which exist for managing/protecting biodiversity resources.

I...the socio-political processes and institutions involved in managing biodiversity problems and issues.

J...the local, regional and global actions which are being implemented/planned to manage biodiversity resources.

GOAL LEVEL III: THE INVESTIGATION AND EVALUATION LEVEL

Learners should develop the knowledge and skills necessary to investigate biodiversity issues and evaluate alternative solutions for solving these issues, including at least the following...

A...the ability and willingness to monitor trends in their natural and social world and anticipate future implications for biodiversity.

B...the knowledge and skills needed to identify and investigate biodiversity issues and to synthesize the gathered information.

C...the ability to analyze the critical components of a biodiversity issue including stakeholders, status of science/technology, values and beliefs of stakeholders.

D...the ability to identify alternative solutions and to evaluate the solutions in terms of relevant information about science, stakeholder perceptions (values and beliefs), and available (political, social, economic, natural) resources for implementation of alternatives.

E...the ability to clarify their own values and priorities related to a biodiversity issue.

F...the ability to identify and tolerate alternative values and priorities held by others in biodiversity issues.

G...the ability to participate effectively in group processes to evaluate, and select effective solutions which would resolve biodiversity issues and problems.

GOAL LEVEL IV: ACTION SKILLS LEVEL - TRAINING AND APPLICATION

Learners should develop the knowledge and skills necessary to take positive actions to implement solutions to biodiversity problems and issues, including the following...

A...the ability to participate effectively in group processes to evaluate, select and take effective actions which would implement selected solutions to biodiversity issues and problems.

B...the ability to identify, evaluate and select actions which would implement effective solutions to biodiversity problems/issues.

C...the ability to effectively implement selected actions regarding biodiversity problem solutions.

CHAPTER 3: The Nature of Biodiversity Problems

It may help to understand the nature of the biodiversity problem by considering a similar situation involving a group of fishermen who live and fish on a large lake. None of the fishermen own the lake nor the fish in it; the fish and the lake are shared by all. Since the fish are used by the fishermen, we can think of the fish as *resources*. For generations, all of the fishermen have caught only as many fish as they need for their own family to eat, and the fish resource has provided well, even though the fish resource in the lake is limited. The lake fishery would not support many more families at the current rate of use.

Now a neighboring village has offered to buy fish, and one of the fishermen decides to catch enough to feed his family plus extra fish to sell to the new market. This fisherman increases his catch with no apparent effects on his neighbors. But soon another fisherman decides to follow the lead of the first and he also begins to catch extra fish for the market. Soon, all of the fishermen are increasing their catch to sell on the market.

Since the fishery is unable to sustain this rate of catch, the number of fish decline and the only way the fishermen can maintain their catch rate is to build more boats, use larger nets and find other ways to catch a larger percentage of the fish in the lake. The end of the story is easily predicted. The fish resource will be seriously impaired or destroyed.

Similar events have happened many times in our history--although not always with fish. In these cases, the resources are known by economists as a ***common property resource***; that is, they are used by everyone, but no one user owns them. The use of a common property resource--or ***commons***--is unregulated. It appears to be a frequent trait of humans when dealing with a commons, to consider it an unlimited resource and to use it as they see fit, without regard for conservation. After all, if one individual or group doesn't use it, another will, and so the trend is for each to get as much as they can. The end result is that the resource is soon depleted. In the 1960's this became known as *"the tragedy of the commons"* (Hardin 1968). While common property resources do not always suffer the tragedy of the commons, most do. The principles illustrated by the phenomenon have grave implications for the diversity of life on planet earth.

We can attempt to avoid the tragedy of the commons in several ways. One is to convert the resource to private property. In their own best interest, the owner should conserve the resource and provide for its continued existence, although the owner does not always see the long term value and behave this way. In our earlier hypothetical example, one of the fishers might have become rich enough to buy the lake and control all of the fishing on it. This might protect the fish resource, but would have obvious negative impacts on the other fishers in the village and the neighboring village.

A second means of avoiding the overuse of a resource is through regulation by some authority which can enforce the rules of use and allocate the resource to the users. In our example, a fishery management agency might be appointed by the government to regulate the harvest of the fishers and see to it that the fish resource was not overexploited. But how would the fish resource be

allocated to the fishers? Would everyone get the same amount of fish, even though some were capable of catching more and some less? How would new families enter the fishing fleet? It is difficult for a regulatory agency to provide for the well being of both the resource and the users. However, in those cases where the regulatory agency allocates fairly, enforces the rules, and manages the resource to provide for its continued existence, the tragedy of the commons is avoided.

Another way to avoid over exploitation is for the resource users to voluntarily regulate themselves. This requires that a fair way of dividing up resource use can be found and that everyone is willing to stick to the rules of use. The fishermen on the lake might be able to cooperatively manage their fish resource as long as everyone trusted the agreement and complied with the rules. Human nature and differences in needs and values makes this difficult to achieve, however.

The principle of the tragedy of the commons applies to biodiversity because biodiversity is a collective asset even though in geographic terms it belongs to one nation of the world. Everyone on the planet has a stake in the continued well being of global biodiversity, that is, everyone is a user of this resource. Yet, humans have only recently begun to recognize biodiversity as a valuable resource, and many are still not even aware of its existence and importance. This compounds the problem. It is clear that the fish stocks beyond national waters or the atmosphere that envelopes our planet are common property resources. Everyone knows how they are used and why they are important. Most nations recognize the consequences if every country dumps its pollutants into the atmosphere to be carried "away". But biodiversity is not as easily conceptualized and its use is less direct than fish or air. Though no less important than air to our survival, it may be more difficult to get the world to appreciate the critical nature of biodiversity. Further, even when they acknowledge its existence and importance, individuals, governments and nations may fail to recognize how their actions impact on biodiversity.

How will the world avoid a tragedy of the biodiversity commons? At the global level, each nation must have sovereign rights over their own biological resources. No global authority exists to act as a regulator and enforcer of nations. With the existing political, economic and social arrangement of the planet, it is not likely that such an authority will be accepted soon, if at all. Nor is it possible to assign global biodiversity to private ownership. Although some successful efforts have set aside local areas of threatened habitat (e.g., rain forests) through private ownership, these actions are not without important social and political implications. Many developing countries feel this is concomitant to selling their sovereign rights to those who have the money to buy (e.g. outsiders from North America and Europe).

Obviously, the final option is a voluntary self-regulation of nations and governments. But achieving international self-regulation will not be easy. Many difficult questions exist regarding fair allocation of the planet's biodiversity resource. Developed countries have gained their current quality of life at the expense of their natural resources and biodiversity and in most cases at the expense of the biodiversity of developing countries as well. Should those countries which have not yet developed their resources and biodiversity be prevented from doing so even though it impairs their short term economic development? How should the cost of preserving biodiversity for the globe be shared?

The global biodiversity commons is impacted by the collective actions of individuals, groups, and governments within nations as well as among nations. Collectively, local use and clearing of forests, damming of rivers, use of chemicals and other activities represent a substantial threat to biodiversity. Should individuals or groups within nations be asked to forego short term economic development to preserve biodiversity for the long term benefits of the global population? These are tough questions, but even if we had answers, implementation would be another matter. Existing institutions and governments of nations could potentially appoint regulatory agencies within their boundaries, but these can only be successful if citizens support and comply with the regulatory and allocation efforts.

In fact, *if efforts to conserve our biodiversity--local, regional, national and/or international--are to be successful, they must have the support of the citizens of the world.* Individuals must be educated to recognize the long term values of biodiversity for survival. They must learn alternative ways of using the environment which will allow them to survive with an acceptable quality of life. Decision-makers at all levels must be aware of the need and capable of finding management alternatives to implement sound conservation measures. The complexity of the biodiversity problem requires that not only the scientists in many disciplines find answers, but that our global society finds means to implement those answers. ***Clearly, if the planet is to avoid a tragedy of the biodiversity commons, education must be successful.***

What is biodiversity?

Biological diversity is examined here in the broadest ecological terms. The term biodiversity refers to the full abundance or variety of life -- plant, animal and microbial. This variety of life occurs at all levels of ecological organization, but biodiversity generally refers to genetic, species, and ecosystem diversity. This is the diversity of life upon which the health of the environment depends. The diversity of life is extremely valuable for reasons we will discuss later. Genetic, species and ecosystem diversity are convenient terms, but because the universe is a continuum, some practical difficulties exist in precisely defining each of them.

All life on earth can be organized into a hierarchy from the simple to the complex (fig. 5). Sub-atomic particles are organized into atoms that in turn combine to form molecules. Molecules combine to ultimately form organisms. Groups of individual organisms form populations; populations make up a species. Species interact to form communities. These communities involve abiotic factors -- soil, moisture, nutrients, etc. -- to form more complicated ecological units called ecosystems. Similar, but geographically separated ecosystems are termed biomes. Ultimately, these biomes form the living system of the planet -- the biosphere. While it is useful to identify various levels of this hierarchy, the labels do not always fit.

For example, the concept of species is meant to convey that some organisms have a common evolutionary history and are capable of interbreeding. This means they are more closely related ancestrally to other members of the same group (species) than they are with other organisms (species). There should also be more physical, chemical and behavioral similarities among members of the same species. In effect, because they cannot sexually reproduce with other types of organisms (species), a species is reproductively isolated, and its integrity as a species is maintained.

However, even within a geographically distinct population of one species, there is much variation in physical, chemical and behavioral characteristics. Consider the variations among people. Some of

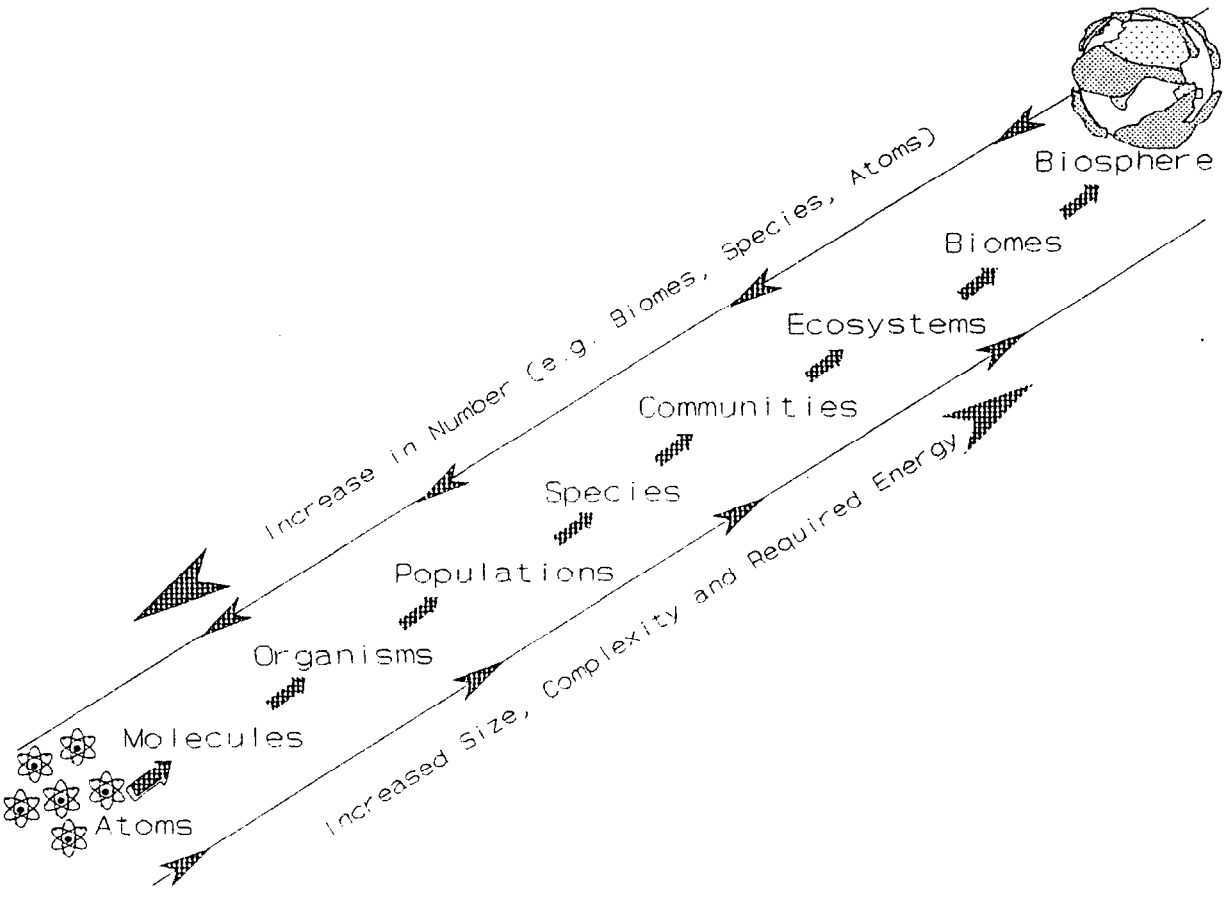


Figure 5. Life is organized into a continuum of levels.

these variations are so pronounced, that we refer to "races" of the human species. Similarly, we sometimes must use a "subspecies" category to emphasize differences between two geographically distinct populations of the same species. Science is constantly faced with the question of "how similar must two organisms or populations be, in order to constitute the same species? But it is precisely this variation among members of a species which makes genetic and species diversity so valuable, as we shall see.

Other difficulties in applying the term "species" exist. For example, reproductive isolation cannot be applied to organisms that only reproduce asexually. These latter species must be defined using other criteria. Similar difficulties exist in precisely defining ecological communities and ecosystems. However, it is not necessary to concern ourselves with the technical problems of the species and ecosystem concepts. The problem of biological diversity will be challenge enough.

Genetic Diversity

As we have stated, genetic diversity is the variation in the genetic composition of individuals within a species. Genes are the fundamental units of heredity that determine an individual's characteristics that are passed on from parents to offspring, such as fur color in lions or leaf shape in acacia trees. The set of genes possessed by an individual organism is called its genotype. Each individual is usually slightly different in some character from all other members of its species, because each individual (except twins, clones, etc.) has a unique genotype. For example, human beings have 2 eyes, so there is little or no variation in the gene(s) for number of eyes. However, eye color in humans can be quite variable -- from dark brown or almost black to light blue or almost clear. So humans have a great deal of genetic diversity for eye color. The different forms of the same gene are called **alleles**. So there are **multiple alleles** for eye color in humans.

As a general rule, large populations have greater genetic diversity than small populations. Likewise, species that are composed of many populations usually have more genetic diversity than do species restricted to one or few populations. While we are rapidly developing techniques required to monitor the amount of genetic variability in a population or species, we still lack the resources to characterize the genotype of single individuals. For this reason, genetic diversity is usually compared between populations by characterizing the amount of **heterozygosity** within each population. Heterozygosity is measured by examining specific traits (usually enzymes) to determine if there are multiple alleles present in the population for that trait. If all of the individuals in a population show the same genetic pattern for a particular trait than the population is said to be **homozygous** for that trait. If more than one genetic pattern is evident for a particular trait, the population is heterozygous for that trait. Genetic diversity increases with increased heterozygosity.

Species Diversity

At the most basic level, **species diversity** can be defined as simply the number of species within a particular geographic area. However, there are some problems with this simple definition. While diversity does increase as the number of species present increases, species diversity is also a function of the size of the represented populations. More diverse ecosystems have many species with equal population sizes. Another ecosystem having the same number of species, but having a few species with large populations and the rest with very small populations would be less diverse.

It is assumed that all species play important roles in the structure and function of ecosystems (although humans have yet to identify the roles for most species). However, our attention is usually given to highly visible birds and mammals (**mega-vertebrates**) when we focus on biodiversity problems. Biologists have described about 43,900 different vertebrate species. Of these only 13,000 are birds and mammals. *In contrast, 990,000 species of invertebrates have been identified.* Most taxonomists agree that very few vertebrate species are left to be discovered and described, but that the vast majority of invertebrate species have yet to be discovered. Although outnumbered, the role of the vertebrates should not be underestimated. For example, it is estimated that 94% of rain forest trees depend on fruit-eating vertebrates for seed dispersal.

The animals only make up one component of the species diversity in an ecosystem. Other types of organisms make up significant but often overlooked components of ecosystem diversity. Almost 250,000 different species of plants have been described. There are 31,000 species of protozoans (single-celled organisms) and about 74,000 species of fungi and algae. Bacteria and blue-green algae make up almost 4,800 species and there are over 1000 species of viruses. As with the invertebrates, more species of these groups have yet to be described than have been described.

Many of the less visible organisms may be as important as the mega-vertebrates in the functioning of ecosystems. For example, each hectare of the Brazilian Amazon contains a few dozen birds and mammals but in excess of one billion invertebrates. Each hectare is estimated to produce about 200 kilograms of animal tissue of which 186 kilograms (93%) consists of invertebrates (Wilson 1987). Ants and termites alone make up 1/3 of this biomass and play a critical role in recycling nutrients by breaking down plant material.

Ecosystem Diversity

Ecosystems have both biotic and abiotic components (e.g., sunlight, rainfall, soil type, pH). Since they are systems, they are comprised of both structure and functional relationships. The structure is provided by the actual living organisms (e.g., species of grasses and herbivores) that are present. The functional relationships revolve around the pathways by which energy and nutrients move through the ecosystem. Plants which use sunlight to produce carbohydrates are eaten by herbivores which in turn are eaten by carnivores.

Ecosystem diversity may be defined as the abundance and variety of ecosystems in a particular area. This area is often referred to as a **landscape**, although landscape is slightly misleading because there are aquatic (freshwater and marine) ecosystems. While the concept of an ecosystem is easy to envision, it may be difficult to identify where one ecosystem ends and another begins. For example, a marsh, lake and the lake's watershed can each be thought of as an ecosystem, but the marsh ecosystem is part of the lake and the lake in turn is part of the watershed. Although the physical boundaries of a landscape and any particular ecosystem are usually arbitrarily defined by the specific scientific or policy questions being addressed, the areas where these distinctive ecosystems overlap constitute important ecological areas known as ecotones. Typically, an ecotone contains a diversity of species because they contain representatives from each adjacent ecosystem as well as species which are distinctive to that ecotone.

In addition to the diversity of ecosystems found within a landscape, there is diversity in the ecosystems that make up a biome. Tropical rain forests are the most diverse terrestrial ecosystems, but really represent not one but a variety of ecosystems. In Costa Rica, the lowland forest along the Caribbean coast differs greatly from the cloud forest found at the continental divide, though both can be classified as rain forest. Also, rain forests are not restricted to the tropics. The northwestern United States has a rain forest ecosystem that is structurally distinct from those found anywhere in the tropics. Coral reefs are the most diverse aquatic biome and may even support a greater diversity of species than do tropical rain forests. The Great Barrier Reef can be partitioned into a number of smaller reef systems, each one a distinct ecosystem. The coral reefs of the Indo-West-Pacific region

support at least 3000 species of fish (16% of the total estimated number of marine and freshwater fish) and are more diverse than those found near Hawaii or the Bahamas.

What is the distribution of biodiversity in space and time?

Geographic scale

Biodiversity can be examined on increasingly larger geographic areas, from a drop of water to the entire planet. For example, although genetic diversity is examined at the population level, it is theoretically possible (though a practical impossibility) to compare the genotypes of all of the individuals in a family group (e.g., a pride of lions). Genetic diversity may be assessed in a geographically restricted population or in one spread over a large area. For example, the orangutans are found only on two islands in Indonesia, but reindeer (called caribou in North America) are found throughout the far northern portions of North America, Europe, and Asia.

When examining ecosystems, landscapes could be defined on a very local level or perhaps on a continent-wide level. On a local level, the landscape my contain only one or a few ecosystems. For example, the small collection of hills that is the watershed for the stream that supplies a village with water may be viewed as an ecosystem. To ensure a constant supply of clean water, the diversity of structural and functional relationships within this landscape is of interest. On a continent-wide level, the diversity of different ecosystems would be of interest. There may be deserts, savannahs, rain forests, thorn forests, and agricultural areas.

One of the fundamental problems associated with scale is that while science can often provide information about a scale which has been defined, science can only rarely define what scale is appropriate. For example, suppose a farmer clears the trees and plants a row crop on 5 hectares in a 10,000 hectare forest. Science can assess the loss of biodiversity (probably genetic and species diversity) of those 5 hectares. It can also show that the diversity of the remaining forest has only been minimally reduced. The question is, what scale of biodiversity is most important? How much loss of diversity should we be concerned with? These are policy questions and involve value trade-offs which concern the citizens of every nation.

Distribution in space

Species and ecosystems are not uniformly distributed on either the land or in the seas, although some patterns exist. Ecologists have found that the diversity of species increases from the poles to the equator. Diversity also tends to decline with decreasing rainfall and increasing elevation. Islands usually have fewer species than the mainland (McNeely 1988). A single 50 hectare plot in the Malaysian rain forest contained 835 species of trees. A similar sized area of temperate forest would

contain about 2 dozen species of trees (Durning 1989). Another way to examine the difference between temperate and tropical areas is to compare the entire country of Denmark with 1 hectare of rain forest in Malaysia. All of Denmark does not have even twice the number of tree species found in the single hectare in Malaysia (Reid and Miller 1989). A similar latitudinal gradient is also found for organisms other than trees. Freshwater insects are 3 to 6 times more diverse in the tropics than in temperate areas. About 80 mammal species per 10,000 Km^2 are estimated to exist in the tropics but only about 40 in a similar sized temperate area. The diversity of corals in Australia's Great Barrier reef increases five-fold from the southern (temperate) end to the northern (tropical) end (Reid and Miller 1989).

Tropical rain forests, which blanket much of the lowland tropics, cover about 7% of the earth's surface, but may contain half of all the species on earth (Durning 1989). Fifteen tropical rain forest "**hotspots**" have been identified (fig. 6). The term "hotspot" is used to describe areas of high species diversity. They account for only about 12% of the remaining tropical rain forest, but may contain from 1/3 to 1/2 of all of the world's plant species (Wolf 1991). The 15 hotspots include (1) the tropical Andes, (2) the Atlantic forests of Brazil, (3) Madagascar, (4) Indonesia, (5) the Philippines, (6) lowland forests along the Caribbean coast of Central America, (7) highland forests along the Pacific coast of Central America, (8) the Upper Guinean forests, (9) the eastern Arc Mountains of Tanzania, (10) western Ghats, India, (11) the Sinharaja Forest of Sri Lanka, (12) the eastern Himalayas, (13) peninsular Malaysia, (14) northern Borneo, and (15) Melanesia (Wolf 1991).

One theory for the high level of diversity in the tropics, particularly the lowland tropics, is that it has been created not only by current, but by historic climatic conditions. During its history, the earth's climate has changed drastically a number of times; warm periods alternated with cold periods (Ice Ages). During the last glacial period, tropical rain forests contracted to form small "islands" surrounded by dry savannahs. Over time the populations in each island became genetically and physically distinct from populations in other islands (Wolf 1991). That is, new species evolved in the rain forest islands. When the glacial period ended, the tropics became warmer and wetter and the rain forests spread. As they spread the newly distinct species dispersed with them, resulting in high levels of diversity throughout most of the tropics. The earth is still in a warm period and the tropics remain warm and wet and the high levels of diversity have been preserved.

The local geography of an area also controls the level of diversity. For example, even in the tropics, it is too cold and dry near the tops of tall Andean peaks to support anything but a tundra ecosystem. The dry rain shadows created by tropical mountains will support grass savannahs but not rain forests.

Not all of the most highly diverse ecosystems are found in the tropics. Mangroves and estuaries, for example, tend to have high levels of species diversity and are also found in temperate regions. These ecosystems are not warm, do not necessarily receive a great deal of rain, and do not receive 12 hours of sunlight a day all year round as the tropics do. So why are they so rich in species? Mangroves and estuaries are ecosystems that link terrestrial, freshwater, and marine systems and as such tend to be repositories of nutrients. The high levels of nutrients allow them to support large numbers of diverse organisms.

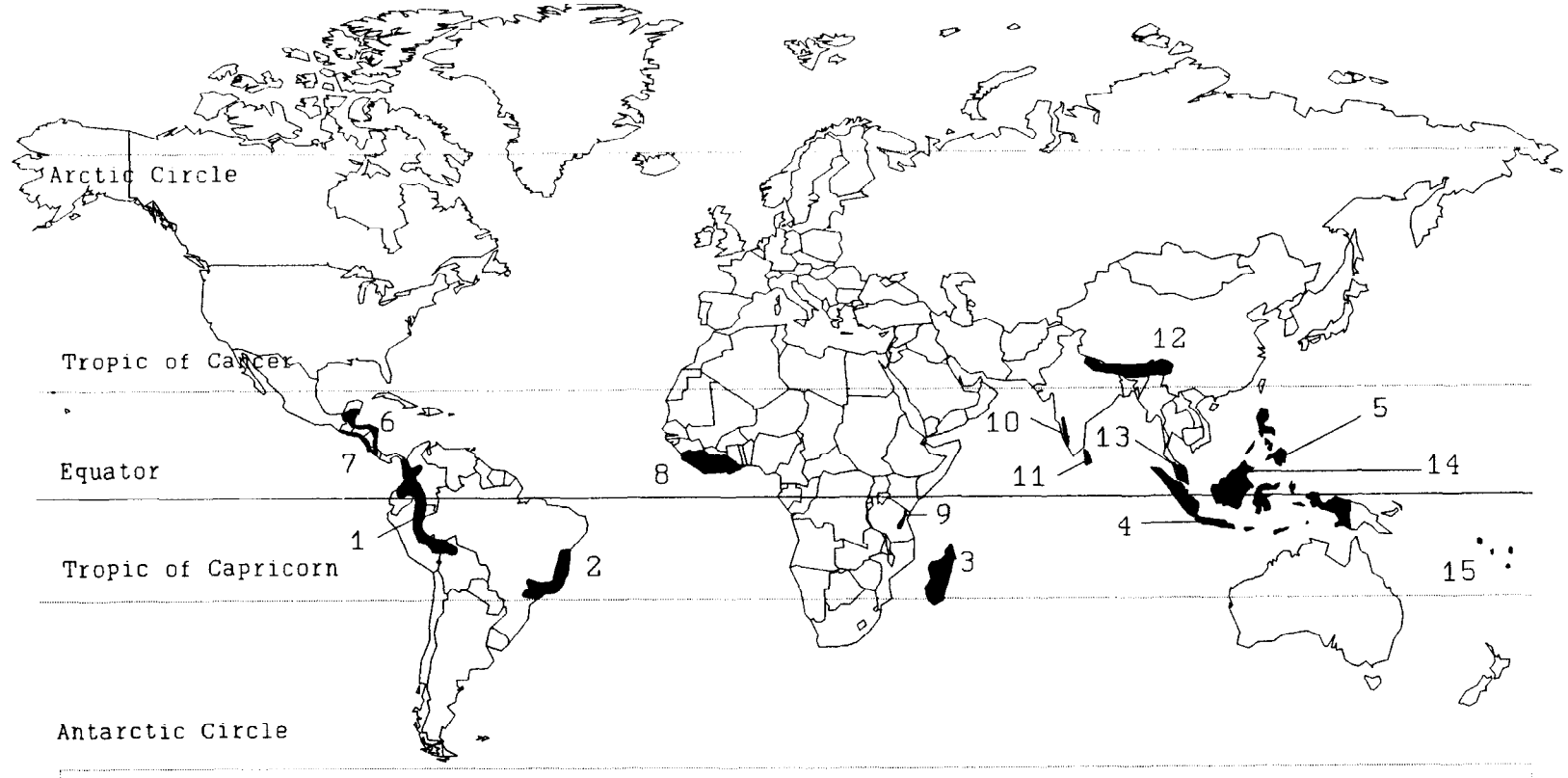
The diversity of ecosystems in an area is more difficult to document and consistent latitudinal trends are not as clear as they are for species diversity. For example, temperate areas may have more terrestrial ecosystems (depending upon how an ecosystem is defined) than tropical areas simply because there is more land mass in the temperate zone. Further, our classification of ecosystems and their long term land use history often obscures the true ecological variability among these systems. For example, even though desert ecosystems are found in North and South America, Asia, Africa, and Australia, each desert represents a distinct ecosystem. In the southwestern United States at least 3 desert ecosystems can be identified. The Mojave, Sonoran and Chihuahuan deserts are each unique ecosystems.

Distribution in time

The structure -- i.e. the diversity -- of any ecosystem changes over time due to processes which occur within ecosystems. Succession is a progressive, and often predictable change in ecosystem structure over time. For example, if part of a forest ecosystem was destroyed by fire, over time that area would change from one type of community to another and may eventually again become a forest similar to the original. As succession progresses, species diversity generally increases in the early stages. In a temperate region, the diversity would increase, then decrease in the later stages as the forest canopy closes and a few individual species become dominant (Barbour et al 1980). Therefore, in the temperate region, perturbations such as fire or wind, which set back succession to earlier stages can maintain maximum species diversity (Loucks 1970). The rate at which succession progresses to the later stages and thus how species diversity changes over time is dependent on the rate at which propagules arrive and the frequency of disturbances.

Global species diversity has also been constantly changing. Evolution of new species and extinction of existing species are natural processes which have occurred for approximately 4 billion years. The distressing point, however, is the rate at which species have become extinct in recent years. During the past 600 million years one species has gone extinct every year or so (Raup and Sepkoski 1984). In recent years, however, this rate has increased thousands of times higher (Ehrlich and Ehrlich 1981). Factors that have affected historical extinction patterns have included climate change, barriers to colonization, natural climatic disasters, human developments, and land use practices. For example, humans have destroyed forests for agricultural land and timber products, resulting in loss of habitat and associated species in these ecosystems. Native bird species have become extinct in New Zealand due to the introduction of predators by humans (King 1984).

Figure 6. The location of tropical rain forest "hotspots" in the world.



1. Tropical Andes
2. Atlantic forests of Brazil
3. Madagascar
4. Indonesia
5. Philippines
6. Middle American Lowland forests
7. Middle American Highland forests
8. Upper Guinean forests
9. Eastern Arc Mountains, Tanzania
10. Western Ghats, India
11. Sinharaja Forest, Sri Lanka
12. Eastern Himalayas
13. Peninsular Malaysia
14. Northern Borneo
15. Melanesia

(see Wolf 1991)

Why is biodiversity important?

Biodiversity is important because it produces benefits which humans value. Many of those benefits are associated with the ecological functions of biodiversity in maintaining viable populations and ecosystems. The human species has been slow in acknowledging it, but the quality and very existence of our own lives does depend on the continuing functions of our planet's ecosystems. Biodiversity is not just important--it is a critical component of our environment. It is probable that not all species perform equally important functions in the ecosystem. However, every species has some role, and some are indispensable. Since our ecological science has not yet identified the relative importance of all species, it is imperative that we act conservatively to maintain the highest level of diversity possible. In this section, we will consider several examples which illustrate the critical nature of biodiversity in our current ecosystems.

We also derive important benefits from biodiversity beyond those associated with ecological functions. These additional benefits are the result of the many uses we find for biodiversity. Because we have biodiversity on this planet, we have a source of medicines and drugs, alternative foods, energy, building supplies and many other means of supporting ourselves economically. Many of these sources have not yet been utilized to their full potential. The loss of these resources would affect our quality of life and, in some cases, human survival. These non-ecological benefits are also illustrated in this section.

A cautionary note is needed here. When discussing biodiversity and its importance, there is a tendency to dwell heavily on the tropical rain forests. This is in many ways logical and to some degree appropriate. Tropical rain forests are the most diverse terrestrial ecosystems. They are also the most threatened. However, the conservation of biodiversity in less species-rich ecosystems is equally critical (Reid and Miller 1989). These ecosystems provide the resources required by the local people for survival. The various foods, medicines and industrial products used by humans have come from virtually every ecosystem from every corner of the earth.

Ecological importance of biodiversity

Stability of ecosystem functions and processes

Think of an ecosystem as an extensive web with many interconnecting strands. The strands represent functional relationships between species in the ecosystem. The more species, the more strands in the web. It is easy to see that in a complex web with many strands, the removal of one strand would have little effect on the web. Several strands might be removed and the complex web may still function and hold together, although some strands might be more important structurally than others. In contrast a very simple web may fall apart if only one strand were destroyed. In our analogy, removing a web represents an environmental change that causes the extinction of a species. The collapse of the web, reflects the failure of the ecosystem to function when critical relationships are destroyed. The webs represent a simple ecosystem with less species diversity (e.g., a temperate forest) and a complex, diverse ecosystem (e.g., tropical rain forest).

Generally, this describes the theoretical relationship between species diversity and ecosystem stability. The more species diversity in an ecosystem, the more resistant to environmental changes it appears to be. However, this relationship is controversial among scientists. Ecologists have argued whether diversity brings about stability or whether stability of an environment (e.g. rainfall, temperature) which is constant may allow the establishment of large numbers of different species, suggesting that stability brings about diversity (Lewin 1986). Other work has indicated that the more diverse the substrata or the climate, or episodic events such as fire, the more diverse the ecosystem: in other words, it appears that diversity begets diversity. Regardless of the exact relationship, species diversity is certainly a critical element in maintaining the complicated and often dynamic processes in ecosystems.

Genetic diversity

The amount of genetic diversity in a population is directly related to that population's ability to adapt to environmental changes. Populations (and species) that exhibit higher levels of heterozygosity have a higher probability of surviving changes than do populations that tend to be more homozygous. The offspring born into a homozygous population will tend to be adapted to the old environmental conditions. In a changing environment, with each succeeding generation, fewer and fewer offspring would be expected to survive to reproductive age. However, some of the offspring in a heterozygous population may, by chance, be adapted to the new environmental conditions. These individuals will survive to produce offspring, some of which will in turn be adapted to the new environment. Over time, populations may become so different genetically, that they represent new species. Even so, the ecosystem functions are maintained and the benefits of genetic diversity are realized.

An example that illustrates the ramifications of limited genetic diversity in a population is the golden toad. Golden toads were restricted to a small area in the Monteverde Cloud Forest Reserve in the Tilaran Mountains of Costa Rica. In 1987 more than a thousand golden toads were observed mating and laying eggs along the streams in the reserve. They are now feared to be extinct. This was a small, geographically restricted species which lacked the genetic diversity to adapt to a major climatic shift. Extinction was caused in this case not by direct human encroachment, but apparently because the species lacked the necessary genetic diversity to adapt to a 1987 drought associated with a southern oscillation of the oceanic current El Nino (Pounds 1991).

Species interactions

Scientists have not yet explored the vast majority of ecological relationships among living things. However, everywhere we look there are examples of the importance of species interactions in maintaining species diversity. The relationship between species interactions and the diversity of species is illustrated by the interactions between grasses and ungulate species in the Serengeti ecosystem (Bell 1971).

In northern Tanzania, zebras, wildebeest, and Thompson's gazelles migrate in succession

(zebras first, Thompson's gazelle last). These migrations, in turn, are synchronized with the availability of long and short grasses. The species of grazers are specialists. Zebras migrate first and feed on the coarse, longer grasses which compete with the shorter grass species. This allows the shorter grasses to grow more abundantly. The shorter grass species are preferred by the wildebeest and the Thompson's gazelles migrating later. In this case, a reduction in the zebra population may lead to a decline in the wildebeest and Thompson's gazelle population (Bell 1971). If their numbers were reduced, zebras would not adequately remove the coarser, longer vegetation, and the shorter grasses eaten by the wildebeest and gazelle would not be plentiful enough to maintain their populations.

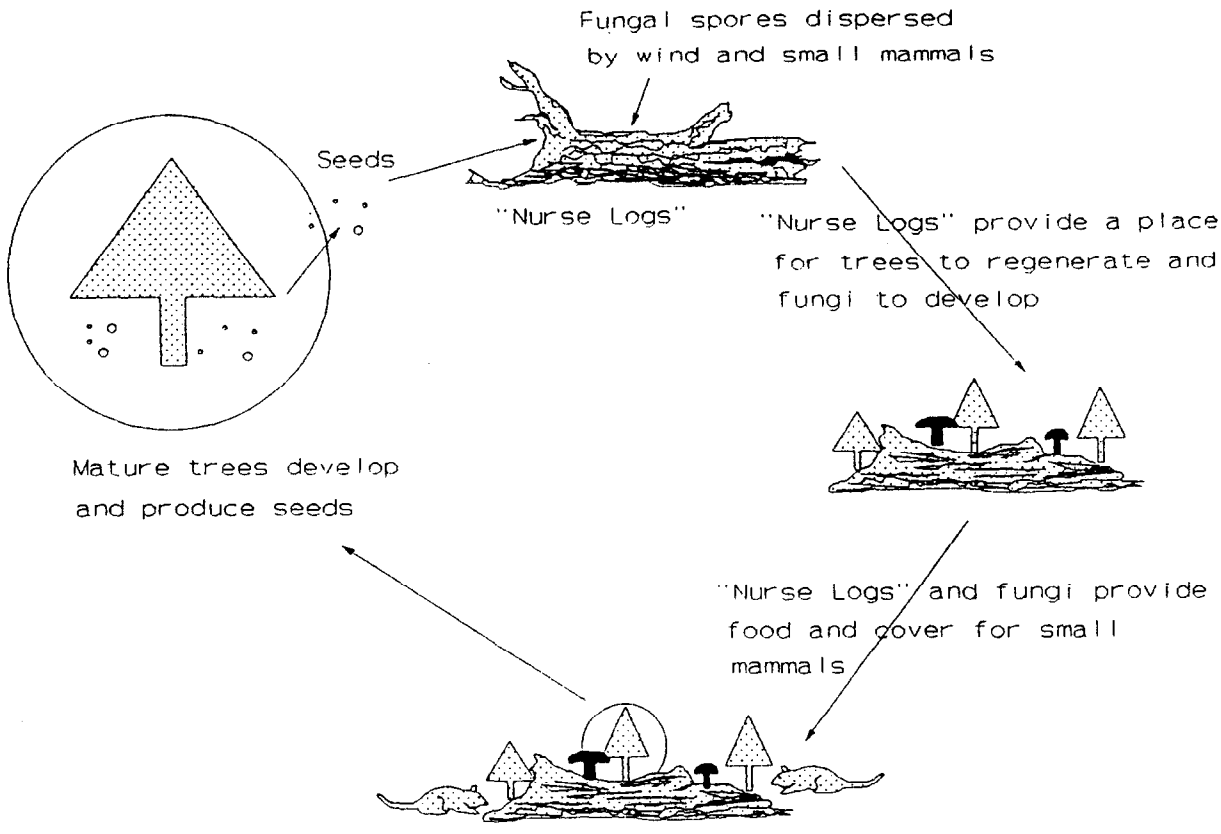
The interactions of 3 plant species and a species of red ant provides another example of how species interactions are dependent on species diversity -- and provides a unique benefit to humans. In the Amazon, the Kayapo Indians cultivate manioc (a root), beans and corn for food. Manioc secrets a nectar. Red ants attracted to the nectar chew through bean vines that would otherwise trap the manioc stems. The surviving bean vines climb the taller the corn stalks, which can easily support them. The beans add nitrogen to the soil, which is used by the corn. Thus, because of the action of the ants 3 crops can be grown successfully in the same area (Durning 1989).

Nutrient cycling

Nutrient cycling is an ecosystem process on which all species ultimately depend. Nutrients such as nitrogen and other fertilizers must be recycled within an ecosystem or they may be leached from the soil and lost from the system. Species in ecosystems have formed complex means of keeping nutrients available to the entire system. The process and species diversity are interdependent.

Old-growth Douglas fir stands in the Pacific Northwest of the U.S.A. exhibit a significant relationship among "nurse logs", fungi, and small mammals (Maser et al. 1978) that demonstrates the importance of biodiversity in nutrient cycling (fig. 7). "Nurse logs" are decomposing logs which provide an excellent bed for seeds to germinate and for small trees to develop (Hunter 1990). Nurse logs also provide an environment for particular types of fungi to develop. As the fungi develops it may physically penetrate the small roots of young trees. The fungi can provide nutrients (fertilizer) from decomposing matter; the young tree provides the fungus with energy from carbohydrates which are formed during the process of photosynthesis. Both species benefit and the nutrients are returned directly to growing trees rather than escaping to the soil and being dissolved away into the ground water. The fungi produce toadstools and mushrooms (e.g., truffles) which are the reproductive stages of the fungi that produce spores. These are eaten by voles, chipmunks, and squirrels. The fungi spores are eventually dispersed through small mammal feces. Nurse logs, therefore, not only provide a substrate for fungi and trees to develop but act as a food source for small mammals and supply nutrients which are returned to the system as the log decomposes. Removal of one of these components could greatly affect the existence of the other two. In tropical rain forests, even more complex relationships have been observed which maintain a recycling of nutrients within the ecosystem. Loss of certain critical species in the cycle can disrupt the flow of nutrients and cause a further decline in species diversity.

Figure 7. Species interactions in an old-growth Douglas Fir forest of northwestern North America.



Stabilization of Climate

Living organisms, and therefore ecosystem processes are capable of modifying their environment. These modifications create and maintain conditions favorable for life. For example, large tracts of undisturbed forest may help maintain the rainfall in the immediate vicinity of the forest. The forest recycles water vapor at a constant rate and the canopy structure promotes atmospheric turbulence (McNeely 1988). Forest cover may also depress local ambient temperature. This relieves water stress on adjacent agricultural areas and makes life more tolerable for humans. Large tracts of undisturbed forest also absorb and hold the carbon dioxide humans produce in our extensive use of fossil fuels. If extensive forested areas are logged, atmospheric carbon dioxide concentrations may increase which contributes to global warming. In addition, burning the wood harvested would release even more carbon dioxide into the atmosphere. It has been estimated that residents of the First World generate approximately 11.5 metric tones of carbon dioxide annually (Hinrichsen 1990). In order to stabilize such carbon dioxide emissions, reductions of 60-80% in

these emissions are needed by the middle of the next century. While greater efficiency and conservation in our energy use will be the primary strategy to decrease carbon dioxide levels, decreasing the rate of deforestation will also contribute to a reduction in carbon dioxide buildup in the atmosphere.

Direct importance of biodiversity to humans

The biota may be called the life support system of humans. It feeds us, produces oxygen. Ecosystems ensure a source of food for humans. The ecological benefits of biodiversity, therefore, are passed on to humans. There are also many direct benefits of biodiversity to humans. Examples of such benefits include the use of plants and plant extracts as sources of medicines and drugs, alternative foods and energy sources, building supplies, and income generating livelihoods such as extraction programs and tourism.

Medicines and drugs

While many drugs today are produced synthetically, some major medicines such as morphine and quinine still come from plants. It is estimated that more than 25% of all medicines available today are derived from tropical plants. Four-fifths of the human population may be nurtured by traditional medicines, many of which are derived from tropical plants (Ryan 1991). Over 40% of all the pharmaceuticals available in the U.S.A. are still derived from natural sources. Two commonly known medicines which were naturally produced include aspirin (originally derived from willow tree bark) and penicillin (from a fungus). Not all medicines derived from natural products come from plants. Antimicrobial and antiviral substances have been derived from marine fauna and arthropods. Penicillin, tetracycline, and cyclosporin are derived from fungi and microbes (Reid and Miller 1989). In countries such as the People's Republic of China, Japan and India there is much interest and support to search for new drugs from plants (Farnsworth 1988). The retail market value of prescription and over-the-counter plant-based drugs in developed nations in 1985 was in excess of $43 billion[2] (McNeely 1988). The value of this natural source of medicines is immense. Maintaining a rich diversity of species will enhance our chances of finding the critically needed medicines to cure existing or new diseases.

Alternative foods

Presently, approximately 80% of the world food supply is provided by fewer than two dozen species of plants and animals (Council on Environmental Quality 1981). By depending upon such a few number of species we are: (1) decreasing the genetic diversity of crops that we depend upon, (2) changing diverse forested areas into monocultures, (3) reducing the numbers of actual and potential ancestors of crops which may provide genetic diversity to develop new strains of crop species (Nations 1988), and (4) failing to meet the present food demands of a growing population.

[2]References are to U.S.A. dollars in this module.

To change these conditions, researchers are examining the many naturally occurring edible food plants (approximately 75,000) in existence that could be substituted for our predominate food plants -- wheat, corn, rye, and soybeans (Wilson 1988).

The tropics hold potential for supplying alternative food sources due to the diversity of plant species which exist in these regions and their history of providing us with a variety of foods. Coconuts, peanuts, and sugar are just a few of the many food items which originated in the tropics. Scientists project that many under-exploited tropical species will become more commonly used in the future (Plotkin 1988). Some examples include: uvilla (fruits to be eaten raw or for wine making), lulo (frozen concentrate drink), pupunha (a source of carbohydrates and protein), amaranths (currently sold in health food stores and marketed as a breakfast cereal), and guanabana (popular in China, Australia, Africa, and Philippines as a raw fruit, drink, or yogurt) (Plotkin 1988).

Energy sources

Much of the energy used on this planet is derived from living or long-dead plants. Wood is used by approximately 1.5 billion people, across all cultures, to fulfill 90% of their fuel needs (Eckholm 1975). In sub-Saharan Africa, wood accounts for over 80% of the total energy consumed (Reid and Miller 1989). If properly managed, wood may serve as a renewable energy resource. However, in many parts of the world, wood supplies cannot be replenished fast enough to meet the growing energy demands. Nonrenewable fossil fuels are our primary sources of energy, particularly in developed nations. These fuels are the result of the natural changes in the earth's diversity tens of millions of years ago. Renewable energy sources other than wood should be found that will reduce our dependency on nonrenewable resources and lower the demands on our forests.

It is not generally recognized that rice husks are used around the world as an alternative energy source. Presently, approximately 60 million tons of rice husks are produced annually and are used for energy production with another 12 million tons which could be used (Beagle 1978).

Building supplies

The most significant use of the world's biota is in the form of wood products for construction. The global timber trade in 1989 was estimated to be in excess of $77 billion dollars (Reid and Miller 1989). In the book, Appropriate Technology Sourcebook, Darrow and Saxenian (1986), review examples of a variety of building materials which are used by cultures throughout the world. Biological diversity can allow further development and experimentation with some of these materials. Thus, it may reduce our dependency on one traditional product -- wood. This, in turn, reduces the need to deforest ecosystems that are difficult to restore.

One example summarized by Darrow and Saxenian (1986) is the use of rice husks to make cement. To make the "cement", rice husks are burnt, possibly as an energy source, and then combined with lime. Rice husk ash cement is used on the Indian sub-continent and although it is of relatively lower strength it may be used for many rural projects (Smith 1984).

Local income generating livelihoods

Extractive programs

Millions of the world's poorest people live in the world's richest ecosystems, tropical rain forests. In many tropical forests, extractive programmes provide the indigenous people with a sustainable livelihood. In an extractive programme, renewable resources (e.g., medicinal plants, latex from rubber trees) are harvested (i.e., extracted) from the forest without the forest being cut or burned. In some cases tracts of forests are set aside as extractive reserves. The reserves are areas of the forest set aside by the government, but managed by the local community. The forest residents control the harvest of the forest products and share in the benefits of proper management. The forest is spared destruction (Ryan 1991). A variety of non-timber products are harvested from tropical forest ecosystems. Forest dwellers in Borneo and Thailand provide the Chinese market with the nests of cave-dwelling swiftlets. The nests are used to make bird's nest soup. The rattan trade is worth in excess of $3 billion a year to southeast Asian countries. In 1989, the export of Brazil nuts and palm heart each generated about $20 million for Brazil. Minor forest products (primarily chicle for chewing gum, allspice, and xate for floral arrangements) earn Guatemala $7 million in export revenue annually (Ryan 1991).

When managed properly, extractive programs provide a sustained income for forest residents. Other, more exploitive and destructive forest industries can provide higher revenues, but the high returns are very short lived and the forests are seriously damaged or lost. For example, rubber tapping in Brazil generates about $5.00 per acre. This economic return should remain fairly constant for a period in excess of 40 - 50 years. Slash and burn agriculture generates about $12.00 per acre the first year crops are harvested. However, within 6 or 7 years of the original planting the soil will no longer support crops and the economic return is $0.00. Cattle ranching generates about $10.00 per acre, but 8 or 9 years after the slash and burning, the economic return is $0.00 (Durning 1989).

Extractive programs cannot be viewed as panaceas that will save all threatened ecosystems and the people residing there. Unless properly managed, extractive programs can result in the over-harvest and depletion of the resource. In the 1960's a typical rattan collector in the Philippines could gather 200 pieces per day; by the 1980's the daily harvest was down to 35 pieces per day (Ryan 1991). The forests of Thailand have been so severely depleted that the country has gone from being a net exporter of rattan and lumber to being a net importer of both products (Ryan 1991).

Domestication of wild species also threatens extractive programs. As the products of wild species can be produced in high quantities at low cost on farms and plantations, the economic return from extractive programs dwindles. Brazil nut plantations have been started in Malaysia and Manaus, Brazil. The Brazilian plantation will begin to produce large numbers of nuts in 1991. Estimates from the Institute for Amazon Studies in Curitiba, Brazil suggest that only 30,000 hectares of plantation grown Brazil-nut trees will be enough to provide as many Brazil nuts as can be produced in the entire country from natural populations (Ryan 1991). Since rubber tappers in Brazil derive most of their income from two crops, rubber and Brazil nuts, such plantation production levels

could be disastrous for this group.

Tourism

In many countries a significant portion of the tourist generated revenue is directly related to the biodiversity of that country. Tourists visit a particular area to hunt or fish and/or view wildlife and natural ecosystems. The tourist industry in Kenya is the largest source of foreign exchange revenue, with a third of the revenue provided directly by 7 national parks (IUCN/UNEP 1986). In Botswana, in the mid-1970's the total government revenue derived from hunting alone was in excess of $8.5 million. In areas that have sufficiently large game populations, hunting and fishing provide job opportunities for local residents, primarily as guides.

While all tourism benefits from the characteristics of a diverse environment (clean air, water, natural areas, etc.), an important form of nature-related tourism specifically dependent on biodiversity is nonconsumptive ecotourism. The extent to which ecotourism and native biodiversity can provide benefits to local residents is illustrated with an example from Costa Rica. The Monteverde Cloud Forest Reserve comprises over 10,000 hectares of lower mountain and montane tropical cloud forest in the Cordillera de Tilaran of Costa Rica. The reserve was founded by private efforts in 1972 and is administered by the Tropical Science Center, a nonprofit Costa Rican association. The number of visitors to the reserve has grown from just over 3000 in 1980 to over 22,000 in 1990. In 1990, these visitors paid over $150,000 in entrance fees to visit the reserve and view the plants and animals. This represents only a small fraction of the revenue tourists brought to Monteverde. Additional tourist dollars were spent on such things as motel rooms, meals, guides, and souvenirs. The tourist industry centered around the reserve provides jobs for local residents in the reserve and in local restaurants and motels. Without these jobs most young people would have to leave Monteverde to find work.

While ecotourism allows a local population to exploit the diversity of its natural resources, there are potential disadvantages to such an industry. Increased numbers of tourists can result in both ecological and sociological changes (IUCN/UNEP 1986). The presence of large numbers of humans can cause destruction to the environment and changes in behavior of the wildlife. Large numbers of tourists require transportation and places to eat and sleep. The wilderness that originally attracted tourists can quickly begin to resemble an urban area. The way of life changes for residents of the area. Traditional types of work are abandoned as employment in tourist related jobs become available. Agricultural or forest lands are lost to development as hotels, motels, and restaurants are built. Once quiet rural areas are overrun by increasing numbers of tourist buses and motorcycles. The latter seem to quickly replace horses and walking as the primary means of local transportation.

What are the threats to biodiversity?

The species in a healthy, natural ecosystem evolve together, adapting over time to shifts in climate and to new predators and competitors. Most populations are genetically variable enough to adapt to fairly gradual changes in their environment. Changes brought about by the destruction of

required habitat, introduction of novel predators or competitors, or direct intervention of humans, however, usually occur too rapidly to allow most wild species to adjust.

Habitat destruction and fragmentation

Habitat destruction is one of the major threats to biodiversity. Huge tracts of forested lands are cleared annually. It has been estimated that 11.3 million hectares of mature forests are deforested annually (Lanly 1982). Agricultural land is lost to urbanization and desertification. Aquatic habitats are drained or so chemically altered they become essentially nonexistent. Many of these changes have come about because the number of humans on the planet continues to grow. Increased availability of health care in developing nations has extended life expectancy and decreased infant mortality. Along with these changes comes the pressure to feed and house growing numbers of people. Modern modes of transportation, efficient machines (versus hand labor) to clear the land, and government policies have accelerated habitat destruction and fragmentation.

Habitat fragmentation occurs when ecosystems are broken into smaller components, often isolated from each other. For example, a large forested area might be reduced to a several small patches of forest isolated from one another by agricultural lands. Such fragmentation may cause isolation and changes in the microclimate (due to radiation, wind, water) of fragments. Fragmentation of large natural ecosystems may cause the disappearance of thousands of species by the end of this century (Lovejoy 1980).

Habitat is often lost in continually widening circles from urban areas. One example is the destruction of the Atlantic forest of Brazil that was once found in the area occupied by the city of Sao Paulo. As the city has grown, more and more of the forest has been destroyed. Less than 2% of the forest type now remains and many of the species associated with this area became extinct before they were described by scientists (Murphy 1988). As evidenced in the Amazon rain forest, large pockets of destruction can also begin great distances from any urban area. The effects of such habitat destruction in our tropical and temperate regions of the world will have differing effects on plant, mammal, and bird distributions. For example, many plants and birds are good colonizers and therefore may not be as adversely affected as mammals. Exceptions would be those plants with specific pollination and dispersal requirements and birds which are weak flyers such as parrots and pheasants. Unfortunately, many important plant and bird species may be limited in such ways.

Habitat destruction, particularly deforestation and drainage of wetlands and urbanization of coasts, has been linked to land-ownership patterns and government policies. In many countries a small percentage of the population owns a disproportionately large percentage of the land. In Guatemala, for example, 2% of the landowners claim 63% of the agricultural land (Brough 1991). In both Brazil and El Salvador, 2% of the landowners control 60% of the arable land. Thirty-nine percent of the farmable land in Zimbabwe is owned by white farmers, who make up less than 1% of the population (Brough 1991). Landless individuals, often at the urging of the government, homestead marginal agricultural land in an attempt to improve their lives. Government policy often requires practices that are detrimental to the environment. In Ecuador, for example, homesteaders can obtain title to forest plots only if they clear at least half of their land (Brough 1991). Such a

policy is not at all restricted to Ecuador or South America. In many countries land disputes are settled in favor of the party that "improved" the land. In wetland ecosystems, improvement invariably means damming or draining these areas for crop production. Governments in both developed and undeveloped countries also provide subsidies and tax credits for industries that engage in deforestation. The logging industry and cattle ranching are examples of two such government subsidized industries.

Climate change and global warming

Although yet a topic of controversy, many scientists predict that global warming of several degrees is likely to occur within the next 50-100 years. A 2 degree (Celsius) change is considered large by scientists when compared to normal fluctuations and it is estimated it would leave the planet warmer than at any time in the past 100,000 years (Schneider and Londer 1984).

Species ranges and mortality affected by precipitation and temperature

The fossil records show that communities of the past have dealt with climate changes by shifting their ranges to coincide their optimum climate (Peters 1988). If computer projections are correct, rising temperatures will make conditions in California and Oregon unsuitable for seed germination of the Douglas Fir by next century, and that species may be eliminated from those states. Additionally, changes in the global precipitation pattern could result in shifts in prime agriculture lands. Most of the agricultural products currently being cultivated have been selected for a particular geographic area. These cultivares may not be as productive or even viable if the climate changes. This makes even more pronounced, the need to preserve the genetic diversity needed to find food species which can adapt to a new climatic regime. Although climatic shifts would have severe impacts in North America, these problems would pale in comparison to effects in other countries with marginal agriculture (e.g., India, China) or those threatened by sea level rise such as the Maldives, Philippines, and Netherlands.

Plant and animal interactions

A major climatic change may result in mixing species of natural communities and create new plant and animal associations (Van Devender and Spaulding 1979) as species redistribute their ranges to meet shifts in optimum climate. These new associations may cause stressful interactions among species which do not normally occur together and could lead to the extinction of species.

Fixed location of present refuges

Developing and developed nations alike have moved to set aside habitats that are protected from extensive human exploitation. These protected habitats are usually in the form of national parks or nature preserves. These areas are usually selected because they contain unique lifeforms or endangered or threatened species. If the climate shifts to the degree that protected habitat is altered, populations of the protected species may no longer be viable. Since they are islands of wilderness (fragments) in an ocean of human development no new reserves or parks could be

established.

Pollution and chemicals

Although chemical spills and the improper use of pesticides and herbicides can result in the localized destruction of species and ecosystems, pollution is not yet one of the primary demonstrable causes of species extinctions. For example, industrial sludges have been documented to contain levels of dioxin and other toxics that laboratory tests suggest are unsafe. However, detectable effects on an organisms' health in natural ecosystems have not been found (Anthony and Kozlowski 1982, Dressler et al. 1986).

Toxic by-products of urban areas, such as polychlorinated biphenyls, sulfur dioxide, and pesticides may pose a threat to biodiversity (Ehrlich and Ehrlich 1981). Air and water pollution may stress ecosystems and reduce the size of sensitive populations (Reid and Miller 1989). Air pollution has been linked to forest diebacks in Europe and the U.S.A.. Air pollution and acid precipitation may weaken tree species and facilitate infections by diseases and may reduce productivity (Reid and Miller 1989). Acid precipitation also harms aquatic ecosystems by changing the pH of the water, resulting in dieoffs of pH sensitive species.

Introduced species

Humans have rarely been content with the species which occur in their local geographic area. Various species have been shuffled both intentionally and accidentally. Managing for biodiversity does not necessarily mean biologists should introduce as many species as possible into area. The effects of introducing tigers, lions, and elephants into New York City would certainly increase the diversity of the city. However, these introductions would also cause a number of significant problems.

Introduced species may potentially effect native species by competing with them, breeding with them and destroying unique genetic types, or by altering predator-prey interactions. Historically, the most disruptive species have included mammalian herbivores, vertebrate and invertebrate predators, and species that can easily invade new ecosystems (Vitousek 1988). Some of the most well documented cases of introduced species impacting specific ecosystems include Old World rats, fire ants, and mongooses.

The mongoose was introduced on Caribbean islands to control snake populations and the Old World rat, which was introduced accidentally. The result of this introduction was that snake numbers were only partially controlled. Mongooses preyed heavily on native species of birds, mammals, and reptiles, and nearly eliminated several species (Robinson and Bolen 1984). They had very little impact on the rat population.

Not all species introductions are done on purpose. A well documented case involves the accidental introduction of the brown tree snake to Guam (Ripley 1991). Brown tree snakes were

originally residents of New Guinea, northern Australia, and other southwest Pacific Islands. It is believed that they arrived on Guam as stowaways in military cargo during World War II. Today certain areas of Guam may have as many as 30,000 brown tree snakes per square mile! These snakes have virtually wiped out four species of lizard and many native forest birds. In particular danger is the flightless Guam rail. There were an estimated 80,000 Guam rails in the early 1970's; by 1985 there were fewer than 50 (Ripley 1991). Captive breeding and reintroduction programs have for the now saved the species from extinction.

Direct human intervention

Humans have been directly responsible for the loss of biodiversity through the degradation of ecosystems and the decimation of wildlife populations. Fragile ecosystems have been destroyed by such factors as past forest management and agricultural practices and urbanization. As a result, many of these ecosystems and the species associated with them, may never be replaced. Unregulated hunting, past game management practices, and the control of selected predators both in the tropical (e.g., large cats) and temperate (e.g., raptors) regions of the world have also been factors responsible for the direct loss of many species. Virtually all of the large fish and wildlife species have disappeared from the Peruvian Amazon near the city of Iquitos. These fish and animals were harvested to provide meat to the residents of Iquitos (Ryan 1991).

Natural change (disturbances and destruction) has always been a driving force of all natural systems. Often biodiversity must be preserved by allowing natural changes, rather than by preventing them. Two examples serve to illustrate how our well intentioned land management sometimes threatens rather than enhances biodiversity. This is due to a lack of understanding of these natural processes.

A case that illustrates this concept occurs in the acacia woodlands in Chobe National Park, Botswana (Lewin 1986). The Chobe National Park is composed of a mixture of grasslands and acacia woodlands which supports large populations of various species of herbivores (giraffe, zebra, impala, buffalo) and predators (lions, jackals, hyenas). The coexistence of acacia woodlands, large numbers of herbivores, and predators illustrates the principle that ecosystems are constantly changing and are dependent upon the other components of the ecosystem. Many park officials feel that the acacia woodlands are in jeopardy of being lost because new stands are not developing and current stands are being heavily browsed by the herbivores. While this situation worries many park officials, ecologists believe that this is a short-term change which is essential to maintain the Chobe National Park ecosystem.

The history of the park indicates that acacia woodlands became established in the late 1800s when populations of elephants and other large herbivores were very low due to disease and drought. In the early 1900s, hydrological conditions improved and the acacia woodlands expanded. This allowed populations of herbivores to again increase. As herbivore populations rebounded, food was again abundant for the predators in the park. The large populations of herbivores were again preventing the production of new stands of acacia and heavily browsing the mature stands.

Drought returned in the early 1980s, and park officials noticed a further decline in the acacia. As the drought-stressed and heavily browsed acacia resource declines, ecologists expect an eventual reduction in herbivores and then a decline in predators. As herbivore populations decline, the acacia woodlands can again expand. In order to have the unique association of acacia woodlands, large herbivore populations, and a variety of predators in the ecosystem, park officials must be willing to accept change in the system. Over the long term, the populations in the ecosystem cannot be stable. The continued existence of the unique acacia woodlands ecosystem depends on a delicate and fluctuating interaction among species and climatic shifts.

Yet another example is the Yellowstone National Park in western United States. When the park was established in 1872, fires occurred approximately every 20-25 years (Hart 1990). In 1886, however, the National Park Service initiated a total fire suppression program that lasted until 1972. After 1972, fire policy was changed to allow naturally occurring fires to burn if they did not threaten human life or buildings. After more than a century of fire suppression, some species of plants which were adapted to frequent fires had been reduced in the park. Many of these species were valuable for wildlife habitat. The natural distribution of forest and open areas had been replaced by new patterns because of the fire protection policy. Again, these new patterns were not as productive of wildlife species. Biodiversity had been diminished in the park due to inappropriate management. In 1988, a major fire was allowed to burn in the park. Its pathway throughout much of the park produced an erratic pattern of burned and unburned areas. While it was not a completely "natural" event because of the fire intensity in some areas caused by a buildup of fuelwood in the protected forest areas, the burn did result in a diversity of vegetative successional stages and patterns which will enhance wildlife species and increase biodiversity in the park.

CHAPTER 4:

Managing for Biodiversity

What Can be Done to Manage Biodiversity?

Several alternatives exist relative to biodiversity management objectives. Should management strive to maintain the present level of diversity in an area, enhance biodiversity, or return the area to some "historic" level? The goal of most projects will undoubtedly be to maintain the current level of diversity. However, many programmes associated with threatened or endangered species will attempt to enhance genetic variability in small populations. Few, if any projects will actually have a reduction of diversity as an objective. Even programmes aimed at removing exotic species are really attempting to maintain or restore native species and thus biodiversity levels. For example, burros are not native to the Grand Canyon in the southwestern U.S.A. They were brought to the area and released by gold prospectors. Through their feeding and creation of trails, the burros have done considerable damage to the Grand Canyon ecosystem and threaten the existence of some plant species. A programme was initiated to remove the burros from the Grand Canyon. The removal of one species (burro) will assure the survival of a number of native plant species.

It is much more cost effective to *maintain* a given level of diversity than it is to try to *restore* it after it has been lost. It is costly and difficult to enhance diversity which generally involves returning species to areas from which they disappeared (reintroductions) and/or intensive habitat management and manipulation. It is very difficult to create a new ecosystem or population.

Programmes that attempt to return an area to some historical level of diversity are often referred to as reclamation or more commonly restoration ecology. One obvious question is, "How far back in time should we go?". Ecosystems are not static, they change over time. So, to what stage should we restore the ecosystem to? There is no easy answer to these questions. The decision will depend upon the state of our ecological science, the biological and financial resources we have to work with, and the political and social factors involved. The decision to restore an ecosystem to a former stage may be hampered by not knowing all of the species that were present. Some of the former species may have become extinct and no longer be available. We may have to accept that the best we can do is to establish an ecosystem that is only approximately functionally equivalent to our historical goal.

The specific conservation goals will also be constrained by economic, technological and political realities. Most of the nations with the highest levels of biodiversity can be classified as developing nations and lack the financial and technological resources to adequately address environmental issues. The average annual per capita income in Zaire is about $160, while in Switzerland it is about $16,500 (McNeely 1988). In biologically rich but economically poor nations, natural resources must be used for the human population. However, natural resources can be properly managed to meet human and conservation needs.

The actual management strategies employed depend upon whether the ultimate goal of a project is to conserve or preserve diversity. Conservation can be defined as "the management of human interactions with the variety of life forms and the complexes in which they occur so as to provide the

maximum benefit to the present generation while maintaining their potential to meet the needs and aspirations of future generations." (Reid and Miller 1989, page 106). Inherent in this definition of conservation are the ideas that (1) man is a natural and integral part of the biosphere and (2) sustainable development is possible. Sustainable development is economic development that takes into account ecological and economic principles so that both economic growth and ecological systems can be maintained for an indefinite period of time. The strategy assumes that resources can and will be used in a reasonable fashion and at a reasonable rate, so that they do not become depleted.

Preservation and conservation are not equivalent ideas. Preservation means that resources (species, ecosystems, or select geographic areas) are set aside (e.g., in sanctuaries) and protected from human use. In this management strategy, humans are either caretakers or intruders in the ecosystem. The approach recognizes that not all resources can be used in a sustainable manner. Today the terms preservation and conservation are often incorrectly used inter-changeably. Preservation is also sometimes viewed as one strategy within the larger field of conservation biology. This latter use redefines conservation to encompass any strategy that attempts to maintain diversity. Since this is the way the terms will be used most frequently amongst conservation biologists, we will use conservation in this manner. Programmes to meet biodiversity objectives will necessarily contain both conservation and preservation strategies.

We will present four broad strategies to meet biodiversity objectives. These strategies encompass both in situ and ex situ programmes. In situ conservation may be defined as the conservation of genetic, species and ecosystem diversity in a natural environment, i.e. in the wild. Ex situ conservation is the preservation of genetic material (seed, pollen, sperm, individual organisms) somewhere other than in its original or natural habitat (Reid and Miller 1989). Ex situ programmes may include (1) preserving genetic material in seed banks, gene banks, zoos, and botanical gardens; (2) increasing population numbers through captive breeding programmes at zoos and, (3) the reintroduction of species to the wild.

In situ practices are more cost effective and may benefit a larger number of species. At this time the ex situ conservation of a diversity of species, particularly vertebrates, and their genetic material is not generally cost effective. Captive breeding and reintroduction programmes are extremely expensive and have met with varied -- although increasing -- success. Clearly in situ conservation is the preferred strategy and primary emphasis in the area of ex situ conservation should focus on the preservation of genetic material in gene banks.

Gene Banks

Gene banks are any facility or area established for the preservation of individuals (usually seeds), tissues, or reproductive cells of plants or animals (Reid and Miller 1989). Gene banks can be in situ or ex situ. In many cases reserves, refuges and certain agricultural situations can be thought of as in situ gene banks, established with the primary purpose of conserving wild genes. These wild genes are of primary importance to agriculture and a growing human population. Wild relatives of domesticated plants often provide the new genetic material needed to enhance or sustain crop

yields. In many isolated parts of the world, varieties of plants that are only known to residents are grown or collected for food. For example, the Kayapo Indians of the Amazon Basin cultivate 13 distinct bananas, 16 sweet potato strains, and 17 different yams. Many of these are unknown to non-Indians (Durning 1989).

Most of this genetic diversity must be preserved in situ. The task of conserving this genetic diversity in laboratories or seed museums would be overwhelmingly complex. Some types of plants cannot be successfully stored ex situ. Rubber trees, many palm trees, cacao, and many tropical fruit trees must also be conserved in situ (Reid and Miller 1989). It is usually impractical to store viable animal genetic material, so animals need to be conserved in situ as well.

However, since we cannot possibly preserve in situ everything that humans might ever need, ex situ gene banks are vitally important to conservation efforts. Most ex situ gene banks maintain collections of plant material and most of this material is of importance to agriculture. The material to be stored must be chosen carefully and properly cared for once it has been collected. It is unknown how long most seeds can remain viable. Use of gene banks may allow samples of species to be distributed world wide so that additional research and education programmes can be developed. For example, the International Rice Research Institute gene bank distributed approximately 4,400 samples from its 57,000 seed accessions in one year (Ashton 1988). Improving research programmes, through gene banks, will hopefully improve our ability to manage wild populations.

In Situ Conservation in Protected Areas

"Natural and semi-natural ecosystems are the primary reservoirs of the world's biodiversity" (Reid and Miller 1989, p. 67). In a natural ecosystem the impact of humans is no greater than the impact of any other biotic factor. In a semi-natural ecosystem moderate levels of human disturbance are tolerated (Reid and Miller 1989). In many nations, legally established "protected areas" exist where the primary management goal is the maintenance of natural or semi-natural ecosystems. Protected areas are arguably the most valuable in situ strategies for conserving biodiversity. The International Union for Conservation of Nature and Natural Resources/United Nations Environment Programme (IUCN/UNEP) has established eight Protected Area Designation categories (IUCN/UNEP 1986). These areas are categorized by the primary management objectives for each area. Strictly protected areas are created to maintain biological diversity and natural formations and include scientific reserves, national parks, and natural monuments (Reid and Miller 1989). The remaining five categories allow controlled resource exploitation while retaining limited but significant commitments to maintaining biodiversity and include managed nature reserves, protected landscapes, resource reserves, anthropological reserves and multiple-use areas (Reid and Miller 1989).

Currently, over 120 nations have approximately 3,100 national parks and similar conservation areas, totaling about 400 million hectares (Harris 1984). The Man and The Biosphere (MAB) Programme of UNESCO has developed an international network of 300 biosphere reserves located in 75 countries. These reserves will help maintain diverse ecosystems over a broad geographic area.

To develop and/or maintain reserves and refuges to conserve species, several factors must be considered including : project objectives, special needs of species, ability to acquire large enough tracts of lands for reserves/refuges, and location and design of reserves/refuges. Reserves should have heterogeneous topography, soil, vegetation, and successional stages in order to provide suitable microclimatic areas for the survival of remnant populations during climatic changes (Peters 1988). Various nature reserve designs have been proposed to conserve biodiversity and reduce extinction rates. However, there is considerable debate over which one provides the best conditions for the maximum number of species (Diamond 1975). Given the projected climatic changes associated with global warming that may occur in the future, it is difficult to plan the types and locations of reserves existing species will need (Peters 1988).

A limitation of the refuge system is the difficulty of getting designated areas properly implemented. For various reasons, areas intended as refuges often become "paper parks". Paper parks are those which have been established on maps and/or in legal documents (i.e., on paper), but because the stated management goals have never been implemented these parks do not function as protected areas.

Conserving biodiversity will require more than the establishment of large tracts of protected land, even when they are truly managed as biodiversity refuges. The ranges and life requirements of many species, especially large mammals, are rarely met within specific political or geographic boundaries. Species may range outside nature reserves to meet food requirements, select mates, or migrate to other seasonal ranges. Therefore, to complement conserving habitats and species within reserves, private landowners surrounding reserves will have to help manage larger landscapes for the species/habitats of concern. This will undoubtedly entail a cost to those private landholders and create social and political issues. Current efforts by conservationists, natural resource managers, and policy makers are attempting to incorporate parks into regional natural resource management plans, to surround parks with lands of comparable land use, and to ensure that communities adjacent to parks and reserves receive some benefits from the programme (Harris 1984).

Government and Nongovernment Organization (NGO) Programmes

Conserve habitat

Conserving habitat is critical in managing landscapes for a diversity of species because it provides the food, cover, water and space that species require to live and reproduce. If habitat for a species is destroyed, that species must either disperse to a new location where biological requirements can be meet, be brought into a captive environment, or die. To prevent habitat from being destroyed, some government and NGO programmes have been influential in regulating land use practices, which have assisted in the conservation of habitat.

One example of a federal programme used in the U.S.A. to conserve habitat is the Conservation Reserve Programme (CRP). The Food Security Act of 1985 authorized the CRP to encourage farmers to retire erodible land and edges around streams and lakes from crop production and establish permanent cover. Benefits of the programme may include erosion control, increasing the

quantity and quality of fish and wildlife habitat, dependable per-acre income, cost shares, reduced surplus agricultural commodities, and establishment of trees and shrubs. Enrollment of land in the CRP, therefore, has great potential for enhancing wildlife populations and habitat, however, the benefits of the programme are only now being investigated.

Although some government policies promote habitat destruction, they also may mandate the conservation of habitat. One government policy in the U.S.A. which has had significant impacts on the conservation of forest is the Multiple Use-Sustained Yield Act of 1960. Specifically, this policy requires the U.S. Forest Service to consider all recreational activities and fish and wildlife habitat requirements, along with timber production, when developing forest management plans. Because Federal forests comprise approximately 112 million hectares of all forested lands in the U.S.A., with the Forest Service being the largest land-holder, the standards of this act may be instrumental in conserving habitat for a diversity of wildlife species (Stockwell 1990).

Costa Rican government officials are attempting to control habitat destruction in their country by integrating conservation practices with agriculture development and building a reforestation programme. Presently, the government is attempting to teach the concept of "sustainable development" to landowners and is working with park personnel in order to mesh park needs with the livelihoods of landowners. Without such a programme, officials fear that landowners may eventually want to use park land for farming or timber harvesting. It is this type of multidisciplinary management approach and top level political commitment which is needed globally to reduce habitat destruction and manage landscapes for biodiversity (Sun 1988).

Two examples of international programmes involving predominantly NGO's are the Tropical Forestry Action Plan (TFAP) and the Bosque Eterno de los Ninos in Costa Rica. Such programmes are critical to conserving our tropical rain forests which are being destroyed at the rate of 20 hectares every minute (Burley 1988).

The Tropical Forestry Action Plan is a programme which was developed by the U.N. Food and Agriculture Organization, international development agencies, NGO's, and representatives from more than 60 countries to reduce or eliminate the loss of tropical forests. Specifically, the Plan addresses problems associated with fuelwood, social forestry, conservation of forests, and attempts to enhance research, education, and training. Since its development in 1985, various countries and agencies have made substantial commitments to forestry and agricultural projects. Many agencies such as the U.S. Agency for International Development and the Canadian International Development Agency have financed conservation plans, management plans for critical wildlife species, or established parks.

It is hopeful that with the TFAP, numerous forestry and agricultural projects will be developed which may serve as demonstrations for other countries and agencies to follow. One example is the attempt to conserve parts of the Amazon Basin as extractive reserves by the Brazilian rubber tappers. Development of these reserves would not only protect forests from clear cutting but also would enable rubber tappers to maintain an occupation they have practiced for generations (Burley 1988).

The Bosque Eterno de los Ninos is an international children's rain forest reserve near Monteverde, Costa Rica. The 8,177 hectares of montane and tropical rain forest are located in northwestern Costa Rica on the Atlantic slope of the Tilaran mountain range. The Bosque Eterno de los Ninos is a preserve purchased with donations from children and NGO's throughout the world. Swedish school children involved in Barnens Regnskog (Children's Rain Forest) raised over $100,000 in funds and grants to help purchase the tropical forest. The Children's Tropical Forests, U.K. also raised substantial amounts of money to purchase land. Additionally, NGO's in Germany, Japan, Canada and the U.S.A. are involved in the project.

Control of wildlife products market

National and international efforts to regulate the harvest and marketing of wildlife products have had varying impacts on the conservation of selected species. Examples to be presented include the (1) 1990 ban on the international trade in elephant products and (2) continued trade in rhinoceros horns for medicinal purposes.

Concern over declining numbers of elephants in certain areas of Africa led to a 1990 ban by CITES (Convention on International Trade in Endangered Species) on the international trade of elephant products. While competition with an expanding human population undoubtedly played a role in the elephant's decline, poaching was assumed to be the major source of loss. Prior to the ban, large numbers of elephants were being illegally killed for their ivory. The number of elephants on the African continent fell from about 1.3 million in 1980 to about 600,000 in 1989. East African elephants were hit the hardest. In Kenya alone, the herd declined from about 65,000 in 1981 to 17,000 in 1989. Without the programme it was estimated that the African elephant would be extinct in 10 years (Cheater 1991). It is too soon to determine how affective the CITES ban will be in reviving elephant numbers, but the global market for ivory is now almost nonexistent. Ivory prices have plummeted from over $200.00 a kilo in 1989 to as low as $2.00 a kilo in 1991 (Cheater 1991). Widespread poaching is no longer profitable enough to justify the danger.

The CITES ban on the trade of elephant products was not supported by all African nations. Botswana, Malawi, Namibia, South Africa, Zambia, and Zimbabwe all opposed the ban because it threatened a major source of revenue for conservation projects and local development. Zimbabwe, for example, has been very successful in managing its elephant herds. The number of elephants in Zimbabwe actually increased in the 1980's and there are now an estimated 60,000 elephants in the country. In the 10 years prior to the ban the sale and processing of elephant products (ivory, meat, skins) generated $24 million (Cheater 1991). This money was spent to build schools, clinics and roads and was used to fund game management programmes, including hiring anti-poaching patrols for Zimbabwe's parks and reserves. This revenue is no longer available.

There are presently five species of rhinoceroses. The black and the white species are found in Africa, and the one-horned, the Javan, and the Sumatran are located in Asia. It is estimated that 85% of the world's rhinoceroses have been killed within the past 20 years (Hurt 1991). This has left less than 11,000 individuals existing in wild populations and caused all species to be listed as endangered.

The primary cause for the decline in rhinoceros numbers is the continued poaching to obtain horns and other body parts (e.g. skin) for trading and for medicinal purposes. Currently, China, South Korea, Taiwan, and Thailand have failed to regulate the rhinoceros horn market, therefore, creating a loophole for poachers and dealers and minimizing the effectiveness of international conservation efforts to save these species (Hurt 1991). Presently, with more sophisticated methods of trapping and the market value of rhinoceros horn products, poachers can earn more from the sale of **one** rhino horn, than they can make in a year as a farmer or merchant (Hurt 1991). In Taiwan market places, rhinoceros horn powder may sell for as much as $60,000/kg (U.S.A.) (Hurt 1991).

Conservation efforts in the areas of protection programmes and translocations of rhinoceroses from poaching "hot spots" have greatly helped population numbers. However, additional work needs to be done in the areas of international pressure and national legislation, rhinoceros management plans, training programmes that emphasize management of wild populations, anti-poaching programmes, population surveys, and educational outreach programmes with villages (Hurt 1991).

Curb pollution

Air and water pollutants can have great effects on biodiversity by disrupting natural ecosystems (Ehrlich and Ehrlich 1981). What happens in almost any part of the world can have ramifications elsewhere. Acid precipitation from cars and industry in Great Britain harms lakes and forests in Scandinavia. Chemicals used in North America deplete the ozone and increase the risk of skin cancer in Australia. Residue from the pesticide DDT used in Central America has been found in the Great Lakes of North America (Renner 1989). National and international actions will be required to curtail these effects. For example, 1987 Montreal Protocol programme established largely by the U.N. Environment Programme, calls for a 50% reduction in CFC (chlorofluocarbons) production by 1998. CFC's are the gases believed to be the primary cause of ozone depletion. Another example is that of the "30-percent club". In 1984, nine European nations and Canada agreed to reduce their emissions of sulphur-dioxide -- the primary cause of acid precipitation -- by at least 30% by 1993. In 1990, 12 European nations pledged to cut nitrogen oxide emissions by 30% by 1998 (Renner 1989). That not all nations have joined these pacts illustrates the difficult political nature of these solutions.

Captive breeding and reintroductions

Reintroduction may be defined as the restoration of a species to it's original habitat. This may occur through translocation of a species from one location, where it is abundant, to another where the species can be established. Reintroductions may also occur by removing species from the wild to a captive breeding facility where presumably they will breed and then offspring are released into the wild.

There are problems associated with reintroducing species. Reintroductions may not provide resource managers with the results they desired or may produce results which negatively affect other species within an ecosystem. By transferring animals from one location to another new pathogens or diseases may be introduced to species which currently inhabit an area. Also, the practice of

releasing individuals reared in captive environments has received considerable criticism in recent years due to the cost associated with rearing captive individuals, the "tamed" behavioral characteristics many captive reared individuals may exhibit, and possible changes in the genetic composition of populations. Because of the potential impacts of "unsuccessful" reintroductions, they should only be included as a final alternative in a management plan. More cost effective techniques should be attempted first such as habitat management/protection, law enforcement, and public education.

Captive breeding and reintroduction programmes are usually the last methods employed when dealing with rare or endangered species. Captive breeding programmes only began as conservation measures in the 1970's. Initially this shift in use of captive breeding was a response to declining populations of some species, the realization that zoos had contributed to the decline of some species, new endangered species regulations, and the need to facilitate the return of some species to the wild. Effectively, with this change in philosophy, captive breeding programmes became producers instead of consumers.

Many species, however, have been reintroduced successfully using these techniques. Examples include the white-tailed sea eagle (Great Britain), goshawk (Great Britain), the griffon vulture (France), the peregrine falcon (U.S.A.), and the American bison (U.S.A.) (Terrasse 1985).

Captive programmes have both positive and negative aspects which relate to the conservation of species. On the negative side...

...they are directed at saving only a few critically endangered species,

...funds may be spent more effectively on habitat management,

...they often give the public the perception that species will not go extinct if they are kept in captivity,

...often captive programmes are initiated too late (e.g. California condor, black-footed ferret),

...resources and time limits the number of species which can be bred, and

...captive breeding may change a species genetic composition and ultimately affect many of their behavioral characteristics.

One case study which can be used to illustrate negative aspects of zoos and captive breeding programmes is the white rhino. The white rhino does not reproduce well in captivity. Captive white rhinoceroses are typically maintained in solitary "pens" to prevent males from fighting and injuring each other. However, it may be that not allowing males to "compete" inhibits sexual activity. If so, a case could be made that funds to conserve the white rhinoceros would be more effectively spent on law enforcement and/or to restrict the marketing of white rhinoceros horn products.

Captive breeding programmes have successfully helped restore the American bison. Due to

unregulated hunting and destruction of habitat very few bison remained in the U.S.A. by the beginning of the twentieth century (Robinson and Bolen 1984). Bison reserves were established throughout the U.S.A. and stocked with individuals from the Bronx Zoo in New York, U.S.A. Due to preservation through a captive breeding programme, the American bison is no longer in danger of extinction.

Other examples of successful captive breeding programmes involving a variety of vertebrates can be cited. For the last four years, California condors have existed only in zoos. The last wild condor was captured in 1987 but because of a very successful captive breeding programme there are now 52 condors in captivity. Two zoo-born condors are scheduled to be released in the fall of 1991 and California condors will once again be alive in the wild. In 1972 only a small number of Arabian Oryx existed and these were all in zoos. By 1980 their numbers had increased to the point that 18 could be released in Oman. Today there are about 120 Arabian Oryx in that population.

Status of science and technology

Taxonomy, genetic diversity, and life history

To conserve biodiversity it is essential to identify the organisms that exist in a particular ecosystem, their genetic diversity, and their natural history and ecology. Unfortunately, without more research, such information is often not available. The problems created by conducting conservation management without adequate information are illustrated by the tuatara; a lizard-like reptile found only on the islands of New Zealand. These once plentiful animals declined in number as human populations spread to their home islands. A conservation programme was established to protect the reptiles. Since it was assumed that there was only 1 species of tuatara, populations on some islands were allowed to go extinct while those on other islands were protected. However, recent scientific evidence indicates that there were actually three species of tuatara. The conservation programme did not provide adequate protection for all 3 species and 2 of them may now be extinct.

Ecosystem function

The management of biodiversity requires a thorough understanding of the underlying processes that shape and structure our fragile ecosystems (e.g., nutrient cycling, species interactions) and of mechanisms which may degrade ecosystem functions. For example, a greater understanding of the effects that human development projects have on ecosystems needs to be identified.

Further, to adequately maintain or restore ecosystems, information is needed on the structural and functional roles that individual species play. A major question to be answered is whether each species plays a unique role in an ecosystem or whether certain species are functionally equivalent to other species? In other words, if one species were eliminated from an ecosystem, which--if any--other species are capable of performing the functional roles of the lost species. If each species is unique, then to maintain an ecosystem, each species must be conserved. However, if there are functional equivalents, then certain species can be allowed to disappear without destroying the ecosystem.

Our lack of knowledge to adequately restore ecosystems is illustrated by the following example. Forest areas on the upper slopes of the Tilaran mountains of Costa Rica were cleared for pasture in the years following World War II. The pastures were planted with grasses from Africa and used to support dairy cattle. Over time a number of these pastures were no longer used to support cattle. It was assumed that these pastures would naturally return to their forested state. However, despite the close proximity of forested lands, even after 20 years the old pastures remain open; little woody vegetation can be found on the sites.

Biogeography and climate change

Until recently, little attention has been directed to the ecological impacts of climate change. Vast information is needed on the potential effects of temperature, precipitation, and CO^2 on individual species, changes in interspecific interactions, and effects on species distribution by future climate changes.

To gather information on how climatically stressed ecological communities may respond to drastic climate changes, "community creation" experiments are being conducted (Peters 1988). In these experiments, communities are created outside their normal climatic ranges or plant species are planted in microhabitats which simulate climate changes. Such studies will enable ecologists to predict changes in species diversity caused by shifts in climatic conditions -- a capability which is critical if land management strategies are to be developed which minimize the loss of biodiversity.

Traditional practices and sustainable use

Traditional knowledge and skills for using biological diversity may suggest ways for our global society to utilize ecosystems in a sustainable manner. It is clearly true that, "the ecological wisdom of rain forest people dwarfs the scientific knowledge of tropical biologists and botanists" (Durning 1989, page 33). For example, sustainable use of tropical forests will require that the forest dwellers be given an increasing role in determining what will happen in the forest. The sustainable methods of crop production used by forest dwellers must be taught to those migrating from urban areas into the forest. These immigrants must gain a greater understanding of the relationship between indigenous people and the forest they inhabit and use. Conservation of biological diversity is going to require an appreciation of the skills and knowledge of the native people of the world and involve the work of sociologists and anthropologist as well as resource economists and natural resource managers.

CHAPTER 5:

The Nature of Biodiversity Issues

All issues are problems, but not all problems are issues...

Problems are situations that endanger something which we value. ***Issues*** are problems that involve conflict(s) between individuals or groups (stakeholders[3]) that have some interest in the outcome of the issue. Volcanoes, earthquakes and hurricanes threaten human lives and property and therefore create *problems*. Such problems create *issues* when we disagree over who should pay to restore damaged property or to protect lives. The loss of biodiversity creates environmental problems, but it also creates issues. There are conflicts over what the status and importance of biodiversity might be, the best means of managing biodiversity, the relative value of biodiversity benefits and many other aspects.

Not every environmental management problem creates issues. But 99% of them do! If an environmentally literate citizen is going to be effective at environmental problem solving, many of the action skills required relate to issues or conflict resolution. Educators (as well as policy makers) who must deal with environmental issues would benefit by understanding the dynamic nature and the important components of issues in general. A basic approach to issue analysis should include: (1) the developmental nature of issues and (2) three components of issues which have implications for environmental education.

The Developmental Nature of Issues

Issues can often be seen to develop over time (fig. 8). They begin at an early (latent) stage when the potential for conflict originates, but few people have yet identified or focused on the possible issue. Actually, at this stage, it is a non-issue. But, as we shall see, a very important stage to be considered. At the emerging stage, some stakeholders have become concerned about the problem. Members of a stakeholder group may be communicating among themselves concerning the issue, but not to other groups. At the emerging stage, there is growing concern, but very little effort at resolving the issue. At the existing stage, stakeholders are communicating their concerns to each other and to environmental management agencies or governments. People are taking action to get the issues resolved. If these efforts are not successful, the issue may develop into the disruptive stage where stakeholders have taken strong positions on the issue.

At this stage, there is a tendency for little meaningful communication to be exchanged between conflicting groups. Stakeholders seek legal and/or political means to protect their own interests. Very often the disruptive issue is characterized by emotionally charged public participation. Stakeholders are strongly polarized on the issue. The term "disruptive" is used to describe this stage because the processes involved disrupt the normal process of management. For example, when citizens fear that a government wildlife agency is not adequately enforcing laws to protect biodiversity, they may

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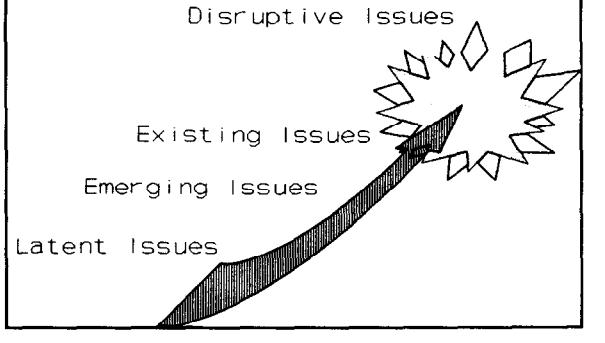
[3]"Stakeholder" has become an accepted term among professionals who study or manage natural resource issues and is used here for convenience.

request judicial intervention to force the agency to comply with their wishes. If the court concurs, the management decision no longer rests with the normal authority (i.e., agency), thus the issue has become disruptive. This is not necessarily wrong, since there is no reason why environmental issues should not be resolved through political or legal means as other social issues are. However, as we shall see, there are distinct advantages to avoiding the disruptive issue stage if it is possible.

Figure 8. Most biodiversity issues proceed through stages to become more intense, political and difficult to resolve.



Of course, not all issues go through this development. Some are resolved early and never become disruptive. A few might be viewed as unimportant and never develop at all. And many go through the development so fast that they seem to begin as disruptive stages. However, this process of developing issues is important because it has several implications for environmental educators.

Implication 1: The ability of citizens to behave rationally often diminishes as an issue progresses towards a disruptive stage.

People experience stress when a situation includes surprise, threat and a short time to react in. While mild stress may improve problem solving, in extremely stressful situations behavior is usually characterized by several features which make objective, rational issue analysis and problem solving difficult. For example, stakeholders in a stressful conflict will fail to consider other values, narrow their perspectives, reject new information, and be unwilling to consider other alternatives. These and other such behaviors make severe stress undesirable for issue resolution, since objectivity is impaired.

As issues approach the disruptive stage, perceived threat (risk) and limited time become more critical, and the level of stress increases for stakeholders with strong interests. The behaviors associated with stress are more likely to occur in later, more intense stages than at earlier issue stages. If citizens could attend to latent or emerging issues rather than existing or disruptive stages, a more objective approach to problem solving would be possible. *The difficulty is in motivating citizens to get involved before issues become intense and stressful.*

Citizens need to understand the reactions of themselves and others to stressful, intense issues, and develop means of maintaining objective problem solving processes even in disruptive issue stages. The environmentally literate citizen will engage in proactive issue management and attempt to reduce environmental management by crisis.

Implication 2: During stressful situations, individuals rely on thoughts and problem solving devices that they have developed previously.

Another feature of stressful behavior is that people tend to fall back on habit or previously learned responses. Often this leads to failure to objectively think through a response to the situation. However, if citizens have become habitual users of productive problem solving (e.g., collecting and analyzing information, considering alternative values) they are more likely to use these even during moderately stressful environmental issues. Thus, an undesirable response to stress (reacting automatically) can become a benefit if environmental education is successful in preparing citizens to utilize effective, objective problem solving processes.

Implication 3: Environmentally literate citizens can become more effective by learning to identify issue stages and monitor trends.

The creation of new product markets today can result in serious impacts for biodiversity around the world tomorrow. The development of new technology can open up opportunities to exploit unregulated species or habitats. For example, new fishing technology (nets, electronic gear, refrigeration, etc.) has endangered fish species that were previously unprofitable to harvest. Innovative methods of harvesting and transporting lumber have jeopardized previously untouched mountainous habitat. New demands for various hides and furs have stimulated overharvest of species and threatened them with extinction. Changing land use practices even on a smaller scale (e.g., agricultural, forestry or recreation) may suggest serious consequences for local biodiversity.

The best time to develop and implement management plans to guide the use of new technology or opportunity is early, when the trends or potential uses are first noted. Management plans to regulate and protect the resource commons are more likely to be successful if they can be completed before new stakeholders establish destructive practices and/or organize powerful vested interest groups to oppose management efforts. Environmentally literate citizens need to understand the importance of--and be skilled at--monitoring and interpreting trends in our natural and cultural environments so that latent problems and issues can be identified and dealt with at earlier rather than later stages. A subset of this implication is that environmental education should familiarize students with the skills and processes of planning.

Implication 4: If issues are not resolved and they become disruptive, they often enter the judicial or legislative process where decisions are generally made on a political rather than ecological basis.

As we shall discuss later, most issues involve value conflicts which are very difficult for stakeholders to resolve among themselves. Important biodiversity issues which cannot be resolved early, often are subjected to judicial or legislative procedures to work out solutions. By their very nature, these are political and not scientific processes. As with any problem solving, there are both strengths and weaknesses of these processes.

On the positive side, judicial and legislative processes are designed to represent and consider many values and interests in an issue. Therefore, if environmentally literate citizens are prepared to participate in the political decision-making process (Goal Level IV), they have an opportunity

as individuals or groups to act as proponents of biodiversity values. Additionally, even though these processes are slow, legal and legislative bodies may be able to provide closure on issues that could not otherwise be settled since they have more authority than most resource management agencies.

However, a weakness of these legal and political procedures for biodiversity (and environmental) management is that during the political process, short term values often are given priority over long term benefits. Further, values which can be measured in economic terms are more easily considered and given more weight than values which are not easily quantified. Therefore, ecological benefits are often overshadowed by shorter term economic and similar benefits of biodiversity management.

Certainly, many biodiversity issues will enter disruptive stages and have to be resolved through political or legal actions because of their complex and often international nature. *Environmentally literate citizens must be prepared to participate in these processes, in addition to being skilled at efforts to resolve many of these issues at early stages.*

Identifying Some Critical Components of Biodiversity Issues

Biodiversity and other environmental issues are usually complex social phenomena with many critical components that should be analyzed and considered in working towards resolution. Following are three such components which provide guidance to educators dealing with biodiversity/environmental education:

1. the status of our scientific and technological knowledge regarding the issue,

2. the extent and accuracy of the knowledge (beliefs) held by stakeholders in the conflict, and

3. the values and assigned priorities held by the stakeholders.

Status of Our Scientific and Technical Knowledge

For any biodiversity problem or issue, the number of alternatives we can consider is limited by the ability of our scientific and technical information to suggest them. The complex ecological nature of biodiversity issues makes this an important component to consider, because our science is often not adequate to suggest and/or evaluate alternative solutions. This is not unusual. Our world is complex and we do not fully understand any of its processes or components. Any time we make decisions, there is some degree of uncertainty because our science cannot predict results with 100% assurance of results. Further, this uncertainty is often accompanied by risk to something we value. Risk influences the development and the intensity of the issues associated with the problem.

In spite of the fact that science can never provide us with perfect answers, it is the best basis we have for decision making. In any issue or problem, we must evaluate the adequacy of our science in

generating or evaluating alternative solutions. This allows us to assess uncertainty and associated risk, if any. If decision time is short, we must often make decisions even if the scientific basis is grossly inadequate. Basing our decisions on whatever information science can provide may be better than a total guess or making our decisions by default.

As a case in point, consider the difficult challenge of determining which tropical forests are most deserving of protection from critically needed economic development and land use. If scientists had a hundred years to complete their studies of tropical ecosystems, they might understand the rain forests well enough to answer such questions with adequate certainty. Unfortunately, they do not have a hundred years. In some cases, they don't have even one year! For economic, social and political reasons, we are being forced to make decisions immediately as to whether certain rain forest habitats should be protected. Since we do not have complete scientific data, what should be done? Should we simply not develop any rain forests further unless we know for certain what the ecological consequences will be? It is not likely that the world society will forego such use for that period of time. Should we then ignore the potential risks of biodiversity loss and simply let the market place determine what ecosystems will be destroyed and what biodiversity can be lost? The risks involved make this an equally unacceptable solution.

Four scientists have taken the position that a little information is better than none at all in making such decisions (Roberts 1991). They have developed the Rapid Assessment Program (RAP) which uses the limited scientific processes and information now available to make recommendations for protecting certain ecosystems from destruction. These scientists go into threatened areas and, in a very short time, collect data that will help decide which of these areas are most deserving of protection. Their methods are dependent on the special talents of these four scientists in identifying bird and tree species and, to a lesser extent, mammal species. The RAP team assumes that since trees and birds are such dominant and important species in the rain forest, the number and kinds of tree and bird species will act as overall indicators of the richness and importance of biodiversity in a given tract of rain forest. Based on their assessment, they then make projections as to the potential loss of biodiversity and make recommendations regarding the importance of the region and its need for protection. Some scientists and environmentalists endorse this approach that at least some assessment is better than none at all.

However, the RAP method has itself become an issue. Some scientists have said that the methods used do not have scientific value and therefore, information generated by the RAP team is worse than no information at all. For example, the RAP team does not always sample an area during all seasons, and some (bird) species may not be evident at certain times of the year. Other scientists point out that more difficult species to identify and count (e.g., ants, butterflies, reptiles) may actually reflect more important biodiversity. Further, the number of bird and tree species may not accurately indicate the true value of biodiversity in a region. Whether or not the RAP method is an answer, the situation serves to illustrate the critical aspect of the scientific, technological component of many biodiversity issues.

It is clear that our current ecological science is not adequate. We do not yet understand ecology well enough to evaluate alternative solutions, to suggest risk-free biodiversity management plans and

to resolve biodiversity issues and problems. The implications for environmental education are that students must be prepared to...

...understand the nature of scientific processes and information, and the role of science as a problem solving process for biodiversity and other issues.

...seek informed sources to evaluate the adequacy of science to provide solutions to a particular biodiversity problem and identify the extent of uncertainty and risk associated with selected alternatives.

...recognize the valuable yet tentative nature of scientific knowledge and support the need to make timely decisions with the best science available when necessary.

...remain informed on critical principles of science and technology with important implications for biodiversity management.

The Status of Stakeholder Beliefs and Values

The Role of Beliefs in Issues

In Chapter 2, we discussed the importance of beliefs (our perception of reality or knowledge) and values (our standards of importance) in forming attitudes. Conflicts in both beliefs and values of stakeholders can be--and usually are--critical components of an issue. However, in some issues, stakeholders may agree on what is important (values), but disagree on what to do about an issue (differing beliefs) (fig. 9). Endangered species protection often includes issues where all stakeholders agree that preserving the species is the priority value, but disagree on how it should be accomplished. For example, many agree that the African elephant is endangered and that it is important to maintain the species. However should it be done by placing a ban on ivory products in an effort to destroy the economic incentive to poach elephants? Or should it be done by encouraging community ownership and economic benefits from managed elephant herds? In Zimbabwe, this latter approach led to responsible management and protection of the elephant population.

Figure 9. A simplified analysis of the African elephant issue to illustrate conflicts in beliefs.

Type of Conflict	Issue	Status of Sciences	Belief Conflict
Beliefs	How do we protect the African Elephant from illegal harvest stimulated by the market for ivory?	In this case, our socio-political as well as ecological sciences cannot provide a basis for a risk-free management plan.	#1. We can eliminate all illegal harvest by removing all economic benefits: ban ivory trade; vs, #2. We can achieve protection by citizens through ownership and economic benefits of managed, regulated elephant herd

Often conflicts in beliefs of stakeholders occur because our scientific knowledge base is incomplete, but sometimes it is because some of the stakeholders are uninformed. If appropriate information is available, this type of issue would be easiest--although not necessarily "easy"--to resolve through education. If we knew with certainty the most effective means of protecting elephants, we might be able to get agreement on a management strategy.

Although our beliefs reflect what we perceive to be true in a situation, not necessarily what is actually true, beliefs play a powerful role in our positions in conflicts. We use our beliefs to identify the consequences of various situations. Someone who has knowledge about the processes and importance of species interactions in a tropical rain forest, is more likely to consider the ecological consequences of losing rain forests than one who does not have such knowledge. Often, we evaluate issues with our current belief system and fail to use educational processes to ensure that our beliefs reflect the most accurate and current information available. This is partly because it is sometimes difficult to handle and conceptualize enough information to do a thorough job of evaluating alternatives in a complex issue. At other times, we are so focused on defending certain values, we fail (refuse) to accept information which conflicts with our current understanding. In such cases, we often consciously or unconsciously accumulate information strictly for the purpose of defending our position. While this is all natural, it is not an objective process and does not lead to the most comprehensive consideration and selection of alternatives.

The implications of the nature of belief conflicts in biodiversity issues for environmental education are:

1: stakeholders must be prepared to objectively evaluate their belief systems and the belief systems of others to determine how adequate those belief systems are for the task of evaluating and selecting alternatives in an issue.

2: effective, current and pertinent information must be presented to citizens regarding biodiversity issues.

3: citizens must be prepared to locate and utilize sources of information which will serve to update their own belief systems regarding biodiversity and associated issues and problems.

The Role of Values in Issues

Issues also exist where stakeholders agree on what is true (beliefs), but disagree on what is most important about the issue (values) (fig. 10). A case in point would be a proposal to destroy a large tract of wetlands in order to allow development for industrial sites. Both sides (developers and protectionists) may agree on the ecological and sociological consequences of the proposed development; however, the pro-developers value the benefits of industrial land use, while protectionists place priority on the ecological benefits. This represents a conflict of basic values. Issues involving value conflicts are the most difficult to resolve because we have not found proficient means to work through value conflicts at local, regional or international levels. When value conflicts cannot be resolved between stakeholders, they usually become disruptive and enter the judicial or legislative process where decisions are generally made on a political rather than ecological basis.

Figure 10. An illustration of the role of values in a biodiversity issue.

Type of Conflict	Issue	Status of Sciences	Value Conflict
Values	Should a large tract of wetlands be protected or used to develop an industrial site?	Ecological science is adequate to describe the values of wetland and the impacts of development.	#1. Ecological benefits of the wetlands deserve priority consideration; vs #2. Short term economic growth is of more importance than this particular wetland and associated biodiversity.

Unfortunately, value conflict is a key component of most issues. Environmental education must prepare students to analyze two aspects of the value conflicts:

1. What are the values and the priorities being advocated by each of the stakeholder groups in the issue?

Resolving value conflicts will require attention to all of the values in the conflict, not just those that are most obvious. Knowing the value positions provides opportunity to find similarities and potential partnerships among stakeholders. It may also identify needs to make some of the stakeholders more aware of values they have not yet considered. Most importantly, until all values are considered, it will not be possible to evaluate alternative solutions effectively.

2. To what extent have the stakeholders clarified their own values and established priorities?

Stakeholders are not always clear about what is important in an issue. They often misunderstand their own values and overlook the values of other stakeholders. For example, when preservationists work to set aside large areas of threatened rain forests and prohibit any human activity, including subsistence hunting and gathering by indigenous people, have they consciously made the decision that the benefits of total preservation are more valuable than the diversity of human culture? Perhaps, but in many cases, humans tend to simplify issues and respond to values which are most salient at the time.

Issue analysis should attempt to determine the extent to which stakeholders have engaged in these critical processes of understanding their own values and those of others. Environmental education should prepare citizens who understand this need and who have the skills to effectively clarify their own values and establish priorities.

What are the Values of Biodiversity?

In our sophisticated global economy, decisions are increasingly based on economic criteria. What something is worth in the market place usually presides in determining its use. Economics is the science dedicated to determining the worth of goods and services, primarily based on the values established in the market place. When we buy a loaf of bread in the market, we express a value for the bread. Economists have developed sophisticated means of estimating and working with these market values to determine the total value of the bread or some other good or service.

These principles of economics may be applied to the task of establishing values for natural resources that can be bought and sold, and thus have market value (e.g., fish, lumber, furs). We can even place some form of value on unique, diverse ecosystems as tourist attractions. Ecotourism is becoming more popular as people travel great distances to see, study and enjoy endangered ecosystems (e.g., tropical rain forests) or species (e.g., whales). Their willingness to pay to visit these sites provides some basis for estimating resource values.

However, there are some values of biodiversity that are difficult to measure. How do we measure the value of polar bears to a person who never cares to go to their natural habitat to see them, doesn't want to buy the fur of one, but who's quality of life is enhanced by knowing that polar bears exist? Of what value are the countless species which have become symbolic features in human culture, quite separate from their use for utilitarian purposes (e.g. food or fur)? Is the value of a tropical rain forest only measured by what people will pay for its lumber, furs, medicines or

recreational opportunities?

Resource economists are developing various means of estimating these "non-market" values. For example, they have defined some as "option values". What is it worth to someone to preserve the option to use a resource sometime in the future? How much would someone in Europe be willing to pay in order to insure that polar bears would continue to exist so that they might someday go on a polar bear photographic safari? "Existence values" capture another nonmarket value. How much would a person in England be willing to pay to preserve polar bears just so they would know polar bears exist; even though they had no desire to see, hunt or photograph them? These monetary estimates of biodiversity values are important as we make difficult choices in our economically minded global society. However, these assigned values do not represent the full range of values which people may hold towards biodiversity. Other social scientists work to identify this broader range of held environmental values. They are less concerned with quantifying the assigned values--market and non-market values--which economists work with. For environmental educators, an understanding of the range of held values will be useful in developing and implementing environmental education programmes. A model of attitudes towards animals developed by Kellert[4] (1976), serves to illustrate the range of values which may be held towards biodiversity and influence the development of biodiversity issues and management decisions (fig. 11).

These attitudes are not mutually exclusive. Each of us has a profile of attitudes or values regarding an environmental attribute (e.g., biodiversity). Attitude profiles of the American public, trained wildlife managers and public school teachers in Michigan and Missouri are presented in (fig. 12). It is not surprising that trained wildlife managers have very strong ecologistic and naturalistic attitudes[5]. School teachers have profiles identical to those which Kellert found for college educated respondents in the United States and tend to have stronger moralistic and humanistic views than managers or the general public. However, the important point is that all groups on the graph show some evidence of all attitudes in the model. The important differences are the relative strengths of these values.

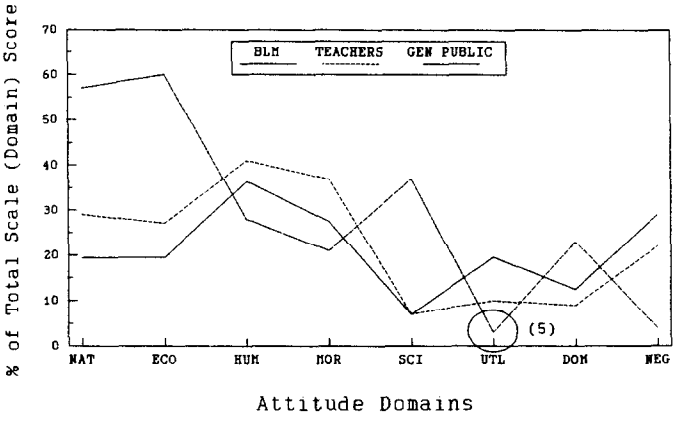
[4]While this attitude model was developed to describe attitudes towards animals, it reflects basic held values which are useful to describe orientations toward natural resources. The senior author has adapted the model considerably for use in research on public attitudes towards environmental issues and the version presented in this discussion does not necessarily reflect the thinking of Dr. Kellert.

[5]Actually, wildlife managers should have a strong utilitarian value, not the very low value shown here. This low score on the utilitarian attitude is probably due to the nature of the questions which attempted to measure this attitude on the original research measure. Some of the questions asked respondents to choose between development and protection of unique ecosystems. Even though the biologists are resource use-oriented by training and profession, their strong ecologistic values would prevent them from choosing the development option in the questions.

Figure 11. Basic domains of attitudes regarding animals and the environment. The attitudes reflect basic values which are useful in understanding biodiversity issues. (Adapted from Kellert 1976)

DOMAIN	PERSPECTIVE
NATURALISTIC	AN AESTHETIC VALUE PLACED ON UNDISTURBED AND/OR NONHUMAN QUALITY
ECOLOGISTIC	VALUE OF THE DYNAMICS AND PRINCIPLES OF ECOSYTEMS; EXTENDS BEYOND VALUING A HEALTHY ENVIRONMENT FOR THE SAKE OF HUMAN SURVIVAL
HUMANISTIC	BELIEF THAT ANIMALS CAN SUFFER; VALUE PLACED ON THE WELL BEING OF INDIVIDUAL ANIMALS OR OTHER ENVIRONMENTAL ENTITIES;
MORALISTIC	BELIEF THAT ANIMALS AND/OR OTHER ENVIRONMENTAL ENTITIES (E.G., SPECIES; PRISTINE WILDERNESS) HAVE RIGHTS TO EXIST; VALUE IS PLACED ON THOSE PERCEIVED RIGHTS
UTILITARIAN	VALUE PLACED ON ANIMALS OR OTHER ENVIRONMENTAL ENTITIES AS RESOURCES TO BE USED FOR THE SURVIVAL OF HUMANS
DOMINIONISTIC	BELIEF THAT HUMANS ARE SUPERIOR TO OTHER SPECIES AND VALUE PLACED ON ABILITY TO DOMINATE AND MANIPULATE THE ENVIRONMENT
NEGATIVISTIC	BELIEFS THAT ANIMALS OR OTHER ENVIRONMENTAL ENTITIES ARE DANGEROUS OR UNDESIRABLE; REFLECTS A LOW VALUE HELD FOR ENVIRONMENTAL CONTACT

Figure 12. Attitudes towards wildlife resources among professional wildlife managers (BLM), teachers and citizens of the U.S.A. (Peyton and Langenau 1985, Seimer et al 1987, and Kellert 1976).



Some of these attitude profiles and associated values have particularly important implications for biodiversity issues. For example, someone with a strong *moralistic* attitude accepts that the natural world has some inherent rights to exist, and places a strong value on those rights. This attitude places the rights of ecosystems and species on a par with those of humans. A strong moralistic attitude is not compatible with a view that the ecosystem is a human resource. People who hold strong moralistic attitudes in combination with strong *ecologistic* and weak *utilitarian* attitudes, often advocate complete protectionism in biodiversity issues. If this position is maintained, it is difficult to negotiate issue resolution and compromise.

Contrast the moralistic protectionist with someone who has very strong utilitarian and ecologistic values and recognizes the potential benefits of biodiversity to be derived by current or future generations. The positions of both will be to protect biodiversity (Figure 13). However, the utilitarian perspective is more likely to be accepting of management. A utilitarian approach might be to actually find more uses of biodiversity to enhance its value to society and thus assure its existence over time through conservation rather than preservation. (This is not meant to imply that preservation might not at times be an appropriate management strategy. The example is being used here to illustrate the different perspectives and strategies involved.)

Figure 14 applies these attitudes in a more complex analysis of the issue regarding African elephants. Earlier the controversy was used to show the conflict of beliefs. However, value conflicts are involved as well, since many who wish to ban the ivory trade are motivated by moralistic and/or humanistic values and also seek to protect individual elephants from any form of hunting. Utilitarian value priorities are being reflected by those who advocate protecting the elephant species as a valuable economic resource. These supporters may also have humanistic and moralistic attitudes. They wish to protect the individual elephants from unnecessary suffering or poor treatment, but place the highest priority on the welfare of the species.

Figure 13. Diverse attitudes support the same environmental behavior.

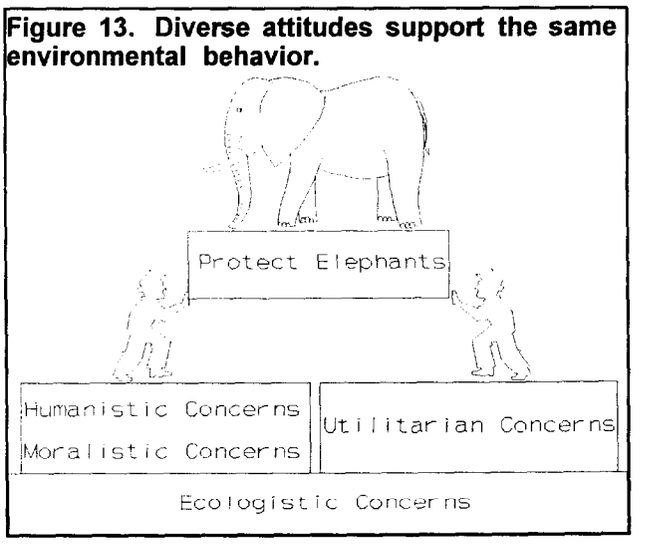


Figure 14. A more realistic analysis of the African elephant issue which shows the role of value as well as belief conflicts in the controversy. The differences in humanistic, moralistic, and utilitarian priorities may play a key role in this controversy.

Issue	Status of Sciences		Position on Issue	
			Ban Ivory Trade; Destroy Economic Incentives	Develop Protection Through Economic Incentives
How do we protect the African Elephant from illegal harvest stimulated by the market for ivory?	Some need for scientific basis: E.g., Socio-political science cannot provide a basis for controlling illegal behaviors. Ecology is not adequate to design risk-free wildlife management plan given the stressed population and habitat conditions.	VALUES	Value Elephants Moralistic, Humanistic Priorities Ecologistic Values	Value Elephants Utilitarian Priorities Ecologistic values
		BELIEFS	Elephants have rights Ivory trade will destroy the species	Elephants are resources Ivory trade provides incentive for protection and management

Stakeholders on either side of an issue who have a narrow perspective of values, often make issue resolution difficult. If these stakeholders are highly motivated, skilled, and/or powerful members of their society, they may actually win their side of a specific issue. However, if biodiversity is to survive, and if current and future generations are to derive necessary benefits, biodiversity will have to be managed to realistically provide for the diversity of values held in our global society. Therefore, it is more desirable to have stakeholders in a biodiversity issue who recognize and respect a wide range of values rather than stakeholders who are strongly polarized around only some.

Two critical implications exist for environmental education...

1...environmentally literate citizens must recognize and respect a wide range of values in addition to their own, and be willing to work to find ways to optimize use of our biodiversity to serve a multitude of needs.

A word of caution may be appropriate here. Research has clearly shown that as people become more understanding of other perspectives (e.g., values, consequences) in an issue, they become less disposed to becoming involved and taking action. It becomes harder for an individual to take action on an issue position when they understand and respect the position of others. Environmental education programmes must make the learner aware of this tendency. The environmentally literate citizen must understand that knowing both sides of an issue does not remove the responsibility to participate in making difficult choices.

2...communication skills are imperative for the environmentally literate citizen if difficult value conflicts are to be resolved at early stages of issue development.

We have already established the desirability of working to resolve issues at early rather than disruptive stages. Consider the benefits if local groups were able to work through issues revolving around local land use decisions and develop alternatives which were acceptable both to proponents of local biodiversity and to the needs of the local economy. This is a rare accomplishment today, in part due to a lack of skills among stakeholders to communicate effectively on sensitive, emotional matters. Whether it is on a local or international level, or at an emerging or disruptive stage, resolving issue conflicts between stakeholder groups will require effective communication processes.

Experts in conflict resolution are refining special techniques which may be used to facilitate the difficult process of communication. The skills involved are all interpersonal communication skills that may be applied to nonformal interpersonal exchanges or to highly structured interactive group meetings. Some of these interactive meetings are well known, such as the nominal group technique which serves to overcome some of the difficulties of communication by assuring that all participants have an equal opportunity to express ideas. A more complicated meeting format is the facilitated group meeting in which a trained facilitator uses a host of techniques to guide participants through difficult decision making.

Many professional managers who must manage issues are becoming more proficient at using such techniques to replace or supplement formal public hearings in which communication tends to be unidirectional--from stakeholders to the management agency--and fails to achieve effective communication between stakeholder groups. However, these advances will be of limited value unless citizens are prepared to participate in them. Citizens must be skilled in the personal communication processes, and they must also be aware of the effectiveness of at least some of the group techniques which are available.

Environmental educators should teach the skills of group problem solving and communication and provide opportunities for students to experience effective methods of communication. Role playing is one strategy which provides such an opportunity. In environmental education, role playing is often used to simulate participation in an environmental issue and to provide learners with an opportunity to apply knowledge and become sensitive to alternative value positions. Role playing scenarios could also be created to allow students to simulate the resolution of certain value conflicts. However, to be truly effective, role playing must be accompanied by an explicit treatment of the communication process involved in the activity. For example, the role playing might be preceded by describing the process of communication which is needed to achieve objective consideration of alternative values. Following the role play activity students could analyze the specific communication skills which were used, how effective they were, and what alternative approaches might have been used by the groups. If possible, students could be encouraged to attend various public meetings and analyze the communication (meeting) format and evaluate its effectiveness.

Simply using such group problem solving activities is not sufficient. The educators must fully understand the processes and goals to be achieved so that they maximize the opportunities to educate environmentally literate citizens.

Why is Biodiversity Management Difficult?

Since biodiversity is a commons, it must be managed by society as a whole to be protected. Management of a commons for a global society with diverse values and needs will necessarily create issues. Obviously the nature of environmental issues in general and biodiversity issues in particular is complex and difficult. Biodiversity issues are made especially difficult because of a lack of scientific information to serve as a basis for identifying problems and evaluating solutions. However, they are also difficult because our global society does not share even the limited understanding which our science currently provides.

Nor do our world citizens understand the important values of biodiversity. But even if our science was more complete and our world citizens knowledgeable about the status and benefits of biodiversity, we would still face difficult value conflicts over biodiversity. This is because we do not all value the same benefits to the same extent. The ecological benefits to be derived by managing for biodiversity are long term benefits which are often rejected in favor of shorter term benefits. At times these short term benefits are critical needs for some stakeholders and the decision to preserve biodiversity appears to set priorities for the well being of future generations over those now living.

A controversy involving the Pacific Yew along the western edge of North America provides an excellent illustration of the conflict between current generations and future generations. Recently, it has been learned that the bark of the Pacific Yew can be used to produce a drug which may cure cancer. The drug, taxol, is particularly effective for ovarian cancer. Unfortunately, it takes all of the bark from three 100-year old trees to produce sufficient quantities of the drug to treat one cancer patient. Still more unfortunately, the Pacific Yew and its old growth forest habitat is already threatened because of past lumbering activities. If enough bark were harvested to meet projected needs for taxol, the Pacific Yew would be seriously endangered, and the habitat which it is a part of would be drastically altered.

A major controversy surrounding the use of the northwest old growth for lumbering existed even before the issue over the Pacific Yew. Environmentalists have been working to halt the harvest of old growth in order to protect what little of this habitat remains. In addition to their concern for biodiversity in general, there are several species such as the spotted owl which are eminently threatened by continuing harvest of the forest. The efforts of these environmentally concerned citizens to protect the remnants of this unique ecosystem from logging, would also prevent the harvest of Pacific Yew. Thus, preserving biodiversity threatens the lives of women who are afflicted with ovarian cancer. Ironically, one of the benefits of biodiversity--that of providing a source of medicines for humans--may be denied to those who need it, in order to preserve biodiversity itself! The conflict is painfully clear. Should we preserve the northwest old growth habitat for future generations, or use it to maintain life for some of today's generation? As we learn more about biodiversity and its benefits, it becomes clear that it is not just future generations which will depend on it for survival. The value choices are not easily made.

What Does the Nature of Biodiversity Issues Mean for Environmental Education?

The role of environmental education in this difficult resource management problem becomes more clearly defined and important when the nature of issues is considered. Education must train new scientists to be capable of researching the complexity of ecosystems and providing the information base we need to make effective decisions. Current and future policy makers must be prepared to acknowledge the important values of biodiversity and to integrate these values into our world policy. And environmental education must produce an informed world citizenry capable of working through difficult choices.

Section 3: Environmental Education Strategies for Biodiversity

CHAPTER 6:
Infusing Biodiversity/Environmental Education in the Curriculum

Where and How Do We Teach Biodiversity?

Several recommendations were introduced in Chapter 2 regarding the selection of teaching strategies for environmental education. Here, those recommendations are applied in more detail to the task of biodiversity education.

Recommendation 1:
Environmental education is most effectively implemented in an infusion model.

Thus far, we have established that, while *biodiversity* is an ecological topic, *biodiversity problems and issues* are connected to every fabric of our global society. We must draw upon sociology, psychology, communications, economics, geography, history and many other disciplines in order to develop and implement resolutions to these complex issues. Our educational system should prepare world citizens to cope with biodiversity--and other environmental--issues by *infusing* the topic appropriately throughout these disciplines in the curriculum. Students whose only exposure to biodiversity problems is a short unit on ecology in their biology classes will be poorly equipped to understand and respond to biodiversity problems. Below are three ways that biodiversity education might be approached in a formal school curriculum to achieve all biodiversity/environmental education goal levels:

1. as a well coordinated infusion model in which appropriate environmental education biodiversity goals are achieved in selected disciplines, using teaching strategies and materials designed specifically for that purpose;

2. as a random infusion model in which teachers in the system are trained in biodiversity/environmental education so they can independently select/design methods to infuse biodiversity into their own teaching assignments;

3. as a self-contained comprehensive unit which is implemented in one course and covers all four goal levels regarding biodiversity problems.

To illustrate, if Activity #3 (Chapter 7) were being adapted for a well coordinated infusion model, the many disciplinary aspects of the activity could be separated and developed into smaller activities for use in appropriate classes. Students would learn of climate and cultural distribution in geography classes, and the distribution of ecosystems in a biology class. A "capstone" course (e.g., environmental education) in grade 12 might be designed to allow students to bring together their understanding of ecosystem distribution, cultural geography, and history to make the inferences regarding relationships between cultural and ecological distributions on the planet. Alternatively, in a random infusion model, the entire activity might be selected by a trained teacher. In this setting, there is no way to assure that students would be exposed sequentially in different grades and in

different courses to the necessary components. Therefore, the students would explore the entire activity in one class. This approach risks the possibility that another teacher might also learn of the activity and decide to use it as well. In this case, it would be repetitive for some students; for others it would be their first experience with the activity. The activity could also be selected for use as one of many activities in a self-contained, comprehensive unit.

Of the three approaches, the coordinated model is preferred, but is the most difficult to attain. In addition to teacher training, this model requires that the biodiversity teaching materials be designed and coordinated to fit a specific educational curriculum. It will also require a "capstone" experience; i.e., a culminating unit which allows the students to synthesize the component parts of the biodiversity topic into a cohesive understanding and set of competencies for responding to biodiversity problems (see Activity 8).

Although it is a more challenging model to implement, there are advantages to the coordinated infusion model. Those advantages discussed in Chapter 2 are reviewed briefly below:

1. The importance and critical nature of biodiversity problems will be reinforced by exposing students to the topic repeatedly throughout their secondary educational experience.

2. The need to accept environmental criteria in our personal and social actions--and the skills to do so--can be strongly reinforced by integrating (infusing) biodiversity criteria into the problem solving of various disciplines.

3. The coordinated infusion model allows educators to:
   ...take full advantage of the students' readiness and capability to learn,
   ...improve understanding and retention, and
   ...present complex, overwhelming problems in more solvable, understandable pieces.

A randomly infused biodiversity/environmental education model can potentially provide many of the same advantages of the coordinated model. However, without the structure of a coordinated curriculum, there is a greater chance that teachers may not use all opportunities to infuse biodiversity or other environmental education into their own teaching assignments.

A primary advantage of the comprehensive unit is that fewer teachers in a school system need to be trained in biodiversity or environmental education. The disadvantage is that this model lacks many of the benefits reviewed above for the infusion approaches. In some educational situations, it may be necessary to utilize a comprehensive unit or class rather than an infusion model for biodiversity education. Certainly, such an opportunity should not be passed up--especially in the absence of a fully infused biodiversity curriculum. A comprehensive biodiversity unit can be very effective if it is implemented in a curriculum which has an environmental education infusion programme in place. In this situation, biodiversity would be one of many environmental problems which might be dealt with in some detail as part of the environmental education curriculum.

A Coordinated Infusion Model

The specific design for an infusion curriculum is dependent on the characteristics of the secondary programme to which it is being adapted. The model presented in figure 15 is for the purpose of illustrating some opportunities for infusion in a listing of courses assumed to exist in a hypothetical secondary curriculum. It is recognized that some secondary programmes will offer more specialized classes (e.g., economics) which provide more specific opportunities for infusion. Similarly, some of the classes included in this model will not be universally offered in secondary programs. The teaching activities described in Chapter 7 serve to illustrate how some of these integrations may be achieved.

To illustrate the coordinated infusion model, consider how the range of benefits (Goal Level II: Conceptual Awareness Level; Figure 15) could be integrated into several disciplines. The ecological importance of biodiversity would be covered in biological science classes. In social science classes, the importance of biodiversity in forming cultural values and perceptions and in shaping the nature, vigor and economy of societies could be taught. Opportunities exist in art and in language arts for further reinforcing and exploring the relationships between cultural values and biodiversity. The importance of biodiversity to outdoor recreation applies to physical education. Many opportunities exist in health classes to show the importance of biodiversity as an indicator of environmental health and thus, a reflection of risk to human health. Similarly, agricultural practices often depend on natural resources directly related to the conditions related to biodiversity such as climatic conditions, soil fauna, genetic stock resistant to new diseases, etc. In a well coordinated infusion model, these environmental concepts would be presented to each student as they move through the secondary curriculum. Redundancy would be avoided--except where desired for reinforcement--by careful planning and design/selection of curricular materials. This model would necessitate some forms of "capstone" courses or units that would make students aware of how the various components needed to be integrated to understand the full significance of biodiversity/environmental education.

Recommendation 2:

Strategies that teach the inquiry skills needed for Goal Levels III and IV, should be considered as the core of the environmental education curriculum.

Inquiry skills (e.g., formulating problems, collecting information, analyzing and interpreting data, hypothesizing, issue analysis) are essential to the environmentally literate citizen who wishes to implement environmentally positive behaviors. Lecture--when properly done--is an effective means of disseminating information in some educational settings, but it is a very ineffective means of developing these inquiry skills, the attitudes and all of the knowledge required of an environmentally literate citizen. To become environmentally literate, students need to become ***involved*** with the subject matter; they need to ***practice*** the skills; and they must be given the ***opportunity*** to develop appropriate attitudes.

Two strategies that are especially effective in environmental education are the case studies

method and the autonomous investigation and evaluation model (Hungerford et al 1989). Both methods involve students with specific environmental problems and issues. However, in the autonomous investigation and evaluation model, the students work with issues which they select, and all aspects of the issue are independently analyzed by the learner. The role of the instructor in this model becomes one of supervision and providing feedback to the student.

Methods for using case studies vary, but student involvement is less autonomous and the specific issue or case is usually selected for the student. The case study model exposes students to one or more examples of an environmental problem or issue. Often these cases may include analysis done by someone else, and the student *observes* rather than *participates* in the process of applying knowledge and skills of issue analysis to selected cases. In the case study model, the instructor provides more structure and controls the extent, pace and method of study.

An effective use of the latter approach is to use case studies to illustrate and teach specific portions of the biodiversity curriculum framework (Goal Levels). For example, case studies could be used to introduce the concept of issue development and the desirability of proactive management rather than crisis management of environmental problems. Case studies of environmental issues which were ignored until they were critical could be compared with problems which were anticipated and planned for. The strategy might be to give students the principles of issue development and other concepts to be taught and ask them to identify these as they observe the unfolding of each type of issue. However, a more powerful approach would provide more opportunity for inquiry. Students could be asked to analyze the issues in order to formulate for themselves, the principles and concepts which describe the nature of issue development and the advantages of proactive planning and management.

In another example of case study use, instances of individual and group actions to implement solutions to biodiversity problems could be analyzed. Again, students are given the principles of environmental action and asked to identify examples of them in the case studies; or asked to perform the more powerful inquiry process using the assigned case studies to derive the action principles.

Case studies could be used in combination with the autonomous investigation and evaluation model to achieve the desired educational goals (fig. 16). Case studies might be used early in an infusion programme to illustrate certain concepts at Goal Level II. However, to introduce the inquiry processes at Levels III and IV, case studies could be used as deductive inquiry experiences. The culminating (i.e., capstone) experience in the infusion programme could then be an autonomous investigation and evaluation of a biodiversity issue leading to the student's formulation of solution and action recommendations. This involvement develops and reinforces students' Level III and IV skills.

The reader should consult Activities #3, #7, #8 and #9 for examples of biodiversity/environmental education activities which incorporate effective use of inquiry skills.

Figure 15. A model illustrating opportunities for teaching various biodiversity goal levels in a coordinated infusion framework. Primary responsibilities for contributions are indicated by "xx". Those marked with "x" identify disciplines which can make specific but smaller contributions to the goal level component.

GOAL LEVEL I: ECOLOGICAL FOUNDATIONS LEVEL	SCI	SOC SCI	LANG ARTS	PHYS EDUC	HEALTH EDUC	AGRIC	ARTS	MATH
...DEFINE BIODIVERSITY	XX	X				X		
...DESCRIBE WHERE BIODIVERSITY EXISTS	XX	X				X		
...DESCRIBE ECOLOGICAL IMPORTANCE	XX					XX		
...DESCRIBE FACTORS THAT THREATEN	XX	X				XX		

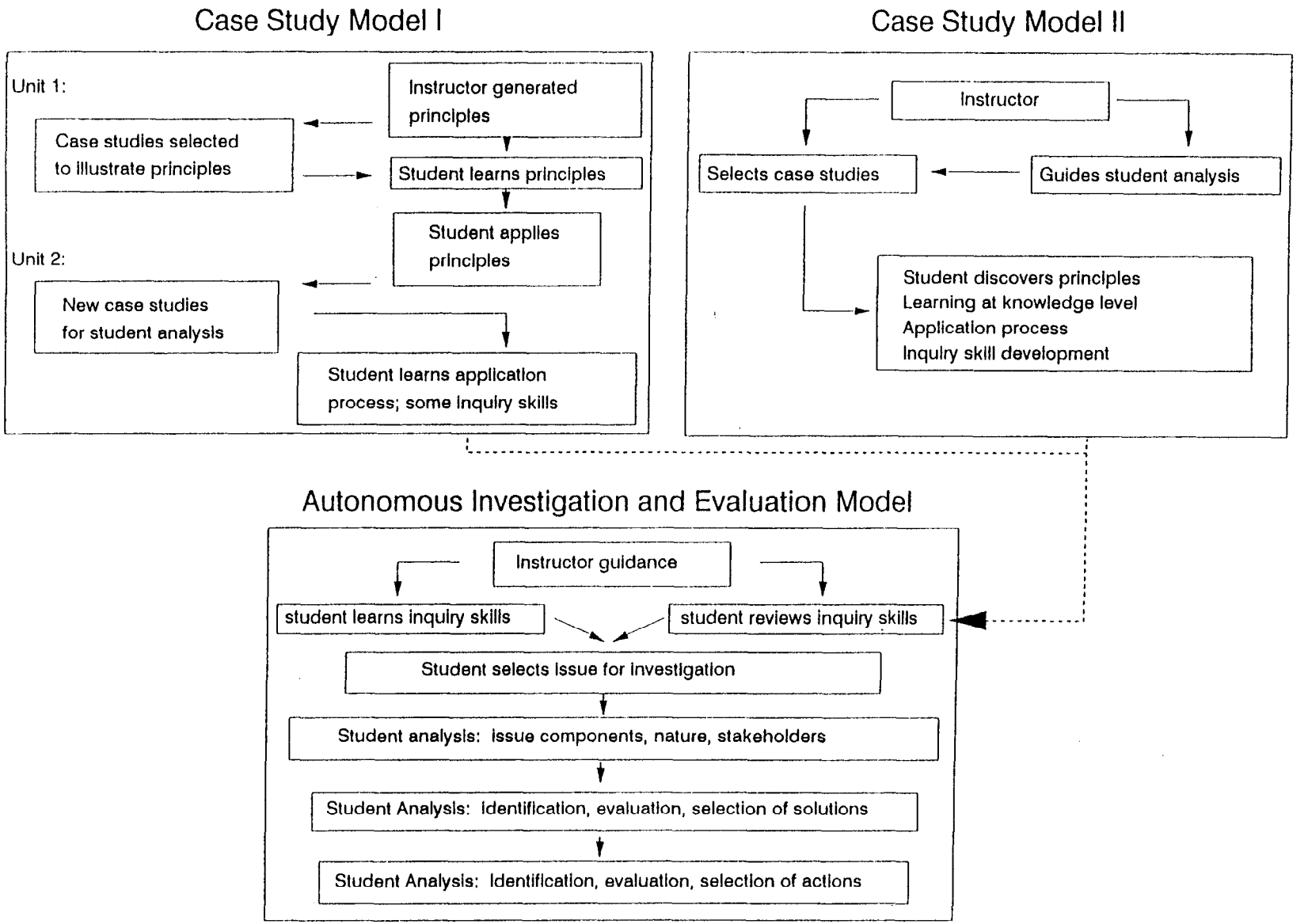
GOAL LEVEL II: CONCEPTUAL AWARENESS LEVEL	SCI	SOC SCI	LANG ARTS	PHYS EDUC	HEALTH EDUC	AGRIC	ARTS	MATH
...CURRENT, FUTURE BIODIVERSITY ISSUES	X	XX				XX		
...NATURE OF BIODIVERSITY ISSUES		XX	X					
...HUMAN BEHAVIOR IN STRESSFUL ISSUES		XX	X					
...RANGE OF BIODIVERSITY VALUES	X	XX				X	XX	
...RANGE OF BIODIVERSITY BENEFITS	X	XX	X	X	XX	XX	X	
...RELATIONSHIP OF CULTURE AND BIODIVERSITY	X	XX	XX	X	X	XX	XX	
...ROLE OF BEHAVIOR OF INDIVIDUALS		XX	X	X		XX		
...SCIENTIFIC, TECHNOLOGICAL MEANS OF MANAGING BIODIVERSITY PROBLEMS	XX	X				XX		
...SOCIAL, POLITICAL PROCESSES AND INSTITUTIONS FOR MANAGING BIODIVERSITY PROBLEMS		XX				X		
...LOCAL, REGIONAL, GLOBAL EFFORTS TO MANAGE BIODIVERSITY	XX	XX	X		X			

Figure 15, Continued

GOAL LEVEL III: INVESTIGATION AND EVALUATION LEVEL (THE ABILITY...)	SCI	SOC SCI	LANG ARTS	PHYS EDUC	HEALTH EDUC	AGRIC	ARTS	MATH
...AND WILLINGNESS TO MONITOR TRENDS...ANTICIPATE FUTURE IMPLICATIONS	XX	XX				XX		XX
...TO IDENTIFY AND INVESTIGATE BIODIVERSITY ISSUES; SYNTHESIZE INFORMATION	XX	XX	XX					XX
...TO ANALYZE COMPONENTS OF ISSUES (STAKEHOLDERS, STATUS OF SCI/TECH, VALUES, BELIEFS)	XX	XX	XX			X		X
...TO IDENTIFY AND EVALUATE ALTERNATIVE SOLUTIONS	XX	XX	XX		X	XX		X
...TO CLARIFY OWN VALUES AND PRIORITIES		XX	XX	X	X		X	
...TO IDENTIFY AND TOLERATE ALTERNATIVE VALUES AND PRIORITIES		XX	XX	X			X	
...TO PARTICIPATE EFFECTIVELY IN GROUP DECISION MAKING PROCESSES	X	XX	XX	X	X	X	X	X
...TO EVALUATE AND SELECT EFFECTIVE SOLUTIONS	XX	XX			X	XX		X

GOAL LEVEL IV: ACTION SKILLS LEVEL (THE ABILITY...)	SCI	SOC SCI	LANG ARTS	PHYS EDUC	HEALTH EDUC	AGRIC	ARTS	MATH
...TO PARTICIPATE EFFECTIVELY IN GROUP DECISION MAKING PROCESSES	X	XX	XX	X	X	X	X	X
...TO IDENTIFY, EVALUATE, SELECT ACTIONS TO IMPLEMENT SOLUTIONS	X	XX	X			XX		X
...TO EFFECTIVELY IMPLEMENT SELECTED ACTIONS	X	XX	X	X		XX	X	

Figure 16. Case studies may be used separately or in conjunction with the autonomous investigation and evaluation model.



Recommendation 3:

Strategies which explicitly teach about the role of values and valuing processes in environmental issues must be included.

In the early 1970's, some emphasis was given to *teaching* specific environmental values, i.e., indoctrinating students with the values associated with the environment. To some extent, this is defensible and desirable. Certainly, we recognize that environmentally literate citizens must place some priority on environmental values if they are to participate in the maintenance of environmental quality. That implies some degree of sensitivity to the environment, and that some appreciation or value be placed on its existence. However, this is not to suggest that they should necessarily be *indoctrinated* with a set of values and priorities. Rather, students should be made aware of these values, and provided the *opportunity* to adopt or reassign priorities to environmental values (e.g., become sensitive to and appreciative of the natural environment).

Primarily, this is because priorities tend to be abandoned if they were originally accepted through indoctrination rather than arrived at through a process of introspection and internal decision making. For example, consider a student who has accepted that the natural environment (e.g., biodiversity) is important because it was presented that way in the classroom. When confronted with conflict between these environmental values and their own value priorities (e.g., economic welfare) the environmental value is not likely to be given priority. The alternative is to have the student use classroom opportunities to arrive at that environmental priority *within their own value framework*; i.e., to consider both long and short term benefits and values involved, and to make *a priori* decisions about what is most important. In this case, it is more likely the relative importance will remain stable even when confronted with decisions contrasting biodiversity with other important values.

Certainly, in some situations students will not consistently choose to modify their own behaviors in favor of environmental values and at the expense of other values. Our goal must be to insure that these students are making *informed* choices which evaluate all known consequences against clearly identified values and with the best information available.

To accomplish this desired value education, strategies should be used which enable students to:

...understand the role of values and value conflicts in environmental issues;

...be aware of the wide range of values which affect environmental decision making;

...clearly identify values and priorities held by parties involved in or affected by environmental issues;

...identify their own value priorities and objectively evaluate the short and long range consequences of alternative actions; and,

...effectively work with others in a manner which tolerates values and priorities different from their own so that solutions to issues can be selected and implemented.

Several specific strategies exist for values education to accomplish the criteria above. The

reader is directed to Activities #1 and #5 in Chapter 7 for detailed instructions for using the moral dilemma method and the values continuum. An inquiry model which involves students in objectively identifying values and consequences of alternative solutions would accomplish many of these values education goals as well. Since this module cannot illustrate all potential strategies, the reader is encouraged to consult other sources referenced in the bibliography.

Recommendation 4:

Environmental education must utilize interactive group learning strategies in order to develop skills which enable them to participate in group problem solving during biodiversity issues.

The environmental education goal applies not only to the solutions and actions appropriate for the individual, but to the collective actions of local, regional and global societies. The need for the world citizen to work effectively with others was never more critical. Environmentally literate citizens must be capable of interacting with others in the process of investigating and evaluating issues, and in selecting and implementing actions. This is true for many reasons, not the least of which is the need to understand, tolerate and consider the values of others in the process of making environmental decisions.

Effective group problem solving can provide ideas which are far more powerful than those normally originating from a single individual. However, group problem solving is a difficult process for many individuals in many cultures. The skills of working in groups must be learned, and in many societies, that must be done as a part of formal education. Curricula and instructors should provide opportunities for dealing with environmental issues in small groups, and *should provide direction and feedback on the group processes involved* as well.

The following illustrates the educational approach desired. Students might be placed into groups and assigned a challenging problem task. For example, they might be asked to develop a list of benefits of global biodiversity, and then place a priority on the most important in the list. The object of the follow up class discussion would be not the biodiversity priorities, but the group process.

Leading questions by the instructor would initiate student thinking. "How do you think your group works together?" "What do you like best about working in groups?" "What do you like least about working in groups?" Responses to such questions are listed for the class to be able to see. Students will identify frustration at not always being able to get their ideas heard and/or considered. Some students dominate. Some students with good ideas, rarely contribute. Often the group doesn't stay on track and good ideas are mentioned but not developed or are lost altogether.

Students would then be asked to brainstorm behaviors that are very productive in groups, i.e., "what do people do in groups that really helps us to make progress?" " What kinds of behaviors make it difficult to work in groups?" Again lists would be generated.

If the teacher feels the class is capable, they might then be asked to formulate a set of rules for

working in groups that everyone should follow. Even the teacher's role might be described. This would provide a group of rules which students themselves have developed and would be likely to enforce among themselves.

Eventually, in this activity, the teacher should introduce some techniques that do assist groups in working together. The following processes are simple tactics for establishing a "safe" communication environment. These tactics encourage everyone to express their own ideas and provide respect for alternative thoughts. Many versions are possible, but simple rules such as these have been the basis for some very sophisticated and effective group processes.

Group Memory: One difficulty in group communication is keeping everyone focused on the same thoughts. Placing ideas on a flip chart with large sheets of paper serves this purpose. As sheets are filled, they are taped on a wall where everyone can see them and refer to them as the discussion proceeds. These become the group's memory and are extremely effective in focusing the communication.

Round Robin: This is a version of the nominal group method. When the group is brainstorming, they are given a few minutes (1 to 3) to consider the task independently. Students are sitting in a circle so that everyone can communicate if necessary. Then the discussion leader goes around the circle and invites each person, one at a time to contribute one of their ideas. The process continues until no more ideas are contributed. At this stage, there is no discussion of the ideas. The group's objective is to get all the ideas out so that they can be considered.

Following the brainstorming phase, each person can explain their own ideas, and answer questions for clarification. *It is the group leader's responsibility to keep the interaction non-threatening, so that no one has to defend their ideas, only explain the meaning!!*

Classification: Once all the ideas have been explained and are understood, the group can focus on combining ideas that are essentially the same and simplifying the list.

Setting Priorities: Each group member is given a number of red sticky dots (any color or shape that can be seen clearly). The number depends on the length of the list and how many priorities the group wishes to end up with. Each member goes to the list and places their number of dots beside the items they wish to give priority to. If each has three dots, someone may decide one item is so important that all three are stuck beside that item. At the end, all are tallied and priorities are established. This can be followed by further explanation and even a repeat voting process if the group feels it has shared more information and wishes to vote again.

For examples of activities utilizing group strategies, the reader should consult Activities #1, 5 and 9 in Chapter 7.

How Do We Evaluate Our Efforts At Biodiversity/Environmental Education?

Evaluation is a critical part of education. Educators traditionally deal with evaluation in terms of *how well the students are doing.* However, it is also vital to evaluate *how well the educational programme is doing.* We need to approach the evaluation of biodiversity/environmental education efforts from both perspectives--programme evaluation and student evaluation.

Programme evaluation can be divided into two phases. Formative evaluation provides feedback during the development of biodiversity curricula or teacher training experiences. As information is gathered during the formative evaluation, it is used to guide further development of the educational product. Generally, formative evaluation can proceed in segments, so that various components of the curriculum or other product are evaluated separately. Thus, teachers might be asked to review specific teaching activities and suggest changes. Some of the activities might be tried out in various classrooms; not necessarily as a cohesive unit, nor in completely finished form. Teachers or other professionals might be asked to look at the overall curriculum framework, goals or other components to provide input on them. Many sources of information might be used to guide development processes and suggest needed revision during the formative evaluation.

Summative evaluation involves a comprehensive evaluation of the entire product in its implementation form. Thus, summative evaluation requires that the programme be evaluated in its entirety, under the exact conditions for which it was designed. It is intended to evaluate all aspects of the educational programme, including: effectiveness of curriculum materials, use by teachers, and appropriateness of the implementation model. Information from the summative evaluation also provides information for further revision. However, its immediate use is to guide decisions regarding the use of the programme. Results of the summative evaluation may suggest which grade levels or discipline areas are more suited for the programme use. Additional teacher training might be suggested by summative evaluation of a new curriculum.

Both forms of programme evaluation would use broad sources of information in order to evaluate the usefulness of the educational product. In both cases, the evaluation should determine the extent to which anticipated and desired objectives are being achieved. Both should also determine whether any unanticipated outcomes resulted.

To illustrate the importance of this evaluation process, consider the following experience. An environmental educational programme which focused on the management of a North American game bird called the ruffed grouse was designed for middle school science classes by the senior author. An outside evaluator designed and analyzed the summative evaluation of the programme. The evaluator decided to determine whether the programme influenced students' perception of the status of the ruffed grouse population. Since the ruffed grouse is a popular and abundant game bird, this was not a concern of the curriculum developers. However, the evaluator found that the educational programme caused students to erroneously believe that the ruffed grouse was an endangered species. While the problem was easily taken care of by simple revisions, this result was a complete surprise and quite contrary to the actual goals of the curriculum. It would have been regrettable had the curriculum been distributed in its original form. The experience serves to illustrate not only the

value of an summative evaluation, but also the wisdom in having the project evaluated by someone other than the curriculum developer(s) who is free to investigate all important possible impacts of the educational product.

Evaluation can be based on several kinds of data collected on several components and from a variety of sources. Student achievement in knowledge, attitudes and skills can be measured to infer whether specific educational objectives were achieved. Some of these evaluation techniques regarding student achievement would also be useful for the classroom teacher to use in determining student progress. Teacher behaviors can also be assessed to evaluate the adequacy of curriculum instructions. It also might help to explain student outcomes from the programme. For example, low student gains on certain objectives might be due to teachers being unable to find time or resources to implement certain parts of the curriculum.

Measures of Student Achievement in Biodiversity Education

A cautionary note regarding the use of affective and cognitive changes is in order. The development of reliable and valid test questions is a familiar process to classroom educators. Most of us have accepted the difficulties of developing tests which effectively measure student knowledge and cognitive skills even though our interpretations of the results are often open to challenges. Since the challenges are often from students, they usually go unanswered and our method of evaluating students remains basically unchanged. However, this does not remove the limitations of our measures of student achievement. Measuring student attitudes is an even more difficult process. Further, classroom teachers are even less prepared to deal with attitude measures than cognitive measures. The methods described here illustrate viable approaches to evaluating biodiversity/environmental education impacts. However, since it is beyond the scope of this module to provide such complete background in evaluation, the reader is encouraged to seek additional assistance from individuals who have been trained in the development and use of these evaluation methods. This is especially true for measures in the affective domain.

Cognitive Gains

Measuring student achievement is a means of evaluating whether objectives developed for the biodiversity/environmental education unit were accomplished . These objectives should be based on the curriculum framework statements provided in Figure 4 (Chapter 2) and certainly should reflect the range of goal levels (I-IV). However, the planning of objectives and evaluations should also be guided by an understanding of the range of cognitive skill levels which can be included. Educators have long classified objectives according to the level of cognitive skill involved (Bloom 1956). These six levels range from "knowledge" (lowest) to "evaluation". An effective environmental education programme will include objectives from all levels. In our biodiversity curriculum framework, all six

levels of cognitive objectives would be developed for each of the four goal levels. However, Goal Levels III and IV would require a greater emphasis on (higher) objectives that require more cognitive skill (i.e., problem solving) of students. The following are examples of evaluation items for levels of cognitive objectives:

knowledge level: involves the recall of specific information and implies that at least the information has been memorized.

Example of knowledge level measure: "List the location of 15 recognized biodiversity hotspots."

comprehension level: implies an ability to translate information or skill from one form to another; suggests that the information is not only memorized, but understood to some extent.

Example of comprehension level measure: "Select three of the following biodiversity hotspots and explain in your own words why each area has been declared a hotspot by ecologists."

application level: involves the ability to apply information or skills to new situations, e.g, students understand an abstract idea well enough to be able to apply it to a specific (concrete) situation.

Example of application level measure:

"Before 1987, a species of toad known commonly as "golden toads" was restricted to a small area in the Monteverde Cloud Forest Reserve in the Tilaran Mountains of Costa Rica. More than a 1000 golden toads were observed mating and laying eggs along the streams in the reserve. In 1987, a severe drought occurred in this normally moist habitat. Today, the golden toad species is believed to be extinct.

Apply your knowledge of the nature of change and the value of genetic diversity to explain why the golden toad species could not adapt and survive."

analysis level: requires the cognitive ability to break an idea down into meaningful parts and discover the relationships among those parts.

Example of analysis level measure:

"Read the following description of the Pacific Yew in North America and identify the stakeholders in the issue and their primary concerns (values). Explain which values each group of stakeholders may hold in common and describe important differences in values and priorities among the stakeholders. Explain how these similarities and differences in values would be important to anyone interested in resolving the issue."

(see Activity #1 for a description of the Pacific Yew case)

synthesis level: involves the ability to construct new ideas or processes from components learned separately.

Example of synthesis level measure:

"From your experience studying about the biodiversity issue case studies we have examined in class, develop an outline which identifies the critical things which should be looked for by anyone who is trying to understand a biodiversity issue in order to discover alternative solutions."

evaluation level: requires the cognitive ability to make judgements based on an analysis of a situation.

Example of evaluation level measure:

"One solution to disappearing areas of high diversity such as mangrove swamps or tropical rain forests is to have the areas become the property of individuals or groups who wish to maintain the existing diversity. One action to implement this solution is for people in other countries to raise funds to purchase some of the land in order to prevent the people who inhabit the region from developing--and thus diminishing--the diverse natural resources. This is the Monteverde Rain Forest in Costa Rica was set aside. Select a biodiversity problem involving a developing country and evaluate this solution and action for that situation. Your evaluation should use ecological, economic, political, social and cultural criteria."

The examples above serve to illustrate the range of cognitive skills which need to be evaluated as part of a comprehensive biodiversity/environmental education programme. The examples are not intended as recommended questions that should be included in every--or any--situation. It should be clear that the higher cognitive skills are implicit in our biodiversity Goal Levels III and IV, however these goal levels may also include lower cognitive objectives. For example, it may be desirable for students to remember (knowledge) important sources of information about environmental laws or policies in their own government. This would enable them to achieve even higher level objectives of developing and evaluating plans of action regarding biodiversity/environmental issues.

It is not always necessary for the teacher to differentiate closely between various levels of objectives and evaluation items (e.g., synthesis vs evaluation levels). However, it is necessary to use a model such as that presented here as a planning guide to be sure the full range of cognitive levels are being taught and measured. Since low cognitive levels are easiest to measure, excellent--but busy--teachers too often fall into the trap of not spending sufficient time developing a full range of measures in their evaluation programmes. As a result, knowledge and comprehension items dominate most test and classroom questions. This indicates to students that these are the most important things to be learned and they concentrate on such "facts" and fail to work on the extremely important major concepts and processes. Given the curriculum framework we have presented (Figure 4) with the strong emphasis on problem solving skills, it is absolutely necessary that students

be focused and evaluated on far more than memorizing facts about biodiversity.

Designing objectives and evaluation items that reflect the full range of cognitive levels and environmental education goal levels is in itself, not sufficient. The method of teaching must be consistent with these high level objectives. For example, in the evaluation item above for the synthesis level, if the teacher has already provided students with such a set of guidelines which could be used in the outline required, this evaluation would not be at the synthesis level. It most likely would be measuring whether they had memorized (knowledge) the components, perhaps whether they understood (comprehension) the components, and maybe whether they could apply (application) them, but not whether they had the cognitive skill and associated information about biodiversity issues to synthesize the guidelines. As curriculum developers and teachers expand the biodiversity/environmental education framework into a programme of objectives and teaching methods, they must be aware of the importance of this principle that objectives, teaching methods and evaluations be consistent with regard to cognitive levels!

The evaluation examples above could be used in a variety of formats. They could require either oral (discussion) or written responses. Written responses could be in the form of tests, or major assignments requiring considerable student time to complete. Oral responses could serve to evaluate either individuals (e.g., asking one individual in a class to respond) or groups (e.g., requiring the group to make a formal report to the class).

Obviously, the cognitive skills in levels III and IV will be more difficult to evaluate with traditional tests. If students learn these processes through use of case studies or autonomous investigation strategies, it may be that their ability to adequately analyze issues, evaluate and recommend solutions and actions is the most accurate form of evaluation. The difficulty, of course, is that responses cannot easily be evaluated as simple right or wrong answers as they can on multiple choice or short answer tests. The evaluator must make up criteria which reflect the desired knowledge and processes and apply these to the finished student projects being used as a basis for evaluation. For example, when given an issue to analyze, does the student follow a process which identifies all of the important components of an issue? Do students evaluate the ecological, sociological and other consequences of any solutions which are considered? If a capstone experience has been used at the senior level, this may be the basis for evaluating the accumulative impact of the total infusion programme as well as the capstone experience itself. This capstone experience might be the autonomous investigation of a student selected biodiversity issue described in Activity 8. In this case, students would submit a research paper/report which would serve as the basis for evaluation.

It is difficult to measure all cognitive student gains with tests or projects such as that described above. Curriculum evaluators and teachers can use other sources of information to infer curriculum impacts on student knowledge and skills.

Classroom behaviors: E.g., students can be observed in the classroom to determine whether the curriculum is improving their use of specific strategies for effective participation in group problem solving procedures. Student voluntary comments on current articles in local papers, magazines

or other sources can indicate improved information gathering. The nature of the comments might suggest that students are attending to trends and considering environmental implications.

Citizen behaviors: E.g., student attendance at local meetings concerning environmental or other social issues may indicate improved use of information gathering or the use of opportunity to participate in action taking. Students may voluntarily write letters in response to current biodiversity or other environmental issues.

Teacher perceptions: E.g., teachers have the opportunity to observe students and formulate insights about their response to educational experiences. While such observations are vulnerable to observer bias, they are valuable sources of data to support or challenge trends found in other valuative data. Teachers observe student use of library sources, student conversational topics during unstructured classroom time, student questions during class discussions and other behaviors which suggest student changes in perception.

Affective Gains

Evaluation of student achievement should involve both cognitive and affective aspects of the biodiversity curriculum framework. Evaluating curriculum impacts on student attitudes is very difficult because of our lack of valid measurement devices to do so. Most of our attempts involve student response to attitude items in which they agree or disagree to some extent with a stated position. Affective evaluation implies a measurement of attitudes, but also an assessment of the value components of attitudes. Held values, relative priorities, attitudes towards biodiversity, attitudes towards their role in maintaining biodiversity and many other specific applications of the biodiversity curriculum framework fall into this affective category.

To guide attempts at evaluating attitude development and value shifts in students, a model proposed by Krathwohl et al (1964) would be useful. This model is similar in nature to the cognitive levels proposed by Bloom (1956) and suggests that students may exhibit different levels of valuing. The following describes each of these levels and illustrates means of evaluating objectives for each.

receiving level: students accept the proposed value sufficiently to consider it.

Example of assessing receiving level:

The teacher can observe whether students are attentive and listen during a discussion on benefits of biodiversity; students may be observed using "free" class time reading an assigned article on the topic.

responding level: students would engage each other or the teacher in a discussion about the value.

Example of assessing the responding level:

The extent to which students participate in a discussion about biodiversity values suggests whether the group or individuals are at this level of valuing. Further evidence is provided when they voluntarily bring in and discuss unsolicited current newspaper items on biodiversity that relate to the benefits of biodiversity.

valuing level: students at least verbally state that they have accepted the value as being of importance to themselves.

Example of assessing the valuing level:

Students may voluntarily make statements in class that they value biodiversity benefits. This level can be more directly measured by designing attitude survey questions asking whether biodiversity benefits are important to them. The following is overly simplified, but serves to illustrate:

"Please circle the word which describes best how you feel about the following statement.

'I believe biodiversity is valuable and should be maintained.'

Strongly Agree	*Agree*	*Undecided*	*Disagree*	*Strongly Disagree"*

organization level: students assign a priority to the value relative to other values they recognize; thus they are organizing their value framework to accommodate the value in question.

Example of assessing the organizational level:

Students can state that the benefits of biodiversity are more or less important than other selected values, perhaps in a class activity or on a written attitude survey. Again, the following simple example illustrates:

"Now that we have studied the issue involving Arctic oil exploration and its possible impacts on global biodiversity, as well as on global economy, local culture, public health, etc., please express your opinion regarding the relative importance of each of the following which would guide you when considering tradeoffs in resolving this issue. Please check one box for each value. Remember, you are not assessing what the impacts would be on each of these, but rather how much weight should be placed on each value when impacts are assessed."

VALUE	NOT IMPORTANT	SLIGHTLY IMPORTANT	IMPORTANT	CRITICAL	UNDECIDED
HEALTH OF THE NATIVE PUBLIC					
ECONOMIC WELL BEING OF NATIVE PEOPLE					
IMPACTS ON NATIVE CULTURE					
AVAILABILITY OF ENERGY FOR WORLD USE					
THREATENED LOSS OF BIODIVERSITY					

characterization level: not only does a student assign relative importance, but their behavior reflects the assigned importance of biodiversity benefits.

Example of assessing the characterization level:

Students might initiate or participate voluntarily in a movement in their school to collect money to be donated to support some action on behalf of a solution which reflects their values. Students who voluntarily attend public debates or hearings on environmental issues are characterizing some values which are involved in the issue. This level would be difficult to assess reliably by survey or test question, although some indication of their intentions to behave on behalf of their values, or their self reported behaviors could be measured.

Attitude surveys using Likert scales (strongly agree, agree, undecided, disagree, strongly disagree) can be effective indicators of some attitudes and their components. One principle to be followed in designing evaluations using such surveys is to attempt to measure not only general attitudes, but the specific value and belief components of the attitudes. It may be less informative to know that students agree with maintaining endangered coral reefs, than to know what beliefs and values they are using to formulate that attitude.

Another useful format for developing attitude measures is the semantic differential method. In this process, some object or entity can be stated and a list of opposing descriptors paired below it. This allows students to quickly respond and provides some indication of attitude shifts when repeated over time. This method also provides a quick assessment of certain beliefs as well as the overall value and qualities which are valued. The following simplistic example will serve to illustrate how the semantic differential might be designed.

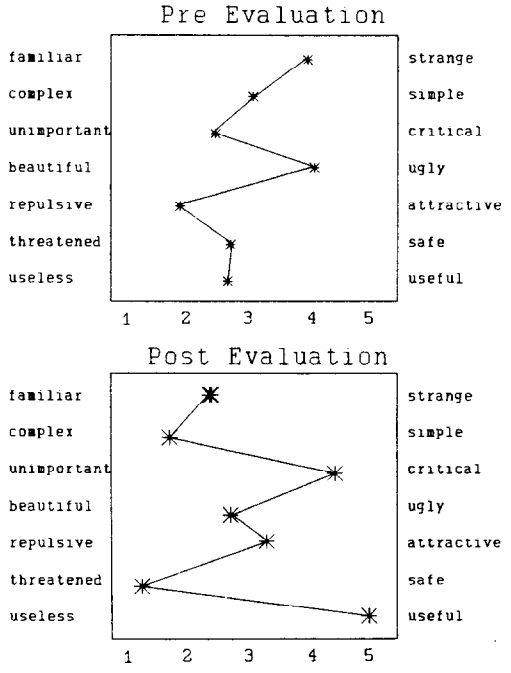
"In your opinion, which adjective in each pair best describes how you feel about **mangrove swamps**. Please circle one number for each of the paired adjectives. A '1' circled in the first line

indicates mangroves are familiar to you; a '6' suggests you think they are strange; a '3' shows you think mangroves are neither familiar nor strange, but somewhere in between."

Mangrove Swamps

Familiar	1	2	3	4	5	Strange
Complex	1	2	3	4	5	Simple
Unimportant	1	2	3	4	5	Critical
Beautiful	1	2	3	4	5	Ugly
Repulsive	1	2	3	4	5	Attractive
Threatened	1	2	3	4	5	Safe
Useless	1	2	3	4	5	Useful

The semantic differential example above reflects an attitude measure rather than a value measure since adjectives are included which assess beliefs (e.g., threatened/safe; complex/simple) as well as values (unimportant/critical; beautiful/ugly). Taken in its entirety, the item above provides a rough description of an individual's attitude about mangrove swamps. Responses from an entire class could be combined on an assessment after a biodiversity unit on mangroves and compared with results from a preassessment. A graph can be made by plotting the (class) mean scores given for each adjective pair. This provides a vertical attitude "profile" for the class and shifts in various components are easily observed. The following hypothetical example of student mean scores before and after a lesson on mangrove swamps illustrates how this can be done.



Assessing Curriculum and Materials Design

If evaluation shows that student achievement is high following participation in the biodiversity infusion programme, developers may still wish to evaluate other aspects of the programme to infer their relative importance and suitability. If the curriculum fails to achieve desired results with students, evaluations of various programme aspects may help identify needs for revision. The materials and curriculum design themselves can be evaluated by outside professionals who have established their credentials in education. Again, they may be asked either to evaluate the materials and design from the standpoint of identified programme objectives, or allowed to create their own criteria for evaluation. If time and resources permits, the latter offers distinct advantages as discussed earlier.

Assessing the Implementation Process

A biodiversity programme will be designed with a particular mode of implementation in mind. The extent to which it is successful may depend on the implementation occurring as designed; e.g., are the materials being used by teachers in the manner which was intended? In the types of infusion and comprehensive programmes discussed in this module, implementation will be largely determined by teachers. Implementation process may be assessed by observing the use--or records of use--of the programme materials by teachers, measure of the teachers' own perceptions as to their use of the recommendation procedures, and student perceptions of the use of the programme materials. These data can be collected by personal interviews, questionnaire surveys or direct observations.

CHAPTER 7:

Model Teaching Activities for Biodiversity\Environmental Education

The activities presented in this chapter illustrate all four goal levels of the biodiversity curriculum framework. However, even though ecology is fundamental to biodiversity education, an emphasis has been placed on selecting activities achieving levels II, III and IV. This was done because the teaching of ecological foundations has been well described in other publications (e.g., Unesco/UNEP IEEP Publication #29). Secondary education science texts are also available which cover this important goal level.

The activities have also been developed to show the potential contribution which can be made by disciplines dealing with the social sciences, language arts (communications), arts and humanities. These disciplines have critical roles to play in teaching the value and cultural aspects of biodiversity issues.

This small collection of activities cannot serve as a comprehensive environmental education programme for secondary biodiversity education. Rather, the activities are included as models and to suggest many adaptations and further educational activities to curriculum developers and teachers.

Each activity lists the relevant goal levels and subcomponents described in the biodiversity curriculum framework (fig. 4). Subject areas are also listed for each activity, but these should not be considered restrictive, since these activities could be adapted in many ways to make them suitable for infusion in other disciplines. The teacher background in most cases is a brief summary of concepts discussed in more detail in previous chapters of this module. The reader is encouraged to refer frequently to pertinent discussions in earlier chapters for assistance in expanding these activities. It may be especially helpful to make frequent use of the curriculum framework, the background on biodiversity and associated issues in Chapters 3,4 and 5, and Chapters 2 and 6 for discussions of implementing biodiversity/environmental education. In addition, some activities include material presented for the first time (e.g., values education strategies, marketing as a persuasive technique), and these background discussions are more detailed here.

Activity #1: A Moral Dilemma

Framework Goal Levels: II A, B, D, E; III C, E, F, G

Subject Areas: Social Science

Teacher Background:

This activity is based on the following principles:

A. The purpose of values education is not necessarily to teach a set of values, although that may be the goal of the values indoctrination approach. Values education should provide students an opportunity to **identify** their own values and the values of others; **evaluate** those values and their consequences; and to **modify** their own values as students feel necessary.

B. The purpose of morals education is not necessarily to teach a set of morals or cultural beliefs. It is intended to facilitate the development of students' own moral reasoning levels.

C. There is strong evidence that individuals move through levels of moral reasoning just as they move through stages of cognitive development.

D. Students may progress to higher moral reasoning levels when they are exposed to the higher reasoning levels of others.

E. For morals education to be effective, the student must experience a **personal**, **social**, and **cognitive conflict** during a discussion of a moral issue (known as a moral dilemma).

F. Opportunities must be provided for a student to apply his/her own current level of moral reasoning to solve the problem presented in the moral dilemma.

G. The activity must allow each student to identify and cope with inconsistencies in his/her own reasoning in a variety of moral issues.

H. Students must deal with their own moral reasoning inconsistencies in a non-judgmental environment. Students' internal evaluations of their own moral positions in the dilemma(s) must be based on alternative **reasoning**, not on judgmental statements of right and wrong by others.

The role of the teacher in this activity is to: (1) encourage students to experience personal conflict in the dilemma; and (2) to facilitate discussions which allow students to apply and evaluate their own levels of reasoning. The chart summarizes the stages of the activity and describes the teacher and student roles for each stage.

Table 1. Teacher/Student Roles in the Moral Dilemma Exercise

STRATEGY	TEACHER ROLE	STUDENT ROLE
1. Present the Dilemma	Introduce the activity Present the scenario	Read dilemma
2. Clarify the Dilemma and take a position	Guide discussion Check students' understanding Make the dilemma personal for students Ask students what should be done in their opinion	Understands Dilemma Reflects independently on their position Expresses a position on the question
3. Discuss in Small Groups	Assign students to groups Present analysis questions Facilitate discussions with probe questions Focus discussion on the moral issues	Investigate their own reasoning Respond to analysis questions
4. Discuss as a Class	Record reasons on chalk board or on overhead Guide discussion with probe questions	Each group reports conclusions and reasons Discuss issues Evaluate reasons
5. Summarize the Dilemma	**Summarize** class positions and reasons Encourage students to again reflect on their **own** position and reasons Stress that they are not right or wrong	Reflect independently again on their own position and reasons to identify changes in perception

Overview:

Students are presented with a moral dilemma involving the Pacific Yew which is a member of an endangered ecosystem in northwestern North America. As students consider what should be done in the dilemma scenario which is provided to them, they will also be introduced to the idea of biodiversity, its benefits and the problems associated with it. This activity could be used as an introductory activity for a unit on biodiversity.

Materials: Moral dilemma scenario; optional: small colored stickers, felt markers, large easels for taking groups notes (one per group)

Procedure:

1. The procedures described above in the background section should be studied and adapted carefully to this activity. The role of the teacher is to facilitate the discussion and to maintain a value fair learning environment; i.e., everyone should feel comfortable exploring and expressing values. It is also important to keep students on task and to be ready with probe questions at appropriate times to cause them to evaluate their thinking further. Effective group interaction processes should be explained to the students if they are not already introduced to these procedures. For example, the Round Robin technique and the voting methods described in this module would be useful during this activity (see pages 75, 76).

2. Read the following scenario to students. It may also be useful for them to have copies of their own to refer to during their group discussions.

> ***Scenario:*** *The Pacific Yew grows in many very old forests along the western edge of North America. The bark of Pacific Yew can be used to produce a drug which may cure cancer. The drug, taxol, is particularly effective for ovarian cancer and has been shown to save lives of women afflicted with the disease. Unfortunately, it takes all of the bark from three 100-year old trees to produce sufficient quantities of the drug to treat one cancer patient. Still more unfortunately, the Pacific Yew lives in old growth forest habitat which is already threatened because of past lumbering activities. If enough bark were harvested to meet projected needs for taxol to save lives of cancer victims, the Pacific Yew would be seriously endangered. The habitat which the Yew lives in could also be drastically altered.*
>
> *Suppose you are a forest manager who has been given the responsibility of deciding whether the Pacific Yew can be harvested to produce taxol. Environmentalists are lobbying to prevent you from allowing the harvest of Pacific Yew or any other trees from the endangered forest. Loggers and medical professionals are trying to convince you to allow harvest of Pacific Yew. If you refuse to give a permit, some women will die who would have been saved by the taxol. If you give the permit, the Pacific Yew, and eventually the forest, will be destroyed.*
>
> *The decision is yours. No law or policy exists which states what is to be done.* ***What <u>should</u> you do in this situation?***

3. Ask: "How many of you believe you <u>should</u> allow the harvest of the Pacific Yew?" "How many of you believe you should not allow its harvest?" *(Note: Do not ask "<u>would</u> you allow the harvest?" Keep students focused on the moral and ethical questions.)* In both cases, note how many students hold up their hands. If sufficient numbers exist on both positions, create groups which include about half for harvest and half against. If everyone takes one side or the other, you have two options.

(1) Make the scenario a stronger dilemma. For example, if most oppose the harvest, ask them to assume their own mother/daughter/friend has the cancer and needs the medicine. If most favor the harvest, change the scenario to indicate that if the Yew and its habitat are destroyed, potential medicines will be lost which could greatly benefit future generations, even though some people of this generation will live because of the decision.

(2) Ask students to role play one of the positions even though they did not choose it themselves. This is a very effective strategy and will result in very good interchange among group members.

4. Ask each class member to write down what they feel they should do regarding the permit to harvest the Yew and to describe their reasons. Assure them that this is for their own use and they will not be called upon to read them or defend their positions.

5. Assign groups the task of analyzing the dilemma and formulating a group report--<u>not a group consensus.</u> Groups should be guided by the following questions.

A. What do you know is true in this situation?

(Students could make a list which everyone agrees to. This represents the beliefs or information base of their decision making.)

B. What do you think might be true in this situation?

(Students make a list of possible truths. It is an important task to distinguish what is actually known from things which are not substantiated.)

C. What is important about this dilemma; i.e. what are all the values which are at stake in the issue?

(Students must consider all the values at stake: e.g., present and future lives, ecological values; some may indicate that the forest has "rights".)

D. What are all the reasons why you should permit the harvest of the Pacific Yew?

(This allows students to synthesize the beliefs and values they have identified into logical reasons.)

E. What does the group feel are the most important two reasons why the permit should be granted?

(The difficult task of setting priorities is involved here.)

F. What are all the reasons why you should not permit the harvest of the Pacific Yew?

G. What does the group feel are the most important two reasons why the permit should not be granted?

6. Following the group consideration of the dilemma, each group should report to the rest of the class what their discussion points were concerning the questions above. The teacher's role is to ask for clarification when needed and to maintain a value fair environment by preventing students from being placed in a defensive mode. They should be asked to clarify, but not to defend their reasoning.

7. When group reports are completed, again ask each student to independently write down what they now think they should do regarding the dilemma and the primary reasons for their position. After this is completed, ask if anyone would care to share whether they had shifted their position and/or changed their reasons. Again, they are not to defend--merely explain their thinking. This step is important because it allows the student to experience the important task of being responsible for their own value decisions. They are provided a "safe" environment to freely change their positions. Students who have role played positions different than their own often change more than other students in such activities.

8. Closing the activity would be a good time to provide more information on biodiversity and the nature of biodiversity problems. The topic can now be generalized beyond the Pacific Yew in North America. If local or regional problems exist, students can be made aware of their relevance at this time.

Activity #2: Defining/Observing Biodiversity

Framework Goal Levels: I A, D

Subject Areas: Science, Aesthetic Arts, Language Arts

Teacher Background:

Biological diversity refers to three levels of differences: differences in the types of ecosystems (plant and animal associations), the number of different species and, the diversity of genetic makeup both within and among species. The planet's biodiversity is important to human beings in many ways. For example, it provides a potential resource for food, medicine and industrial material. Ultimately, the three forms of biodiversity are the factors underlying successful adaptation to a changing environment. As human beings decrease this biodiversity, they decrease the ability of life on the planet to adapt to abiotic changes.

Overview:

Students will visit an outdoor site and observe differences in ecosystems and in plant and animal species in order to understand biological diversity from first hand experience. Teachers should select and visit the area for the field trip before hand to determine how to best use it for the activity. An area of the school yard will suffice, but a natural area might provide greater diversity. The activity could also be done in the classroom using slides or pictures and/or plant specimens brought in from the outdoors if a field trip is not feasible. The activity could be completed in one or two lesson periods or extended over a period of days, using both the field and classroom.

One of the instructional strategies used is the "scanning" technique, a method for systematically observing, identifying, comparing, contrasting, analyzing and interpreting the ecosystem in general and plant and animal species in particular. To begin scanning, the teacher directs students to look for sensory elements of the ecosystem: color, line, texture, shape, and space. Next, students are directed to observe the relational aspects of these elements. To help the students decode the ecosystem, the language of color, line, texture shape, and space is developed through the use of semantic differential questions. In this activity the questions are the key to understanding the environmental education Goal Levels. To that end, teachers should familiarize themselves with Goal Level I A and D and, using the guidelines in the procedures, develop questions in advance of the lesson.

A science extension and suggestions for adapting the activity for use in aesthetic education and language arts is given in Extension/Adaptation. Aesthetic and language art teachers are encouraged to stress awareness of biodiversity as a source of art and writing ideas.

Materials: Paper, pencil, list of polar words (e.g. line: thick/thin, curved/straight, long/short; shapes: angular/straight; space: full/empty, etc.), measuring instruments (optional), drawing/painting materials (optional)

Procedure:

1. Looking for differences among ecological communities

Take your class outside to a natural area (forest, savannah, prairie, swamp, estuary or even a weedy lot.) Have your class sit near the edge of the area so they can get an overview. Instruct the students to slowly scan this environment from one side to the other, first scanning close to where they are sitting, then scanning in the distance. After the time has elapsed ask your students to complete the following worksheet (Table 2) by circling their choice:

Table 2. Student Scanning Worksheet

In the area you just studied,

Are the Colors Mainly:	
Warm	Cool
One	Many
Fall	Spring
Winter	Summer
Orderly Patterns	Random Patterns

Are the Lines:	
Straight	Curved
Parallel	Perpendicular
Smooth	Jagged

Are the Shapes:	
Large	Small
Regular	Irregular
Square	Round
Common	Unusual

Is the Texture:	
Smooth	Rough
Fall	Irregular
Winter	Hard
Lush	Sparse
Bumpy	Even
Shiny	Dull
Warm	Cold

Are the Spaces:	
Small	Large
Open	Closed
Consistent	Inconsistent

Instruct your students to re-examine the area and observe and record the following:

Patterns of plant growth that they detect (what kinds of plants grow on high parts of the area, low or wet areas, near the edge, in the middle);

Animals or animal signs and where they are found;

What non-living (abiotic) things they find in the area;

Any evidence of change (such as fire, fallen trees, erosion, etc.);

Anything unique about this area that makes it different from other natural areas they have seen, read about, or visited (such as the presence of a river or stream, large geologic features, mature trees, or rare plants or animals).

2. Looking for differences between species (types of plants and animals)

Instruct students to choose 3 kinds (species) of plants and to compare the 3 kinds using something similar to the chart below.

Table 3. Worksheet: Scanning Diversity

LEAVES					
Species 1:		Species 2:		Species 3:	
large	small	large	small	large	small
smooth edge	irregular edge	smooth edge	irregular edge	smooth edge	irregular edge
opposite	alternate	opposite	alternate	opposite	alternate
hairy	smooth	hairy	smooth	hairy	smooth
light	dark	light	dark	light	dark

STEMS					
Species 1:		Species 2:		Species 3:	
woody	soft	woody	soft	woody	soft
smooth	rough	smooth	rough	smooth	rough
bark covering	no bark	bark covering	no bark	bark covering	no bark
hairy	smooth	hairy	smooth	hairy	smooth
light	dark	light	dark	light	dark

GENERAL SHAPE					
Species 1:		Species 2:		Species 3:	
large	small	large	small	large	small
smooth	ragged	smooth	ragged	smooth	ragged
short	tall	short	tall	short	tall
light	dark	light	dark	light	dark

LOCAL DISTRIBUTION					
Species 1:		Species 2:		Species 3:	
wet	dry	wet	dry	wet	dry
edge	middle	edge	middle	edge	middle
single	group	single	group	single	group
hill	valley	hill	valley	hill	valley

With your students in a group, discuss their findings. Ask them questions about their results such as, "Why do plants of different species grow in the same area?", "Why aren't plants of the same species exactly the same?", or, "Why are some plants found in one area of the ecosystem and not another?". Through these questions have students understand that plants (and animals) utilize different "niches" or life strategies to use the food, energy, minerals, water, etc. in an ecosystem or natural environment. The greater the difference in strategy generally the greater the difference in species.

3. Looking for differences within species

Have students collect two plants of the same species. Teams should select different plant species so that observed individual differences can be more generally applied to many species.

Each team should record as many differences between their two plant specimens as they can observe. Ask them to try to identify whether the differences are environmental or genetic differences. In some cases, they should be able to infer the cause of the differences with some certainty.

Ask students what advantage a species would have if not all members of the species had exactly the same genetic makeup. This should lead to a discussion of adaptation to environmental differences and changes and allow the principle of genetic variation and adaption to be established.

The differences in species as well as the variation within species and populations of plants and animals is due to genetic differences. These differences comprise genetic and species diversity. This diversity is important ecologically as it allows for change and adaptation to a changing environment. (An option to further emphasize genetic differences is to have students note hair color, eye color, height and other such differences among students in the class. How many members of the class are allergic to particular substances? This suggests differences in body chemistry, and students might be asked what implications this would have for the human species.)

Extension/Adaptation

1. The scanning exercise can be extended to include "expressive" interpretation with emphasis placed on moods, emotional states, or feelings stimulated by the environment. This could be used in a language arts lesson using the polar opposite words as the basis for a poem, chant, or song.

2. Art activities can focus on the questions regarding color, shape, texture, line and space. A part of the environment which was scanned can be drawn or painted.

3. An advanced biology class might be encouraged to make more precise measurements while in the field. They can make inter- and intraspecies comparisons, record abiotic factors (soil type, temperature, wind, humidity and light) observe, canopy cover, animal live trapping, etc. A lesson on taxonomic identification might be included in this activity.

Activity #3: Biogeography (People, Places and Biodiversity)

Framework Goal Levels: I A, B, C

Subject Areas: social studies, geography, history

Teacher Background:

The biosphere includes all of the earth's livable areas, as is independent of political or national boundaries. Biodiversity refers to the diversity of ecosystems, species and genetic makeup within species that exist in the biosphere.

The diversity of ecosystems and species is not evenly distributed throughout the world. Diversity is concentrated in the tropics where light, temperature and moisture are abundant for life. In fact, species biodiversity tends to decrease as one moves north or south from the equators because light and temperature decrease. However, other local geographical features influence patterns of biodiversity. For example, coral reefs, mangrove swamps, estuaries and wetlands are distributed independently of latitude. Many of these areas of high and valuable biodiversity exist because of special geological features which provide excellent support for life. For example, when nutrients are concentrated by ocean currents and upwellings, conditions are created for highly diverse coral reefs which then become important in many ways. They provide fish nurseries, barriers to protect shorelines and other benefits. Mangrove swamps, estuaries and wetlands are the beneficiaries of conditions which concentrate nutrients as well. Rivers that erode the watershed of nitrogen, phosphorous or other such materials deposit these valuable fertilizers where they enter lakes or oceans and create ideal conditions for developing highly diverse wetland ecosytems.

Human cultures are also diverse in their customs, standards of living and economic wealth. These cultures are distributed on the planet in particular patterns for reasons that can also be tied to the geology and geography of the earth. Cultural impacts influence current and historical biodiversity and often change the natural distribution patterns. People living in the tropics are situated amongst the richest diversity of the world's resources. People living in more temperate ecosystems have less biological diversity in their environment. However, industrial and affluent societies can have impacts on biodiversity distribution world-wide. Nations have responsibilities to conserve biodiversity which overlap ecological boundaries. Temperate and tropical societies need to cooperate to find a way to balance conservation and development of these biodiversity resources.

Overview:

This activity develops the concept of biodiversity and draws on mapping exercises to present the distribution of biodiversity on the planet. Students plot data on a world map and interpret it to draw inferences about the distribution of biodiversity.

Materials: Paper, pencil or pen, world maps (reference), globe, student maps (sample provided) and a large wall map

Procedure:

1. Begin the activity by asking your students to volunteer names of plants and animals in your locality. Make a list on a chalkboard or large sheet of paper so that it is visible to the class. Remind your students that insects and worms are animals too. After they run out of names, ask them if they think they have a complete list. Tell them that it is estimated that there are between 10 and 30 million species of living organisms on the earth. The different species of plants and animals are referred to as the planet's biodiversity of species. The list they compile for their locality reflects--but is not the total--species diversity for your local area.

2. Ask students what kinds of plants and animals they would expect to find and what the terrain would look like, if they were suddenly placed in the middle of the arctic tundra. Make a list of the species and the features which students name. Then repeat the process for the tropical rain forest. If time permits and students are familiar enough, as them to do this for a temperate region such as southern Canada or northern United States, or a desert region like the Sahara. Establish that they already have some idea of what are called bioregions (a region of the earth that has an overall similar biology such as the Amazon basin or arctic tundra). Each of these regions is unique in the kinds of species that live there, but also are different in the number of species that live there--biodiversity. All of the species in a bioregion represents the regional biodiversity and all of the plants and animals on earth represent the global biodiversity.

3. Distribute globe maps of the world to your students. A large map of the globe and/or a three-dimensional globe will also be useful. Present Table 5 to your students. Each student or student team should have a copy or the information should be projected large enough for the entire class to see it. Instruct them to plot the information on their maps. Ask the students to locate their country on the map. Ask them how the biodiversity of their country/region might compare with another region (choose an area of the world they have studied or let someone volunteer a country or region). Use questions such as the following to develop several concepts:

A. What pattern of species diversity emerges from the mapped data from Table 5?

B. What factors might influence the distribution of biodiversity? (As they list these, factors such as food, energy, water, shelter, etc. should be mentioned. Lead them towards the concept of plants as the basis for a "food chain" because they convert the sun's energy (photosynthesis) into food energy.)

C. Specifically call their attention to the differences in plant species in tropical areas versus eastern North America. This fits the trend of declining diversity. However, how can they explain the difference in plant species found in the western and middle tropic region of Africa?

D. What data could we plot on our maps to allow us to predict where we might find the most and the least biodiversity? (Many factors are possible, including human populations, pollution, etc.; however, for now, focus on light, moisture, temperature and nutrients.

Table 5. Estimated Numbers of Plant Species in Various Bioregions of the Earth*

Bioregion	Estimated No. of Plant Species
Tropical Africa	30000
West Tropical Africa	7300
Sudan	3200
Southern Africa	23000
Brazil	40000
Peninsular India	20000
Australia	25000
Eastern N. America	4425

*Adapted from Wilson 1988

4. Instruct students that they are going to test their hypothesis by plotting these factors (global temperatures, rainfall and sunlight) on their maps. Student teams should research social studies or geography textbooks and/or a world atlas to collect data on average temperatures and rainfall around the world. Students need to decide on the number of plots necessary and the best way to categorize and plot the data on their maps. You may wish to have them use a color and/or pattern code and a map key to present the data but this is optional. Students should include names of selected countries and fill in continent and national boundary lines where appropriate.

Tell your students they are going to use their maps to first locate the areas of abundant biodiversity on the planet and then to plot the amount of biodiversity relative to one another.

5. To initially test the hypothesis, have students plot the data in the following table on their maps to see that the trends hold up. Data for some bioregions are presented in the table. It is recommended that students work in teams for this task. Teams will have to analyze the data and devise a color coding system in order to show patterns on their maps.

6. Assign teams the task of gathering human population, ecological, geological and climatic information for various regions of the world. Each team should be assigned a different region such as:

Salt marshes/estuaries: eastern seaboard of Canada and U.S., southern coastal regions of Argentina, British Isles, southern Scandinavia, Denmark, Germany, Netherlands and Baltics, southwestern Alaska, northwestern Canada

Mangroves: Central America, Brazil, Ecuador, Peru, Guyana, southeast Asia, northern Australia

Coral reefs: Caribbean, Brazil, Benin & Equatorial Guinea & Tanzania (Africa), Madagascar, Red Sea and Persian Gulf countries, Australia (north coast) and South Pacific rim countries (Papua, New Guinea, Philippines, Malaysia), Hawaii

Teams should prepare a report which presents the following information:

...location of the region on a map
...climatic and geological features
...indicators of biodiversity, numbers of species,
...relationship of the ecosystem with the geological features
...special features of the biodiversity (e.g., valuable resources in tropics)
...awareness of any special biodiversity problems in the region

7. Following the team reports, lead a discussion with students which serves to answer the following questions:

Is there a relationship between latitude and diversity?
What might create an exception to the relationship between latitude and diversity?
What are some examples of these exceptions and where are they found?
Is there always a direct positive relationship between precipitation and diversity? Where might this not hold true? (poles)
What factors must come together to produce the greatest biodiversity? (sunlight, temperature, useable moisture, and nutrients)
Considering the factors listed above, where might other areas of high biodiversity be? (coral reefs, mangrove swamps, estuaries and wetlands -- have students locate and indicate some of these on their maps)

Extension:

Ask your students if they can think of ways in which human activities are influenced by the biodiversity in a region. Their answers should suggest relationships between things like agriculture and growing conditions, fishing from species-rich coral reefs, mangroves and estuaries, lumbering in the large tracts of forests in the tropics, and so on. Ask them if they can give examples of the reverse; i.e., how does human activity affect the biodiversity in a region?

Ask students to look for correlations within the data presented in Table 6[6]. Have them again use world maps to plot data and find relationships with the distribution of biodiversity. In addition, have them denote special circumstances with respect to size of country, proximity to oceans or

[6]These data are adapted from The World (p.241-245, Anonymous, 1989) and World Resources (p.244-250, p.306-307, World Resources Institute, 1990).

seas, etc. Ask how these geographical differences might influence species diversity, economics, etc. How might the data be misleading without considering these additional factors? For example, Kenya is located in a semi-desert not unlike Niger. However, Kenya has a population density similar to a European country but a very low per capita income. Habitat loss is considerable yet its number of threatened species is low. How can these inconsistencies be explained? (Kenya is located in a mix of bioregions and has a large coastal area.)

Once students have data plotted on maps ask them to consider the following questions.

Is there any relationship between economy (per capita income) and biodiversity?

Is there any relationship between human population density and biodiversity?

Sample World Map to be Used With Activity #3

Table 6. Data on distribution of mammal species, forest and grasslands and economic status of nations.

Country	Population/mi^2	Mammals			Birds			Forest		Grass		GNP/Capita (U.S. $)
		# Species	# Threatened	(%)	# Species	# Threatened	(%)	Current km^2	(%)	Current km^2	(%)	
Kenya	115	307	12	4	860	12	1	22,738	71	276,816	43	330
Niger	15	131	9	7	NA	1	NA	22,780	80	109,850	75	258
Zaire	37	409	24	6	1086	27	3	832,548	57	54,050	30	153
Zimbabwe	60	194	7	4	635	7	1	171,688	56	NA	NA	585
So. Africa	82	279	20	7	NA	10	NA	204,440	46	322,572	62	1,820
Argentina	30	255	26	10	927	18	2	360,000	50	1,300	NA	2,394
Brazil	44	394	42	11	1567	35	2	NA	NA	NA	NA	2,021
Colombia	69	358	25	7	1665	28	2	NA	NA	NA	NA	1,238
Canada	67	210	7	3	426	14	3	4,426,060	NA	276,629	NA	15,160
U.S.A.	67	466	49	11	1090	79	7	2,994,780	26	30,000	100	18,529
Guatemala	210	174	9	5	666	8	1	NA	60	NA	NA	947
Turkey	173	124	2	2	217	36	17	NA	NA	NA	NA	1213
India	667	341	29	9	1178	135	12	499,285	78	0	0	311
Japan	843	186	4	2	632	35	6	NA	NA	NA	NA	15,764
Philippines	519	96	7	7	541	2	.01	63,429	79	0	0	589
France	265	113	59	52	342	136	40	NA	NA	NA	NA	12,789
Germany	639	94	44	47	305	98	32	NA	NA	NA	NA	14,399
Netherlands	918	60	35	65	257	85	33	NA	NA	NA	NA	11,856
Portugal	294	56	25	45	288	113	39	NA	NA	NA	NA	2,827
United Kingdom	610	77	24	31	233	35	15	NA	NA	NA	NA	10,419
U.S.S.R.	22	357	78	22	765	80	10	375,730	38	NA	NA	2,477
Australia	5.7	320	43	13	700	23	3	420,000	NA	NA	NA	11,103

Activity #4: The Nature of Change

Framework Goal Levels: I; D, E

Subject Areas: Social studies, geography, biology, life science

Teacher Background:

Change is a fact of nature. Plants and animals have been faced with environmental change in the form of geologic change (volcanoes, continental drift, earthquakes, etc.), climatic change, and organic change brought about by the succession of plant communities for millions of years. The ability of plants and animals to change and survive environmental changes is called adaptation. Some organisms--such as humans--can adapt to relatively new situations rapidly through learned behavior. However, the basic response to environmental change over time, is through genetic adaptation. This process requires a trial and error approach over several generations of organisms. If the type, rate or extent of a natural environmental change is extreme (volcanic eruption, drought, flooding, fire), organisms can not adapt rapidly enough and cease to exist. Fortunately many of these natural changes are localized and species from surrounding natural communities will eventually invade and recolonize a devastated area.

Some human activities create extreme environmental change (clearcutting of forests, paving of roadways, building of cities, some farming practices, industrial pollution, etc.). Initially these effects were localized but as the human population inhabited more and more of the earth, the effects have become regional and even global. The changes impact whole ecosystems and entire bioregions (such as the Amazon basin). The rate and extent of the change is so extreme that entire species and even genera are being wiped out and becoming extinct. Human activity must be balanced with nature's ability to adapt or the earth's biodiversity will be reduced to an unrecoverable level which eventually will have negative impact on all human activity.

Overview:

This activity relates change in nature to factors that can reduce biodiversity. Students are asked to identify changes in their environment and examine living responses to those changes. They should come to realize that the inability of living organisms to adapt to rapid or extreme changes in the environment threatens biodiversity. The teaching strategies include an outdoor field trip but the activity could be done in the classroom using specimens or pictures.

Materials: field notebooks, pencils, chalkboard or large paper, access to outdoor study area

Procedure:

1. Ask your class to name one factor in the classroom environment that has changed since they arrived (temperature, light, humidity, noise level). Follow with a series of questions to stimulate interest and introduce them to the topic of change applied to their physical, social, political and cultural environments.

A. What are some other social, political or cultural changes they have noticed recently in school, the community, the country, or the world?

B. Would they describe these changes as slow or rapid?

C. (For selected examples) would they describe the change as good or bad? How do they determine whether a change is good or bad?

D. What do they do when bad changes occur in their environment? (Discuss the fact that we must change or respond also. For example, when the temperature drops, we must either change the type of clothing we wear or run the risk of becoming sick. During the 1990's people living in what was the Soviet Union faced remarkably rapid shifts in their political and economic environments. How did they have to change in order to adapt?)

E. What makes changes easier for students to adjust to? What makes changes hard to adjust to?

This is an important discussion to establish that adjusting to change depends on:

...the type of change (changes in temperature are easier to adjust to than changes in air quality such as occurs when smoke or pollutants get into the air; shifts in cultural preferences for clothing styles are more easily adapted to than changes in economic systems.)

...the intensity or degree of change (if their income drops by 1%, that is easier to adjust to than if it drops by 25%)

...the rate of change (a slow drop in temperature is easier than a sudden drop of several degrees; a change in government organization over two decades could be less disruptive than the same shift over a period of 5 years).

...the predictability of the change (an unexpected change is generally much more difficult than the same change if it were anticipated. In ecology, even though changes in the desert climate are very severe and intense, they happen with predictable regularity and life has been able to evolve means of adapting to them. When workers know there will be seasonal slumps in their economy and layoffs predictably occur each year, they are able to plan and adapt to these stresses more easily than when unexpected layoffs occur.)

Try to get students to generate this list of principles through their own life experiences. However, it may be necessary for you to present them before moving on to the next step.

2. Have students brainstorm the predictable kinds of environmental changes which plants or animals would have to respond to in order to survive. Make a list of these and have students write the list into a table similar to the one below to use during the next part of the activity. E.g.,

fluctuations in food availability,
temperature changes seasonally or daily,
moisture changes seasonally or daily,
predators,
competitors,
disease.

3. At this point, have your class go to the outdoor site you have selected (a natural area is preferred, but a weedy lot or even a grassy area would suffice). Tell them they will have 15 minutes to find evidence of these changes and evidence that living things are responding or can respond to each of the environmental changes they listed. You might get them started by pointing out leaves changing color and/or dropping off a tree, plants sending up new stems to replace those broken or mowed off, behavior of birds. While the following points might be made without having students go outdoors to make observations, the activity will serve stimulate their thinking and provide more concrete examples.

Table 7. Student Worksheet: Observing Change

Environmental Change	Evidence of the change	Example of Response	Response Learned?	Response Inherited? (genetic)		
				Structural	Physiological	Behavioral
Periodic drought (**)	*Cracked earth*	*Wilted Plant*	*No*	*yes*	*yes*	
Seasonal temperature changes	*Cracked concrete or asphalt*	*Winter plumage on bird*	*no*	*yes*	*yes*	*no*
Presence of predator		*Bird flies when approached*	*partly*			*partly*
Fluctuating food sources		*Ants carrying food from dead caterpillar to hole in ground*	*no*			*instinctive feeding response*

(**) These are examples of the types of responses to be obtained from students.

After the time has elapsed, ask students to describe any observations of evidence that change is occurring and that life is responding to the changes. Discuss briefly the environmental stimulus for each change response, i.e., what was the living thing responding to? Next, determine whether the response was probably learned or inherited (genetic). If inherited, was the response a structural,

physiological or behavioral response. Some examples of student responses are given in Table 7 to clarify the procedure. It is not necessary to establish with complete certainty whether the observed behaviors were learned or genetic in origin. The intent is to get students to understand that organisms can adapt in certain ways in order to survive environmental changes.

Ask your class to look at the chart in order to understand how plants and animals deal with change, i.e., adapt. Ask them which type of adaptation is most effective for the individual organism: learned or genetic and why? (learned behavior is most useful for the individual organism; the organism can only respond genetically to a fixed, narrow range of changes; genetic adaptation has to be passed on through generations, while learned behavior can change within an individual's life span.)

The students should be made to understand that an individual organism cannot make genetic changes to be able to survive environmental shifts; genetic change can only be done by populations or species over generations. Individual organisms of some species are capable of learning adaptive responses and passing these behaviors on to successive generations by teaching them, but the learned behaviors are not genetically inherited.

4. Remind students that many changes are extreme, intense, rapid and/or unpredictable and are therefore difficult for organisms to adapt to. Ask them to brainstorm a list of changes that fit these conditions; e.g.,

climatic changes over time (global warming),
volcanic eruptions,
fire,
pollution,
presence of new competitors,
new predators,
new disease.

Students may be aware of examples of these sorts of changes which have caused populations or species to become extinct. For example, the species of golden toad in the Costa Rica rain forest was eliminated by a drastic change in climate (see the section on ecological importance of biodiversity in Chapter 3). New predators introduced into the Hawaiian Islands caused the extinction of many bird species indigenous to the islands. In a few cases, species have adapted to some of these extreme changes. Some conifer trees (e.g., jack pine in North America) have evolved seed cones which are not only resistant to the heat from forest fires, but they are caused to open and distribute their seeds after the fire has burned. This gives the species an advantage over others in re-establishing itself in the area.

5. Explain to the class that all the living things on earth comprise the planet's biodiversity. Human activity on the planet is putting that biodiversity at risk. Have your class suggest some human activities that would be similar to--or cause--extreme, rapid, intense and/or unpredictable changes. Construct a chart similar to that below and have the students suggest appropriate examples.

Human Activity	Environmental Change	Implications	
		Natural	Social
Clearcutting extensive tropical and temperate rainforests	Removes dominant climax species	Destroys existing ecosystem and interactions required for species survival thus reducing biodiversity; disrupts nutrient cycle and other abiotic factors	Short term economic benefits; loss of productive land; loss of natural resource
Sulfur emissions from energy consumption	Increases acidic components in ecosystem	Creates adverse change in chemical composition of environment; reduces species diversity	Short term economic benefits; threats to public health and property; threatened collapse of natural resources
Highly industrialized economies releasing man-made toxic chemicals	Changes chemical composition of environment	Reduction of species diversity due to intolerance of toxic chemicals	Short term economic benefits; diminished public health; threatened collapse of natural resources
Release of large amounts of CO_2 and CH_4 into atmosphere	Potential atmosphere and global warming; changes in climate	Failure of species to adapt to climatic conditions; reduction of biodiversity	Threatened public health and property; collapse of needed natural resources

From this discussion, your class should realize that humans are the greatest source of change today on the planet. Humans are causing changes which are extreme, rapid, of a life threatening nature, and global in extent. Many living species will not be able to evolve adaptations rapidly enough to adjust to many of these changes in air and water quality, loss of habitat and other environmental aspects. In the presence of such overwhelming change, what is the likely result to be? Students should understand from this discussion that loss of biodiversity will certainly continue at an increasing rate, unless environmental changes are brought under control. The tradeoffs which must be decided will involve some highly valued short term benefits as well as long term benefits and costs.

Extension/Adaptation

1. Have your students keep a diary of changes in a natural area, their community or area outside their school. Have them record changes in temperature, wind velocity, color of plants, amount of plant life, evidence of animals, texture soil, etc. and indicate whether they are seasonal or unpredictable changes.

2. Apply the concept of adaptation and change over time to the ecosystem level. (The activity above applied these concepts to the individual organism and to the species levels.) Change in ecosystems over time is called "succession". Create a long term study plot by plowing or tilling up a different small area each year for several years, in a field or lot close to the natural area being observed. Let the areas grow back naturally and have students document the changes by performing field analysis once a week. Data could be kept over a number of months or even years and compared between classes. Sketches of the area could be made from week to week as a visual recording of change. The student could write in a diary once a week as if that plot of earth were writing and noticing how it was changing and how it was reacting to those changes. Some form of change in the types of plants living there will occur over several years.

Succession can be observed in a shorter time span in artificially made "microcosms" or small worlds. This could be a gallon jar which has been sealed after a small aquatic community was placed into it. Pond organisms including algae, insects, plankton, snails and other small species would be placed into the jar with the water. Seal the jar with vaseline and set it into light. Students can observe the community over time and watch it change dramatically until some sort of climax community is established. This will probably be a simple community dominated by bluegreen algae and microorganisms. Several jars can be set up and placed into different environments (dark, light, cold, warm, alternating, etc.) to compare community response. One of the differences between these communities and natural communities is the inability of new species to enter the community and change its makeup. Changes will occur, but they will involve shifts in dominance among species already present.

3. Look at current biodiversity changes from a prehistoric view. Introduce the geologic eras and the effects which each major cooling or warming of the Earth has had on the species diversity. Have students read articles about global warming and the probable effects on global species biodiversity. What makes this climatic change any worse than past changes in Earth's climate? What makes a loss of biodiversity today any more serious than in the past; for example, when dinosaurs became extinct?

4. Review the cultural and technological changes which have occurred in various parts of the world and categorize them in terms of rate, type, and intensity. Students should then evaluate the impacts these cultural and technological shifts have had on biodiversity and discuss the relative benefits and risks which changing culture and technology create. Have changing societies experienced more benefit or more costs from such changes? How does the answer differ when future generations are considered versus present or past generations?

Activity #5: Prairie Restoration, A Values Education Case Study

Goal Levels: I; A, C, E, I, III; C, IV; C

Subject Areas: Science, Social Studies

Teacher Background:

We can maintain or achieve biodiversity in many ways including by preservation or restoration. Preservation usually means preserving large tracts of undisturbed or minimally altered habitats and ecosystems that support important biodiversity. Restoration comes in the form of reestablishing habitats--and therefore biodiversity--that have been altered or destroyed. In order for restoration to take place, plants and animals must be brought in from other areas to be used in the regeneration process.

Both preservation and restoration have advantages and disadvantages. Restoration is perhaps the more controversial of the two and is usually a last resort strategy. The expense and lack of significant impact on the ecosystem are the two negative aspects most often cited. Preservation requires a large expense as well (both from purchase of large areas of habitat and, in some cases, removing their resources from the economy) but can have a much larger impact on conservation of species from both a qualitative and quantitative perspective. Yet, with all the controversy surrounding restoration, both methods of biodiversity management may be needed to maintain important biodiversity on the planet.

The difficult choices associated with these actions to protect biodiversity provide excellent opportunity to develop values education experiences for students. The values continuum is a simple values education strategy with a number of educational benefits. For example, it can be used to help learners identify their own value priorities and understand what factors influence their own values. Following is a detailed description of how to use the values continuum. You may wish to use these examples as an activity in itself.

The activity uses a list of opposing statements such as 1a and 1b in the following examples; but appropriate statements can be developed to introduce any issue. These are read by two individuals such as two students, or yourself and one student. The readers will stand at opposite sides of the room facing each other. (This can also be done outside on a nice day.) The students take a position between the two that reflects how much they agree with one or the other statement. A student who strongly agrees with statement number 1 a. would stand close to that reader. Students who agree less strongly will position themselves further away. An undecided or neutral student would go to the center. This produces a continuum of values so students can see how their own position compares with everyone else's.

At various times you will want to engage students in discussions while they are standing in their positions. For many of the issues, the object is for the student to recognize what his or her own values are and to see the diversity of values in other class members. However, items 1 and 4 would allow you to point out to the students how an individual may express conflicting values. It is important for students to realize that they sometimes act on conflicting sets of values without knowing it. The need to identify and prioritize one's own values should become evident.

For item 5 you will provide additional information about the issue and some students will change

their positions. This makes the point that many of our values are influenced by what we believe to be true. Other important concepts can be developed in this discussion, such as ...

... some of our values are evidently not influenced by what we know about situations (e.g., we may just accept certain values because our parents, church, etc. taught us to do so).

... sometimes our value priorities (how we feel) are influenced by information (what we "know" to be true). This makes the whole matter of evaluating information very important.

... what we "know" as true actually falls into at least two categories: (1) that which can be proven by observation or other evidence to be true (fact), (2) that which we infer to be true based on what we know (inferences). Inferences may be totally unsubstantiated or be supported by so much evidence they are accepted as facts.

... many times our **values** influence what we **believe**. Once individuals have accepted a value position on some issue, they often reject any information which is not supportive of that position.

Although this activity cannot develop all of the valuing skills necessary in resolving issues, the important goal is to concern students with the process of valuing. Many issues can be used to stimulate interest and to develop the important points described in the activity.

Examples of Position Statements and Teaching Strategy

	List A		List B
1 a.	I would prefer to live in the middle of a city.	1 b.	I would prefer to live in a quiet place in the country.
2 a.	I would prefer to use wilderness areas for backpacking and hiking with no cars or other motor vehicles allowed.	2 b.	I would prefer to be able to use a motor vehicle to get into a wilderness area.
3 a.	I prefer going to a ball game.	3 b.	I prefer to go hiking.
4 a.	I don't want my use of wilderness areas, parks, or forest lands to be regulated. People should be able to do what they want to do with wilderness areas.	4 b.	I prefer to have regulated wilderness areas, parks and forest lands which people can use in only certain ways at certain times.

This may be a good place to ask students about their own value conflicts. Often, more students will select living in the country than the city. They could be asked to share their reasons. They may value the quiet and solitude and "natural" beauty of the area. However, as more people act on those

values, the country becomes the victim of urban sprawl and the qualities of country living are destroyed. Similar conflicts may exist in our use of wilderness without regulations. In North America, some areas are so extensively used by backpackers, it is impossible to get a wilderness experience because so many other people are there. Campsites are overused, trails are eroded, etc. A permit system has been initiated to decrease the number of users in some areas. This maintains the quality of the environment in some respects, but for many backpackers the necessary freedom of choice is lacking. This is a definite value conflict for this group.

5 a.	I think the wild burros of California should be shot and eliminated from the desert.	5 b.	I think the wild burros of California should be preserved and left alone.

This represents a very sensitive issue of what to do with exotic species which have become part of another ecosystem. People value the exotic species for various reasons, yet that may conflict with their values for healthy ecosytems and biodiversity. For example, many people immediately agree with 5 b. when they think of the "cute" burros being shot. However, this is a good opportunity to have students realize the relationships between how we feel and what we know -- or don't know. Read the following information to the students now that they have taken a position of this issue.

The wild burro of the California desert was introduced by early prospectors. Since it didn't evolve as part of the desert ecosystem, there are few checks on its population. It has not achieved a "balance" with the rest of the desert and as a result the burro population is expanding rapidly and destroying much of the desert plant population. Burros are out-competing the native Desert Bighorn Sheep and endangering their very existence.

The desert is a very fragile ecosystem and unless the burros are controlled, much of the desert will be destroyed. Some humane societies have trapped burros to remove them and insist that the government trap rather than shoot the burros to control them. However, cost of trapping burros is very expensive -- and there are hundreds if not thousands of burros. Money used to trap burros might deprive wildlife biologists from needed resources for other important management programs. Trapping is very slow and it is difficult to find suitable homes for all of these burros, so there is doubt as to whether it would really be effective.

After you share this information with the students, ask them to again consider their values and reread the two statements to them (5 a. and 5 b.). Ask students if this information impacted on their value decisions.

If time permits, discuss this and other concepts pertaining to belief-value relationships. In particular you should emphasize the following three points:

1. Individuals sometimes determine their value priorities without considering all the values involved. In this case, the value of a natural desert ecosystem and the plants and animals endangered by the burros should be considered, in addition to the value of the burros.

2. Our values and value priorities are sometimes formed without accurate or complete knowledge. Again, in this issue, many students probably took a stand without much knowledge at all.

3. When we become committed to a value position or attitude, often we find it difficult to give fair consideration to other values or information that aren't consistent with our own position (e.g., if we like Joe and someone says Joe is a liar, we may refuse to believe it). Did anyone find themselves in this situation in the burro issue?

Overview:

This learning module gives students the opportunity to analyze the effects of restoration, compare the results to preservation and become aware of the economic and human consequences of biodiversity conservation. Students will be involved with a case study of a biodiversity issue. They will be asked to identify the range of values associated with the issue. A values continuum teaching strategy will be used to examine not only the various values inherent in this particular case but the students' own value priorities will be identified as well.

Materials:

Prepared statements to be read by students and/or teacher, large room or outdoor setting, copies of case study and scenario

Procedure:

1. Arrange your classroom so that students can move freely about from one end to the other or take your class to a gym, playground or other large open area. Have the students arrange themselves in the middle of the space. Tell them you (and/or other students) are going to read "position" statements from opposite ends of the room. After listening to each statement, they should position themselves close to the person who read the statement they most agree with. The stronger the agreement the closer they should stand to that person. Students who can not choose between statements should remain in the middle.

Position Statement One:

1a. I believe people have more right to exist on this planet than other species of life.

1b. I believe other species of life have as much right to exist on this planet as people.

2. After your students have arranged themselves along the continuum stimulate discussion by asking questions such as, "Would you like to share with us why you feel more comfortable in that position?" Avoid stating your questions which cause the student to feel compelled to defend their

position; e.g., "Why are you in the middle?". After hearing from several students, ask whether there are any reasons that might cause them to change their position on the continuum. Students in the middle may feel species are important ecologically, may feel a moral or ethical obligation to other species or may simply have pets that they consider important. These distinctions are important to bring out with no stigma attached as to the rightness or wrongness of the positions. After hearing several viewpoints reread the statements and ask them to reconsider and move if they would like to. Some students may wish to change positions or move along the continuum at this point and they should feel free to do so. Stress that each person should be aware of their own reasons for their position. After productive discussion has ended, read the second position statement and ask the students to respond to this new issue by positioning themselves along the continuum.

Position Statement Two:

2a. I believe the well-being of people alive today is more important than the well-being of future generations of people.

2b. I believe the well-being of future generations of people are more important than the well-being of people living today.

3. Statement two may be harder for students to decide on. Remind them that they may change positions at any time. Middle-position students will feel the generations are equally important, or else they are undecided. Students supporting position 2a might make the case that without present generations, future generations could not exist. Conversely, some may feel future generations are the purpose of present generations. While a prolonged discussion might be generated here, it is important to allow students some time to examine their reasoning.

Ask them to assume that a decision has to made that will either use something for people who are alive today, or save it for future generations. It cannot be used for both. In that situation what is their attitude? Reread the position statements and ask them to move on the continuum.

4. Tell your students you are going to describe (or read) a scenario to them. They are to listen carefully and identify the possible positions inherent in this scenario. After they have established the polar positions on this issue, they are to position themselves on the continuum according to their values related to this issue.

The Scenario:

Tell your students that a new road is being built to a small community. The road will connect the community with a larger city that has a hospital. A large deposit of gravel has been located under a local prairie (a local natural area could be substituted here if prairies are not found in your region). If the gravel is mined, the natural area will be destroyed along with a number of rare plants and animals. This gravel deposit is the only one available in the area. Using the local gravel supply is the only way the community can afford to build the road and use the hospital.

5. The two positions presented in this scenario are whether to develop the road or preserve the prairie. Present the two positions at opposite ends of the continuum as:

1a. I believe the gravel should be used to develop the road to provide access for the hospital.

1b. I believe the prairie should be protected at all costs and the gravel should not be used for the road.

After students have arranged themselves along the continuum, ask them to think about their value priorities that determined these positions. Explain that we make decisions about our lives based on the values we hold. The stronger we hold a value, the more determined we are to maintain our positions on it. Often, however, we have several values and we have to prioritize them. Sometimes we have conflicting values and we must choose between them. Make a list of the values the students held which influenced their position on the continuum. Point out to the class that there are many value positions represented in most issues (as there probably are many represented by the class).

6. Refer back to the scenario and ask your class if anyone can think of any alternatives to the positions presented. If no one mentions moving the prairie (or a portion of it), offer it as a suggestion and elicit comments from the class. After some discussion (some students may not think it is feasible) tell your class that this has actually been done and that they are going to read a case study describing these events. Divide your class into teams and assign the following worksheet to be completed as they analyze the study. (The case study synopsis follows the worksheet.)

Case Study Worksheet: The student issue analysis worksheet presented in Activity 8 can be used for this activity. To conserve space, it was not reproduced here. The worksheet can be simplified for this analysis, or you may wish to design another worksheet using the following questions as guidelines.

What are the values in the conflict?
Who are the stakeholders?
What values do they give priority?
Describe the environmental action which was taken to save the prairie.
What are the costs of the actions to the people involved in the issue?
How effective was the action? What did it accomplish?
Will this action significantly help to prevent our world wide biodiversity loss?
What other types of actions might have been considered?

Scenario:

An Ice Age Prairie fights for its Life in the 90's![7]

An old prairie has new life in Illinois. A 10,000 year old two acre prairie slated for destruction is now relocated and protected in Elgin, Illinois, a community near Chicago. This rare plant community was saved by a first-of-its-kind project which restored nearly 82 percent of the original species.

The land area that now includes the state of Illinois was dominated by a tall grass prairie ecosystem after glaciers receded from North America some 12 - 15,000 years ago. The ecosystem may have included up to 75% of the state before European settlement and subsequent agriculture in the mid 1800's. Now, less than 2000 acres of indigenous prairie or about 1% of the original remains.

The two acre prairie was on a privately owned hill of gravel which a gravel company was eager to mine. Surveys in the 1970s and 1980s identified 81 native plant species in the community and the prairie was being monitored closely by state and local conservation groups as well as botanists. Attempts at preservation through legal and economical acquisition of the land failed. The area was not adjacent to or a part of any county, state or federally owned or protected holding. The sympathies of the city board, which had jurisdiction over the issue, were split between those wishing to preserve the prairie and the economic concerns of the city and the gravel company. A coalition of environmental groups negotiated with the company to buy the property. The amount of money needed, according to the company, would have to include revenues lost by not mining the gravel. In addition, certain concessions, such as not mining in proximity of the prairie, would be necessary on the part of the gravel company. Neither the monetary amount nor the concessions could be agreed upon by the two parties. The prairie looked doomed.

Fortunately for the prairie, another alternative existed. A representative of the Illinois branch of the Nature Conservancy had located a site that, with some alteration, would be similar to the soil and drainage type at the original site. In addition, the new site was part of the Bluff Spring Fen Nature Preserve and, consequently, it would attain a protected status. A few problems did exist, however. There would be some financial commitment although not nearly as large as outright purchase of the original site. The physical task of moving the prairie would be immense and, most importantly, it had never been done before. Success was not guaranteed.

The transplantation of the prairie was carried out using bulldozers, tree spades and over 400 volunteer workers. The plants were dug up, transported six miles to the new site and replanted on a hill which had been created by human labor. After one year, all but 18 of the 81 species that had been present at the old site have been found (four species had been destroyed by mining before the move). Most of the rarest, most highly prized species have reappeared. According to project leader the task has been monumental and it will still take several years for the prairie to reestablish itself. The leader stated that, while this will never again be a pristine prairie, the project, "established in people's minds the worth of a rare, native ecosystem. The moving of this hill was part of something that is very new on this planet, and that is how an advanced, metropolitan civilization can live in harmony with, and even expand, nature."

[7] Adapted from an article which appeared in the Chicago Tribune, August 4, 1991

Activity #6: Folklore to Fact (Text Analysis for Biodiversity)

Framework Goal Levels: (I), II; A, E, F, III; B

Subject Areas: Language arts, Social sciences, Science

Teacher Background:

Literature, whether it is fact, fiction (or folklore), emanates from the knowledge and experience of the writer or storyteller. The storyteller is part of a culture located in some ecological region of the world. The region contains its own unique combination of plants and animals. When someone dips into their data banks of information to tell a story, they pull out bits and pieces of their knowledge about this ecosystem to set the stage for the story. They sometimes unintentionally provide insights into biodiversity phenomena, trends and/or problems.

The purpose of this activity is to extract and analyze the ecosystem components of the kind of stories called folktales. Folktales have been chosen because hearing folktales has been a part of almost every student's experience. Traditionally, folktales have transmitted cultural mores and values and have been a way of explaining why things were the way they were. Their accessibility and the universality of their themes have maintained their appeal through the generations. A more hidden element of folktales is what the reader or the listener is learning about the ecosystem where the folktale takes place. Built into the layers of a folktale, like the mortar between bricks, are references to the land and its plants and animals, the abiotic and the biotic components of the ecosystem.

Overview:

Students are presented with a written version of a folktale and asked to analyze it to detect references and descriptions which give some insight into the biodiversity associated with the location of the story. The activity develops a sense of history and culture as well as providing a stimulating way of illustrating the relationships between human culture and the natural environment. Students also develop skills in critical reading and gain experience in drawing inferences.

It would help the teacher to get together as many folktales as possible and to read them before starting the activity. Familiar folktales from the students' culture, folktales from other parts of the world, new or old folktales, or different versions of the same folktales, can be used. A sample folktale is presented below and will be used in procedure #2 for illustration.

The Song of the Old Wolf[8]

There is a story told among the people of the Dakota nation that once on a time an old man went out to be alone upon a high hill above the Missouri River to give himself to meditation and prayer. He chose this situation because of the grandeur and majesty of the view of the great sweep of the prairie plains and hills, one hill beyond another, away and away to the far horizon. Below flowed the wonderful and mysterious river, whose waters came down from the mighty mountains at the west

[8] Gilmore, Melvin R. 1987. *in* Prairie Smoke. Minnesota Historical Society Press. St Paul 55101. pp136-138.)

and rolled on and on past the villages of many different nations, finally reaching the Great Salt Water.

As the old man thus sat mediating and considering all the manifestations of life and power and mystery of earth and sky, he espied out upon the prairie a group of wolves trotting toward the river. When they reached the river, they plunged in and swam across to the other side, all but one old one who was now too enfeebled by age to dare try his strength against the swift and powerful current of the river.

This old wolf sat down upon the bank of the river and watched his companions as they swam across and trotted away out of sight on the other side. When they had disappeared from sight, he raised his muzzle toward the sky and mournfully sang in a man's voice the following song:

All o'er the earth I've roamed,
I've journeyed far and wide;
My spirit haste and go,
I'm nothing, nothing now,
I'm nothing, nothing now.

Missouri River, flow,
Thou sacred water flow;
My spirit haste and go,
I'm nothing, nothing now,
I'm nothing, nothing now.

After the old wolf had sung this song, he wearily made his way to the top of a hill and lay down in the warm sunshine, in the shelter of a rock, and there waited until his spirit went away.

And so now, when old men of the Dakota nation find the infirmities of age creeping upon them, and feel as though they had been left behind in life's march, they will often go out alone to the summit of some high hill overlooking the Missouri River and, sitting there in solitude, will muse upon their activities and noteworthy deeds in the past, of their companions of former days now long gone from them, and contrast all this with their present inactivity and loneliness. Then they will sadly and quaveringly sing this "Song of the Old Wolf."

Procedure:

1. To begin this activity, ask students to suggest the names of their favorite folktales, ones that they remember reading or having told to them as they were growing up. If the folktales are written down, look them up in libraries or ask the students to bring them to class. If the students know folktales that they have never seen in books, ask them to tell them to you and write them down as a group effort. At the next class, when you have several folktales available, divide the class into as many small groups (or pairs) as there are folktales. Ask the students to do a rough count of the numbers of references to the land (geography or geology), plants and animals in their folktale. Compare the results. Choose one folktale that seems rich in biodiversity information.

2. Make copies of this folktale so each student will have one. Use a world map to show where this folktale takes place. Instruct the students to create a Biodiversity Data Bank from the folktale. Ask

each student to analyze carefully the folktale for words that refer to some ecosystem element. As they find the words, they should write them down on small slips of paper to be put in a "bank" (a bowl or box of some sort.) They should underline the ecosystem element word and be sure to include the descriptive words immediately preceding or following the ecosystem element. Also they need to rewrite the ecosystem element on a new slip of paper every time it occurs in the folktale. For example, from "the Song of the Old Wolf," a Native American folktale (see Overview), here are some words that would be written on separate slips of paper to be put into the Biodiversity Data Bank: people of the Dakota nation, old man, high hill, Missouri River, grandeur and majesty of the wind, great sweep of the prairie plains and hills, one hill beyond another, far horizon, wonderful and mysterious river, waters, mighty mountains at the west, Great Salt Water, earth and sky, prairie, group of wolves, river, swift and powerful current of the river, old wolf, top of a hill, warm sunshine, shelter of a rock, old men of the Dakota nation, summit of some high hill, Missouri River.

3. Draw a "t" chart on the board (or on a piece of paper.) Put Abiotic Ecosystem Elements on one side of the chart and Biotic Ecosystem Elements on the other. Using the Biodiversity Data Bank, take out each slip of paper containing one biodiversity element and decide which side of the chart to write it on. When you have taken out all the data from the "bank," ask the students to look at the "t" chart and to draw a conclusion about whether the folktale creator relied more on abiotic or biotic ecosystem elements to tell the story. Ask the students to try to visualize the ecosystem where the folktale takes place.

4. Now look at each slip of paper again to reexamine these biodiversity facts for their descriptive qualities. Draw a new "t" chart. Label the two columns: Expressive Adjectives and Descriptive Adjectives. Many adjectives used to describe the ecosystem convey expressed value judgements of the writer or storyteller. For example, using the native American folktale, "wonderful," "mysterious," "mighty," "powerful," and "great," imply more value judgment and are opinions. "Old," "high," "far," "swift," and "warm," are more empirical and measurable, and are therefore more likely to be considered factual. Direct the students to consider the expressive adjectives on the "t" chart, the ones that express values and opinion. Ask them to summarize the overall sense of the positiveness or negativeness of the adjectives. In conclusion, discuss whether the folktales convey a positive or negative feeling about the ecosystem.

5. Another way to extend the student's understanding of the meanings of the ecosystem facts in the Biodiversity Data Bank, is to ask them to put two of the facts together that, when linked, suggest an ecological concept inherent in the folktale. For example, if the words "hill" and "valley" are paired, the concept of erosion is suggested. If "river" and "ocean" are linked, the water cycle concept can be discussed. Or if they chose "people of the Dakota nation" and "old men of the Dakota nation," the life-death cycle can be considered. The importance of each of these ecological concepts to the folktale should be discussed. It may become apparent that one of these ecological concepts is a central theme of the folktale. For example, the life-death concept from "The Song of the Old Wolf," is the main theme of this folktale. The natural life-death cycle is an important part of biodiversity.

6. As a final activity in this folklore-to-fact text analysis, ask each student to choose one element from the Biodiversity Data Bank and to rewrite the folktale from the perspective of that ecosystem

element. This activity makes it necessary for the student to think of the folktale from the point of view of one element in the ecosystem. They have to retell the folktale as if they are the wolf, the river, the rock, or another element of the ecosystem telling the story. Since anything can happen in folktales and animals frequently talk in them, this "new" folktale will not seem too farfetched. This part of the whole folktale activity is essential because it reminds the students of the importance of the diverse biological elements in the folktale. When everyone has finished writing, ask the students to read their new versions of the folktale to the class. As an extension, the students could illustrate their "new" folktales.

7. As a final discussion wrap-up, ask the students whether folktales will still have the same meanings if the animals and plants in the stories no longer exist. For example, there are no longer wolves in the vicinity of the Missouri River as written in "The Song of the Old Wolf." Will folktales become myths with no connection to existing ecosystems if the biodiversity of the land is destroyed? If this happens in different parts of the world, what impact will there be on all forms of human expression?

Activity #7: Ethnobotany

Goal Levels: I; A, II; A, E, F, III; B, G

Subject Areas: history, language arts, health, science

Teacher Background:

The historical and present day use of wild plants for food and medicine is well documented. In the course of history people have utilized about 7000 plant species for food. It is estimated that 25,000 species of plants have edible parts. Yet today the world relies heavily on only 200 species, such as wheat, rye millet and rice. A large segment of the world's population depends on foods from cultivated genetic stock which is susceptible to drought and disease and is often grown hundreds and even thousands of miles away from.

Eighty percent of the population in Africa depends principally on herbal medicine. Folk medicine in Paraguay utilizes 1500 species of plants or 10% of the vascular flora of the country. Many medicines commonly used world-wide such as aspirin are derived from plants. Many plants such as wintergreen (for rheumatic pain) and mustard (as a cutaneous stimulant) have been used by cultures around the planet for centuries. Recently, plants such as Rosy Periwinkle and Rauvolfia have been found to yield extracts that help treat leukemia and high blood pressure. The Pacific Yew may contain a cure for ovarian cancer.

New plants and new uses of known plants for medicines are being discovered at the rate of hundreds per year. Wild genetic strains that yield new vigor to cultivated plants are still being discovered in tropical and temperate forest alike. The potential for wild plants to be used for cures for cancer or sources of new biodegradable pesticides are widely accepted. Yet 50 to 150 plant species become extinct everyday. Knowledge about the uses of wild plants is being lost as indigenous human cultures are being absorbed by a modern world. Tribal healers and Shaman are no longer able to find young people to teach in order to pass along their knowledge. The world is depending more and more on synthetic medicines which are limited and expensive.

Overview:

The purpose of this activity is twofold. It is designed to introduce the idea of biodiversity to your students by having them relate to how they use living resources in their lives. This is accomplished in steps one and two. Step three addresses the threat to biodiversity and subsequent loss of resource potential. In step three, students will research the historical/traditional use of our biodiversity and examine this use and potential in light of present biodiversity issues.

Materials: paper (notebooks to record data), pen or pencil, access to resource material on traditional foods and medicines

Procedure:

1. Instruct your students to keep a record of the different types of plants and animals they use in their everyday lives and how they use them (food, medicine, clothing, etc.). This could be done for one day, a week or more. At the end of the time have your students report on their findings. Make a list of all the different types of uses and species on a chalkboard so the entire class can see it. (Make a table with the headings "food", "medicines", "clothing", "extractions", and "other". Have your students make a similar table of their own. Ask students to suggest a non-living substitute for each plant and animal use if they can think of one. Some examples might include rayon and nylon for cotton; synthetics like dacron and polypropolene for wool; vinyl and plastics for leather; urethanes and polyesters for rubber; artificial sweeteners like saccharine for sugar; polysorbate (non-dairy creamers) for milk; phenyloamines and butylamines (petroleum-based synthetics) used to produce synthetic medicines (aspirins, decongestants) and cosmetics (skin creams, deodorants); polyurethanes, polyvinyls and fiberglass used as building materials such as insulations, roof and wall coverings, and carpeting.

Ask them if these same plants and animals would be used around the world for similar uses. (Examples might include: rice, seafood and kelps in Japan; seal, caribou, whale in Alaska, northwest coastal Americas; cow milk and cow blood in Sudan; thatch, bamboo in Asia; adobe, clay in central Africa; pine and hardwoods in the U.S. and Europe). Have them suggest substitutes which other cultures might use. Establish that even in our "modern" age, we still rely on plants and animals for many of the resources we need.

2. Create student teams and assign one of the following topics for each team to research and report back to the class on: food; medicine; clothing; building materials and other types of uses. Each team is to create a list of examples of how wild plants or animals are being or have been used around the world for their assigned use. Have each team make a brief presentation concerning their own findings. This activity need not be an extensive research effort. The activity should suffice to establish that biodiversity is important to human survival and quality of life and to make students aware of a wide range of uses for natural plants and animals.

3. Divide your class again into "research teams". Tell them they have the responsibility of investigating and recording traditional knowledge about the use of local plants and animals in that region/locality. How you assign team topics depends on the local situation. If your community is a relatively homogenous cultural and ethnic society which has occupied the area for a long period of time, you may wish to assign your teams by topic: foods, medicines, clothing or extractions. Each team then collects information from residents of the community about the past and current uses of local wild plants and animals.

However, if your community is comprised of several ethnic groups, some of them may not have a long history in the local region. Some members of each ethnic group may instead be able to provide information about a rich tradition of wild plant and/or animal use in their home country. In this case, you might assign teams to ethnic groups and request each team to collect information about all forms of uses.

The class should discuss how best to collect this information. Examples might be historical records in local libraries; interviews with professional naturalists, doctors or others who might be acquainted with uses; or interviews with local residents who may have knowledge as users or past users of such information. This latter method offers the richest opportunity since it provides a vehicle to get youth in the community to interact with elders who can share cultural information and a sense of history that might otherwise be lost to the current generation. Grandparents, homes for the elderly, and elderly citizens at random might be used as sources in your community. Of course, not only the elderly can provide suitable information. Students will need first to learn skills related to many parts of this process, including: accessing such information in local libraries; effectively and correctly approaching individuals for interviews; constructing and planning the interview; conducting the interview; analyzing and interpreting the information; preparing their team reports. Instruct each team that they will be reporting their findings to the rest of the class in the form of a journal article. It is likely that the results will be interesting enough that the class can publish the articles in their own journal.

4. Summarize this unit by presenting the importance of biodiversity to various cultures in the world and as a vital source of food and medicines. Discuss with students some of the current problems with vanishing habitats and species and what the losses represent. An alternative approach would focus on students' experiences with local or ethnic uses in the previous activities. Ask them to identify any historical losses of species and the importance of the loss and any current threats to biodiversity they became aware of. Apply this to the global situation by providing examples of your own to describe the nature of biodiversity problems and the importance of the loss.

Table 8. Examples of the Uses of Wild Plants for Medicine

Name of the Plant	Where It Is Found	Medicinal Value
Rauvolfia	Shrub in Southeast Asia	Roots produce a tranquilizer; control high blood pressure
Rosy Periwinkle	Small shrub in Madagascar	Treatment for Hodgkin's disease and childhood leukemia
Foxglove	An herb originally from Europe, now widespread	Produces digitalis which treats heart failure
Cinchona	Tree from South America	Quinine, treats malaria; also tonic water
Chondrodendron	A woody vine from South America	Curare, a muscle relaxant during surgery
Aublets	Herbaceous plant in Guyana Rain Forest	Used to stop heart beat during surgery
Mayapple	Herbaceous plant in North American deciduous forests	Derivatives used to treat testicular cancer
Willow	World wide trees	Salicylic acid (aspirin) for pain control
Aloe	Old World tropics and so. Africa	Treats burns, skin irritation
Camphor tree	Asia, China, Japan	Oil for skin lesions, cold sores, etc.
Castor bean	Native of tropical Africa, now widespread	Castor-oil; purgative for food poisoning

Extension/Adaptation

1. Have a wild edible plant feast with your students. If possible, invite all local people familiar with traditional foods to attend (and help prepare the wild edible foods).

2. Assign students a research topic having to do with the importance of wild plants and animals. They might do an ethnobotanical research on an indigenous culture such as the Yananomo in the Amazon basin. Have them suggest possible adaptations of the indigenous diet or medicinal use to the modern world.

3. Have your students write a character sketch of one or more of the people interviewed in their research on traditional uses of plants and animals.

4. Develop the concept that we forego important benefits by restricting ourselves to only a few food choices and overlooking many alternatives that exist. Ask how the materials for food, clothing and medicine may have been different in their own region several years or centuries ago. Why have foods and medicines changed? (There are actually a number of reasons. Foods exported during colonial occupation became important economically even though they may not have been a staple in the country they were grown. Technological advances such as insecticides, fertilizers, centralized food growing and synthetic medicines have had further impacts. Your students may come up with a variety of reasons, but it is important to point out to them that human habit and economics often have more to do with these kind of practices than nutrition or availability. That is, we often eat what we are used to and are not motivated to seek out alternative sources which may be more ecologically compatible, healthful and/or less expensive in the long run.)

Tell your students to choose one food source (e.g., corn), one source of medicine (e.g., willow bark) and one source of clothing (e.g., cotton). You might have the class vote on which they would choose or choose them yourself. Ask your class how their lives might be different with only these resources to choose from. Use this example to introduce the fact that the majority of the world's population is using only a small percentage of the resources available to them. (Quote some of the figures from the teacher's background information.) Ask your students what problems might be associated with depending on just a few resources (disease could wipe out the resource, the resource might be exploited so heavily it is destroyed, medicines might be ineffective against a variety of diseases, etc.). At this point explain to the class that our living resources are derived from the diversity of life on the planet, or the biodiversity and that this diversity is threatened. Part of the threat stems from the lack of knowledge we have about the diversity and the loss of knowledge already gained (e.g., knowledge of shamans and other cultural figures).

Activity #8: Biodiversity in Action

Framework Goal Levels: III; B, C, D, F, IV; A, B, C

Subject Areas: language arts, social science, science

Teacher Background:

It is impossible in such a brief activity description to thoroughly describe all environmental problem solving skills, processes, criteria and other considerations which a teacher must be aware of in order to teach environmental problem analysis. *It is assumed that you are already aware of these procedures or will consult other references to guide you in implementing this activity.* The reader is referred to Chapter 6 (see especially "Recommendation 3") for a discussion of background for the activity described here[9].

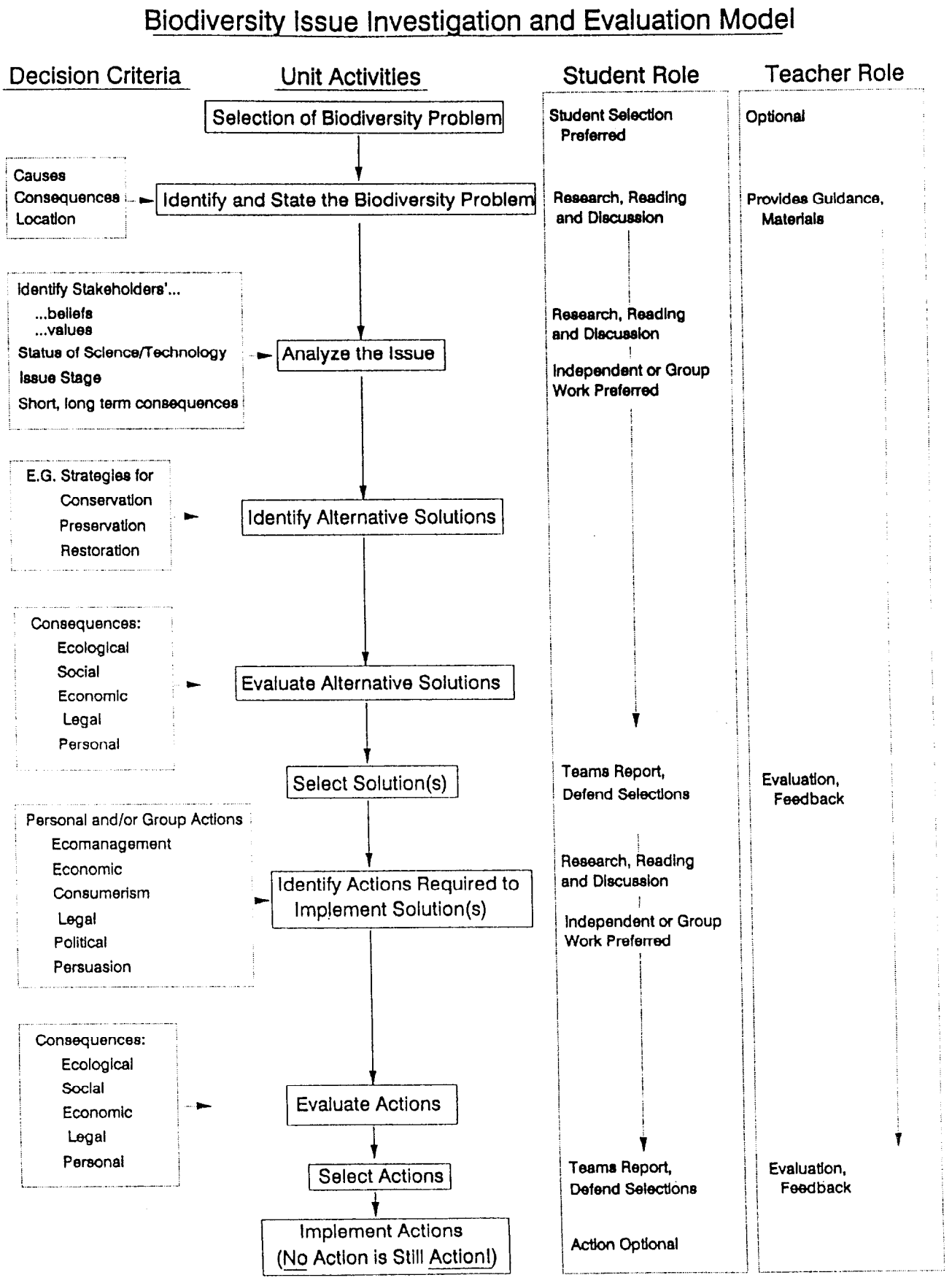
Overview:

It is assumed that your students have previously been through some biodiversity education and are familiar with the ecology of biodiversity and the nature of biodiversity issues (Biodiversity Framework Goal Levels I and II). This activity is intended to be a "capstone experience". It addresses goal levels III and IV by requiring your students to conduct an investigation of a case study. This is a major unit and could require several weeks to achieve in a secondary classroom if fully implemented. The approach used here is to initiate the unit with a selected case study and then allow students to select their own issues and work independently or in groups on different biodiversity problems. Figure 17 presents an overview of the use of the autonomous investigation and evaluation model. The case study and the analysis serves to illustrate the development of an issue analysis process. The students then refine and apply this process as they investigate an issue of their own choosing. You could provide more structure in the activity by selecting a series of appropriate case studies and using these in a hierarchical fashion to illustrate each succeeding phase of the biodiversity problem investigation and evaluation process. By substituting this method for the autonomous investigation, you could set the pace for students and move them through the unit together. While this is effective in achieving some of the desired environmental education goals, research has shown us that students who independently investigate issues of their own choosing exhibit higher skill levels and more environmental behaviors.

You are encouraged to choose or make students aware of local issues for investigation. The case study provided below could be replaced by a more pertinent issue for your students. The use of student teams is also strongly recommended as a teaching strategy. Learning to work in groups at problem solving tasks is an important goal of environmental education.

[9]Environmental education programmes are available which help teach this problem solving approach. For an example, see Hungerford et al 1988 or Hungerford et al 1989.

Figure 17. An overview of the autonomous learner model.



Procedure:

Step 1. (*Optional Review*) Ask your students to name activities (human or natural) that are contributing to the decrease in the world's biodiversity. They should be able to name local, regional and global activities (strip mining, dynamite fishing coral reefs, deforestation, volcanoes, fires). Have them discuss the possible consequences of a decrease in the world's biodiversity.

Step 2. Allow your class to read the following synopsis of an issue and ask them to analyze the issue using something similar to the worksheet provided below.

The Case Study Synopsis: Oiling up the Rain Forest (Adapted from The Rain Forest at Risk, Newsweek: August 12, 1991, p42.)

Ecologists are warning of a new threat to the Amazon basin: American oil companies. Countries such as Peru and Bolivia, with their economies and governments experiencing hard times, have invited international oil companies to explore the region known as the Andean Amazon.

The exploration has created a great deal of controversy. Peru's president Alberto Fujimori banned oil drilling in the nation's parks and reserves but recently opened up a tract of rain forest to a U.S. company, Texas Crude Exploration, Inc. in northeastern Peru. The tract, twice the size of the Grand Canyon, includes the Pacaya-Samiria national Reserve, a site called the "womb of the world." Scientists point out that it is a spawning ground for exotic and endangered species like the pink river dolphin, the Amazon manatee and the South American river turtle. Thousands of natives also reside there.

While many Peruvians are simply worried about surviving themselves, others are concerned that they will be sacrificing local gene banks for foreign governments. International groups such as Rain forest Action Network are organizing protests as well. Ecologists predict that building roads and infrastructure needed for drilling could open up the tropical forests to clear-cutting settlers. In addition, the slow-moving swamp waters of the region would be devastated should an oil spill occur. Ecologists point out that similar wells pollute the water near the drilling sites. Oil officials disagree and state that there would be no sign of the wells five years after drilling.

Crude-oil production in Peru is down 50 percent since 1980 and proponents of the exploration warn that not allowing foreign companies to explore because the area is in a reserve or national park may be very dangerous for the economy. President Fujimori has pledged not to allow drilling if it is proven scientifically that drilling would cause irreparable damage.

What president Fujimori decides to do can determine the fate of the neighboring Amazon ecosystems. Scientists have discovered a deposit of 2 billion to 3 billion barrels of oil in the Colombian Amazon. Ecuador is considering a bid from the U.S. company, Conoco to drill in the Yasuni National Park which is home to the nearly extinct Huaorani tribe. Protests from environmental and indigenous groups have forced a postponement of that decision.

Student Issue Analysis Worksheet

1. Below list the stakeholders and their position on the issue. Stakeholders are the individuals, groups, organizations or countries who have an interest in the outcome of this problem.

2. For each major stakeholder (individual or group), list the primary values or benefits they are concerned about.

3. For each major stakeholder, list any beliefs which seem to play an important role in their perspective or position on the issue.

Table 9. Stakeholder Analysis Worksheet

Stakeholder	*Position on Issue*	*Describe Primary Values*	*Describe Important Beliefs*

4. Based on the article, what is the status of our science and technology? List any needs for more scientific knowledge or technology that the article identified.

5. What--if any--solutions are posed in the article?

6. Did you think of any other possible solutions? List them.

7. How would you describe the article as a source of information? Describe any biases you observed. Do you question its' accuracy?

8. If you were interested in doing something about this issue, what information would you need? List some very specific questions that you would try to get answers to.

Step 3. Discuss each part of the analysis sheet with the class so that each team broadens its understanding of the issue. It is important that the class understands that while some knowledge has been gained from the article, more information would be needed before anyone could attempt to formulate and implement solutions.

The following illustrate some of the points which students may bring up for discussion.

Identify/define the problem:

Loss of species, genetic and ecosystem diversity as a result of habitat degradation from oil drilling in tropical rain forest, specifically the Amazon Basin.

Short-term consequences: loss of revenue from potential resource, deteriorating economic conditions if drilling stopped; dislocation of indigenous peoples, disruption of ecosystem if drilling allowed.

Long-term consequences: possible political upheaval if drilling stopped; destruction of rare and valuable ecosystem, loss of genetic resource if allowed.

Primary reasons for the problem: oil is valuable resource; economy of country dependent on the resource; country lacks funds/technology to develop/exploit resource itself. The issue is over whether we should seek known short term benefits, or avoid possible long term risks.

Stakeholders in the issue:

Governments in the Amazon basin where oil has been found, foreign oil companies, indigenous peoples living in area where oil has been found, citizens of Peru who look to development of natural resources for the economic well being of their country, environmentalists and scientists concerned over disruption of Amazon ecosystem, world citizens.

Need for more science and technology:

The impact of drilling on the rain forest cannot be predicted with certainty and so some risk is involved. The probability of risk to the ecosystem is not known.

Alternative solutions to the problem:

Scientific evidence that drilling will have no/minimum effect; drill outside of ecologically sensitive areas; find another resource to develop that would replace dependence on oil and not harm ecosystem; world conservation measures to reduce need for oil; swap for debt to assist economy

In the example, several solutions might be considered. The Peruvian government might suggest forgiveness of debt from a country such as Holland in return for total protection of the reserve and park. Other resources might be found in the rain forest that could be used in a non-destructive, sustainable way such as medicines, foods or industrial uses for sap (e.g. rubber). World-wide energy conservation might be encouraged to decrease the demand for oil, thus conserving the oil and the ecosystems in which it is found.

Solutions should be discussed by the class. For example, critics may be quick to point out that energy conservation does little for Peru's economy. Students should be careful to consider all the

consequences of solutions.

Step 4. For purposes of this exercise, have the class decide on a solution to the problem even though not all desired information is available to them. Then ask the class what actions would be necessary to see that the solution is successfully implemented. For example, if finding alternative non-destructive use of rain forest resources is a solution, research grants to universities or scientists for exploration may be necessary. Political action by citizens to bring about needed legislation to appropriate funds would be another level of action. Public awareness of this solution might be needed to provide the political support. Publicizing indigenous medicines in the media, and these threatened benefits might be another required action.

Alternative actions must be assessed with respect to a number of criteria (consequences): effectiveness, ecological, political, economic, social, legal, and personal. Boycott actions and political pressure could pose a personal safety risk in some situations. Some actions may be too expensive or may deprive other needed environmental programmes of support.

It is not necessary to get closure on the solutions and actions required to resolve the specific biodiversity issue used in the case study. This exercise is needed to make students aware of the criteria which should be considered in analyzing a biodiversity problem and deciding what should be done about it. The discussions will suggest to them the type of information needed.

Step 5. Pose the question to students: "If you were interested in doing something about this biodiversity issue or any other issue, what processes would you have to go through to be able to identify the best solutions and actions required?" Spend as much time as necessary on this item to have students develop a procedural outline for investigating an issue and recommending actions to be taken. The exercise should produce guidelines for what information they need, what criteria they would use to make their decisions, and the processes they would go through in their analysis. Students should not be left with the idea that only risk-free, highly certain decisions should be made. Rather they should see this process as an effort to make the best informed choices possible, and thus to minimize unnecessary risk.

Step 6. Form student teams and ask them to assume they have been appointed to a United Nations Task Force on Biodiversity. Their mission is to select a biodiversity issue and prepare a report which recommends and defends solutions and environmental actions. The recommendations should encompass actions by individuals, groups, organizations, or governments. The teams must independently research their own selected biodiversity problem. Be sure each team understands the various components of the task and that it will require several days (or even weeks) to complete the assignment. They will be asked to present their report to a United Nations Committee on the Environment (class).

Activity #9: Selling the Public on Biodiversity

Framework Goal Levels: I; A - E, II; A - H, III; A - G, IV; A, C

Subject Areas: language arts, biology, social sciences

Teacher Background:

Several categories of environmental action are available for the environmentally literate citizen including economic, ecomanagement, consumer, legal, political and persuasive actions. Persuasive actions reflect extremely critical communication skills and provide the basis of several of the other action categories. This makes persuasive skills especially important goals for environmental education.

In capitalistic, market economies where success is dependent on persuading consumers to buy a particular product or service, a strategy known as "marketing" has become increasingly important during recent years. Marketing is generally underestimated and misunderstood by most people who think it is a process advertisers use to sell products. However, the process implies a total system of relating products and services to consumer needs and preferences. Promotion and persuasion are important parts of marketing, but when they are combined with the other aspects of the process, marketing becomes a repackaging of critical communication skills and principles. Marketing offers an interesting and contemporary way to teach these basic communication skills.

Both the private and the public sectors are utilizing the marketing approach to providing products and services to the public more efficiently. Private businesses, of course, use the process in order to increase or maintain sales. Public resource agencies are beginning to realize that the process has much to offer to their task of regulating the use of scarce natural resources.

In order to make this approach successful, the marketer must understand 1) the product or service, 2) the customers, and 3) the process of communication. Therefore, a marketing approach must provide a better understanding of customers, evaluates products and services to see that they meet customer preferences and needs, and develops promotion strategies which are specifically designed for selected audiences.

Successful marketing usually includes a process of ***segmentation*** in which an analysis of consumers enables producers to divide the public into ***market segments.*** Some of these market segments can then be selected and ***targeted*** in the marketing process. The basis on which the public is segmented depends on finding some useful differences which would suggest effective ways of designing the product/service or promotional strategy. Targeting segments implies that products/services can be better designed to appeal to the selected customer segments, and/or that promotion of existing products/services can be made more specific for those identified segments. For example, instead of designing just one type of automobile for everyone, different models are designed to suit various types of customer preferences. Promotion (e.g. through advertising) would then be targeted towards these selected markets. How, where and when the promotion is delivered, the message in the promotion, and all other aspects of the promotional campaign would be carefully designed to meet the characteristics of the targeted segment.

Overview:

This is really a lesson in persuasive environmental action. In this activity, marketing will be applied to the task of getting people to value biodiversity and to implement behaviors which are necessary to protect and manage biodiversity. A marketing approach to public attitudes about biodiversity will require three major phases: 1) Assess the Situation, 2) Develop a Marketing Strategy, and 3) Implement the Marketing Strategy. These phases will be explained in the procedures along with suggestions on how students can apply them to biodiversity. Students will need to survey the population to determine the segments. The activity could be done by individual students but would be more productive if groups or teams were formed. Students can then divide their efforts and sample different segments of the population, brainstorm survey questions, research various aspects of biodiversity, and discuss strategies as data are collected. The team can then present their marketing strategies as a group.

Materials: Magazines, newspapers with commercial ads; access to radio, television (or taped commercial programming), pencils, paper, copy machine to create survey sheets (optional)

Procedure:

For this activity, it is assumed that students are aware of the meaning and importance of biodiversity. If not, an introductory activity should be selected before this activity is used.

1. Bring in examples of persuasive efforts and ask students to analyze them in a class discussion. Other forms exist but commercial advertising is the most readily available. You could use magazine or other printed ads and/or television commercials. Ask students to determine the following for these persuasive messages:

a. What is the purpose of the example?

(The purposes of commercial ads are not always to sell a product directly. Sometimes it is to enhance the image of the company. For example, Toyota placed an ad in Audubon magazine which admonished owners of Toyota 4-wheel drive trucks from using them offroad in pristine natural environments. Obviously, readers of Audubon magazine are not likely to do so in the first place, but that was not really the intent of the ad. It was to convince environmentally concerned citizens that Toyota was environmentally responsible. Even though these readers may not be potential buyers of 4-wheel drive trucks, they would be encouraged to buy other types of cars from Toyota because of the "positive environmental image".)

b. What is the primary audience for which it is intended?

(In the example above, the environmentally conservative readers of Audubon who also represent a likely market for the passenger cars built by Toyota. In other ads, students should be able to identify clear targets of the ads to be children, middle aged adults, the

elderly, the rich, the poor, urban dwellers, rural dwellers, etc.)

c. How is the message (or method of delivery, etc.) designed specifically for that audience?

(The ad in Audubon magazine is an obvious example. Putting ads on cereal boxes is another. Television commercials during prime time news features will be designed for an entirely different audience than those airing during children's programs. Consider the difference in ads on the sports page of a newspaper from those in a women's section. Placement of the message is only one way of targeting an audience. The design of the message itself, the way it is communicated and many other direct and subtle strategies are used which students should be able to observe. An important aspect are the values or benefits which are identified. A car manufacturer may attempt to sell its product to one group based on the car's styling, color and convenience; to another based on price and economy; and still another group may be convinced through the safety features.)

d. What communication principles seem to be used most often?

(Students should realize that ads seem to be targeted for specific audiences. They reflect a great deal of understanding about the characteristics, preferences, values, and beliefs of the target audience. Much attention is paid to the form of the message and the technical production. There are other more subtle but very important principles regarding the structure of the message that students may be able to deduct from the analysis, although these may not always be simple to identify and understand.)

e. What ethical considerations are there in these examples?

(Are the ethics of the messages or the communication techniques acceptable to all the students? For example, do any of the examples achieve their objective, but cause audiences to make poor choices or overlook negative consequences?)

This process of analyzing the promotional strategies which are currently being used to modify consumer behaviors in their own society will be very beneficial to students. Not only will they develop some principles of good communication techniques, but the process of studying advertising, for example, will improve their own environmental consumer skills and evaluation of advertising messages.

2. Inform the students that they are to assume the role of marketing teams to sell some group or groups on some aspect of biodiversity management or protection. Introduce the concepts and principles of marketing which have been explained in the background section and which are detailed in the following procedures. Form the teams and explain the following process to them.

A. Assess the situation and establish your specific mission, goals and objectives.

Teams are to review what they know about biodiversity and its problems: the status of

biodiversity locally and globally; the status of current local (and global) attitudes regarding biodiversity; current or needed public behaviors that influence the condition of biodiversity; current efforts to improve public behaviors or attitudes toward biodiversity.

They should decide what the specific marketing objectives will be for their project. Will the students decide to market a specific aspect of diversity--perhaps a local, endangered element of biodiversity? Is their objective to change attitudes in general, or will they attempt to modify specific attitudes regarding specific aspects of biodiversity? Do their objectives involve behavioral changes--e.g. attempt to gain support for a particular piece of legislation, gain compliance with existing wetland protection regulations, solicit donations to an effort to preserve biodiversity, etc.? Or is their objective to change behaviors in general regarding biodiversity?

This is an important time to consider the ethics of the objectives. One important difference in the goal of this activity and marketing by businesses, is that persuasive efforts should remain within the context of rational, objective problem solving. Should we use means to convince people to act in favor of the environment when the method causes them to overlook other important negative consequences?

As a result of this phase of planning, they should have a clearly stated problem they are dealing with, a set of goals, and a specific set of objectives.

B. Develop your marketing strategy.

Based on their selected objectives, each team must decide what sector of the public will initially be considered for targeting (e.g., legislators; business or industrial leaders; local vs. global; farmers vs. urban dwellers; old vs young vs all ages, etc.)

Students must then collect and analyze data on the public, and divide the public into market segments based on some useful differences in characteristics. A basis for segmentation might be the value orientation towards the natural environment. One segment of the population might be found which values the natural characteristics of biodiversity--beauty, solitude, complexity, wildness. Another segment might value the environment for the uses that can be made of biodiversity resources--food, medicines, building products. Still another segment might value the recreational opportunities associated with a biologically diverse ecosystem--camping, hiking, hunting, fishing. Fear or distrust will likely characterize how some people view the natural environment, and thus, another segment could be identified.

The value characteristic might be combined with certain other attributes such as differences in place of residence (e.g., urban or rural), age, or gender, to create more refined markets to target. Exactly how the segments are defined will depend on the objectives of the project and, of course, the data that can be either collected or found elsewhere.

Teams must decide very carefully what segments will be most important for them to target

with their marketing programmes. This information should be used to revise the marketing objectives established earlier, since it will serve to make the objectives more explicit and direct further work.

During this phase, a business or industry would also plan for the marketing mix by considering designs of the product, the price, the place, and the promotion. In the students' use of marketing, however, there may be little that they can modify in the price or place of the product--biodiversity; although they may find very creative ways to integrate these elements into their marketing design. The primary tool for them to use in this activity is promotion. Their challenge is to use what they have learned about their product, their targeted audience and communication skills to promote biodiversity to their selected "consumers". They will have to find ways to present biodiversity in such a way that will "sell the product" and achieve their objectives with their selected market segment(s).

C. Implement the Marketing Strategy.

At this stage, students develop materials and procedures according to the promotional plan they have designed and present them. How extensive this activity becomes is up to the instructor and educational setting. It could be a very simple, entertaining approach where students have been restricted to strategies suitable for television or radio. In this case, teams could act out television commercials with simple props to convey the message. At the other extreme, teams might be encouraged to actually develop complete marketing strategies and produce them in some technical form. Television or radio commercials might actually be produced. A complete promotional campaign might include brochures and letters intended for mailing campaigns to solicit funds; magazine and newspaper ads; posters; speeches; telephone or neighborhood canvassing programs; etc.

3. As the marketing strategies are presented by each team, students should evaluate the efforts using the following guidelines:

a. Were all the promotions consistent with their selected audiences?
b. Were all persuasive methods (e.g., communication methods) equally effective?
c. Were any of the marketing strategies "dishonest" or unethical in order to be more effective? (E.g., was distorted or misleading information used; tactics used to focus attention on positive aspects in order to get audiences to overlook important negative considerations?)

CHAPTER 8:

Implementing the Environmental Education Module on Biodiversity

Some recommendations are provided here for biodiversity/environmental education curriculum development and inservice teacher training. It is envisioned that a diversity of situations and conditions surrounding the use of the module exists for either of these two efforts. Since it is impossible to anticipate all of these applications and needs, the recommendations reflect general principles which should prove useful when adapting the module to specific situations.

Developing Biodiversity Curriculum Materials

Recommendation 1: Adapt the overall design of curriculum materials to the educational resources and practices of the system in which they will be used.

If an environmental education infusion model is already in place in a public school programme, biodiversity materials (e.g., readings, activities) can be adapted and/or developed and inserted into this existing structure. Thus, biodiversity simply becomes one of the environmental themes which add richness to the environmental education structure. The environmental education structure would guide development and selection of appropriate biodiversity content and activities to achieve all goal levels.

In the more likely event that an environmental education infusion model is not in place, the task is more comprehensive. In this situation, the environmental education infusion structure in the curriculum could be initially developed around biodiversity. Additional growth of the environmental education programme could occur with the addition of other themes (e.g. global change, energy, toxic contamination, solid waste disposal).

The benefits of the infusion model have been strongly emphasized in this module. However, alternative models may be more effective or otherwise suitable for a specific situation. A comprehensive inter- or monodisciplinary model (i.e. a complete biodiversity unit taught in one course) may be necessary because of curriculum restrictions, lack of opportunity for training all disciplinary teachers, or insufficient time. Or perhaps an incompletely infused biodiversity/environmental education programme--putting larger biodiversity education experiences into a small part of the curriculum--is all that is possible at the beginning. In these instances, curriculum developers must create fewer, but more extensive units which allow students to achieve in all four goal levels. The reader is encouraged to consult the recommendations in Chapter 6 for additional points regarding the development of biodiversity/environmental curricula. The use of case studies and the autonomous investigation and evaluation model as discussed in chapter 6 may be most appropriate here (fig. 16).

Recommendation 2: Design the curriculum materials using many local and/or regional biodiversity

case studies and examples to provide more concrete experiences for students and to broaden the opportunities for students to develop investigative, evaluative and action skills.

Regardless of the total design of the environmental education curriculum into which biodiversity will be inserted, it is essential that the materials reflect not only the global status of biodiversity, but the status of local and regional problems and issues as well. The global situation certainly has an impact on every world citizen, and students must develop some ownership in biodiversity problems at this level. However, greater interest may be generated--at least initially--by using more familiar situations. Familiar, local examples also are more concrete concepts and perhaps more effective in developing student understanding than global relationships which tend to be more vague and abstract for secondary aged students. It is also more likely that local or regional issues and problems provide a more realistic understanding of the tradeoffs involved in these difficult issues. Focus on local or regional problems would also provide more opportunity for students to identify and evaluate effective solutions and actions. More empowerment of students (including locus of control) may be developed by incorporating local or regional biodiversity materials. Many of the activities and strategies described in the module reflect generic educational processes or biodiversity principles and they can be improved by inserting relevant (e.g., local, familiar) biodiversity examples and information. (For example, a moral dilemma could be developed from a local or regional situations in order to adapt Activity #1 and make it more effective with students). *A major task of the curriculum developer will be to ensure that appropriate materials (e.g., movies, slides, videos, readings, case studies) reflecting useful local, regional and global biodiversity topics are collected together and integrated into the finished curriculum for teacher use.*

Recommendation 3: Follow a systematic plan for developing biodiversity/environmental education materials so that opportunities can be maximized to produce a fully comprehensive and effective program.

The scope of curriculum development may range from one of developing a discreet unit to the large task of designing a complete infusion structure for biodiversity, and, ultimately, environmental education. In either case, the following guidelines may prove useful in identifying the tasks which must be accomplished (Hungerford and Peyton 1986). The exact process may certainly be modified to meet the scope of the curriculum project at hand.

Figure 18. A recommended process for developing an extensive environmental education curriculum. (Hungerford and Peyton 1986, p39-40)

I. Organize a curriculum Core Development Team (CDT).
   A. Choose CDT members.
   B. Establish tasks and timelines for the CDT.
   C. Collect appropriate resources, e.g., curriculum materials and professional references.
   D. Identify the constraints that will impinge upon the curriculum development effort and plan for resolving same.

II. Identify professional consultants who will serve as a Recommended Support Team (RST).
   A. Establish tasks and timelines.
   B. Identify liaison procedures to be used between RST and CDT.

III. Develop the curriculum's scope and sequence.
   A. Define curriculum goals.
   B. Define concepts, skills and attitudes to be incorporated as objectives into the curriculum (the scope).
   C. Assign objective components to appropriate grade levels and content areas (the sequence).

IV. Evaluate the existing school program with respect to potential environmental education infusion elements.
   A. Identify environmental education objectives which already exist in the present curriculum.
   B. Identify materials in present curriculum which could be modified to meet environmental education objectives.
   C. Identify deficiencies in present curriculum where new materials must be selected or developed to complete the proposed environmental education scope and sequence.

V. Inventory and evaluate the community/regional resources available for use in the environmental education curriculum.

VI. Prepare the environmental education curriculum.
   A. Review and evaluate the materials which have been collected for potential adaptation or adoption.
   B. Organize writing teams to adapt or develop environmental education materials needed to complete the curriculum.

VII. Develop plans for both pilot and full scale implementation.

VIII. Develop a comprehensive evaluation program.

Providing Teacher Training in Biodiversity\Environmental Education

Teacher training in biodiversity may occur before, during or after the development of curricular materials. Involving teachers in training before completion of the curricular materials has the advantage of improving teacher ownership of the finished product, and thus, their ultimate use of the materials. It is also likely to be more effective since teachers can help design a curriculum which uses the most beneficial opportunities to integrate biodiversity/environmental education activities. Since teachers can provide an important resource in the curriculum building process, it is strongly recommended that teachers be involved from the onset of the curriculum development process. If the planning guide in figure 18 is used, teachers should be a part of the Core Development Team. However, involvement of even more classroom educators could be accomplished early by short information sessions in which teachers are invited to offer suggestions for continued work. Brief questionnaires might be used to survey teachers in a district to both inform them and to obtain their input and acceptance of the project. Any workshop training provided to teachers could also very effectively include opportunities for teachers to assist in developing or adapting the curriculum as will be discussed later.

The specific training required by teachers will depend largely on their current status regarding environmental education in general and biodiversity in particular. Teachers who have been already involved in an infusion model based on the Tbilisi Declaration or on the goal levels referenced in this module, may require a workshop which presents only the technical and scientific aspects of biodiversity and familiarizes participants with--and/or allows the teachers to develop or adapt--case studies and teaching materials which they can use. However, teachers who have not been trained in environmental education will require much more substantive training in the goals and strategies of environmental education itself so that they have a framework of understanding into which to place biodiversity training. Teachers who lack experience with issue analysis or environmental action themselves, will not be as effective in teaching these skills as teachers who do possess some training or experience. Regardless of the scope of the workshop, some guiding principles should be considered.

Recommendation 1: If resources permit, teacher training should involve teachers in repeated experiences over a period of time (e.g., a year) rather than a single workshop experience.

This is more true for teachers without previous environmental education training. The following are only a few of the many reasons for this recommendation. First of all, this model allows teachers to implement biodiversity activities in their classrooms, then gain more feedback at a later workshop. It also allows curriculum developers to collect useful information in revising curriculum materials. Mutually supportive networks are more likely to develop among teachers who are involved in this training over time. This networking encourages teachers to use the materials and to seek assistance from one another when it is needed. Finally, one should also not overlook the fact that teachers also can become overwhelmed by large complex tasks. Repeated workshop experiences can allow the teacher trainer to break up the curriculum into "small wins"--achievable pieces of the programme.

Recommendation 2: The workshop should train teachers with the same curriculum materials and activities that the teachers are intended to use themselves in the classroom.

It has been well established that teachers tend to use instructional strategies and activities which they have experienced themselves in training. Activities such as those presented in Chapter 7 of this module, could train teachers on the biodiversity framework. They have been selected to cover all four goal levels and many subject areas for infusion. Teachers would very effectively learn about biodiversity at the same time they were experiencing effective strategies for teaching about biodiversity.

Whatever the source, powerful activities should be selected which model desired teaching behaviors, process and content. These should certainly include knowledge of local, regional and global biodiversity problems, some of the very difficult and fundamental values education strategies, analysis of issues and alternatives, and consideration of possible environmental actions unless teachers are already trained in these areas.

Recommendation 3. Training experiences for teachers ideally should have adequate time for teachers to complete an assessment of their own programmes and adapt/design their own suitable curriculum materials.

The teachers' own programmes would be analyzed to determine current components which relate to the desired biodiversity/environmental goals, and to find other opportunities where biodiversity/environmental education activities could be infused. The workshop should assist teachers to select, adapt or develop appropriate teaching activities and materials for their own classroom. This might be the means by which local and regional case studies are researched, selected and developed into educational materials. Once teachers have been trained on more generic biodiversity principles and/or global problems and issues, they could be allowed to develop more local or regional applications. Further, specific teaching activities which have been developed or are being considered, could be tailored by the teachers themselves to be appropriate for their classrooms.

These strategies would provide learning benefits as teachers applied the principles to local and regional cases, in addition to adapting the curriculum content to the local community. This approach not only makes the final product more useful to the teachers, but it improves their likelihood of properly implementing the programme materials since people do a better job on tasks for which they feel ownership.

Recommendation 4: When dealing with a technically difficult topic which spans several disciplines, it is desirable to enroll teachers in teams of two or more disciplines if possible.

Thus, a life science educator, a social science teacher and a language arts or communications instructor from the same school would make an excellent team for biodiversity/environmental education. During the workshop experience, they could assist each other in learning the foundational

elements and understanding the problems and issues. Each could learn more from the experience since teaching to others is one of the most effective means of learning ourselves. This also supports the "small wins" concept since none of the team members need be totally competent for the entire multidisciplinary topic. Each will be aware of the entire biodiversity curriculum framework, but each will have their own major area of responsibility. By sharing the tasks, they can more effectively and efficiently produce multidisciplinary teaching materials that span all goal levels. Further, the team training experience will initiate a process of cooperation to enhance the infusion of biodiversity education in the curriculum.

Recommendation 5: Use parts or all of this module for training.

Readings from Chapters 3 and 4 will provide background on biodiversity. Chapter 5 will provide background on the nature of issues and the need for values education. The activities in Chapter 7 can be adapted for training teachers on the fundamental ideas and strategies of biodiversity/environmental education.

Recommendation 6: The teacher training process should provide copies of actual references which deal with biodiversity topics pertinent to teachers' own local or regional areas, and which will supply them with a powerful repertoire to draw from as they continually adapt teaching materials.

These references should include articles from newspapers, popular magazines, scientifically oriented publications, videos and movies. Materials should be selected which reflect the nature of issues, various forms of conflict, scientific information needs, and environmental solutions and actions.

Recommended UNESCO-UNEP/IEEP References

This module has presented guidelines for developing curricula and teacher training on the biodiversity theme within the broader guidelines of environmental education. However, it is not possible to thoroughly develop all foundational ideas and skills associated with developing environmental education curriculum and training experiences for teachers in this one module. Fortunately, the (Unesco-UNEP) International Environmental Education Programme has produced a comprehensive set of volumes which present many of these foundational aspects. These publications reflect a diversity of expertise and will serve as excellent resources for educators engaged in planning for curriculum development and/or teacher training in biodiversity education. Figure 19 identifies some of these publications and the pertinent topics which they contain. Professionals working in biodiversity education are urged to consult these additional sources for more information on identified topics.

Figure 19. A summary of Unesco-UNEP/IEEP publications which provide useful detailed information for curriculum development and/or teacher training.

Pub. No.*	Curr. Plan. & Devel.	Evaluation	Teaching Strategies					Sources: Teaching Activities	Preserv. Train.	Inserv. Train.	General Comments
			Ecology	Values Educ.	Case Studies	Autonomous Invest, Eval.	Env. Action				
#1	X	X							X	X	Good discussion of international trends and models
#9	X		X	X	X			X	X	X	Good inquiry lesson for social studies
#22	X	X									Provides very detailed model for curriculum planners
#25								X	X	X	Comprehensive discussion of teacher training in environmental education
#26	X	X		X	X			X	X		Excellent discussion of specific teaching strategies in addition to those in this table
#29	X		X	X	X	X	X	X			Excellent middle school curriculum model with many examples; in depth consideration of case study and investigation models; many topics applicable to secondary level

* The IEEP references are listed by publication number. The entire reference may be found in the literature cited section of the module.

CHAPTER 9:

CONCLUSION

Proper management of biodiversity is more than an aesthetic desire, it is a life-supporting need. It may or may not be seen as a moral obligation to our environment, but it is most certainly a moral obligation to ourselves and to future generations. Effective, optimal management of biodiversity will require appropriate individual and collective behavior of world citizens. The means to achieve that behavior is environmental education.

Environmental education is quite correct in setting as its goal, the environmentally literate citizen who is willing and capable of taking individual and group actions to maintain and enhance a balance between the quality of human life and the quality of the environment, e.g. biodiversity. But environmental educators must be realistic in setting objectives and selecting strategies. The extent to which our environment is preserved, conserved, developed or destroyed presents difficult choices which will require truly environmentally literate citizens. The process of deciding cannot be taken lightly. The decisions should not be left to chance as humans plunge ahead, guided only by narrow, short term goals and limited only to economic values--not if we also value continued health for ourselves and future generations. Citizens who are not environmentally literate cannot successfully resolve such complex, value laden problems. Even environmentally literate citizens are going to find these to be among the most challenging tasks of our time.

However, environmental education can successfully influence the behavior of many citizens of developed nations. They can be educated to acknowledge the benefits of biological diversity and to understand the types of behavioral changes necessary to properly manage it. The difficulty lies in sorting through the many values involved and establishing new priorities. It will be difficult to get such citizens to voluntarily modify their behaviors to become more environmentally responsible, but it is certainly achievable.

To successfully involve these citizens of developed countries in optimal environmental management will require, in part, that they be presented with alternatives to current behavior. Such alternatives could include agricultural methods that build rather than destroy soil, alternative crops that are more compatible with existing environmental conditions, alternative land use that achieves optimal sustained yield of existing resources rather than destroying or replacing them, and energy policies that treat the earth as a finite resource. Obviously, there are many tasks for our scientists and technologists to complete.

However, changing human behavior is not a simple "technological fix". There must also be adjustments to knowledge and value priorities, i.e., attitudes. Without these adjustments, at best new technologies will not be adopted, or worse, technology will add to the existing problems. Obviously, there are also many tasks for us as environmental educators to complete.

Environmental education can target future policy makers, scientists, educators and citizens and be effective in changing their outlook on the environment. Use of more compatible technologies can be increased through environmental education. As our environmental crises increase in number and intensity, it is likely that environmental education will gain more support from society to achieve its

challenging task with this affluent segment of world society.

However, not everyone in the world can afford to value the environment and needs of future generations so highly. It will be difficult to develop positive attitudes and conserving behavior towards our natural environment among many poverty-stricken citizens of developing nations. Maslow (1970) suggested that humans have a hierarchy of needs that must be taken care of. Love and self esteem are of little importance without food and shelter. Without food for survival, there is little need to conserve the environment for future generations. It is not surprising that many people of the world who are barely able--or unable--to provide those basic physical needs for themselves are unconcerned about actions that benefit environmental quality. The motivations provided by poverty, starvation, and ill health cannot be changed merely by education about environmental quality. However, environmental education can help some of these citizens enhance their survival and the status of biodiversity by presenting them with more compatible options. Poverty, starvation and poor health place severe restrictions on environmental education, but there is an appropriate role. Potential behavioral changes among at least some developing societies are well worth the effort.

Environmental education then, has many different audiences. The general approach to biodiversity education presented in this module, must be adapted and applied appropriately to train citizens to implement positive environmental behaviors to the extent of their abilities and opportunities. These actions range from their own environmental behaviors--including choices as consumers, farmers, or resource users--to their political and humanitarian activities. Any effort to educate these audiences by simply telling them what to do, will fail. Our focus must be on preparing them to participate in the decision process themselves, and to intelligently consider more of the values and consequences involved: environmental as well as economic; long term as well as short term. We will not always agree on the answers, but we should all be a part of the process.

At the rate at which we are modifying our planet's ecosystem, this responsibility cannot be taken lightly. Nor can we procrastinate. The goals of environmental education must be infused effectively into our world's educational system. Intelligently weighing the environmental consequences of personal, social, institutional, economic and all other decisions must become second nature to our world population.

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